MONITORING REPORT FOR 2015

CLARK FORK RIVER OPERABLE UNIT

prepared for

Montana Department of Environmental Quality
Remediation Division
Federal Superfund and Construction Bureau
P.O. Box 200901
Helena, MT 59620-0901

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RESPEC

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CLARK FORK RIVER OPERABLE UNIT

by

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EXECUTIVE SUMMARY

This performance monitoring program evaluates the progress of remedial actions in the Clark Fork River Operable Unit (CFROU) of the Milltown Reservoir/Clark Fork River Superfund sites toward meeting performance goals or identified reference values. Environmental media monitored in 2015 included surface water, instream sediment, vegetation, macroinvertebrates, periphyton, fish, and birds. This report summarizes results of data collected for each of these environmental media and evaluates progress toward attainment of performance goals or in relation to reference values as of 2015.

Heavy metals originating from historic mining, milling, and smelting processes associated with operations in Butte and Anaconda accumulated in the Clark Fork River streambanks and floodplain over a period of at least 100 years. The primary sources of contamination are tailings and contaminated sediments mixed with soils in the streambanks and floodplains, which erode during high streamflow events and enter the river and other surface waters. In addition to erosion, heavy metals are leached from the contaminated sediments and tailings directly into the groundwater and eventually to surface water. These contaminant transport pathways result in impacts to terrestrial and aquatic life along the Clark Fork River, as described in the Record of Decision (ROD) for the site.

The Montana Department of Environmental Quality (MDEQ), as lead agency and in consultation with the U.S. Environmental Protection Agency (USEPA) and the National Park Service, oversees, manages, coordinates, designs, and implements remedial actions for the Clark Fork River site. The MDEQ coordinates with the Natural Resource Damage Program (NRDP) of the Montana Department of Justice regarding implementation and integration of restoration components to supplement the remedial actions. The MDEQ coordinates with the National Park Service to implement remedial actions on the Grant-Kohrs Ranch.

Data collected in 2015 represents the sixth year of monitoring in the CFROU. Remediation activities in the CFROU in 2015 included active tailings removals and reconstruction in Phases 2 (1.9 river miles), Phases 5 and 6 (4.3 river miles), and the Eastside Road pasture areas adjacent to Phases 12 and 13 (approximately 100 acres).

Monitoring under this program was first conducted by MDEQ and RESPEC personnel in the spring of 2010, prior to initiation of any remediation actions within the CFROU. Since 2010, some monitoring sites have been added to the monitoring program in Clark Fork River tributaries. In addition, this monitoring program has been coordinated with long-term monitoring by the U.S. Geological Survey (USGS) to complement data collected by the USGS and minimize data duplication by each program. Monitoring methods and quality assurance protocols guiding collection and analysis of the data described in this report are summarized in the project sampling and analysis plan (SAP) and the project quality assurance project plan (QAPP).

The CFROU monitoring network in 2015 included sixteen sample sites; seven mainstem sites and nine tributary sites. Not all sites were sampled for each environmental medium or for each analyte of each environmental medium (e.g., some surface water sites were only sampled for mercury and methylmercury rather than the full suite of analytes). The monitoring network was essentially the same in 2015 as in 2014 although two additional surface water, sediment, and biological (i.e., macroinvertebrate and periphyton) monitoring sites were added to the monitoring network in 2015. One new site (CFR-34; Clark Fork River at Williams-Tavenner Bridge) was added on the Clark Fork River mainstem downstream from the Grant-Kohrs Ranch National Park property. Site CFR-34 was added to provide a more detailed assessment of water and instream sediment chemistry and aquatic biota that may be related to remediation planned for Phase 15 in the vicinity of the Grant-Kohrs Ranch property. In addition, one site was added on Silver Bow Creek (SS-19; Silver Bow Creek at Frontage Road) immediately upstream from the Warm Springs Ponds inlet. Site SS-19 was sampled under the Streamside Tailings Operable Unit monitoring program in 2015 but those results are included in this report to provide a comparison of conditions upstream and downstream from the Warm Springs Ponds. For surface water and instream sediment chemistry, the monitoring program primarily monitored concentrations of metal contaminants of concern (COCs; arsenic, cadmium, copper, lead, and zinc). However, for surface water, additional data was collected including nutrient and common ion concentrations, and other field parameters (e.g., acidity). Surface water samples were collected during each calendar quarter with two additional samples collected during the spring snowmelt runoff period. Sediment samples were collected during the first and third quarters. Macroinvertebrate and periphyton samples were collected during the summer (third quarter). Fisheries data, collected by Montana Fish Wildlife and Parks, included trout population abundance at long-term reference sites, *in situ* mortality of confined fish at selected sites, and stream chemistry data. Bird monitoring data, collected by GoBirdMontana, included monitoring of bird diversity at three sites in Reach A of the CFROU.

Streamflows throughout the upper Clark Fork River watershed were variable and ranged from well below to slightly above the long-term median for the period of record at nearly all sites during monitoring periods during 2015. For example, during the winter (January and February) streamflows were generally above the median, perhaps due to warmer than average winter temperatures. The spring runoff peak was similar to the long-term median but streamflows receded toward summer baseflow levels more rapidly following the peak compared to the long-term median.

No exceedances of surface water performance goals occurred for any COCs except arsenic and lead. Of 36 samples collected in the mainstem Clark Fork River in 2015 (from six sites during six sample periods), no samples (0%) had cadmium, copper, or zinc concentrations exceeding the performance goals. Three samples (8%) had lead concentrations exceeding the performance goal in the mainstem all of which occurred during the falling limb of the spring runoff hydrograph. Arsenic commonly exceeded performance goals in Reach A but no exceedances occurred in Reach C at Turah. Of 30 samples collected in the Clark Fork River in Reach A (five sites during six sample periods), 90% exceeded the dissolved arsenic and 27% exceeded the total recoverable arsenic performance goals. Sources of arsenic to the Clark Fork River in Reach A appear to be the Mill-Willow Creek watersheds and the Warm Springs Ponds. In Mill-Willow Creek, 92% (11 of 12) of the samples exceeded the dissolved arsenic and 58% (7 of 12) exceeded the total recoverable performance goals in those sites. Arsenic concentrations in

Mill-Willow Creek were approximately the same at sites above and below the Mill-Willow Bypass suggesting that arsenic loading occurs in the upper portion of the watershed rather than in the bypass reach. In Silver Bow Creek immediately downstream from the Warm Springs Ponds (and also downstream from the Mill-Willow Creek confluence), 67% (4 of 6) of the samples exceeded the dissolved arsenic and 50% (3 of 6) exceeded the total recoverable arsenic performance goals but no samples in Silver Bow Creek immediately above the Warm Springs Ponds exceeded either arsenic performance goals.

The highest instream sediment COC concentrations in the mainstem of the Clark Fork River were typically observed in the uppermost sample sites in Reach A, and the lowest concentrations were typically observed at the downstream-most site at Turah in 2015. Concentrations of arsenic, copper, lead, and zinc exceeded the "probable effect concentration" (PEC; the higher of the two reference values for the CFROU) at all of the Clark Fork River mainstem monitoring stations during both sample periods in 2015. Among all sediment sampling sites in the CFROU (15; each sampled twice annually), arsenic most commonly exceeded the PEC (93%) followed by copper (87%), lead, and zinc (77%), and cadmium (70%). All sediment samples collected in the CFROU exceeded the lower reference value ("threshold effect concentration") in 2015.

Vegetation monitoring data was collected during the third quarter of 2015 in Phase 1 of Reach A in the CFROU. This was the second year of "Year-1" monitoring for Phase 1 because not all revegetation activities had been completed in the third quarter of 2014 when vegetation monitoring was first conducted in Phase 1. Three vegetation monitoring metrics were evaluated in 2015 which had applicable Year 1 performance targets: woody plant survival on the floodplain (target >80%), total native herbaceous cover on the floodplain (target >20%), and noxious weed cover on the floodplain (<5%). Overall, woody plant survival was 85.5%, total native herbaceous cover was 31.0%, and noxious weed cover was 0.1%, and therefore all Year-1 performance targets in Phase 1 of Reach A were achieved.

Overall biotic integrity of the macroinvertebrate community was either "none" or "slight" at all Clark Fork River tributary and mainstem sites; overall biointegrity scores throughout the CFROU ranged from 72.5 to 99.2. For metals sensitivity, index classifications in the mainstem were "none" at all sites, and metals sensitivity scores ranged from 83.3 to 98.6. Metals sensitivity index classifications in the tributary sites were "slight" at all sites and scores ranged from 70.8 to 91.7. Nutrient sensitivity index classifications were "none" or "slight", and scores ranged from 61.1 to 100.0.

Periphyton monitoring included bioindices to evaluate the sensitivity of diatom algae assemblages to sediment, metals, and nutrients. Impairment was more likely than not (i.e., ≥51%) for sediment at three tributary sites: the Mill-Willow Creek (above the Mill-Willow Bypass), Mill-Willow Creek (below the Bypass), and the Little Blackfoot River. Impairment from sediment was more likely than not at one Clark Fork River mainstem site (at Gemback Road). Impairment from metals was more likely than not at two tributary sites (Silver Bow Creek at Warm Springs and the Little Blackfoot River), and four mainstem sites (at Galen, near Galen Road, at Gemback Road, and at Turah). Impairment from nutrients was more likely than not at four tributary sites (both Mill-Willow Creek sites, Silver Bow Creek at Warm Springs, and the

Little Blackfoot River), and four mainstem sites (at Galen, at Gemback Road, at Deer Lodge, and at Turah).

Survival patterns of caged fish in 2015 did not suggest that remedial activities negatively influenced fish survival. Most of the mortalities of the caged fish occurred during summer low streamflow periods when water temperatures were highest. Based on fish population monitoring in the Clark Fork River, brown trout populations were low throughout the river. These results may be due to poor survival of fish hatched in 2012 which were age-3 fish during the 2015 sampling period. Age-3 fish commonly are the most abundant fish sampled during electrofishing surveys because younger fish (age-0 to age-2) are not generally available for capture using that sampling method and older fish are less abundant. Poor survival of fish hatched in 2012 may have been due to drought-like conditions during that year. Mortality estimates derived from population sampling data suggest that trout mortality was highest in Reach A, moderate in Reach B, and lowest in Reach C, and these results were consistent with prior mortality estimates from radiotelemetry work in the river. Montana Fish, Wildlife, and Parks also initiated stream microchemistry work in 2015 to determine the natal stream of mainstem fish. Additional research will be conducted for this work in 2016 and 2017.

Finally, bird monitoring was conducted for the first time in 2015 in Phases 1, 7, and 15 of Reach A in the CFROU. In total, 84 species were observed, and diversity was similar among phases: Phase 1 (50 species), Phase 7 (63 species), and Phase 15 (57 species). Of the 84 species observed there were 18 duck, goose, and swan species; three loon and grebe species; two cormorant and pelican species; one heron species; seven vulture and hawk species; one falcon species; two rail and crane species; five shorebird species; five gull species; one dove species; one kingfisher species; three woodpecker species; three flycatcher species; three corvid species; five swallow species; one chickadee species; three kinglet species; two mimic species; three New World warbler species; seven sparrow species; seven blackbird species; and one finch species. Five species observed are listed as species of concern by the state of Montana: the common loon, American white pelican, great blue heron, Franklin’s gull, and bobolink.

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1.0 INTRODUCTION

The Record of Decision (ROD) for the Clark Fork River Operable Unit (CFROU) identified a 120-mile section of the Clark Fork River as a distinct Superfund operable unit [USEPA, 2004]. The CFROU extends from the Silver Bow Creek and Warm Springs Creek confluence to the former Milltown Reservoir site at the Clark Fork River and Blackfoot River confluence [Figure 1-1]. Historic mining, milling, and smelting activities in Butte and Anaconda resulted in heavy metal (cadmium, copper, lead, and zinc) and arsenic contamination in the floodplain soils and streambanks of the CFROU [Bartkowiak et al., 2011]. Sources of metal contaminants of concern (COCs) in the CFROU are tailings mixed with soil within the historic 100-year floodplain (primary source), contaminated surface water and shallow groundwater, contaminated instream sediments, and contaminants in irrigation ditches adjacent to the CFROU [USEPA, 2004]. In 2008, a consent decree was negotiated between the state of Montana, the U.S. Government, and the Atlantic Richfield Company for cleanup of the CFROU [Montana v. AR, 2008; U.S.A. v. AR, 2008]. The consent decree established that the state of Montana, through the Montana Department of Environmental Quality (MDEQ), would serve as lead agency to develop and implement the remedial design, remedial action, and operation and maintenance of the remedy for the CFROU [Montana v. AR, 2008; U.S.A. v. AR, 2008].

Specific remediation standards were establishend in the CFROU ROD for surface water, groundwater, and vegetation but not for other environmental media [USEPA, 2004]. In lieu of specific standards, reference values have been adopted by MDEQ for instream sediment, geomorphology, periphyton, macroinvertebrates, and fish. The MDEQ has established this monitoring program to assess the effectiveness of contaminant removal from remediation on attainment of remediation standards or reference values. Data is collected to describe abiotic (surface water, instream sediment, river geomorphology) and biotic (terrestrial vegetation, periphyton, aquatic macroinvertebrate, and fish) conditions in the CFROU to evaluate if remediation standards or reference values are met and evaluate if conditions are improving over time. Data collected in 2015 represents the sixth year of data collected for this monitoring program, which began in 2010. The following paragraphs provide a brief summary of remedial work conducted in the CFROU to date.

Remediation activities in Phase 1 [Figure 1-2] of the CFROU began in 2013 and project construction was completed in spring 2014. Revegetation actions in Phase 1 were completed in fall 2014. Phase 1 consists of the upstream-most 1.6 river miles of the Clark Fork River, immediately downstream from the Warm Springs Creek and Silver Bow Creek confluence. In total, approximately 330,000 cubic yards of contaminated material was removed from a 60 acre project area.

Remediation of Phase 2 [Figure 1-3] began in the summer of 2015 and construction was in progress throughout the remainder of the year. Phase 2 consists of the river banks and floodplain along a 1.9 river mile section (88 acres) of the Clark Fork River, immediately downstream from Phase 1. Completion of construction actions in Phase 2 are anticipated for the summer of 2016 with revegetation actions expected to be complete by spring 2017. The estimated volume of contaminated material to be removed in Phase 2 is 400,000 cubic yards.

Remedial plans for Phases 3 and 4 [Figure 1-4] are currently in the design phase. These phases together consist of a 4.5 mile river length and an accompanying floodplain area of 261 acres. Construction activities are anticipated to begin in these phases in late 2016 or early 2017.

Remediation of Phases 5 and 6 [Figure 1-5] began in the summer of 2014 and construction was in progress throughout 2015. Phases 5 and 6 consist of the river banks and floodplain along a 4.3 river mile section (125 acres) of the Clark Fork River, immediately downstream from Phase 4. Completion of construction actions in Phases 5 and 6 are anticipated for the summer of 2016 with revegetation actions expected to be complete by spring 2017.

Remedial plans for Phase 7 [Figure 1-6] are currently in the design phase. Phase 7 consists of a 1.9 mile river length and an accompanying floodplain area of approximately 84 acres. Construction activities are anticipated to begin in Phase 7 during the summer of 2016.

Remedial plans for Phases 8 and 9 [Figure 1-7] are currently in the sampling and site characterization phase. Phases 8 and 9 consist of a 5.1 mile river length and accompanying floodplain area. The expected start date for construction has yet to be determined for Phases 8 and 9.

Remediation occurred in 2012 and 2015 in the "Eastside Road" pasture areas adjacent to Phases 12 and 13 [Figure 1-8]. This work consisted of removal of contaminated material from pastures in an area of approximately 100 acres that had been flood irrigated with contaminated water from the Clark Fork River. This project area is located outside the Clark Fork River floodplain. Ongoing monitoring of vegetation establishment and weed control is being conducted in the Eastside Road and pastures. That monitoring work is not described within this report.

Remedial plans for the "Arrowstone Park" area [Figure 1-9] in the town of Deer Lodge, Montana are currently in the sampling and site characterization phase. The Arrowstone Park project area consists of a 1.2 mile river length and accompanying floodplain area. The start date for construction activities in the Arrowstone Park area is yet to be determined.

Remediation occurred in residential yards and the "Trestle" area of Deer Lodge, Montana in a portion of Phase14 [Figure 1-10]. This work consisted of removal of contaminated material from residential yards and a recreational area along the Clark Fork River in the City of Deer Lodge. The work was completed in 2011 and approximately 10,000 cubic yards of contaminated soils were removed.

Remedial plans for Phases 15 and 16 [Figure 1-11] are currently in the design phase. These phases together consist of a 2.7 mile river length and an accompanying floodplain area of approximately 120 acres, which lie within the boundary of the Grant Kohrs Ranch National Park. Construction activities are anticipated to begin in these phases in 2016 and a total estimated volume of 400,000 cubic yards of contaminated material will be removed.

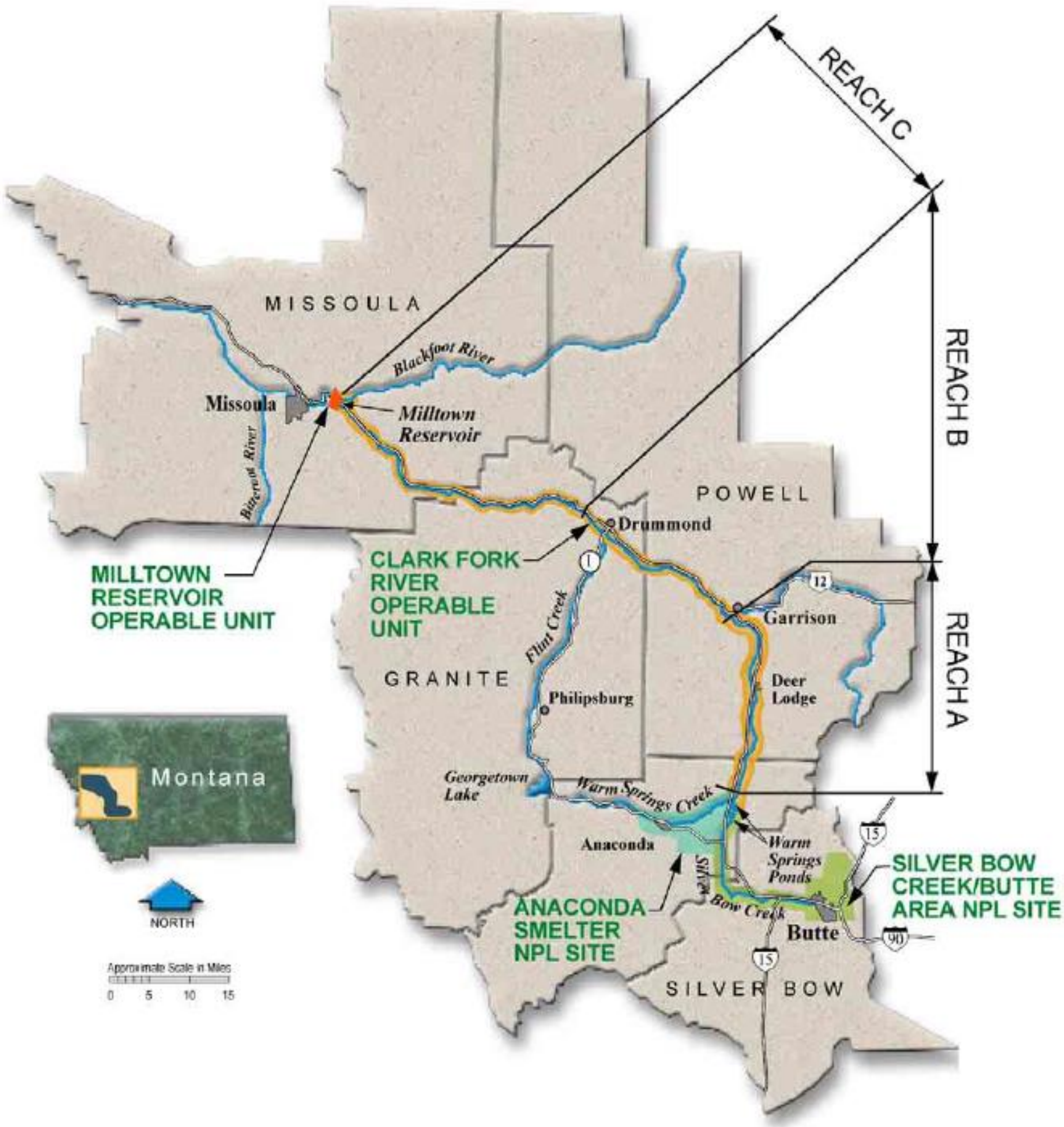

Figure 1-1. Remedial reaches of the Clark Fork River Operable Unit [Source: USEPA, 2004].

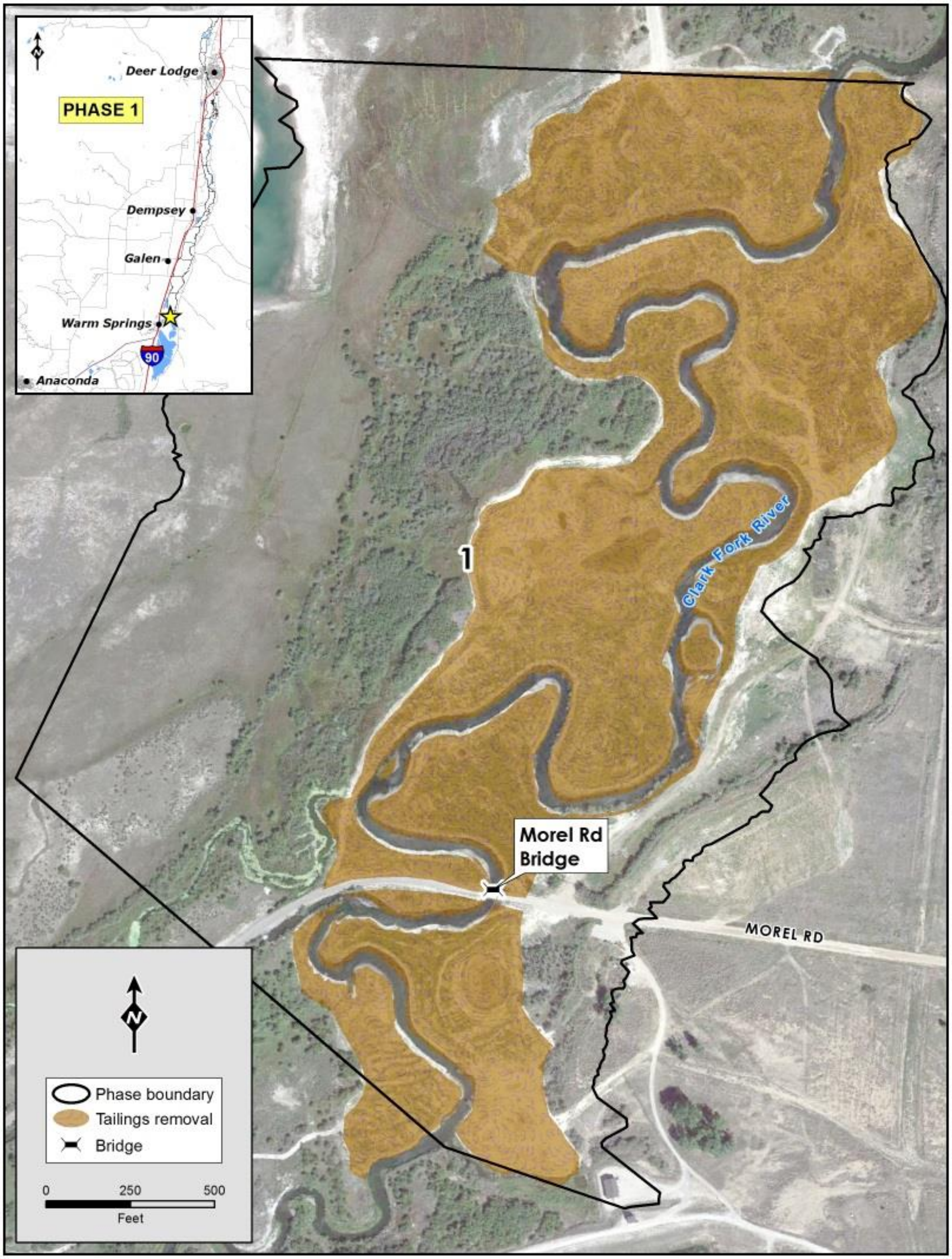

Figure 1-2. Phase 1 project area in the Clark Fork River Operable Unit [Source: Bartkowiak, 2016].

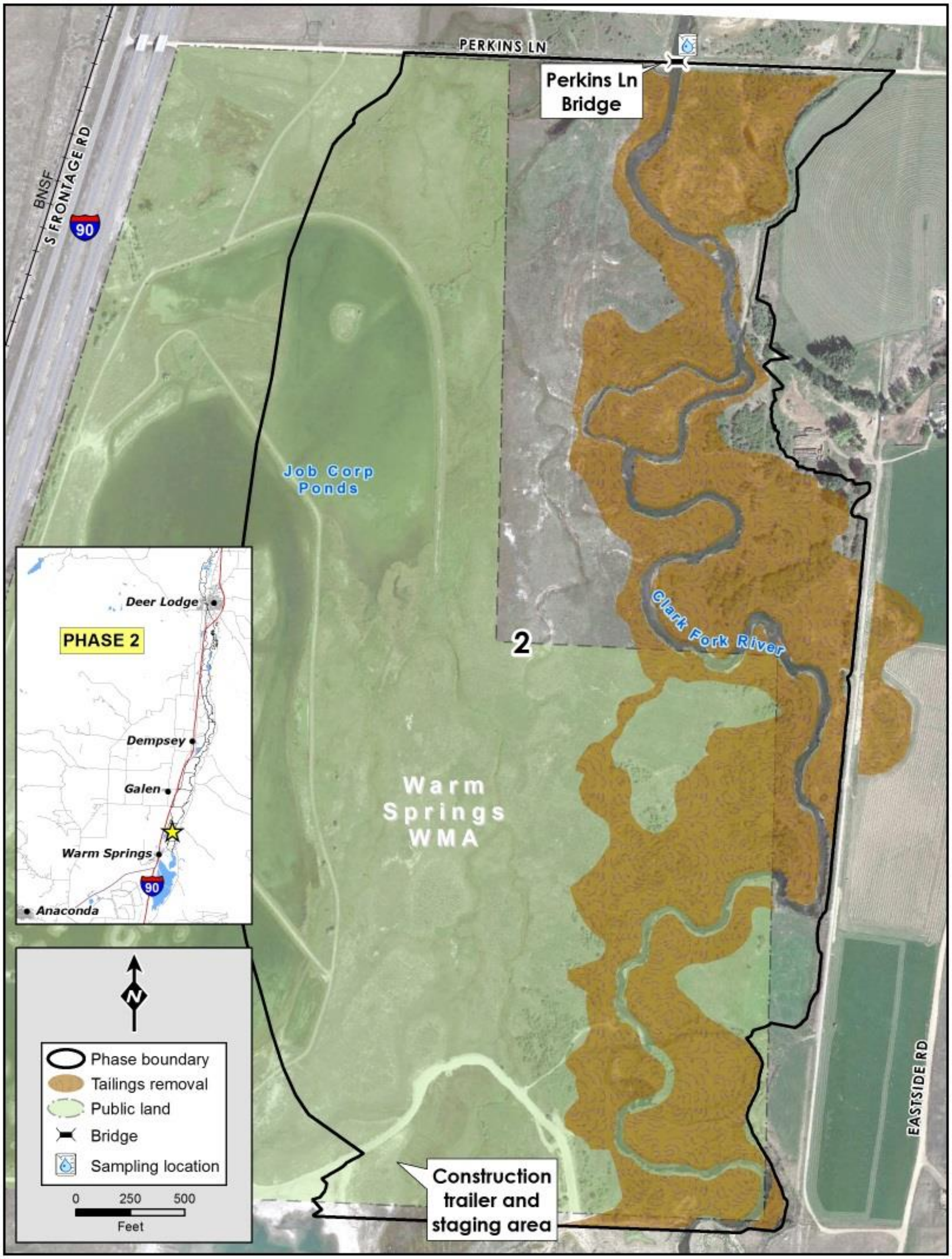

Figure 1-3. Phase 2 project area in the Clark Fork River Operable Unit [Source: Bartkowiak, 2016].

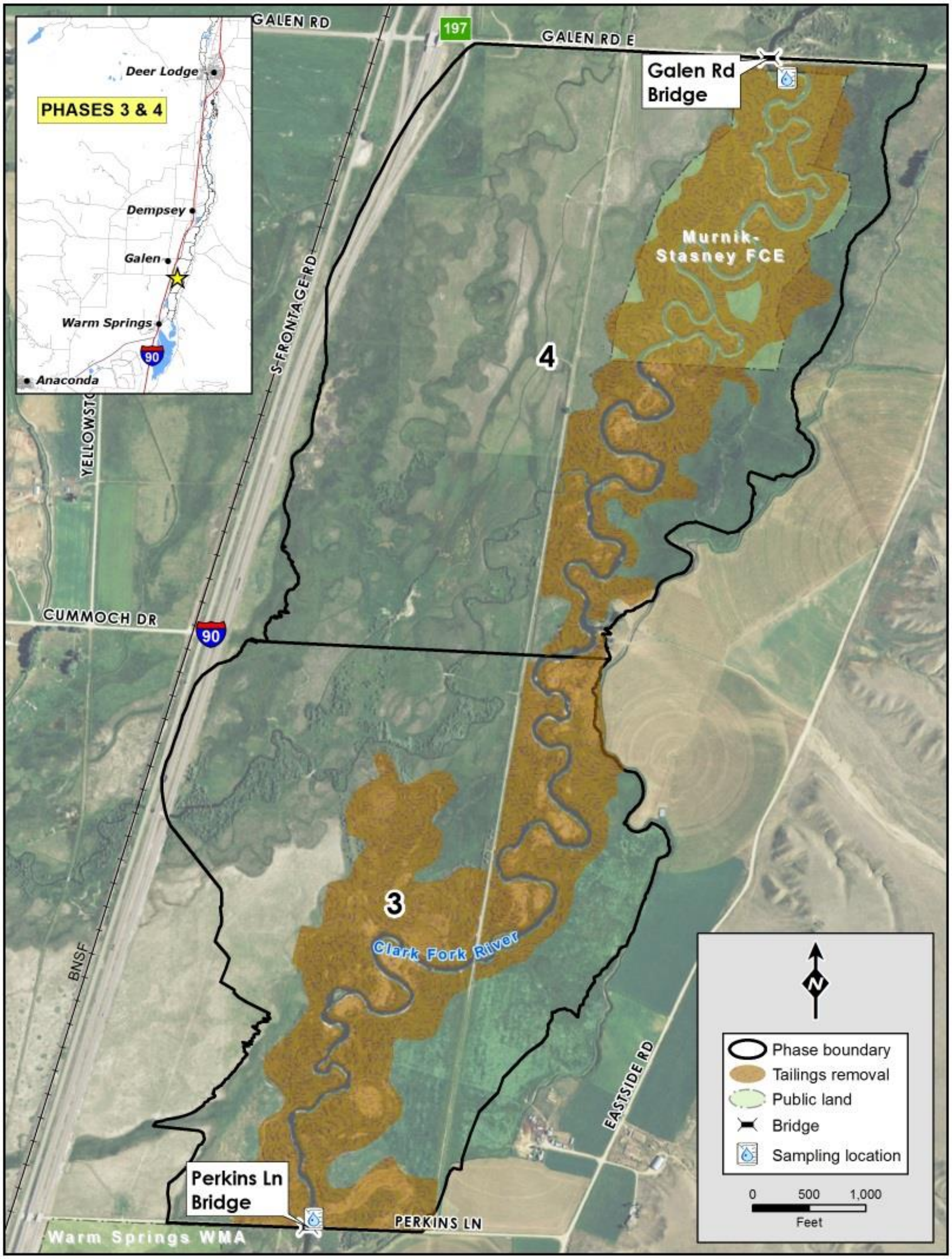

Figure 1-4. Phase 3 and 4 project areas in the Clark Fork River Operable Unit [Source: Bartkowiak, 2016].

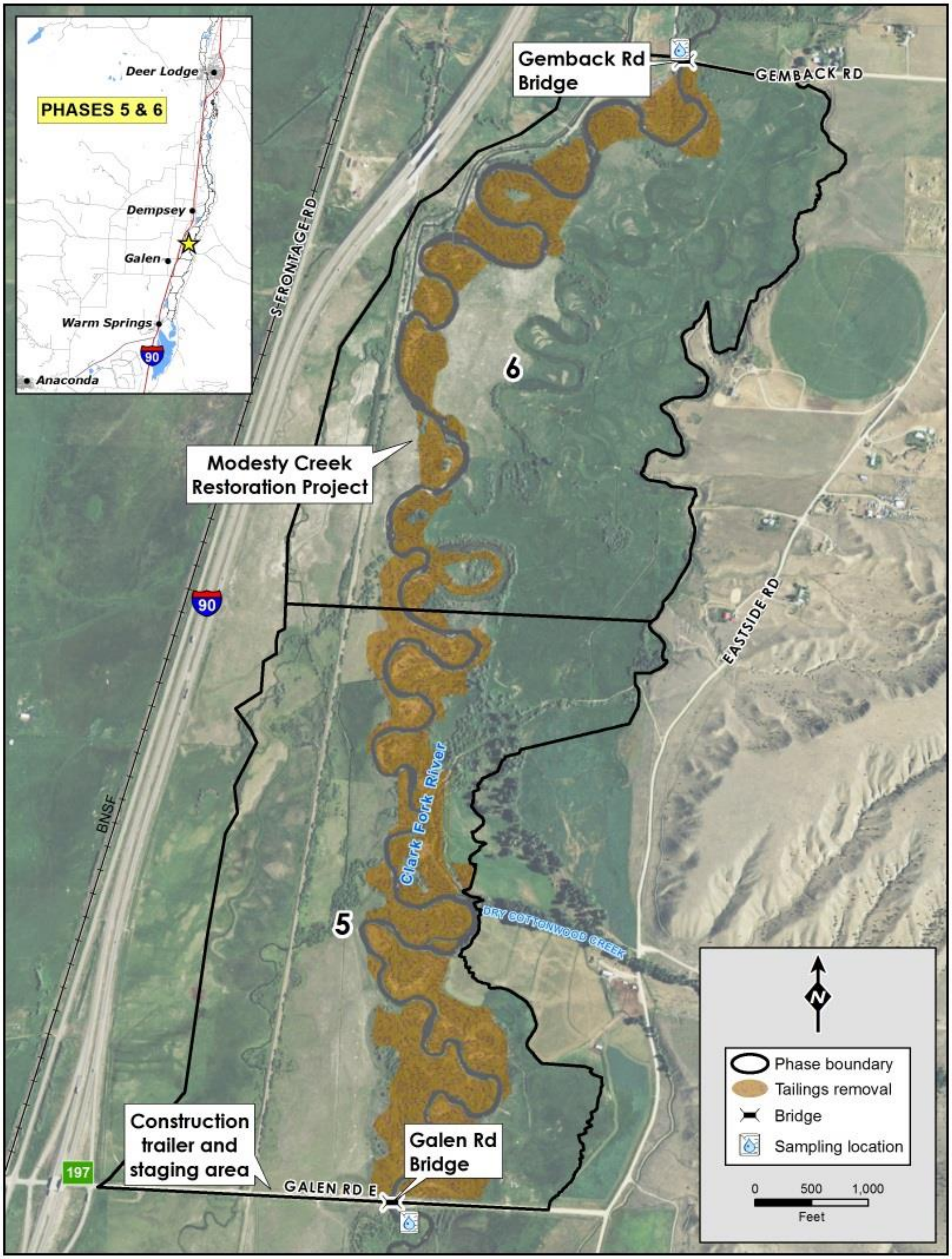

Figure 1-5. Phase 5 and 6 project areas in the Clark Fork River Operable Unit [Source: Bartkowiak, 2016].

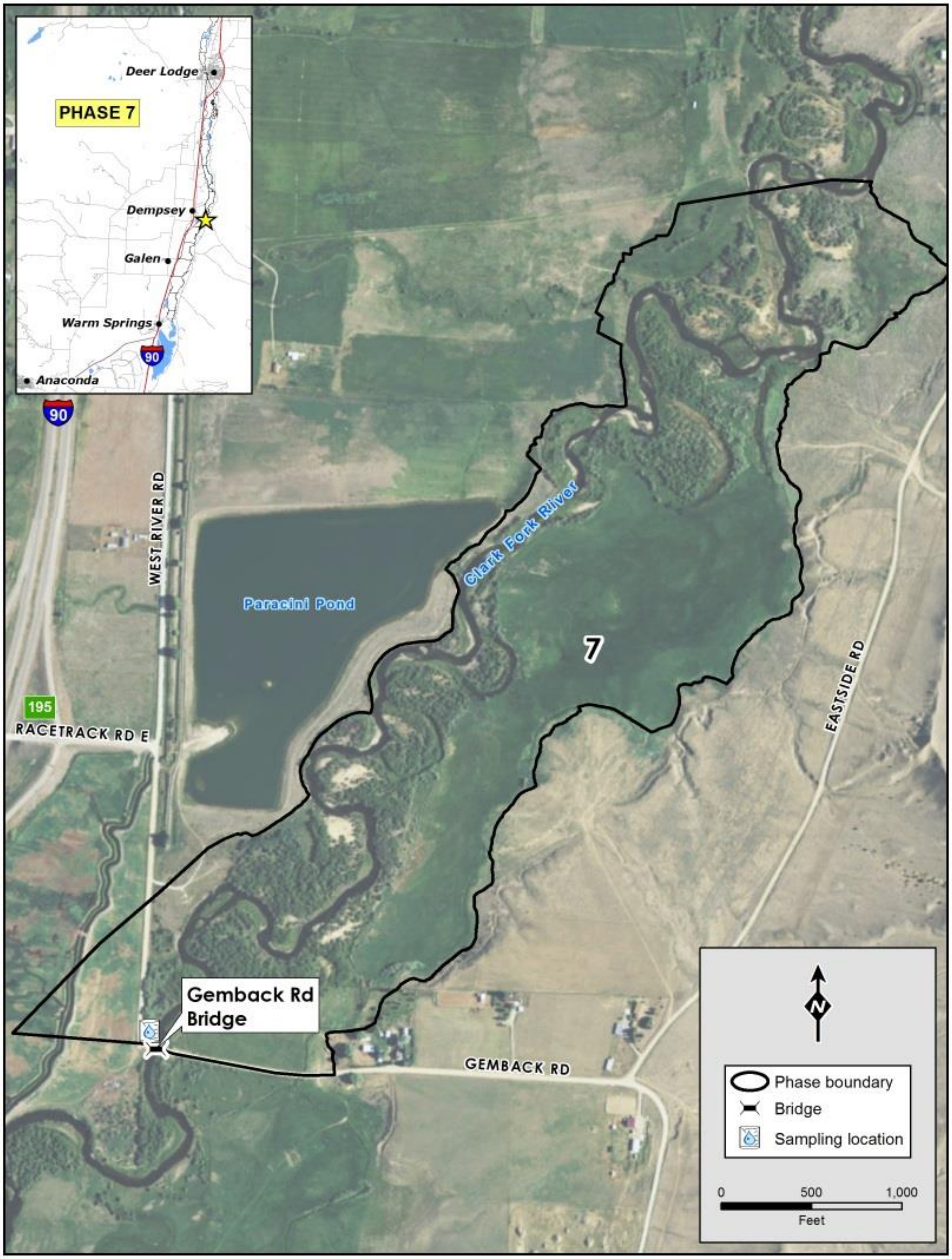

Figure 1-6. Phase 7 project area in the Clark Fork River Operable Unit [Source: Bartkowiak, 2016].

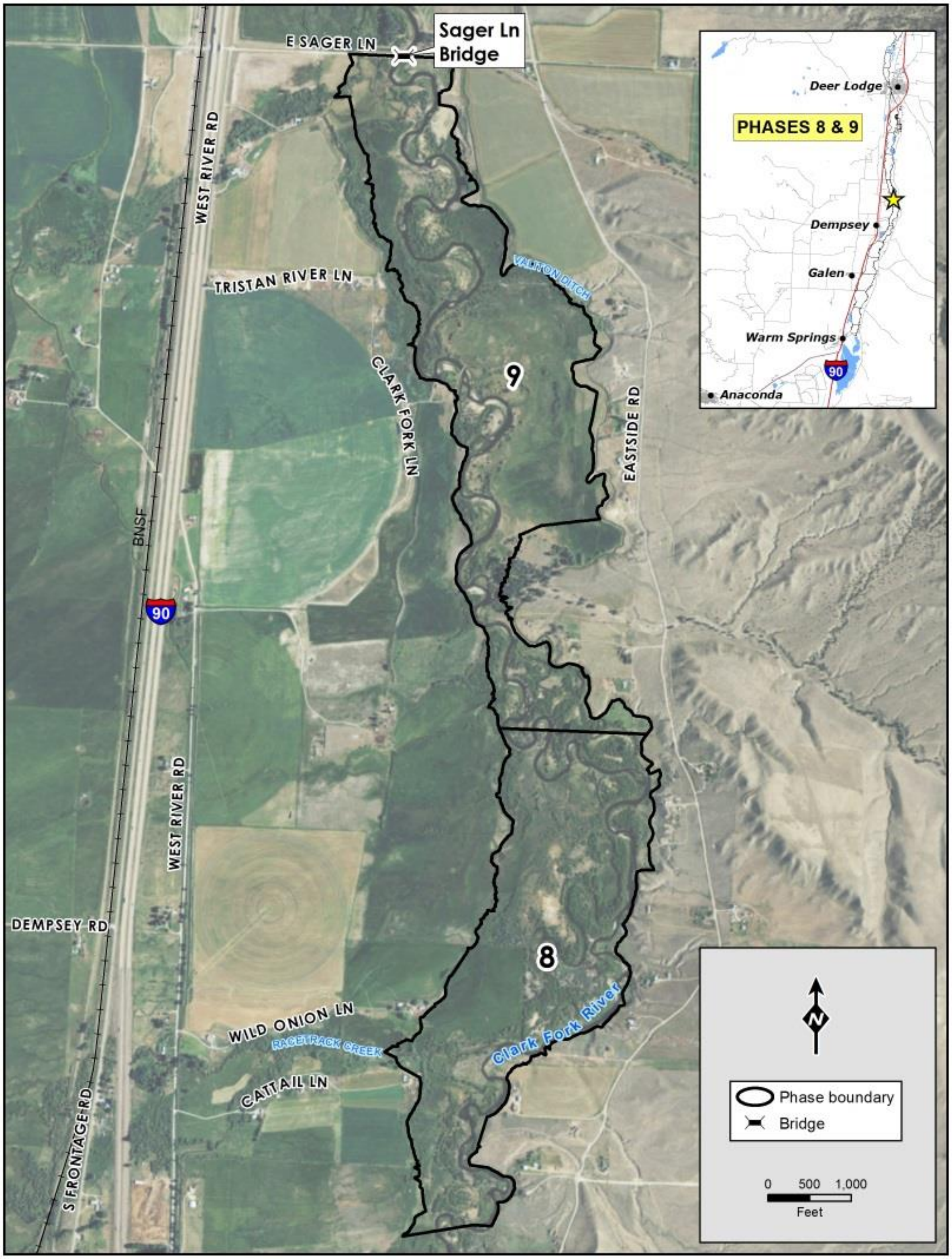

Figure 1-7. Phases 8 and 9 project areas in the Clark Fork River Operable Unit [Source: Bartkowiak, 2016].

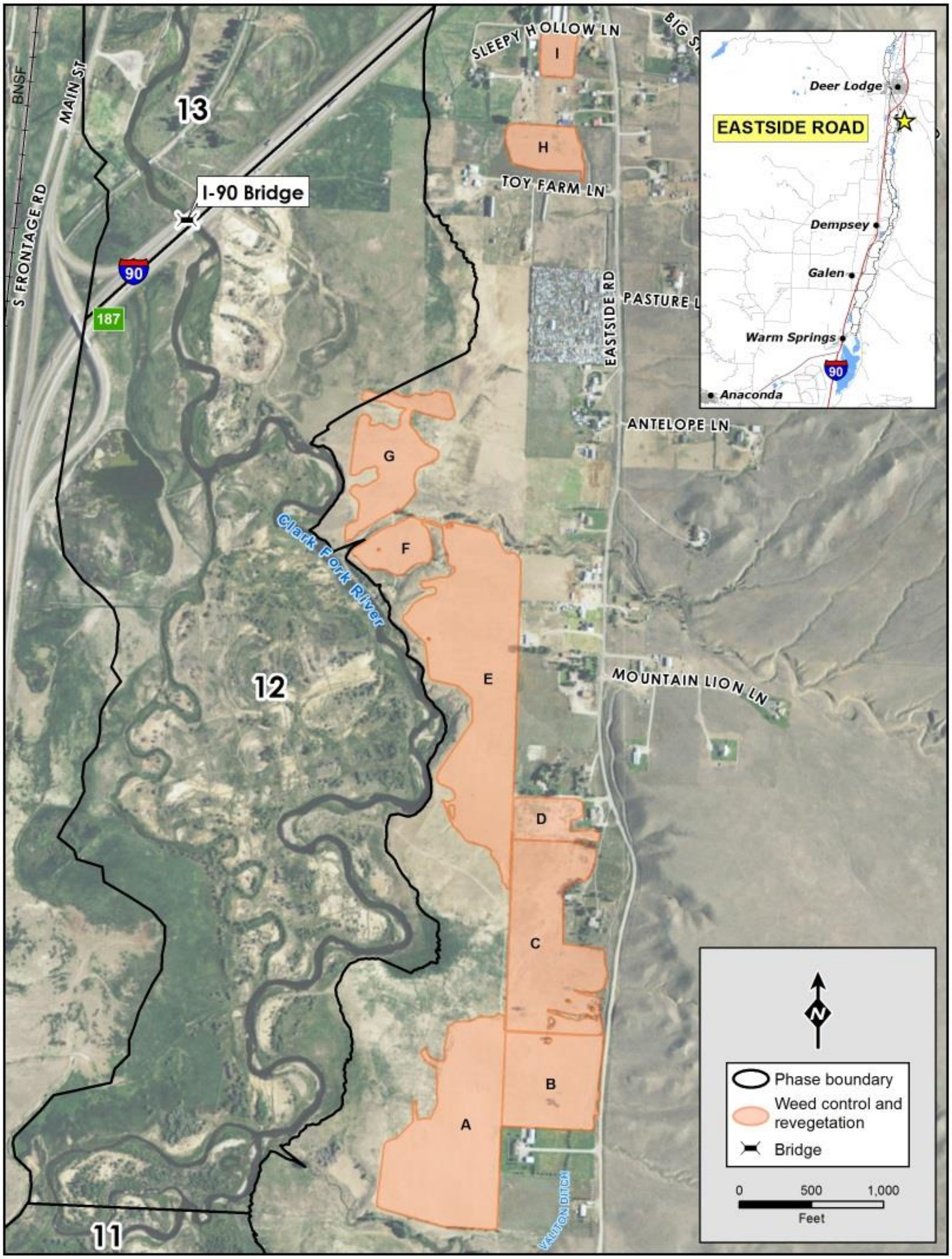

Figure 1-8. Eastside Road project area in the Clark Fork River Operable Unit [Source: Bartkowiak, 2016].

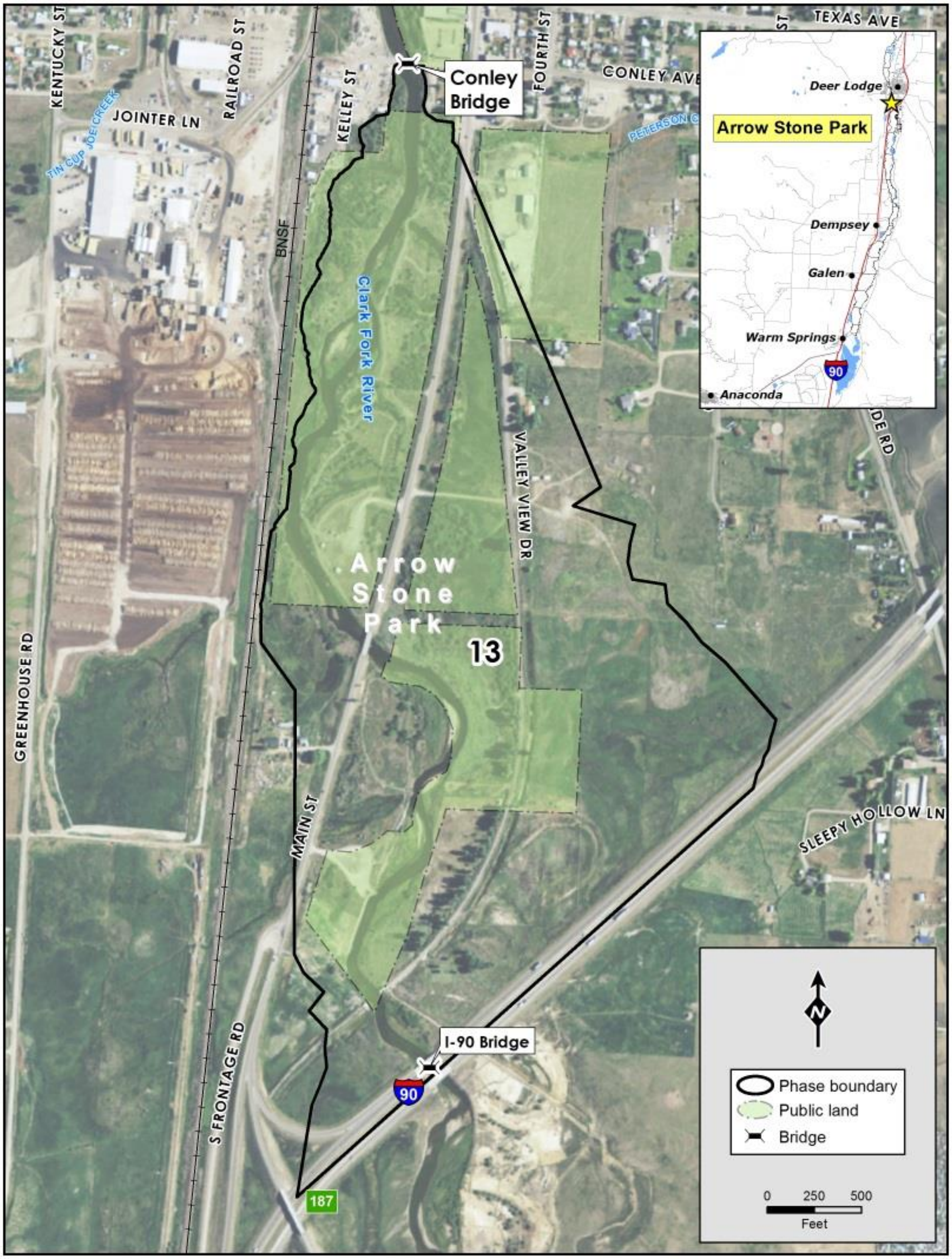

Figure 1-9. Arrowstone Park project area in the Clark Fork River Operable Unit [Source: Bartkowiak, 2016].

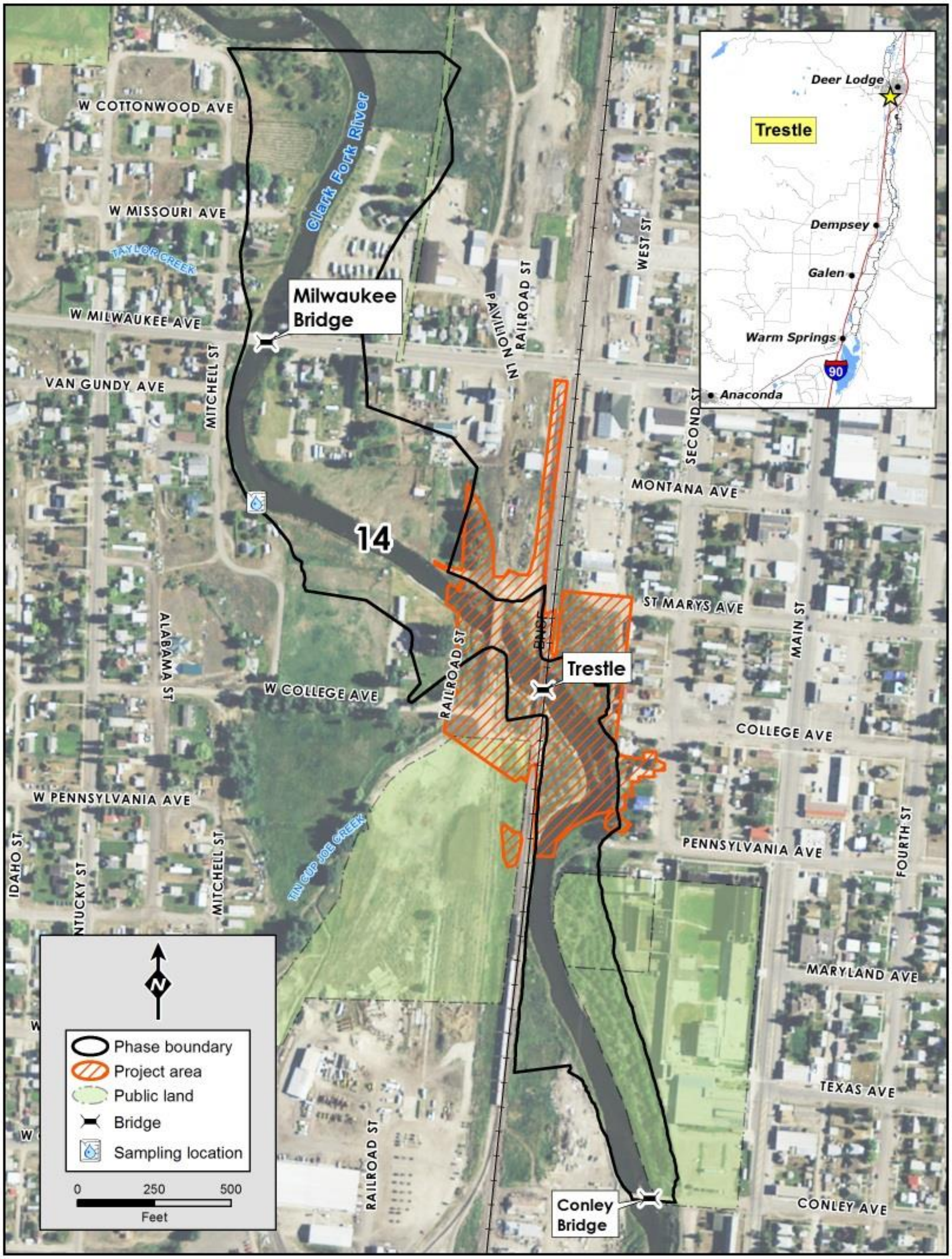

Figure 1-10. Trestle project area in the Clark Fork River Operable Unit [Source: Bartkowiak, 2016].

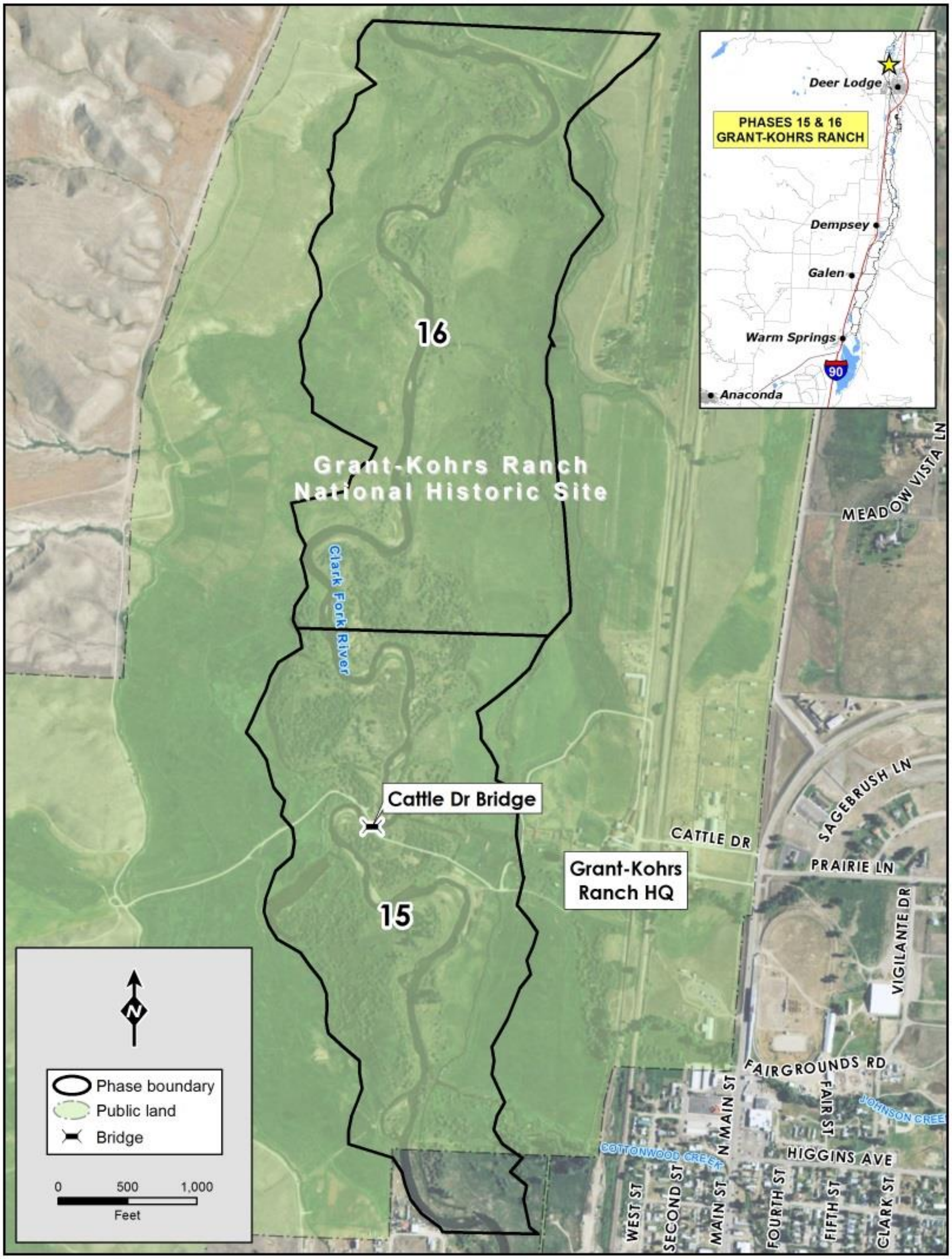

Figure 1-11. Phase 15 and 16 project areas in the Clark Fork River Operable Unit [Source: Bartkowiak, 2016].

2.0 SURFACE WATER

2.1 INTRODUCTION

Performance goals were established in the CFROU ROD for surface water [USEPA, 2004]. The goal for surface water quality is for concentrations of all metal contaminants of concern (COCs) to be below the concentrations identified in the CFROU ROD [Table 2-1]. The remedy for the Clark Fork River is expected to achieve these goals through the removal of contaminated floodplain soils (i.e., "slickens"), *in situ* (i.e., on site) treatment of floodplain soils with relatively low COC concentrations, and streambank stabilization. Additional removals of contaminated floodplain materials, proposed as part of remediation, may reduce arsenic concentrations as well. When the remediation activities are completed, surface water quality in the Clark Fork River is expected to fully support the growth and propagation of coldwater fishes (e.g., salmonids) and associated aquatic life. Surface waters will be monitored at specific locations along the Clark Fork River. Performance goals must be met at each location in order for the remedial actions to be considered successful.

This report evaluates progress toward attainment of surface water performance goals as defined in the CFROU ROD [Table 2-1]. Water chemistry data were collected in 2015 to evaluate COC concentrations in order to make direct comparisons to relevant performance standards. In addition to COC concentrations, data are collected to describe other water quality characteristics which influence the toxicity of metal contaminants or otherwise influence the ecology of the Clark Fork River. Other water quality characteristics described include total suspended sediment, common ion, and nutrient concentrations and other physical properties of water (e.g., acidity).

Table 2-1. Remediation performance goals for surface water in the Clark Fork River Operable Unit [USEPA, 2004].

Contaminant of Concern	Performance Standard		
	Aquatic Life Standard[1]		Human Health or Drinking Water Standard (µg/L)
	Chronic (µg/L)	Acute (µg/L)	
Arsenic	150	340	10/18[2]
Cadmium	0.25	2	5
Copper[3]	9	13	1,300
Lead	3.2	81	15
Zinc	119	119	2,100

2.2 METHODS

The purpose of the surface water monitoring program is to collect data describing the temporal and spatial variation of metal and nutrient concentrations, and other physical properties of surface water in the CFROU. These data provide a long-term record of environmental conditions in the CFROU. As of 2015, six years of CFROU surface water data (2010-2015) have been collected under this monitoring program. This long-term record provides a dataset to evaluate the effect of remediation on environmental conditions in the CFROU over time. Changes to the surface water monitoring program have occurred over time and a record of these changes is provided in the project sampling and analysis plan (SAP) [Naughton et al., 2015a].

2.2.1 Monitoring Locations

Surface water was monitored at 16 CFROU sites in 2015 [Figure 2-1]. The monitoring network included seven sites in the Clark Fork mainstem and nine sites on tributary streams [Figure 2-1; Table 2-2]. The monitoring site locations in 2015 included all sites monitored since 2013 plus one additional mainstem site and one additional tributary site. Tributary sample sites in Lost Creek, Racetrack Creek, and the Little Blackfoot River have been adjusted over time [Table 2-2]. Monitoring sites were also altered between 2012 and 2013 to provide a more detailed spatial representation of the Clark Fork River mainstem in Reach A [Figure 2-1]. Additionally, some sites were removed from the monitoring network to avoid duplication of water quality sampling efforts by the U.S. Geological Survey (USGS).

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[1] The aquatic life standards for cadmium, copper, lead, and zinc vary in relation to water hardness. The values displayed in this table correspond to a water hardness of 100 mg/L.

[2] The performance standard includes both the federal maximum contaminant level (MCL; 10 µg/L; dissolved concentration) and the state of Montana standard (18 µg/L; total recoverable concentration).

[3] Based on the federal ambient water quality criteria (USEPA [1986]; dissolved concentration).

2.2.1.1 Clark Fork River Mainstem

Each of the mainstem sample site locations were selected for a specific monitoring objective. The five mainstem Clark Fork River monitoring sites in Reach A (CFR-03A, CFR-07D, CFR-11F, CFR-27H, CFR-34) were included to provide a detailed spatial representation of conditions in Reach A where the remedial work is occurring [Figure 2-1]. Site CFR-34 was added to the monitoring network in 2015 to monitor upcoming remedial work planned in Phases 15 and 16 [Figure 1-11]. The Reach C site (CFR-116A) represents conditions in Reach C at the downstream end of the Clark Fork River in the CFROU [Figure 2-1]. Currently, no remedial actions are planned for Reach C. One mainstem site is located downstream from the Flint Creek tributary (CFR-84F) [Figure 2-1]. Site CFR-84F is intended to assess the influence of Flint Creek inflows, which typically has elevated mercury concentrations [Langer et al., 2012; Ingman et al., 2014] on water quality in the mainstem.

2.2.1.2 Tributaries

Tributary site locations were selected to assess the significance of COC or nutrient loading from sources outside the CFROU. Each tributary has one sample site located near the tributary confluence with the Clark Fork River, with the exception of Mill-Willow Creek and Silver Bow Creek which each have two sites [Figure 2-1].

2.2.1.2.1 Mill-Willow Creek

Mill-Willow Creek is a tributary to Silver Bow Creek and flows into Silver Bow Creek immediately downstream from the Warm Springs Pond outfall [Figure 2-1]. The Warm Springs Pond system captures the Silver Bow Creek streamflow and routes the water through a lime treatment facility and a series of tailings ponds designed to precipitate heavy metals [see: www.cfrtac.org]. Historically, Mill and Willow Creeks confluenced with Silver Bow Creek upstream from the Warm Springs Ponds. However, because contaminant levels in Mill and Willow Creeks were low relative to Silver Bow Creek, streamflows from Mill and Willow Creek were routed around the Warm Springs Pond system through a designed channel commonly referred to as the "Mill-Willow Bypass". The Mill-Willow Bypass was remediated between 1990 and 1995 to remove tailings and contaminated soils along the stream channel and floodplain and to reduce toxic discharges to Silver Bow Creek and the upper Clark Fork River [see: www.cfrtac.org].

Two sample sites are located in Mill-Willow Creek: MCWC-MWB and MWB-SBC [Figure 2-1]. Site MCWC-MWB is located at the upstream end of the Mill-Willow Bypass to demonstrate background water quality conditions in Mill-Willow Creek. Site MWB-SBC is located near the Silver Bow Creek confluence. Increases in contaminant concentrations between MCWC-MWB and MWB-SBC suggest that contaminant loading is occurring in the Mill-Willow Bypass reach of Mill-Willow Creek.

2.2.1.2.2 Warm Springs Creek

The Clark Fork River mainstem begins at the confluence of Silver Bow Creek and Warm Springs Creek [Figure 2-1]. Warm Springs Creek is a major tributary to the Clark Fork River in Reach A. Warm Springs Creek typically has relatively low nutrient concentrations and relatively cool streamflows. Water chemistry in Warm Springs Creek is monitored at site WSC-SBC [Figure 2-1].

2.2.1.2.3 Silver Bow Creek

Silver Bow Creek is one of the two upstream-most tributaries to the Clark Fork River. Silver Bow Creek historically was the primary source of COCs to the Clark Fork River [MDEQ and USEPA, 1995] but it has undergone extensive remediation since 1998 and COC concentrations are reduced compared to historic levels [Sando et al., 2014; Ingman et al., 2015]. All streamflow from Silver Bow Creek is captured by the Warm Springs Ponds and treated to reduce metal loading to the Clark Fork River [see: www.cfrtac.org].

Two sample sites are included on Silver Bow Creek; Silver Bow Creek at Frontage Road (SS-19) located immediately above the Warm Springs Ponds and Silver Bow Creek at Warm Springs (SS-25) located immediately below the discharge of the Warm Springs Ponds and the Mill-Willow Bypass [Figure 2-1]. In 2015, site SS-19 was sampled as part of the Streamside Tailings Operable Unit monitoring program and was not sampled during all CFROU sample periods in 2015. Sample collection methods for site SS-19 are described in the SSTOU sampling and analysis plan [Naughton et al., 2015b]. Site SS-19 was not sampled during two of the three second quarter (spring) sample periods.

2.2.1.2.4 Lost Creek and Racetrack Creek

Lost Creek and Racetrack Creek originate in the Flint Creek Range on the west side of the Deer Lodge valley [Figure 2-1]. Major portions of both watersheds are used for cattle grazing and agriculture and streamflows are heavily diverted for irrigation. Surface water monitoring in Lost Creek and Racetrack Creek was discontinued in 2013 because these tributaries had relatively low COC concentrations [Ingman et al., 2013]. Water chemistry in Lost Creek is monitored by the USGS [Dodge et al., 2014]. Instream sediments and biological monitoring were conducted at these sites in 2015. Monitoring in Lost Creek occurs at LC-7.5 and in Racetrack Creek at RTC-1.5 [Figure 2-1].

2.2.1.2.5 Little Blackfoot River

The Little Blackfoot River is a major tributary to the Clark Fork River. The Little Blackfoot River and Clark Fork River confluence is located at the boundary between CFROU Reach A and Reach B [Figure 2-1]. Water quality and quantity in the Little Blackfoot River may be influenced by a variety of land uses including agriculture and irrigation in lower portions of the watershed and abandoned mining in headwater portions of the watershed [Montana Engineer's Office, 1959; Lyden, 1987; Ingman, 2002; MDEQ and USEPA, 2011; 2014]. Water chemistry, instream sediment and aquatic biota are monitored in the Little Blackfoot River. Monitoring in the Little Blackfoot River occurred at LBR-CFR-02 in 2015 [Figure 2-1]. Following the first sample period of 2014, the Little Blackfoot River site was relocated (and renamed) upstream approximately four miles to minimize safety hazards from road traffic during high streamflow periods when sampling from the road bridge at the previous site (LBR-CFR) [Table 2-2].

2.2.1.2.6 Flint Creek

Flint Creek enters the Clark Fork River near the boundary between Reach B and Reach C [Figure 2-1]. Flint Creek is a major source of mercury to the Clark Fork River [Langner et al., 2012; Ingman et al., 2014]. Site FC-CFR monitors water chemistry in Flint Creek [Figure 2-1].

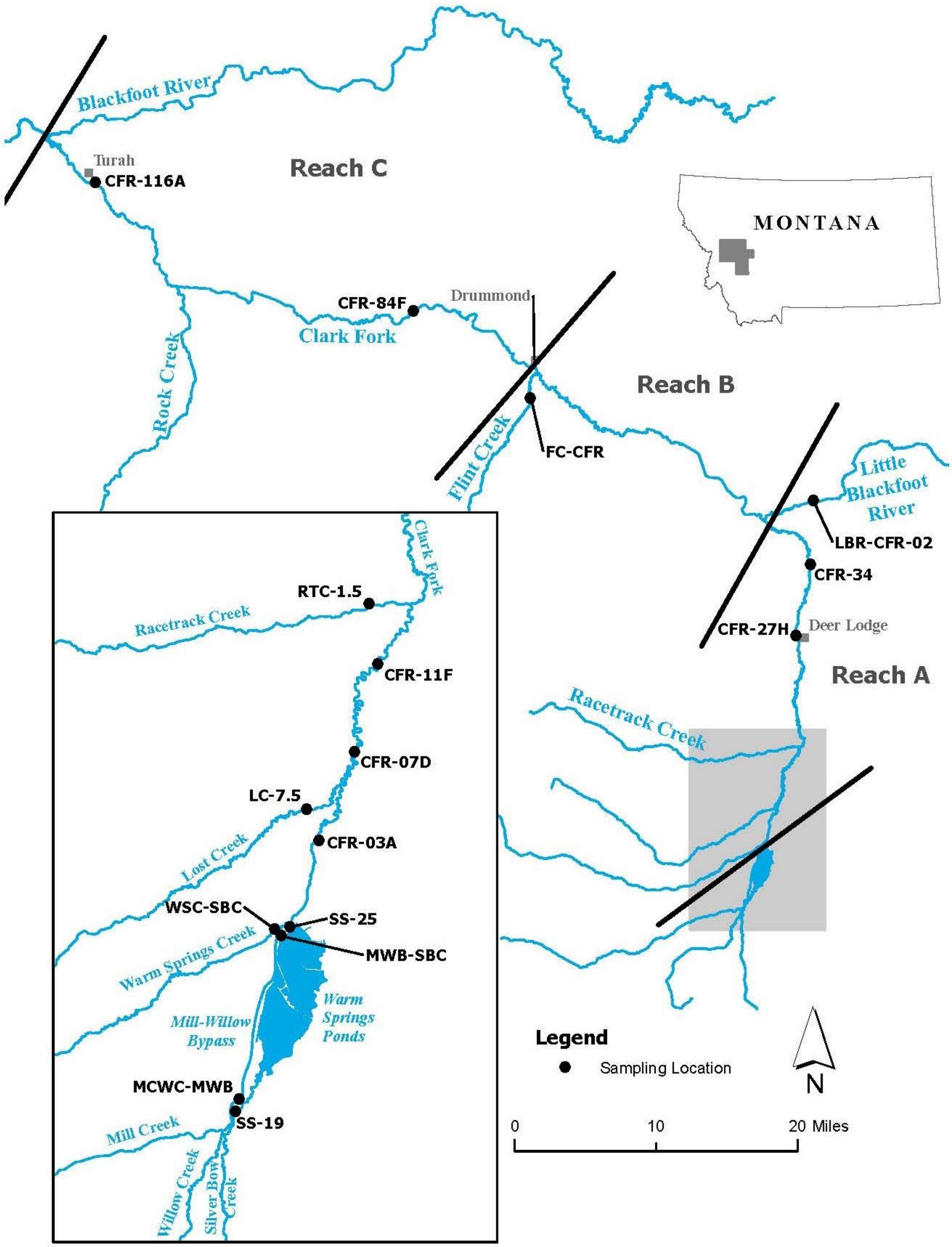

Figure 2-1. Surface water sampling locations in the Clark Fork River Operable Unit, 2015.

Table 2-2. Surface water sampling locations in the Clark Fork River Operable Unit, 2015. Streamflows were measured at all sites which did not a have co-located USGS streamflow gauge.

Site ID	Site Location	Co-located USGS Streamflow Gauge	Location (GPS coordinates, NAD 83)	
			Latitude	Longitude
Mainstem Sites				
CFR-03A	Clark Fork River near Galen	12323800	46.20877	-112.76740
CFR-07D	Clark Fork River at Galen Road	none	46.23725	-112.75302
CFR-11F	Clark Fork River at Gemback Road	none	46.26520	-112.74430
CFR-27H	Clark Fork River at Deer Lodge	12324200	46.39796	-112.74283
CFR-34	Clark Fork River at Williams-Tavenner Bridge	none	46.47119	-112.72492
CFR-84F	Clark Fork near Drummond	12331800	46.71204	-113.33137
CFR-116A	Clark Fork at Turah	12334550	46.82646	-113.81424
Tributary Sites				
SS-19[4]	Silver Bow Creek at Frontage Road	none	46.12247	-112.80032
SS-25	Silver Bow Creek at Warm Springs	12323750	46.18123	-112.77917
MCWC-MWB	Mill-Willow Creek at Frontage Road	none	46.12649	-112.79876
MWB-SBC	Mill-Willow Bypass near mouth	none	46.17839	-112.78270
WSC-SBC	Warm Springs Creek near mouth	12323770	46.18041	-112.78592
LC-7.5[5]	Lost Creek near mouth	12323850	46.21862	-112.77384
RTC-1.5[6]	Racetrack Creek near mouth	none	46.28395	-112.74921
LBR-CFR-02[7]	Little Blackfoot River at Beck Hill Road	none	46.53710	-112.72443
FC-CFR	Flint Creek near mouth	12331500	46.62891	-113.15151

2.2.2 Monitoring Schedule

At least one monitoring event occurred during each calendar quarter of 2015. Each quarterly monitoring event occurred near the end of each quarter. The first monitoring event (Q1) occurred in the late winter, prior to spring runoff, from March 24-25. Three monitoring events were conducted in the second quarter (Q2) to capture the rising (Q2-Rising), peak (Q2-Peak), and falling (Q2-Falling) portions of the spring runoff hydrograph. The Q2 monitoring events were conducted on April 28-29 (Q2-Rising), May 12-13 (Q2-Peak), and June 9-10 (Q2-Falling). The late summer (Q3) monitoring event was scheduled during low streamflow conditions on

[4] In 2015, site SS-19 was sampled under the Streamside Tailings Operable Unit (SSTOU) monitoring program four times per year.

[5] Site LC-7 (GPS Location: 46.22665, -112.76017) was replaced by site LC-7.5 in 2013.

[6] Site RTC-1 (GPS Location: 46.28406, -112.74484) was replaced by site RTC-1.5 in 2013.

[7] Site LBR-CFR (GPS Location: 46.51964, -112.79312; co-located USGS gauge: 12324590) was replaced by site LBR-CFR-02 in 2014.

September 9-10. The late fall (Q4) monitoring event occurred on December 1-2. Sampling at SS-19 occurred on Mach 26 (Q1), May14 (Q2-Peak), September 8 (Q3), and December 3 (Q4).

2.2.3 Monitoring Parameters

Surface water samples were analyzed for the parameters and analytes listed in Table 2-3. Parameters and analytes were the same at all sites with the exception of FC-CFR and CFR-83F. At site FC-CFR, total mercury and total methylmercury concentrations were analyzed in addition to all other analytes. At site CFR-84F, a surface water sample was collected but only analyzed for mercury and methylmercury concentrations. All parameters listed in Table 2-3 were monitored as well as some additional parameters as described in Naughton et al. [2015b].

Eight of the 16 monitoring stations in the MDEQ Clark Fork River monitoring network were co-located with active USGS streamflow gauging stations [Table 2-2]. USGS streamflow records were accessed and included in this report. Streamflows at monitoring stations without co-located USGS gauges were measured manually.

Table 2-3. Sampling parameters and analytes for surface water monitoring of the Clark Fork River Operable Unit, 2015.

Parameter	Analytes
Metal concentrations (total recoverable and dissolved)[8]	Arsenic, cadmium, copper, lead, zinc, mercury, methylmercury
Nutrient concentrations	Nitrogen (total nitrogen, nitrate plus nitrite, ammonia), phosphorus (total), and carbon (dissolved organic; DOC)
Common ion concentrations (total)	Sulfate, alkalinity, bicarbonate
Field parameters	Total suspended sediment (TSS) concentration, hardness, water temperature, pH, specific conductivity, dissolved oxygen (DO) concentrations, turbidity

2.2.4 Sample Collection and Analysis

Sample collection, analysis, and quality assurance procedures were described in the quality assurance project plan [DeArment et al., 2013]. Methods generally followed standard operating procedures (SOPs) developed for the Clark Fork River [AR, 1992]. Field sampling procedures were in accordance with MDEQ [2012a] and followed "clean hands/dirty hands" procedures to minimize sample contamination as described in USGS [2006][9]. Composited surface water samples were collected using width-depth integration according to methods described in USGS [2006]. When streamflows were high and samples could not be safely collected by wading,

[8] At CFR-84F, no nutrient or metal concentrations were measured except mercury and methylmercury. At FC-CFR, mercury and methylmercury were measured in addition to all other analytes.

[9] We deviated from the USGS [2006] protocols to minimize sample contamination (Section 4.0.2) in two regards. First, we did not collect samples sequentially in the order of least to greatest potential for contamination. Second, samples were processed outside the sampling vehicles, rather than within an enclosed space.

samples were collected with the aid of a crane mounted D-95 sampler operated from road bridges. Field parameters (water temperature, pH, dissolved oxygen concentration, and conductivity) were measured during each monitoring event with a field multimeter (YSI Professional Plus or YSI 556). Turbidity was measured with a field turbidity meter (Hach Model 2100P Portable Turbidimeter). Streamflows were measured using a portable electromagnetic streamflow meter (Marsh-McBirney Flo-Mate 2000). Calibration methods for field meters, data recording and handling methods, and quality assurance and quality control procedures are described in the quality assurance project plan [DeArment et al., 2013]. Samples were analyzed by Energy Laboratories (Helena, Montana). Requested laboratory analysis procedures for each analyte are presented in Table 2-4.

Table 2-4. Analytes, methods, and reporting limits for surface water samples in the Clark Fork River Operable Unit, 2015. All samples were analyzed by Energy Laboratories in Helena, Montana.

Analyte	Requested Method	Requested Reporting Limit (mg/L)[10]	Holding Time (days)	Bottle	Preservative
Water Samples - Physical Properties and Inorganics					
Solids, Total Suspended (at 105C)	A 2540 D	1	7	1 L HDPE	4 ± 2 C
Alkalinity, Total (as CaCO3)	A 2320 B	4	14	500 mL HDPE	
Alkalinity, Bicarbonate (as HCO3)	A 2320 B	4	14		
Chloride	EPA 300.0	1	28		
Sulfate	EPA 300.0	1	28		
Hardness (as CaCO3)	A 2340 B	1	180		
Water Samples – Nutrients					
Carbon, Dissolved Organic	A 5310 C	0.5	7	250 mL brown glass	H3PO4 to pH <2, 4 ± 2 C
Nitrogen, Ammonia (as N)	EPA 350.1	0.05	28	250 mL HDPE	4 ± 2 C
Nitrogen, Nitrate-Nitrite (as N)	EPA 353.2	0.02			H2SO4 to pH<2, 4 ± 2 C
Nitrogen, Total	A 4500 N-C	0.05	30		4 ± 2 C
Phosphorus, Total	EPA 365.1	0.003	28		H2SO4 to pH<2, 4 ± 2 C
Water Samples - Dissolved Metals (0.45 µm filtered)					
Arsenic	EPA 200.8	0.001	180	250 mL HDPE	HNO3 to pH <2
Cadmium	EPA 200.8	0.00003			
Copper	EPA 200.8	0.001			
Lead	EPA 200.8	0.0003			
Zinc	EPA 200.8	0.008			
Water Samples - Total Recoverable Metals					
Total Recoverable Metals Digestion	EPA 200.2	-	-	-	-
Arsenic	EPA 200.8	0.001	180	250 mL HDPE	HNO3 to pH <2
Cadmium	EPA 200.8	0.00003			
Calcium	EPA 200.7	1			
Copper	EPA 200.8	0.001			
Lead	EPA 200.8	0.0003			
Magnesium	EPA 200.7	1			
Potassium	EPA 200.7	1			
Sodium	EPA 200.7	1			
Zinc	EPA 200.8	0.008			
Mercury	EPA 245.1	0.000005	28	250 mL HDPE	HNO3 to pH <2,
Methylmercury	EPA 1630	0.05 ng/L	28	250 mL FLPE	HCl to pH <2,

[10] Requested reporting limits are either the required reporting limit of MDEQ [2012b] or MDEQ [2014], or the lowest reporting limit previously provided by the analytical laboratory, whichever is lower.

2.2.5 Data Analysis

Data analysis included description of spatial trends and temporal (quarterly and annual) trends in analyte (metals and nutrients) concentrations and physical properties. Attainment of performance goals was assessed by comparing analyte concentrations at specific sites to remedial performance goals. Assessment of nutrient monitoring results also included comparisons of total nitrogen and total phosphorus concentrations to numeric water quality standards for the Clark Fork River (ARM 17.30.631) or to those recently established for other streams in the Middle Rockies Ecoregion [MDEQ, 2014].

Evaluation of some performance goals from data collected in this report requires an assumption that the measured analyte concentrations are consistent over time. For example, the chronic aquatic life standard (ALS) is typically based on 96-hour mean concentrations [MDEQ, 2012b]. Similarly, the acute ALS are typically based on 1-hour mean concentrations [MDEQ, 2012b]. However, in this monitoring program analyte concentrations are measured at a specific point in time and mean concentrations over time are not available. Therefore, all assessments of ALS exceedances assume that the measured concentration was representative of the required mean concentration.

Compliance ratios are calculated for each total recoverable COC concentration and presented through time in scatterplots. A compliance ratio is calculated as the ratio of the sample concentration to the applicable water quality standard or performance goal. Compliance ratio results are presented as line graphs on a semi-logarithmic scale ranging from 0.01 to 100. On this scale a value of 1.0 corresponds to a concentration equal to the performance goal or water quality standard. Compliance ratios exceeding 1.0 represent exceedances of the performance goal or water quality standard.

2.2.6 Data Validation

Data quality objectives (DQOs) were established in the CFROU monitoring project quality assurance project plan (QAPP) for data "representativeness", "comparability", "completeness", "sensitivity", "precision", "bias", and "accuracy" [DeArment et al., 2013]. Methods for field and laboratory quality assurance and quality control (QA/QC) procedures are also described in detail in the project QAPP. A completed QA/QC checklist, summary tables of field duplicate and field blank results, and assessments of data quality objectives are included in Appendix A.

2.3 RESULTS

2.3.1 Streamflows

Streamflows at the CFROU monitoring stations in 2015 are depicted in hydrographs for the following USGS gauging stations: Silver Bow Creek at Warm Springs (USGS 12323750) [Figure 2-2], Clark Fork near Galen (USGS 12323800) [Figure 2-3], at Deer Lodge (USGS 12324200) [Figure 2-4], near Drummond (USGS 12331800) [Figure 2-5], and at the Turah Bridge (USGS 12334550) [Figure 2-6].

Streamflows in the upper Clark Fork River watershed were variable in 2015 and ranged from well-below normal to slightly above normal depending on the monitoring site and monitoring event. Streamflows at mainstem CFROU monitoring sites were briefly elevated during the winter months of January and February. These elevated streamflows largely subsided by March. Mainstem streamflows in Q1 were slightly above normal for those dates based on long-term USGS streamflow gauging station records. The three Q2 monitoring events were intended to target the rising limb, peak, and falling limb of the spring snowmelt runoff period. Streamflows during the Q2 monitoring events were generally normal for those dates. The Q2-Peak monitoring event from May 12-13 occurred within two days of the peak recorded flows at several of the USGS stations but slightly higher peak streamflows occurred approximately two weeks later in the Clark Fork River at Deer Lodge [Figure 2-4], near Drummond [Figure 2-5], and at the Turah Bridge [Figure 2-6]. Streamflows during the Q3 monitoring event were well below normal compared to the long-term records. Streamflows during the Q4 monitoring event were normal to slightly below normal compared to the long-term records.

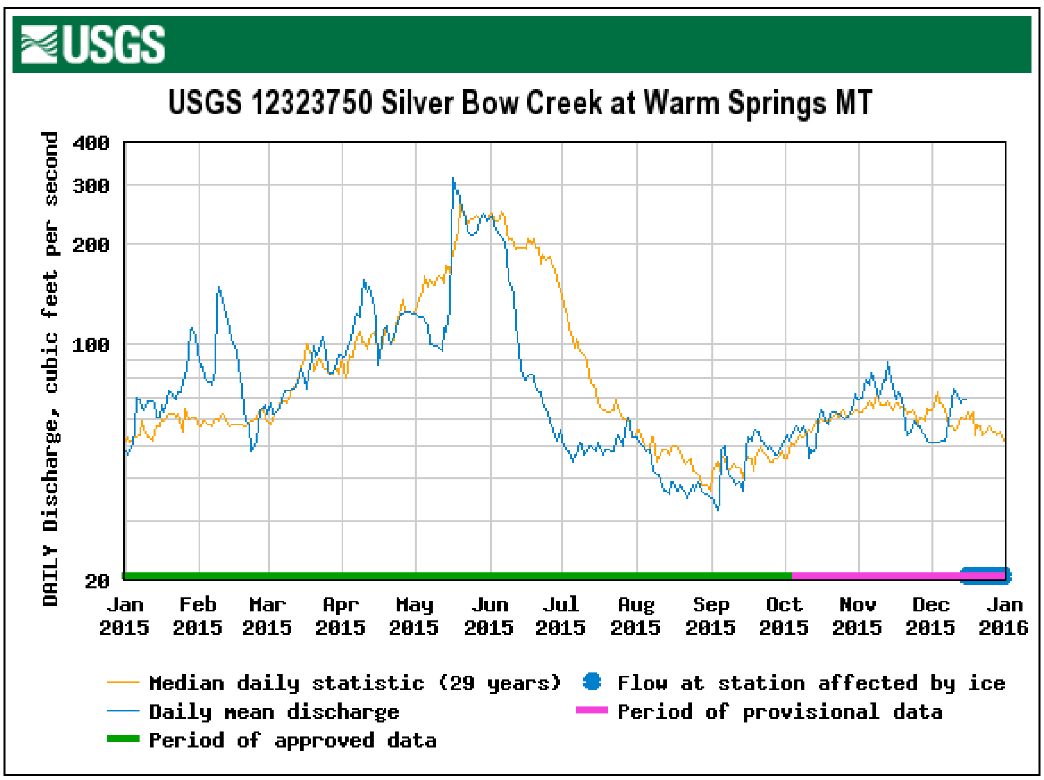

Figure 2-2. Hydrograph for Silver Bow Creek at Warm Springs, 2015.

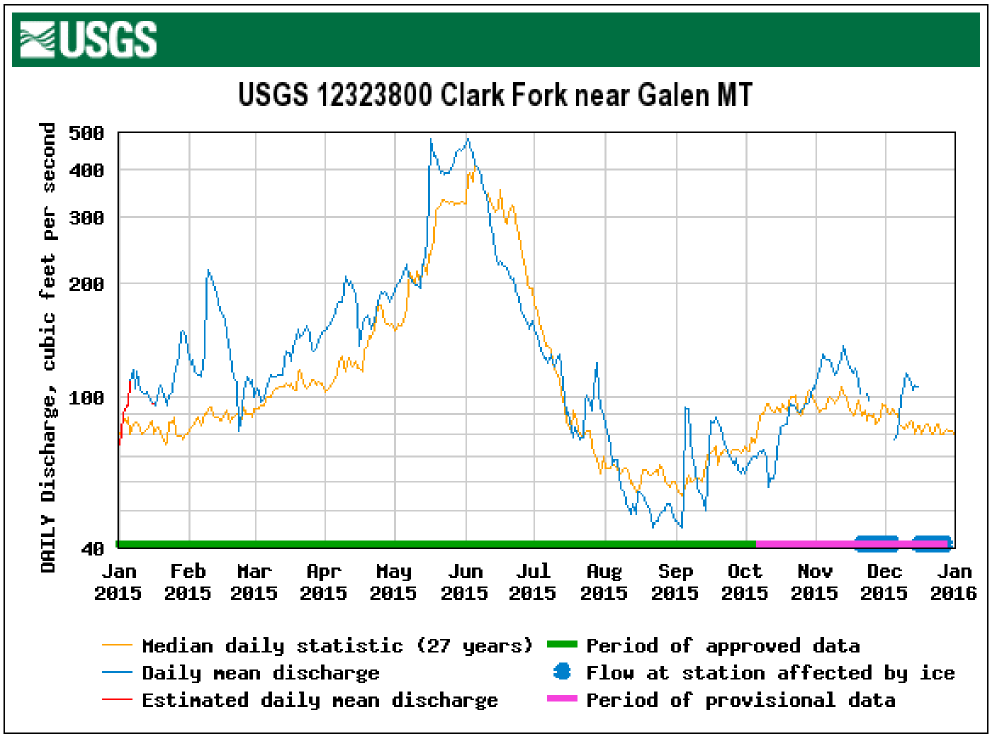

Figure 2-3. Hydrograph for Clark Fork near Galen, 2015.

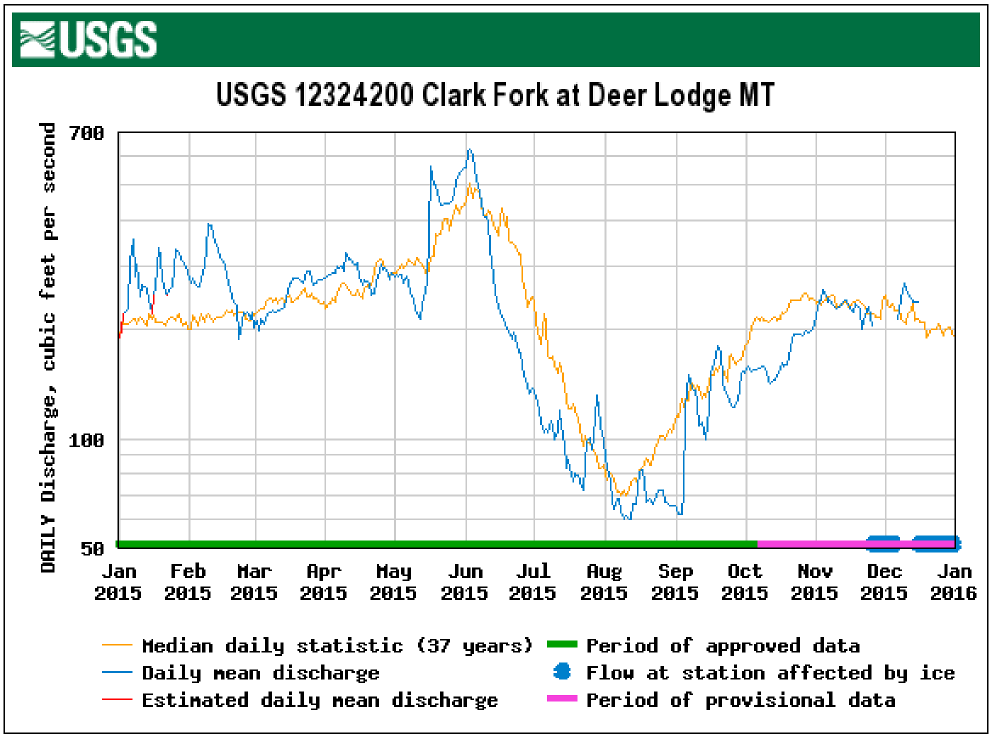

Figure 2-4. Hydrograph for Clark Fork at Deer Lodge, 2015.

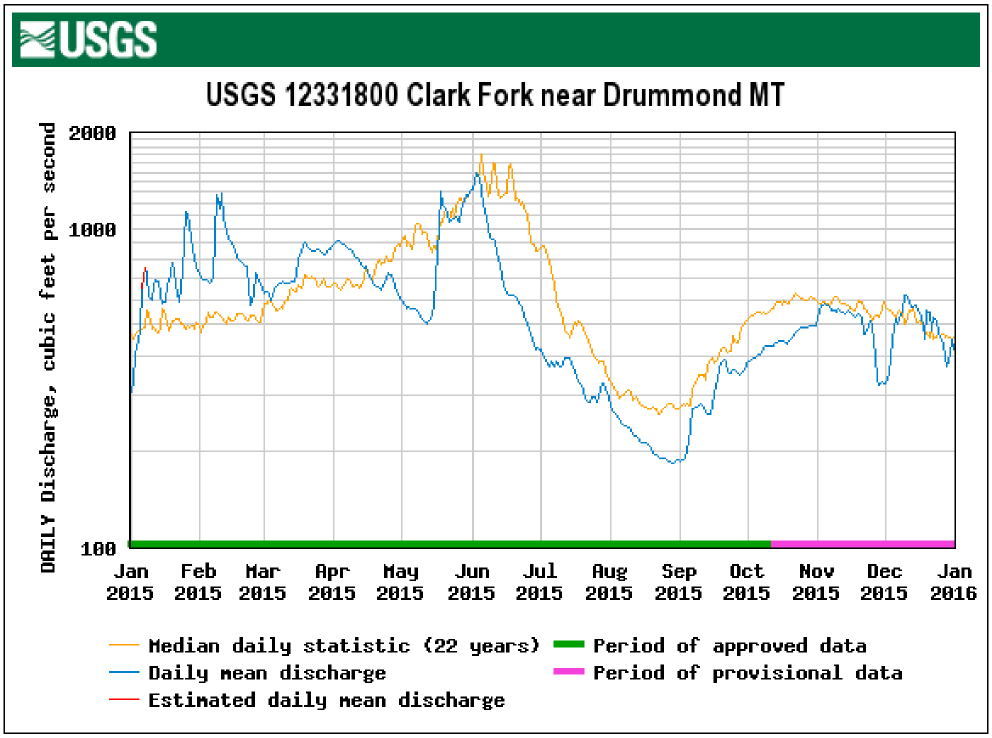

Figure 2-5. Hydrograph for Clark Fork near Drummond, 2015.

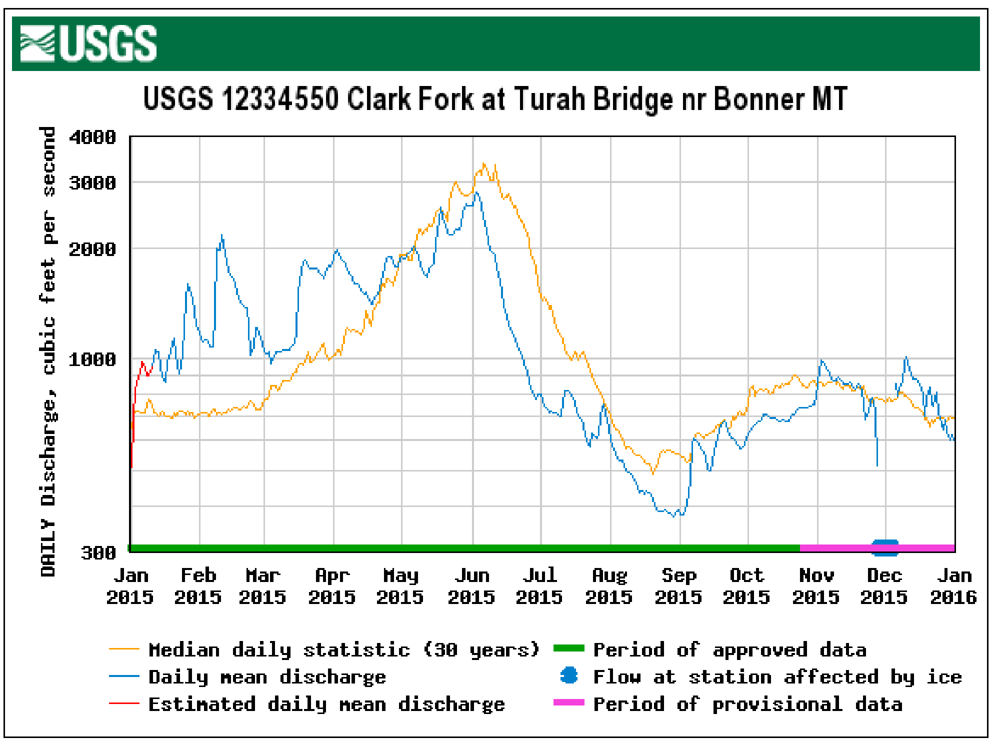

Figure 2-6. Hydrograph for Clark Fork at Turah Bridge, 2015.

2.3.2 Field Parameters

2.3.2.1 Water Temperature

Clark Fork River mainstem and tributary water temperatures in 2015 are presented Figure 2-7 (mainstem) and Figure 2-8 (tributaries). The maximum water temperatures at all mainstem monitoring stations in 2015 were observed during the Q2-Falling monitoring event and ranged from 15.3-20.9 C [Figure 2-7]. In the tributaries, the maximum water temperatures were highest during the Q2-Falling event at four of the sites and highest in Q3 at the other sites [Figure 2-8]. The highest water temperatures in the Clark Fork River mainstem occurred at Deer Lodge (20.2 C) and at the Williams-Tavenner Bridge (20.9 C). The highest water temperature in the Clark Fork River tributaries occurred at Flint Creek (19.0 C) during the Q2-Falling event. The lowest water temperatures in the Clark Fork River mainstem occurred in Q4 at all sites and ranged from -0.1-0.1 C. The lowest water temperatures in the Clark Fork River tributaries occurred in Q4 at all sites and ranged from -0.1-1.7 C.

Maximum water temperatures at Clark Fork River mainstem monitoring stations in 2015 were higher than the maximum temperatures observed from 2010-2014. From 2010-2014, the maximum annual temperatures in the Clark Fork River mainstem were always <17 C whereas the highest temperature recorded in 2015 approached 21 C. The tributary monitoring site in Warm Springs Creek had the lowest and least variable water temperatures of all sites in 2015.

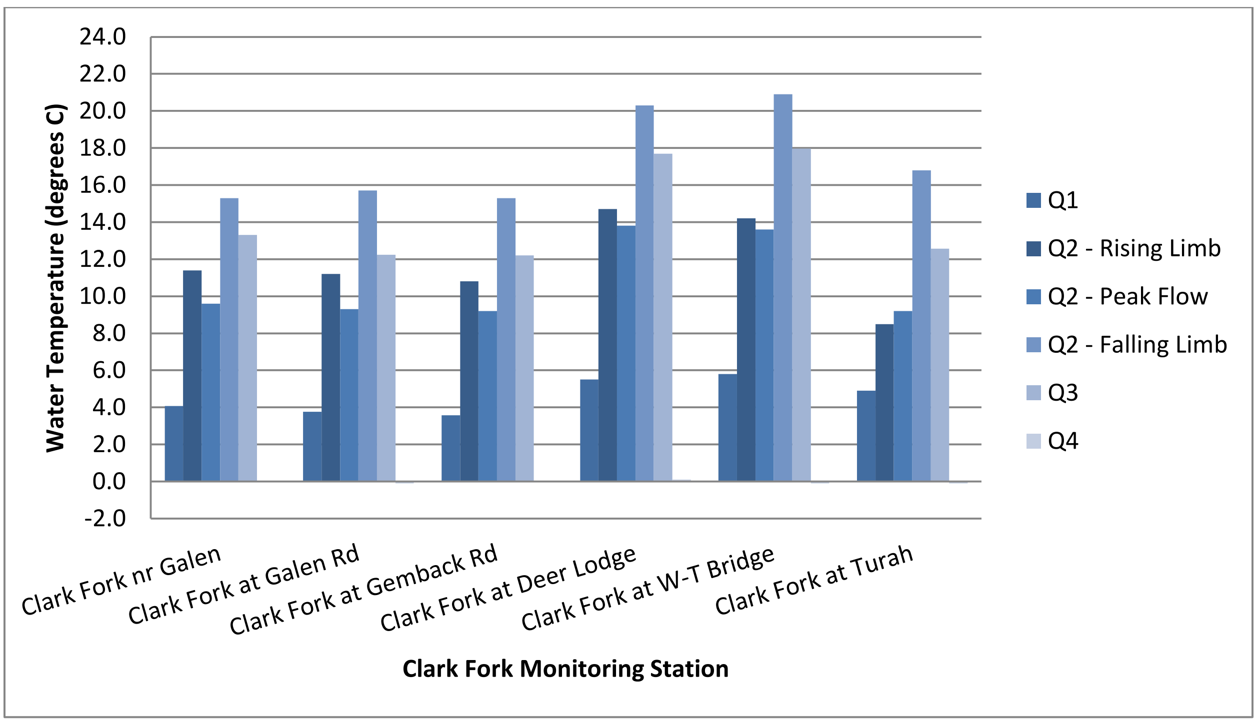

Figure 2-7. Surface water temperatures at mainstem sampling sites in the Clark Fork River Operable Unit, 2015. Temperatures during the fourth quarter (Q4) monitoring period were at or near 0 C.

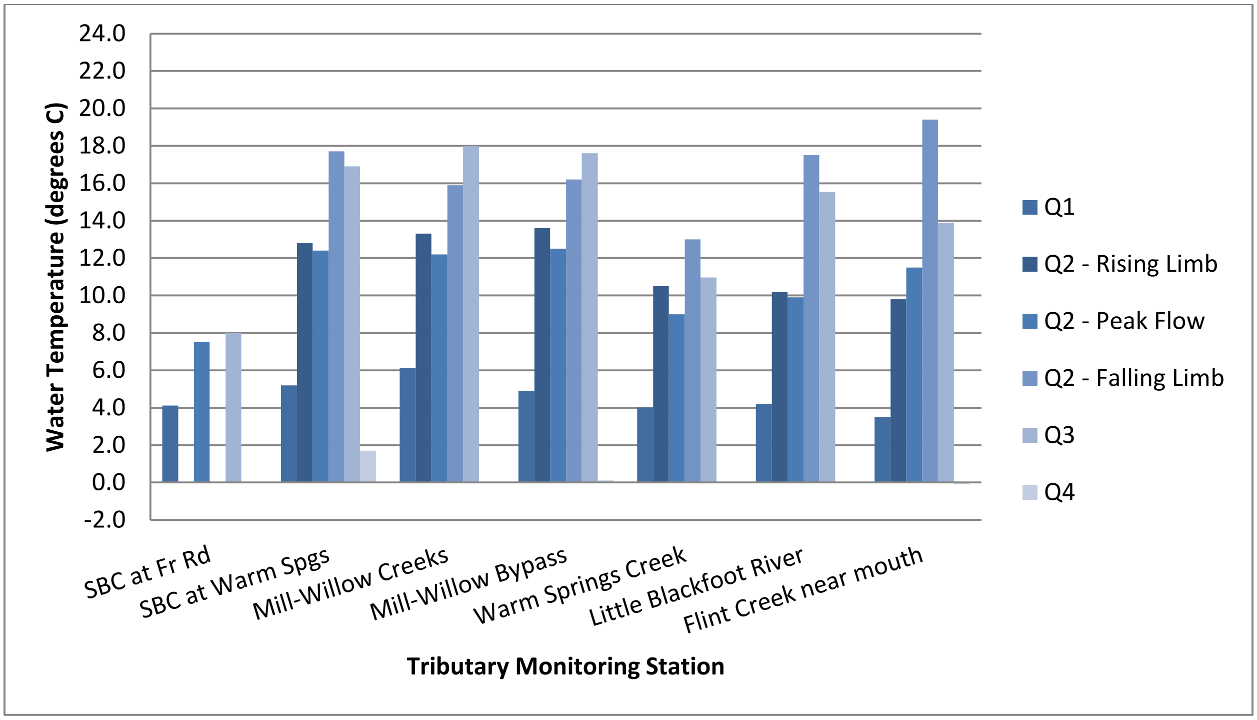

Figure 2-8. Surface water temperatures at tributary sampling sites in the Clark Fork River Operable Unit, 2015. Temperatures during the fourth quarter (Q4) monitoring period were at or near 0 C at some sites. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "SBC at Fr Rd" site.

2.3.2.2 pH

In 2015, pH in the upper Clark Fork River mainstem monitoring stations ranged from 7.67-9.12 [Figure 2-9]. In the tributary monitoring stations, the range of pH was slightly larger (7.09-9.03) [Figure 2-10]. In Q3, one pH measurement from the Clark Fork River at the Williams-Tavenner Bridge (9.12) and one measurement from Silver Bow Creek at Warm Springs (9.03) had pH above the optimal range for the protection of aquatic life (6.5-9.0). The highest pH tended to occur in Q3 at most stations. Spatially, the highest pH tended to occur at the mainstem sites at Deer Lodge and the Williams-Tavenner Bridge and in Silver Bow Creek at Warm Springs. The pH levels at CFROU monitoring stations in 2015 were within the range of values measured during the 2010-2014 period.

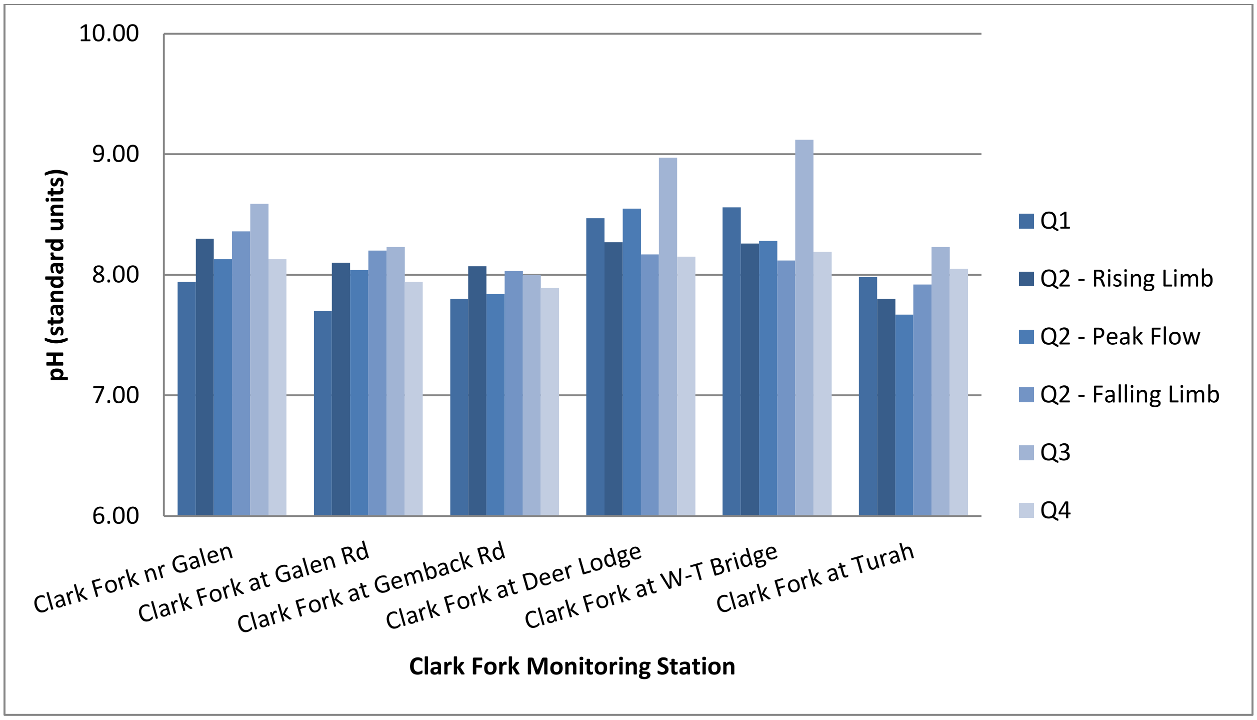

Figure 2-9. Surface water pH at mainstem sampling sites in the Clark Fork River Operable Unit, 2015.

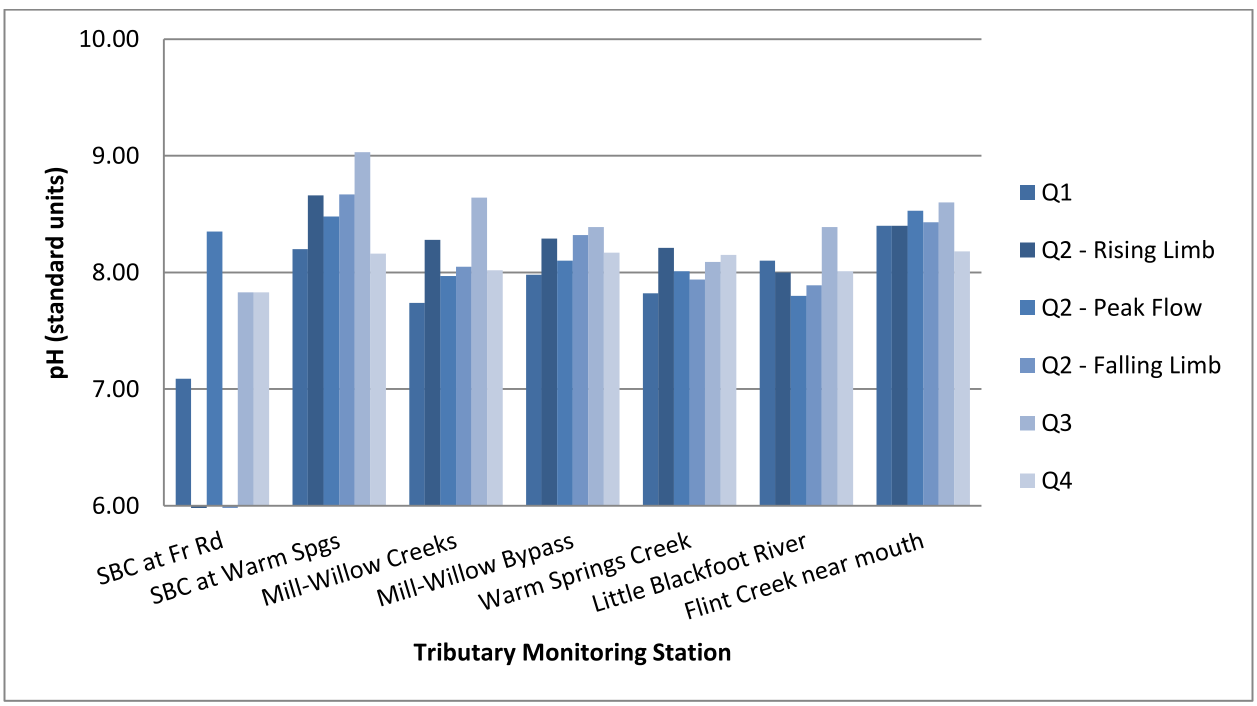

Figure 2-10. Surface water pH at tributary sampling sites in the Clark Fork River Operable Unit, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "SBC at Fr Rd" site.

2.3.2.3 Conductivity

The highest conductivities at all of the CFROU monitoring sites in 2015 occurred in Q3 or Q4 [Figure 2-11; Figure 2-12]. The lowest conductivities occurred during the Q2 monitoring events [Figure 2-11; Figure 2-12]. Conductivity in the mainstem Clark Fork River tended to progressively increase from the headwaters station near Galen downstream to Gemback Road and then decreased downstream from Gemback Road [Figure 2-11]. In the mainstem, conductivity was always lowest at Turah [Figure 2-11]. Conductivity at CFROU stations in 2015 ranged from 177-569 µS/cm [Figure 2-11]. The conductivity range at the mainstem stations in 2015 was smaller than in 2014 (104-594) and 2013 (111-560 µS/cm), but greater than in 2010 (176-466 µS/cm), 2011 (113-439 µS/cm), and 2012 (138-456 µS/cm). Conductivity increased substantially between the two sites in the Mill-Willow Creek system [Figure 2-12]. The lowest conductivity among tributary sites occurred in Mill-Willow Creek at Frontage Road during the Q2-Falling monitoring event (114 µS/cm). The highest conductivity occurred in the Mill-Willow Bypass in Q3 (615 µS/cm).

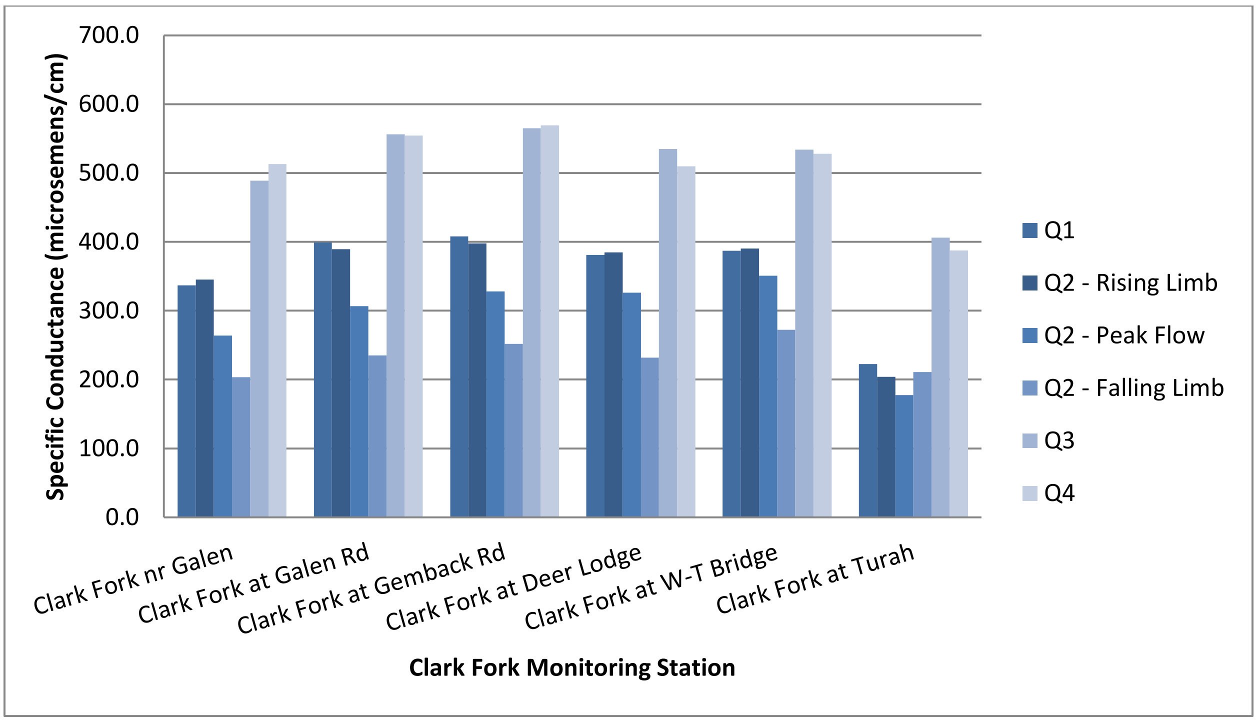

Figure 2-11. Conductivity at mainstem sampling sites in the Clark Fork River Operable Unit, 2015.

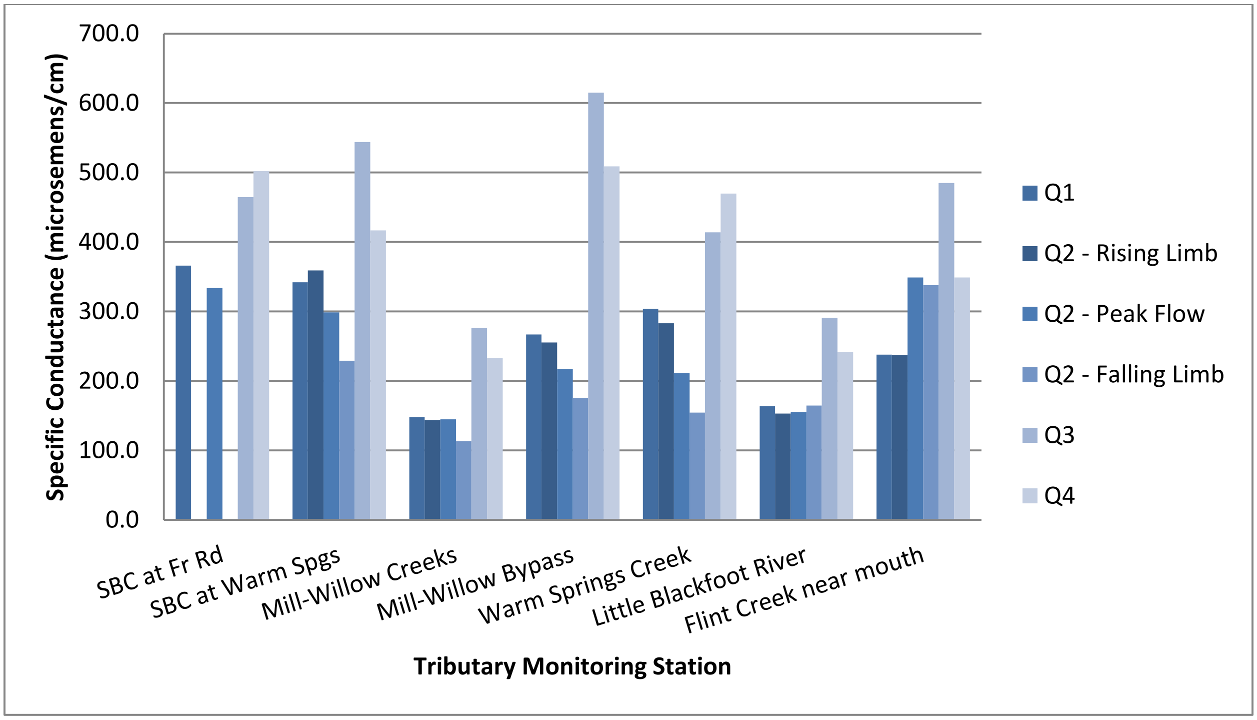

Figure 2-12. Conductivity at tributary sampling sites in the Clark Fork River Operable Unit, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "SBC at Fr Rd" site.

2.3.2.4 Dissolved Oxygen

Dissolved oxygen concentrations in the Clark Fork River mainstem in 2015 ranged from 7.21-15.07 mg/L [Figure 2-13] and saturation levels ranged from 67.3-112.2% [Figure 2-14]. Dissolved oxygen concentrations in the Clark Fork River tributaries in 2015 ranged from 7.37-15.76 mg/L [Figure 2-15] and saturation levels ranged from 71.9-118.6% [Figure 2-16]. In the mainstem, the minimum annual dissolved oxygen concentration was observed at Gemback Road in Q3 and the maximum concentration was observed at Turah in Q4 [Figure 2-13]. In the tributaries, the minimum annual dissolved oxygen concentration was observed in the Little Blackfoot River in Q3 and the maximum concentration was observed in Flint Creek in Q1 [Figure 2-15]. All dissolved oxygen concentrations in the CFROU in 2015 were above levels which inhibit water quality and cause water use limitations. The highest dissolved oxygen concentrations at nearly all monitoring stations occurred in Q4. The highest dissolved oxygen concentrations measured in the Little Blackfoot River and in Flint Creek were observed in Q1. The observed range of dissolved oxygen concentrations at Clark Fork River mainstem sites in 2015 was greater than in 2014 (8.29-15.23), 2013 (8.45-15.20 mg/L), 2012 (8.49-14.05 mg/L), 2011 (8.60-14.85 mg/L), and 2010 (8.69-15.03 mg/L).

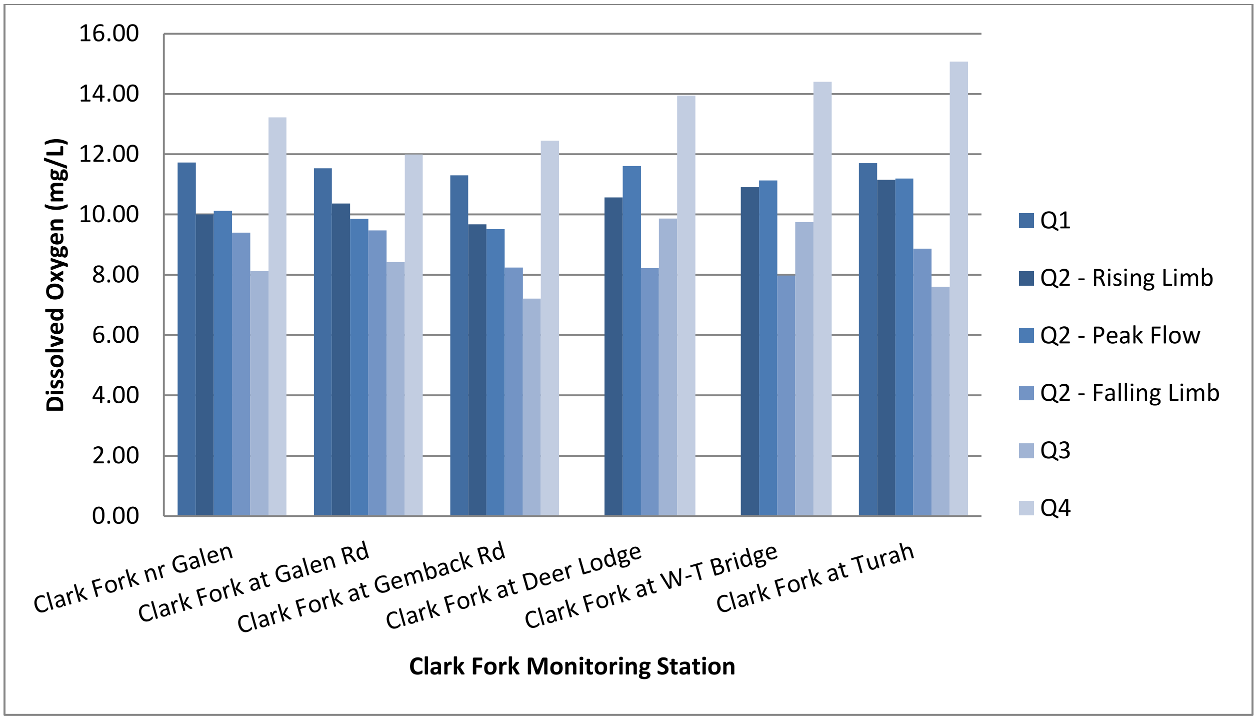

Figure 2-13. Dissolved oxygen concentrations at mainstem sampling sites in the Clark Fork River Operable Unit, 2015.

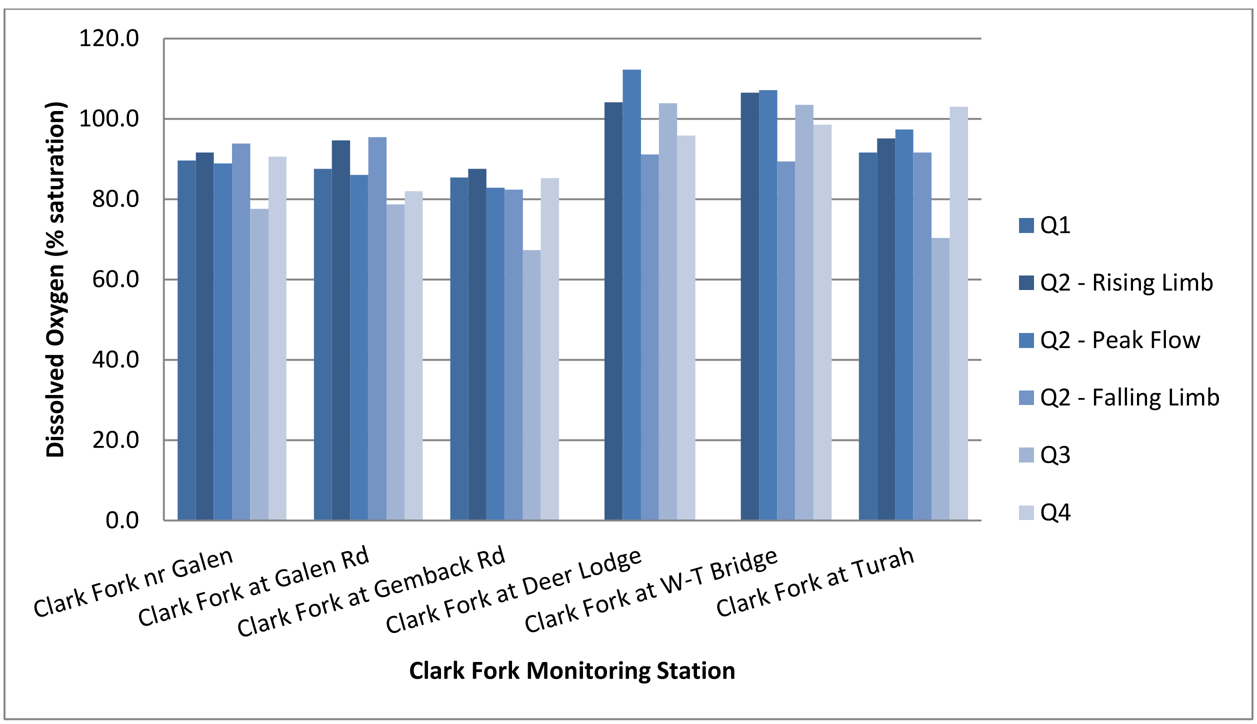

Figure 2-14. Dissolved oxygen saturation at mainstem sampling sites in the Clark Fork River Operable Unit, 2015.

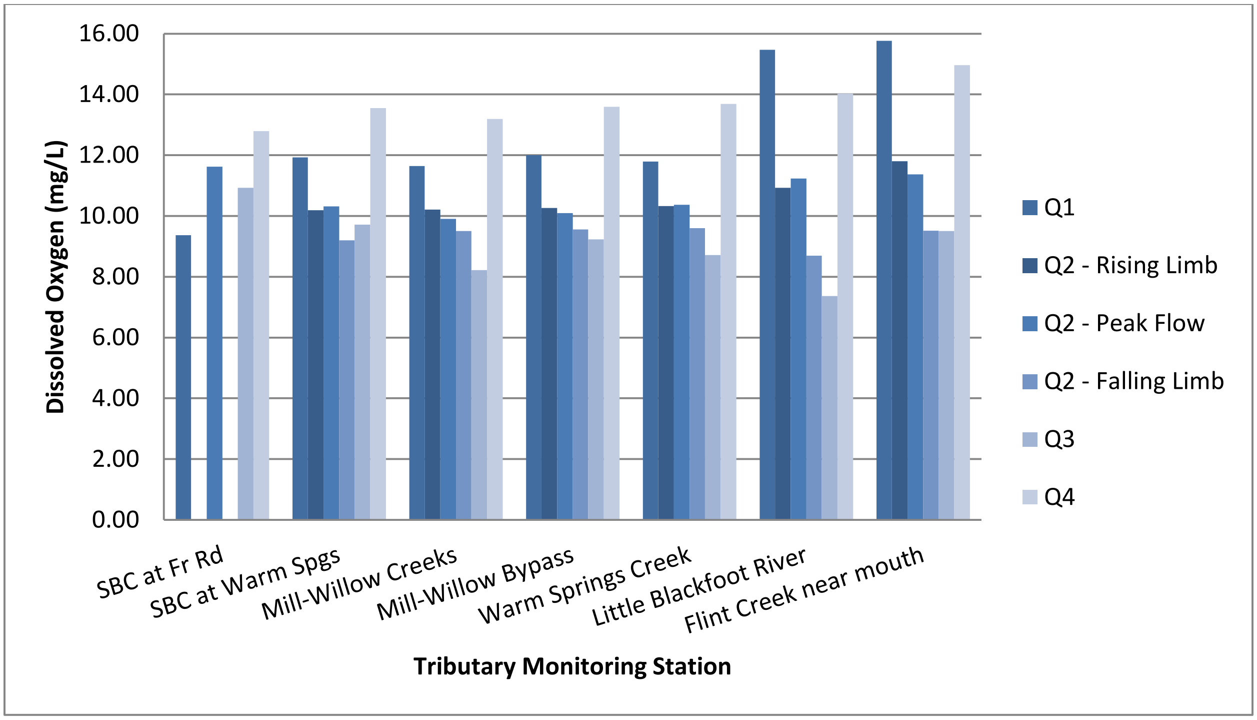

Figure 2-15. Dissolved oxygen concentrations at tributary sampling sites in the Clark Fork River Operable Unit, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "SBC at Fr Rd" site.

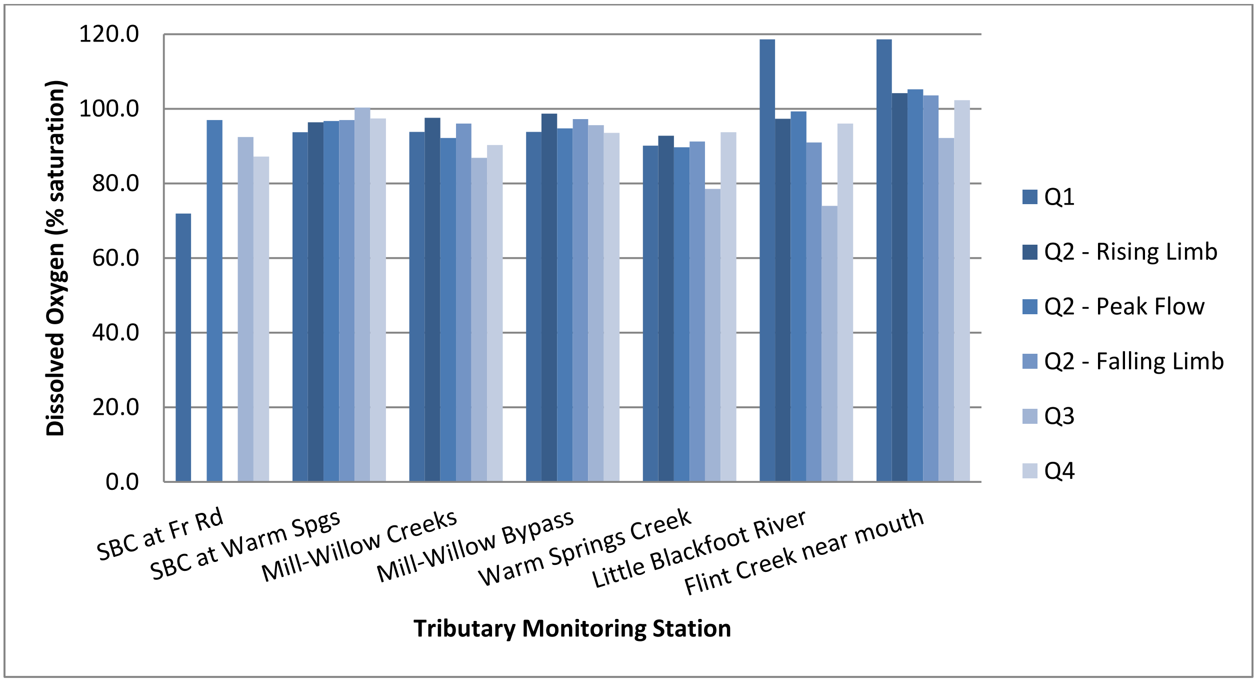

Figure 2-16. Dissolved oxygen saturation at tributary sampling sites in the Clark Fork River Operable Unit, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "SBC at Fr Rd" site.

2.3.2.5 Turbidity

Turbidity in the Clark Fork River mainstem in 2015 ranged from 0.91-13.10 NTU [Figure 2-17]. In the mainstem, the minimum annual turbidity was observed at Galen Road in Q3 and the maximum turbidity was observed at the Williams-Tavenner Bridge during the Q2-Falling event [Figure 2-17]. In the mainstem, turbidity tended to increase from the near Galen site to the Williams-Tavenner Bridge site and then declined downstream to the Turah site [Figure 2-17]. Turbidity in the mainstem was generally low (<10 NTU) in 2015 except for three samples from the Williams-Tavenner Bridge and Turah sites [Figure 2-17]. Turbidity was similar in 2015 to prior monitoring years (2010-2014), with a few exceptions. During the Q2-Peak 2011 sample period, turbidity in the mainstem was considerably higher than in other years. In addition, in Q1 2014 turbidity was higher at the Clark Fork River at Deer Lodge and Turah sites than during Q1 other years.

Turbidity in the Clark Fork River tributaries in 2015 ranged from 0.79-10.00 NTU [Figure 2-18]. In the tributaries, the minimum annual turbidity was observed in the Mill-Willow Bypass in Q3 and the maximum turbidity was observed in Flint Creek in Q1 [Figure 2-18]. Turbidity in tributaries in 2015 was similar to prior years (2010-2015) with some exceptions. As with the mainstem sites, turbidity during the Q2-Peak 2011 sample period in the tributaries was considerably higher than in other years. Turbidity in Mill-Willow Creek at Frontage Road was also higher in Q4 2014 than during Q4 in other monitoring years.

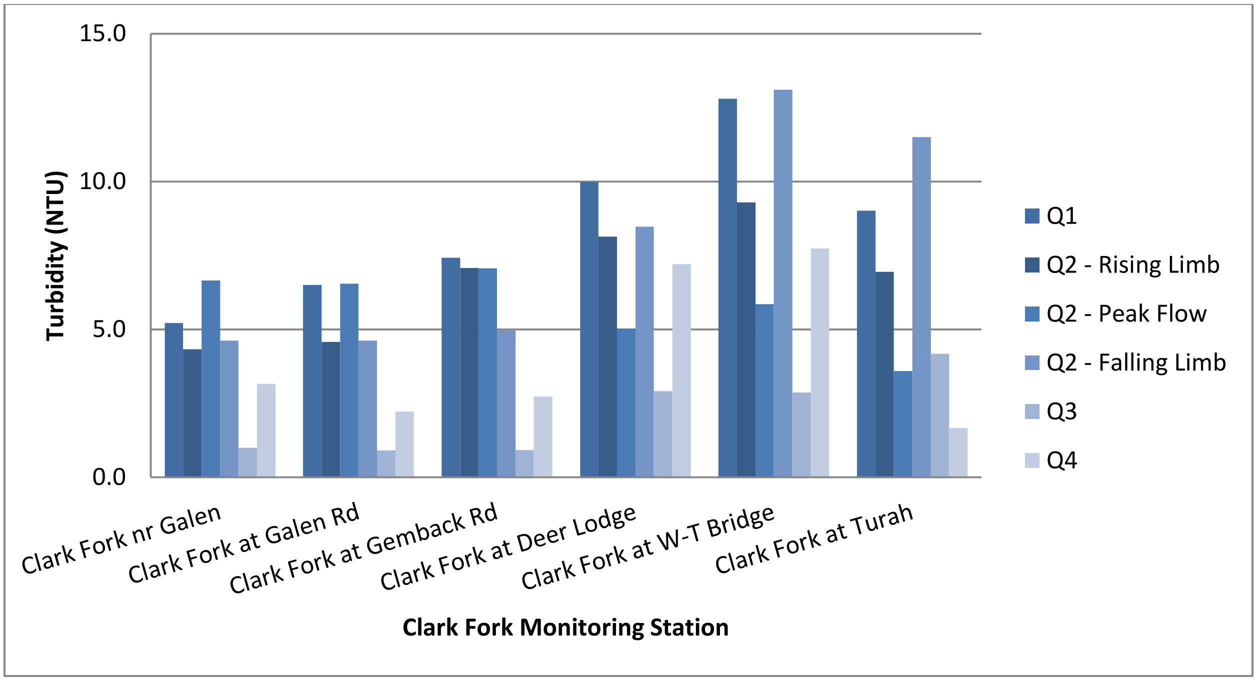

Figure 2-17. Turbidity at mainstem sampling sites in the Clark Fork River Operable Unit, 2015.

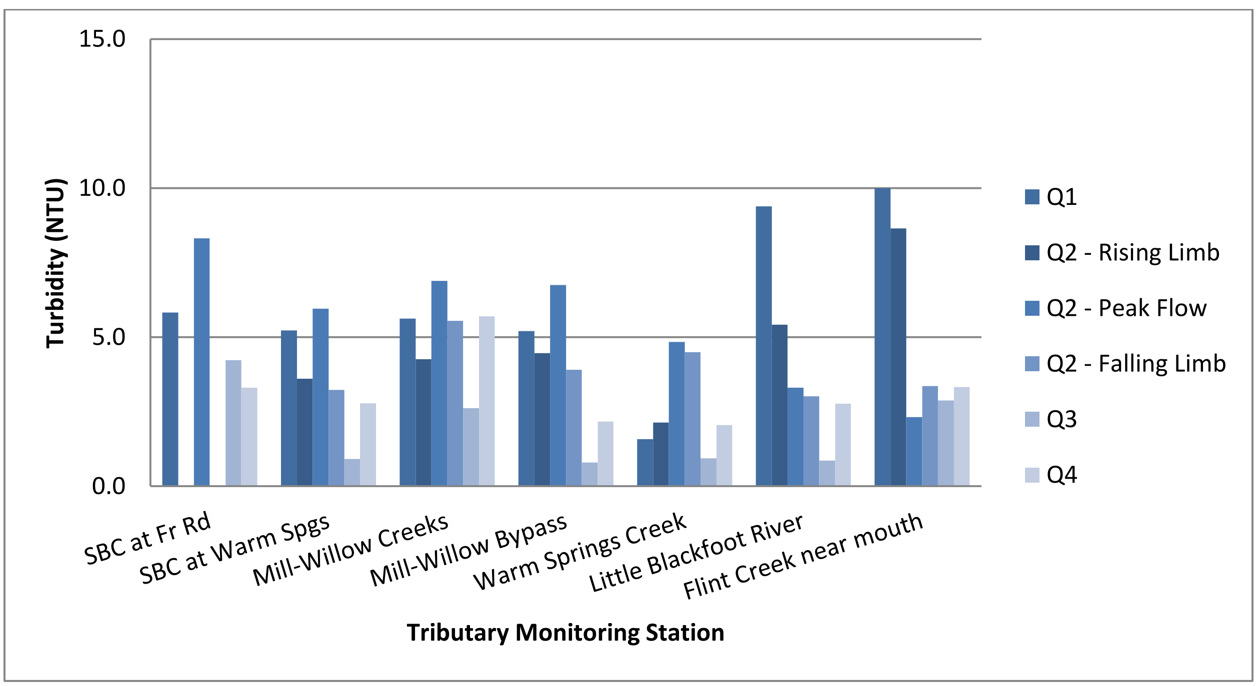

Figure 2-18. Turbidity at tributary sampling sites in the Clark Fork River Operable Unit, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "SBC at Fr Rd" site.

2.3.3 Total Suspended Sediment

Total suspended sediment concentrations in the Clark Fork River mainstem in 2015 ranged from <1-31 mg/L [Figure 2-19]. In the mainstem, the minimum annual total suspended sediment concentration was observed near Galen in Q3 and the maximum total suspended sediment concentration was observed at Deer Lodge and the Williams-Tavenner Bridge during the Q2-Falling monitoring event [Figure 2-19]. Total suspended sediment concentrations at several Clark Fork River mainstem monitoring stations in 2015 were elevated during the Q2-Falling event particularly at Deer Lodge, the Williams-Tavenner Bridge, and Turah [Figure 2-19]. Generally, total suspended sediment concentrations in the Clark Fork River mainstem increased from the near Galen site to the Williams-Tavenner Bridge and decreased downstream at Turah [Figure 2-19]. The largest increases in total suspended sediment concentrations between mainstem sites occurred from Gemback Road to Deer Lodge, particularly during the Q2-Falling monitoring event [Figure 2-19]. Total suspended sediment concentrations at CFROU mainstem monitoring stations during most monitoring events in 2015 were similar to concentrations measured between 2010 and 2014. However, peak total suspended sediment concentrations measured during Q2 (between 2010-2013) were generally higher than concentrations measured from 2014-2015.

Total suspended sediment concentrations in the Clark Fork River tributaries in 2015 ranged from 1-23 mg/L [Figure 2-20]. In the tributaries, the minimum annual total suspended sediment concentration was observed in the Mill-Willow Bypass and Warm Springs Creek in Q3 and the maximum total suspended sediment concentration was observed in Flint Creek in Q1 [Figure 2-20]. Generally, total suspended sediment concentrations in the tributaries were lower and less variable than at mainstem stations [Figure 2-19; Figure 2-20].

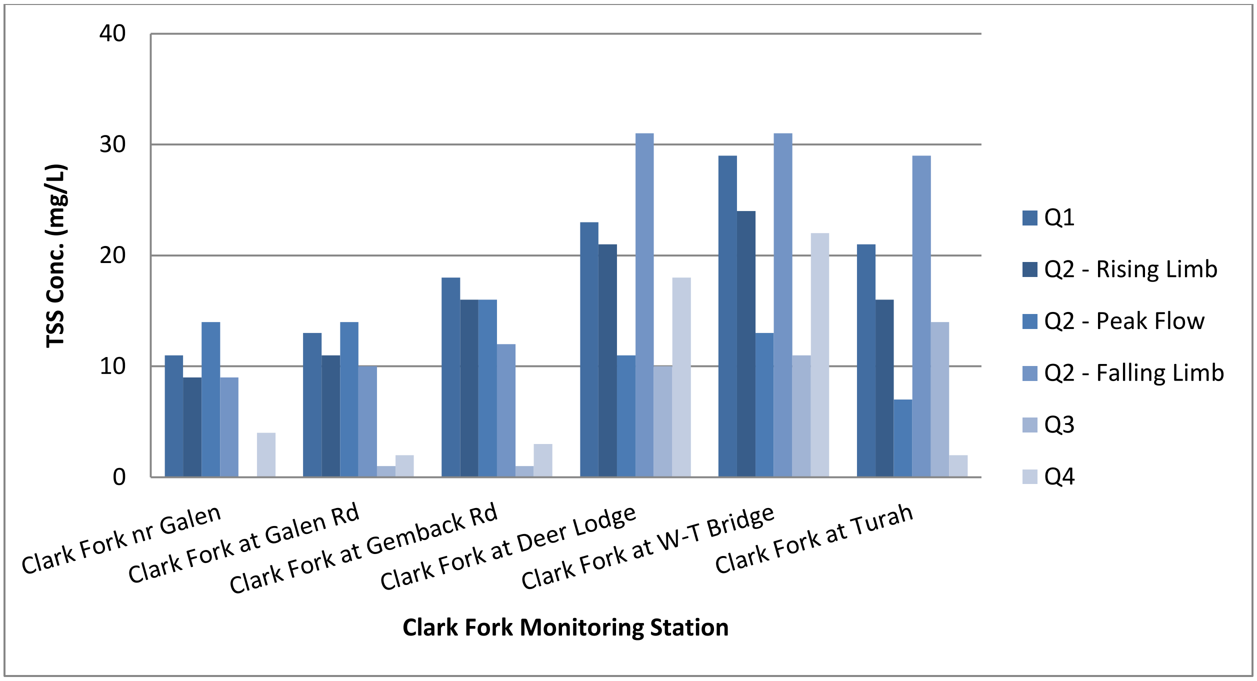

Figure 2-19. Total suspended sediment concentrations at mainstem sampling sites in the Clark Fork River Operable Unit, 2015. Missing bars indicate a concentration below the analytical reporting limit.

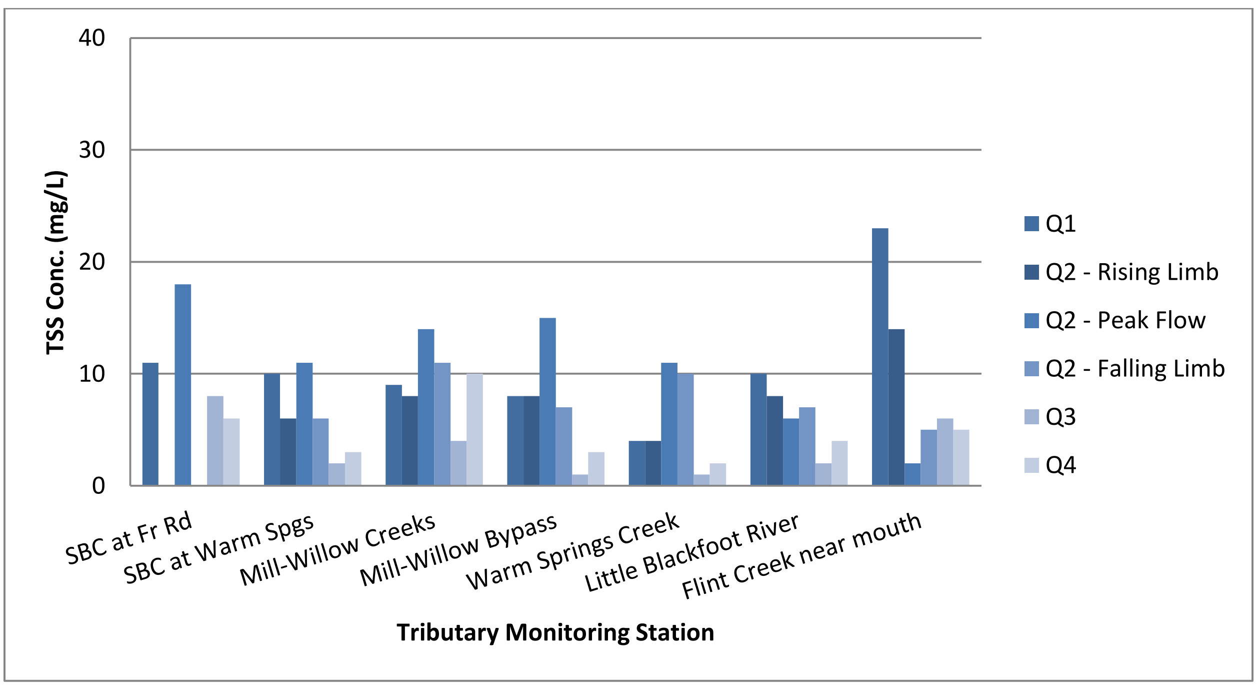

Figure 2-20. Total suspended sediment concentrations at tributary sampling sites in the Clark Fork River Operable Unit, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "SBC at Fr Rd" site.

2.3.4 Common Ions

2.3.4.1 Hardness

Water hardness in the Clark Fork River mainstem in 2015 ranged from 87-298 mg/L [Figure 2-21]. In the mainstem, the minimum annual water hardness was observed at Turah during the Q2-Peak event and the maximum water hardness was observed at Gemback Road in Q4 [Figure 2-21]. Water hardness in the mainstem sites at those hardness levels would be classified as ranging from “moderately hard” to “very hard”. Water hardness during 2015 quarterly monitoring events was within the range observed in the 2010-2014 period.

Water hardness in the Clark Fork River tributaries in 2015 ranged from 55-287 mg/L [Figure 2-22]. In the tributaries, the minimum annual water hardness was observed in Mill-Willow Creek during the Q2-Falling event and the maximum water hardness was observed in the Mill-Willow Bypass Q3 [Figure 2-22]. Between the Mill-Willow Creek site and the Mill-Willow Bypass site water hardness essentially doubled during the 2015 monitoring events [Figure 2-22].

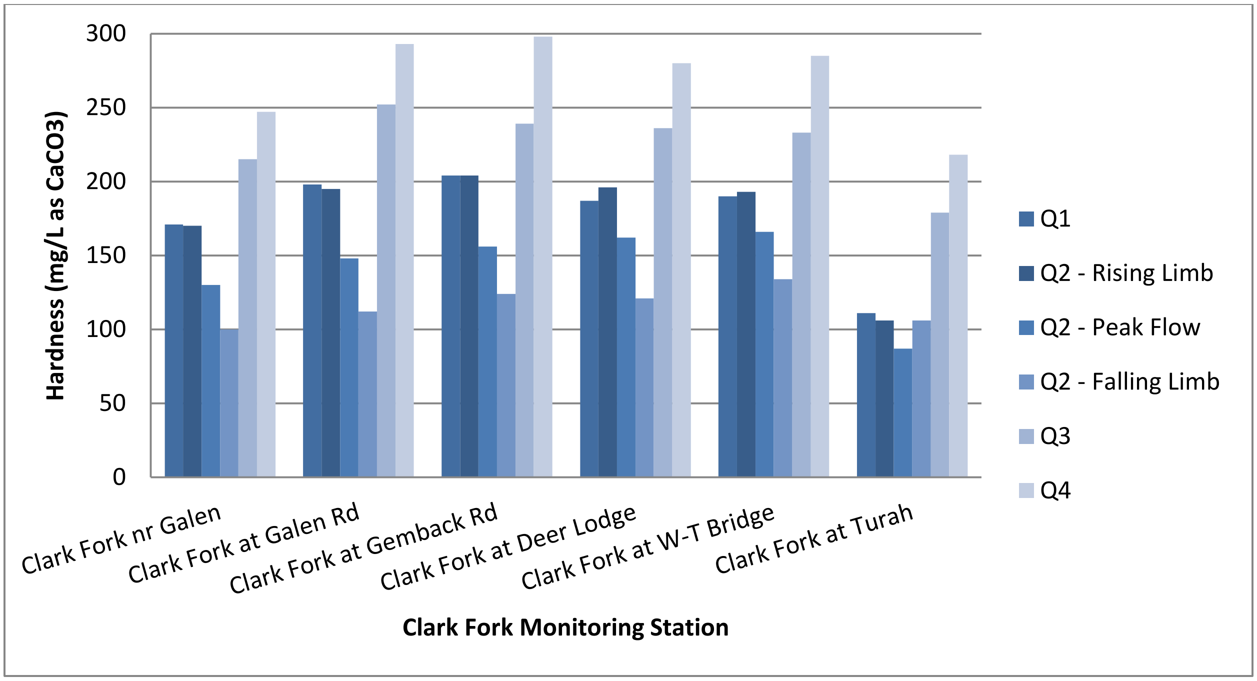

Figure 2-21. Water hardness at mainstem sampling sites in the Clark Fork River Operable Unit, 2015.

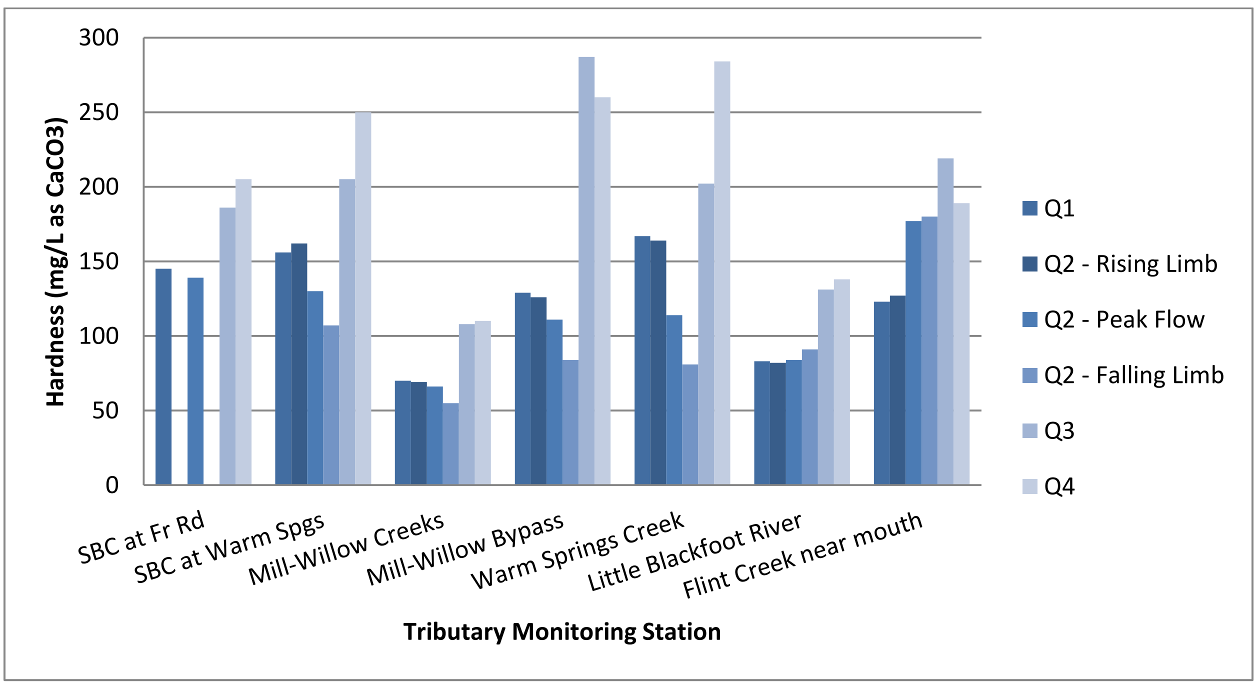

Figure 2-22. Water hardness at tributary sampling sites in the Clark Fork River Operable Unit, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "SBC at Fr Rd" site.

2.3.4.2 Alkalinity and Bicarbonate

Alkalinity in the Clark Fork River mainstem in 2015 ranged from 74-180 mg/L [Figure 2-23]. In the mainstem, the minimum annual alkalinity was observed at Turah during the Q2-Peak event and the maximum alkalinity was observed at Gemback Road, at Deer Lodge, and at the Williams-Tavenner Bridge in Q4 [Figure 2-23]. Bicarbonate alkalinity in the Clark Fork River mainstem in 2015 ranged from 90-220 mg/L [Figure 2-25]. In the mainstem, the minimum annual bicarbonate alkalinity was observed at Turah during the Q2-Peak event and the maximum bicarbonate alkalinity was observed at the Williams-Tavenner Bridge in Q4 [Figure 2-25]. Total and bicarbonate alkalinity in the mainstem Clark Fork River in 2015 increased modestly from the near Galen site to the Williams-Tavenner Bridge site and decreased downstream to Turah [Figure 2-23; Figure 2-25]. Mainstem total and bicarbonate alkalinity was generally lowest during the Q2-Falling event and highest in Q3 or Q4 [Figure 2-23; Figure 2-25]. Total and bicarbonate alkalinity in the mainstem in 2015 was within the range observed in prior years.

Alkalinity in the Clark Fork River tributaries in 2015 ranged from 56-220 mg/L [Figure 2-24]. In the tributaries, the minimum annual alkalinity was observed in Mill-Willow Creek during the Q2-Falling event and the maximum alkalinity was observed at Flint Creek in Q3 [Figure 2-24]. Bicarbonate alkalinity in the Clark Fork River tributaries in 2015 ranged from 68-260 mg/L [Figure 2-26]. In the tributaries, the minimum annual bicarbonate alkalinity was observed in Mill-Willow Creek during the Q2-Falling event and the maximum bicarbonate alkalinity was observed in Flint Creek in Q3 [Figure 2-26]. Tributary total and bicarbonate alkalinity was generally lowest during the Q2-Falling event and highest in Q3 or Q4 [Figure 2-24; Figure 2-26]. Total and bicarbonate alkalinity in the tributaries in 2015 was within the range observed in prior years.

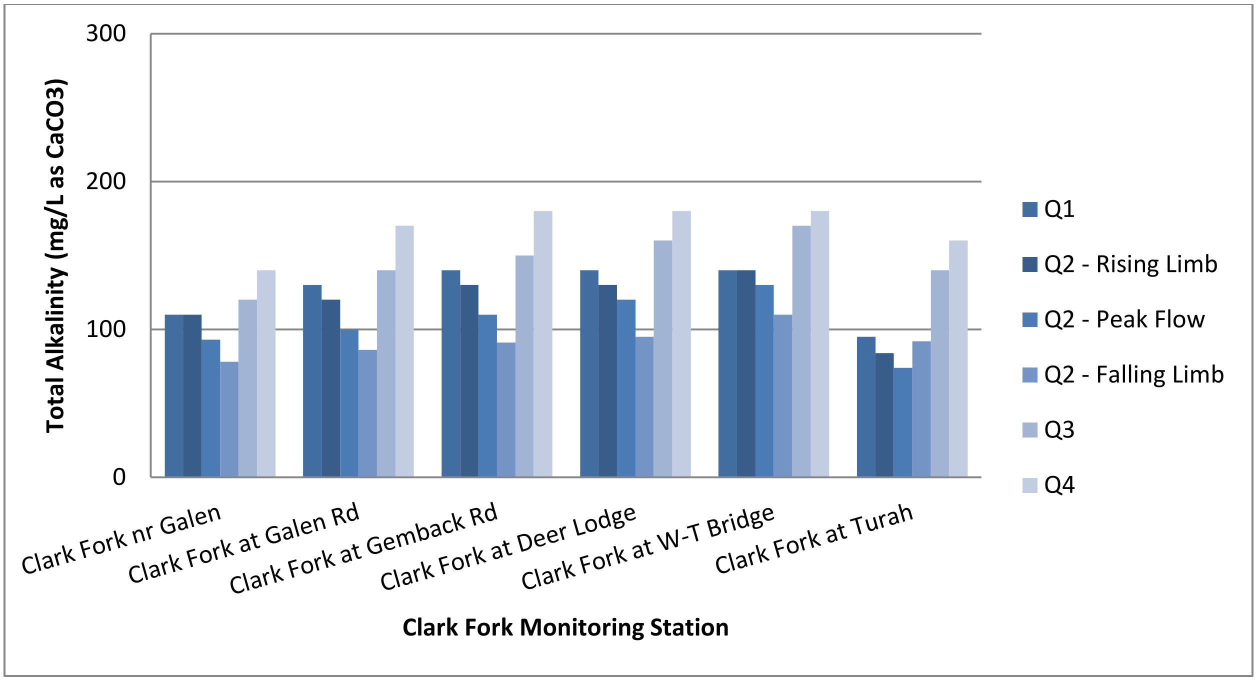

Figure 2-23. Alkalinity at mainstem sampling sites in the Clark Fork River Operable Unit, 2015.

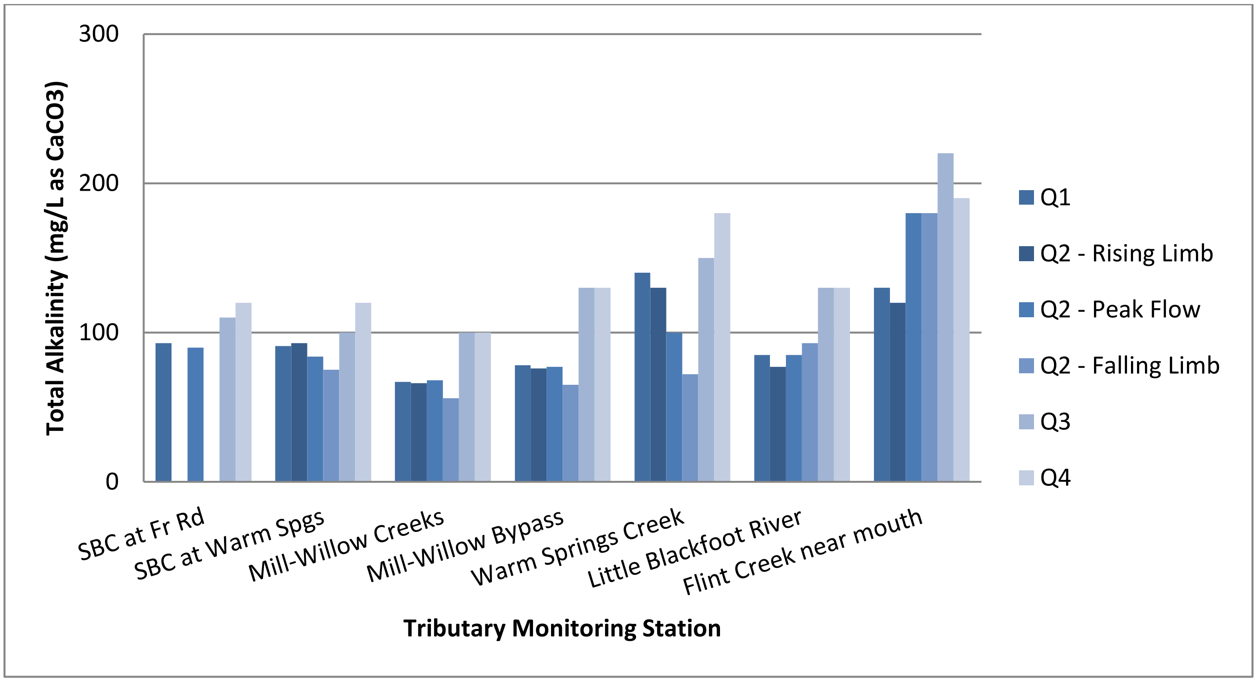

Figure 2-24. Alkalinity at tributary sampling sites in the Clark Fork River Operable Unit, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "SBC at Fr Rd" site.

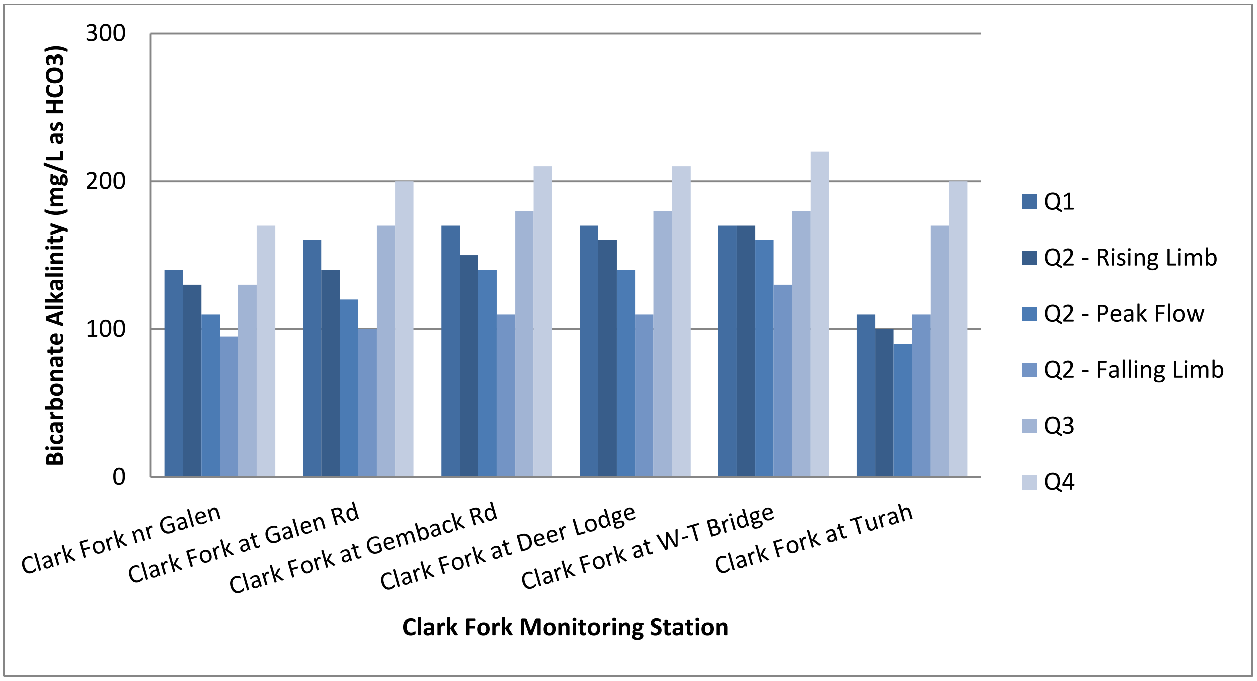

Figure 2-25. Bicarbonate alkalinity at mainstem sampling sites in the Clark Fork River Operable Unit, 2015.

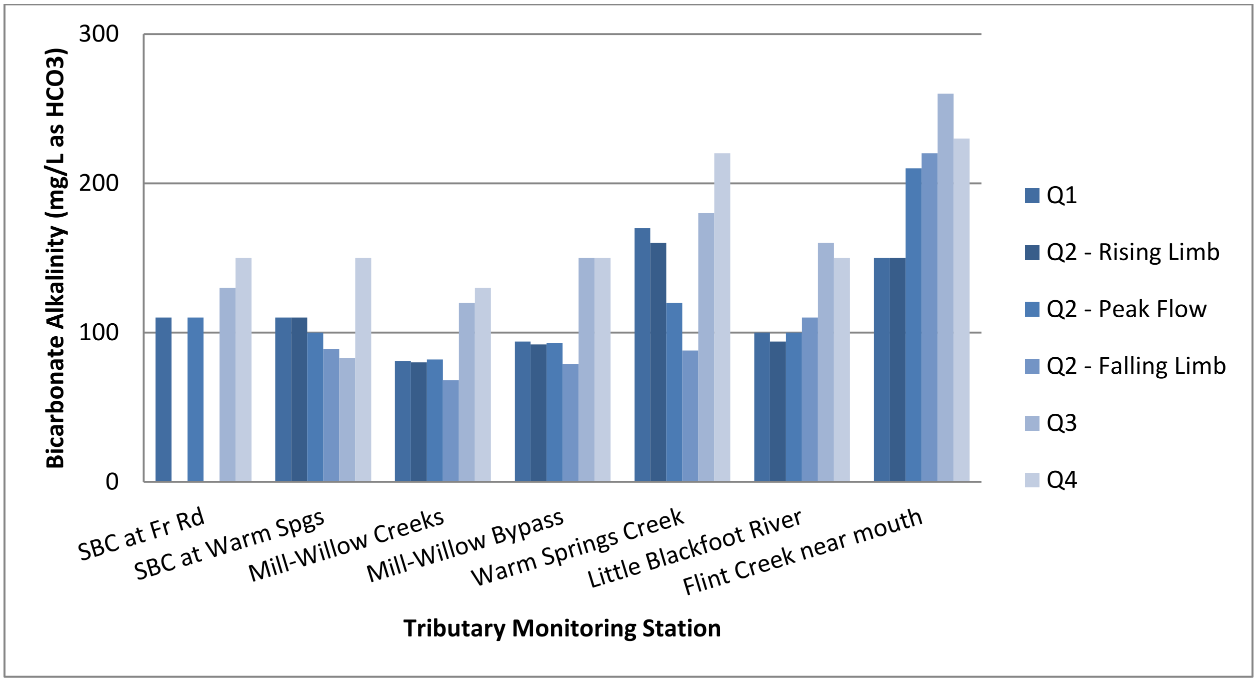

Figure 2-26. Bicarbonate alkalinity at tributary sampling sites in the Clark Fork River Operable Unit, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "SBC at Fr Rd" site.

2.3.4.3 Sulfate

Sulfate concentrations in the Clark Fork River mainstem in 2015 ranged from 18-161 mg/L [Figure 2-27]. In the mainstem, the minimum annual sulfate concentration was observed at Turah during the Q2-Peak event and the maximum sulfate concentration was observed at Gemback Road in Q4 [Figure 2-27]. Sulfate concentrations in the mainstem were substantially higher during low water periods compared to high water periods (i.e., the three Q2 events) [Figure 2-27]. Mainstem sulfate concentrations were similar from near Galen to Gemback Road and declined downstream from Gemback Road [Figure 2-27]. Sulfate concentrations in the mainstem in 2015 were within the range of values observed from 2010-2014.

Sulfate concentrations in the Clark Fork River tributaries in 2015 ranged from 5-177 mg/L [Figure 2-28]. In the tributaries, the minimum annual sulfate concentrations were observed in Mill-Willow Creek during the Q2-Falling event and the maximum sulfate concentrations occurred in the Mill-Willow Bypass in Q4 [Figure 2-28]. Sulfate concentrations increased substantially (by approximately five times) between the Mill-Willow Creek and Mill-Willow Bypass sites [Figure 2-28]. Sulfate concentrations in the tributaries in 2015 were within the range of values observed from 2010-2014.

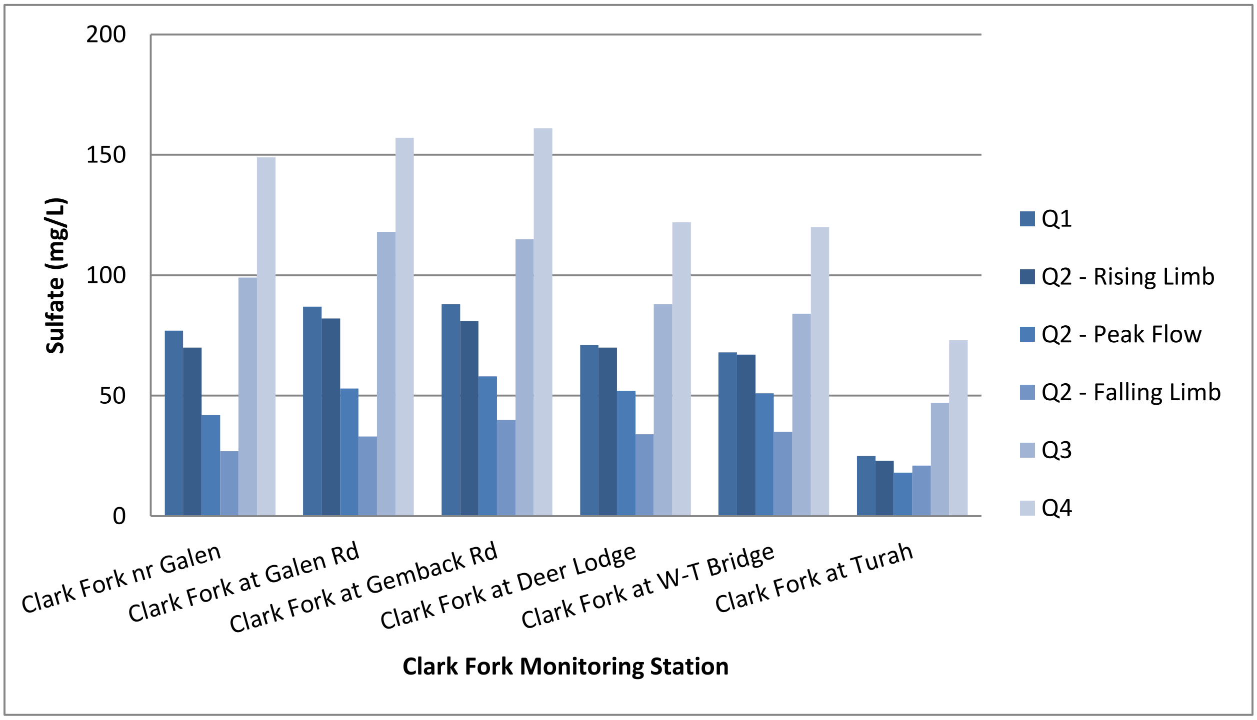

Figure 2-27. Sulfate concentrations at mainstem sampling sites in the Clark Fork River Operable Unit, 2015.

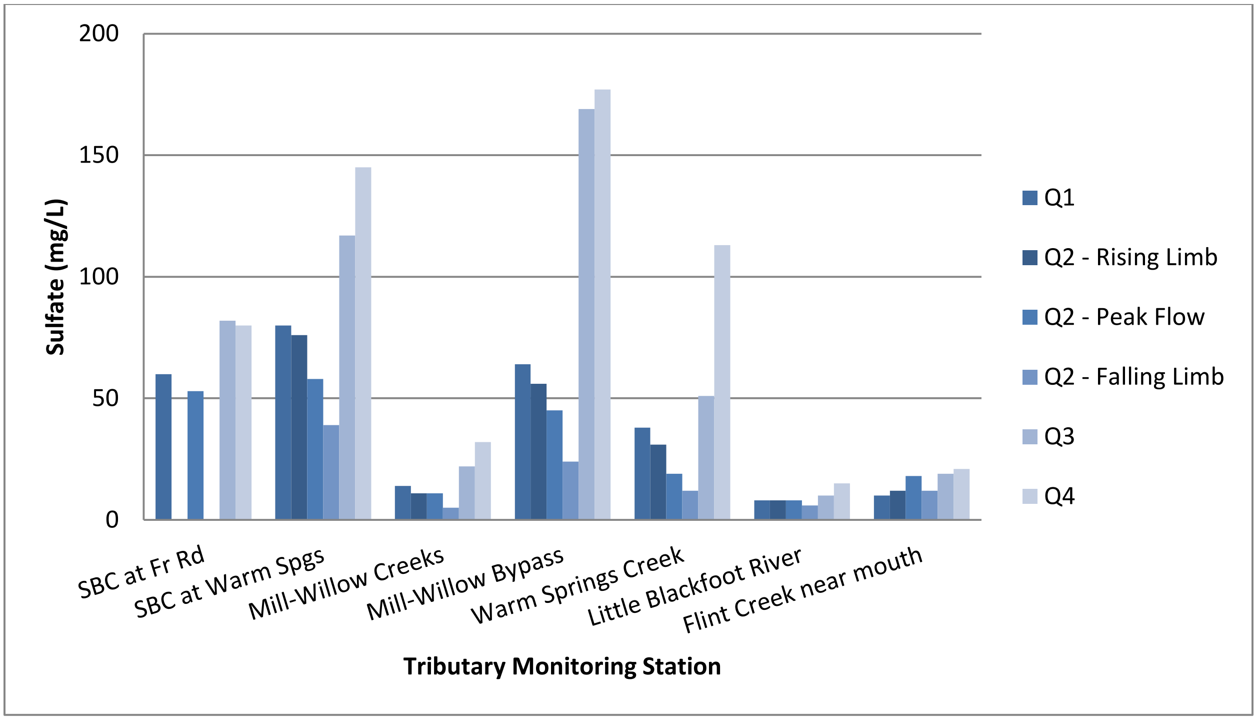

Figure 2-28. Sulfate concentrations at tributary sampling sites in the Clark Fork River Operable Unit, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "SBC at Fr Rd" site.

2.3.5 Nutrients

2.3.5.1 Total Nitrogen

Total nitrogen concentrations in the Clark Fork River mainstem in 2015 ranged from 0.12-0.75 mg/L [Table 2-5]. In the mainstem, the minimum annual total nitrogen concentration was observed at Turah during Q1 and Q3 and the maximum concentration was observed at the Williams-Tavenner Bridge in Q4 [Table 2-5]. During Q3, no mainstem samples had total nitrogen concentrations exceeding total nitrogen standards [Table 2-5]. However, the total nitrogen standards would have been exceeded at least once at all mainstem sites (except at Turah) during other quarters were those standards to apply during other sampling periods [Figure 2-29]. Mainstem total nitrogen concentrations during 2015 monitoring events were within the range of concentrations observed from 2011-2014.

Total nitrogen concentrations in the Clark Fork River tributaries in 2015 ranged from <0.05-2.96 mg/L [Table 2-5]. In the tributaries, the minimum annual total nitrogen concentration was observed in Warm Springs Creek (Q2-Rising and Q3) and the Mill-Willow Bypass (Q3) and the maximum concentration was observed in Silver Bow Creek at Frontage Road (Q4) [Table 2-5]. During Q3, both Silver Bow Creek sample sites had total nitrogen concentrations exceeding total nitrogen standards but no other tributary sites exceeded the standard [Table 2-5]. The Silver Bow Creek site at Frontage Road exceeded the standard by nearly six times in Q3 [Table 2-5]. Total nitrogen standards would have been exceeded at both Silver Bow Creek sites during most other quarters, and at Flint Creek during two other quarters, were those standards to apply during other sampling periods [Figure 2-30]. In Silver Bow Creek, total nitrogen concentrations were approximately 3-6 times lower at Warm Springs (downstream from the Warm Springs Ponds) compared to at Frontage Road (immediately upstream from the Warm Springs Ponds) [Figure 2-30]. Tributary total nitrogen concentrations during 2015 monitoring events were within the range of concentrations observed from 2011-2014.

Table 2-5. Total nitrogen concentrations (mg/L) at Clark Fork River Operable Unit monitoring stations, 2015.

Site ID	Site Location	Sample Period					
		Q1	Q2			Q3	Q4
			Rising	Peak	Falling		
Mainstem Sites							
CFR-03A	Clark Fork River near Galen	0.22	0.26	0.22	0.24	0.23	0.44
CFR-07D	Clark Fork River at Galen Road	0.28	0.26	0.29	0.27	0.17	0.53
CFR-11F	Clark Fork River at Gemback Road	0.32	0.29	0.24	0.28	0.18	0.55
CFR-27H	Clark Fork River at Deer Lodge	0.32	0.35	0.25	0.38	0.18	0.69
CFR-34	Clark Fork River at Williams-Tavenner Bridge	0.35	0.36	0.33	0.48	0.20	0.75
CFR-116A	Clark Fork River at Turah	0.12	0.17	0.14	0.20	0.12	0.19
Tributary Sites							
SS-19	Silver Bow Creek at Frontage Road	1.86	---	1.02	---	1.79	2.96
SS-25	Silver Bow Creek at Warm Springs	0.23	0.33	0.35	0.32	0.41	0.50
MCWC-MWB	Mill-Willow Creek at Frontage Road	0.11	0.10	0.27	0.27	0.10	0.27
MWB-SBC	Mill-Willow Bypass near mouth	0.13	0.11	0.28	0.23	ND	0.27
WSC-SBC	Warm Springs Creek near mouth	0.10	ND	0.10	0.11	ND	0.20
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	0.11	0.12	0.15	0.19	0.06	0.07
FC-CFR	Flint Creek near mouth	0.19	0.20	0.26	0.36	0.21	0.34

--- Not sampled.

ND Not detected at analytical reporting limit.

(shaded) Exceeds Clark Fork River total nitrogen standard (0.30 mg/L; applies June 21 to September 21; ARM 17.30.631) and Middle Rockies Ecoregion total nitrogen standard (also 0.30 mg/L; applies July 1 to September 30; MDEQ [2014]).

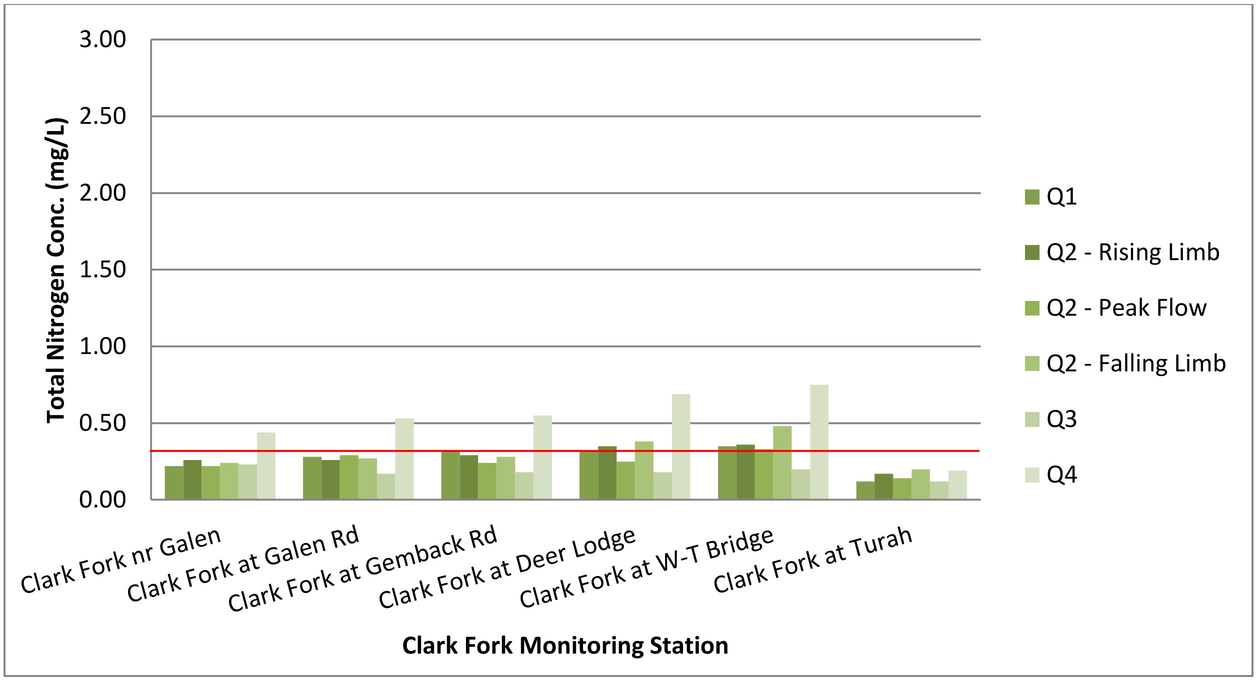

Figure 2-29. Total nitrogen concentrations (mg/L) at Clark Fork River mainstem monitoring stations, 2015. Red line represents total nitrogen standard [MDEQ, 2014].

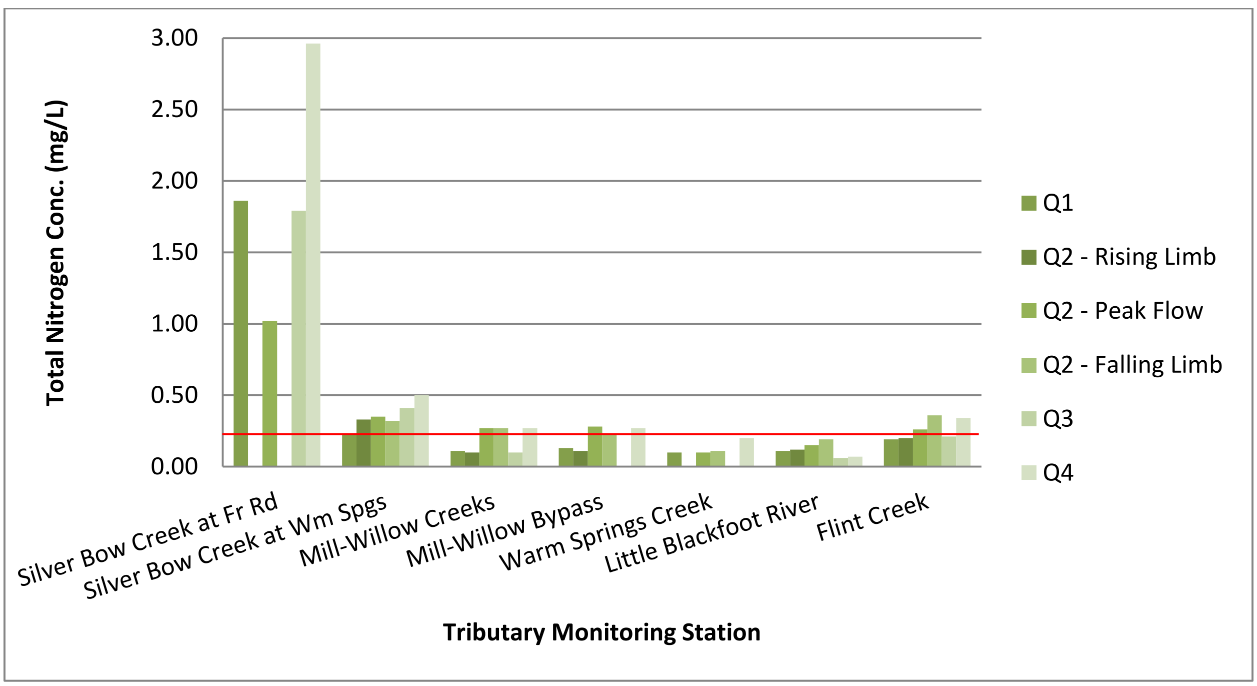

Figure 2-30. Total nitrogen concentrations (mg/L) at Clark Fork River tributary monitoring stations, 2015. Red line represents total nitrogen standard [MDEQ, 2014]. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "Silver Bow Creek at Fr Rd" site. Other sites or sample periods with no bars indicate concentrations below the analytical reporting limit.

2.3.5.2 Nitrate Plus Nitrite Nitrogen

Nitrate plus nitrite nitrogen concentrations in the Clark Fork River mainstem in 2015 ranged from <0.02-0.40 mg/L [Table 2-6]. In the mainstem, the minimum annual nitrate plus nitrite nitrogen concentrations were below detection limits and occurred at all sites in Q1 and Q3 and at specific sites during other periods and the maximum concentration was observed at Deer Lodge and the Williams-Tavenner Bridge in Q4 [Table 2-6]. At all mainstem sites, nitrate plus nitrite nitrogen concentrations were highest during Q4 [Table 2-6]. Mainstem nitrate plus nitrite nitrogen concentrations during 2015 monitoring events were within the range of concentrations observed from 2011-2014.

Nitrate plus nitrite nitrogen concentrations in the Clark Fork River tributaries in 2015 ranged from <0.02-1.78 mg/L [Table 2-6]. In the tributaries, the minimum annual nitrate plus nitrite nitrogen concentrations were below detection limits and occurred at all sites (except Silver Bow Creek at Frontage Road) in Q2-Rising, Q2-Peak, Q2-Falling, and Q3 and at some sites during other periods and the maximum concentration was observed in Silver Bow Creek at Frontage Road in Q4 [Table 2-6]. In Silver Bow Creek, nitrate plus nitrite nitrogen concentrations were approximately 15-30 times lower at Warm Springs (downstream from the Warm Springs Ponds) compared to at Frontage Road (immediately upstream from the Warm Springs Ponds) [Figure 2-32]. Tributary nitrate plus nitrite nitrogen concentrations during 2015 monitoring events were within the range of concentrations observed from 2011-2014.

Table 2-6. Nitrate plus nitrite nitrogen concentrations (mg/L) at Clark Fork River Operable Unit monitoring stations, 2015.

Site ID	Site Location	Sample Period					
		Q1	Q2			Q3	Q4
			Rising	Peak	Falling		
Mainstem Sites							
CFR-03A	Clark Fork River near Galen	ND	ND	ND	ND	ND	0.11
CFR-07D	Clark Fork River at Galen Road	ND	ND	ND	ND	ND	0.28
CFR-11F	Clark Fork River at Gemback Road	ND	0.02	0.02	ND	ND	0.28
CFR-27H	Clark Fork River at Deer Lodge	ND	0.08	0.03	ND	ND	0.40
CFR-34	Clark Fork River at Williams-Tavenner Bridge	ND	0.09	0.05	0.04	ND	0.40
CFR-116A	Clark Fork River at Turah	ND	ND	ND	ND	ND	0.09
Tributary Sites							
SS-19	Silver Bow Creek at Frontage Road	1.20	---	0.60	---	1.54	1.78
SS-25	Silver Bow Creek at Warm Springs	0.05	ND	ND	ND	ND	0.12
MCWC-MWB	Mill-Willow Creek at Frontage Road	0.05	ND	ND	ND	ND	0.12
MWB-SBC	Mill-Willow Bypass near mouth	ND	ND	ND	ND	ND	0.10
WSC-SBC	Warm Springs Creek near mouth	ND	ND	ND	ND	ND	0.14
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	ND	ND	ND	ND	ND	ND
FC-CFR	Flint Creek near mouth	0.06	ND	ND	ND	ND	0.20

--- Not sampled.

ND Not detected at analytical reporting limit.

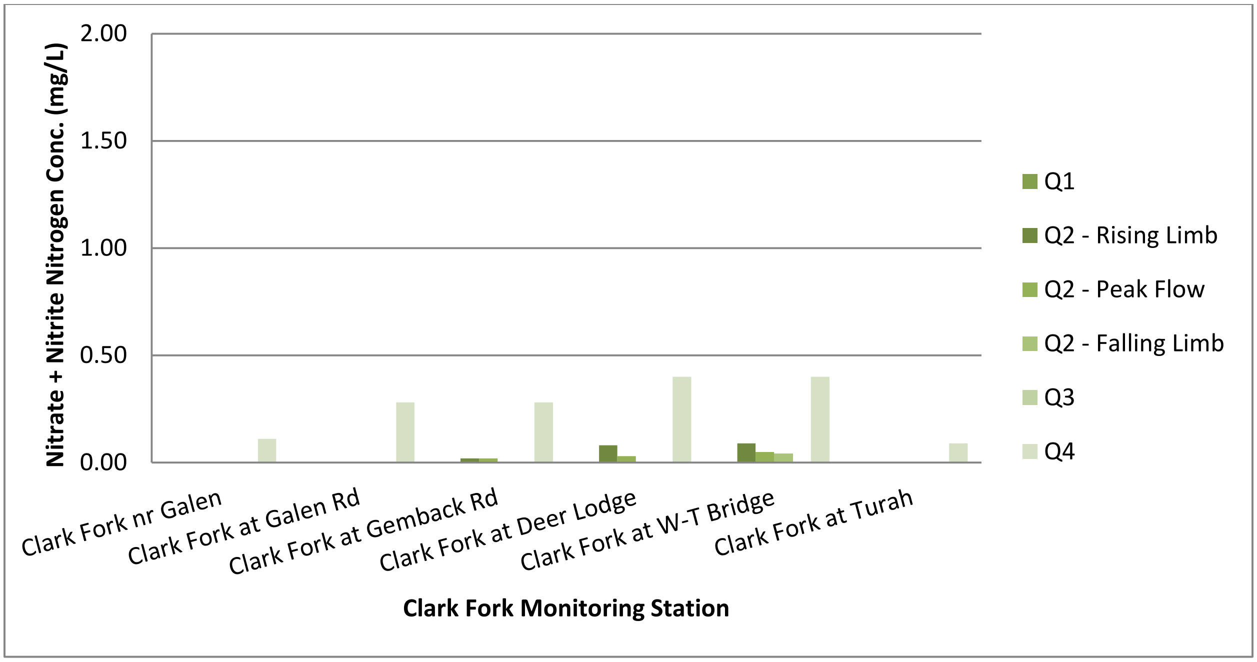

Figure 2-31. Nitrate plus nitrite nitrogen concentrations (mg/L) at Clark Fork River mainstem monitoring stations, 2015. Sites or sample periods with no bars indicate concentrations below the analytical reporting limit.

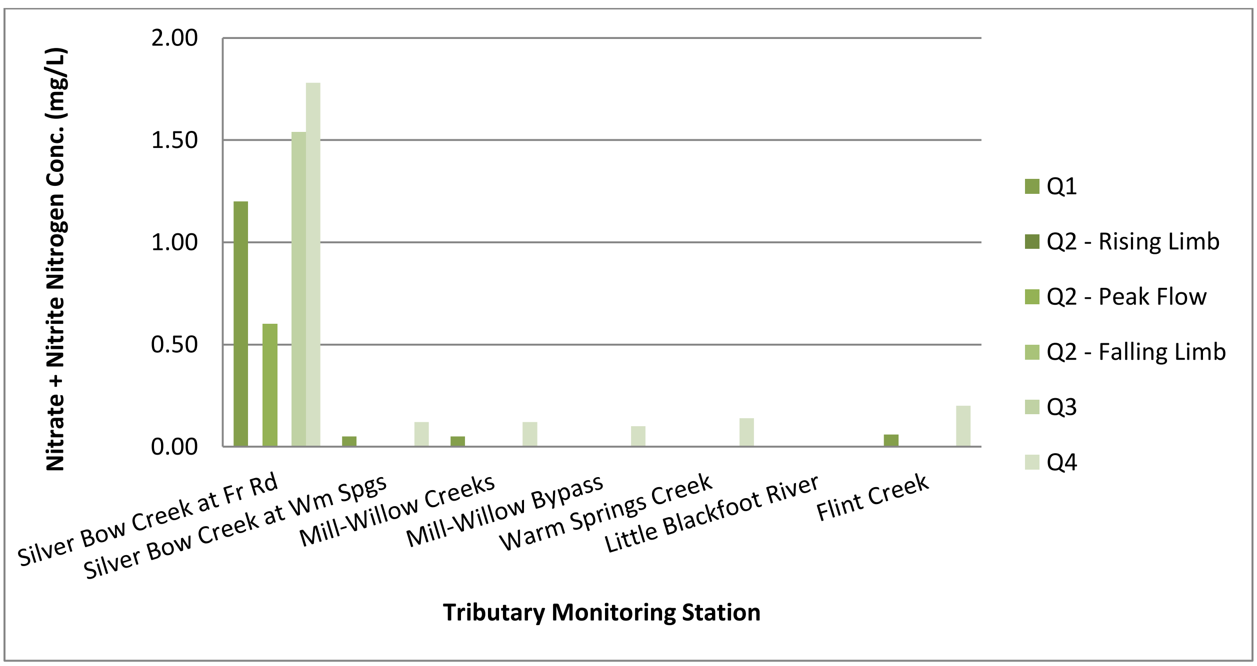

Figure 2-32. Nitrate plus nitrite nitrogen concentrations (mg/L) at Clark Fork River tributary monitoring stations, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "Silver Bow Creek at Fr Rd" site. Other sites or sample periods with no bars indicate concentrations below the analytical reporting limit.

2.3.5.3 Total Ammonia

All total ammonia concentrations in the Clark Fork River mainstem in 2015 were below the analytical reporting limit (0.05 mg/L) [Table 2-7]. All samples from the tributaries in 2015 had total ammonia concentrations below the analytical reporting limit except the Q4 sample from Silver Bow Creek at Frontage Road [Table 2-7].

Table 2-7. Total ammonia concentrations (mg/L) at Clark Fork River Operable Unit monitoring stations, 2015.

Site ID	Site Location	Sample Period					
		Q1	Q2			Q3	Q4
			Rising	Peak	Falling		
Mainstem Sites							
CFR-03A	Clark Fork River near Galen	ND	ND	ND	ND	ND	ND
CFR-07D	Clark Fork River at Galen Road	ND	ND	ND	ND	ND	ND
CFR-11F	Clark Fork River at Gemback Road	ND	ND	ND	ND	ND	ND
CFR-27H	Clark Fork River at Deer Lodge	ND	ND	ND	ND	ND	ND
CFR-34	Clark Fork River at Williams-Tavenner Bridge	ND	ND	ND	ND	ND	ND
CFR-116A	Clark Fork River at Turah	ND	ND	ND	ND	ND	ND
Tributary Sites							
SS-19	Silver Bow Creek at Frontage Road	ND	---	ND	---	ND	0.88
SS-25	Silver Bow Creek at Warm Springs	ND	ND	ND	ND	ND	ND
MCWC-MWB	Mill-Willow Creek at Frontage Road	ND	ND	ND	ND	ND	ND
MWB-SBC	Mill-Willow Bypass near mouth	ND	ND	ND	ND	ND	ND
WSC-SBC	Warm Springs Creek near mouth	ND	ND	ND	ND	ND	ND
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	ND	ND	ND	ND	ND	ND
FC-CFR	Flint Creek near mouth	ND	ND	ND	ND	ND	ND

--- Not sampled.

ND Not detected at analytical reporting limit.

2.3.5.4 Total Phosphorus

Total phosphorus concentrations in the Clark Fork River mainstem in 2015 ranged from 0.009-0.063 mg/L [Table 2-8]. In the mainstem, the minimum annual total phosphorus concentration was observed at Gemback Road and at Deer Lodge in Q3 and the maximum concentration was observed at the Williams-Tavenner Bridge during the Q3-Falling monitoring event [Table 2-8]. During Q3, three of six mainstem sites (near Galen, at Galen Road, and at Williams-Tavenner Bridge) had total phosphorus concentrations exceeding the Clark Fork River mainstem-specific total phosphorus standard [Table 2-8]. In addition, one mainstem site (near

Galen) also exceeded the Middle Rockies Ecoregion-specific total phosphorus standard [Table 2-8]. However, the Clark Fork River mainstem-specific total phosphorus standard would have been exceeded at least once at all mainstem sites during other quarters were those standards to apply during other sampling periods [Figure 2-33]. Mainstem total phosphorus concentrations during 2015 monitoring events were within the range of concentrations observed from 2011-2014.

Total phosphorus concentrations in the Clark Fork River tributaries in 2015 ranged from 0.005-0.210 mg/L [Table 2-8]. In the tributaries, the minimum annual total phosphorus concentration was observed in Warm Springs Creek (Q3) and the maximum concentration was observed in Silver Bow Creek at Frontage Road (Q3) [Table 2-8]. During Q3, both Silver Bow Creek sample sites and the Flint Creek site had total phosphorus concentrations exceeding the Middle Rockies Ecoregion-specific total phosphorus standard but no other tributary sites exceeded the standard [Table 2-8]. The Silver Bow Creek site at Frontage Road exceeded the standard by more than ten times in Q3 [Table 2-8]. Total phosphorus standards would have been exceeded at both Silver Bow Creek sites during all other quarters (except Q4 at Warm Springs) and at all other sites (except Warm Springs Creek) during most sample periods were those standards to apply during other sampling periods [Figure 2-34]. In Silver Bow Creek, total phosphorus concentrations were approximately 3-4 times lower at Warm Springs (downstream from the Warm Springs Ponds) compared to at Frontage Road (immediately upstream from the Warm Springs Ponds) [Figure 2-34]. Tributary total phosphorus concentrations during 2015 monitoring events were within the range of concentrations observed from 2011-2014.

Table 2-8. Total phosphorus concentrations (mg/L) at Clark Fork River Operable Unit monitoring stations, 2015.

Site ID	Site Location	Sample Period					
		Q1	Q2			Q3	Q4
			Rising	Peak	Falling		
Mainstem Sites							
CFR-03A	Clark Fork River near Galen	0.033	0.026	0.030	0.040	0.041	0.025
CFR-07D	Clark Fork River at Galen Road	0.031	0.029	0.031	0.037	0.022	0.021
CFR-11F	Clark Fork River at Gemback Road	0.034	0.030	0.030	0.040	0.009	0.023
CFR-27H	Clark Fork River at Deer Lodge	0.037	0.037	0.025	0.051	0.009	0.034
CFR-34	Clark Fork River at Williams-Tavenner Bridge	0.047	0.044	0.034	0.063	0.029	0.044
CFR-116A	Clark Fork River at Turah	0.035	0.028	0.020	0.051	0.020	0.018
Tributary Sites							
SS-19	Silver Bow Creek at Frontage Road	0.194	---	0.130	---	0.210	0.160
SS-25	Silver Bow Creek at Warm Springs	0.041	0.032	0.042	0.052	0.072	0.030
MCWC-MWB	Mill-Willow Creek at Frontage Road	0.039	0.042	0.046	0.049	0.024	0.027
MWB-SBC	Mill-Willow Bypass near mouth	0.034	0.039	0.039	0.042	0.010	0.018
WSC-SBC	Warm Springs Creek near mouth	0.013	0.013	0.018	0.018	0.005	0.013
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	0.035	0.033	0.025	0.036	0.021	0.026
FC-CFR	Flint Creek near mouth	0.043	0.058	0.047	0.068	0.053	0.037

--- Not sampled.

ND Not detected at analytical reporting limit.

(green) Exceeds the Middle Rockies Ecoregion total phosphorus standard (0.030 mg/L; applies July 1 to September 30; MDEQ [2014]).

(peach) Exceeds Clark Fork River total phosphorus standard (0.020 mg/L; applies to mainstem sites from June 21 to September 21; ARM 17.30.631).

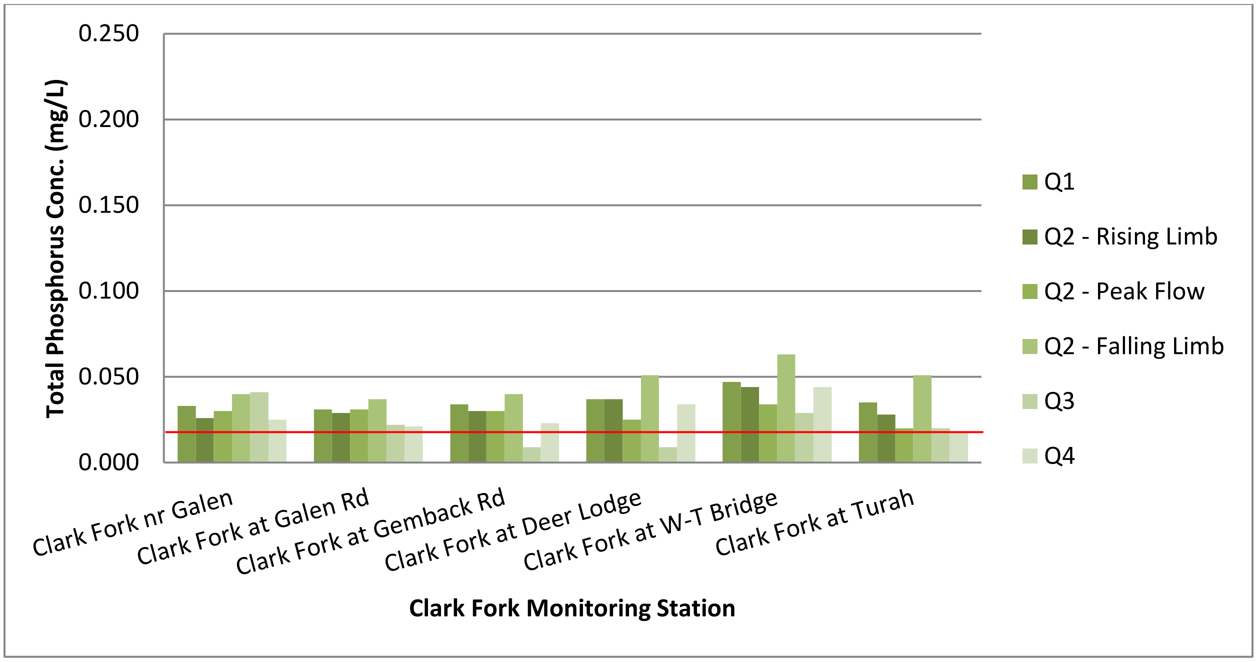

Figure 2-33. Total phosphorus concentrations (mg/L) at Clark Fork River mainstem monitoring stations, 2015. Red line represents total phosphorus standard [ARM 17.30.631].

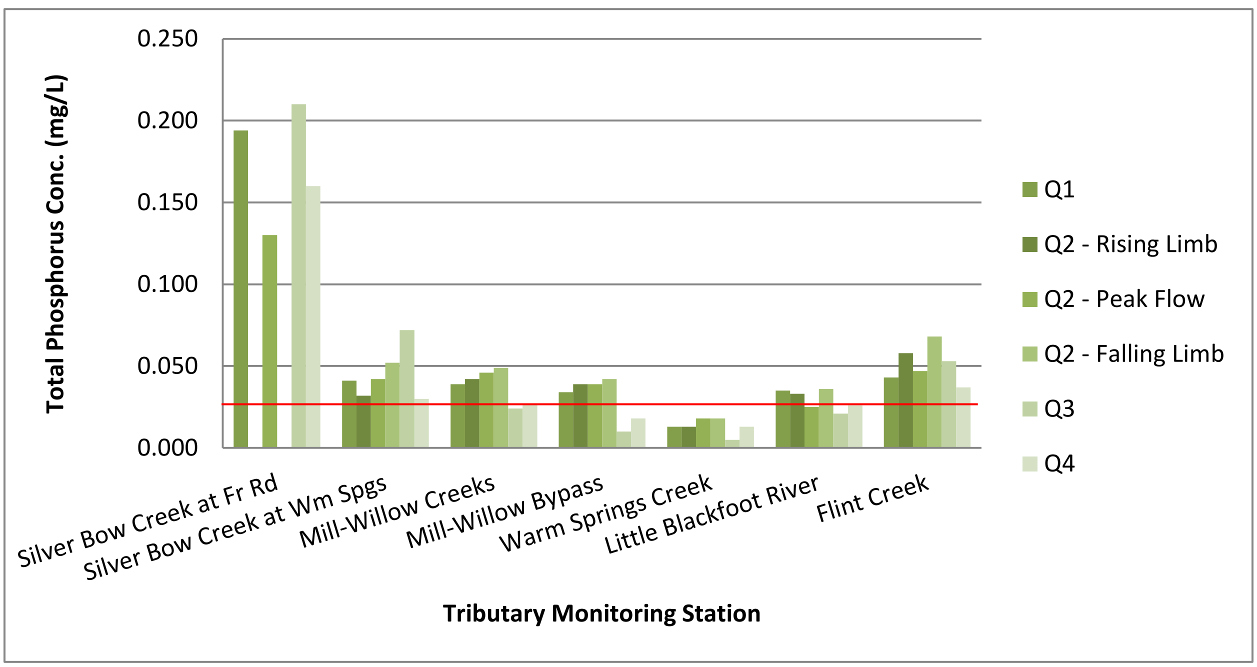

Figure 2-34. Total phosphorus concentrations (mg/L) at Clark Fork River tributary monitoring stations, 2015. Red line represents total phosphorus standard [MDEQ, 2014]. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "Silver Bow Creek at Fr Rd" site.

2.3.6 Contaminants of Concern

2.3.6.1 Arsenic

Dissolved arsenic concentrations in the Clark Fork River mainstem in 2015 ranged from 0.004-0.025 mg/L [Table 2-9] and total recoverable concentrations ranged from 0.004-0.026 mg/L [Table 2-10]. Arsenic concentrations in mainstem monitoring sites during 2015 were consistently lowest at Turah and were generally three times higher at the mainstem sites in Reach A, from the near Galen to the Williams-Tavenner Bridge sites [Figure 2-35]. Arsenic concentrations among the Reach A sites were similar during each sample period [Figure 2-35].

All mainstem sites had the highest arsenic concentrations during the Q2-Falling monitoring event [Figure 2-35]. The lowest concentrations at all stations were observed in Q1 or Q4, when streamflows were relatively low [Figure 2-35]. Most of the arsenic measured in the mainstem monitoring stations during 2015 was present in the dissolved form rather than as a sediment-associated form [Figure 2-35].

In the mainstem, exceedances of the most restrictive performance goal from the CFROU ROD [Table 2-1] for dissolved arsenic (0.010 mg/L) occurred during at least five of the six sample periods at all mainstem sites in Reach A in 2015 [Table 2-9]. Exceedances of the most restrictive performance goal from the CFROU ROD [Table 2-1] for total recoverable arsenic (0.018 mg/L) occurred during the Q2-Falling monitoring event at all mainstem sites in Reach A in 2015 and also occurred at near Galen in Q3 and at Galen Road in Q3 and Q4 [Table 2-10].

There does not appear to be an increasing or decreasing compliance ratio trend in the mainstem at near Galen [Figure 2-36], at Deer Lodge [Figure 2-37], or at Turah [Figure 2-38] from 2010-2015. All mainstem sites appeared to demonstrate a moderately pronounced seasonal trend with the highest arsenic compliance ratios occurring during the runoff period (Q2); however, this seasonal trend was less pronounced at Turah [Figure 2-36; Figure 2-37; Figure 2-38]. At all of these three sites, the compliance ratio for dissolved arsenic was generally higher (typically approximately double) compared to the compliance ratio for total recoverable arsenic [Figure 2-36; Figure 2-37; Figure 2-38]. In 2015, dissolved arsenic compliance ratios in the mainstem were generally consistent among Reach A sites and reached a maximum of 2.5 [Figure 2-39]. The 2015 mainstem compliance ratios for total recoverable arsenic were generally consistent among Reach A sites and reached a maximum of 1.44 [Figure 2-40].

Dissolved arsenic concentrations in the Clark Fork River tributaries in 2015 ranged from 0.004-0.037 mg/L [Table 2-9] and total recoverable concentrations ranged from 0.004-0.040 mg/L [Table 2-10]. Arsenic concentrations in tributary monitoring sites during 2015 were consistently lowest in Silver Bow Creek at Frontage Road, Warm Springs Creek, and the Little Blackfoot River and were highest (typically three to four times higher) in Silver Bow Creek at Warm Springs, in Mill-Willow Creeks, and in the Mill-Willow Bypass [Figure 2-41]. Between Silver Bow Creek sites above (at Frontage Road) and below (at Warm Springs) the Warm Springs Ponds arsenic concentrations increased substantially during all paired sample periods [Figure 2-41]. Between Mill-Willow Creek sites above (at Frontage Road) and below (at Silver Bow Creek) the Mill-Willow Bypass arsenic concentrations were similar during all paired sample periods [Figure 2-41].

Tributary sites generally had the highest arsenic concentrations during the Q2-Falling or Q3 monitoring event [Figure 2-41]. The lowest concentrations at all tributary stations were observed in Q1 or Q4, when streamflows were relatively low [Figure 2-41]. Most of the arsenic measured in the tributary monitoring stations during 2015 was present in the dissolved form rather than as a sediment-associated form [Figure 2-41].

In the tributaries, exceedances of the most restrictive performance goal from the CFROU ROD [Table 2-1] for dissolved arsenic (0.010 mg/L) occurred during at least four of the six sample periods in Silver Bow Creek at Warm Springs, and at both Mill-Willow Creek sites in 2015 [Table 2-9]. Additionally, the most restrictive performance goal from the CFROU ROD for dissolved arsenic concentration was exceeded once in 2015 in Warm Springs Creek (Q1) and Flint Creek (Q2-Falling) [Table 2-9]. Exceedances of the most restrictive performance goal from the CFROU ROD [Table 2-1] for total recoverable arsenic (0.018 mg/L) occurred during at least three of six sample periods in Silver Bow Creek at Warm Springs, and at both Mill-Willow Creek sites in 2015 [Table 2-10]. No other tributary sites exceeded the most restrictive performance goal from the CFROU ROD for total recoverable arsenic in 2015 [Table 2-10].

There does not appear to be an increasing or decreasing compliance ratio trend in Silver Bow Creek at Warm Springs from 2011-2015 [Figure 2-42]. As with the mainstem sites, Silver Bow Creek at Warm Springs appeared to demonstrate a pronounced seasonal trend with the highest arsenic compliance ratios occurring during the runoff period (Q2) [Figure 2-42]. In 2015, dissolved arsenic compliance ratios in the Silver Bow Creek and Mill-Willow Creek sites regularly exceeded one and reached a maximum of 3.7 in Mill-Willow Creeks and the Mill-Willow Bypass during the Q2-Falling sample period [Figure 2-43]. The 2015 tributary compliance ratios for total recoverable arsenic also commonly exceeded one in Silver Bow Creek at Warm Springs and the Mill-Willow Creek sites, but these total recoverable compliance ratios were lower than the dissolved compliance ratios [Figure 2-44].

Table 2-9. Dissolved arsenic concentrations (mg/L) at Clark Fork River Operable Unit monitoring stations, 2015.

Site ID	Site Location	Sample Period					
		Q1	Q2			Q3	Q4
			Rising	Peak	Falling		
Mainstem Sites							
CFR-03A	Clark Fork River near Galen	0.011	0.013	0.014	0.019	0.025	0.008
CFR-07D	Clark Fork River at Galen Road	0.010	0.013	0.013	0.021	0.020	0.018
CFR-11F	Clark Fork River at Gemback Road	0.011	0.013	0.013	0.021	0.018	0.017
CFR-27H	Clark Fork River at Deer Lodge	0.010	0.012	0.013	0.020	0.016	0.012
CFR-34	Clark Fork River at Williams-Tavenner Bridge	0.011	0.013	0.013	0.020	0.018	0.012
CFR-116A	Clark Fork River at Turah	0.004	0.004	0.004	0.008	0.007	0.006
Tributary Sites							
SS-19	Silver Bow Creek at Frontage Road	0.005	---	0.006	---	0.007	0.006
SS-25	Silver Bow Creek at Warm Springs	0.005	0.015	0.022	0.030	0.033	0.007
MCWC-MWB	Mill-Willow Creek at Frontage Road	0.018	0.023	0.029	0.037	0.017	0.009
MWB-SBC	Mill-Willow Bypass near mouth	0.017	0.022	0.027	0.037	0.022	0.012
WSC-SBC	Warm Springs Creek near mouth	0.012	0.006	0.005	0.005	0.007	0.005
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	0.004	0.004	0.004	0.006	0.005	0.004
FC-CFR	Flint Creek near mouth	0.006	0.007	0.009	0.013	0.010	0.009

---	Not sampled.
(shaded)	Exceeds specified arsenic surface water performance goal for dissolved concentration (0.010 mg/L) [USEPA, 2004].

Table 2-10. Total recoverable arsenic concentrations (mg/L) at Clark Fork River Operable Unit monitoring stations, 2015.

Site ID	Site Location	Sample Period					
		Q1	Q2			Q3	Q4
			Rising	Peak	Falling		
Mainstem Sites							
CFR-03A	Clark Fork River near Galen	0.014	0.014	0.016	0.021	0.024	0.010
CFR-07D	Clark Fork River at Galen Road	0.013	0.015	0.016	0.023	0.020	0.019
CFR-11F	Clark Fork River at Gemback Road	0.015	0.016	0.016	0.023	0.017	0.018
CFR-27H	Clark Fork River at Deer Lodge	0.015	0.016	0.015	0.025	0.017	0.014
CFR-34	Clark Fork River at Williams-Tavenner Bridge	0.016	0.016	0.016	0.026	0.018	0.016
CFR-116A	Clark Fork River at Turah	0.006	0.005	0.004	0.011	0.007	0.006
Tributary Sites							
SS-19	Silver Bow Creek at Frontage Road	0.006	---	0.007	---	0.007	0.006
SS-25	Silver Bow Creek at Warm Springs	0.015	0.016	0.024	0.031	0.032	0.010
MCWC-MWB	Mill-Willow Creek at Frontage Road	0.021	0.025	0.032	0.040	0.018	0.011
MWB-SBC	Mill-Willow Bypass near mouth	0.020	0.024	0.031	0.037	0.021	0.013
WSC-SBC	Warm Springs Creek near mouth	0.005	0.006	0.006	0.007	0.008	0.006
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	0.005	0.005	0.005	0.006	0.005	0.004
FC-CFR	Flint Creek near mouth	0.009	0.009	0.009	0.013	0.010	0.009

--- Not sampled.

Exceeds specified arsenic surface water performance goal for total recoverable concentration (0.018 mg/L) [USEPA, 2004].

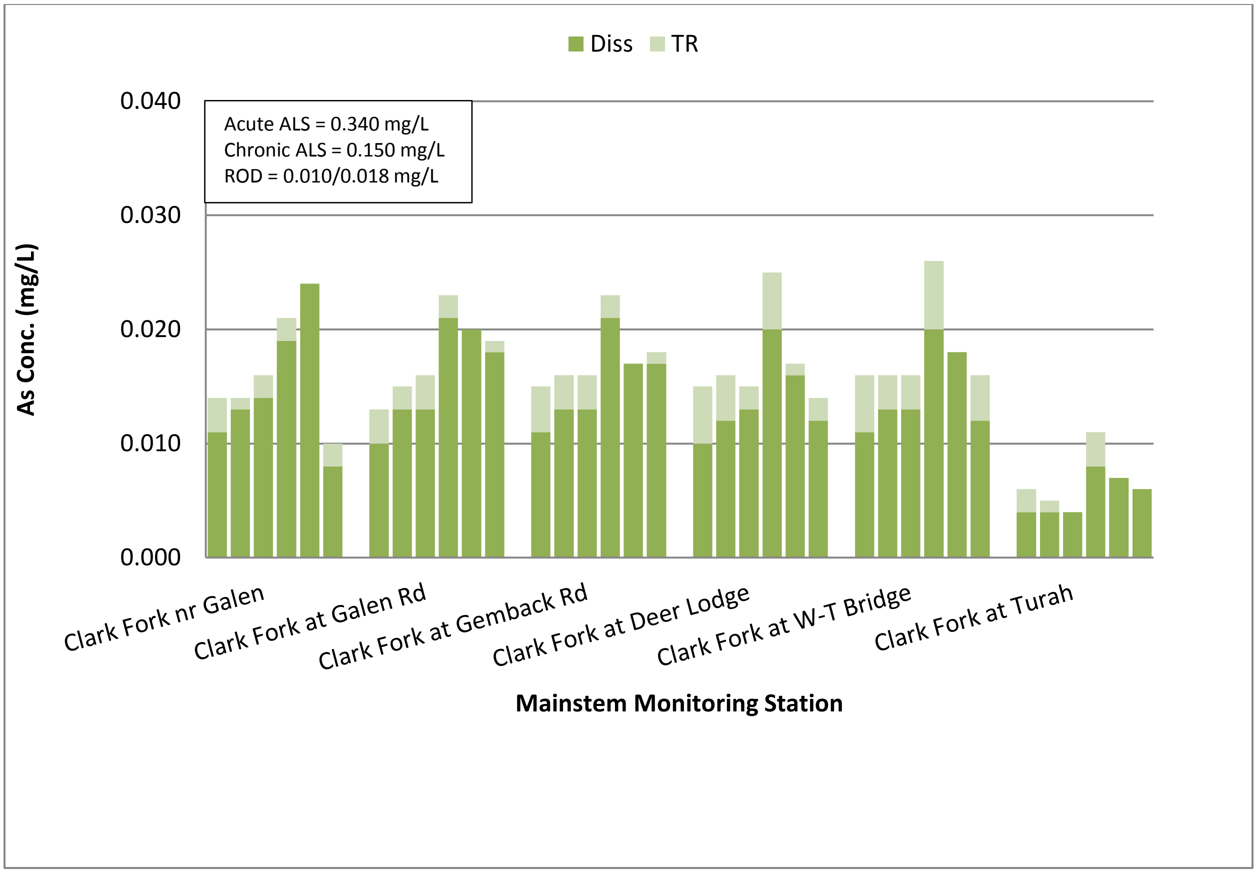

Figure 2-35. Total recoverable (TR) and dissolved (Diss) arsenic (As) concentrations at mainstem sampling sites in the Clark Fork River Operable Unit (CFROU), 2015. Applicable water quality standards are the acute and chronic aquatic life standards (ALS) [MDEQ, 2012b] and the arsenic performance goals from the CFROU Record of Decision (ROD) [USEPA, 2004]. The ROD performance goals are 0.010 mg/L for dissolved and 0.018 mg/L for total recoverable arsenic [USEPA, 2004].

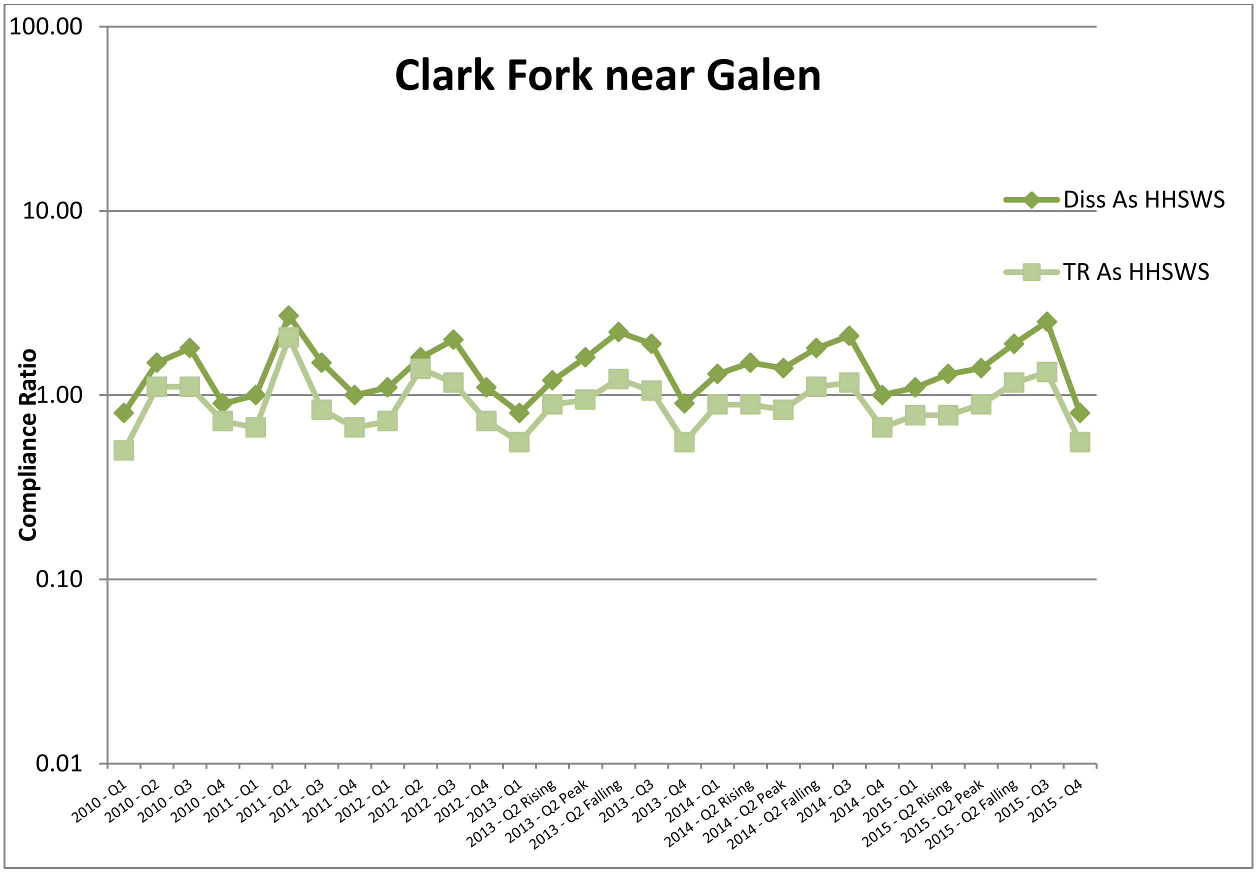

Figure 2-36. Total recoverable (TR) and dissolved (Diss) arsenic (As) compliance ratios for the Clark Fork River near Galen site, 2010-2015. Compliance ratios are based on the Clark Fork River Operable Unit Record of Decision performance goals for dissolved (Diss As HHSWS) and total recoverable (TR As HHSWS) arsenic concentrations [USEPA, 2004].

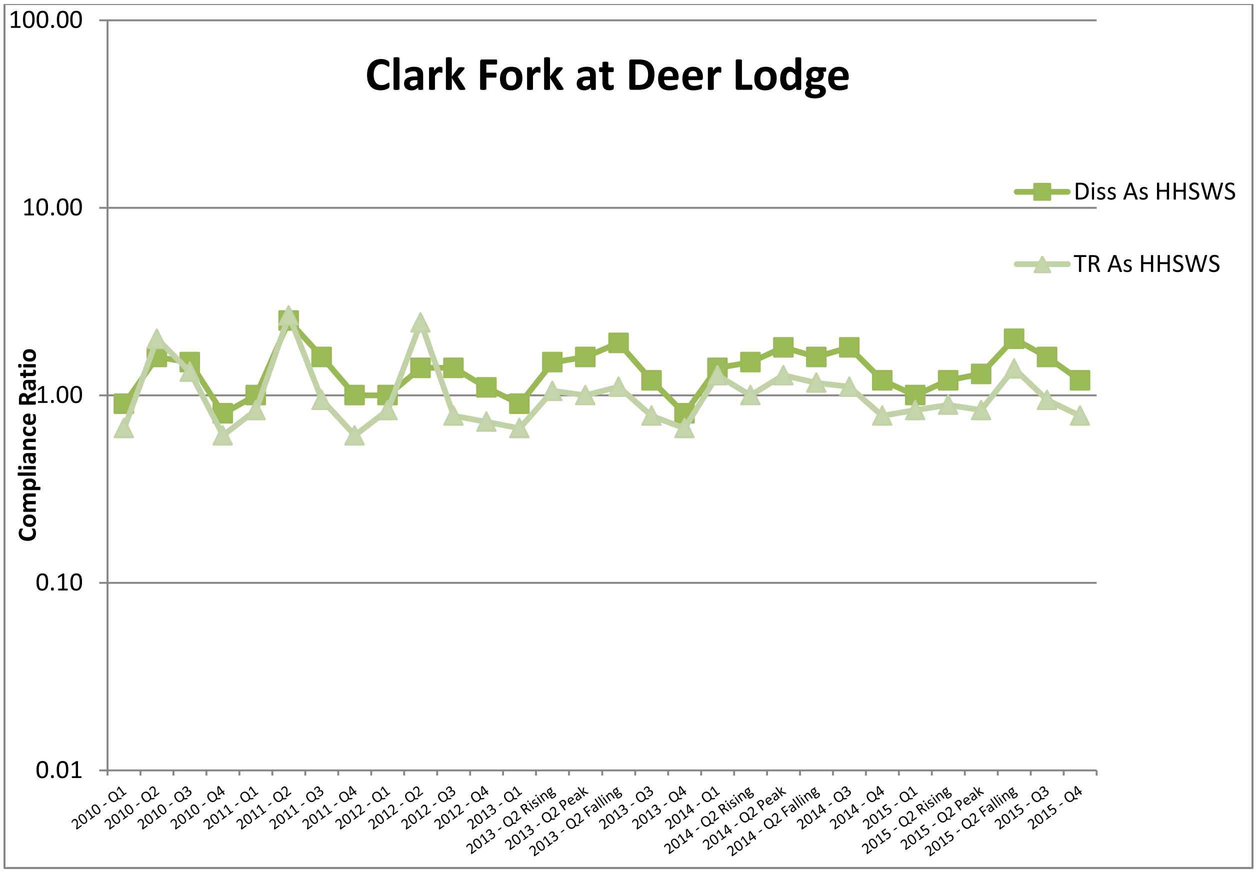

Figure 2-37. Total recoverable (TR) and dissolved (Diss) arsenic (As) compliance ratios for the Clark Fork River at Deer Lodge site, 2010-2015. Compliance ratios are based on the Clark Fork River Operable Unit Record of Decision performance goals for dissolved (Diss As HHSWS) and total recoverable (TR As HHSWS) arsenic concentrations [USEPA, 2004].

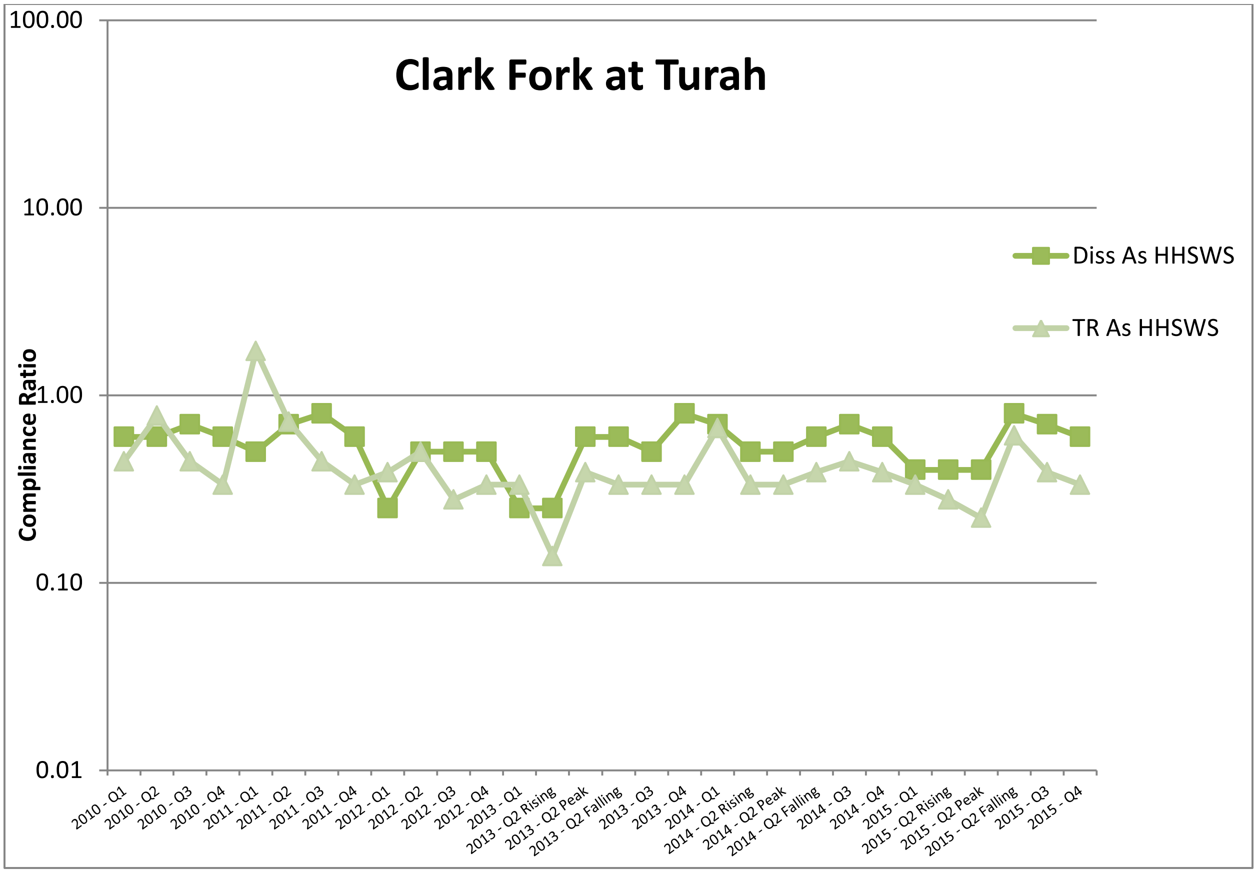

Figure 2-38. Total recoverable (TR) and dissolved (Diss) arsenic (As) compliance ratios for the Clark Fork River at Turah site, 2010-2015. Compliance ratios are based on the Clark Fork River Operable Unit Record of Decision performance goals for dissolved (Diss As HHSWS) and total recoverable (TR As HHSWS) arsenic concentrations [USEPA, 2004].

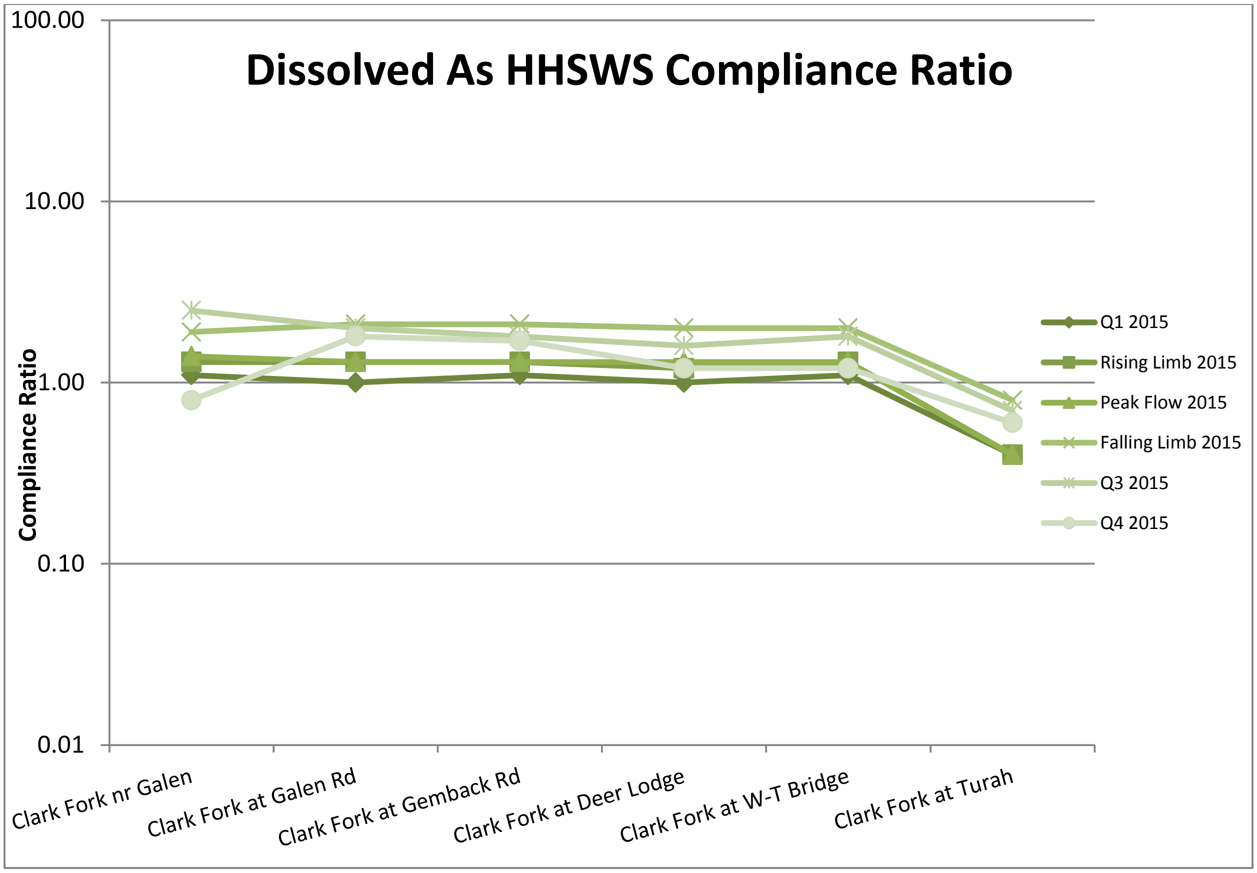

Figure 2-39. Dissolved arsenic (Diss As) compliance ratios for the Clark Fork River mainstem sites, 2015. Compliance ratio is based on Clark Fork River Operable Unit Record of Decision performance goal for dissolved arsenic (Dissolved As HHSWS) concentration [USEPA, 2004].

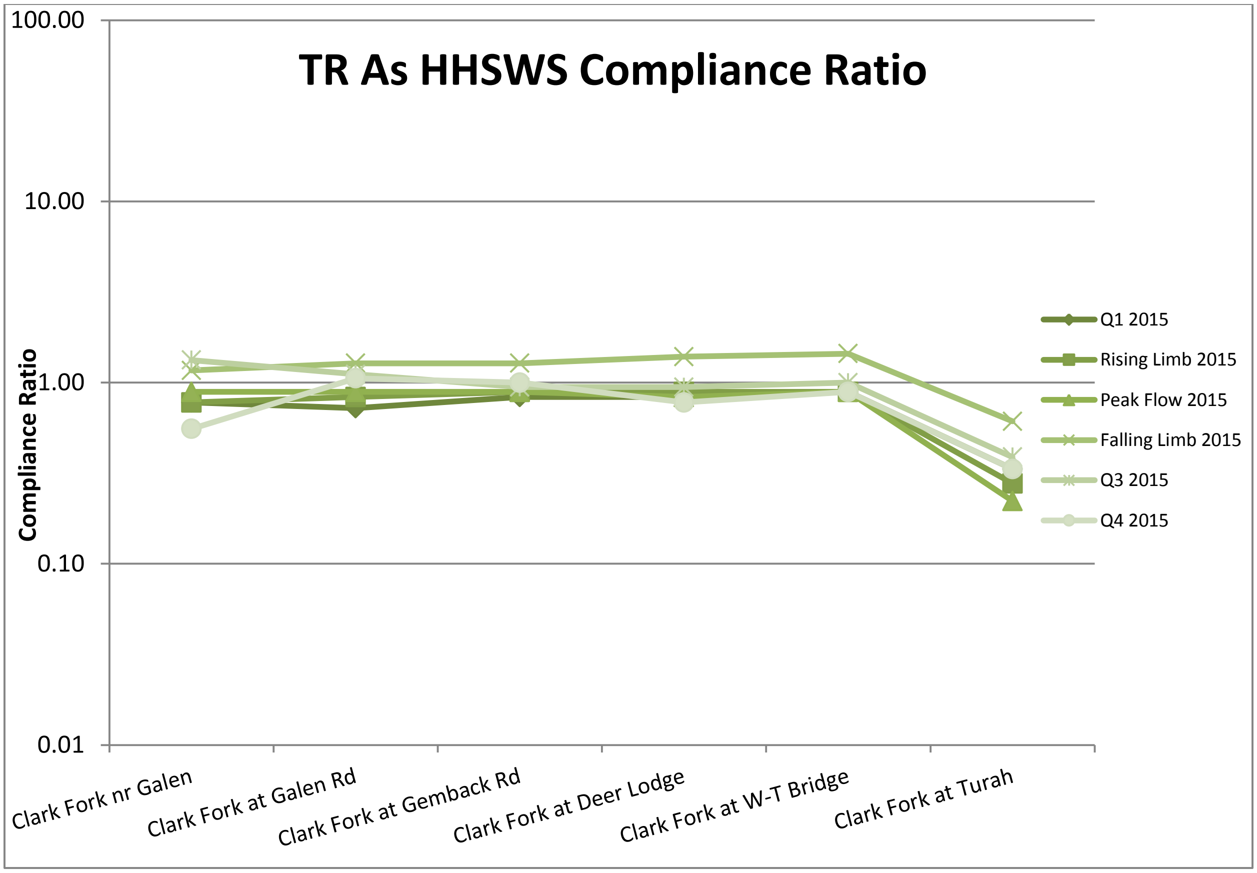

Figure 2-40. Total recoverable arsenic (TR As) compliance ratios for the Clark Fork River mainstem sites, 2015. Compliance ratio is based on Clark Fork River Operable Unit Record of Decision performance goal for total recoverable arsenic (TR As HHSWS) concentration [USEPA, 2004].

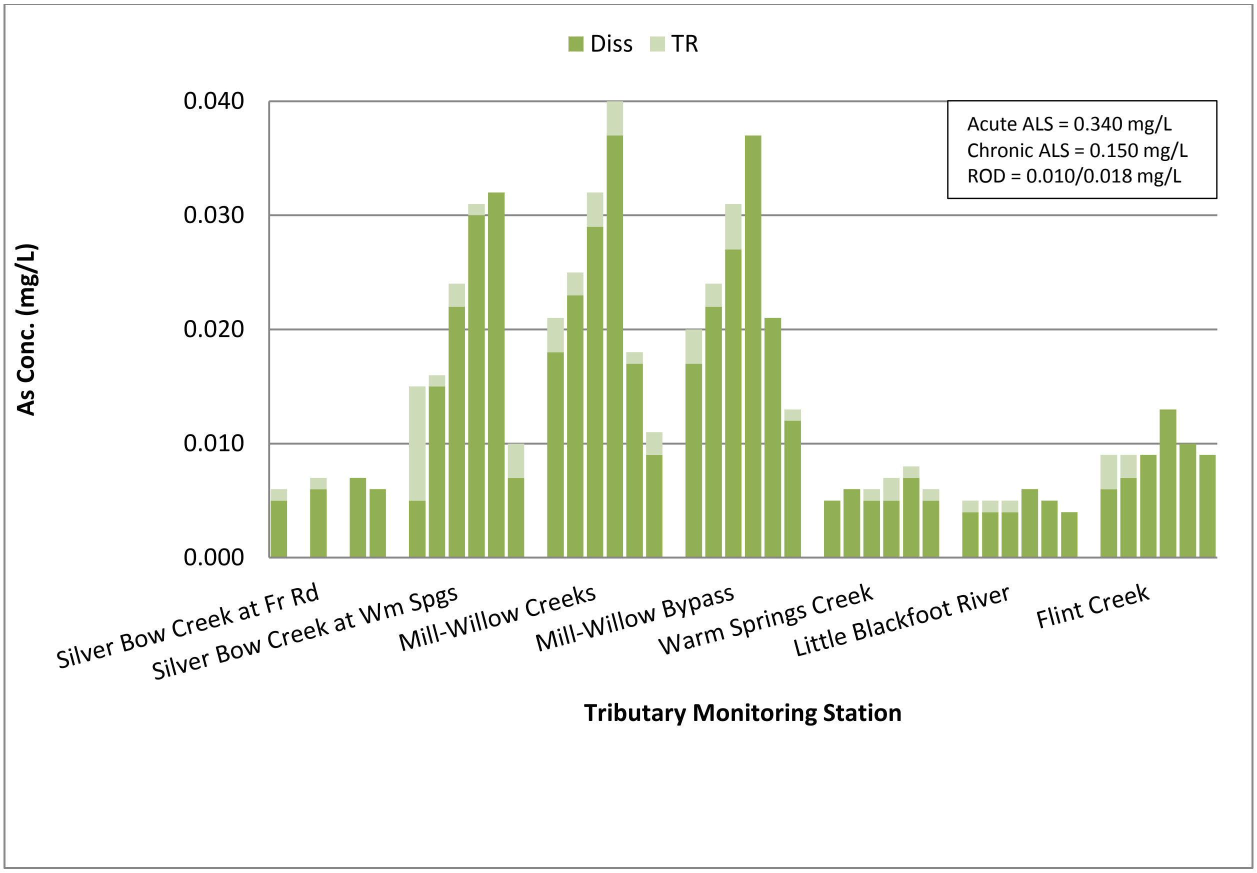

Figure 2-41. Total recoverable (TR) and dissolved (Diss) arsenic (As) concentrations at Clark Fork River tributary sites, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "Silver Bow Creek at Fr Rd" site. Applicable water quality standards are the acute and chronic aquatic life standards (ALS) [MDEQ, 2012b] and the arsenic performance goals from the CFROU Record of Decision (ROD) [USEPA, 2004]. The ROD performance goals are 0.010 mg/L for dissolved and 0.018 mg/L for total recoverable arsenic [USEPA, 2004].

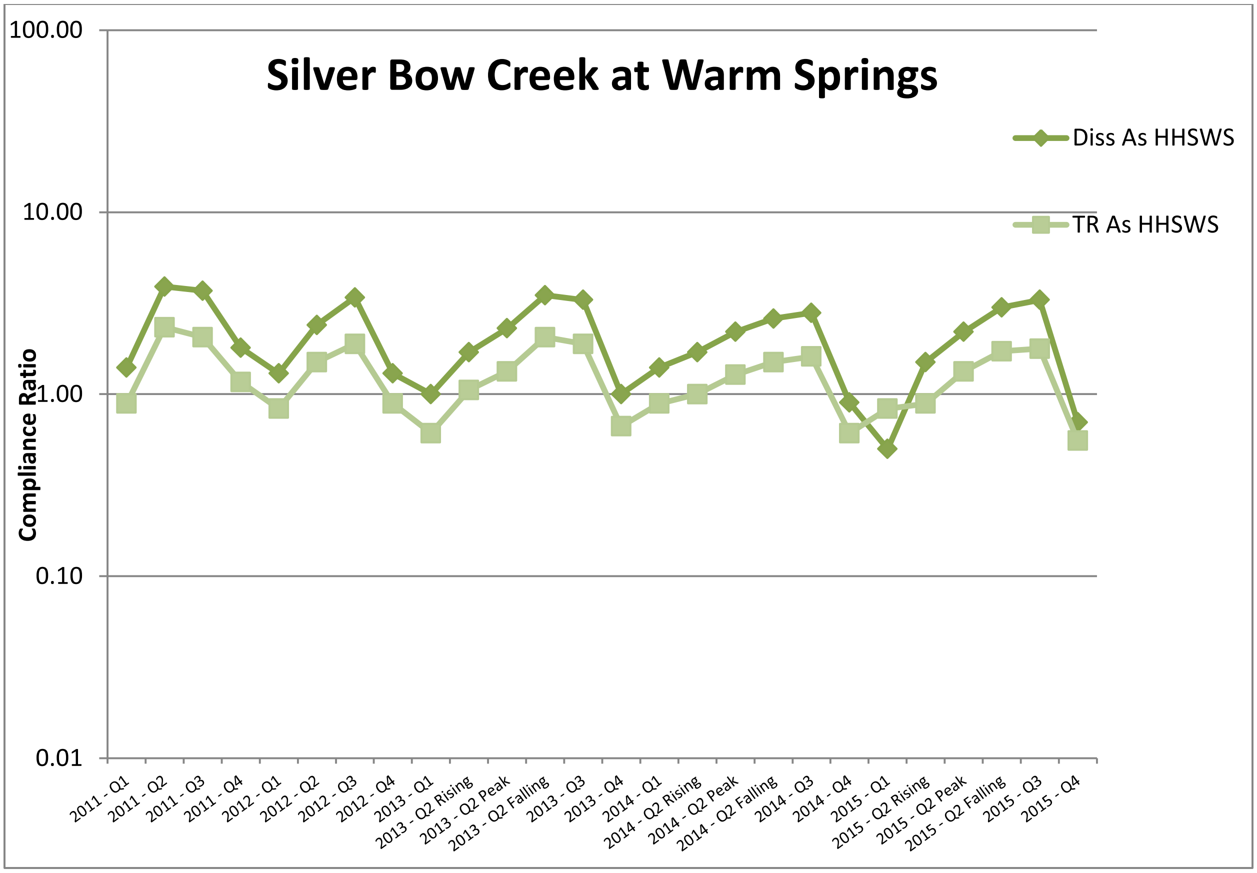

Figure 2-42. Total recoverable (TR) and dissolved (Diss) arsenic (As) compliance ratios for the Silver Bow Creek at Warm Springs site, 2011-2015. Compliance ratios are based on the Clark Fork River Operable Unit Record of Decision performance goals for dissolved (Diss As HHSWS) and total recoverable (TR As HHSWS) arsenic concentrations [USEPA, 2004].

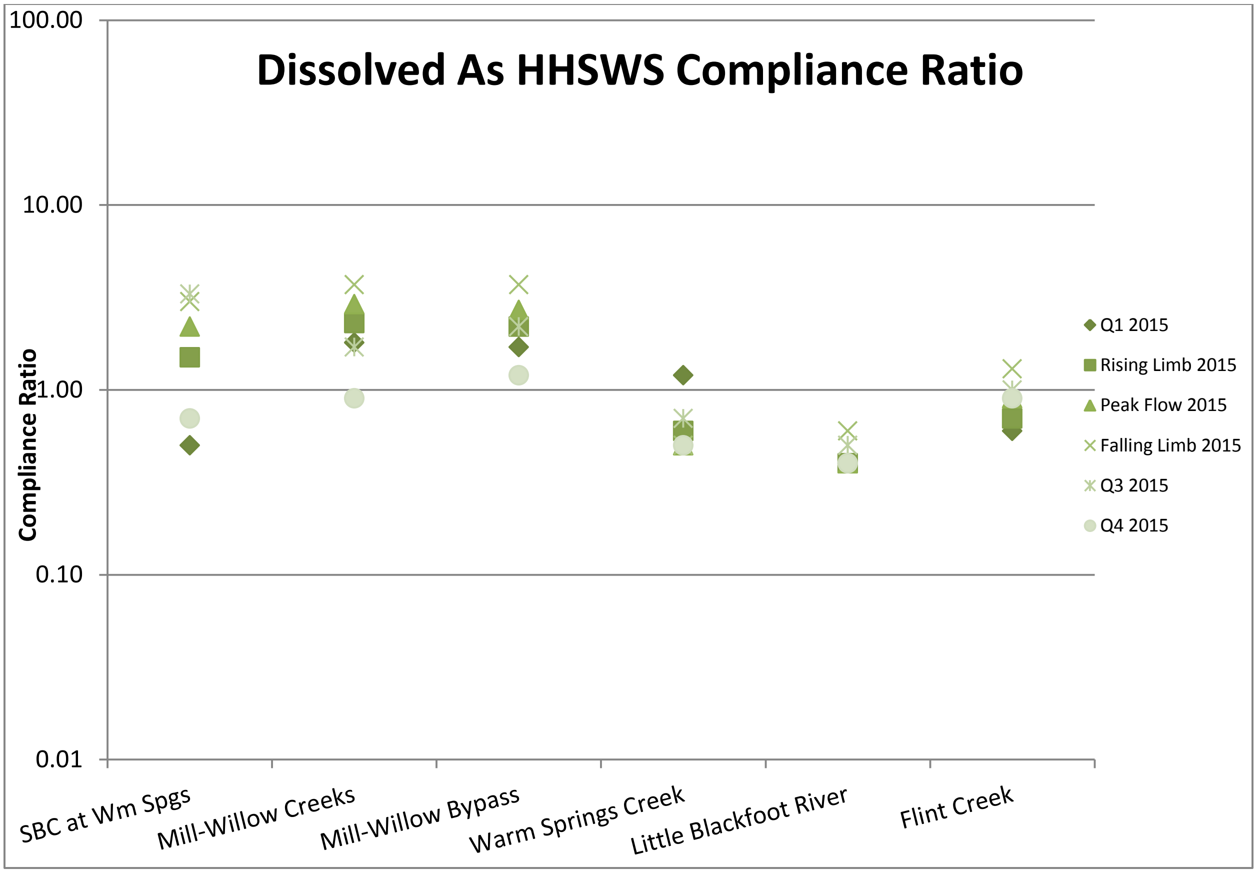

Figure 2-43. Dissolved arsenic (As) compliance ratios for the Clark Fork River tributary sites, 2015. Compliance ratio is based on Clark Fork River Operable Unit Record of Decision performance goal for dissolved arsenic (Dissolved As HHSWS) concentration [USEPA, 2004].

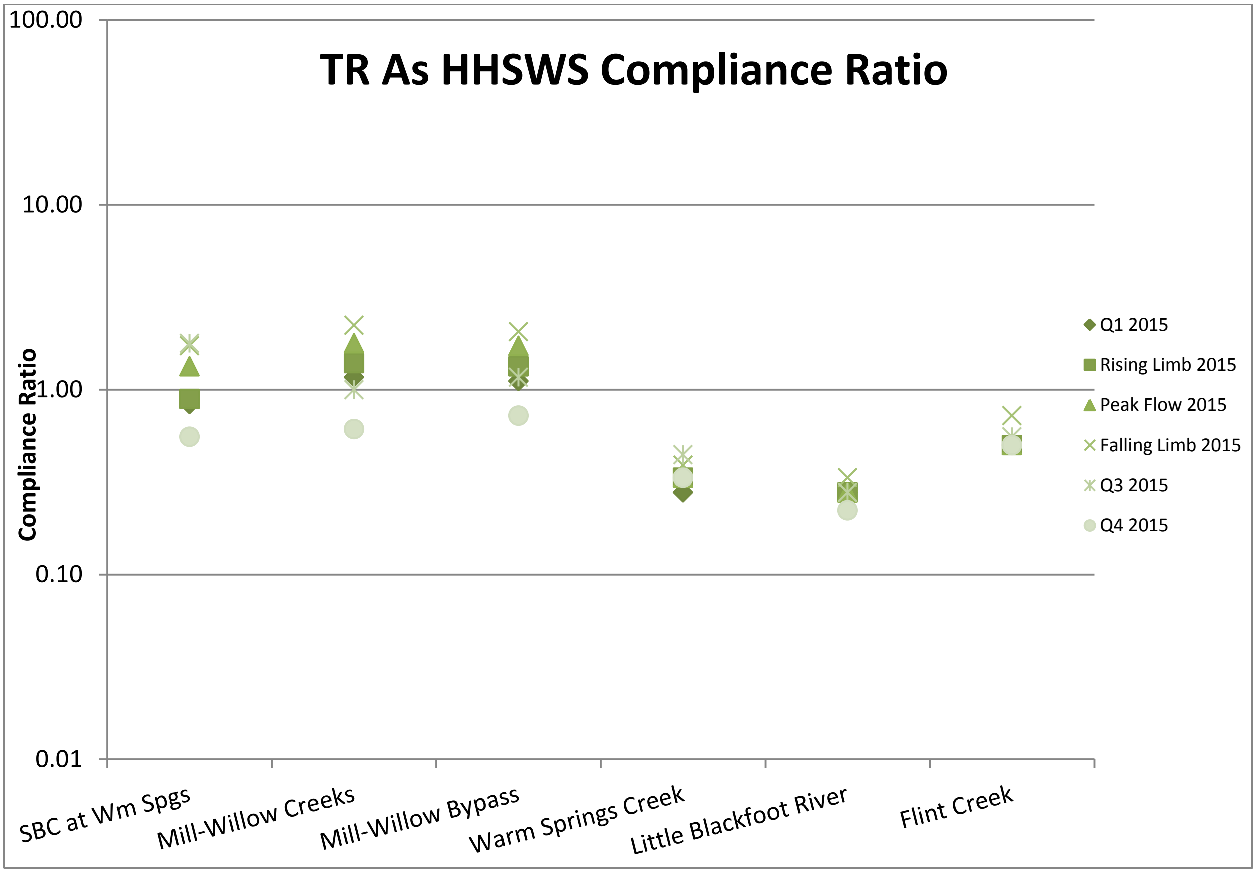

Figure 2-44. Total recoverable arsenic (TR As) compliance ratios for the Clark Fork River tributary sites, 2015. Compliance ratio is based on Clark Fork River Operable Unit Record of Decision performance goal for total recoverable arsenic (TR As HHSWS) concentration [USEPA, 2004].

2.3.6.2 Cadmium

Dissolved cadmium concentrations in the Clark Fork River mainstem in 2015 ranged from <0.00003-0.00006 mg/L and total recoverable concentrations ranged from 0.00003-0.00025 mg/L [Table 2-11]. Cadmium concentrations in mainstem monitoring sites during 2015 were generally lowest at Turah and were generally highest at the Williams-Tavenner Bridge site [Figure 2-45]. Mainstem cadmium concentrations in generally increased with downstream distance between each site in Reach A during each sample period [Figure 2-45].

The highest cadmium concentrations in most of the mainstem occurred during one of the Q2 monitoring events [Figure 2-45]. The lowest concentrations at most stations occurred in Q3, when streamflows were relatively low [Figure 2-45]. Most of the cadmium measured in the mainstem monitoring stations during 2015 was present in the sediment-associated form [Figure 2-45].

In the mainstem, no exceedances of the most restrictive performance goal from the CFROU ROD [Table 2-1] occurred for cadmium [Table 2-11].

There appears to be a very slight decreasing cadmium compliance ratio trend in the mainstem at near Galen [Figure 2-46], at Deer Lodge [Figure 2-47], and at Turah [Figure 2-48] from 2010-2015. All mainstem sites demonstrated a pronounced seasonal trend with the highest cadmium compliance ratios occurring during the runoff period (Q2) [Figure 2-46; Figure 2-47; Figure 2-48]. In 2015, dissolved cadmium compliance ratios in the mainstem were generally consistent among Reach A sites and reached a maximum of 2.5 [Figure 2-39]. The 2015 mainstem compliance ratios for total recoverable cadmium were consistently highest in Reach A downstream from the Gemback Road site and reached a maximum of 0.77 at Deer Lodge during the Q2-Falling monitoring event [Figure 2-49].

Dissolved cadmium concentrations in the Clark Fork River tributaries in 2015 ranged from <0.00003-0.00004 mg/L and total recoverable concentrations ranged from <0.00003-0.00017 mg/L [Table 2-11]. Cadmium concentrations in tributary monitoring sites during 2015 were consistently lowest in the Little Blackfoot River and Flint Creek, and consistently highest in Silver Bow Creek at Frontage Road [Figure 2-50]. Between Silver Bow Creek sites above (at Frontage Road) and below (at Warm Springs) the Warm Springs Ponds, cadmium concentrations decreased substantially during all paired sample periods [Figure 2-50]. Between Mill-Willow Creek sites above (at Frontage Road) and below (at Silver Bow Creek) the Mill-Willow Bypass, cadmium concentrations generally increased modestly during paired sample periods [Figure 2-50].

Tributary sites generally had the highest cadmium concentrations during the Q2-Peak monitoring event [Figure 2-50]. The lowest concentrations at all tributary stations were observed in Q1 or Q4, when streamflows were relatively low [Figure 2-50]. Most of the cadmium measured in the tributary monitoring stations during 2015 was present in the sediment-associated form, with the exception of Silver Bow Creek at Frontage Road where a relatively large proportion of the cadmium was in the dissolved form [Figure 2-50].

In the tributaries, no exceedances of the most restrictive performance goal from the CFROU ROD [Table 2-1] occurred for cadmium [Table 2-11].

There appears to be a very slight decreasing cadmium compliance ratio trend in Silver Bow Creek at Warm Springs from 2011-2015 [Figure 2-51]. In 2015, cadmium compliance ratios were highest in Mill-Willow Creek but never exceeded one at any tributary site [Figure 2-52].

Table 2-11. Total recoverable cadmium concentrations (mg/L) at Clark Fork River Operable Unit monitoring stations, 2015.

Site ID	Site Location	Sample Period					
		Q1	Q2			Q3	Q4
			Rising	Peak	Falling		
Mainstem Sites							
CFR-03A	Clark Fork River near Galen	0.00008	0.00011	0.00016	0.00009	0.00004	0.00010
CFR-07D	Clark Fork River at Galen Road	0.00011	0.00011	0.00014	0.00011	0.00004	0.00007
CFR-11F	Clark Fork River at Gemback Road	0.00016	0.00015	0.00015	0.00012	0.00004	0.00006
CFR-27H	Clark Fork River at Deer Lodge	0.00018	0.00019	0.00014	0.00024	0.00008	0.00015
CFR-34	Clark Fork River at Williams-Tavenner Bridge	0.00020	0.00021	0.00017	0.00025	0.00007	0.00018
CFR-116A	Clark Fork River at Turah	0.00008	0.00008	0.00003	0.00016	0.00006	0.00004
Tributary Sites							
SS-19	Silver Bow Creek at Frontage Road	0.00036	---	0.00033	---	0.00024	0.00036
SS-25	Silver Bow Creek at Warm Springs	0.00009	0.00008	0.00015	0.00010	ND	0.00008
MCWC-MWB	Mill-Willow Creek at Frontage Road	0.00009	0.00011	0.00017	0.00011	0.00007	0.00009
MWB-SBC	Mill-Willow Bypass near mouth	0.00008	0.00010	0.00016	0.00009	ND	0.00003
WSC-SBC	Warm Springs Creek near mouth	0.00007	0.00007	0.00011	0.00007	ND	0.00006
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	ND	0.00003	ND	0.00006	ND	ND
FC-CFR	Flint Creek near mouth	0.00005	0.00004	ND	ND	ND	ND

---	Not sampled.
ND	Not detected at analytical reporting limit.
	Exceeds chronic aquatic life standard [MDEQ, 2012b].

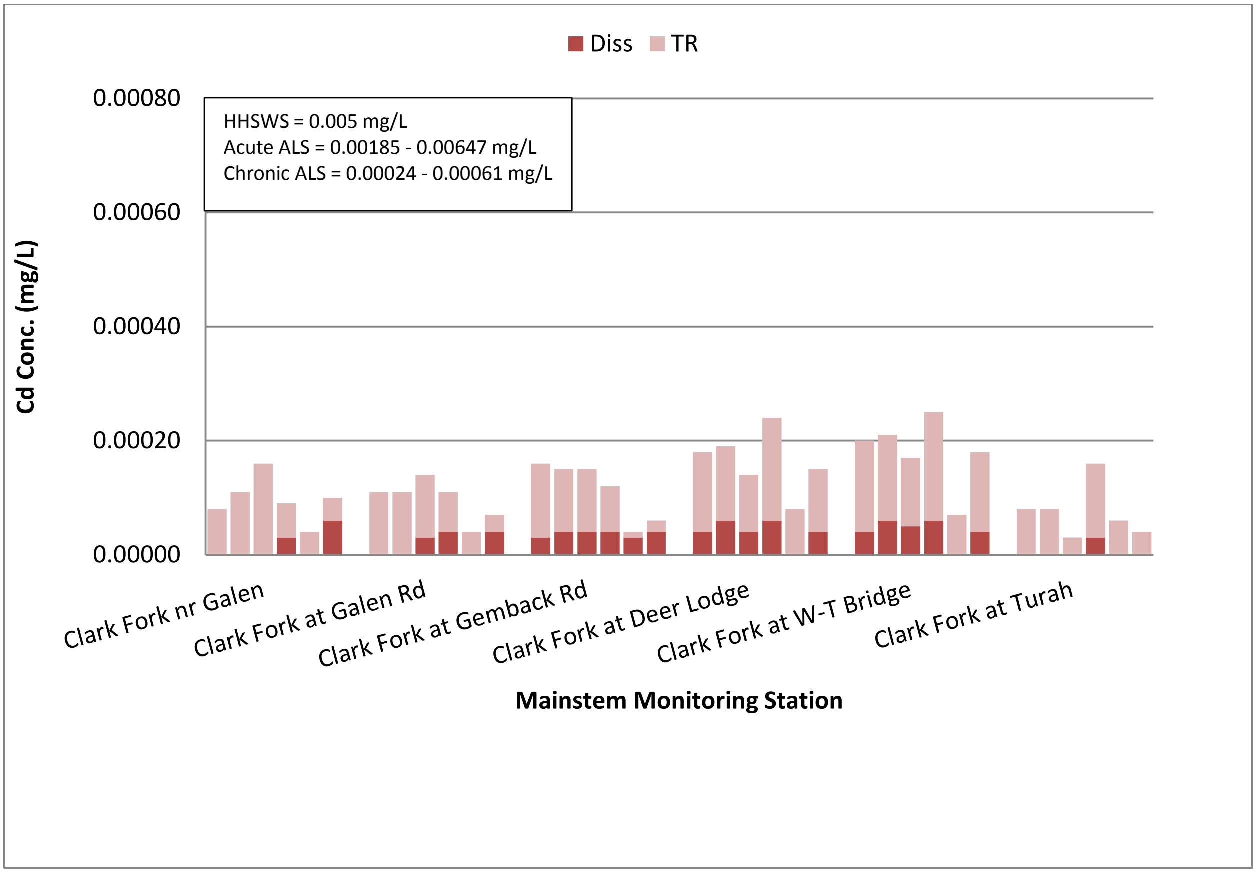

Figure 2-45. Total recoverable (TR) and dissolved (Diss) cadmium (Cd) concentrations at mainstem sampling sites in the Clark Fork River Operable Unit, 2015. Applicable water quality standards are the aquatic life standards (ALS) and the human health surface water standard (HHSWS) [MDEQ, 2012b].

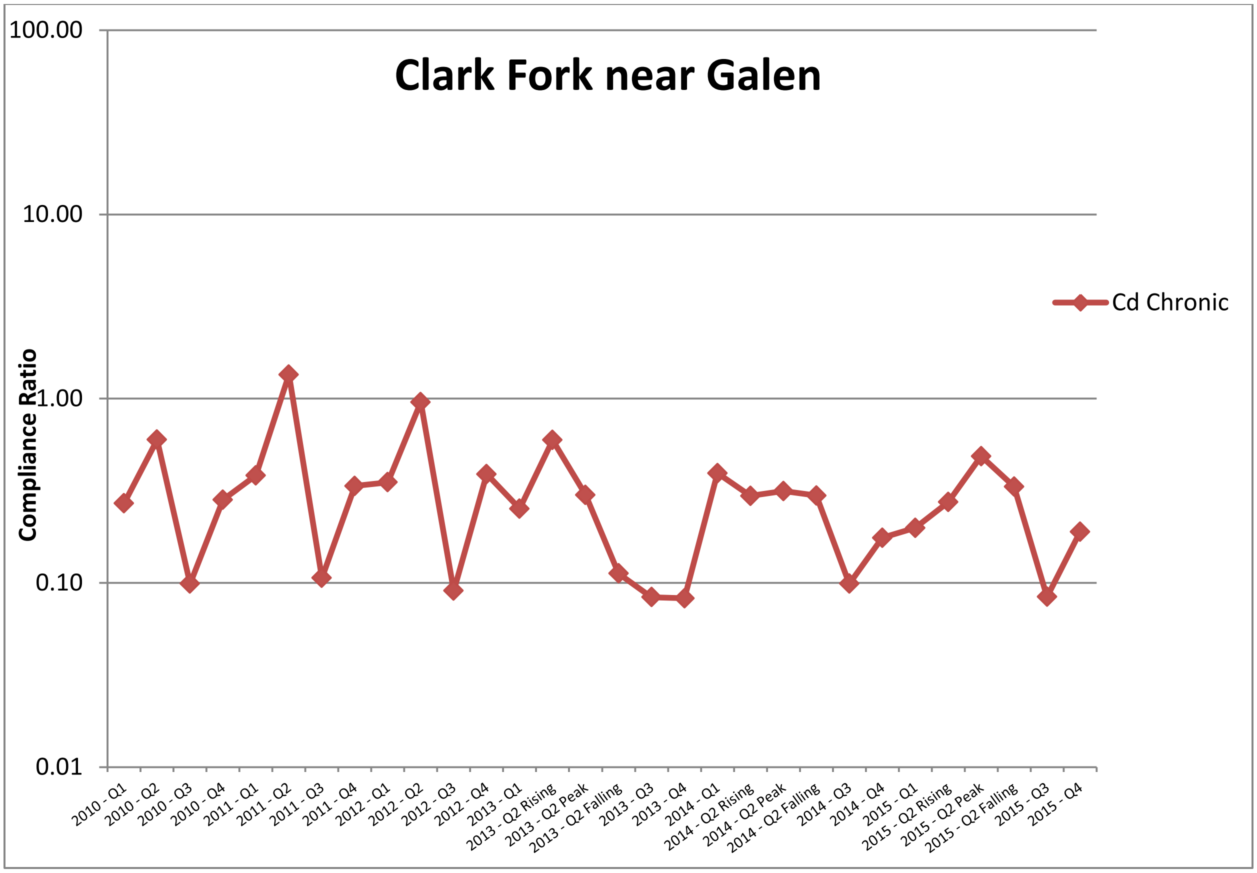

Figure 2-46. Total recoverable cadmium (Cd) compliance ratios for the Clark Fork River near Galen site, 2010-2015. Compliance ratios are based on the chronic aquatic life standard [MDEQ, 2012b].

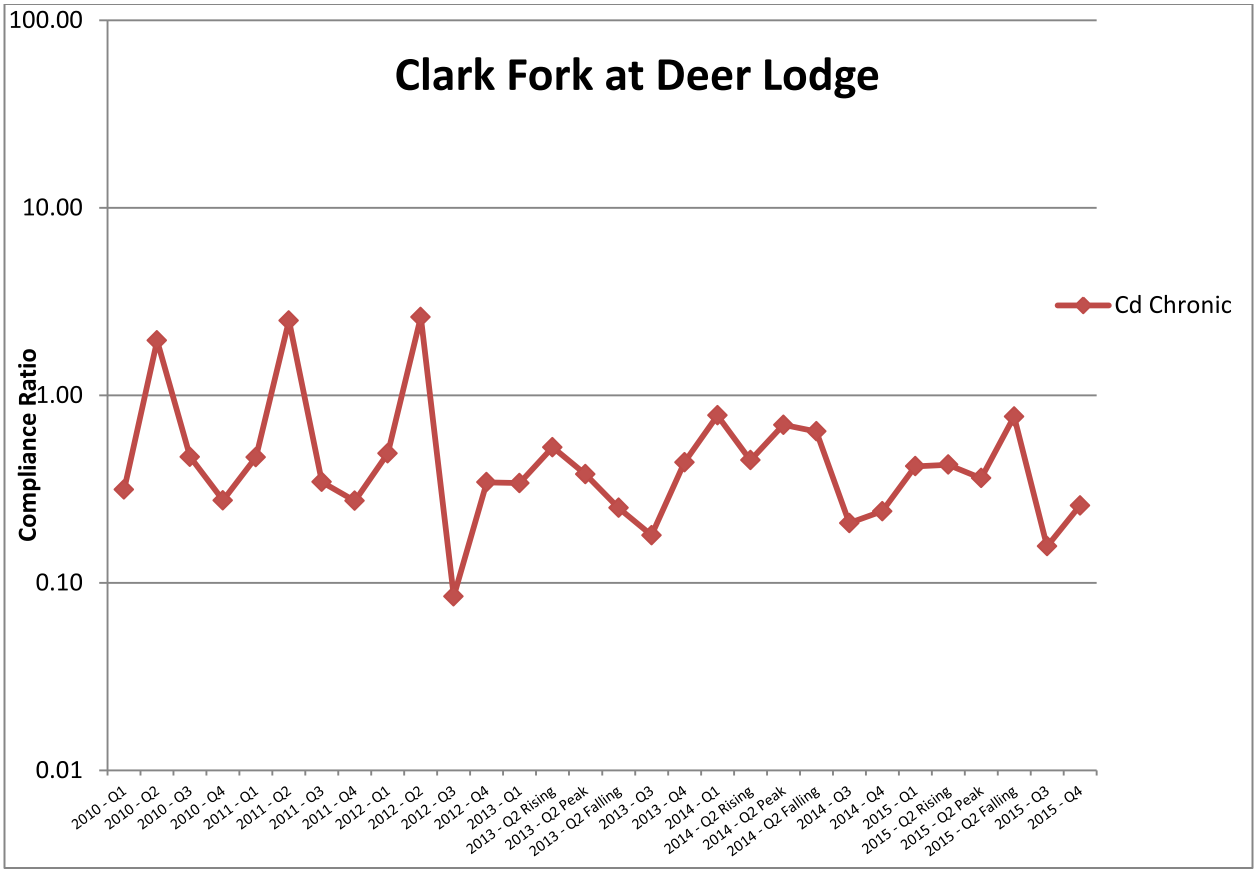

Figure 2-47. Total recoverable cadmium (Cd) compliance ratios for the Clark Fork River at Deer Lodge site, 2010-2015. Compliance ratios are based on the chronic aquatic life standard [MDEQ, 2012b].

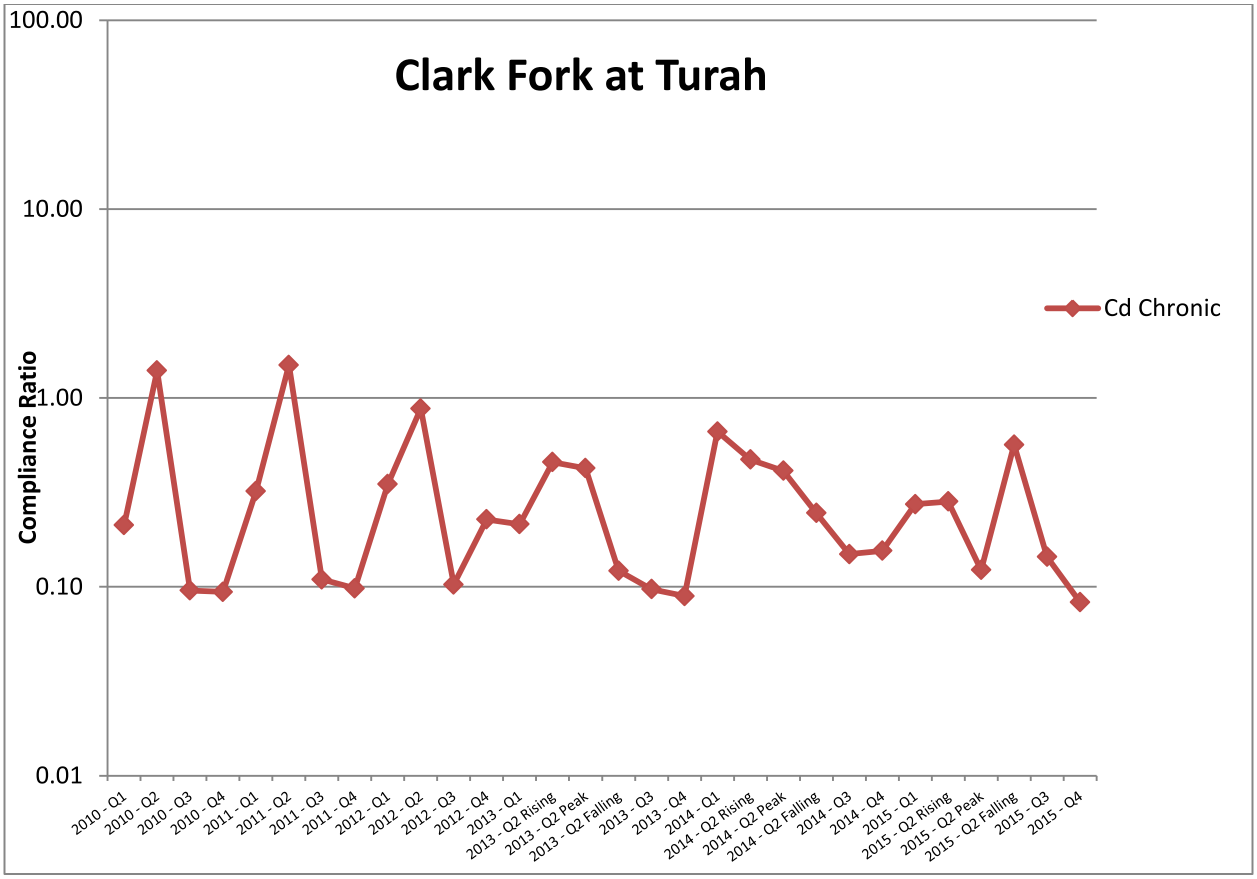

Figure 2-48. Total recoverable cadmium (Cd) compliance ratios for the Clark Fork River at Turah site, 2010-2015. Compliance ratios are based on the chronic aquatic life standard [MDEQ, 2012b].

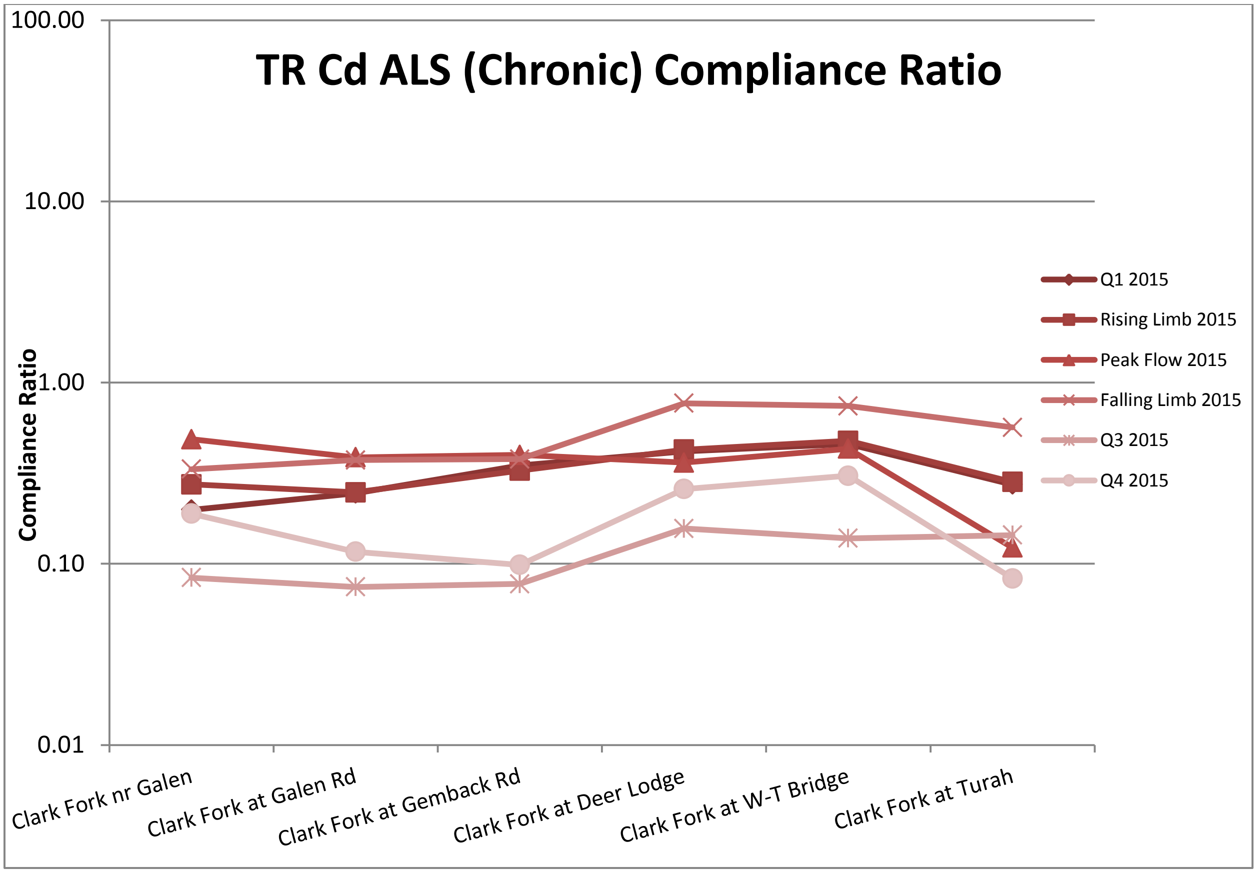

Figure 2-49. Total recoverable cadmium (TR Cd) compliance ratios for the Clark Fork River mainstem sites, 2015. Compliance ratios are based on the chronic aquatic life standard (ALS) [MDEQ, 2012b].

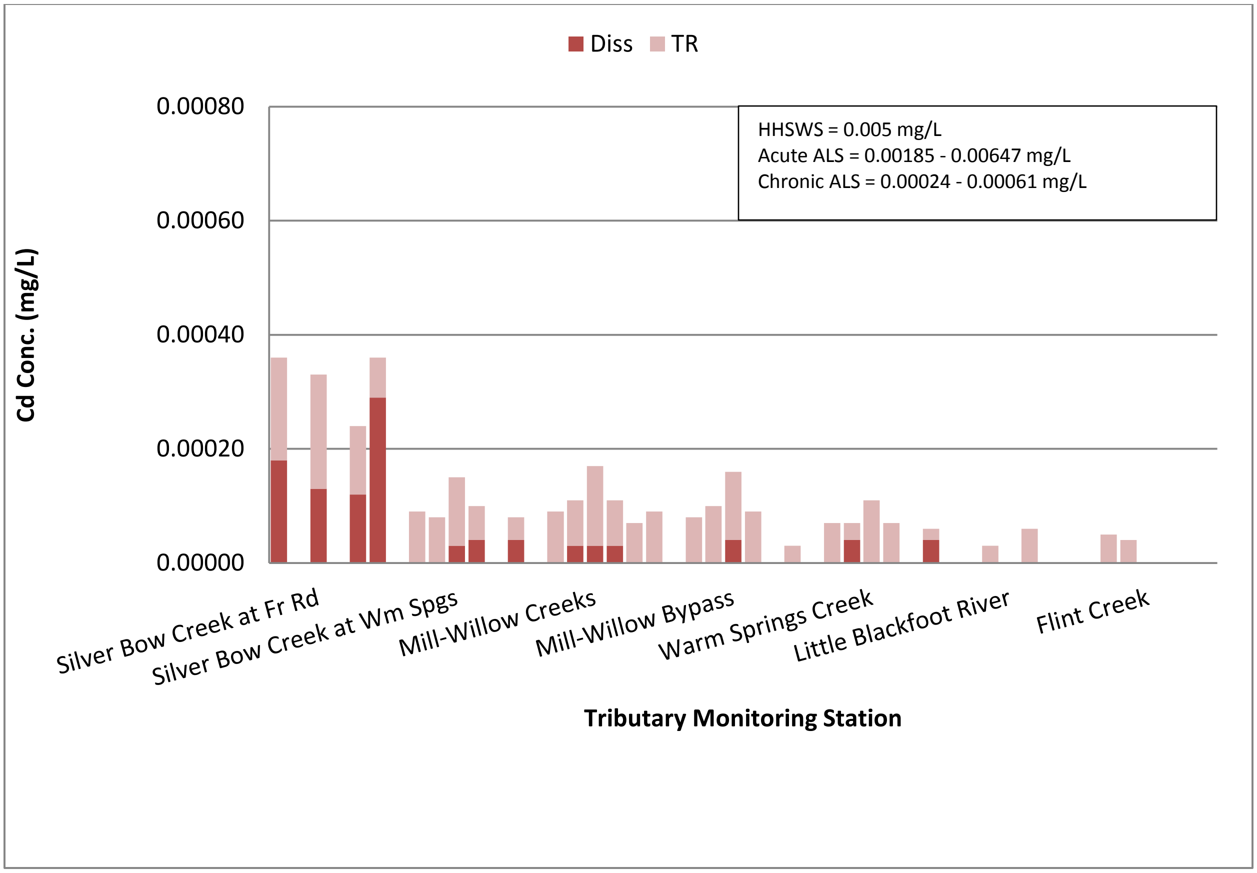

Figure 2-50. Total recoverable (TR) and dissolved (Diss) cadmium (Cd) concentrations at Clark Fork River tributary sampling sites, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "Silver Bow Creek at Fr Rd" site. Other sites or sample periods with no bars indicate concentrations below the analytical reporting limit. Applicable water quality standards are the aquatic life standards (ALS) and the human health surface water standard (HHSWS) [MDEQ, 2012b].

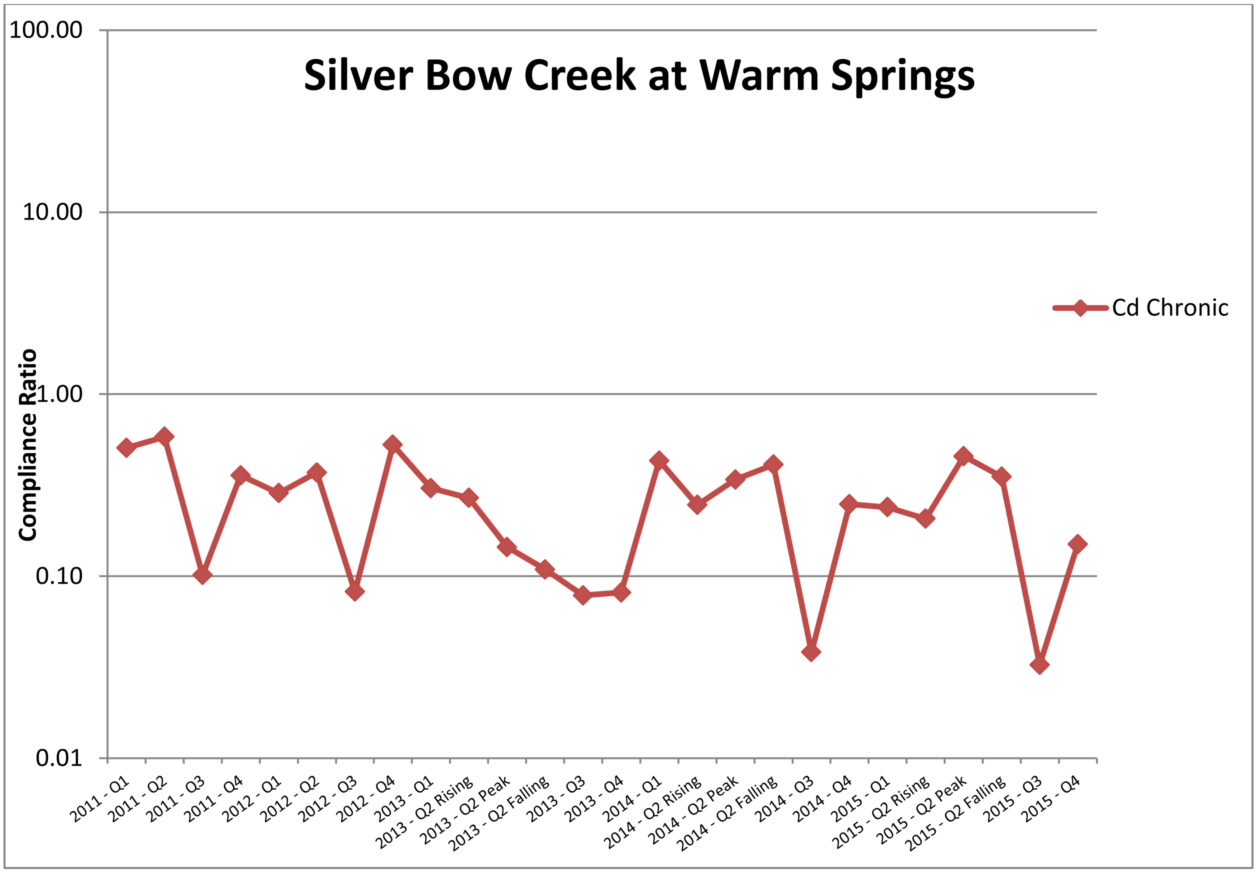

Figure 2-51. Total recoverable cadmium (Cd) compliance ratios for the Silver Bow Creek at Warm Springs site, 2011-2015. Compliance ratios are based on the chronic aquatic life standard [MDEQ, 2012b].

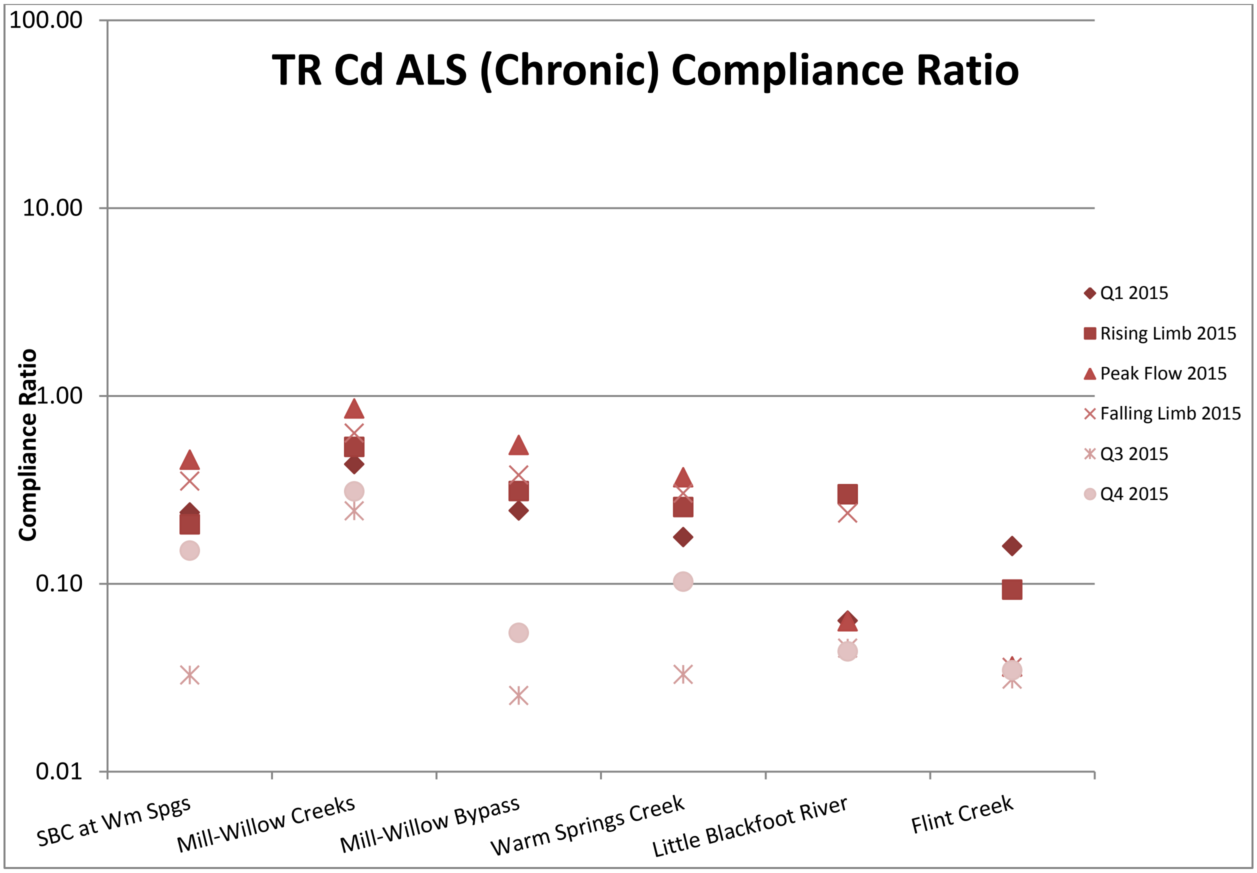

Figure 2-52. Total recoverable cadmium (TR Cd) compliance ratios for the Clark Fork River tributary sites, 2015. Compliance ratios are based on the chronic aquatic life standard (ALS) [MDEQ, 2012b].

2.3.6.3 Copper

Dissolved copper concentrations in the Clark Fork River mainstem in 2015 ranged from 0.002-0.0013 mg/L [Table 2-12], and total recoverable concentrations ranged from 0.003-0.065 mg/L [Table 2-13]. Copper concentrations in mainstem monitoring sites during 2015 were generally lowest at near Galen or Turah and were generally highest at the Williams-Tavenner Bridge site [Figure 2-53]. Mainstem copper concentrations generally increased with downstream distance between each site in Reach A during each sample period, particularly for total recoverable concentrations [Figure 2-53].The highest copper concentrations in most of the mainstem occurred during the Q1 or one of the Q2 monitoring events [Figure 2-53]. The lowest concentrations at most stations occurred in Q3 or Q4 when streamflows were relatively low [Figure 2-53]. Most of the copper measured in the mainstem monitoring stations during 2015 was present in the sediment-associated form, particularly in those samples with particularly high total recoverable concentrations [Figure 2-53].

In the mainstem, no exceedances of the most restrictive performance goal from the CFROU ROD [Table 2-1] occurred for dissolved copper [Table 2-12]. However, multiple exceedances of the MDEQ [2012b] aquatic life standards, which are based on total recoverable concentrations, occurred in the mainstem [Table 2-13]. Exceedances of the chronic ALS [MDEQ, 2012b] occurred during at least two sample periods at all mainstem sites and occurred during at least four sample periods at Gemback Road, at Deer Lodge, and at Williams-Tavenner Bridge [Table 2-13]. In addition, exceedances of the acute ALS [MDEQ, 2012b] occurred during at least two sample periods at all mainstem sites (except near Galen) and occurred during at least four sample periods at Deer Lodge and at Williams-Tavenner Bridge [Table 2-13].

There does not appear to be an increasing or decreasing copper compliance ratio trend in the mainstem at near Galen [Figure 2-54], at Deer Lodge [Figure 2-55], and at Turah [Figure 2-56] from 2010-2015. All mainstem sites demonstrated a pronounced seasonal trend with the highest copper compliance ratios occurring during the runoff period (Q2) [Figure 2-54; Figure 2-55; Figure 2-56]. In 2015, dissolved copper compliance ratios in the mainstem generally increased at each downstream site and peaked at either Deer Lodge or the William-Tavenner Bridge, but the maximum 2015 compliance ratios were below one (0.70) [Figure 2-57]. The 2015 mainstem compliance ratios for total recoverable copper were also highest in Reach A at the sites downstream from the Gemback Road site and reached a maximum of 5.46 at Deer Lodge during the Q2-Falling monitoring event [Figure 2-58].

Dissolved copper concentrations in the Clark Fork River tributaries in 2015 ranged from <0.001-0.012 mg/L [Table 2-12] and total recoverable concentrations ranged from <0.001-0.021 mg/L [Table 2-13]. Copper concentrations in tributary monitoring sites during 2015 were consistently lowest in the Little Blackfoot River and Flint Creek and consistently highest in Silver Bow Creek at Frontage Road [Figure 2-59]. Between Silver Bow Creek sites above (at Frontage Road) and below (at Warm Springs), the Warm Springs Ponds copper concentrations decreased by about half during all paired sample periods [Figure 2-59]. Between Mill-Willow Creek sites above (at Frontage Road) and below (at Silver Bow Creek), the Mill-Willow Bypass copper concentrations were similar during Q1 and Q2 sample periods, but decreased in Q3 and Q4 [Figure 2-59].

Tributary sites generally had the highest copper concentrations during the Q2-Peak monitoring event [Figure 2-59]. The lowest concentrations at all tributary stations were observed in Q1 or Q4, when streamflows were relatively low [Figure 2-59]. About half of the copper measured in the tributary monitoring stations during 2015 was present in the sediment-associated form [Figure 2-59].

In the tributaries, no exceedances of the most restrictive performance goal from the CFROU ROD [Table 2-1] occurred for copper [Table 2-12]. However, some exceedances of the MDEQ [2012b] aquatic life standards, which are based on total recoverable concentrations, occurred in the tributaries [Table 2-13]. Exceedances of the chronic ALS [MDEQ, 2012b] occurred in Silver Bow Creek at Frontage Road (Q1 and Q2), at Mill-Willow Creek at Frontage Road (Q1 and all Q2 sample periods), in the Mill-Willow Bypass (Q2-Peak), and at Warm Springs Creek (Q2-Peak and Q2-Falling) [Table 2-13]. Exceedances of the acute ALS [MDEQ, 2012b] occurred in Silver Bow Creek at Frontage Road (Q1 and Q2), at Mill-Willow Creek at Frontage Road (Q2-Peak and Q2-Falling), and in Warm Springs Creek (Q2-Falling) [Table 2-13].

There appears to be a very slight decreasing copper compliance ratio trend in Silver Bow Creek at Warm Springs from 2010-2015 [Figure 2-60]. In 2015, dissolved copper compliance ratios in the tributaries were consistently below one [Figure 2-61]. The 2015 mainstem compliance ratios for total recoverable copper in the tributaries were highest in Mill-Willow Creek and Warm Springs Creek and reached a maximum of 1.99 in Mill-Willow Creek during the Q2-Peak monitoring event [Figure 2-62]. Total recoverable compliance ratios during the Q2-Peak monitoring event were higher in Mill-Willow Creek and Warm Springs Creek compared to Silver Bow Creek at Frontage Road despite the higher total recoverable copper concentrations in Silver Bow Creek due to higher water hardness, and thus a less restrictive standard, at Silver Bow Creek during that period.

Table 2-12. Dissolved copper concentrations (mg/L) at Clark Fork River Operable Unit monitoring stations, 2015.

Site ID	Site Location	Sample Period					
		Q1	Q2			Q3	Q4
			Rising	Peak	Falling		
Mainstem Sites							
CFR-03A	Clark Fork River near Galen	0.003	0.003	0.004	0.005	0.004	0.004
CFR-07D	Clark Fork River at Galen Road	0.003	0.004	0.005	0.006	0.006	0.004
CFR-11F	Clark Fork River at Gemback Road	0.004	0.005	0.005	0.008	0.006	0.005
CFR-27H	Clark Fork River at Deer Lodge	0.006	0.008	0.008	0.012	0.007	0.005
CFR-34	Clark Fork River at Williams-Tavenner Bridge	0.007	0.009	0.008	0.013	0.007	0.006
CFR-116A	Clark Fork River at Turah	0.003	0.003	0.002	0.005	0.002	0.002
Tributary Sites							
SS-19	Silver Bow Creek at Frontage Road	0.012	---	0.010	---	0.008	0.011
SS-25	Silver Bow Creek at Warm Springs	0.003	0.003	0.003	0.003	0.001	ND
MCWC-MWB	Mill-Willow Creek at Frontage Road	0.003	0.004	0.003	0.003	ND	0.001
MWB-SBC	Mill-Willow Bypass near mouth	0.005	0.006	0.005	0.003	ND	ND
WSC-SBC	Warm Springs Creek near mouth	0.005	0.005	0.004	0.004	ND	0.001
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	0.003	0.002	0.002	0.003	ND	ND
FC-CFR	Flint Creek near mouth	0.003	0.001	ND	0.001	ND	ND

---	Not sampled.
ND	Not detected at analytical reporting limit.
	Exceeds federal ambient water quality criteria [USEPA, 1986].

Table 2-13. Total recoverable copper concentrations (mg/L) at Clark Fork River Operable Unit monitoring stations, 2015.

Site ID	Site Location	Sample Period					
		Q1	Q2			Q3	Q4
			Rising	Peak	Falling		
Mainstem Sites							
CFR-03A	Clark Fork River near Galen	0.011	0.013	0.018	0.014	0.006	0.009
CFR-07D	Clark Fork River at Galen Road	0.016	0.017	0.025	0.020	0.008	0.009
CFR-11F	Clark Fork River at Gemback Road	0.027	0.025	0.025	0.025	0.007	0.009
CFR-27H	Clark Fork River at Deer Lodge	0.040	0.038	0.024	0.060	0.018	0.024
CFR-34	Clark Fork River at Williams-Tavenner Bridge	0.049	0.041	0.028	0.065	0.015	0.030
CFR-116A	Clark Fork River at Turah	0.015	0.011	0.005	0.030	0.007	0.003
Tributary Sites							
SS-19	Silver Bow Creek at Frontage Road	0.021	---	0.020	---	0.013	0.016
SS-25	Silver Bow Creek at Warm Springs	0.008	0.006	0.011	0.008	0.003	0.006
MCWC-MWB	Mill-Willow Creek at Frontage Road	0.008	0.008	0.013	0.009	0.005	0.009
MWB-SBC	Mill-Willow Bypass near mouth	0.007	0.008	0.013	0.008	0.002	0.002
WSC-SBC	Warm Springs Creek near mouth	0.006	0.008	0.016	0.015	0.005	0.005
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	0.002	0.002	0.002	0.002	ND	0.001
FC-CFR	Flint Creek near mouth	0.002	0.003	0.002	0.002	0.001	0.002

--- Not sampled.

ND Not detected at analytical reporting limit.

(yellow) Exceeds chronic aquatic life standard [MDEQ, 2012b].

(orange) Exceeds acute aquatic life standard [MDEQ, 2012b].

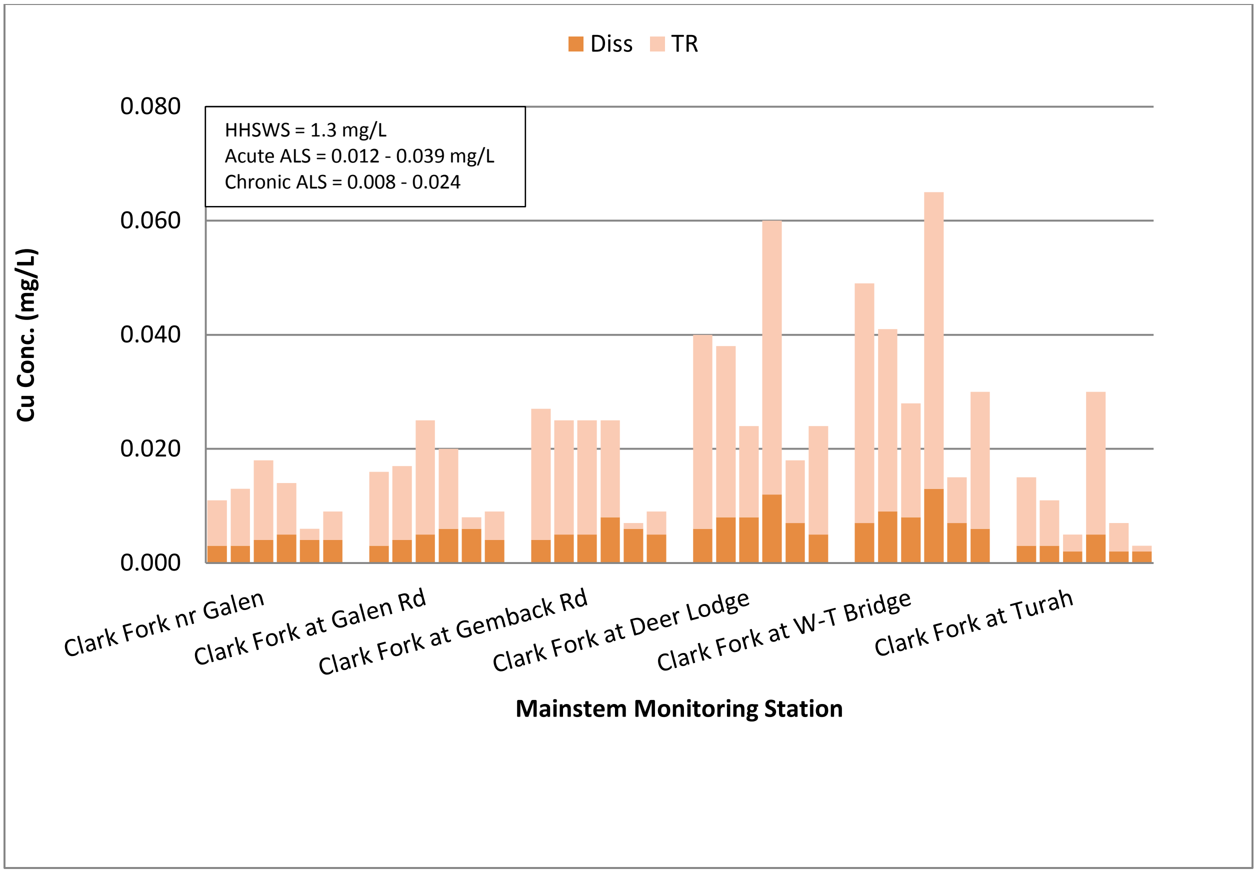

Figure 2-53. Total recoverable (TR) and dissolved (Diss) copper (Cu) concentrations at mainstem sampling sites in the Clark Fork River Operable Unit, 2015. Applicable water quality standards are the aquatic life standards (ALS) and the human health surface water standard (HHSWS) [MDEQ, 2012b].

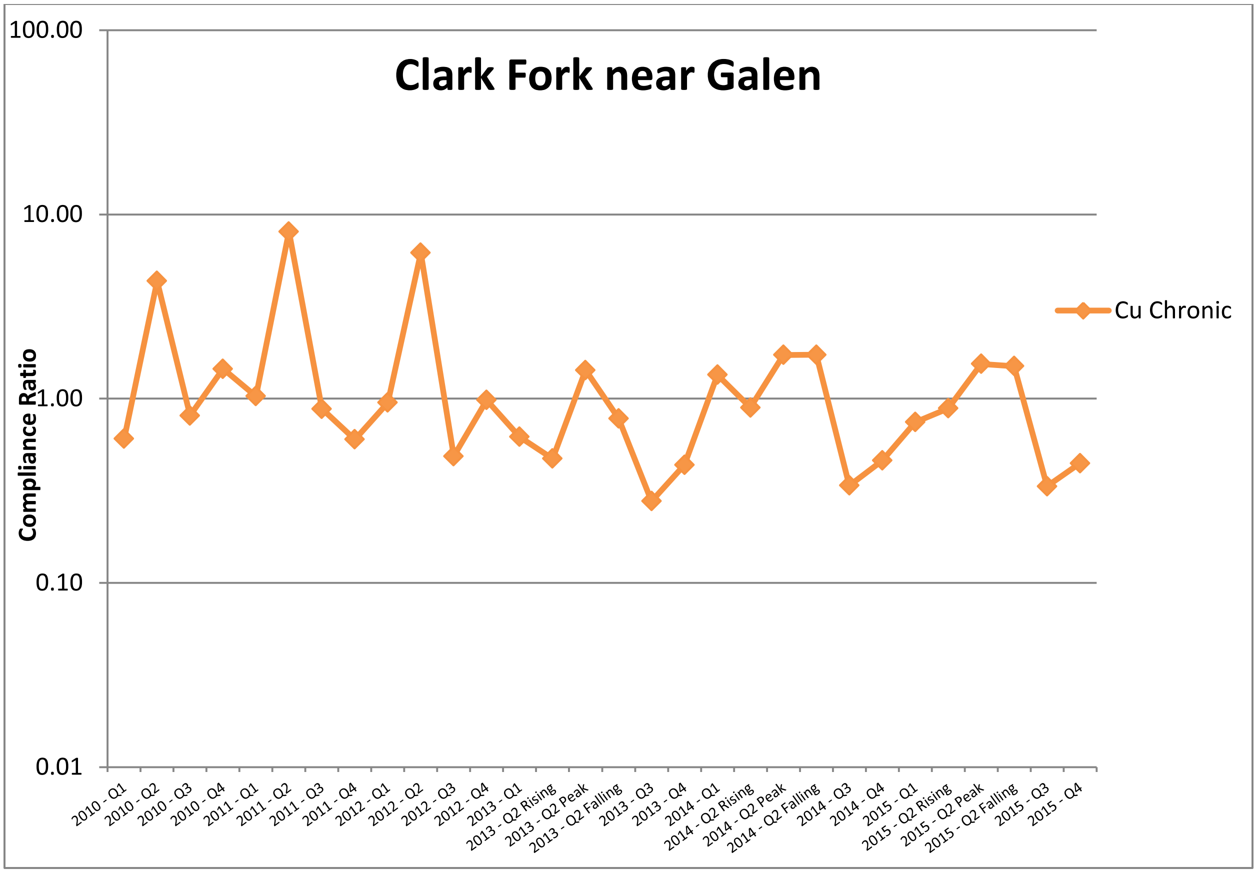

Figure 2-54. Total recoverable copper (Cu) compliance ratios for the Clark Fork River near Galen site, 2010-2015. Compliance ratios are based on the chronic aquatic life standard [MDEQ, 2012b].

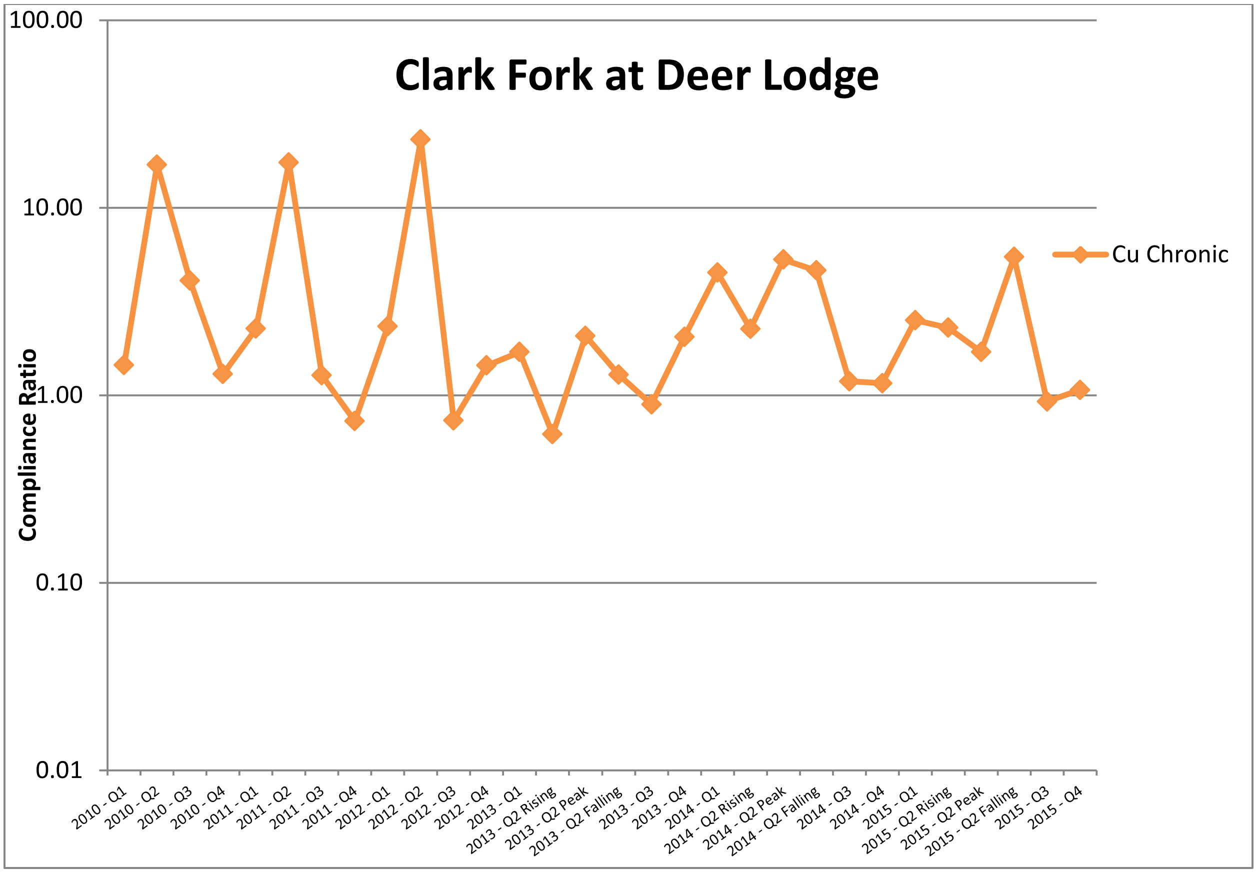

Figure 2-55. Total recoverable copper (Cu) compliance ratios for the Clark Fork River at Deer Lodge site, 2010-2015. Compliance ratios are based on the chronic aquatic life standard [MDEQ, 2012b].

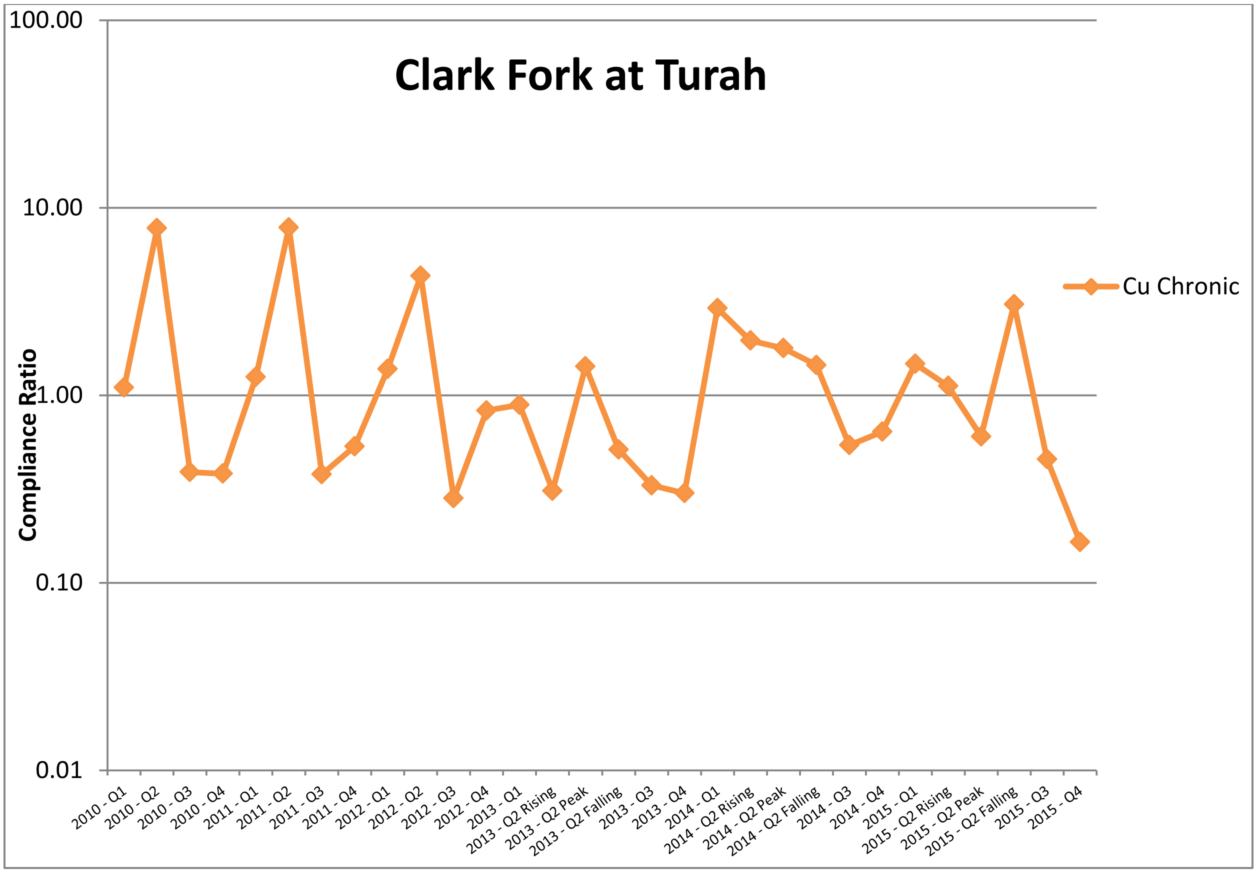

Figure 2-56. Total recoverable copper (Cu) compliance ratios for the Clark Fork River at Turah site, 2010-2015. Compliance ratios are based on the chronic aquatic life standard [MDEQ, 2012b].

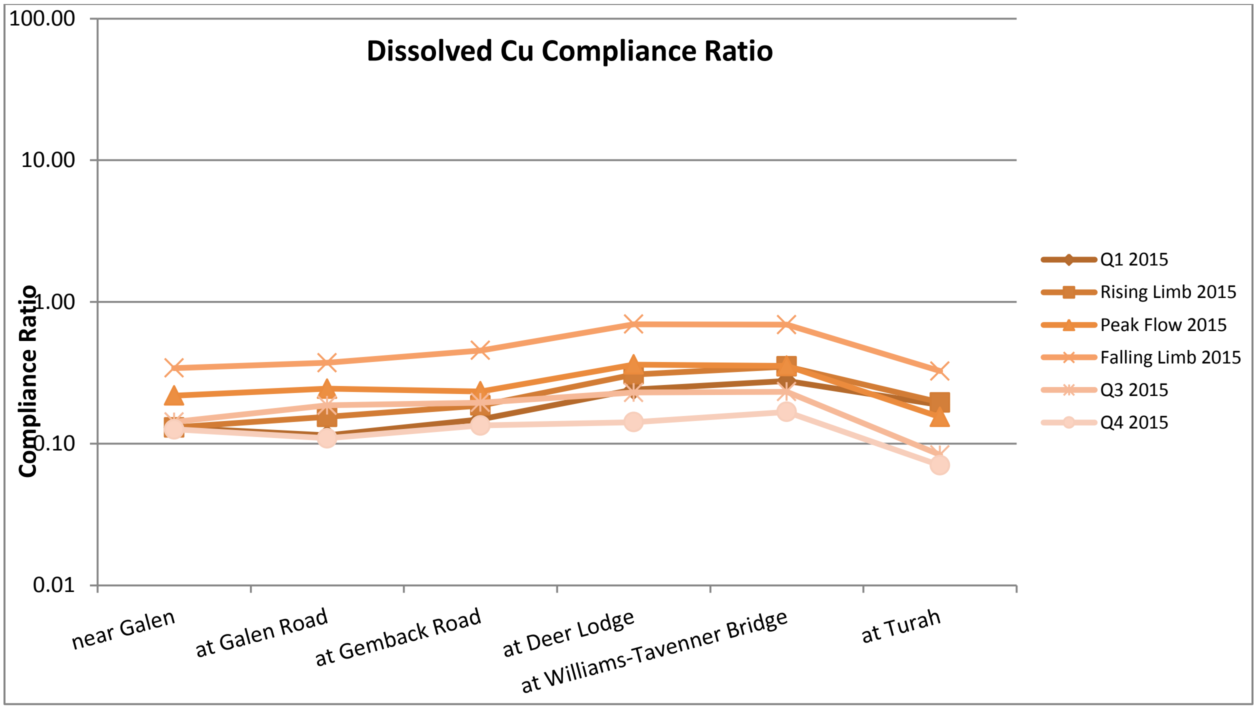

Figure 2-57. Dissolved copper (Cu) compliance ratios for the Clark Fork River mainstem sites, 2015. Compliance ratios are based on the federal ambient water quality criteria [USEPA, 1986].

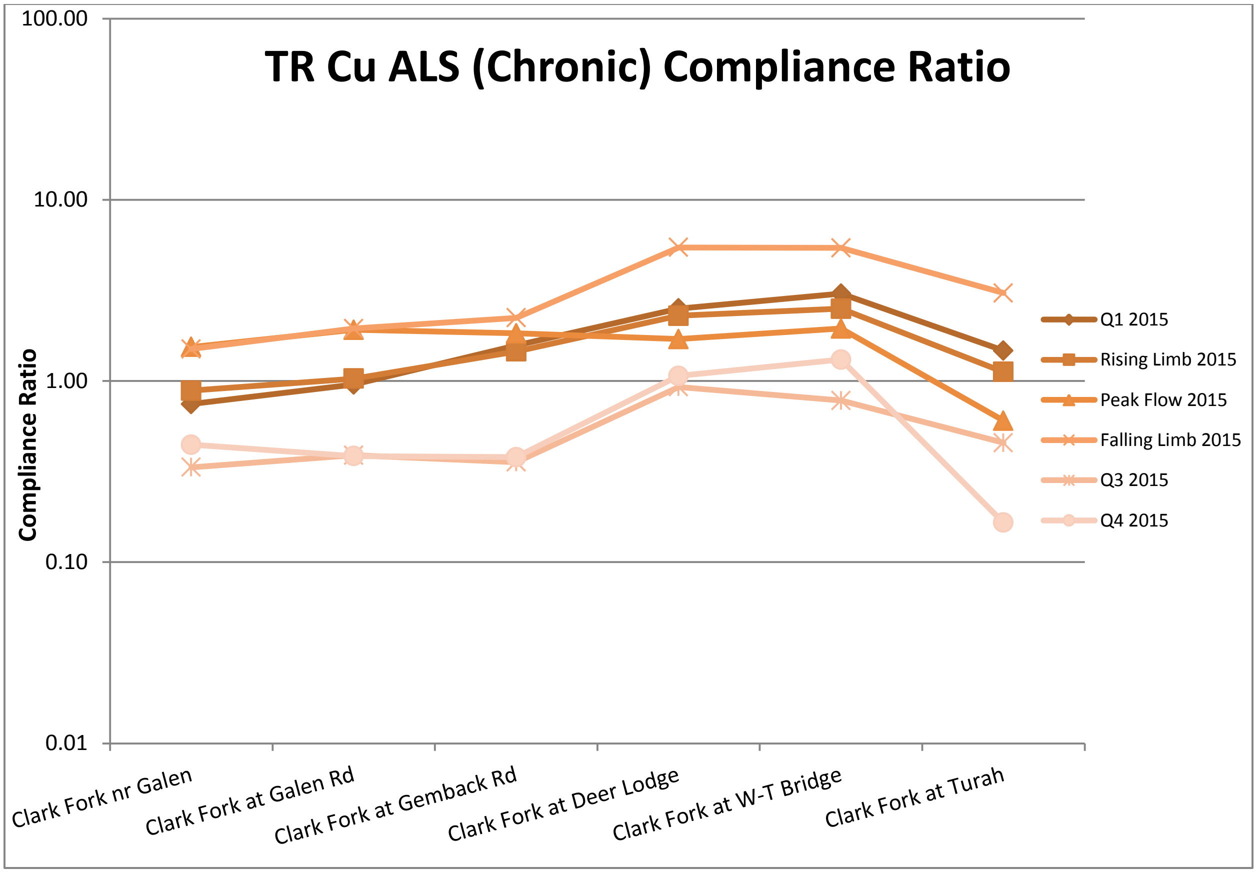

Figure 2-58. Total recoverable copper (TR Cu) compliance ratios for the Clark Fork River mainstem sites, 2015. Compliance ratios are based on the chronic aquatic life standard (ALS) [MDEQ, 2012b].

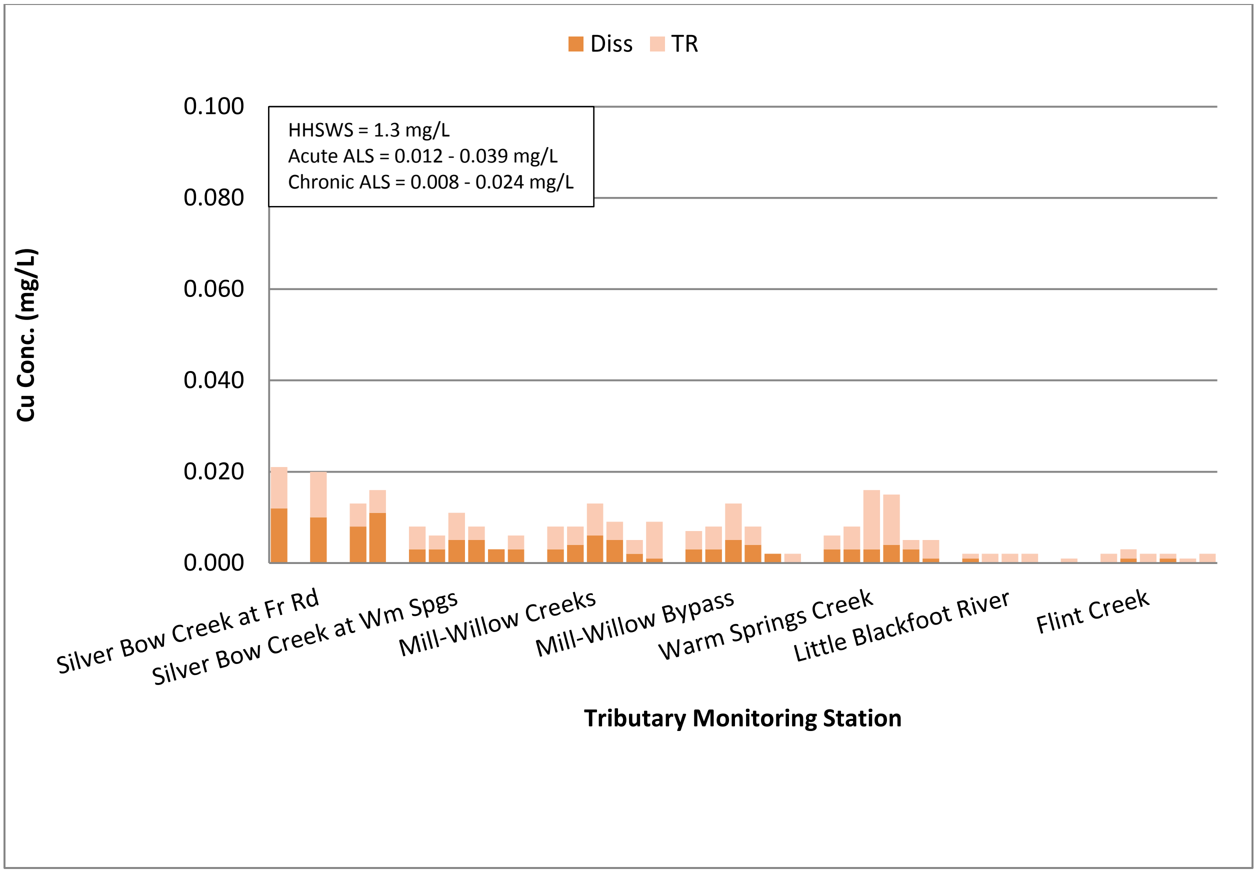

Figure 2-59. Total recoverable (TR) and dissolved (Diss) copper (Cu) concentrations at tributary sampling sites in the Clark Fork River Operable Unit, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "Silver Bow Creek at Fr Rd" site. Other sites or sample periods with no bars indicate concentrations below the analytical reporting limit. Applicable water quality standards are the aquatic life standards (ALS) and the human health surface water standard (HHSWS) [MDEQ, 2012b].

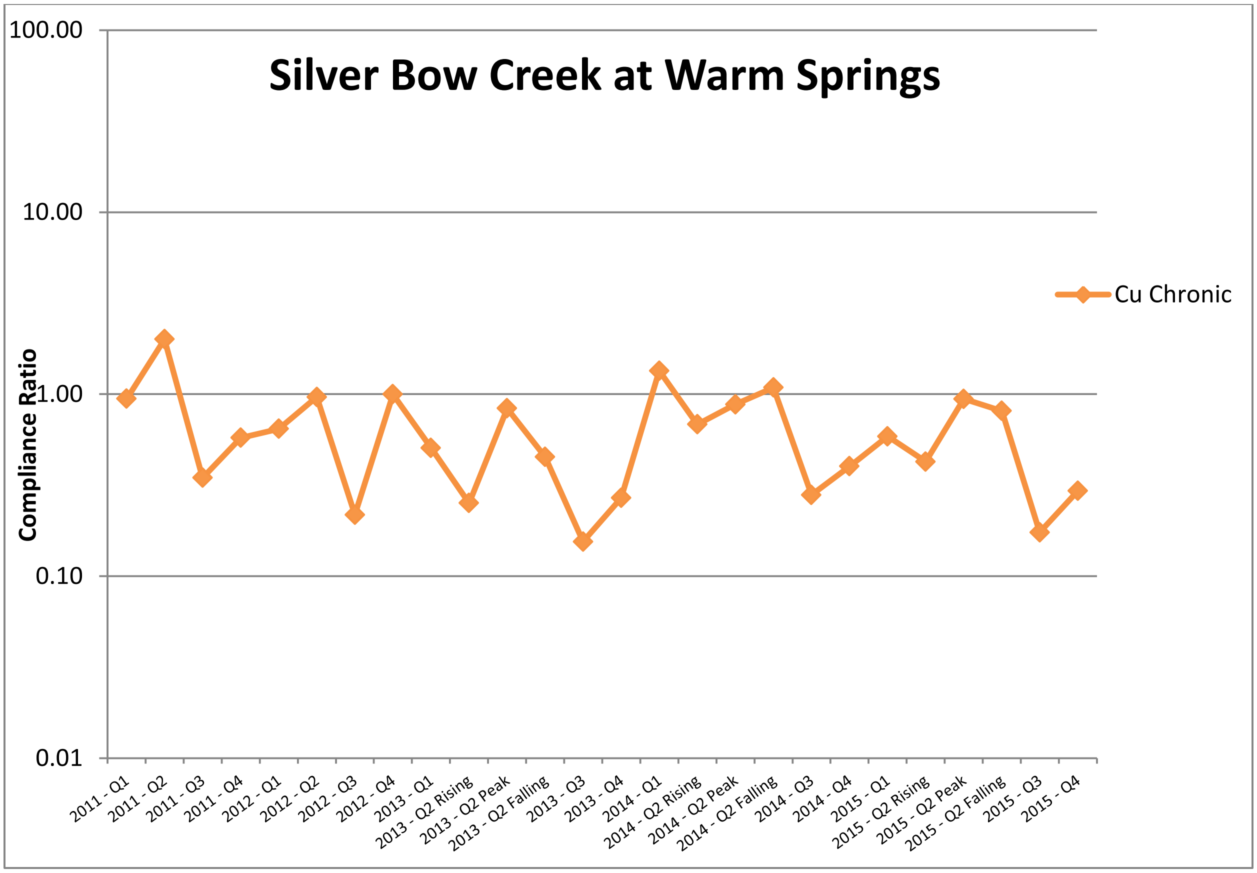

Figure 2-60. Total recoverable copper (Cu) compliance ratios for the Silver Bow Creek at Warm Springs site, 2011-2015. Compliance ratios are based on the chronic and acute aquatic life standards [MDEQ, 2012b].

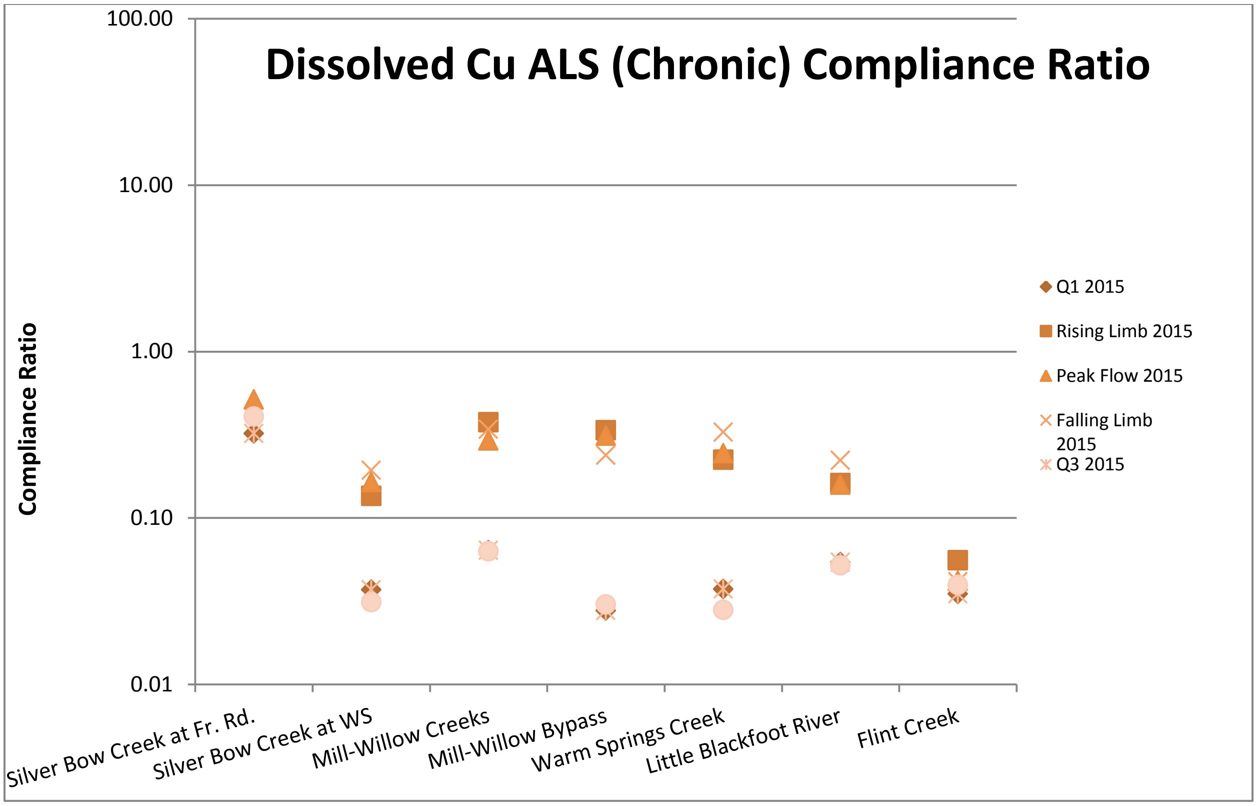

Figure 2-61. Dissolved copper (Cu) compliance ratios for the Clark Fork River tributary sites, 2015. Compliance ratios are based on the federal ambient water quality criteria [USEPA, 1986][11].

[11] The federal ambient water quality criteria [USEPA, 1986] is the CFROU ROD performance standard for the Clark Fork River mainstem sites but is not a regulatory standard for these tributary sites [USEPA, 2004].

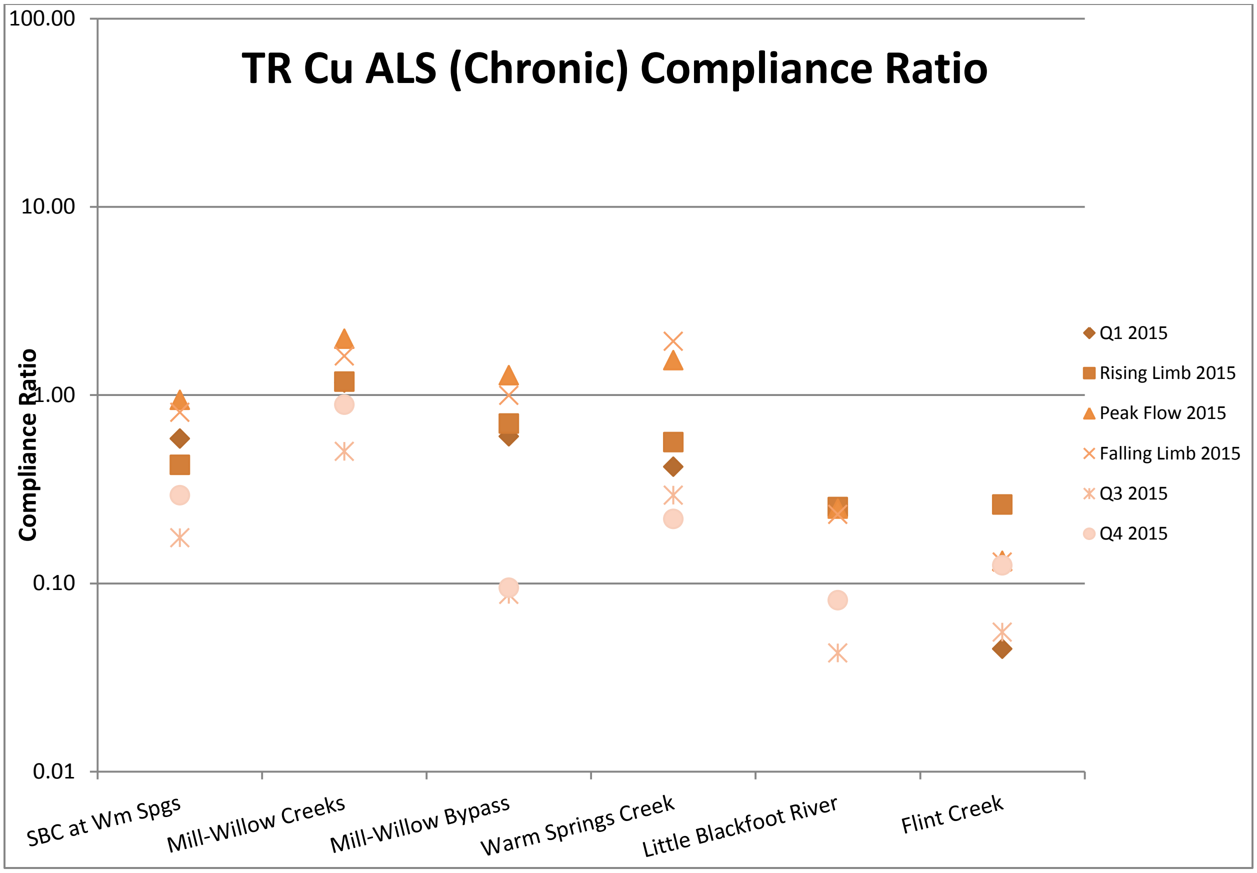

Figure 2-62. Total recoverable copper (TR Cu) compliance ratios for the Clark Fork River tributary sites, 2015. Compliance ratios are based on the chronic aquatic life standard (ALS) [MDEQ, 2012b].

2.3.6.4 Lead

Dissolved lead concentrations in the Clark Fork River mainstem in 2015 ranged from <0.0003-0.0003 mg/L and total recoverable concentrations ranged from <0.0003-0.0070 mg/L [Table 2-14]. Lead concentrations in mainstem monitoring sites during 2015 were generally lowest at near Galen or at Turah and highest at Williams-Tavenner Bridge [Figure 2-63]. Lead concentrations among the Reach A sites tended to increase at each downstream site [Figure 2-63].

All mainstem sites had the highest lead concentrations during either the Q1 or one of the Q2 sample periods [Figure 2-63]. The lowest concentrations were generally observed in Q3 or Q4 although the Turah site had the minimum concentration during the Q2-Peak period [Figure 2-63]. Almost all of the lead measured in the mainstem monitoring stations during 2015 was present in the sediment-associated form [Figure 2-63].

In the mainstem, exceedances of the most restrictive performance goal from the CFROU ROD [Table 2-1] for total recoverable lead were rare and only occurred during the Q2-Falling monitoring period at Deer Lodge, at the Williams-Tavenner Bridge, and at Turah in 2015 [Table 2-14].

There does appear to be a slight decreasing compliance ratio trend in the mainstem near Galen [Figure 2-64], at Deer Lodge [Figure 2-65], or at Turah [Figure 2-66] from 2010-2015. However, this trend appears to be less pronounced at Deer Lodge [Figure 2-65]. All mainstem sites appeared to demonstrate a moderately pronounced seasonal trend with the highest lead compliance ratios occurring during the runoff period (Q2) [Figure 2-64; Figure 2-65; Figure 2-66]. In 2015, total recoverable lead compliance ratios in the mainstem were generally lowest in the three upper Reach A sites (near Galen, at Galen Road, and at Gemback Road), highest at the two downstream Reach A sites (at Deer Lodge and at the Williams-Tavenner Bridge), and variable at Turah [Figure 2-67].

Dissolved lead concentrations in the Clark Fork River tributaries in 2015 ranged from <0.0003-0.0004 mg/L and total recoverable concentrations ranged from <0.0003-0.0043 mg/L [Table 2-14]. Lead concentrations in tributary monitoring sites during 2015 were consistently lowest in Warm Springs Creek and the Little Blackfoot River and were highest at either the Mill-Willow Creek site or Flint Creek [Figure 2-68]. Between Silver Bow Creek sites above (at Frontage Road) and below (at Warm Springs), the Warm Springs Ponds lead concentrations were similar during all paired sample periods [Figure 2-68]. Between Mill-Willow Creek sites above (at Frontage Road) and below (at Silver Bow Creek), the Mill-Willow Bypass lead concentrations were similar during all paired sample periods except Q3 and Q4 when concentrations were higher at the upstream site [Figure 2-68].

The seasonal maxima and minima for lead concentrations by tributary site was variable [Figure 2-68]. Most of the lead measured in the tributary monitoring stations during 2015 was present in the sediment-associated form [Figure 2-68].

In the tributaries, exceedances of the most restrictive performance goal from the CFROU ROD [Table 2-1] for total recoverable lead occurred at two sites: Mill-Willow Creek at Frontage Road (Q2-Peak and Q2-Falling) and Flint Creek (Q1) in 2015 [Table 2-14].

There appears to be a slight decreasing compliance ratio trend in Silver Bow Creek at Warm Springs for lead from 2011-2015 [Figure 2-69]. The 2015 tributary compliance ratios for total recoverable lead exceeded one in Mill-Willow Creek and at Flint Creek and reached a maximum of 1.49 [Figure 2-70].

Table 2-14. Total recoverable lead concentrations (mg/L) at Clark Fork River Operable Unit monitoring stations, 2015.

Site ID	Site Location	Sample Period					
		Q1	Q2			Q3	Q4
			Rising	Peak	Falling		
Mainstem Sites							
CFR-03A	Clark Fork River near Galen	0.0017	0.0018	0.0027	0.0015	0.0003	0.0015
CFR-07D	Clark Fork River at Galen Road	0.0021	0.0022	0.0031	0.0021	0.0004	0.0011
CFR-11F	Clark Fork River at Gemback Road	0.0035	0.0032	0.0032	0.0026	ND	0.0010
CFR-27H	Clark Fork River at Deer Lodge	0.0046	0.0051	0.0025	0.0066	0.0015	0.0030
CFR-34	Clark Fork River at Williams-Tavenner Bridge	0.0057	0.0048	0.0036	0.0070	0.0012	0.0037
CFR-116A	Clark Fork River at Turah	0.0022	0.0016	0.0006	0.0040	0.0009	0.0003
Tributary Sites							
SS-19	Silver Bow Creek at Frontage Road	0.0018	---	0.0022	---	0.0013	0.0013
SS-25	Silver Bow Creek at Warm Springs	0.0016	0.0011	0.0023	0.0010	ND	0.0015
MCWC-MWB	Mill-Willow Creek at Frontage Road	0.0017	0.0018	0.0028	0.0017	0.0014	0.0031
MWB-SBC	Mill-Willow Bypass near mouth	0.0015	0.0016	0.0027	0.0013	ND	0.0006
WSC-SBC	Warm Springs Creek near mouth	0.0004	0.0006	0.0017	0.0013	ND	0.0004
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	0.0010	0.0008	0.0005	0.0005	ND	ND
FC-CFR	Flint Creek near mouth	0.0043	0.0031	0.0006	0.0014	0.0011	0.0009

--- Not sampled.

ND Not detected at analytical reporting limit.

Exceeds chronic aquatic life standard [MDEQ, 2012b].

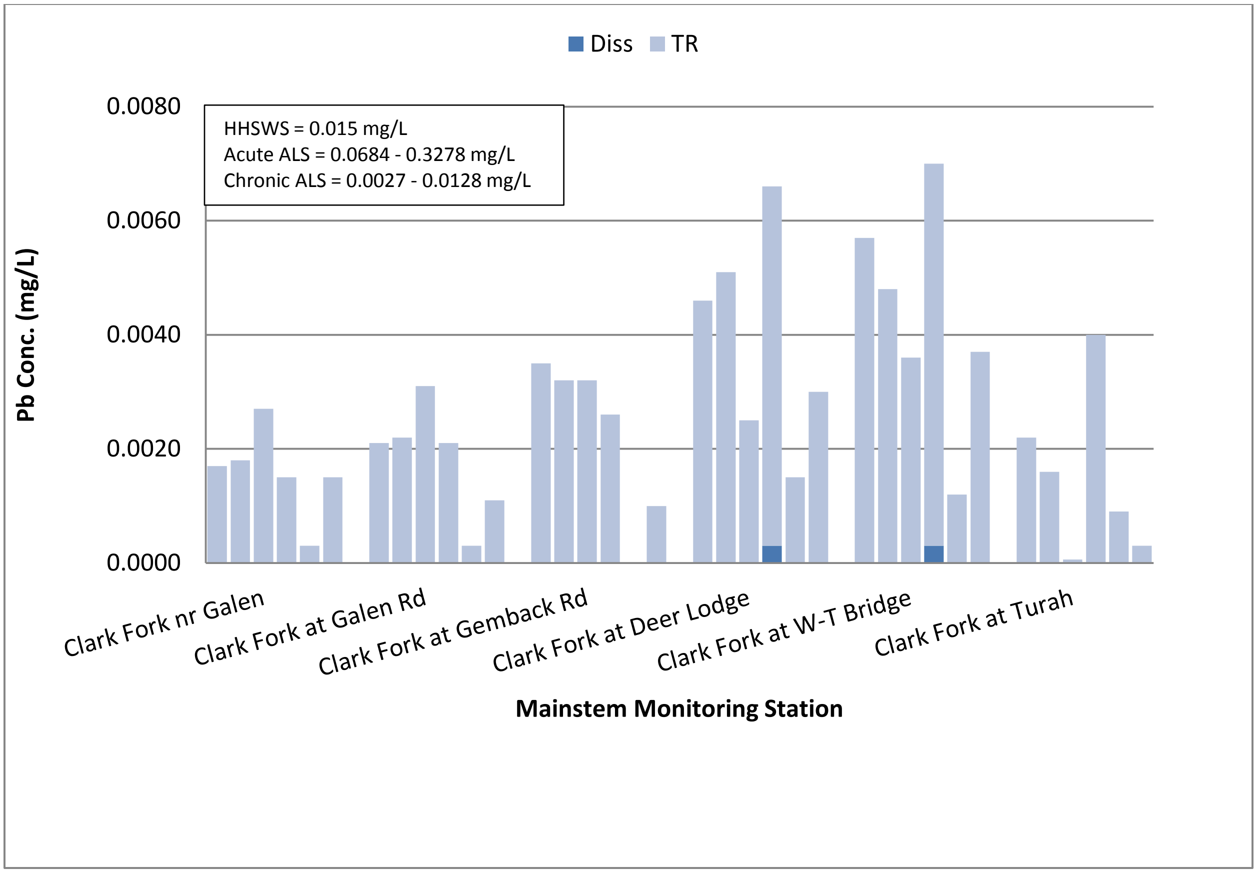

Figure 2-63. Total recoverable (total recoverable) and dissolved (Diss) lead (Pb) concentrations at mainstem sampling sites in the Clark Fork River Operable Unit, 2015. No bars indicate concentrations below the analytical reporting limit. Applicable water quality standards are the aquatic life standards (ALS) and the human health surface water standard (HHSWS) [MDEQ, 2012b].

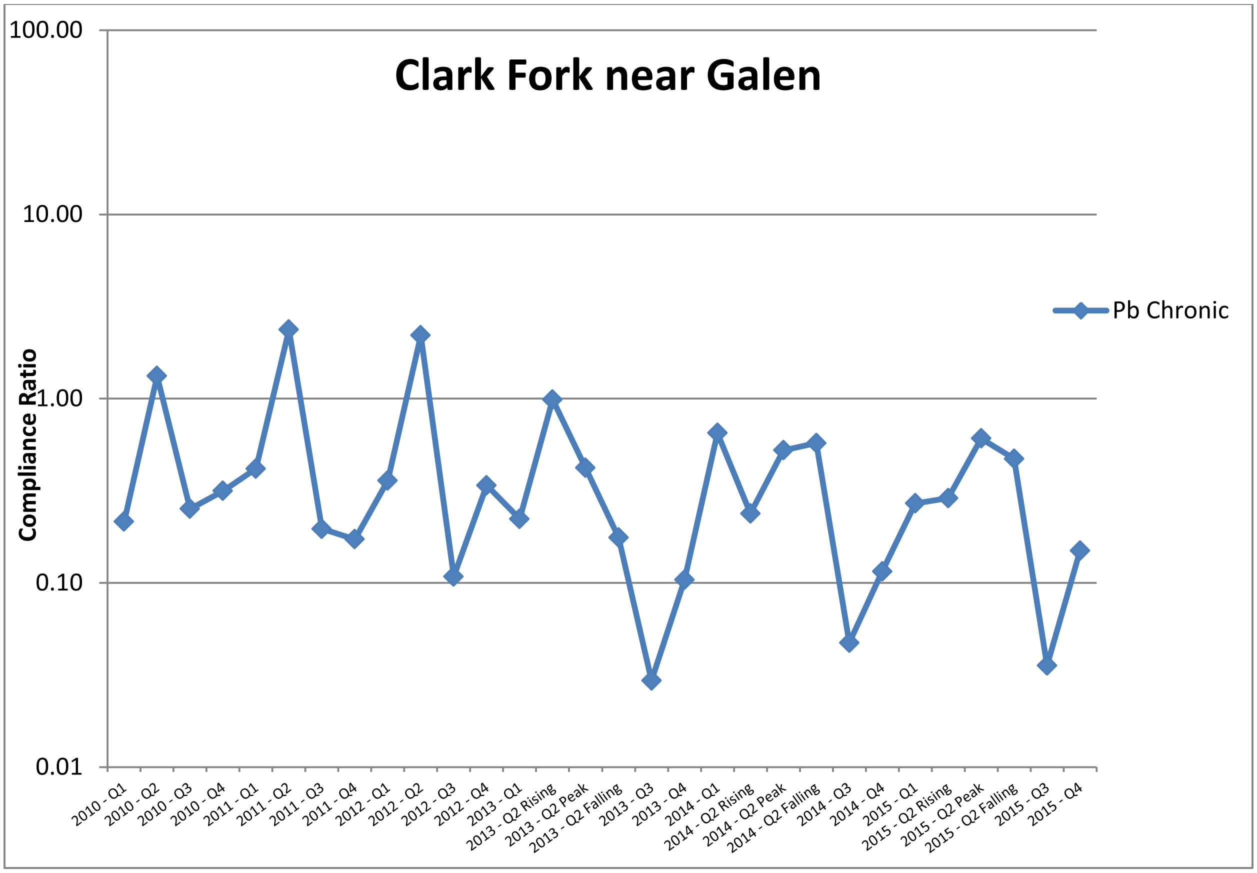

Figure 2-64. Total recoverable lead (Pb) compliance ratios for the Clark Fork River near Galen site, 2010-2015. Compliance ratios are based on the chronic aquatic life standard [MDEQ, 2012b].

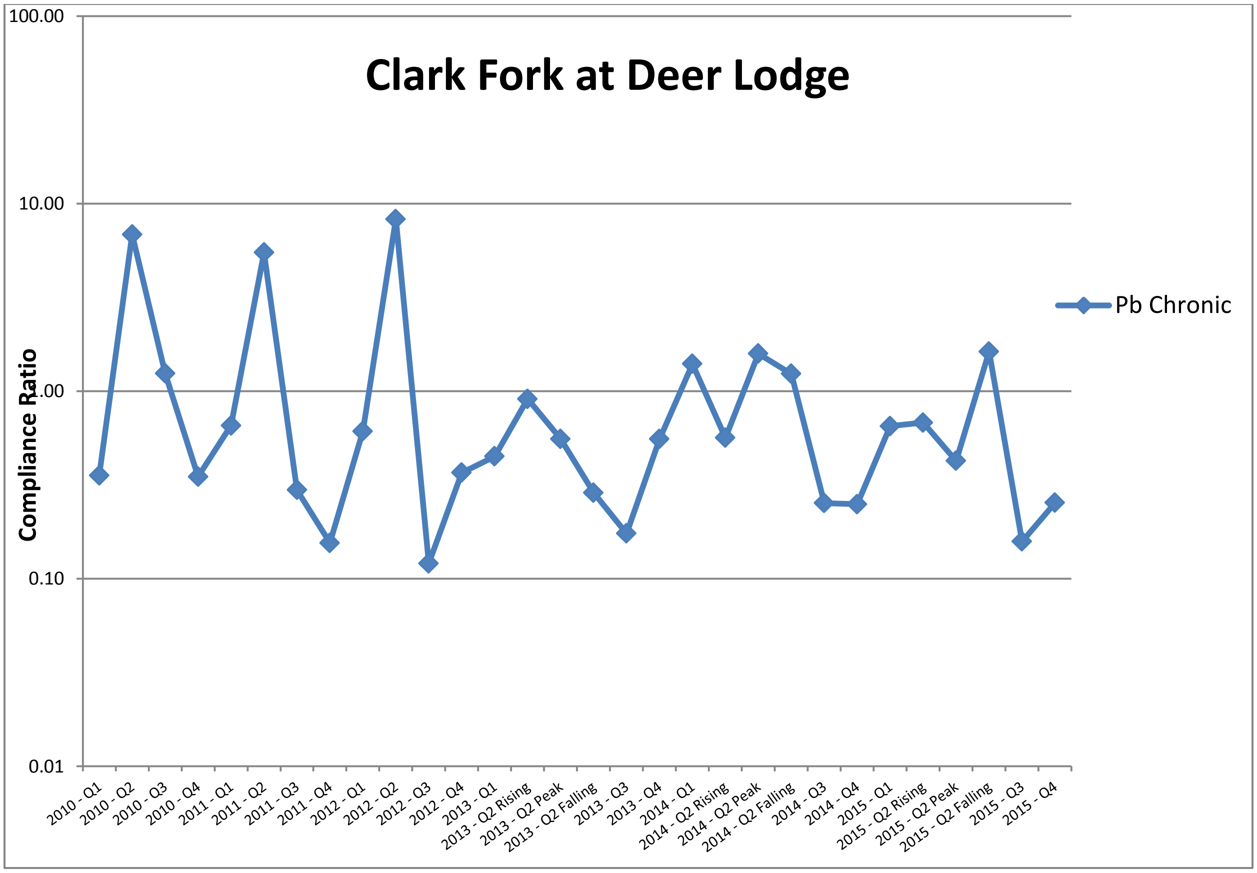

Figure 2-65. Total recoverable lead (Pb) compliance ratios for the Clark Fork River at Deer Lodge site, 2010-2015. Compliance ratios are based on the chronic aquatic life standard [MDEQ, 2012b].

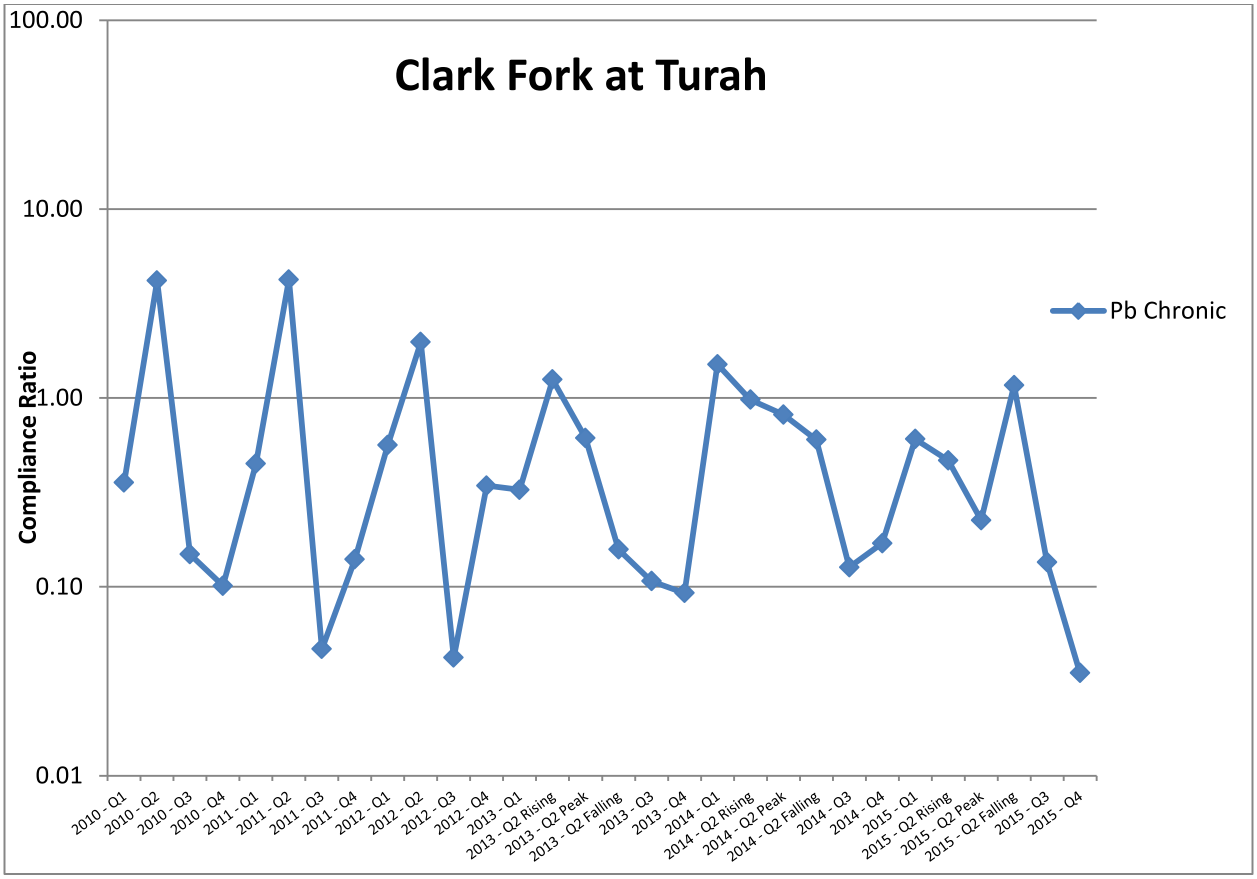

Figure 2-66. Total recoverable lead (Pb) compliance ratios for the Clark Fork River at Turah site, 2010-2015. Compliance ratios are based on the chronic aquatic life standard [MDEQ, 2012b].

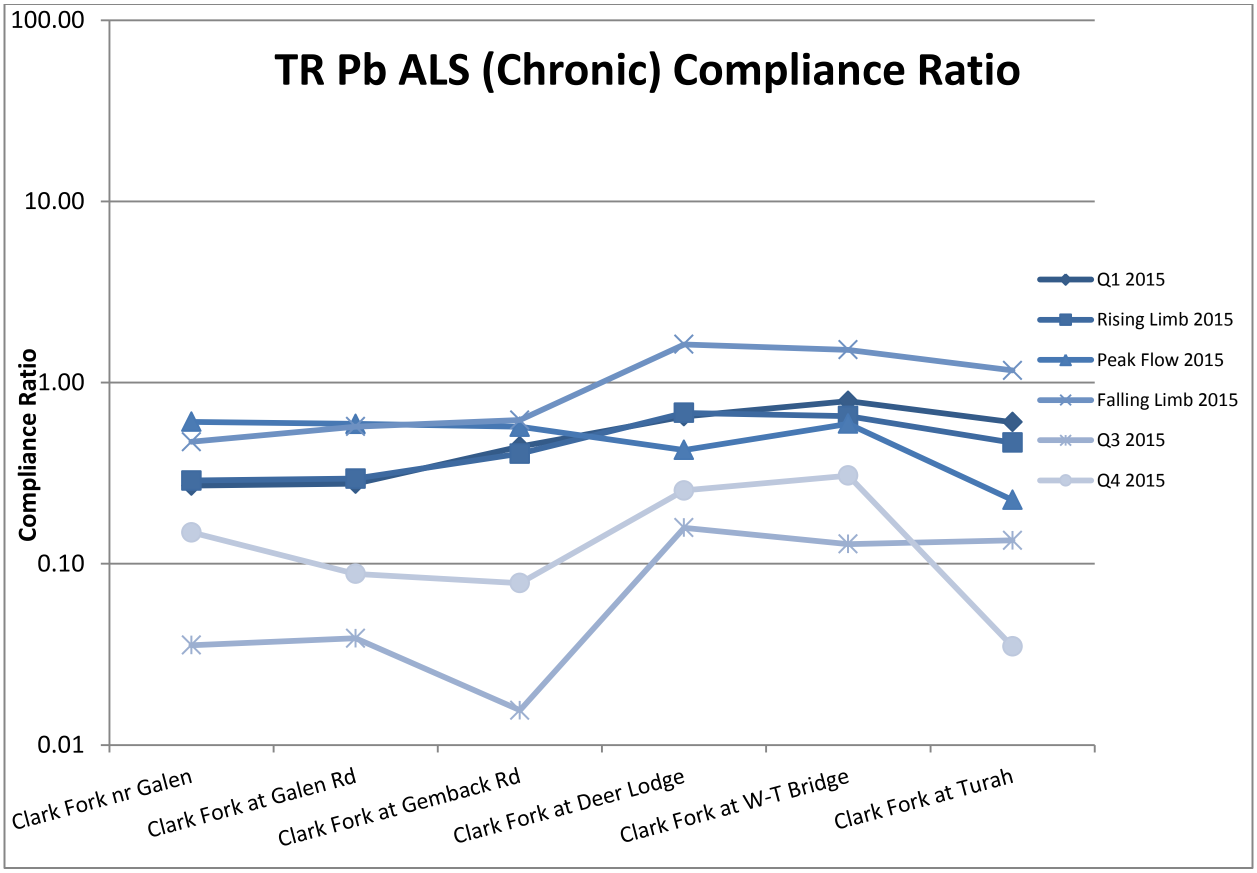

Figure 2-67. Total recoverable lead (TR Pb) compliance ratios for the Clark Fork River mainstem sites, 2015. Compliance ratios are based on the chronic aquatic life standard (ALS) [MDEQ, 2012b].

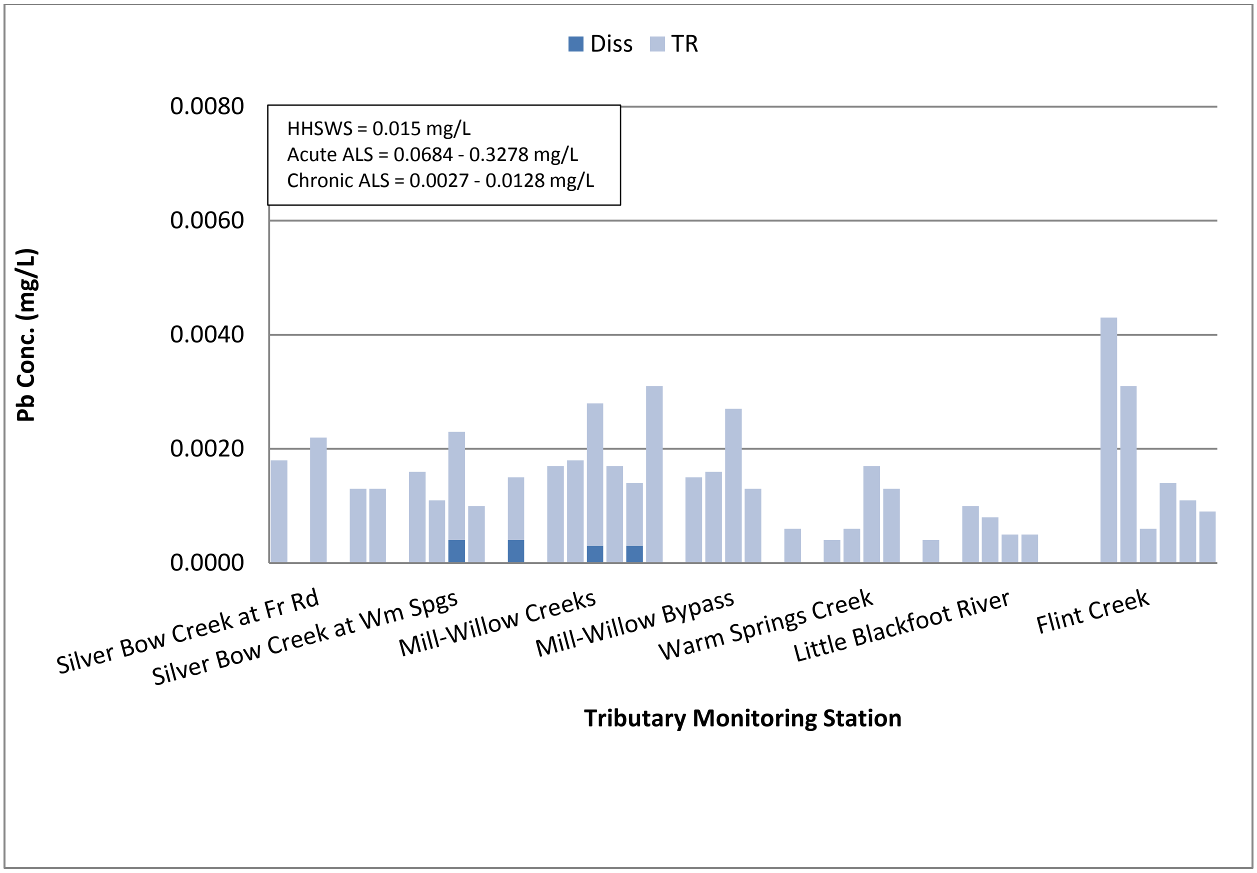

Figure 2-68. Total recoverable (TR) and dissolved (Diss) lead (Pb) concentrations at tributary sampling sites in the Clark Fork River Operable Unit, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "Silver Bow Creek at Fr Rd" site. Other sites or sample periods with no bars indicate concentrations below the analytical reporting limit. Applicable water quality standards are the aquatic life standards (ALS) and the human health surface water standard (HHSWS) [MDEQ, 2012b].

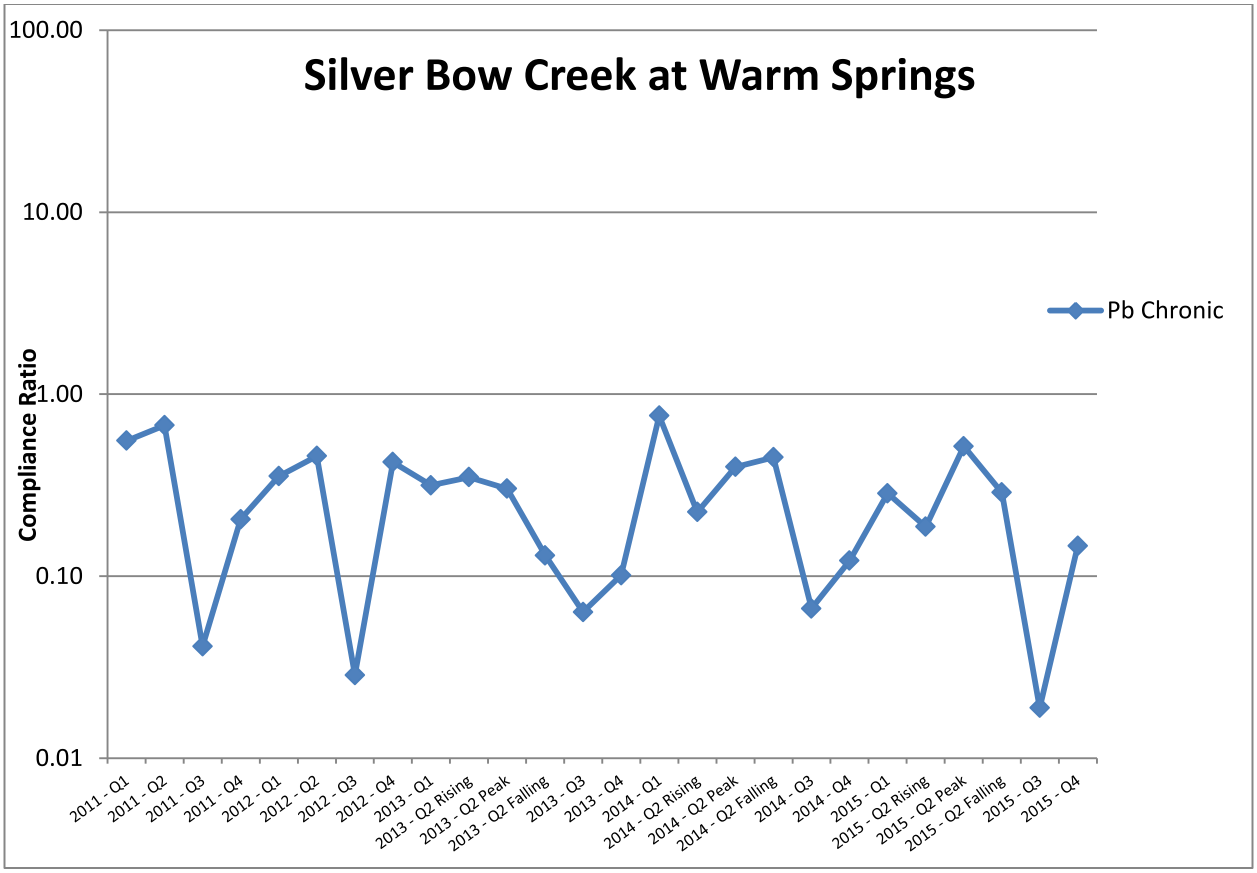

Figure 2-69. Total recoverable lead (Pb) compliance ratios for the Silver Bow Creek at Warm Springs site, 2011-2015. Compliance ratios are based on the chronic aquatic life standard [MDEQ, 2012b].

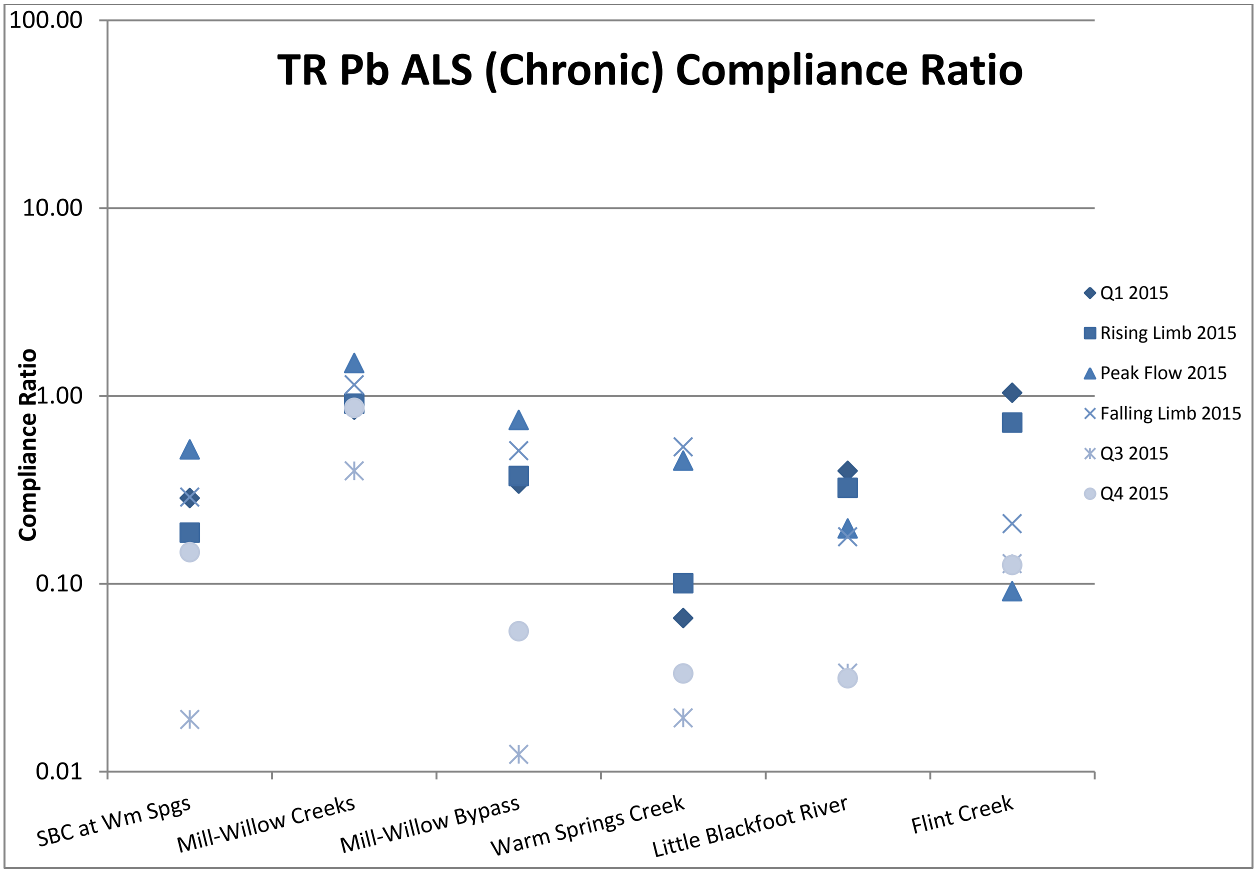

Figure 2-70. Total recoverable lead (TR Pb) compliance ratios for the Clark Fork River tributary sites, 2015. Compliance ratios are based on the chronic aquatic life standard (ALS) [MDEQ, 2012b].

2.3.6.5 Zinc

Dissolved zinc concentrations in the Clark Fork River mainstem in 2015 ranged from <0.008-0.013 mg/L and total recoverable concentrations ranged from <0.008-0.049 mg/L [Table 2-15]. Zinc concentrations in mainstem monitoring sites during 2015 were generally lowest at near Galen and increased at each downstream site to at Williams-Tavenner Bridge before decreasing at Turah [Figure 2-71].

Mainstem sites generally had the highest zinc concentrations during either the Q1 or one of the Q2 sample periods [Figure 2-71]. The lowest concentrations were generally observed in Q3 or Q4 [Figure 2-71]. The majority of the zinc measured in the mainstem monitoring stations during 2015 was present in the sediment-associated form [Figure 2-71].

In the mainstem, no exceedances of the most restrictive performance goal from the CFROU ROD [Table 2-1] for total recoverable zinc occurred [Table 2-15].

There does appear to be a slight decreasing zinc compliance ratio trend in the mainstem at near Galen [Figure 2-72], at Deer Lodge [Figure 2-73], and at Turah [Figure 2-74] from 2010-2015. All mainstem sites appeared to demonstrate a moderately pronounced seasonal trend with the highest zinc compliance ratios occurring during the runoff period (Q2) [Figure 2-72; Figure 2-73; Figure 2-74]. In 2015, total recoverable zinc compliance ratios in the mainstem were generally lowest in the three upper Reach A sites (near Galen, at Galen Road, and at Gemback Road), highest at the two downstream Reach A sites (at Deer Lodge and at the Williams-Tavenner Bridge), and variable at Turah [Figure 2-75]. However, the highest zinc compliance ratio in the mainstem was low (0.32) [Figure 2-75].

Dissolved zinc concentrations in the Clark Fork River tributaries in 2015 ranged from <0.008-0.012 mg/L and total recoverable concentrations ranged from <0.008-0.017 mg/L [Table 2-15]. Zinc concentrations from all tributary samples during 2015 were <0.20 mg/L with the exception of those from Silver Bow Creek at Frontage Road, which were substantially higher [Figure 2-76]. Between Silver Bow Creek sites above (at Frontage Road) and below (at Warm Springs), the Warm Springs Ponds zinc concentrations decreased by nearly 5-10 times during all paired sample periods [Figure 2-76]. Between Mill-Willow Creek sites above (at Frontage Road) and below (at Silver Bow Creek), the Mill-Willow Bypass zinc concentrations were similar during all paired sample periods [Figure 2-76].

The seasonal maxima and minima for zinc concentrations by tributary site was variable [Figure 2-76]. In the tributaries, no exceedances of the most restrictive performance goal from the CFROU ROD [Table 2-1] for total recoverable zinc occurred [Table 2-15].

Compliance ratios in Silver Bow Creek at Warm Springs for zinc from 2011-2015 have been low (≤0.20) throughout the monitoring period [Figure 2-77].

Table 2-15. Total recoverable zinc concentrations (mg/L) at Clark Fork River Operable Unit monitoring stations, 2015.

Site ID	Site Location	Sample Period					
		Q1	Q2			Q3	Q4
			Rising	Peak	Falling		
Mainstem Sites							
CFR-03A	Clark Fork River near Galen	0.015	0.013	0.017	0.011	ND	0.016
CFR-07D	Clark Fork River at Galen Road	0.017	0.017	0.020	0.015	ND	0.015
CFR-11F	Clark Fork River at Gemback Road	0.028	0.024	0.025	0.020	ND	0.015
CFR-27H	Clark Fork River at Deer Lodge	0.035	0.034	0.018	0.045	0.013	0.027
CFR-34	Clark Fork River at Williams-Tavenner Bridge	0.043	0.035	0.025	0.049	0.012	0.035
CFR-116A	Clark Fork River at Turah	0.021	0.015	ND	0.034	0.014	ND
Tributary Sites							
SS-19	Silver Bow Creek at Frontage Road	0.109	---	0.074	---	0.056	0.139
SS-25	Silver Bow Creek at Warm Springs	0.013	0.010	0.014	ND	ND	0.015
MCWC-MWB	Mill-Willow Creek at Frontage Road	0.011	0.010	0.015	0.009	ND	0.016
MWB-SBC	Mill-Willow Bypass near mouth	0.010	0.010	0.015	0.008	ND	ND
WSC-SBC	Warm Springs Creek near mouth	ND	ND	0.009	0.008	ND	ND
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	ND	ND	ND	ND	ND	ND
FC-CFR	Flint Creek near mouth	0.016	0.012	ND	ND	ND	ND

ND Not detected at analytical reporting limit.

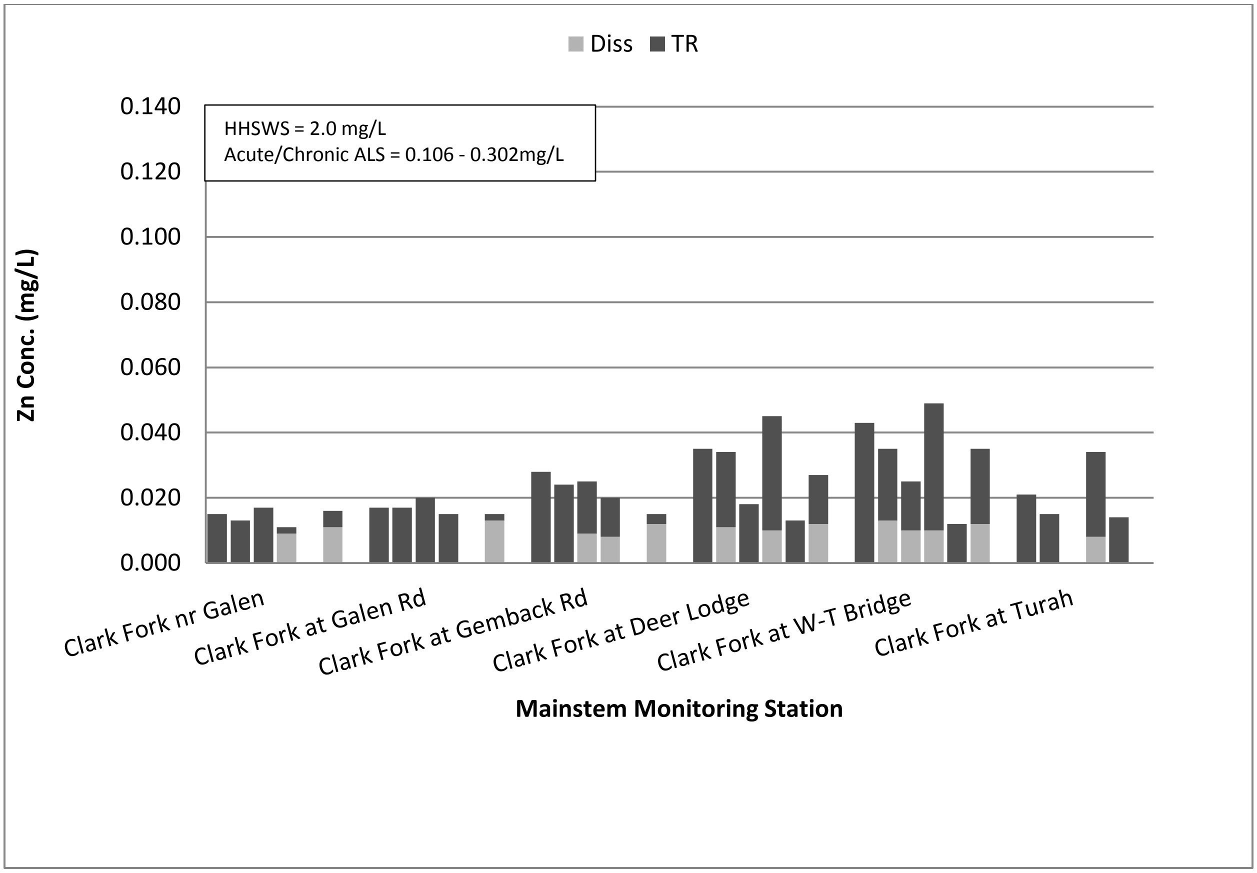

Figure 2-71. Total recoverable (TR) and dissolved (Diss) zinc (Zn) concentrations at mainstem sampling sites in the Clark Fork River Operable Unit, 2015. No bars indicate concentrations below the analytical reporting limit. Applicable water quality standards are the aquatic life standard (ALS) and the human health surface water standard (HHSWS) [MDEQ, 2012b].

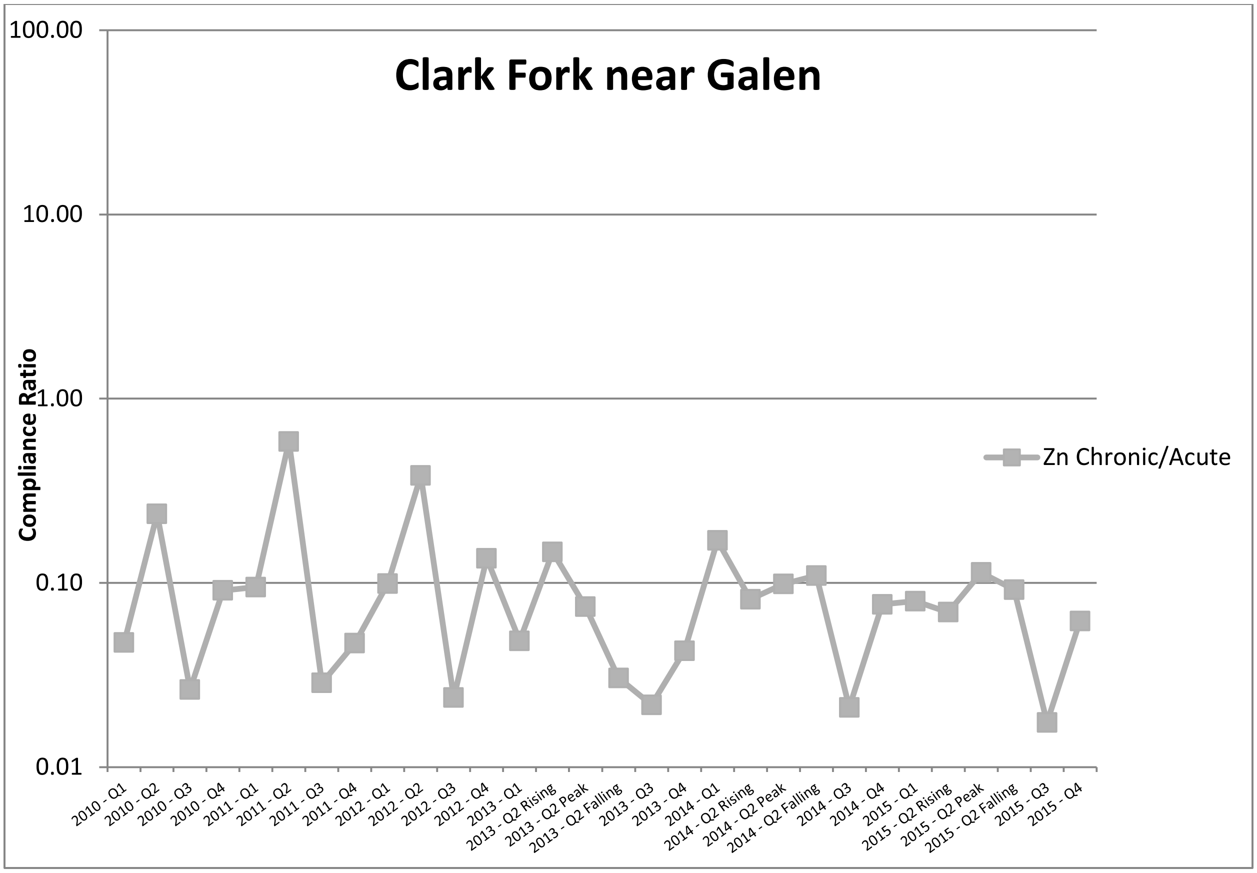

Figure 2-72. Total recoverable zinc (Zn) compliance ratios for the Clark Fork River near Galen site, 2010-2015. Compliance ratios are based on the aquatic life standard [MDEQ, 2012b].

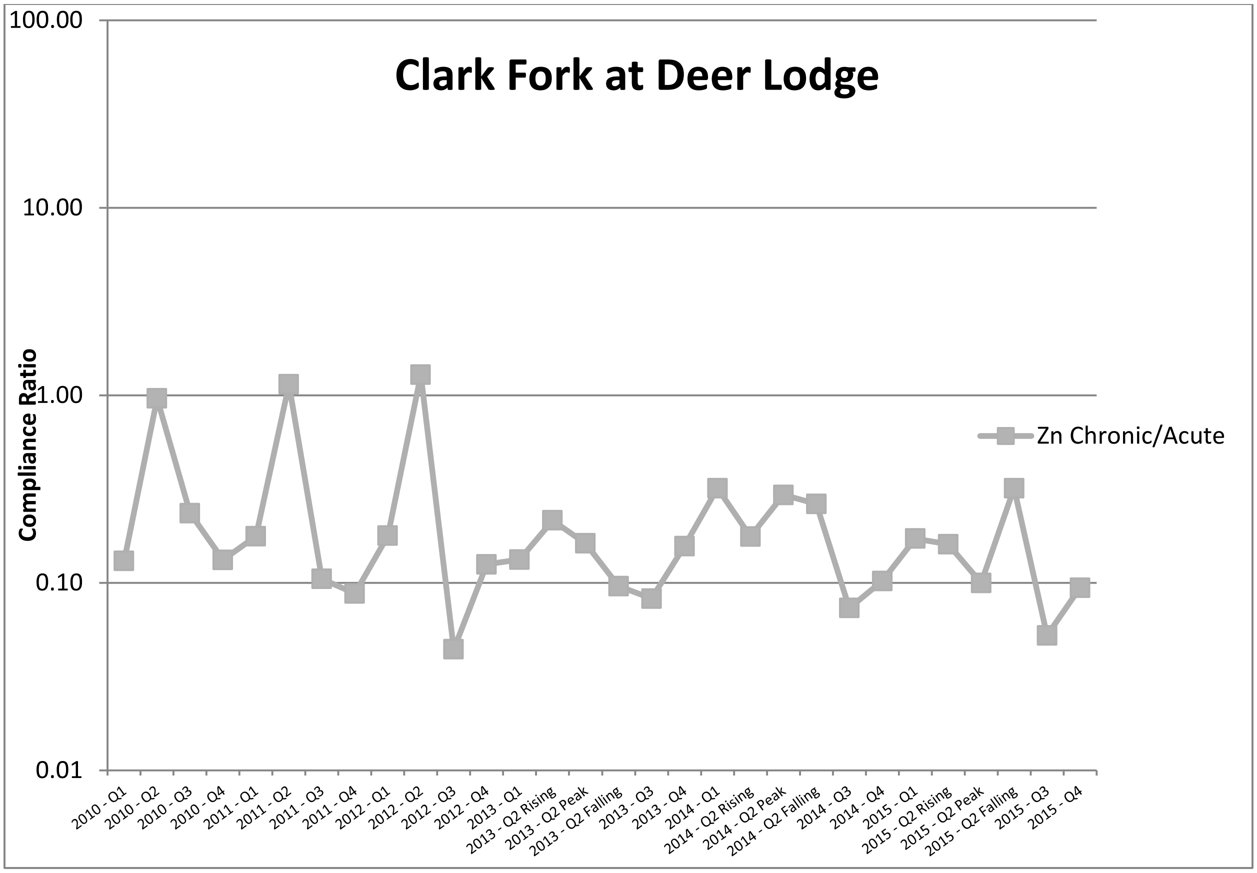

Figure 2-73. Total recoverable zinc (Zn) compliance ratios for the Clark Fork River at Deer Lodge site, 2010-2015. Compliance ratios are based on the aquatic life standard [MDEQ, 2012b].

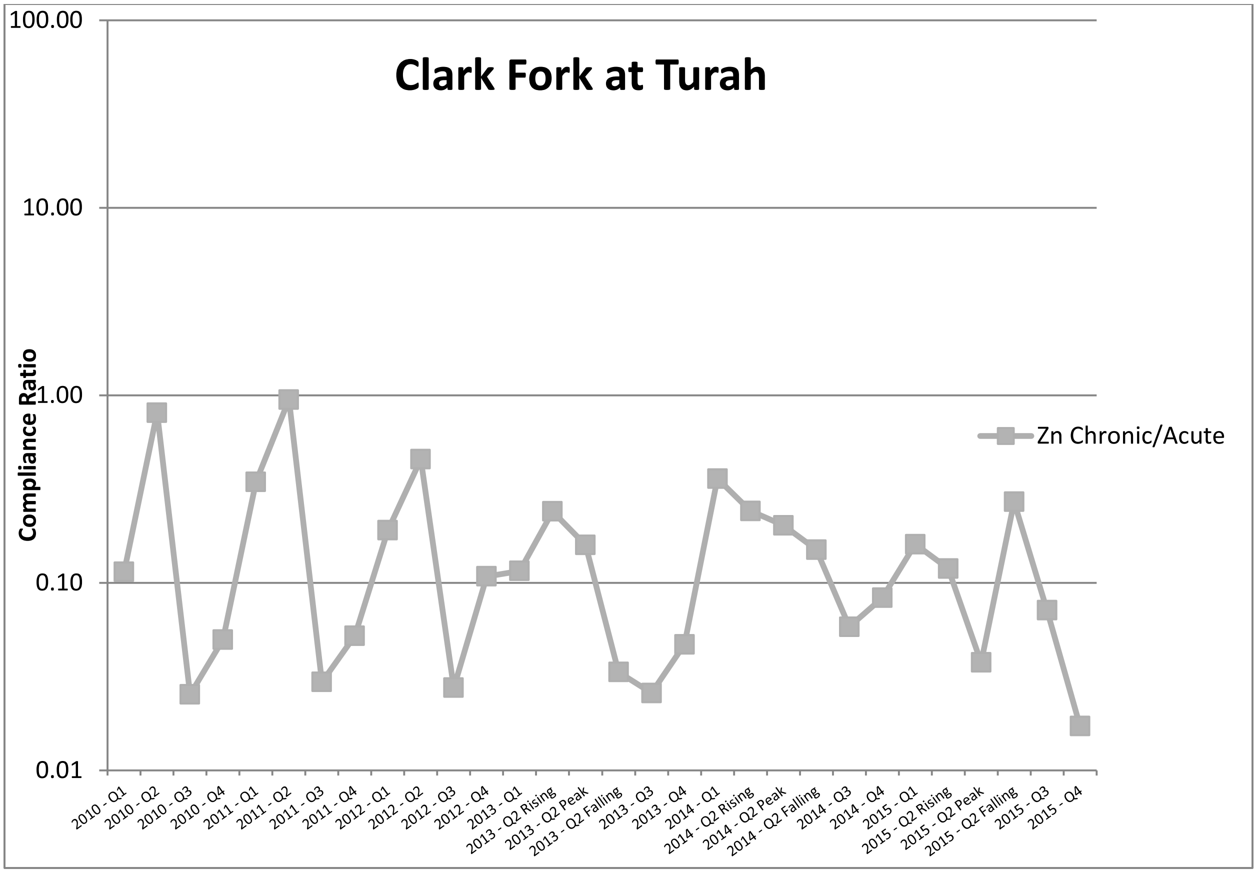

Figure 2-74. Total recoverable zinc (Zn) compliance ratios for the Clark Fork River at Turah site, 2010-2015. Compliance ratios are based on the aquatic life standard [MDEQ, 2012b].

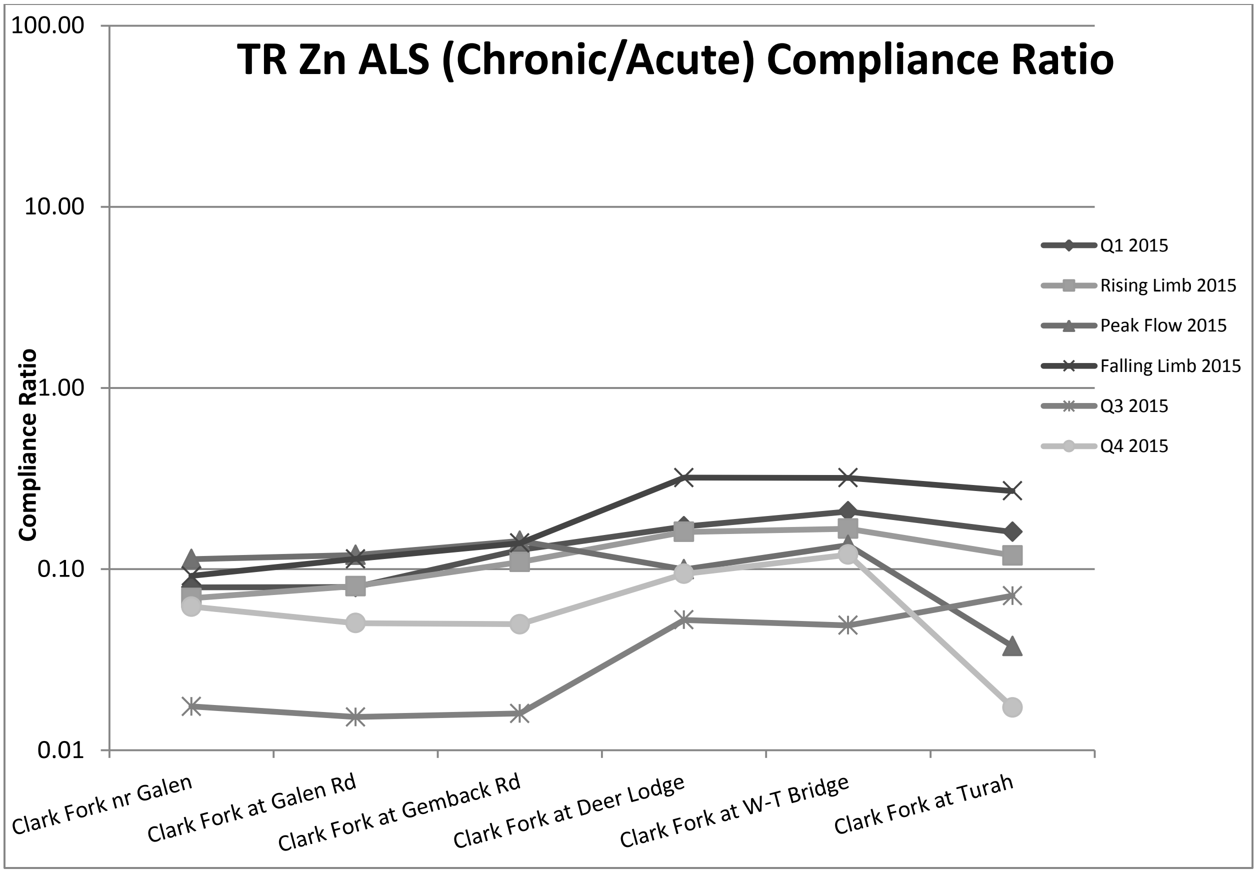

Figure 2-75. Total recoverable zinc (TR Zn) compliance ratios for the Clark Fork River mainstem sites, 2015 Compliance ratios are based on the chronic and acute aquatic life standard (ALS) [MDEQ, 2012b].

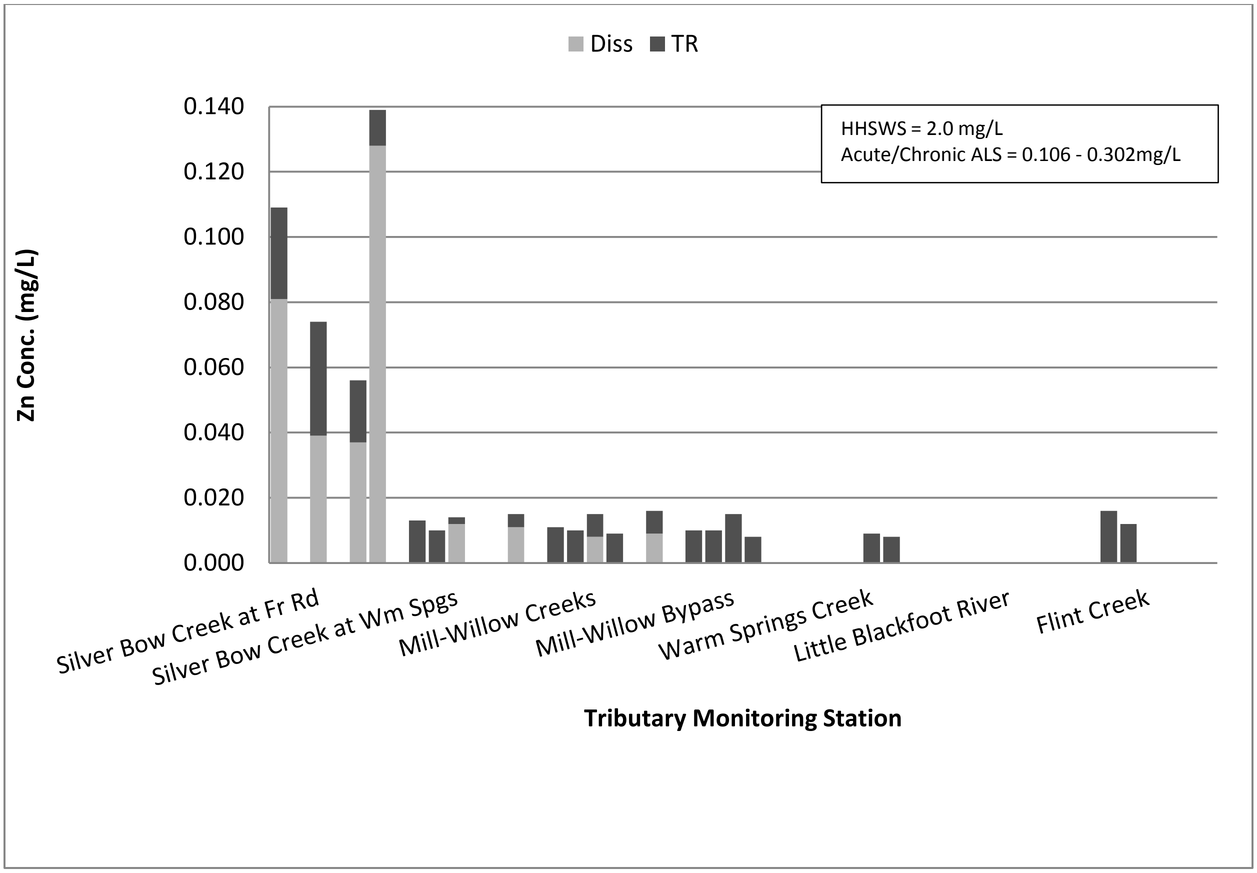

Figure 2-76. Total recoverable (TR) and dissolved (Diss) zinc (Zn) concentrations at tributary sampling sites in the Clark Fork River Operable Unit, 2015. No samples were collected during the Q2-Rising Limb and Q2-Falling Limb monitoring periods at the "Silver Bow Creek at Fr Rd" site. Other sites or sample periods with no bars indicate concentrations below the analytical reporting limit. Applicable water quality standards are the aquatic life standard (ALS) and the human health surface water standard (HHSWS) [MDEQ, 2012b].

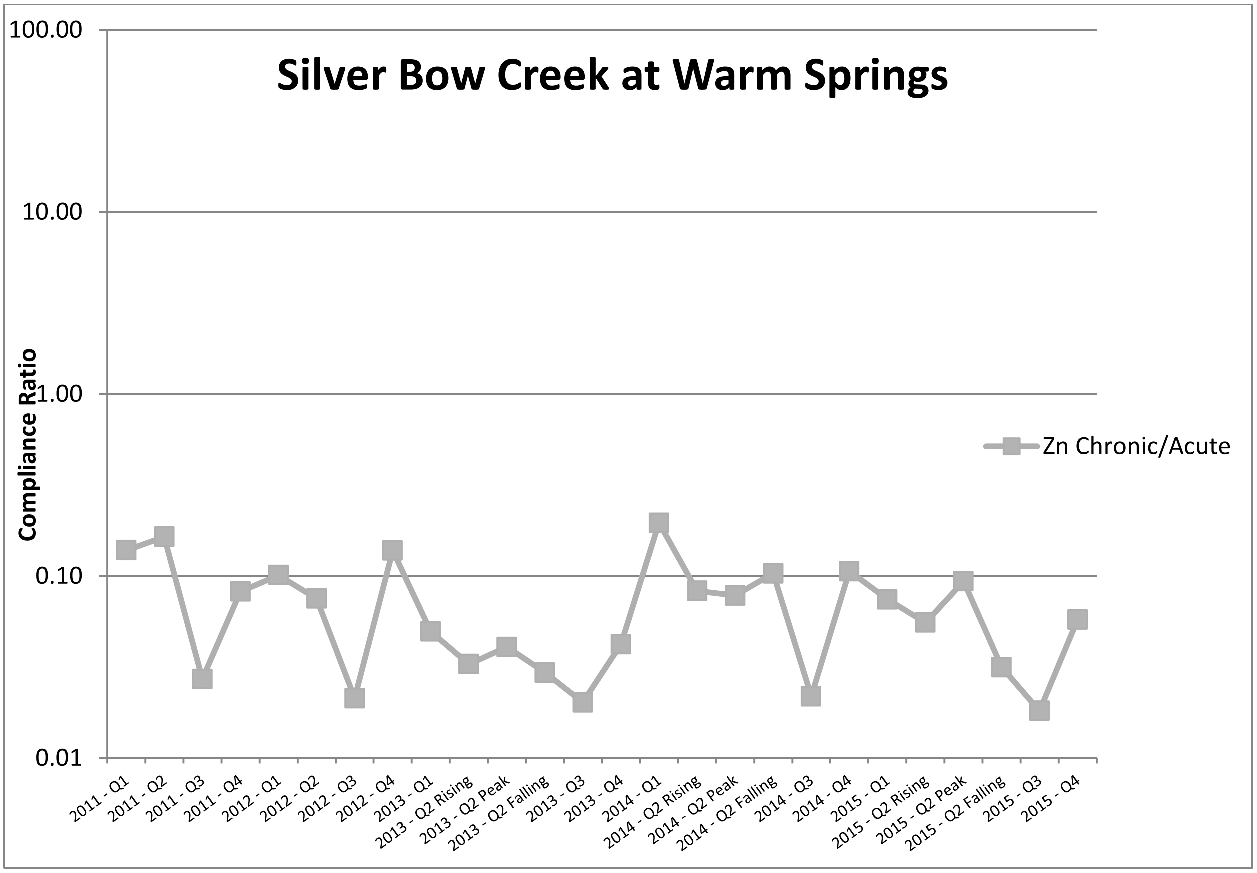

Figure 2-77. Total recoverable zinc (Zn) compliance ratios for the Silver Bow Creek at Warm Springs site, 2011-2015. Compliance ratios are based on the aquatic life standard [MDEQ, 2012b].

2.3.7 Other Metals

2.3.7.1 Mercury

Total mercury concentrations in the Clark Fork River near Drummond in 2015 ranged from 0.000007-0.000083 mg/L [Table 2-16]. Total mercury concentrations in the Clark Fork River near Drummond were highest in Q1 and lowest in Q4 [Figure 2-78]. Three exceedances of the HHSWS occurred in the Clark Fork River near Drummond, all of which occurred in Q1 or Q2 [Table 2-16]. There does not appear to be an increasing or decreasing mercury compliance ratio trend in the Clark Fork River near Drummond from 2012-2015 [Figure 2-79].

Total mercury concentrations in Flint Creek in 2015 ranged from 0.000330-0.000017 mg/L [Table 2-16]. Total mercury concentrations in Flint Creek were highest in Q1 and lowest in Q4 [Figure 2-78]. Three exceedances of the HHSWS occurred in Flint Creek, all of which occurred in Q1 or Q2 [Table 2-16]. There appears to be a slight decreasing mercury compliance ratio trend in Flint Creek from 2012-2015 although due to the large variability in the samples it is difficult to identify any trend over the relatively short duration of monitoring at the site [Figure 2-80].

Table 2-16. Total mercury concentrations (mg/L) at Clark Fork River Operable Unit monitoring stations, 2015.

Site ID	Site Location	Sample Period					
		Q1	Q2			Q3	Q4
			Rising	Peak	Falling		
Mainstem Sites							
CFR-84F	Clark Fork River near Drummond	0.000083	0.000058	0.000016	0.000064	0.000016	0.000007
Tributary Sites							
FC-CFR	Flint Creek near mouth	0.000330	0.000160	0.000022	0.000056	0.000041	0.000017

Exceeds human health surface water standard [MDEQ, 2012b].

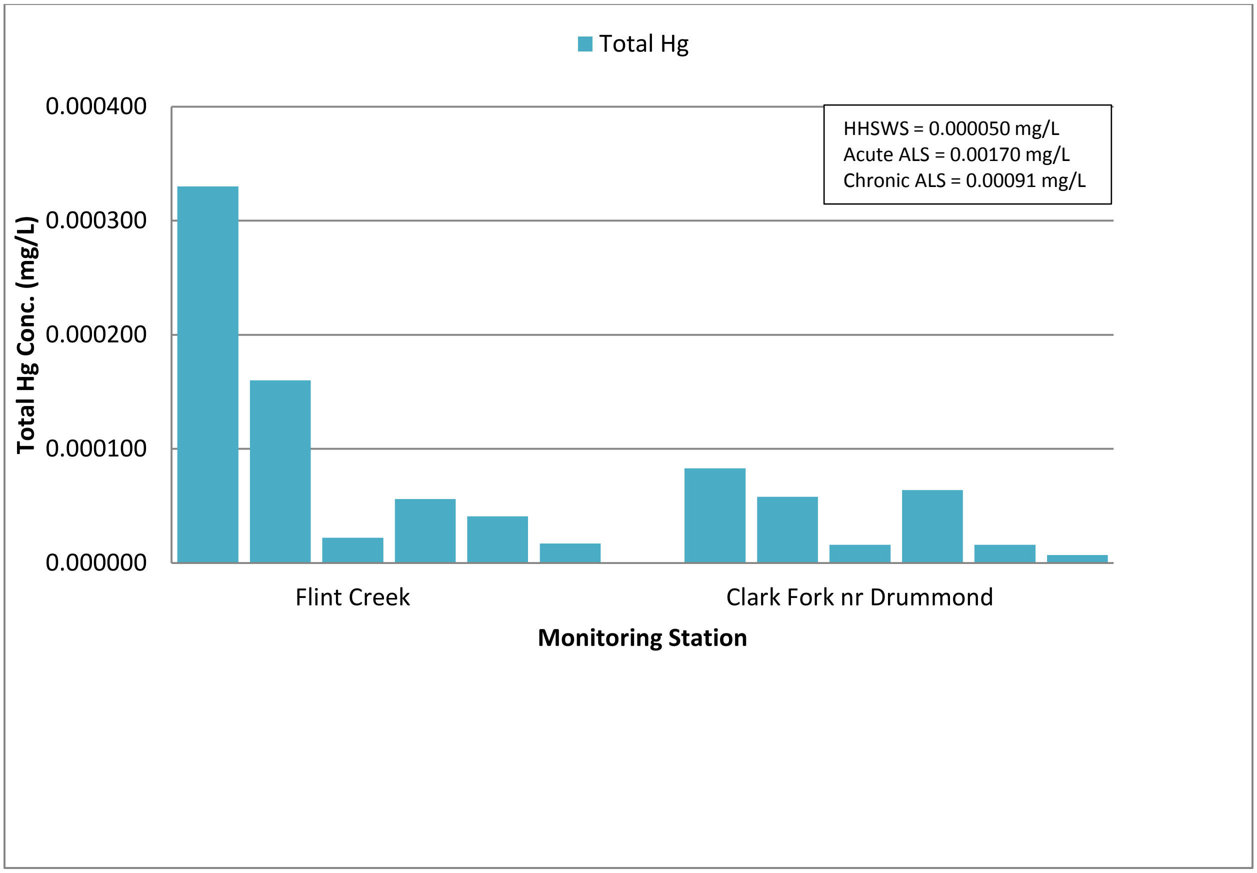

Figure 2-78. Total mercury (Hg) concentrations at sampling sites in the Clark Fork River Operable Unit, 2015. Applicable water quality standards are the aquatic life standards (ALS) and the human health surface water standard (HHSWS) [MDEQ, 2012b].

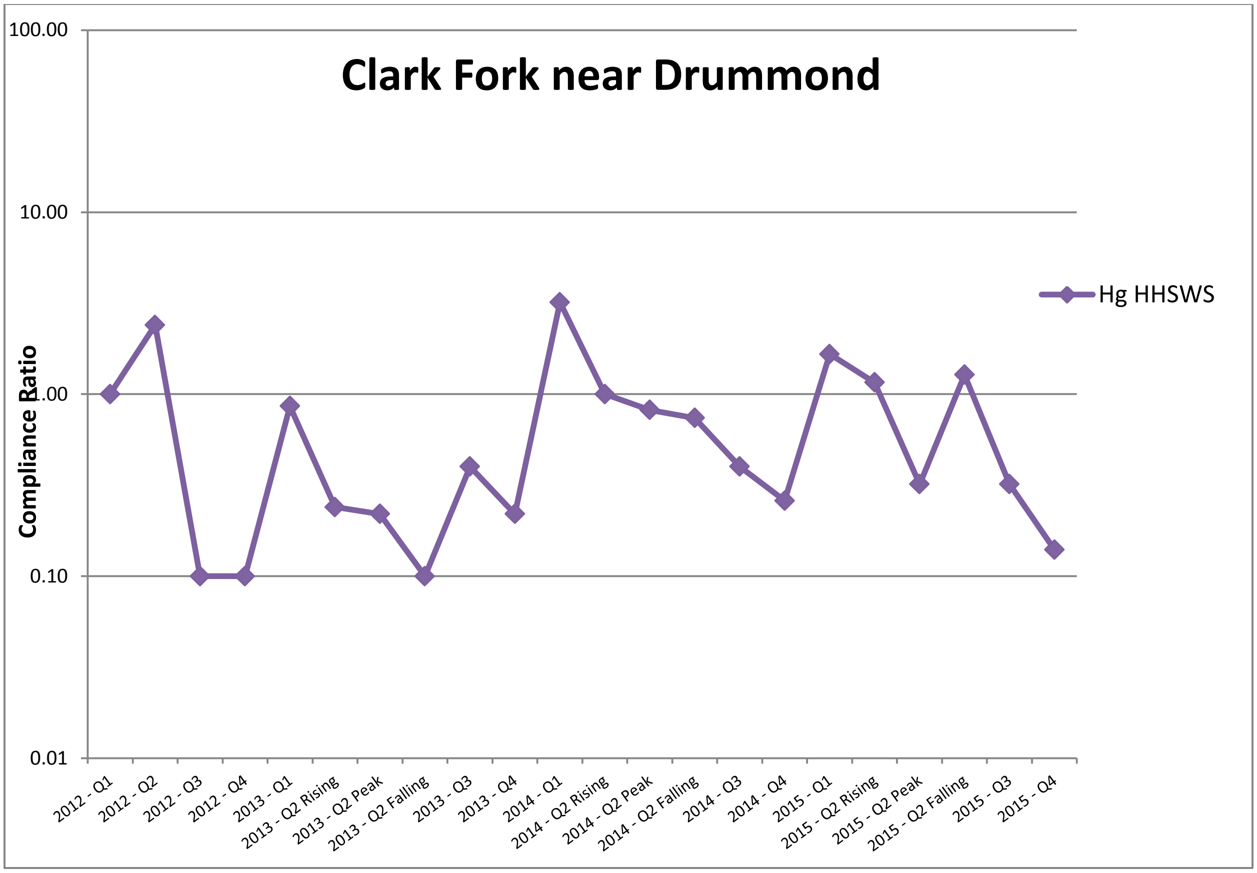

Figure 2-79. Total mercury (Hg) compliance ratios for the Clark Fork River near Drummond site, 2012-2015. Compliance ratios are based on the human health surface water standard (HHSWS) [MDEQ, 2012b].

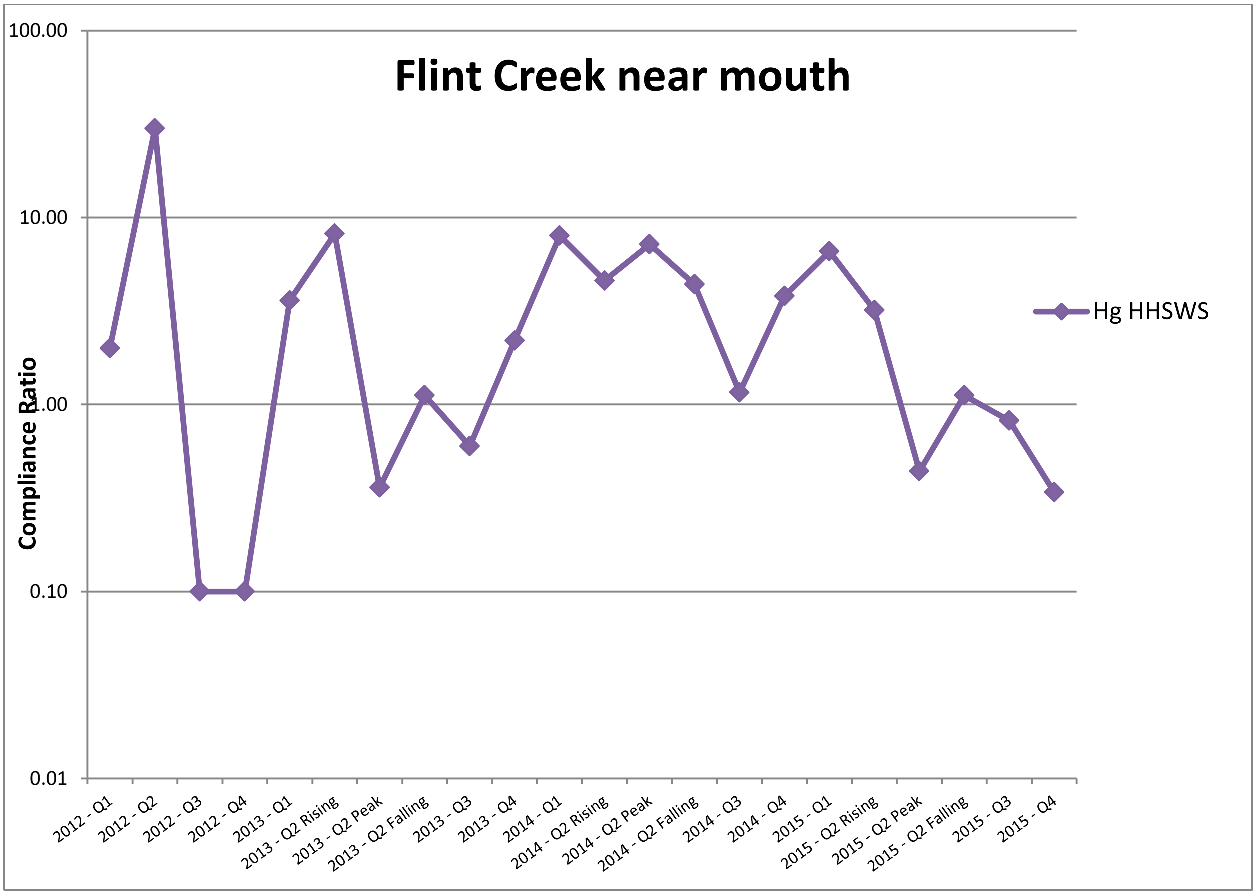

Figure 2-80. Total mercury (Hg) compliance ratios for the Flint Creek near mouth site, 2012-2015. Compliance ratios are based on the human health surface water standard (HHSWS) [MDEQ, 2012b].

2.3.7.2 Methylmercury

Methylmercury concentrations in the Clark Fork River near Drummond in 2015 ranged from 0.145-0.728 ng/L [Table 2-17]. Methylmercury concentrations in the Clark Fork River near Drummond were highest in Q3 and lowest during the Q2-Peak period [Figure 2-81]. T

Methylmercury concentrations in Flint Creek in 2015 ranged from 0.424-1.230 ng/L [Table 2-17]. Methylmercury concentrations in Flint Creek were highest in Q3 and lowest in Q4 [Figure 2-81].

Table 2-17. Methylmercury concentrations (ng/L) at Clark Fork River Operable Unit monitoring stations, 2015.

Site ID	Site Location	Sample Period					
		Q1	Q2			Q3	Q4
			Rising	Peak	Falling		
Mainstem Sites							
CFR-84F	Clark Fork River near Drummond	0.333	0.321	0.145	0.426	0.728	0.227
Tributary Sites							
FC-CFR	Flint Creek near mouth	0.786	1.080	0.819	1.470	1.230	0.424

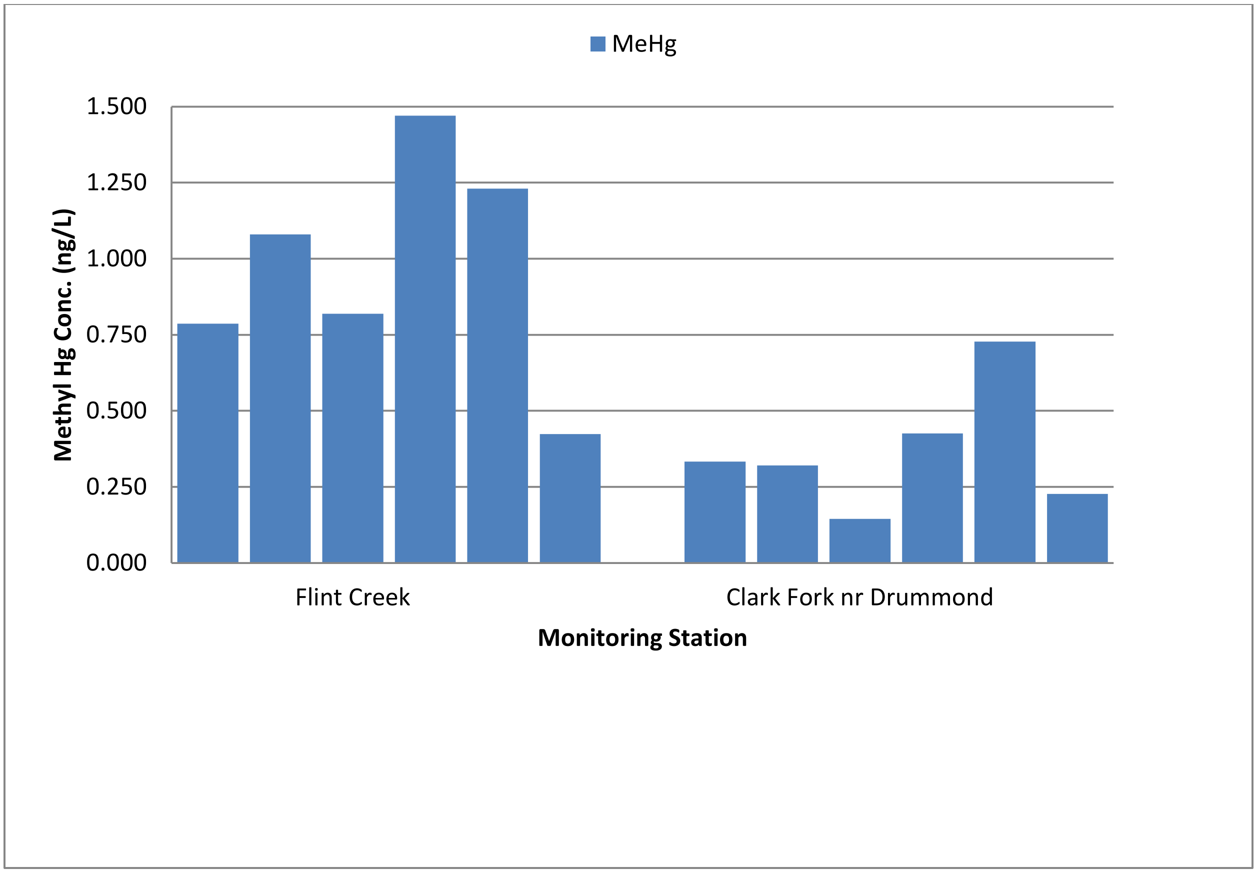

Figure 2-81. Methylmercury concentrations at sampling sites in the Clark Fork River Operable Unit, 2015.

2.3.8 Data Validation

Data derived from laboratory analysis of surface water samples collected at upper Clark Fork River locations were validated through field quality control samples (i.e., field duplicates and field blanks) and laboratory control samples (lab duplicates, blanks, spikes, and reference and calibration standards. Analysis of field quality measures are described in Appendix A. Results of laboratory quality control measures are described in Appendix B. Data quality objectives (DQOs) were evaluated for accuracy and precision. These DQOs were largely met in 2015, with a few exceptions.

Analyte concentrations were measured in field blanks to evaluate sampling accuracy and the extent to which the field techniques may have contaminated the samples. Twelve field blank samples were collected in 2015 and twenty-five analytes were analyzed in each. Six field blanks, were also analyzed for total mercury and methylmercury concentrations. Therefore, in total 312 analyte concentrations were evaluated in the field blanks and 4.5% (14 of 312) of the analytes had concentrations equal to or greater than the respective analytical reporting limit. Alkalinity was detected in 8.3% (1 of 12) of the field blank samples with a concentration of 4 mg/L (reporting limit [RL] = 4 mg/L). Bicarbonate alkalinity was detected in 16.7% (2 of 12) of the field blank samples with concentrations of 4 mg/L and 5 mg/L (RL = 4 mg/L). Water hardness was detected in 8.3% (1 of 12) of the field blank samples with a concentration of 1 mg/L (RL = 1 mg/L). Dissolved zinc was detected in 75% (9 of 12) of the field blank samples; detectable dissolved zinc concentrations in field blanks ranged from 0.008-0.020 mg/L (mean of detectable concentrations = 0.010 mg/L; RL = 0.008 mg/L).

Analyte concentrations were compared in field sample and field duplicate pairs to evaluate overall sampling precision. Twelve field sample and field duplicate pairs were collected in 2015 and twenty-five analytes were analyzed in each. Six field sample and field duplicate pairs were also analyzed for total mercury and methylmercury concentrations. Therefore, in total 312 comparisons were made between field sample and field duplicate pairs and the relative percent difference (RPD) of those pairs exceeded 25% in 1.3% (4 of 312) of the pairs. Some pairs had RPD >25% but either the field sample, field duplicate, or both had a concentration that was less than five times greater than the RL and therefore the RPD from those pairs were disregarded. Field sample and field duplicate pairs with RPD >25%, and sample and duplicate concentrations >5 times the RL included: chloride at CFR-11F on April 29, 2015 (RPD = 46.2%); total mercury at FC-CFR on March 24, 2015 (RPD = 58.8%); total suspended solids at FC-CFR on March 24, 2015 (RPD = 30.0%); and total mercury at FC-CFR on September 10, 2015 (RPD = 44.8%).

2.4 DISCUSSION

2.4.1 Streamflows

Streamflows in the upper Clark Fork River watershed were variable in 2015 compared to long-term records compiled by the USGS. Early in the year, streamflows were elevated presumably due to low elevation snowmelt during an unseasonably warm period in February. Later in the spring and summer, lower than normal streamflows occurred. Those low streamflows likely contributed to lower than average turbidity, suspended sediment concentrations, COC concentrations, and higher than average water hardness. The combination of low COC concentrations and high water hardness contributed to the relatively low occurrence of COC excursions in 2015. Conversely, maximum water temperatures in 2015 were relatively high, which was likely due in part, to the low streamflows during the spring and summer months.

2.4.2 Field Parameters

2.4.2.1 Water Temperature

Water temperature has considerable chemical and biological significance in riverine systems. Stream temperatures reflect seasonal changes in net solar radiation as well as daily changes in air temperature, and vary as a function of stream morphological characteristics, groundwater inputs, shading, the presence of particulate matter in the water column, and other variables.

Optimal water temperatures for most trout species is approximately 12–14 C. Sustained temperatures in the 20–25 C temperature range can be fatal for trout.

Temperature monitoring results for the upper Clark Fork River monitoring stations during 2015 indicated modest seasonal and spatial variations that periodically were higher than the preferred range for cold water organisms such as trout. The maximum recorded water temperature was 20.9 C at the Clark Fork River at Williams-Tavenner Bridge site. However, stream temperatures are extremely variable as a result of weather and diel variation and this monitoring program is not intended to capture extreme temperature swings. More detailed hourly temperature data collected by Montana Fish, Wildlife and Parks indicated that water temperatures in the Clark Fork River and tributaries were extremely stressful for trout, regularly exceeding 20 C and may occasionally exceed 25 C in the summer months at many of these sites (see Section 7.0)

2.4.2.2 pH

Water pH measures the acidity of water as the concentration of hydrogen ions on a logarithmic scale. Acidity is influenced by water temperature, although the relationship is not linear, and typically shows a weak inverse relationship to streamflow as concentrations of base minerals tend to become diluted during runoff conditions. Acidity typically fluctuates on a diel cycle in relation to stream metabolism, with pH highest during the day. As dissolved carbon dioxide (a weak acid) levels increase during the night (because photosynthesis does not occur), pH levels decrease. Stream pH has direct and indirect effects on water chemistry and the biota of aquatic systems. Declines in pH below 6.5 may reduce salmonid egg production and hatching success, and may reduce the emergence of some aquatic insects. The solubility of some metals varies with pH. This is important in systems such as the Clark Fork River where metal concentrations in sediments are elevated. Stream pH also affects a variety of other instream chemical equilibria, for example the proportion of ammonia present in the toxic (un-ionized) form.

The Montana Department of Environmental Quality has concluded that pH levels need to be maintained within the 6.5-9.0 range to protect aquatic life. Generally, pH measured in the Clark Fork River during 2015 monitoring events was within these recommended levels. However, in Q3 2015 pH exceeded 9.0 in Silver Bow Creek at Warm Springs (9.03) and in the Clark Fork River at Williams-Tavenner Bridge (9.12). In addition, pH in Silver Bow Creek immediately downstream from the Warm Springs Ponds is known to commonly exceed 9.0 during the summer (S. Lubick, Pioneer-Technical Services, *unpublished data*). In Silver Bow Creek downstream from the treatment ponds, elevated daytime pH may be the result of excessive liming, diel cycles related to high productivity from nutrient enrichment, or both [Nimmick et al., 2011; Chatham, 2012]. At the Williams-Tavenner Bridge, which is approximately 35 miles downstream from the Warm Springs Ponds, elevated pH during summer afternoons may be related to increased primary productivity from nutrient enrichment.

2.4.2.3 Conductivity

Conductivity is a quantitative measure of the ability of an aqueous solution to convey an electrical current, and is a function of water temperature and the concentration of dissolved ions in water. Conductivity provides an approximation of the concentration of dissolved solids in water as well as its potential suitability for uses that may be limited by excessive salinity. Conductivity also gives general insight into spatial and seasonal changes in water chemistry.

Elevated levels of conductivity reflecting high dissolved solids may limit some water uses, such as irrigation or drinking water. Very low conductivity, as affected by watershed geology, may contribute to low productivity of associated biological systems. Conductivity tends to be inversely proportional to streamflow due to dilution from spring snowmelt runoff, and we observed that conductivity was generally highest during the late summer sample period when streamflows were lowest. Conductivity measured in the Clark Fork River mainstem in 2015 ranged from 177-569 μS/cm. In comparison, the USEPA states, “Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a (conductivity) range between 150 and 500 μS/cm” [USEPA, 2015].

2.4.2.4 Dissolved Oxygen

Dissolved oxygen refers to the amount of oxygen dissolved in water. The capacity of water to hold oxygen in solution is inversely proportional to water temperature. In addition to water temperature, instream dissolved oxygen concentrations are affected by respiration of organisms, photosynthesis of aquatic plants, the biochemical oxygen demand of substances in the water, and the solubility of atmospheric oxygen. Dissolved oxygen levels fluctuate seasonally and over diel cycles due to variation in rates of stream metabolism.

Adequate dissolved oxygen concentrations are required by biological stream communities and for the decomposition of organic matter in the stream. Acceptable levels of dissolved oxygen for the protection of aquatic life are defined in the Montana water quality standards [MDEQ, 2012b]. Values that apply to the upper Clark Fork River range from a high of 9.5 mg/L, measured as a seven-day mean concentration where sensitive early life stages of aquatic species are present, to a low of 4.0 mg/L measured as a one-day minimum where early life stages of aquatic species are not present [MDEQ, 2012b].

No dissolved oxygen concentrations in the CFROU in 2015 indicated water quality or water use limitations associated with low oxygen concentrations (range: 7.2-15.8 mg/L). However, the lowest dissolved oxygen concentrations are expected to occur in the pre-dawn hours and monitoring occurred in the daytime at all sites.

Recent work indicates that anoxic conditions along the stream bottom of the Clark Fork River beneath *Cladophora* mats in Reach C [M. Vallett, University of Montana, *unpublished data*]. It is not known if those conditions also occur in other portions of the Clark Fork River but *Cladophora* growth is prolific in Reach A and B of the CFROU as well. These anoxic conditions may have a strong influence on stream ecology in the Clark Fork River.

2.4.2.5 Turbidity

Turbidity refers to the amount of light that is absorbed or scattered by water. Increasing turbidity or "cloudiness" in surface waters usually results from the presence of suspended silt or clay particles, organic matter, colored organic compounds, or microorganisms. Turbidity usually, but not always, correlates closely with the total suspended sediment concentration which measures the weight of suspended matter in solution. The lack of correlation between those parameters may be due to variation in particle sizes, weights, or refractive properties of the substances that contribute to turbidity.

Turbidity is an important parameter for drinking water. Elevated turbidity may impede recreational and aesthetic uses of water. High turbidity may adversely affect feeding, growth, and habitat quality for salmonids and other fishes, and may influence surface water temperatures. The MDEQ has established maximum allowable increases above naturally occurring turbidity. The allowable increase is 10 nephelometric turbidity units (NTU) for C-2 class streams (Clark Fork River from Warm Springs Creek to Cottonwood Creek), and five units for C-1 (Clark Fork River from Cottonwood Creek to the Little Blackfoot River) and B-1 (remainder of Clark Fork) class streams [ARM 17.30.623; ARM 17.30.626–627].

Turbidity during the 2015 monitoring events was generally low, with only three site measurements exceeding 10 NTU. There were no increases in turbidity between mainstem sites which exceeded 10 NTU in 2015. It is likely the relatively low streamflows during some monitoring periods in 2015 was a strong factor contributing to the relatively low turbidity in 2015. Two of the three measurements exceeding 10 NTU were observed at Williams-Tavenner Bridge site. Flint Creek had the highest turbidity of the tributary monitoring sites.

2.4.3 Total Suspended Sediment

Total suspended sediment measures the mass of material suspended in a given volume of water. Suspended sediment measures sediment in the water column as opposed to sediment transported along the stream bottom, which is known as bedload. Suspended sediment in streams generally includes a range of particle sizes which may vary with watershed geology, stream velocity, bed form, and turbulence. Excess fine sediment interferes with most water uses and may have particularly adverse effects on benthic invertebrate and salmonid fish growth and reproduction. Increased suspended sediment reduces light penetration and may affect primary production by aquatic plants and the morphology of alluvial stream channels. In the Clark Fork River system, many COC concentrations are directly correlated with suspended sediment concentrations.

In general, total suspended sediment concentrations in 2015 were similar to prior years for a given site at a given time. Spatial and seasonal patterns were similar to those for turbidity. The highest mainstem suspended sediment concentrations occurred in the lower half of Reach A at Deer Lodge and at Williams-Tavenner Bridge. The highest total suspended sediment concentrations in the mainstem occurred at Deer Lodge and at the Williams-Tavenner Bridge.

2.4.4 Common Ions

Common ions describe basic water chemistry. Certain ions, such as sulfate, may indicate the presence of mine related contaminants. Calcium and magnesium ions contribute to water hardness, which helps to buffer the toxic effects of some metals. Aquatic life toxicity criteria for metal COCs vary directly in relation to hardness. Hardness mitigates metals toxicity by impeding the rate at which aquatic organisms absorb metals through the gills. Carbonate and bicarbonate alkalinity contribute to the buffering system of surface waters to resist changes in pH. Levels of water hardness and alkalinity also strongly influence the productivity of aquatic systems. Western freshwater fisheries typically have alkalinity of 100–200 mg/L. In 2015, the Clark Fork mainstem alkalinity ranged from 90-220 mg/L. Based on previous monitoring, calcium is the dominant cation at the upper Clark Fork River monitoring network stations.

Water hardness in the Clark Fork River mainstem stations in 2015 ranged from “moderately hard” to “very hard”. In comparison, most rivers in western Montana have “moderately hard” to “hard” water [USGS, 2015]. The moderately elevated water hardness in the Clark Fork River relative to other regional rivers is likely beneficial overall for aquatic life because water hardness mitigates toxicity of heavy metals [USEPA, 1986]. Moderate alkalinity in the upper mainstem Clark Fork River reflect a well buffered system, with good potential for fish production barring other limitations. Sulfate was the second most prevalent anion in the upper Clark Fork River watershed, behind bicarbonate.

In Mill-Willow Creek sulfate concentrations increased by as much as 800% from above to below the Mill-Willow Bypass section of Mill-Willow Creek (between sites MCWC-MWB and MWB-SBC; [Figure 2-1]). Substantial increases occurred during all monitoring periods but the increases were most significant during low water periods Q3 and Q4. These results suggest that remnant sources of sulfate persist along the Mill-Willow Bypass stream corridor.

2.4.5 Nutrients

Numeric water quality standards have been adopted for nutrients in the Clark Fork River from the Warm Springs Creek confluence to the Blackfoot River confluence, a river section which encompasses most of the CFROU [ARM 17.30.631]. The standards apply only to the summer season (June 21 through September 21). The standards for this segment of the Clark Fork River are 0.300 mg/L for total nitrogen and 0.020 mg/L for total phosphorus [ARM 17.30.631]. The standards do not apply to sample sites located on tributaries to the Clark Fork River. Instead, summertime base numeric nutrient standards for the Middle Rockies Ecoregion apply to the tributaries during the July 1 to September 30 time period. These standards are 0.300 mg/L for total nitrogen and 0.030 mg/L for total phosphorus [MDEQ, 2014].

The maximum total nitrogen concentrations observed in the Clark Fork River mainstem in 2015 occurred at the Williams-Tavenner Bridge in Q4. This site is located approximately five river miles downstream from the Deer Lodge sewage treatment lagoons. All Reach A mainstem sites had the highest total nitrogen concentrations in Q4, when assimilative capacity in the river is presumably lowest due to low water temperatures and low stream metabolism. No mainstem sites exceeded the relevant total nitrogen standard which is applicable in Q3. In Q3, when water temperatures were highest, all mainstem sites had non-detectable concentrations of ammonia and nitrate plus nitrite suggesting that any bioavailable nitrogen was assimilated and supporting the conclusion of others that the Clark Fork River is nitrogen-limited [M. Vallett, University of Montana, *unpublished data*].

Nutrient levels in Silver Bow Creek at Frontage Road, upstream from the Warm Springs Ponds, exceeded the total nitrogen standard by nearly six times in Q3. In Q4 at the same site, total nitrogen levels were approximately four times higher than at any site in the CFROU monitoring network, and essentially 90% of the nitrogen was bioavailable (i.e., either ammonia or nitrate plus nitrite).

Three of six mainstem sites (near Galen, at Galen Road, and at Williams-Tavenner Bridge) had total phosphorus concentrations exceeding the Clark Fork River mainstem-specific total phosphorus standard [Table 2-8]. It is unknown if this phosphorus in the Clark Fork River is primarily derived from natural (i.e., geologic) characteristics in the watershed or from nutrient enrichment from anthropogenic influences. In contrast, the Silver Bow Creek site at Frontage Road exceeded the total phosphorus standard by more than ten times in Q3, most of which is known to derive from the Butte wastewater treatment plant [Table 2-8].

2.4.6 Contaminants of Concern

Overall, Reach A, extending from the Warm Springs Creek confluence to the Little Blackfoot River confluence, has the largest volume of streamside tailings in the CFROU. In particular, the uppermost portion of the river located upstream from the town of Deer Lodge has been identified as an area of relatively heavy COC loading to the Clark Fork River [Sando et al., 2014]. Surface water monitoring data collected in 2015 represents the sixth year of monitoring in the CFROU.

Monitoring from 2010-2012 represented baseline conditions in the CFROU immediately prior to the start of remediation. Because remedial activities were just beginning in 2013, it was considered unlikely that monitoring in 2013 would demonstrate much change in COC levels in the river. The 2014 monitoring was the first year following complete cleanup of the Phase 1 project area. In 2015 remedial actions were in progress in additional river sections (Phases 2, 5, and 6) stretching approximately 6.4 miles in total. Remedial actions in other portions of Reach A are likely to occur over a ten-year period.

In 2015, exceedances of performance goals were rare for all COCs except arsenic and copper. Of 36 samples collected in the Clark Fork River mainstem in 2015 (from six sites during six sample periods), no samples (0%) had zinc concentrations exceeding the performance goal, no samples (0%) had cadmium concentrations exceeding the performance goal, and only three (8%) had lead concentrations exceeding the performance goal. Arsenic commonly exceeded the performance goals in 2015 in mainstem sites in Reach A. Of 30 samples collected in the Clark Fork River in Reach A (five sites during six sample periods), 90% exceeded the dissolved arsenic and 27% exceeded the total recoverable arsenic performance goals [USEPA, 2004]. This rate of arsenic exceedances in 2015 was slightly lower compared to 2014. Silver Bow Creek at Warm Springs and both Mill-Willow Creek sites were clearly sources of arsenic to the Clark Fork River as 78% (14 of 18) samples from those sites exceeded the dissolved arsenic, and 56% (10 of 18) exceeded the total recoverable performance goals in those sites [USEPA, 2004]. Arsenic concentrations in Silver Bow Creek entering the Warm Springs Ponds (at Frontage Road) were much lower than the concentrations leaving the ponds (at Warm Springs), particularly during warm periods (Q2 and Q3), indicating that arsenic is likely remobilized in the ponds as described by others [Chatham, 2012]. These results also support findings of the USGS monitoring program. Recent analysis by the USGS identified the Warm Springs Ponds, the Mill-Willow Bypass, and groundwater in the vicinity of the Warm Springs Ponds as substantial arsenic sources to the upper Clark Fork River [Sando et al., 2014].

In addition to arsenic contamination in the Clark Fork River mainstem, total recoverable copper exceeded the chronic ALS [MDEQ, 2012b] in 60% of the 30 Reach A samples collected in 2015. In Q1 and Q2, when streamflows were highest, the chronic ALS [MDEQ, 2012b] exceedance rate for total recoverable copper was even higher (80%) in Reach A. These results support conclusions of Sando et al. [2014] that the Clark Fork River reach upstream from Deer Lodge is a major source of copper loading and copper concentrations throughout the river are strongly related to streamflows. However, there were no exceedances of the most restrictive performance goal from the CFROU ROD [Table 2-1] for dissolved copper in the Clark Fork River mainstem in 2015.

Finally, this report described compliance ratio trends for each COC at some selected sites in the Clark Fork River mainstem. Evaluation of compliance ratio trends through time for the COCs is perhaps the most important analysis in this monitoring program because improved compliance with water quality standards was a primary impetus for the remedy in the CFROU. However, we did not conduct any formal statistical analysis on these data, and simply described our own observations about the data from the plots presented. For some COCs, at some sites, we noticed that there appeared to be slight decreasing trends. However, these analyses are certainly preliminary and given the variability in the data, and the relatively short period of monitoring to date, we do not believe it is appropriate to formally evaluate temporal trends at any of these sites at this time based on the data presented (2010-2015). Any statistical analysis (e.g., a generalized regression model) fit to these data at this time would likely conclude that there is no statistically significant evidence that COC concentrations have changed through time.

2.4.7 Other Metals

Monitoring data continues to implicate Flint Creek as a primary source of mercury and methylmercury to the Clark Fork River.

2.4.8 Data Validation

Generally, this monitoring program has satisfied the data quality objectives and data quality indicators specified in the QAPP [DeArment et al., 2013]. However, quality control procedures have consistently demonstrated that trace level contamination of dissolved field samples with zinc occurs. We suspect that the field filtering apparatus is responsible for the zinc contamination and over the last two years have implemented a variety of minor additional steps in an attempt to reduce zinc contamination in the dissolved samples. These additional steps primarily involved additional rinsing of field filtering equipment with deionized water and sample water. These efforts appear to have done little to reduce the trace level zinc contamination. Therefore, we have requested equipment blank data from GE Healthcare Life Sciences, the company which manufactures the Whatman filters used in this monitoring program, to further investigate potential causes of the zinc contamination in the samples.

It is worth noting that although the contamination of dissolved samples with zinc introduces a slight positive bias (i.e., reported dissolved zinc concentrations are higher than what actually occurs in the river), all field sample dissolved and total recoverable zinc concentrations were well below the performance goals in 2014 indicating that any zinc contamination introduced in the dissolved samples is minimal relative to the action levels. Moreover, most (98.3%) of the other analyte concentrations in the field blanks were below reporting limits indicating that the field methods introduce very little contamination of other substances into the samples.

3.0 SEDIMENT

3.1 INTRODUCTION

No specific remediation performance standards were established within the CFROU ROD for concentrations of COC metals in instream sediments [USEPA, 2004]. In lieu of performance standards the “threshold effect concentration” (TEC) and “probable effect concentration” (PEC), consensus-based sediment quality guidelines for benthic organisms [MacDonald et al., 2000], provide useful reference values for instream sediment quality [Table 3-1]. At metal COC concentrations above the TEC, benthic organisms may be affected by that COC. At metal COC concentrations above the PEC, benthic organisms are likely to be affected by that COC.

Remedial actions within the CFROU to remove floodplain tailings deposits and reduce streambank erosion are expected to result in reduced COC concentrations in instream sediments within the Clark Fork River. Therefore, instream sediment COC concentrations will be monitored in the CFROU prior to, during, and following remediation. This report reviews spatial and temporal trends in instream sediment metals concentrations in the CFROU during the 2014 and prior monitoring years.

Table 3-1. Reference values for contaminant of concern (COC) concentrations (expressed as dry weight concentrations [DW]) in instream sediments within the Clark Fork River Operable Unit. The threshold effect concentration (TEC) and probable effect concentration (PEC) were described in MacDonald et al. [2000].

Contaminant of Concern	Threshold Effect Concentration (mg/kg-DW)	Probable Effect Concentration (mg/kg-DW)
Arsenic	9.79	33
Cadmium	0.99	4.98
Copper	31.6	149
Lead	35.8	128
Zinc	121	459

3.2 METHODS

3.2.1 Monitoring Locations

Instream sediment was monitored at 14 CFROU sites in 2015 [Table 3-2; Figure 3-1]. The monitoring network includes six sites on the Clark Fork River mainstem and eight sites on tributary streams [Table 3-2]. The monitoring site locations in 2015 were the same as the monitoring site locations in 2014 but with a couple additions. First, monitoring site CFR-34 (Clark Fork River at Williams-Tavenner Bridge) was added in 2015 as an additional sample site in the mainstem in Reach A downstream from Phase 15 and 16 [Figure 1-11] where remediation is expected to begin in the summer of 2016. In addition, data from monitoring site SS-19 (Silver Bow Creek at Frontage Road) has been included in this report to provide paired sites to compare Silver Bow Creek sediment concentrations above (SS-19) and below (SS-25) the Warm Springs Pond system. Instream sediment at site SS-19 is sampled under the Streamside Tailings Operable Unit (SSTOU) monitoring program. Methods for instream sediment sampling in the SSTOU are essentially the same as in the CFROU monitoring program and are described in the SSTOU monitoring sampling and analysis plan [Naughton et al., 2015b].

Monitoring sites changed between 2012 and 2013 to provide a more detailed spatial representation of the Clark Fork River mainstem in Reach A. Additionally, some sites were removed from the monitoring network to avoid duplication of sampling efforts by the USGS. A record of changes to this monitoring program since monitoring began in 2010 is provided in Appendix A of the project sampling and analysis plan [Naughton et al., 2015a].

Table 3-2. Instream sediment sampling locations in the Clark Fork River Operable Unit, 2015. Streamflows were measured at all sites which did not a have co-located USGS streamflow gauge.

Site ID	Site Location	Co-located USGS Streamflow Gauge	Location (GPS coordinates, NAD 83)	
			Latitude	Longitude
Mainstem Sites				
CFR-03A	Clark Fork River near Galen	12323800	46.20877	-112.76740
CFR-07D	Clark Fork River at Galen Road	none	46.23725	-112.75302
CFR-11F	Clark Fork River at Gemback Road	none	46.26520	-112.74430
CFR-27H	Clark Fork River at Deer Lodge	12324200	46.39796	-112.74283
CFR-34	Clark Fork River at Williams-Tavenner Bridge	none	46.47119	-112.72492
CFR-116A	Clark Fork at Turah	12334550	46.82646	-113.81424
Tributary Sites				
SS-19[12]	Silver Bow Creek at Frontage Road	none	46.12247	-112.80032
SS-25	Silver Bow Creek at Warm Springs	12323750	46.18123	-112.77917
MCWC-MWB	Mill-Willow Creek at Frontage Road	none	46.12649	-112.79876
MWB-SBC	Mill-Willow Bypass near mouth	none	46.17839	-112.78270
WSC-SBC	Warm Springs Creek near mouth	12323770	46.18041	-112.78592
LC-7.5[13]	Lost Creek near mouth	12323850	46.21862	-112.77384
RTC-1.5[14]	Racetrack Creek near mouth	none	46.28395	-112.74921
LBR-CFR-02[15]	Little Blackfoot River at Beck Hill Road	none	46.53710	-112.72443

[12] In 2015, site SS-19 was sampled under the Streamside Tailings Operable Unit (SSTOU) monitoring program four times per year.

[13] Site LC-7 (GPS Location: 46.22665, -112.76017) was replaced by site LC-7.5 in 2013.

[14] Site RTC-1 (GPS Location: 46.28406, -112.74484) was replaced by site RTC-1.5 in 2013.

[15] Site LBR-CFR (GPS Location: 46.51964, -112.79312; co-located USGS gauge: 12324590) was replaced by site LBR-CFR-02 in 2014.

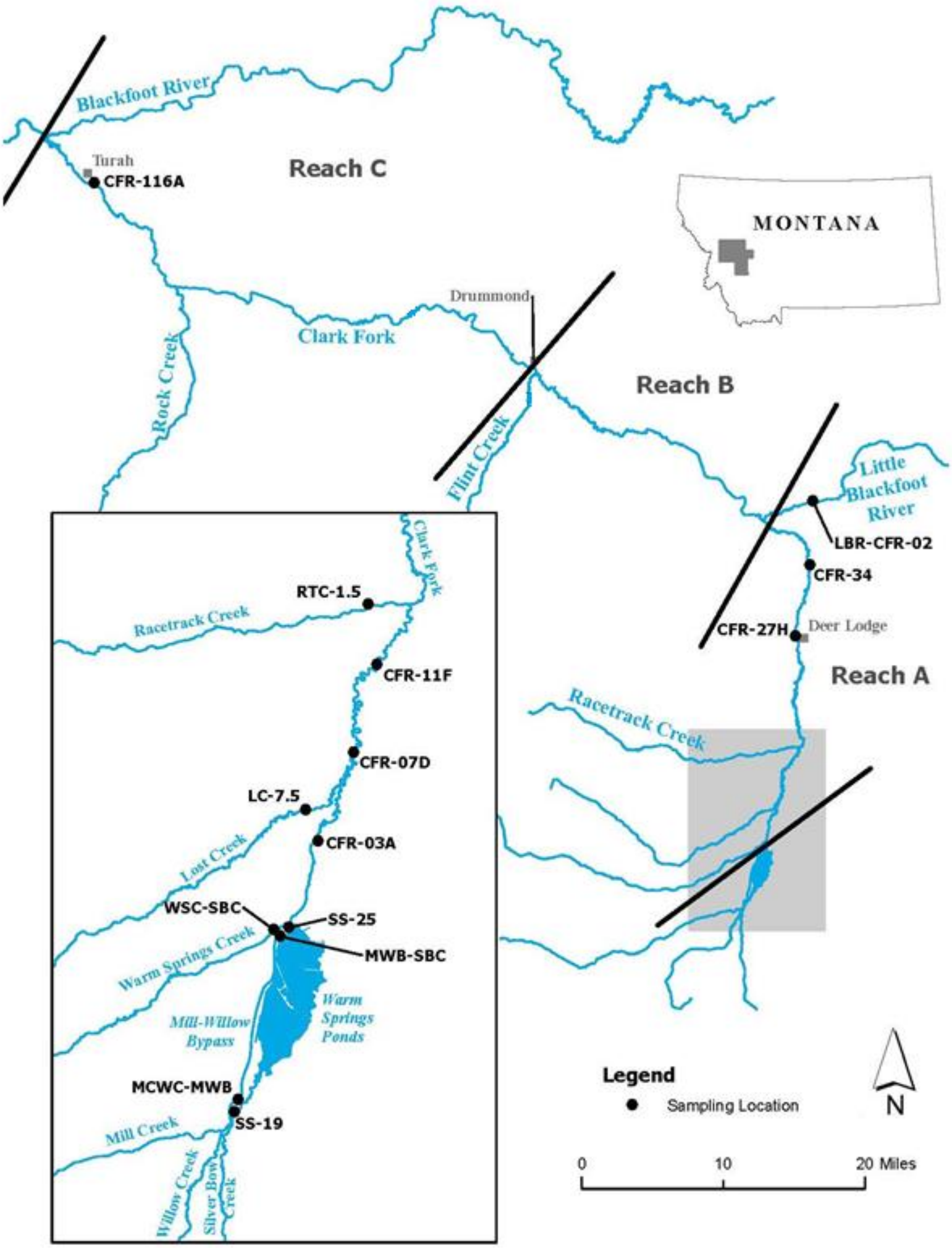

Figure 3-1. Instream sediment sampling locations in the Clark Fork River Operable Unit, 2015.

3.2.2 Monitoring Schedule

At least one surface water monitoring event occurred during each calendar quarter of 2015. Instream sediment samples were collected during the first quarter (Q1) and third quarter (Q3) surface water monitoring events. The first monitoring event (Q1) occurred in the late winter, prior to spring runoff from March 24-25. The Q1 sediment samples from Racetrack Creek and Lost Creek were collected on April 7 due to a sampling oversight during the March 24-25 monitoring period. The late summer (Q3) monitoring event occurred during low streamflow conditions from September 10-11.

3.2.3 Monitoring Parameters

Instream sediment samples were analyzed for dry weight (DW) total extractable metal (arsenic, cadmium, copper, lead, and zinc) concentrations.

3.2.4 Sample Collection and Analysis

Sediment samples were collected by compositing subsamples from at least five deposition zones in wadeable locations at each monitoring site. Sediment was scooped from the streambed with a plastic spoon following the MDEQ standard operating procedure [MDEQ, 2012a]. The fine fraction (particle diameter <0.065 mm) portion of each sample was isolated from each composite sample by wet sieve in the laboratory shortly after collection and retained for analysis of metal concentrations. Each sample was analyzed for total extractable dry weight concentrations (mg/kg-DW) of arsenic, cadmium, copper, lead, and zinc following methods identified in Table 3-3 The relative proportion (by weight) of the fine fraction sediment in each sample was also determined. Sediment samples were analyzed by Energy Laboratories (Helena, Montana). Prior to 2013, each sediment sample was sieved into three size fractions (<0.065 mm, 0.065–1 mm, and 1–2 mm), and each size fraction was independently analyzed for metal concentrations.

Table 3-3. Analytes, methods, and reporting limits for instream sediment sampling in the Clark Fork River Operable Unit, 2015.

Analyte	Requested Method	Requested Reporting Limit (mg/kg-DW)	Holding Time (days)	Bottle	Preservative
Total Metals Digestion	EPA 3050	-	-	-	-
Arsenic	SW 6010B	5	180	1000 mL clear glass wide mouth jars	4 ± 2 C during shipment; -15 C in laboratory
Cadmium	SW 6010B	0.2			
Copper	SW 6010B	5			
Lead	SW 6010B	5			
Zinc	SW 6010B	5			

3.2.5 Data Analysis

Data were analyzed to assess spatial and temporal patterns in sediment COC concentrations. In addition, COC concentrations at each sample site were compared to the TEC and PEC reference values [Table 3-1] to assess exceedances.

3.2.6 Data Validation

Data quality objectives (DQOs) were established in the CFROU quality assurance project plan (QAPP) for “data representativeness”, “comparability”, “completeness”, “sensitivity”, “precision”, “bias”, and “accuracy” [DeArment et al., 2013]. Methods for field and laboratory quality assurance and quality control (QA/QC) procedures are also described in detail in the project QAPP. A completed QA/QC checklist, summary tables of field duplicate and field blank results, and assessments of data quality objectives are included in Appendix A.

Variability in sediment metals concentrations among samples was assessed by comparing field duplicate samples to field samples. Field duplicate samples were collected at the same location and at the same time as field samples and were processed and analyzed by the same methods. The relative percent difference (RPD) between the concentration in the field duplicate and field sample pair was determined for each metal. Two field duplicate samples were collected during each sampling event and RPD statistics were calculated for each field duplicate and field sample pair.

3.3 RESULTS

3.3.1 Sample Size Fraction

The proportion of sediment by size fraction in each 2015 CFROU sediment sample is displayed in Table 3-4.

Table 3-4. Proportion of each sample collected in the Clark Fork River Operable Unit composed of fine fraction (<0.065 mm) sediment particles, 2015.

Site ID	Site Location	Sample proportion (%)	
		Q1	Q3
Mainstem Sites			
CFR-03A	Clark Fork River near Galen	26.8	3.2
CFR-07D	Clark Fork River at Galen Road	17.6	3.6
CFR-11F	Clark Fork River at Gemback Road	20.2	1.8
CFR-27H	Clark Fork River at Deer Lodge	23.1	4.7
CFR-34	Clark Fork River at Williams-Tavenner Bridge	13.2	0.6
CFR-116A	Clark Fork River at Turah	11.6	47.8
Tributary Sites			
SS-19	Silver Bow Creek at Frontage Road	3.6	2.0
SS-25	Silver Bow Creek at Warm Springs	4.2	2.5
MCWC-MWB	Mill-Willow Creek at Frontage Road	16.1	8.1
MWB-SBC	Mill-Willow Bypass near mouth	4.9	8.1
WSC-SBC	Warm Springs Creek near mouth	8.2	43.0
LC-7.5	Lost Creek near mouth	8.4	31.2
RTC-1.5	Racetrack Creek near mouth	1.5	1.5
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	3.9	1.7

3.3.2 Contaminants of Concern

3.3.2.1 Arsenic

Fine fraction (<0.065 mm) instream sediment arsenic concentrations in the Clark Fork River mainstem in 2015 ranged from 68-362 mg/kg-DW [Table 3-5]. Arsenic concentrations in mainstem monitoring sites during 2015 were consistently lowest at Turah and were generally two to three times higher at the mainstem sites in Reach A (from the near Galen to the Williams-Tavenner Bridge sites) [Figure 3-2]. Within Reach A, arsenic concentrations appeared to decrease slightly from the upstream-most Reach A site (near Galen) to the downstream-most Reach A site (at the Williams-Tavenner Bridge), but there was a high degree of variability between sites and sample periods [Figure 3-2]. In the mainstem, exceedances of the TEC and PEC reference values occurred at all sites during all sample periods [Figure 3-2].

Fine fraction (<0.065 mm) instream sediment arsenic concentrations in the Clark Fork River tributaries in 2015 ranged from 32-463 mg/kg-DW [Table 3-5]. Arsenic concentrations in tributary monitoring sites during 2015 were consistently lowest in Racetrack Creek and the Little Blackfoot River and highest in the Silver Bow Creek sites and the Mill-Willow Bypass in Q1 [Figure 3-3]. At most tributary sites, arsenic concentrations were similar between sample periods but at the two Silver Bow Creek sites and the Mill-Willow Bypass, concentrations were considerably higher in Q1 [Figure 3-3]. In the tributaries, exceedances of the TEC and PEC reference values occurred at all sites during both sample periods except in Racetrack Creek and the Little Blackfoot River [Figure 3-3]. In Racetrack Creek and the Little Blackfoot River the TEC was exceeded in both sample periods but the PEC was only exceeded in one of the two sample periods at each site [Figure 3-3].

Table 3-5. Total arsenic concentrations (mg/kg dry weight) in fine fraction (<0.065 mm) instream sediment samples from the Clark Fork River Operable Unit, 2015.

Site ID	Site Location	Sample concentration (mg/kg-DW)	
		Q1	Q3
Mainstem Sites			
CFR-03A	Clark Fork River near Galen	248	237
CFR-07D	Clark Fork River at Galen Road	125	362
CFR-11F	Clark Fork River at Gemback Road	169	179
CFR-27H	Clark Fork River at Deer Lodge	153	109
CFR-34	Clark Fork River at Williams-Tavenner Bridge	190	143
CFR-116A	Clark Fork River at Turah	69	68
Tributary Sites			
SS-19	Silver Bow Creek at Frontage Road	463	79
SS-25	Silver Bow Creek at Warm Springs	244	112
MCWC-MWB	Mill-Willow Creek at Frontage Road	124	110
MWB-SBC	Mill-Willow Bypass near mouth	282	106
WSC-SBC	Warm Springs Creek near mouth	105	112
LC-7.5	Lost Creek near mouth	62	80
RTC-1.5	Racetrack Creek near mouth	33	36
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	34	32

(yellow) Exceeds threshold effect concentration [MacDonald et al., 2000].

(red) Exceeds probable effect concentration [MacDonald et al., 2000].

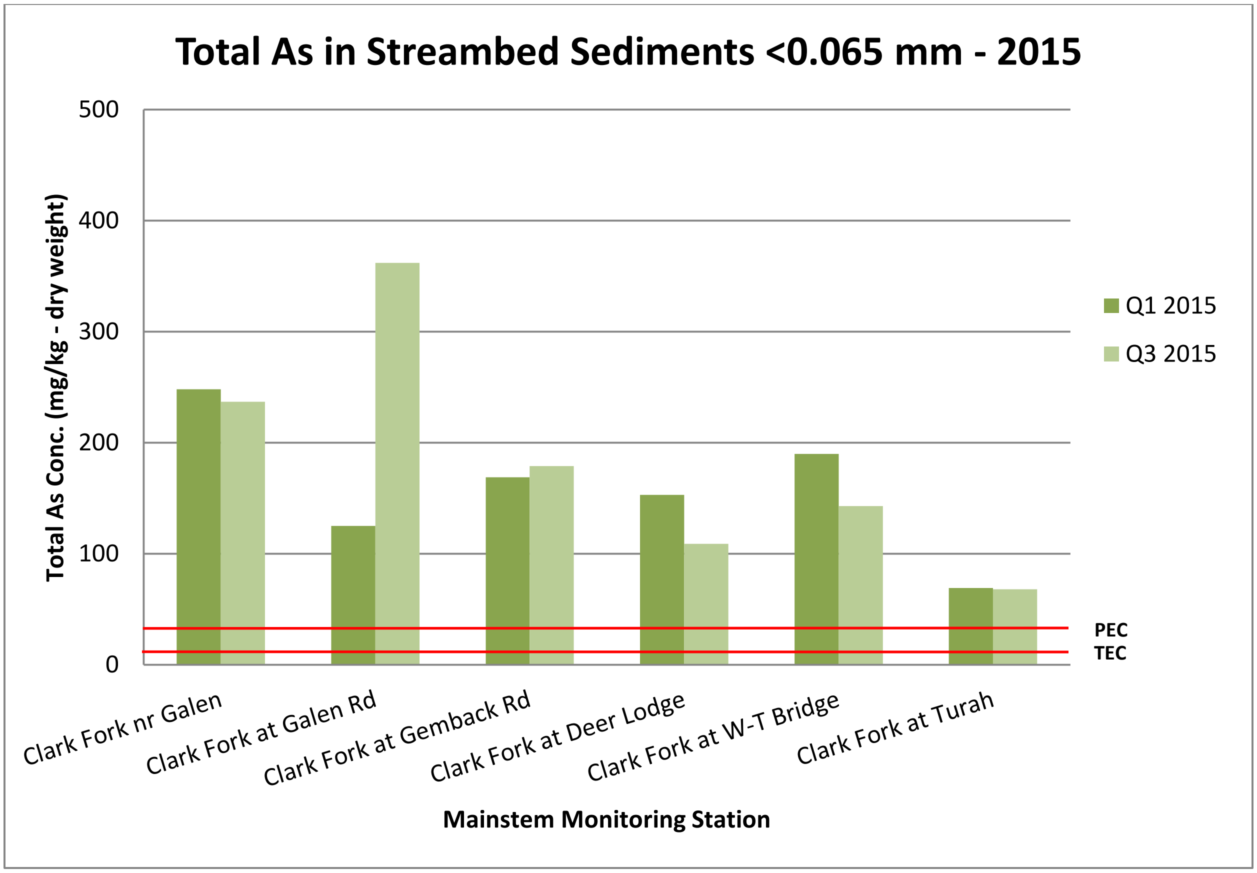

Figure 3-2. Total arsenic (As) concentrations (dry weight) in Clark Fork River mainstem sediment samples, 2015. Red lines represent the "threshold effect concentration" (TEC) and the "probable effect concentration" (PEC) [MacDonald et al., 2000].

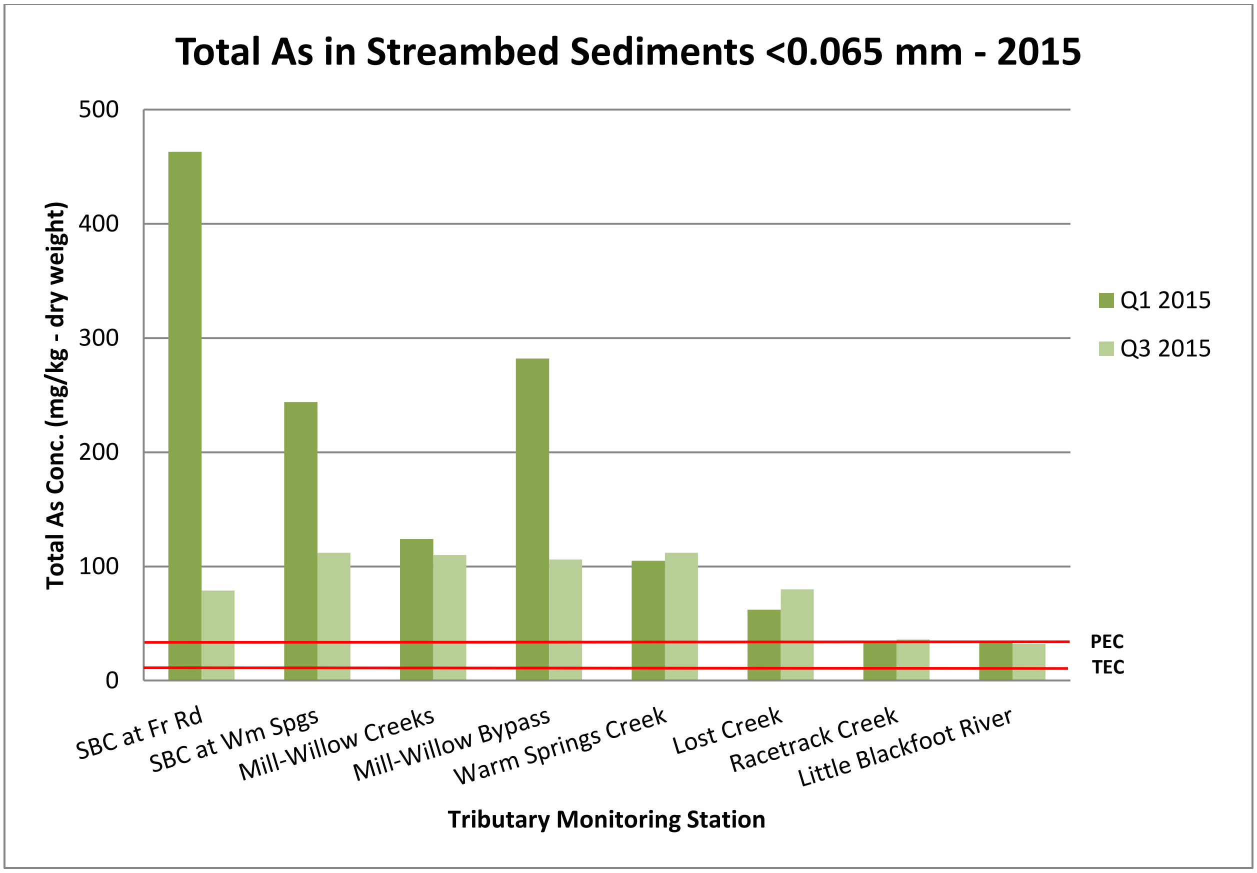

Figure 3-3. Total arsenic (As) concentrations (dry weight) in Clark Fork River tributary sediment samples, 2015. Red lines represent the "threshold effect concentration" (TEC) and the "probable effect concentration" (PEC) [MacDonald et al., 2000].

3.3.2.2 Cadmium

Fine fraction (<0.065 mm) instream sediment cadmium concentrations in the Clark Fork River mainstem in 2015 ranged from 4.4-18.1 mg/kg-DW [Table 3-6]. Cadmium concentrations in mainstem monitoring sites during 2015 were lowest at Galen Road in Q1 and at Turah in Q3 and were highest at Williams-Tavenner Bridge in Q3 [Figure 3-4]. Within Reach A, cadmium concentrations were variable but were highest at most sites (all but near Galen) in Q3 [Figure 3-4]. In the mainstem, exceedances of the TEC occurred at all sites during all monitoring periods [Figure 3-4]. Exceedances of the PEC occurred at all mainstem sites in Q3 and at all mainstem sites except at Galen Road and at Turah in Q3 [Figure 3-4].

Fine fraction (<0.065 mm) instream sediment cadmium concentrations in the Clark Fork River tributaries in 2015 ranged from 1.0-97.0 mg/kg-DW [Table 3-6]. Cadmium concentrations in tributary monitoring sites during Q1 2015 were lowest in the Little Blackfoot River and were lowest in Q3 in Racetrack Creek [Figure 3-5]. Cadmium concentrations in tributary monitoring sites were highest during both quarters of 2015 in Silver Bow Creek [Figure 3-5]. At some tributary sites (i.e., Mill-Willow Creek, Warm Springs Creek, Lost Creek, and Racetrack Creek), cadmium concentrations were similar between sample periods [Figure 3-5]. At the two Silver Bow Creek sites and the Mill-Willow Bypass, cadmium concentrations were considerably higher in Q1 [Figure 3-5]. In the Little Blackfoot River, cadmium concentrations were considerably higher in Q3 [Figure 3-5]. The Silver Bow Creek at Frontage Road site had cadmium concentrations which were nearly 20 times higher than the PEC reference value [Figure 3-5]. In the tributaries, exceedances of the TEC reference value occurred at all sites during all monitoring periods except in the Little Blackfoot River in Q1 [Figure 3-5]. Exceedances of the PEC reference value occurred during both quarters in both Silver Bow Creek sites, in both quarters in both Mill-Willow Creek sites, and in Warm Springs in Q3 [Figure 3-5].

Table 3-6. Total cadmium concentrations (mg/kg dry weight) in fine fraction (<0.065 mm) instream sediment samples from the Clark Fork River Operable Unit, 2015.

Site ID	Site Location	Sample concentration (mg/kg-WW)	
		Q1	Q3
Mainstem Sites			
CFR-03A	Clark Fork River near Galen	14.0	10.1
CFR-07D	Clark Fork River at Galen Road	4.5	9.1
CFR-11F	Clark Fork River at Gemback Road	5.6	10.0
CFR-27H	Clark Fork River at Deer Lodge	6.3	9.1
CFR-34	Clark Fork River at Williams-Tavenner Bridge	10.1	18.1
CFR-116A	Clark Fork River at Turah	4.7	5.7
Tributary Sites			
SS-19	Silver Bow Creek at Frontage Road	97.0	13.2
SS-25	Silver Bow Creek at Warm Springs	12.3	6.7
MCWC-MWB	Mill-Willow Creek at Frontage Road	5.2	6.1
MWB-SBC	Mill-Willow Bypass near mouth	8.4	5.4
WSC-SBC	Warm Springs Creek near mouth	4.4	5.7
LC-7.5	Lost Creek near mouth	3.0	3.2
RTC-1.5	Racetrack Creek near mouth	1.6	1.8
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	1.0	5.0

(yellow)	Exceeds threshold effect concentration [MacDonald et al., 2000].
(red)	Exceeds probable effect concentration [MacDonald et al., 2000].

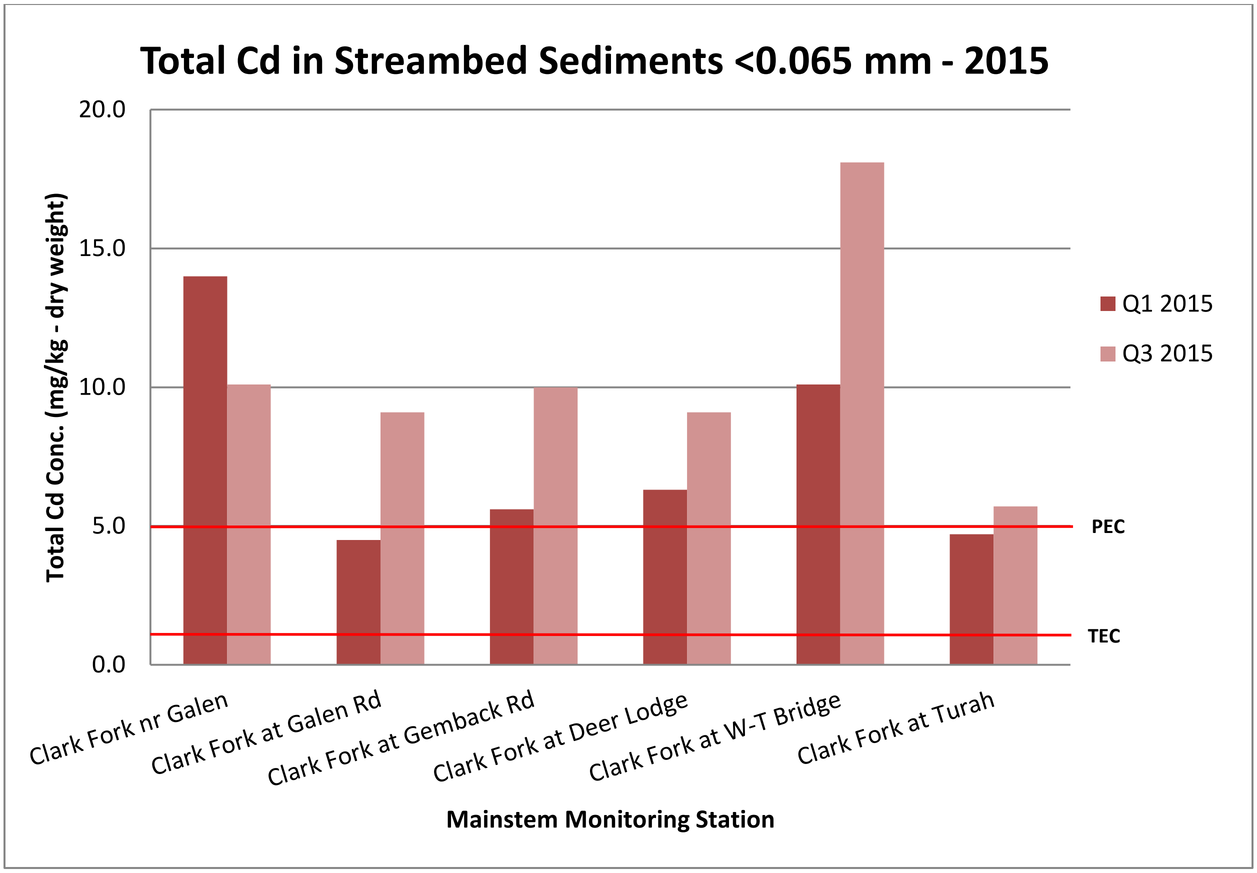

Figure 3-4. Total cadmium (Cd) concentrations (dry weight) in Clark Fork River mainstem sediment samples, 2015. Red lines represent the "threshold effect concentration" (TEC) and the "probable effect concentration" (PEC) [MacDonald et al., 2000].

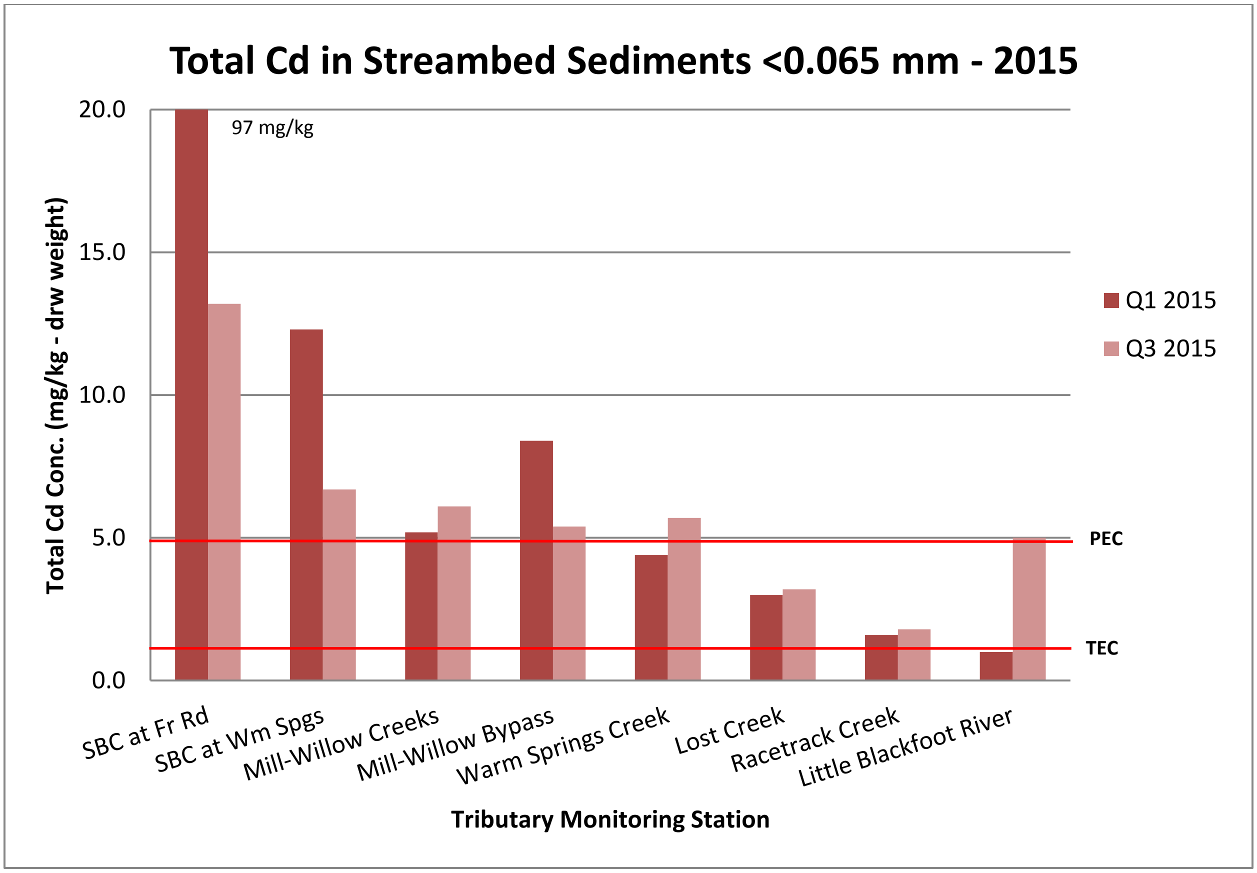

Figure 3-5. Total cadmium (Cd) concentrations (dry weight) in Clark Fork River tributary sediment samples, 2015. Red lines represent the "threshold effect concentration" (TEC) and the "probable effect concentration" (PEC) [MacDonald et al., 2000].

3.3.2.3 Copper

Fine fraction (<0.065 mm) instream sediment copper concentrations in the Clark Fork River mainstem in 2015 ranged from 685-2,630 mg/kg-DW [Table 3-7]. Copper concentrations in mainstem monitoring sites during 2015 were consistently lowest at Turah and highest at the Williams-Tavenner Bridge (Q1) and at Galen Road (Q3) [Figure 3-6]. Within Reach A, copper concentrations were variable and there did not appear to be a clear longitudinal or seasonal trend [Figure 3-6]. In the mainstem, exceedances of the TEC and PEC occurred at all sites during all monitoring periods [Figure 3-6]. The magnitude of PEC exceedances in the mainstem ranged from 4.6-17.7 times [Figure 3-6].

Fine fraction (<0.065 mm) instream sediment copper concentrations in the Clark Fork River tributaries in 2015 ranged from 53-35,700 mg/kg-DW [Table 3-7]. Copper concentrations in tributary monitoring sites during Q1 2015 were lowest in the Little Blackfoot River and highest in Silver Bow Creek at Frontage Road (Q1) and in Warm Springs Creek (Q3) [Figure 3-7]. At some tributary sites (i.e., Mill-Willow Creek, Lost Creek, Racetrack Creek, and the Little Blackfoot River), copper concentrations were similar between sample periods [Figure 3-7]. At the two Silver Bow Creek sites copper concentrations were considerably higher in Q1 [Figure 3-7]. In the Mill-Willow Bypass and Warm Springs Creek, copper concentrations were higher in Q3 [Figure 3-7]. The Q1 sample from Silver Bow Creek at Frontage Road was an anomaly for the site with a concentration that was 240 times higher than the PEC reference value [Figure 3-7]. The Q3 sample from Silver Bow Creek at Frontage Road had concentrations that were within the range of the other tributary sites [Figure 3-7]. In the tributaries, exceedances of the TEC reference value occurred at all sites during all monitoring periods except in the Little Blackfoot River in Q1 [Figure 3-7]. Exceedances of the PEC reference value occurred during both quarters at all sites except Racetrack Creek and the Little Blackfoot River, where no exceedances of the PEC reference value occurred [Figure 3-7].

Table 3-7. Total copper concentrations (mg/kg dry weight) in fine fraction (<0.065 mm) instream sediment samples from the Clark Fork River Operable Unit, 2015.

Site ID	Site Location	Sample concentration (mg/kg-DW)	
		Q1	Q3
Mainstem Sites			
CFR-03A	Clark Fork River near Galen	1570	2070
CFR-07D	Clark Fork River at Galen Road	1210	2630
CFR-11F	Clark Fork River at Gemback Road	1420	1690
CFR-27H	Clark Fork River at Deer Lodge	1670	1370
CFR-34	Clark Fork River at Williams-Tavenner Bridge	2160	1680
CFR-116A	Clark Fork River at Turah	685	906
Tributary Sites			
SS-19	Silver Bow Creek at Frontage Road	35700	674
SS-25	Silver Bow Creek at Warm Springs	696	377
MCWC-MWB	Mill-Willow Creek at Frontage Road	475	408
MWB-SBC	Mill-Willow Bypass near mouth	511	1230
WSC-SBC	Warm Springs Creek near mouth	955	1320
LC-7.5	Lost Creek near mouth	354	412
RTC-1.5	Racetrack Creek near mouth	80	91
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	53	73

(yellow)	Exceeds threshold effect concentration [MacDonald et al., 2000].
(red)	Exceeds probable effect concentration [MacDonald et al., 2000].

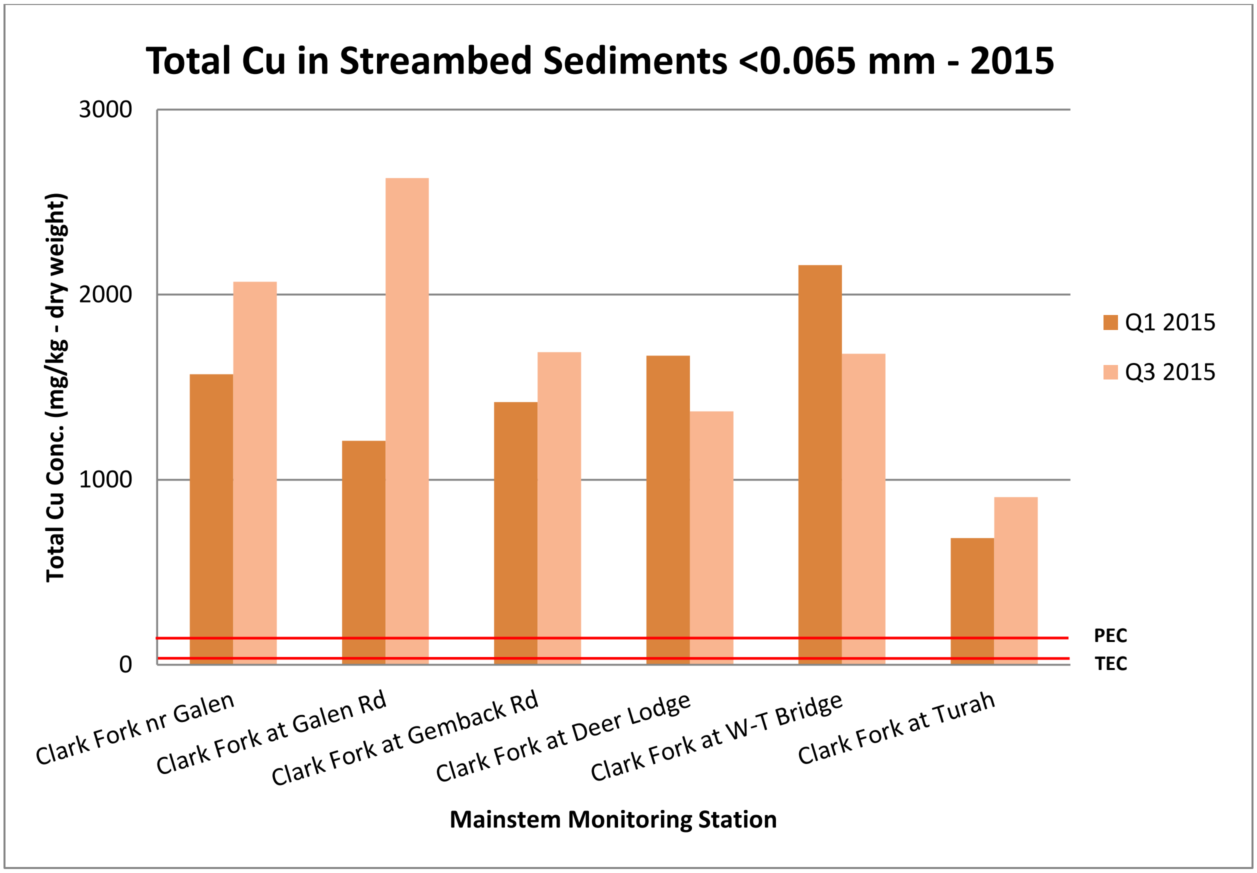

Figure 3-6. Total copper (Cu) concentrations (dry weight) in Clark Fork River mainstem sediment samples, 2015. Red lines represent the "threshold effect concentration" (TEC) and the "probable effect concentration" (PEC) [MacDonald et al., 2000].

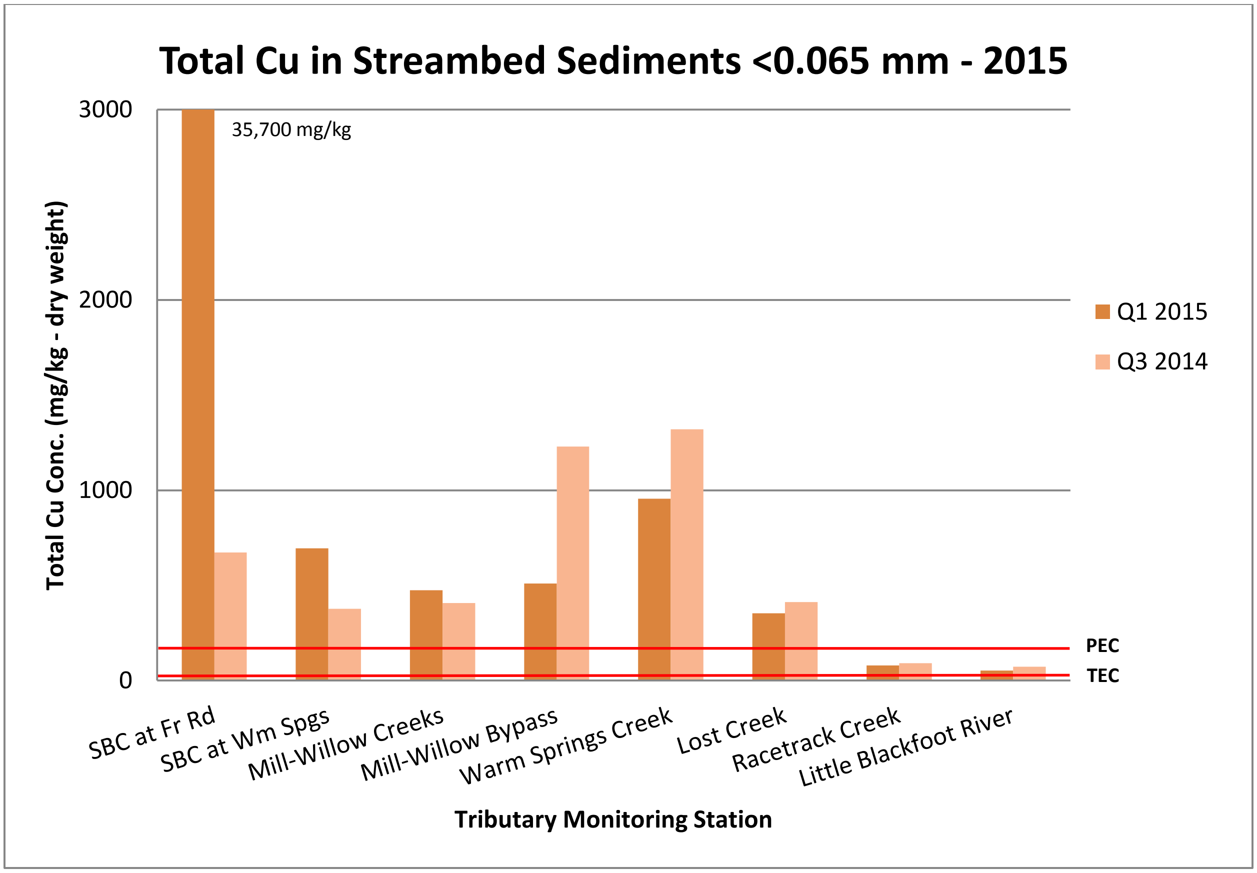

Figure 3-7. Total copper (Cu) concentrations (dry weight) in Clark Fork River tributary sediment samples, 2015. Red lines represent the "threshold effect concentration" (TEC) and the "probable effect concentration" (PEC) [MacDonald et al., 2000].

3.3.2.4 Lead

Fine fraction (<0.065 mm) instream sediment lead concentrations in the Clark Fork River mainstem in 2015 ranged from 143-423 mg/kg-DW [Table 3-8]. Lead concentrations in mainstem monitoring sites during 2015 were consistently lowest at Turah and highest at the Williams-Tavenner Bridge (Q1) and at Galen Road (Q3) [Figure 3-8]. Within Reach A, lead concentrations were variable and there did not appear to be a clear longitudinal or seasonal trend [Figure 3-8]. In the mainstem, exceedances of the TEC and PEC occurred at all sites during all monitoring periods [Figure 3-8].

Fine fraction (<0.065 mm) instream sediment lead concentrations in the Clark Fork River tributaries in 2015 ranged from 56-501 mg/kg-DW [Table 3-8]. Lead concentrations in tributary monitoring sites during Q1 2015 were lowest in the Little Blackfoot River (Q1) and Racetrack Creek (Q3) and highest during both quarters in Silver Bow Creek at Frontage Road [Figure 3-9]. At both Silver Bow Creek and Mill-Willow Creek sites, concentrations were highest in Q1 whereas concentrations were highest in the other tributaries (Warm Springs Creek, Lost Creek, Racetrack Creek, and the Little Blackfoot River) in Q3 [Figure 3-9]. In the tributaries, exceedances of the TEC reference value occurred at all sites during all monitoring periods [Figure 3-9]. Exceedances of the PEC reference value occurred during both quarters at both Silver Bow Creek and Mill-Willow Creek sites and in Warm Springs Creek in Q3 [Figure 3-9].

Table 3-8. Total lead concentrations (mg/kg dry weight) in fine fraction (<0.065 mm) instream sediment samples from the Clark Fork River Operable Unit, 2015.

Site ID	Site Location	Sample concentration (mg/kg-WW)	
		Q1	Q3
Mainstem Sites			
CFR-03A	Clark Fork River near Galen	294	314
CFR-07D	Clark Fork River at Galen Road	164	423
CFR-11F	Clark Fork River at Gemback Road	226	376
CFR-27H	Clark Fork River at Deer Lodge	239	222
CFR-34	Clark Fork River at Williams-Tavenner Bridge	325	355
CFR-116A	Clark Fork River at Turah	143	180
Tributary Sites			
SS-19	Silver Bow Creek at Frontage Road	501	274
SS-25	Silver Bow Creek at Warm Springs	245	152
MCWC-MWB	Mill-Willow Creek at Frontage Road	174	156
MWB-SBC	Mill-Willow Bypass near mouth	223	160
WSC-SBC	Warm Springs Creek near mouth	121	162
LC-7.5	Lost Creek near mouth	59	87
RTC-1.5	Racetrack Creek near mouth	74	67
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	56	94

Exceeds threshold effect concentration [MacDonald et al., 2000].
Exceeds probable effect concentration [MacDonald et al., 2000].

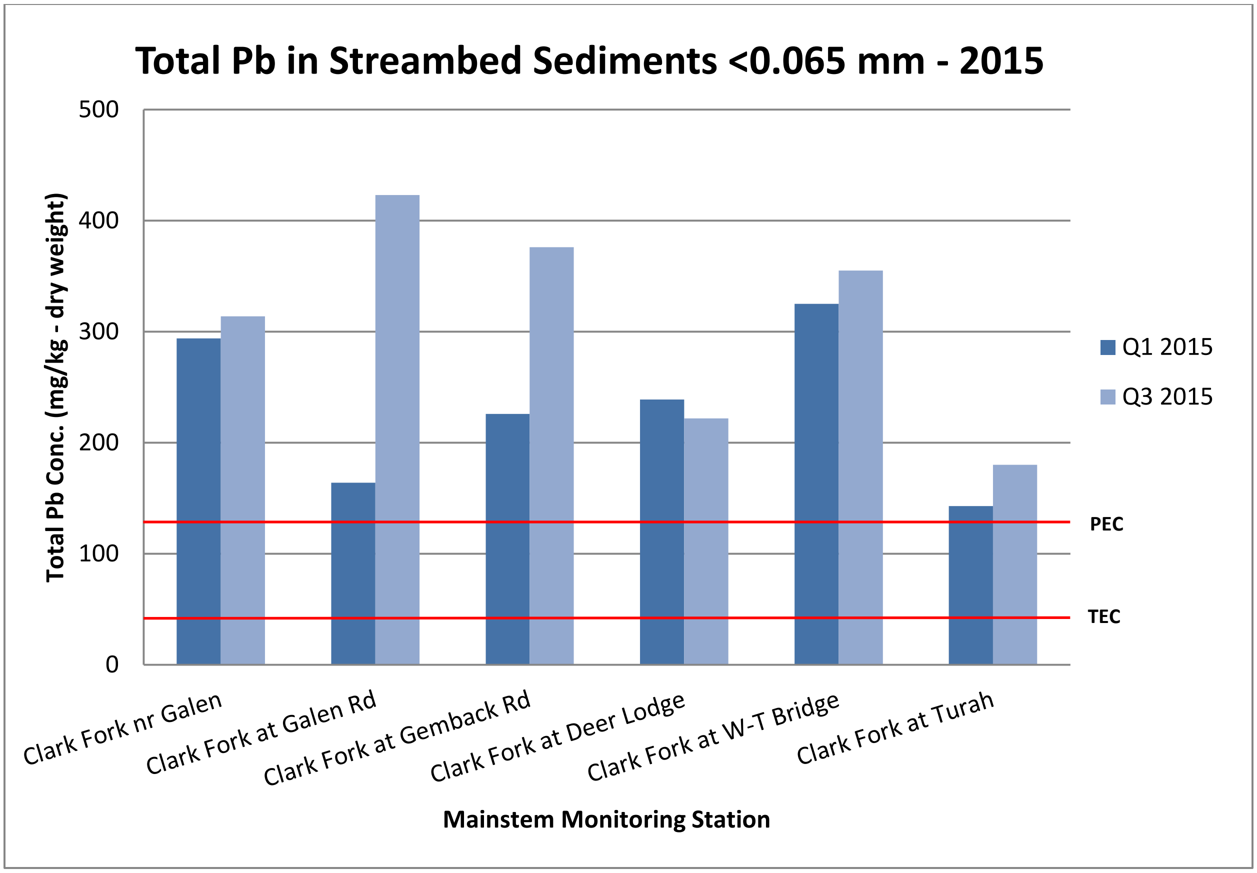

Figure 3-8. Total lead (Pb) concentrations (dry weight) in Clark Fork River mainstem sediment samples, 2015. Red lines represent the "threshold effect concentration" (TEC) and the "probable effect concentration" (PEC) [MacDonald et al., 2000].

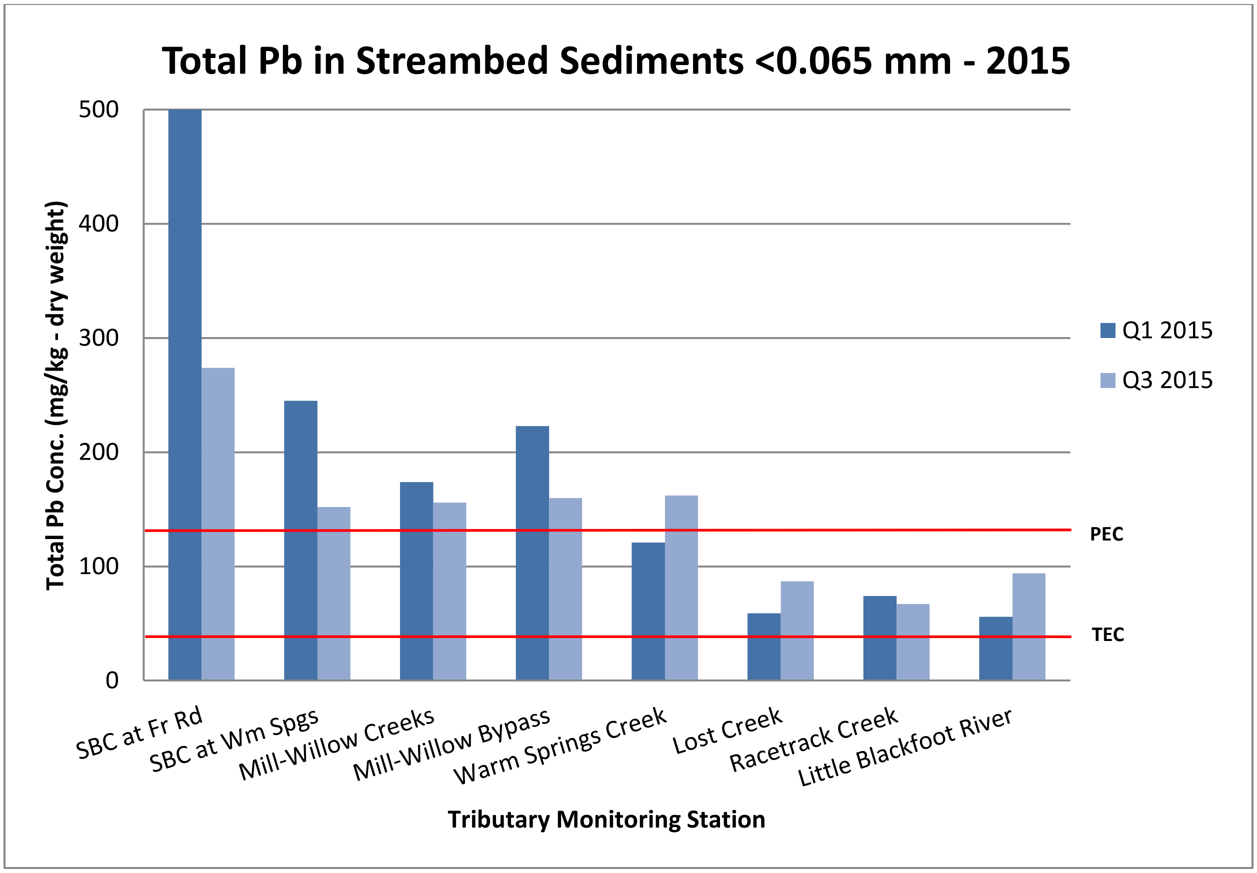

Figure 3-9. Total lead (Pb) concentrations (dry weight) in Clark Fork River tributary sediment samples, 2015. Red lines represent the "threshold effect concentration" (TEC) and the "probable effect concentration" (PEC) [MacDonald et al., 2000].

3.3.2.5 Zinc

Fine fraction (<0.065 mm) instream sediment zinc concentrations in the Clark Fork River mainstem in 2015 ranged from 787-1,880 mg/kg-DW [Table 3-9]. Zinc concentrations in mainstem monitoring sites during 2015 were similar between sites although there was considerable variability [Figure 3-10]. For example, zinc concentrations in the mainstem were lowest at Galen Road in Q1 but then highest at the same site in Q3 [Figure 3-10]. In the mainstem, exceedances of the TEC and PEC occurred at all sites during all monitoring periods [Figure 3-10].

Fine fraction (<0.065 mm) instream sediment zinc concentrations in the Clark Fork River tributaries in 2015 ranged from 163-15,000 mg/kg-DW [Table 3-9]. Zinc concentrations in tributary monitoring sites were lowest during both monitoring periods in Racetrack Creek and highest during both periods in Silver Bow Creek at Frontage Road [Figure 3-11]. At both Silver Bow Creek and the Mill-Willow Bypass sites, concentrations were substantially higher in in Q1 compared to Q3 but at the other tributary sites concentrations were similar between monitoring periods [Figure 3-11]. Zinc concentration in Silver Bow Creek at Frontage Road was high during both quarters, but zinc concentration at the site in Q1 was extremely high as were concentrations in that sample for all other COCs [Figure 3-11]. In the tributaries, exceedances of the TEC reference value occurred at all sites during all monitoring periods [Figure 3-11]. Exceedances of the PEC reference value occurred during both quarters at both Silver Bow Creek and Mill-Willow Creek sites and in Warm Springs Creek in Q3 [Figure 3-11].

Table 3-9. Total zinc concentrations (mg/kg dry weight) in fine fraction (<0.065 mm) instream sediment samples from the Clark Fork River Operable Unit, 2015.

Site ID	Site Location	Sample concentration (mg/kg-WW)	
		Q1	Q3
Mainstem Sites			
CFR-03A	Clark Fork River near Galen	1770	1410
CFR-07D	Clark Fork River at Galen Road	787	1880
CFR-11F	Clark Fork River at Gemback Road	1190	1460
CFR-27H	Clark Fork River at Deer Lodge	1230	1260
CFR-34	Clark Fork River at Williams-Tavenner Bridge	1670	1400
CFR-116A	Clark Fork River at Turah	991	1160
Tributary Sites			
SS-19	Silver Bow Creek at Frontage Road	15000	2780
SS-25	Silver Bow Creek at Warm Springs	1960	939
MCWC-MWB	Mill-Willow Creek at Frontage Road	652	552
MWB-SBC	Mill-Willow Bypass near mouth	1200	538
WSC-SBC	Warm Springs Creek near mouth	456	594
LC-7.5	Lost Creek near mouth	251	300
RTC-1.5	Racetrack Creek near mouth	163	135
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	180	271

(Yellow) Exceeds threshold effect concentration [MacDonald et al., 2000].
(Red) Exceeds probable effect concentration [MacDonald et al., 2000].

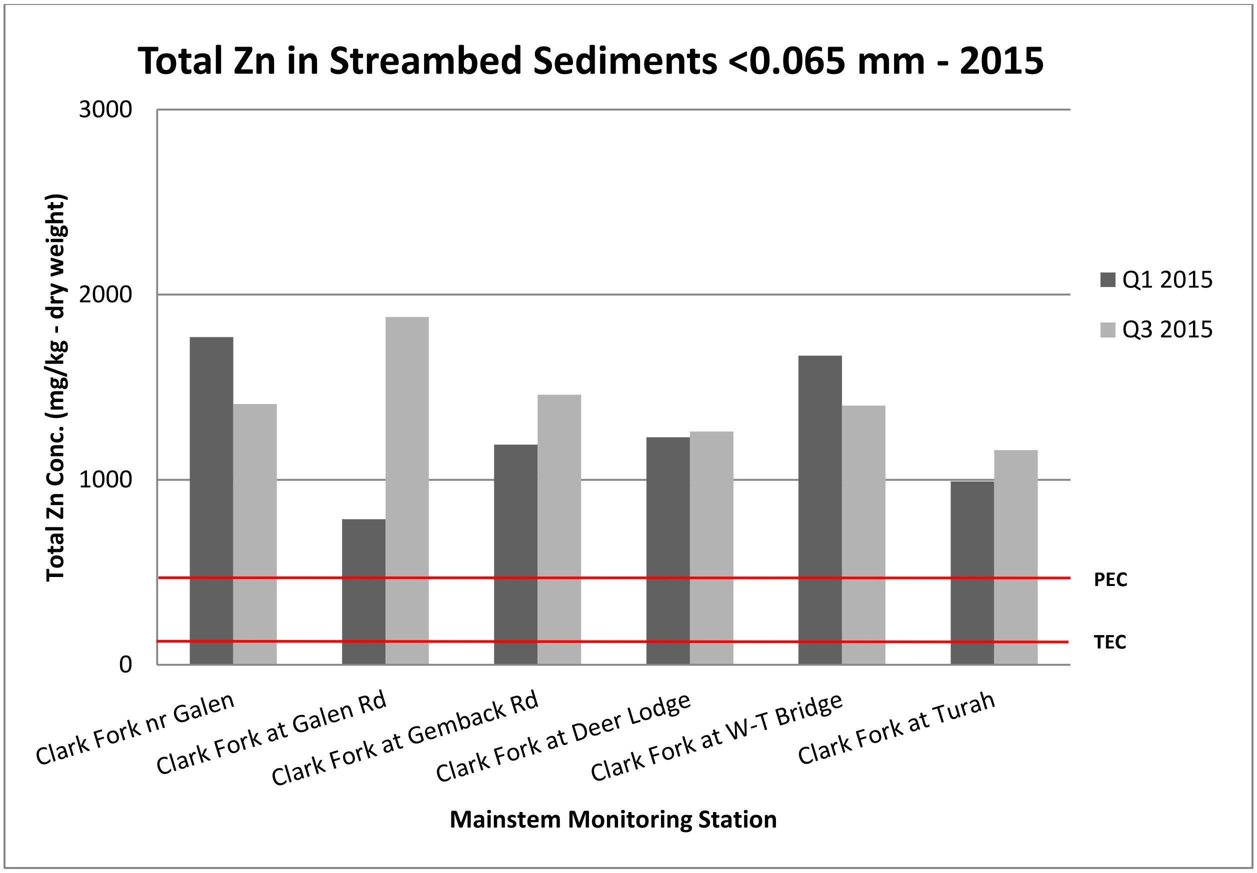

Figure 3-10. Total zinc (Zn) concentrations (dry weight) in Clark Fork River mainstem sediment samples, 2015. Red lines represent the "threshold effect concentration" (TEC) and the "probable effect concentration" (PEC) [MacDonald et al., 2000].

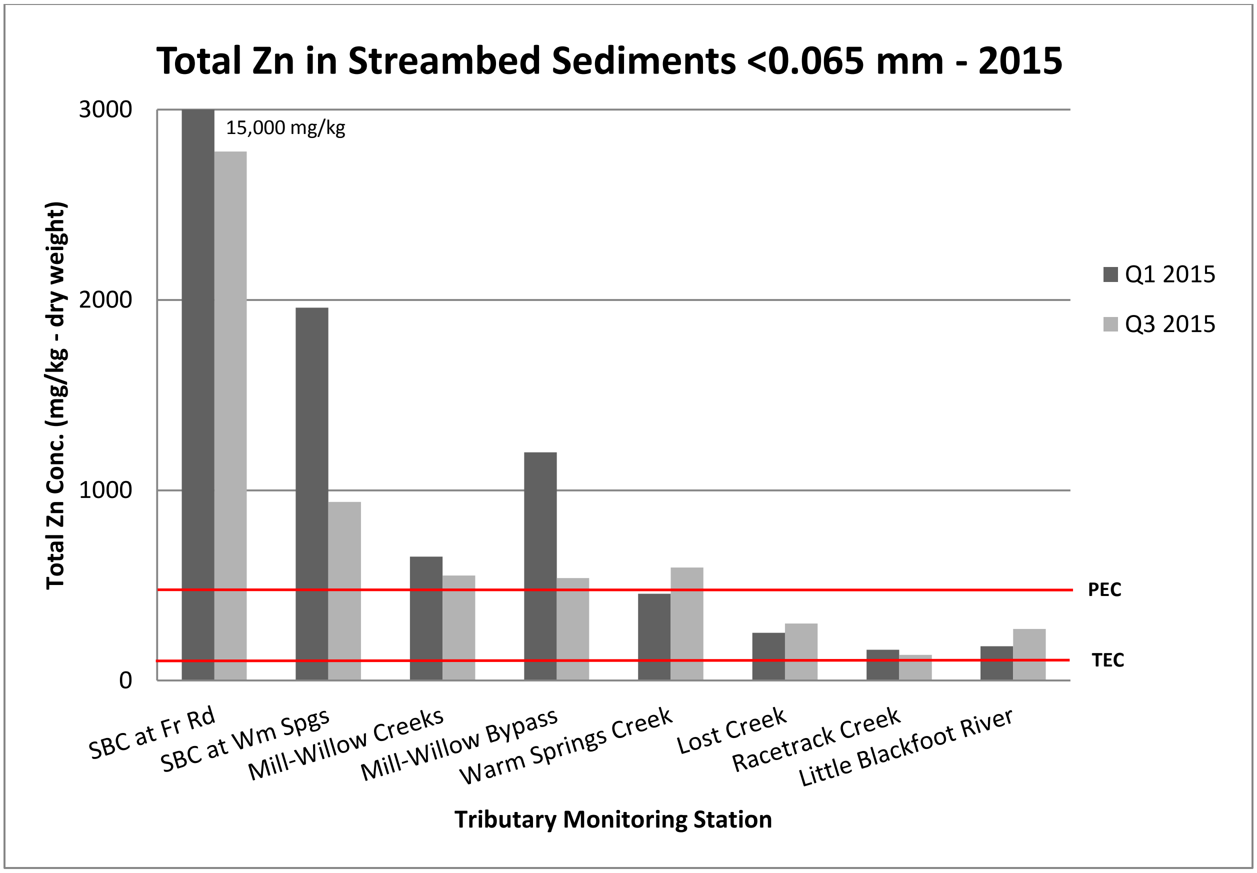

Figure 3-11. Total zinc (Zn) concentrations (dry weight) in Clark Fork River tributary sediment samples, 2015. Red lines represent the "threshold effect concentration" (TEC) and the "probable effect concentration" (PEC) [MacDonald et al., 2000].

3.3.3 Data Validation

The quantitative portion of the data quality objectives (DQOs) for sampling precision consist of comparisons between field sample and field duplicate concentrations for each analyte in the monitoring program. In 2015, four field sample and field duplicate pairs were collected and analyzed to evaluate sampling precision. In each field sample and duplicate pair, five comparisons were made, one for each metal in the fine fraction (<0.065 mm). In total, there were 20 analytes where field sample and duplicate relative percent difference (RPD) comparisons were made. Of those, 1 of 20 (5.0%) had an RPD greater than the DQO specified for sampling precision (40%). That exceedance (54.5%) of the RPD limit occurred for cadmium in the Clark Fork River at Deer Lodge in Q3.

3.4 DISCUSSION

3.4.1 Sample Size Fraction

Variability in sediment metals concentrations at any given monitoring site during any particular sampling event may be influenced by channel morphology and depositional processes. These factors may cause variability in the size composition of the sample, which in turn influences the concentrations of metals in the sample as size fraction is strongly related (inversely) to metal concentration in sediment samples in the CFROU. The proportion of sediment in the fine size fraction (<0.065 mm) was highly variable among sites and among sample periods, and even among field sample and duplicate sample pairs collected at the same site during the same monitoring event. Sediment samples in the CFROU were analyzed in only the fine size fraction to minimize variability due to size fraction.

3.4.2 Contaminants of Concern

In the Clark Fork River mainstem, the highest instream sediment COC metals concentrations tended to occur in Reach A, either at Galen Road or at the Williams-Tavenner Bridge site downstream from Deer Lodge. The lowest concentrations consistently occurred at Turah. All mainstem sites exceeded the PEC for arsenic, copper, lead, and zinc during both sample periods. Concentrations of cadmium exceeded the PEC at all of the Clark Fork River mainstem monitoring stations except at Galen Road and at Turah during both of the Q1 and Q3 2015 monitoring events. Those sites exceeded the PEC during the Q3 monitoring event but not during Q1.

Elevated COC concentrations in sediments of the Clark Fork River tributaries occurred in Silver Bow Creek both above and below the Warm Springs Ponds, in Mill-Willow Creek both above and below the Mill-Willow Bypass, and to a lesser degree in Warm Springs Creek, Lost Creek, and Racetrack Creek. The lowest sediment COC concentrations in the tributaries were consistently in the Little Blackfoot River. Among the tributary monitoring stations, concentrations of sediment arsenic, cadmium, copper, lead and zinc exceeded the PEC at all of the sites except the Little Blackfoot River, Lost Creek, and Racetrack Creek during one or both of the Q1 and Q3 2015 monitoring events. Lost Creek exceeded the PEC for arsenic and copper during both of the Q1 and Q3 monitoring events, but not for cadmium, lead or zinc. Racetrack Creek exceeded the PEC for arsenic in Q3 only, and did not exceed the PEC for cadmium, copper, lead, or zinc in either of Q1 or Q3. The Little Blackfoot River exceeded the PEC for arsenic in Q1 only, and did not exceed the PEC for cadmium, copper, lead, or zinc in either of Q1 or Q3.

At all CFROU sites in all sample periods of 2015, the COC which most frequently exceeded the PEC (in descending order) were arsenic (93%; 26 of 28 samples), copper (86%; 24 of 28 samples), lead and zinc (75%; 21 of 28 samples), and cadmium (68%; 19 of 28 samples).

3.4.3 Data Validation

All but one RPD from field sample and field duplicate pairs in 2015 was within 40% thus satisfying the project goal for “overall precision” for 95% of the data collected in 2015. A complete analysis of data validation procedures and results is described in Appendix A.

4.0 VEGETATION

4.1 INTRODUCTION

Major remediation of the floodplain in Phase 1, Reach A of the Clark Fork River Operable Unit (CFROU) was completed in December 2013 [Bartkowiak et al., 2013]. In total, over 330,000 cubic yards of floodplain waste material was removed and 189,000 cubic yards of rock and vegetative material was used to rebuild the floodplain in Phase 1 [Bartkowiak et al., 2013]. Revegetation activities in Phase 1 began in fall of 2013 [Bartkowiak et al., 2013]. Woody shrub and tree plantings occurred in the fall of 2013 and 2014, and shrub and herbaceous species seeding occurred in the spring and summer of 2014 [Bartkowiak et al., 2014].

Vegetation monitoring data was collected for specific metrics to evaluate progress toward attainment of vegetation performance targets. Monitoring was conducted in the summer of 2014 and 2015. Monitoring in 2015 completes all Year-1 monitoring for Phase 1. Herbaceous cover was monitored in floodplain transect cover plots in 2015. Survival of planted woody vegetation was conducted in floodplain survival monitoring plots in 2014 and 2015. Woody percent cover was monitored within floodplain survival plots in 2015. Streambank vegetation monitoring was conducted in 2014. This report provides detailed methods and results for floodplain plant survival and cover monitoring activities. Methods and results of the streambank monitoring activities for Phase 1 are described in Traxler and Naughton [2015].

4.2 METHODS

4.2.1 Monitoring Locations

Vegetation monitoring occurred in Phase 1 of Reach A in the CFROU in 2015 [Figure 1-2]. In 2015, all vegetation monitoring in Phase 1 occurred on the floodplain. All streambank vegetation monitoring in Phase 1 was completed in 2014. Monitoring of cover and survival of woody vegetation occurred in discrete floodplain plots (referred to hereafter as “floodplain plots”). Monitoring of herbaceous cover occurred in smaller subplots located along linear floodplain transects (referred to hereafter as “floodplain transect subplots”).

4.2.1.1 Floodplain Plots

Floodplain plot locations were selected using a stratified sample design which included a minimum of 10% of the woody plantings in Phase 1. Monitoring plots were selected to include the range of vegetation cover types used in Phase 1 approximately in proportion to the frequency of each cover type in Phase 1 [Sacry et al., 2012; 2014; Sacry and Parker, 2015]. Floodplain cover types included ‘emergent wetland, “floodplain riparian shrub”, “outer bank riparian shrub”, “riparian wetland”, and “upland” cover types. The characteristics of each planting unit were determined from the as-built design overviews. Rectangular monitoring plots were placed around a portion of selected planting units. The size and location of each monitoring plot within each selected planting unit was selected conveniently in order to include the minimum required number of woody plants to meet the objectives of the monitoring program (i.e., monitor 10% of all woody plants and monitor the range of floodplain vegetation cover types and browse treatments)[16]. The location of all floodplain plots monitored in Phase 1 is depicted in Figure 4-1.

[16] Floodplain plant survival monitoring plot corners were marked with 36x5/8 inch steel reinforcing bar (rebar) stakes driven approximately 24 inches into the soil. Each rebar stake was capped and marked with identifying information. Prior to monitoring each floodplain plant survival monitoring plot, survey string was placed around the outside of the plot stakes to delineate plot boundaries.

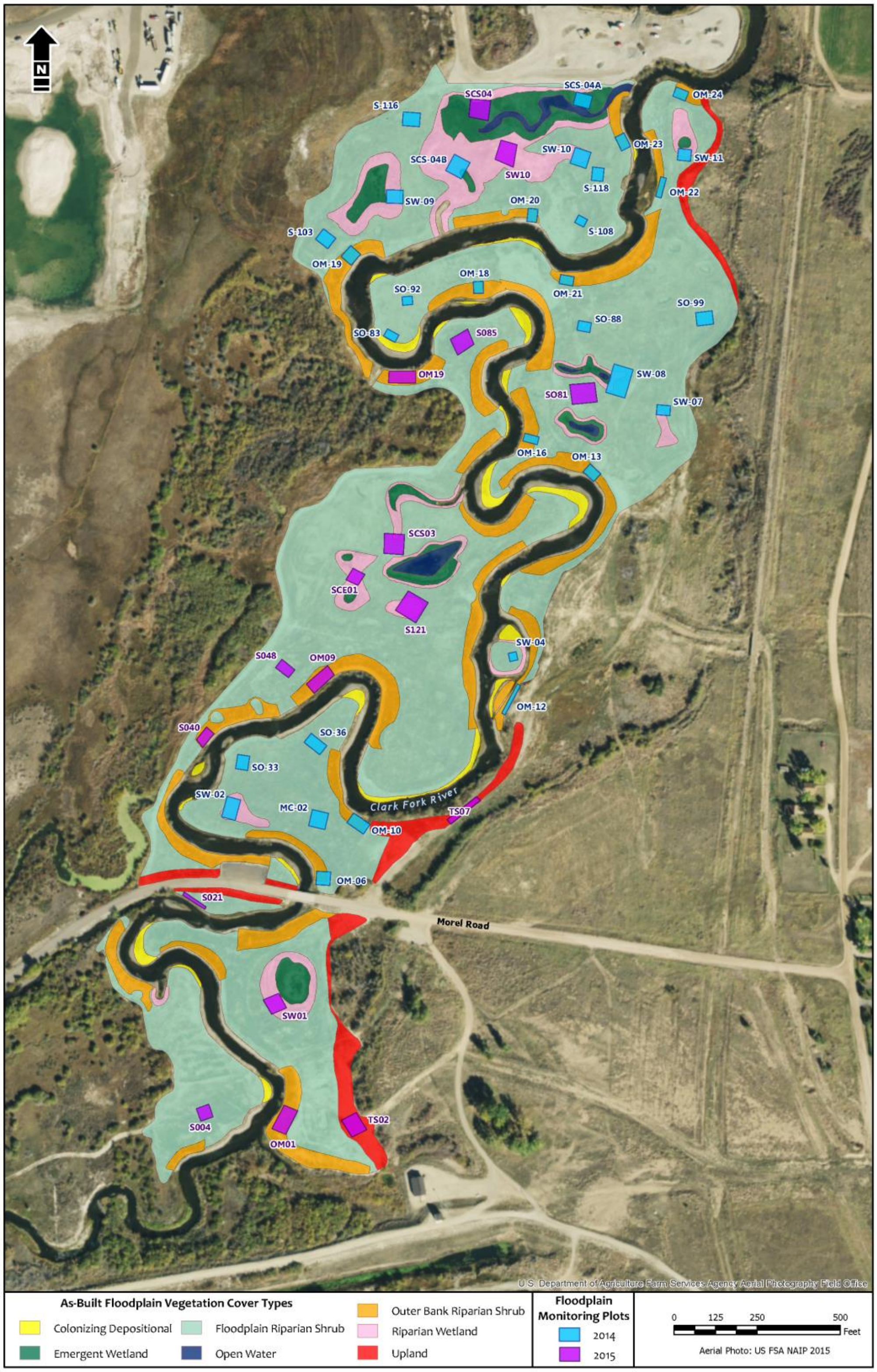

Figure 4-1. Floodplain plots in Phase 1 of the Clark Fork River Operable Unit, 2014-2015.

4.2.1.2 Floodplain Transects

Ten floodplain transects were established in Phase 1 [Figure 4-2] for monitoring of herbaceous vegetation on the floodplain. Transects generally encompassed the entire width of the floodplain and were oriented perpendicular to the river [Figure 4-2]. Transect locations were determined from as-built designs and were intended to represent the diversity of floodplain vegetation conditions in Phase 1 (see Sacry et al. [2012] for details). Based on recommendations of Sacry and Parker [2015], 38 sample points were selected (3-5 sample points per transect) along the ten transects, and at each sample point two subplots were established for monitoring. One sample point was established within each new cover type intersected by each transect. The specific location of the sample point within the cover type was randomly selected. At each of those sampling points, monitoring data was collected in two small (9 square foot; 3x3 foot) subplots [Figure 4-3]. Each subplot was established along a line oriented perpendicular to the transect at distances of five feet and 12 feet from the transect [Figure 4-3]. Transect start points, end points, and sampling point locations were marked in the field with rebar.

Figure 4-2. Floodplain cover monitoring transects in Phase 1 of the Clark Fork River Operable Unit, 2015. Two sub-plots (9 ft^2) were established along a 3'x15' belt transect perpendicular to plot points along each transect.

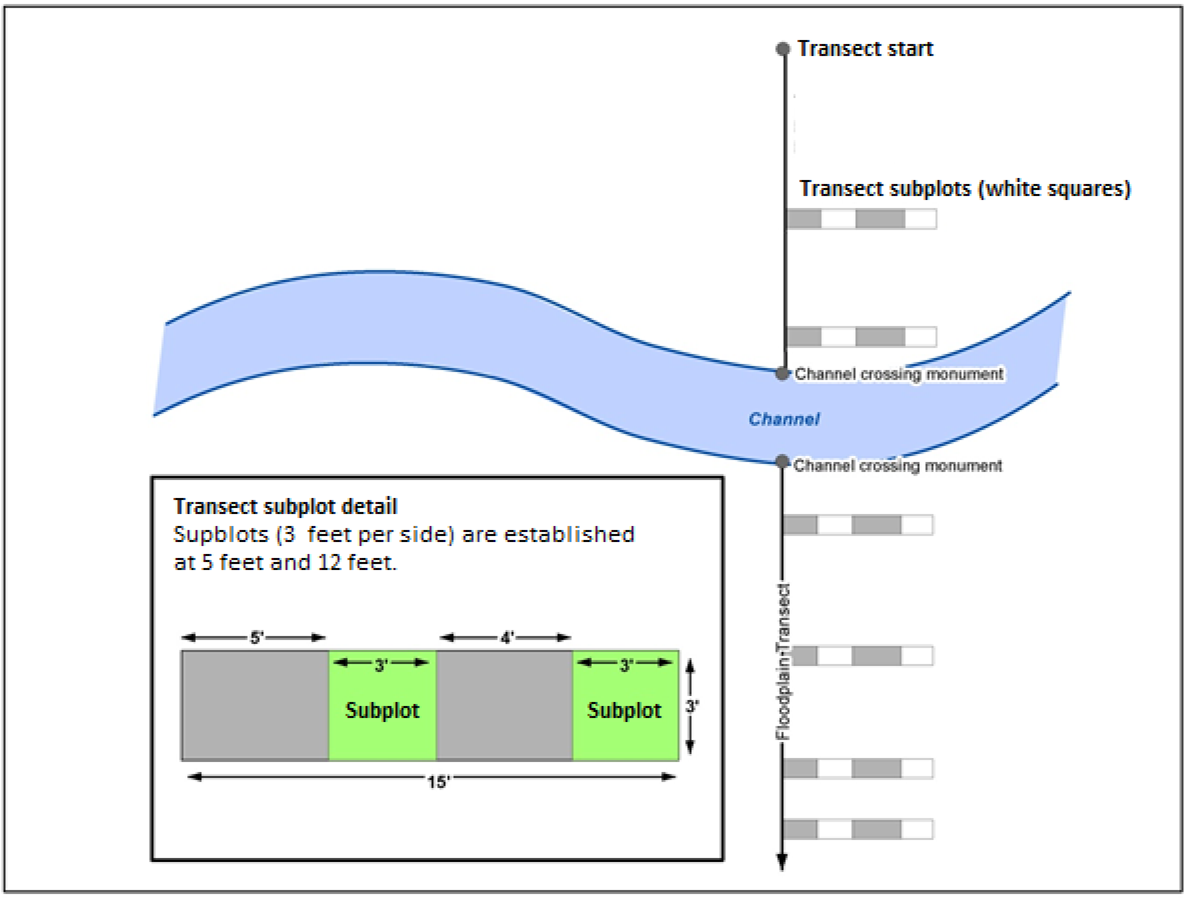

Figure 4-3. Schematic of floodplain transect sampling design for Phase 1 of the Clark Fork River Operable Unit (figure adapted from Sacry et al. [2012]). Floodplain transect and subplot locations determined by Sacry et al. [2012].

4.2.2 Monitoring Schedule

The frequency of vegetation monitoring for Phase 1 of the CFROU varies by monitoring metric. However, regardless of the metric, all vegetation monitoring should occur during the growing season [Sacry et al., 2012]. The 2015 monitoring season was the second year of monitoring to complete Year-1 monitoring in Phase 1.

Prior to data collection activities, a site visit occurred on July 8, 2015 to review site conditions, monitoring protocols, and consider adaptations to the protocols based on observed conditions. The site visit included project managers from the Montana Department of Environmental Quality (MDEQ), members of the design team, and monitoring field staff. Monitoring plots that were established in 2015 were installed from May 19-21, 2015 prior to the site visit on July 8. Monitoring plots were monitored from August 4-7 and August 19-20, 2015. Field activities were conducted by a monitoring team of 2-4 people.

4.2.3 Monitoring Parameters

4.2.3.1 Performance Targets

Data described in this report are intended to evaluate progress toward attainment of vegetation performance targets following remediation of Phase 1 in Reach A of the CFROU. In addition, results of this monitoring will inform adaptive management decisions for ongoing remediation and restoration actions in other phases of the CFROU. This report describes conditions in Phase 1 in Year-1 after remedial activities and all revegetation activities were completed. Performance targets for Phase 1 in Year-1 are presented in Table 4-1. The monitoring metrics used to evaluate the performance targets reflect desired project goals as recommended by Sacry et al. [2012] for streambank and floodplain vegetation. Performance targets for noxious weeds and wetlands were specified in the CFROU ROD [USEPA, 2004].

Four primary monitoring metrics were evaluated in the floodplain of Phase 1 in 2015: woody plant survival, woody plant canopy cover, native herbaceous plant cover, and noxious weed cover. For each of those monitoring metrics, performance targets have been established for Phase 1 [Table 4-1]. Some of these metrics were monitored in the floodplain plots and some were monitored in floodplain transect subplots as described in the following sections.

4.2.3.1.1 Metrics Monitored in Floodplain Plots

Woody plant canopy cover and woody plant survival were monitored in the floodplain plots (see Section 1.2.1.1). Woody plant canopy cover was not monitored in 2014 and therefore all monitoring for this metric occurred in 2015. However, some woody plant survival monitoring occurred in 2014 and in 2015.

In addition to the monitoring metrics with specific performance targets, some other data was collected in the floodplain plots. First, the intensity of vegetation browse by herbivorous animals on each containerized plant monitored was determined. Browse intensity does not have a performance target but may influence woody plant survival and woody plant canopy cover [Sacry et al., 2012]. Therefore, browse intensity data was also collected on those plants as a potential causal factor to explain why those performance targets were, or were not, met.

Second, the occurrence (i.e., presence) of all herbaceous species and noxious species within each floodplain plot was determined, and additional notes were made for each monitoring plot such as the apparent cause of plant mortality, potential needs for maintenance, potential water stress, and identification of possible insect infestations or diseases. The overall effectiveness of each type of plant protection was noted within each plot as well as the condition of the plant protection and need for maintenance.

4.2.3.1.2 Metrics Monitored in Floodplain Transect Subplots

Total native herbaceous cover and noxious weed cover were monitored in floodplain transects (see Section 1.2.1.2). For those metrics, herbaceous vegetation also included woody vegetation that did not exceed eight inches in height.

Table 4-1. Performance targets for vegetation monitoring metrics in Phase 1 of the Clark Fork River Operable Unit following remediation [Source: Sacry et al., 2012].

Objective	Monitoring Metric	Year (post-remediation)				
		1	3	5	10	15
Streambanks[17]	Woody plant canopy cover (%)			40	50	80
Floodplain	Woody plant survival (%)	80[18]				
Floodplain	Woody plant canopy cover (%)			30	50	
Floodplain	Total native herbaceous cover (%)	20[19]		80	80	80
Noxious weeds[20]	Noxious weed cover (%)	<5[21]	<5	<5	<5	<5
Wetlands	Wetland area (acres)				0.47	
Wetlands	Functional effective wetland area (FEWA) score				2.3	

4.2.4 Sample Collection and Analysis

4.2.4.1 Woody Plant Survival

In each floodplain plot, each containerized woody plant was evaluated to determine plant species, survival, and browse intensity. Woody plant survival only has a performance target for Year-1 to evaluate planting success for the containerized plants [Table 4-1]. Plants which were rooted partially on the plot boundaries were considered within the plot if at least 50% of the plant's roots were assumed to be inside the plot.

4.2.4.2 Woody Plant Canopy Cover

In a subsample of the floodplain plots, woody plant canopy cover was evaluated. This metric was determined by sampling points within each selected floodplain plot based on an evenly spaced grid pattern [Figure 4-4]. At each sample location within each floodplain plot (121 sample sites per plot), a vegetation surveyor held a survey rod vertically and if the rod came into contact with any portion of a large woody plant, that sample point was considered to have complete woody plant canopy cover, or conversely, if the rod did not touch any portion of a large woody plant that sample point was considered to have no woody plant canopy cover. Finally, the overall proportion of the 121 sample points within the floodplain plot with woody plant canopy cover was determined.

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[17] Monitored in 2014 (see Traxler and Naughton [2015]).

[18] Monitored in 2014 (see Traxler and Naughton [2015]) and 2015.

[19] Monitored in 2015.

[20] Noxious weeds include those listed by the state of Montana [MDA, 2015].

[21] Monitored in 2015.

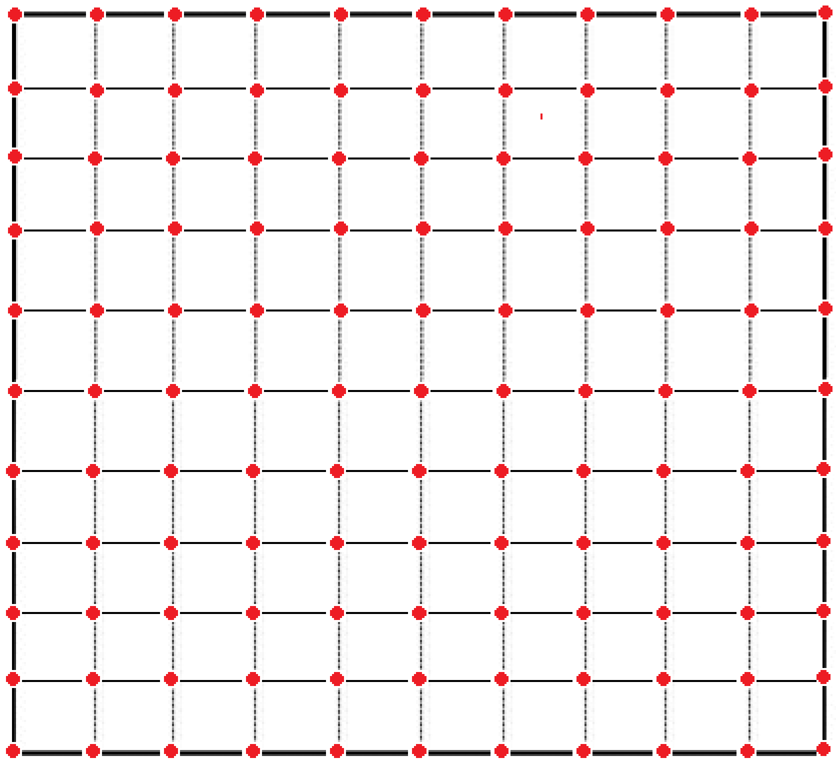

Figure 4-4. Schematic sampling grid for floodplain canopy cover within floodplain plots. Sampling grid lines were evenly spaced (11 per side including the plot boundaries) along each plot side. Samples were collected at each gridline intersection (red dots) for a total of 121 cover measurements per floodplain plot.

4.2.4.3 Total Native Herbaceous Cover and Noxious Weed Cover

The cover percentage of each plant species in each floodplain transect subplot was estimated visually. From those species cover estimates, the native cover metric [Table 4-1] was calculated as the sum of all native species cover estimates within each floodplain transect subplot. We defined native species as those identified as "native" by the Montana Natural Heritage Program [MNHP, 2016]. Plants listed by MNHP [2016] as "exotic" were classified as "nonnative" in this report. Plants not specifically listed by MNHP [2016] as "native" or "exotic" were classified as of "unknown" origin in this report. The noxious weed cover metric was calculated as the sum of all noxious weed cover estimates in each floodplain transect subplot. We defined noxious weeds as those listed by the Montana Department of Agriculture as noxious weeds [MDA, 2015]. No species that we classified as of "unknown" origin were listed as noxious weeds by MDA [2015].

4.2.5 Data Analysis

Mean survival of all planted shrub and tree species in each floodplain plot of Phase 1 was calculated to evaluate the Phase 1, Year-1 performance target. Mean survival was also calculated by cover type and a chi-squared test of equal proportions was used to compare survival among those cover types. Mean survival by cover type and species was also assessed and tabulated. Data collected from the floodplain plots for these analyses included plant survival (binary variable; “alive” and “dead”), plant species (categorical variable at species-level), browse intensity (ordinal variable; “mild” indicating that <50% of current year growth is browsed; “low” indicating that >50% of current year growth is browsed, “moderate” indicating that prior year growth was browsed, and “heavy” indicating that extensive browse resulting in stunted plant growth), and cover type (categorical variable provided by Sacry et al. [2012]). .

Mean woody plant canopy cover among all sampled floodplain plots, among plots originally planted in 2013, and among plots planted in 2014 was calculated to provide a point of comparison to future monitoring years. Quantitative values for woody plant canopy cover in each floodplain plot were measured as the proportion of sample points with canopy cover to the total number of sample points within each plot. Year of planting in these plots was determined from the as-built designs provided by Geum Environmental Consulting, Inc.

Mean total native herbaceous cover and mean noxious weed cover among all sampled floodplain transect subplots was calculated and compared to the performance targets for each respective metric. The total cover proportion of native herbaceous species was calculated as the sum of all native plant species within each subplot. The total noxious weed cover metric was calculated in the same manner.

Proportional occurrence of each herbaceous (grasses, grass allies, and forbs) plant species was also evaluated for the entire phase and by cover type. This statistic does not have a performance target but may be informative to assess the diversity and distribution of species by cover type in Phase 1. Browse intensity was summarized for all plants based on survival status (i.e., alive or dead) to assess the influence of browse on survival. Finally, browse intensity was summarized by species to evaluate if browsers demonstrated a preference for particular plants.

4.3 RESULTS

4.3.1 Performance Targets

4.3.1.1 Woody Plant Survival

In 2014 and 2015, 53 floodplain plots were monitored for woody plant survival within the floodplain planting units [Figure 4-1]. In total, 2,986 out of 31,929 (9.4%) containerized plants (all shrubs or trees) were monitored in those 53 plots. Among all the containerized plants sampled, survival was at least 85.5% [Table 4-2]. Survival was “unknown” for 5.1% of the plants monitored [Table 4-2].

Survival of all containerized plant species was significantly different among cover types (*p*-value from two-sided chi-squared test <0.0001; chi-squared statistic = 70.358). Among all containerized plants, survival was lowest in the upland cover type (69.3%) and ≥81.9% in all other cover types [Table 4-2]. Survival was highest (95.0%) in the outer bank riparian shrub cover type [Table 4-2].

Seventeen species were observed among the 2,986 containerized plants monitored in the floodplain plots. Survival of each species by cover type is tabulated in Table 4-2. Survival was high (90%) for all willow (*Salix*) species [Table 4-3]. Seven willow species were observed including (in order of frequency): narrowleaf willow (*Salix exigua)*, Bebb willow (*Salix bebbiana*), Booth willow (*Salix boothii*), yellow willow (*Salix lutea*), Pacific willow (*Salix lasiandra*), Geyer willow (*Salix geyeriana*), and Drummond willow (*Salix drummondiana*). It was often not practical to identify dead willows to species-level in the field and therefore it is difficult to make survival comparisons among willow species. Eighty two willow plants were observed which could not be identified to species-level, 98% of which were dead.

Other woody plants identified in the floodplain survival plots included speckled alder (*Alnus incana*), birch (*Betula occidentalis*), red-oiser dogwood (*Cornus stolonifera*), rubber rabbitbrush (*Ericameria nauseosa*), black cottonwood (*Populus balsamifera*), quaking aspen (*Populus tremuloides*)*,* shrubby cinquefoil (*Dasiphora fruticosa*), golden currant (*Ribes aureum*), inland gooseberry (*Ribes setosum*), Wood's rose (*Rosa woodsia*), black greasewood (*Sarcobatus vermiculatus*), buffalo berry (*Sheperdia argentea*), , and four dead plants of unknown species [Table 4-3]. Survival of each species was ≥80% except for speckled alder, birch, and shrubby cinquefoil. Speckled alder survival was 79%. Among cover types, speckled alder survival was lowest in riparian wetland (60%) and floodplain riparian shrub (75%) cover types. Birch survival was 72%. Birch survival was lowest in riparian wetland (65%), emergent wetland (65%), and floodplain riparian shrub (71%) cover types. Shrubby cinquefoil survival was 46%. In total, 46 shrubby cinquefoil were monitored, most of which (85%) were observed in the upland cover type where survival was low (41%).

Table 4-2. Woody plant survival by cover type in 53 floodplain plots in Phase 1 of the Clark Fork River Operable Unit, 2014-2015.

Cover Type	Plants (counts)				Alive (%)
	Alive	Unknown	Dead	Total	
Emergent Wetland	193	2	31	226	85.4
Floodplain Riparian Shrub	634	83	57	774	81.9
Outer Bank Riparian Shrub	857	22	23	902	95.0
Riparian Wetland	736	44	112	892	82.5
Upland	133	0	59	192	69.3
Total	2,553	151	282	2,986	85.5

Table 4-3. Survival of planted woody plant species by cover type among 53 floodplain plots in Phase 1 of the Clark Fork River Operable Unit, 2014-2015.

Common name	Taxonomic name	Cover type	Plants (counts)				Alive (%)
			Alive	Unk	Dead	Total	
Speckled alder	*Alnus incana*	Emergent Wetland	1	0	0	1	100
		Floodplain Riparian Shrub	6	1	1	8	75
		Outer Bank Riparian Shrub	20	3	0	23	87
		Riparian Wetland	6	0	4	10	60
		Total	**33**	**4**	**5**	**42**	**79**
Birch	*Betula occidentalis*	Emergent Wetland	54	2	27	83	65
		Floodplain Riparian Shrub	133	40	15	188	71
		Outer Bank Riparian Shrub	91	0	8	99	92
		Riparian Wetland	102	17	39	158	65
		Total	**380**	**59**	**89**	**528**	**72**
Red-oiser dogwood	*Cornus stolonifera*	Emergent Wetland	1	0	0	1	100
		Floodplain Riparian Shrub	65	2	3	70	93
		Outer Bank Riparian Shrub	22	0	3	25	88
		Riparian Wetland	27	3	4	34	79
		Upland	0	0	2	2	0
		Total	**115**	**5**	**12**	**132**	**87**
Black cottonwood	*Populus balsamifera*	Emergent Wetland	2	0	1	3	67
		Floodplain Riparian Shrub	31	0	0	31	100
		Outer Bank Riparian Shrub	28	0	2	30	93
		Riparian Wetland	12	0	1	13	92
		Upland	10	0	1	11	91
		Total	**83**	**0**	**5**	**88**	**94**
Quaking aspen	*Populus tremuloides*	Outer Bank Riparian Shrub	20	0	0	20	100
		Total	**20**	**0**	**0**	**20**	**100**
Golden currant	*Ribes aureum*	Floodplain Riparian Shrub	4	0	0	4	100
		Outer Bank Riparian Shrub	4	0	0	4	100
		Riparian Wetland	4	0	0	4	100
		Upland	20	0	2	22	91
		Total	**32**	**0**	**2**	**34**	**94**

Inland gooseberry	*Ribes setosum*	Emergent Wetland	1	0	2	3	33
		Floodplain Riparian Shrub	10	0	0	10	100
		Outer Bank Riparian Shrub	4	0	0	4	100
		Riparian Wetland	25	0	0	25	100
		Upland	31	0	14	45	69
		Total	**71**	**0**	**16**	**87**	**82**
Wood's rose	*Rosa woodsii*	Floodplain Riparian Shrub	2	0	0	2	100
		Riparian Wetland	3	0	0	3	100
		Outer Bank Riparian Shrub	7	0	0	7	100
		Riparian Wetland	1	0	0	1	100
		Upland	5	0	2	7	71
		Total	**18**	**0**	**2**	**20**	**90**
Bebb willow	*Salix bebbiana*	Emergent Wetland	5	0	0	5	100
		Floodplain Riparian Shrub	75	0	5	80	94
		Outer Bank Riparian Shrub	82	0	2	84	98
		Riparian Wetland	82	0	11	93	88
		Total	**244**	**0**	**18**	**262**	**93**
Booth willow	*Salix boothii*	Floodplain Riparian Shrub	57	6	0	63	90
		Outer Bank Riparian Shrub	94	1	0	95	99
		Riparian Wetland	19	1	0	20	95
		Total	**170**	**8**	**0**	**178**	**96**
Drummond willow	*Salix drummondiana*	Floodplain Riparian Shrub	1	0	0	1	100
		Total	**1**	**0**	**0**	**1**	**100**
Narrowleaf willow	*Salix exigua*	Emergent Wetland	112	0	0	112	100
		Floodplain Riparian Shrub	217	34	0	251	86
		Outer Bank Riparian Shrub	431	18	0	449	96
		Riparian Wetland	398	23	5	426	93
		Total	**1,158**	**75**	**5**	**1,238**	**94**
Geyer willow	*Salix geyeriana*	Emergent Wetland	1	0	0	1	100
		Floodplain Riparian Shrub	12	0	0	12	100
		Outer Bank Riparian Shrub	1	0	0	1	100
		Riparian Wetland	1	0	0	1	100
		Total	**15**	**0**	**0**	**15**	**100**

Pacific willow	*Salix lasiandra*	Emergent Wetland	5	0	0	5	100
		Floodplain Riparian Shrub	4	0	0	4	100
		Outer Bank Riparian Shrub	10	0	0	10	100
		Riparian Wetland	30	0	1	31	97
		Total	**49**	**0**	**1**	**50**	**98**
Yellow willow	*Salix lutea*	Floodplain Riparian Shrub	12	0	0	12	100
		Outer Bank Riparian Shrub	28	0	2	30	93
		Riparian Wetland	10	0	2	12	83
		Total	**50**	**0**	**4**	**54**	**93**
Willow (species unknown)	*Salix* spp.	Emergent Wetland	0	0	1	1	0
		Floodplain Riparian Shrub	2	0	33	35	6
		Outer Bank Riparian Shrub	0	0	1	1	0
		Riparian Wetland	0	0	45	45	0
		Total	**2**	**0**	**80**	**82**	**2**
Buffalo berry	*Sheperdia argentea*	Emergent Wetland	11	0	0	11	100
		Floodplain Riparian Shrub	3	0	0	3	100
		Outer Bank Riparian Shrub	13	0	0	13	100
		Riparian Wetland	15	0	0	15	100
		Upland	58	0	25	83	70
		Total	**100**	**0**	**25**	**125**	**80**
Shrubby cinquefoil	*Dasiphora fruticosa*	Outer Bank Riparian Shrub	2	0	1	3	67
		Riparian Wetland	1	0	0	1	100
		Upland	9	0	13	22	41
		Total	**12**	**0**	**14**	**26**	**46**
Unknown	Unknown	Outer Bank Riparian Shrub	0	0	4	4	0
		Total	**0**	**0**	**4**	**4**	**0**

4.3.1.2 Woody Plant Canopy Cover

Twelve floodplain plots were monitored for woody plant canopy cover in 2015. Among those twelve plots, half (6 plots) were planted in 2013 and the other half (6 plots) were planted in 2014. Among all plots in Year-1 monitoring, mean woody plant canopy cover was 14.8% (standard deviation [SD] = 13.3%; range = 1.7-39.7%). Mean woody plant canopy cover was 25.1% (SD = 11.2%; range = 10.7-39.7%) for the six plots planted in 2013. Mean woody plant canopy cover was 4.5% (SD = 2.9%; range = 1.7-9.9%) for the six plots planted in 2014.

4.3.1.3 Total Native Herbaceous Cover

Mean total percent cover of all herbaceous plants (and small <8 inch tall woody plants) in the 76 subplots of the floodplain transects was 51.0% (SD = 23.1%; range = 9-98%). Mean percent cover of native herbaceous plants was 31.0% (SD = 26.8%; range = 0-97%). One subplot (1.3%) had no native herbaceous plant cover. The five most common native herbaceous plants by mean cover proportion were common yarrow (8.7%), slender wheatgrass (5.7%), Nebraska sedge (4.0%), tufted hairgrass (3.1%), and American mannagrass (2.0%) [Table 4-4]. All of the five most common native herbaceous plant species were included in the various seed mixes for the site. Of the native plants observed, none were classified by the state of Montana as “at risk of extirpation” (i.e., ranked as “S1” or “S2” by MNHP [2016]). The most sensitive species identified in the floodplain cover monitoring plots was Austin's knotweed which has been identified as “S3/S4” by the state of Montana and therefore it is “potentially at risk” of extirpation [MNHP, 2016]. Austin’s knotweed was observed in one plot (1.3%) and cover from Austin’s knotweed in that plot was estimated as 0.1%. The percent cover of each native herbaceous plant species in the floodplain transect subplots is summarized in Table 4-4.

Table 4-4. Native plant cover (%) in 76 floodplain transect subplots in Phase 1 of the Clark Fork River Operable Unit, 2015.

Common name	Taxonomic name	State Rank [MNHP, 2016]	Cover (%)			
			Mean	Standard Deviation	Minimum	Maximum
Grasses						
Western wheatgrass	*Agropyron smithii*	S5	0	0.2	0	2
American sloughgrass	*Beckmannia syzigachne*	S4	0.4	1.9	0	15
Tufted hairgrass	*Deschampsia cespitosa;*	S5	3.1	11.2	0	70
Slender wheatgrass	*Elymus trachycaulus*	S4/S5	5.7	8.3	0	30
American mannagrass	*Glyceria grandis*	S4	2	9.9	0	80
Nuttall's alkaligrass	*Puccinellia nuttalliana*	S5	0	0.1	0	1
Grass Allies						
Nebraska sedge	*Carex nebrascensis*	S5	4	12.6	0	60
Liddon sedge	*Carex petasata*	S4/S5	0.9	5.9	0	45
Northwest Territory sedge	*Carex utriculata*	S5	0.6	4.6	0	40
Creeping spikerush	*Eleocharis palustris*	S5	0.4	2.9	0	25
Baltic rush	*Juncus balticus*	S5	0.8	3	0	25
Bulrush	*Schoenoplectus spp*	Multiple	0	0.1	0	1
Small-fruit bulrush	*Scirpus microcarpus*	S4/S5	0	0.1	0	1
Cattail	*Typha latifolia*	S5	0.2	1.2	0	10
Forbs						
Common yarrow	*Achillea millefolium*	S5	8.7	17.4	0	90
White sagebrush	*Artemisia ludoviciana*	S5	0.6	2.1	0	15
Hairy willowherb	*Epilobium ciliatum*	S4/S5	0	0.1	0	1
Foxtail barley	*Hordeum jubatum*	S5	0.4	2.1	0	15
Wild mint	*Mentha arvensis*	S5	0	0.2	0	1
Water smartweed	*Polygonum amphibium*	S5	0	0.2	0	1
Austin's knotweed	*Polygonum douglasii*	S3/S4	0	0	0	0.1
Sea-side dock	*Rumex fueginus*	SNR	0.3	1.4	0	10
Horned sea-blite	*Suaeda calceoliformis*	SNR	0.7	3.5	0	25
American speedwell	*Veronica americana*	S5	0	0.3	0	2
Saxifrage spp	*Micranthes spp*	Multiple	0.4	1.5	0	10
Silverweed cinquefoil	*Potentilla anserina*	S4/S5	0.1	0.5	0	4
Shrubs						
Fringed sagebrush	*Artemisia frigida*	S5	0.2	1.2	0	10
Birch	*Betula occidentalis*	S4/S5	0	0.1	0	1
Rubber rabbitbrush	*Ericameria nauseosa*	S5	0	0.1	0	1
Bebb willow	*Salix bebbiana*	S5	0.1	1.1	0	10
Narrowleaf willow	*Salix exigua*	S5	1.2	8.1	0	70
Black greasewood	*Sarcobatus vermiculatus*	S5	0	0.3	0	3

4.3.1.4 Noxious Weed Cover

Mean percent cover of noxious weeds among all floodplain transect subplots was 0.1% (SD = 0.7%; range = 0-5%). Two noxious weeds were identified in the floodplain transect subplots: whitetop (*Cardaria draba*) and yellow toadflax (*Linaria vulgaris*) [Table 4-5]. Both observed noxious weeds are ranked by the Montana Department of Agriculture as "2B" in the noxious weed list [MDA, 2015]. MDA [2015] states the following in regards to weeds ranked 2B:

> "These weeds are abundant in Montana and widespread in many counties. Management criteria will require eradication or containment where less abundant. Management shall be prioritized by local weed districts."

Each noxious weed was observed in 2 of the 76 (2.6%) floodplain transect subplots. In each of those subplots, whitetop cover was estimated at 2% and 5% and Yellow toadflax cover was estimated at 0.5% and 3%.

Cheatgrass was also observed in 1 of the 76 (1.3%) floodplain transect subplots. In that subplot, cheatgrass cover was estimated as 0.1%. Cheatgrass is ranked as "3" by MDA [2015]. MDA [2015] states the following in regards to weeds ranked 3:

> "Regulated plants: (NOT MONTANA LISTED NOXIOUS WEEDS) These regulated plants have the potential to have significant negative impacts. The plant may not be intentionally spread or sold other than as a contaminant in agricultural products. The state recommends research, education and prevention to minimize the spread of the regulated plant."

Weed control actions in Phase 1 were conducted by Mountain Valley Plant Management (MVPM). MVPM conducted weed spraying operations within and adjacent to the Phase 1 floodplain between July 16-21, 2015 prior to vegetation monitoring activities in August 2015. MVPM identified the location of weed infestation and subsequently treated areas within the constructed floodplain and within adjacent habitat outside the Phase 1 construction boundaries [Figure 4-5]. The largest infestations of Canada thistle, leafy spurge, cheatgrass, and black henbane (*Hyoscyamus niger*) occurred outside the constructed floodplain in adjacent habitat.

Mean percent cover of all nonnative plants, including those listed as noxious weeds by MDA [2015], was 17.3% (SD=19.2%; range =0-80%). Mean percent cover of plants of unknown origin was 2.7% (SD = 5.9%; range = 0-30%). Plants were of unknown origin either because the origin of that particular species had not been determined by MNHP [2016] (e.g., thickspike wheatgrass [*Agropyron dasystachyum*]), or because that particular plant was not identified in the field to species-level and the genus has both native and nonnative species. The percent cover of each nonnative or unknown origin plant species in the floodplain cover monitoring plots are summarized in Table 4-5.

Table 4-5. Nonnative plant cover (%) in 76 floodplain transect subplots in Phase 1 of the Clark Fork River Operable Unit, 2015.

Common name	Taxonomic name	Noxious weed [MDA, 2015]	Cover (%)			
			Mean	Standard Deviation	Minimum	Maximum
Grasses						
Thickspike wheatgrass^	*Agropyron dasystachyum*		0.1	0.6	0	5
Intermediate wheatgrass	*Agropyron intermedium*		0.4	1.1	0	5
Creeping foxtail	*Alopecurus arundinaceus*		0.3	1.8	0	15
Cheatgrass*	*Bromus tectorum*		0	0	0	0.1
Fescue sppΔ	*Festuca spp*		1.2	4.1	0	30
Canada bluegrass	*Poa compressa*		1.1	2.2	0	10
Gass sppΔ	*Poaceae spp*		0.8	1.8	0	10
Grass Allies						
SedgeΔ	*Carex spp*		0.5	3.6	0	30
Three-stamened rush^	*Juncus ensifolius*		0	0.1	0	1
Whitetop	*Cardaria draba*	X	0.1	0.6	0	5
ButtercupΔ	*Potentilla spp*		0	0	0	0.1
Forbs						
Redtop	*Agropryon stolonifera*		1.9	4.3	0	20
Pit-seed goosefoot	*Chenopodium berlandieri*		0	0.1	0	0.5
Oakleaf goosefoot	*Chenopodium glaucum*		3.6	8.9	0	40
Mexican kochia	*Kochia scoparia*		2.4	9	0	50
Yellow toadflax	*Linaria vulgaris*	X	0	0.3	0	3
Alfalfa	*Medicago sativa*		7	15.7	0	80
ButtercupΔ	*Ranunculus spp*		0.1	0.4	0	3
Curly dock	*Rumex crispus*		0.1	0.7	0	5
Dock sppΔ	*Rumex spp*		0.1	0.7	0	5
Tall tumble-mustard	*Sisymbrium altissimum*		0.1	0.4	0	3
Field sowthistle	*Sonchus arvensis*		0	0.3	0	3
Common dandelion	*Taraxacum officinale*		0	0.1	0	1
White clover	*Trifolium repens*		0.3	1.6	0	10

^ Species origin not specified by MNHP [2016].

Δ Species origin is unknown because the plant was not identified to species-level and some members of the genus are native whereas others are nonnative.

* Regulated plant [MDA, 2015].

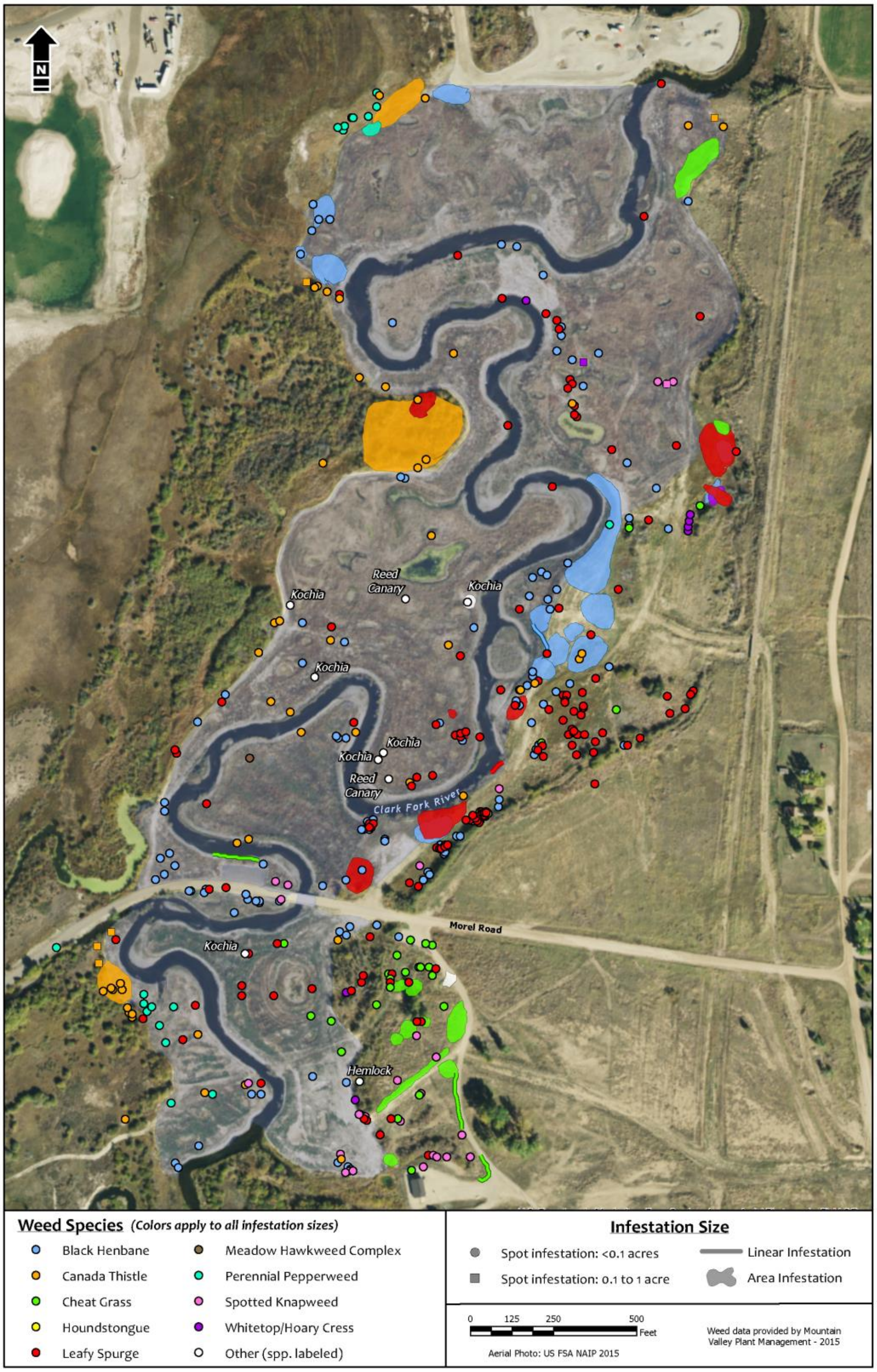

Figure 4-5. Weed infestation areas treated in Phase 1 of the Clark Fork River Operable Unit, 2015 (Source: MVPM [2015]). Shaded region represents the Phase 1 project area.

4.3.2 Occurrence

Sixty herbaceous plant species were observed in the 53 floodplain plots including 12 grasses, 9 grass allies, and 39 forbs [Table 4-6]. In addition, some plants were identified to genus-level but not to species-level including: members of the grass *Poaceae* genus, sedge *Carex* genus, pigweed *Amaranthus* genus, mustard *Brassica* genus, knotweed *Polygonum* genus, and dock *Rumex* genus [Table 4-6].

The five most commonly observed grass species were intermediate wheatgrass (*Agropyron intermedium*) (66%), slender wheatgrass (*Elymus trachycaulus*) (55%), Canada bluegrass (*Poa compressa*) (47%), quackgrass (*Agrypyron repens*) (26%), and tufted hairgrass (*Deschampsia cespitosa*) (17%). Nine of the 12 grass species observed are native; however, three of the most common grasses (intermediate wheatgrass, quackgrass, and Canada bluegrass are nonnative. No grasses observed in the survival plots are noxious weeds.

The five most commonly observed grass allie species were cattail (*Typha latifolia*) (28%), Nebraska sedge (*Carex nebrascensis*) (13%), Baltic rush (*Juncus balticus*) (11%), Woolly sedge (*Carex pellita*) (9%), and whitetop (*Cardaria draba*) (6%). All of the grass allie species observed are native with the exception of whitetop which is a noxious weed.

The five most commonly observed forb species were common yarrow (*Achillea millefolium*) (62%), oakleaf goosefoot (*Chenopodium glaucum*) (45%), Mexican kochia (*Kochia scoparia*) (43%), alfalfa (*Medicago sativa*) (36%), and white sagebrush (*Artemisia ludoviciana*) (32%). Twelve of the 36 forb species observed are native including two (common yarrow and white sagebrush) of the most common forbs. Both common yarrow and white sage were seeded across the site. Four forbs observed in the survival plots are noxious weeds including: spotted knapweed (*Centaurea maculosa*) (2%), Canada thistle (*Cirsium arvense*) (6%), leafy spurge (*Euphorbia esula*) (6%), and yellow toadflax (*Linaria vulgaris*) (2%).

Table 4-6. Occurrence of herbaceous plant species in floodplain plots in Phase 1 of the Clark Fork River Operable Unit, 2014-2015.

Common Name	Taxonomic Name	Native Species [MNHP, 2016][22]	Noxious Weeds [MDA [2015]	Occurrence by cover type (%)					
				Emergent Wetland (*n* = 3)	Floodplain riparian shrub (*n* = 17)	Outer bank riparian shrub (*n* = 17)	Riparian wetland (*n* = 14)	Upland (*n* = 2)	Total (*n* = 53)
Grasses									
Intermediate wheatgrass	*Agropyron intermedium*			0	82	59	79	0	66
Quackgrass	*Agropyron repens*			0	35	35	14	0	26
Rough bentgrass	*Agrostis scabra*	X		0	6	0	0	0	2
American sloughgrass	*Beckmannia syzigachne*	X		0	6	0	29	0	9
Tufted hairgrass	*Deschampsia cespitosa*	X		67	18	0	29	0	17
Hairgass	*Deschampsia spp*	X		0	6	0	21	0	8
Canada wildrye	*Elymus canadensis*	X		0	24	0	14	0	11
Slender wheatgrass	*Elymus trachycaulus*	X		67	35	35	50	50	55
American mannagrass	*Glyceria grandis*	X		0	24	0	14	0	11
Alkali muhly	*Muhlenbergia asperifolia*	X		0	6	0	0	0	2
Canada Bluegrass	*Poa compressa*			0	65	41	50	0	47
Grass spp	*Poaceae spp*	unk		0	0	6	0	0	2
Nuttall's alkaligrass	*Puccinellia nuttalliana*	X		0	0	0	7	0	2
Grass Allies									
Whitetop	*Cardaria draba*		X	0	12	0	7	0	6
Nebraska sedge	*Carex nebrascensis*	X		67	12	0	21	0	13

[22] Species origin is unknown because the plant was not identified to species-level and not all members of the genus are native, or, because the species origin has not been specified by MNHP [2016].

Woolly sedge	*Carex pellita*	X		33	6	0	21	0	9
Sedge	*Carex spp*	unk		0	6	0	7	0	4
Northwest Territory sedge	*Carex utriculata*	X		33	0	0	0	0	2
Inflated sedge	*Carex vesicaria*	X		0	0	0	7	0	2
Creeping spikerush	*Eleocharis palustris*	X		0	6	0	0	0	2
Baltic rush	*Juncus balticus*	X		67	24	0	0	0	11
Cattail	*Typha latifolia*	X		67	41	0	43	0	28
Forbs									
Common yarrow	*Achillea millefolium*	X		33	76	76	57	0	62
Redtop	*Agropryon stolonifera*			33	24	12	50	0	26
Pigweed	*Amaranthus spp*	unk		0	6	0	0	0	2
Stinking chamomile	*Anthemis cotula*			0	12	18	0	0	9
White sagebrush	*Artemisia ludoviciana*	X		0	24	65	14	0	32
Tumbling orache	*Atriplex rosea*			0	6	0	0	0	2
Mustard	*Brassica spp*			0	6	0	0	0	2
Spotted knapweed	*Centaurea maculosa*		X	0	6	0	0	0	2
Fireweed	*Chamerion angustifolium*	X		0	0	18	0	0	6
Pit-seed goosefoot	*Chenopodium berlandieri*			0	24	12	14	0	15
Strawberry goosefoot	*Chenopodium capitatum*	unk		0	0	0	7	0	2
Oakleaf goosefoot	*Chenopodium glaucum*			67	35	53	50	0	45
Canada thistle	*Cirsium arvense*		X	0	12	6	0	0	6
Rocky Mountain bee plant	*Cleome serrulata*	X		0	41	12	43	50	30
Hairy willowherb	*Epilobium ciliatum*	X		0	6	35	0	0	13
Leafy spurge	*Euphorbia esula*		X	0	6	12	0	0	6
Common sunflower	*Helianthus annuus*	unk		0	12	0	0	0	4
Foxtail barley	*Hordeum jubatum*	X		33	35	18	43	0	30
Coarse sumpweed	*Iva xanthifolia*	X		0	0	6	0	0	2
Mexican kochia	*Kochia scoparia*			0	53	35	57	0	43
Yellow toadflax	*Linaria vulgaris*		X	0	6	0	0	0	2

Black medic	*Medicago lupulina*			0	6	0	0	0	2
Alfalfa	*Medicago sativa*			0	41	53	14	50	36
Common large monkeyflower	*Mimulus guttatus*	X		0	6	0	0	0	2
Prostrate knotweed	*Polygonum aviculare*			33	24	6	7	0	13
Spotted ladysthumb	*Polygonum persicaria*			0	6	0	7	0	4
Knotweed complex	*Polygonum species*			0	0	0	7	0	2
Curly dock	*Rumex crispus*			0	12	0	0	0	4
Sea-side dock	*Rumex fueginus*	X		0	6	6	0	0	4
Willow dock	*Rumex salicifolius*	X		0	0	0	7	0	2
Dock spp	*Rumex spp*	unk		0	6	0	0	0	2
Tall tumble-mustard	*Sisymbrium altissimum*			0	6	41	14	50	21
Small tumble-mustard	*Sisymbrium loeselii*			0	12	35	14	0	19
Cut-leaf nightshade	*Solanum triflorum*	unk		0	0	6	7	0	4
Field sowthistle	*Sonchus arvensis*			0	12	35	29	0	23
Spiny-leaf sowthistle	*Sonchus asper*			0	0	6	0	0	2
Horned sea-blite	*Suaeda calceoliformis*	X		0	0	6	21	0	8
Field pennycress	*Thlaspi arvense*			0	0	12	0	0	4
American speedwell	*Veronica americana*	X		0	12	0	7	0	6
Common mullein	*Verbascum thapsus*			0	0	6	0	0	2

4.4 DISCUSSION

Vegetation monitoring in Phase 1 of the CFROU in 2015 was primarily focused on four metrics: floodplain woody plant survival, floodplain woody plant cover, floodplain native herbaceous plant cover, and floodplain cover of noxious weeds. There were Year-1 performance targets for all of those metrics except floodplain woody plant cover. Floodplain woody plant cover was monitored in Year-1 to provide a point of comparison to monitoring in later years to evaluate temporal trends.

Mean floodplain woody plant survival in Phase 1 in Year-1 was between 85.5-96.1% (survival of 5.1% of the plants was "unknown") which achieved the Year-1 performance target (≥80%). Survival was significantly different among cover types but only the upland cover type had mean survival (69.3%) which was below the overall performance target. Plants within the upland cover type which had low (<80%) survival included red-oiser dogwood (0%; n = 2), inland gooseberry (69%; n = 45), Wood's rose (71%; n = 7), buffalo berry (70%; n = 83), and shrubby cinquefoil (41%; n = 22). Dry conditions during the growing season may have been partially responsible for lower than average survival in the planted uplands. All willow species had high (>90%) survival. As a genus, *Salix* survival was slightly lower than for each individual species because it was sometimes not practical to identify dead willows to species-level. Of all the dead willows observed, 42% (80 of 191) were not identified to species-level. Species with low (<80%) survival overall included speckled alder (79%), birch (72%), and shrubby cinquefoil (46%). Birch survival was low (65-72%) in all cover types except outer bank riparian shrub. Browse intensity did not appear to be related to woody plant survival, although this was not evaluated quantitatively because the performance target for survival overall was achieved.

Mean floodplain woody plant cover in a subsample of the floodplain plots was 14.8%. There was a substantial difference in mean cover of floodplain plants planted in 2013 (25.1%) compared to 2014 (4.5%). Although this sample size was small, based on this sample it appears that floodplain woody plant cover in Phase 1 was approaching the Year-5 performance target (30%) after only two growing seasons.

Mean native herbaceous plant cover was 31% which exceeded the Phase 1, Year-1 performance target (≥20%). The most common native plants (all of which were included in seeding mixes for the site) were common yarrow, slender wheatgrass, Nebraska sedge, tufted hairgrass, and American mannagrass. One rare plant (Austin's knotweed) was observed in a single floodplain transect subplot, and this species is listed by the state of Montana as "potentially at risk" of extirpation [MNHP, 2016]. Mean total cover in the floodplain transect subplots was 51%.

Mean noxious weed cover among all floodplain transect subplots was 0.1% which achieved the Phase 1 performance target (<5%). In those plots, two noxious weeds were observed: whitetop and yellow toadflax. Management recommendations by MDA [2015] for such weeds are for eradication and containment. Cheatgrass, a MDA [2015] identified "regulated plant", was also identified in one floodplain cover plot.

Additional noxious weed data presented in this report are the occurrence of noxious weeds in floodplain plots and weed distribution data provided by the weed treatment team. Although these additional data are not used to assess any performance targets we believe inclusion of this information provides a more robust assessment of noxious weed prevalence in Phase 1 in Year-1. In the floodplain plots, five noxious weeds were observed in at least one plot: whitetop, spotted knapweed, Canada thistle, leafy spurge, and yellow toadflax. Noxious weeds were treated throughout Phase 1 and in adjacent areas. Weeds treated included black henbane, Canada thistle, cheatgrass, houndstongue, leafy spurge, meadow hawkweed, pepperweed, spotted knapweed, and whitetop. Black henbane, cheatgrass, and pepperweed are not listed as MDA [2015] noxious weeds.

The total wetland area and functional effective wetland area performance goals will be evaluated in Year-5 [USEPA, 2004]. Therefore, no monitoring of wetlands was conducted in 2014 or 2015, and wetland monitoring will be conducted in Phase 1 in 2019.

Finally, streamflows during the spring snowmelt period in 2014 slightly exceeded the bankfull design level in Phase 1 and resulted in extensive inundation of the floodplain both spatially and temporally. The lowered floodplain elevation in combination with these modest flood levels provided excellent conditions for plant survival and growth in Phase 1 in 2014. Some floodplain plots remained wet in late August when monitoring occurred and soil moisture levels appeared to be high for that time of year (although soil moisture was not quantified). Floodwater redistributed wood that had been placed on the floodplain, and brush trenches and streambank willow cuttings appeared to be effective at capturing and retaining that wood.

In comparison, streamflows during the spring of 2015 did not exceed the bankfull design and precipitation throughout the growing season was below average for the area. With lower than average precipitation, woody vegetation planted in the fall of 2014 demonstrated some signs of stress during the August 2015 monitoring, especially in upland plots with particularly dry soils at the time of monitoring. Despite the relatively poor moisture conditions in 2015, the proportion of herbaceous plant cover in the floodplain exceeded the Year-1 performance target, which underscores the success of seeding operations across the Phase 1 floodplain.

5.0 PERIPHYTON

5.1 INTRODUCTION

This chapter describes results of periphyton (benthic algae) monitoring within the Clark Fork River Operable Unit (CFROU) in 2015. A total of thirteen sites were sampled, including six sites on the Clark Fork River and seven sites on tributary streams. Periphyton monitoring is one element of the Montana Department of Environmental Quality program for evaluating the influence of remediation on the ecology of the Clark Fork River.

Periphyton samples were analyzed for non-diatom (soft-bodied) algae, and diatom algae taxonomy and community structure. A suite of analytical metrics was applied to the diatom data to assess the degree of impairment from metals, nutrients, and sedimentation. These metrics included a stressor-specific tool developed for the Middle Rockies Ecoregion [Teply, 2010a; 2010b] and adopted by MDEQ as a periphyton standard operating procedure for determining the probability of sediment impairment [MDEQ, 2011]. In addition, a variety of diatom metrics developed for Montana mountain streams were used [Bahls et al., 1992; Bahls, 1993; Teply and Bahls, 2005] which are based on autecological preferences or requirements of freshwater diatoms [Lowe, 1974; Van Dam et al., 1994; Bahls, 2006].

Potential water quality or habitat stressors at each site, indicated by the taxonomic and functional composition of the algal flora, are described in a series of site-specific narratives.

5.2 METHODS

5.2.1 Sampling

In September 2015, the periphyton community was sampled at six sites on the Clark Fork River and eight sites on tributary streams [Table 5-1]. Tributary sites were located in Silver Bow Creek (two sites), Mill and Willow Creeks (two sites), Warm Springs Creek, Lost Creek, Racetrack Creek, and the Little Blackfoot River. The sites sampled in 2015 were generally the same as those sampled in 2014 but two additional sites have been added in 2015: Silver Bow Creek at Frontage Road (SS-19) and the Clark Fork River at Williams-Tavenner Bridge (CFR-34). The Silver Bow Creek at Frontage Road site (SS-19) was sampled as part of the Streamside Tailings Operable Unit monitoring program with essentially the same sampling methods as the other CFROU sites [Naughton et al., 2015a]. Results for SS-19 are included in this report to provide a paired site in Silver Bow Creek above (SS-19) and below (SS-25; Silver Bow Creek at Warm Springs) the Warm Springs Ponds. Site CFR-34 is located between Deer Lodge and the Little Blackfoot River confluence, and was added in 2015 to better assess conditions in lower Reach A, downstream from the Grant-Kohrs Ranch. For all sites except SS-19, project staff collected periphyton samples from September 10-11, 2015; the SS-19 sample was collected on September 8, 2015. One composite periphyton sample was collected from multiple substrates and habitat types at each monitoring site. Periphyton samples were collected following the MDEQ PERI-1 method for flowing streams where a defined reach has not been established [MDEQ, 2011]. Periphyton samples were preserved in the field with Lugol's IKI solution and were transported to the laboratory on ice.

Table 5-1. Periphyton sampling locations in the Clark Fork River Operable Unit, 2015.

Site ID	Site Location	Co-located USGS Streamflow Gauge	Location (GPS coordinates, NAD 83)	
			Latitude	Longitude
Tributary Sites				
SS-19	Silver Bow Creek at Frontage Road	None	46.12247	-112.80032
SS-25	Silver Bow Creek at Warms Springs	12323750	46.18123	-112.77917
MCWC-MWB	Mill-Willow Creek at Frontage Road	none	46.12649	-112.79876
MWB-SBC	Mill-Willow Bypass near mouth	none	46.17839	-112.78270
WSC-SBC	Warms Springs Creek near mouth	12323770	46.18041	-112.78592
LC-7.5	Lost Creek near mouth	12323850	46.21862	-112.77384
RTC-1.5	Racetrack Creek near mouth	none	46.28395	-112.74921
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	none	46.53710	-112.72443
Mainstem Sites				
CFR-03A	Clark Fork River near Galen	12323800	46.20877	-112.76740
CFR-07D	Clark Fork River at Galen Road	none	46.23725	-112.75302
CFR-11F	Clark Fork River at Gemback Road	none	46.26520	-112.74430
CFR-27H	Clark Fork River at Deer Lodge	12324200	46.39796	-112.74283
CFR-34	Clark Fork at Williams-Tavenner Bridge	none	46..47119	-112.72492
CFR-116A	Clark Fork River at Turah	12334550	46.82646	-113.81424

5.2.2 Laboratory Analysis

5.2.2.1 Non-Diatom Algae

To prepare samples for analysis of soft-bodied algae, raw periphyton samples were vigorously shaken in the original sample container to homogenize the sample. The contents were then emptied into a porcelain evaporating dish. A small, random subsample of the liquid fraction containing suspended algal material (approximately 3-5 drops) was dispensed onto a welled glass microscope slide using a disposable plastic dropper. Visible (i.e., macroscopic) soft-bodied algae were teased apart and subsampled in proportion to their estimated importance relative to the total volume of algal material in the sample, and this material was added to the liquid fraction on the slide. The assembled subsample was then covered with a 22x30 mm cover slip, and the completed wet mount was analyzed for soft-bodied algae using an Olympus BHT compound microscope as described below.

The cover slip was scanned at 100X following a set pattern in the approximate shape of an hourglass (upper and lower horizontal transects linked by diagonal transects); magnification was increased to 200X or 400X as necessary to resolve detail in smaller specimens. All soft-bodied algae were identified to genus. The relative abundance of each soft-bodied algal genus (and of all diatom genera collectively) was estimated for comparative purposes, according to the following system:

- rare (r): represented by a single occurrence in the subsample;
- occasional (o): represented by multiple occurrences, but infrequently observed;
- common (c): represented by multiple occurrences, regularly observed;
- frequent (f): present in nearly every field of view;
- abundant (a): multiple occurrences in every field of view;
- dominant (d): multiple occurrences in every field of view in abundances beyond practical limits of enumeration.

Soft-bodied genera (and the diatom component) were also ranked numerically according to their estimated contribution to the total algal biovolume present in each sample.

5.2.2.2 Diatom Algae

To prepare samples for diatom analysis, organic matter was oxidized and permanent fixed mounts of cleaned diatom material were prepared. Each raw periphyton sample was vigorously shaken in the original sample container to thoroughly homogenize the material, and a subsample of approximately 20 mL was poured into a 250 mL Pyrex beaker. Each beaker was treated with 30-50 mL of concentrated sulfuric acid (H_2SO_4), and a small quantity of 5% hydrogen peroxide (H_2O_2) and granulated potassium dichromate ($K_2Cr_2O_7$) was added to each beaker. Samples were then covered with a Pyrex watch glass and gently heated to near-boiling for 1-2 hours to completely oxidize all organic matter in the sample. Samples were allowed to cool, and then were topped off with deionized water. The diatom material was allowed to settle for at least eight hours, and the clear supernatant decanted; this process was repeated at least five times to thoroughly flush all traces of oxidants from the diatom material.

Subsample volumes were adjusted to ensure manageable densities of diatom cells in suspension, and a small amount of each sample was dispersed onto clean 22-mm square glass cover slips. The cover slips were air dried, heated to 150 F, and affixed onto standard glass microscope slides with Naphrax mounting medium to create a permanent mount of diatom cells (frustules). To ensure a high quality mount for diatom identification and to make replicates available for archiving, at least two slide mounts were made from each sample; one of the replicates was selected from each sample batch for analysis. An Olympus BHT compound microscope with a SPlan oil immersion objective (1000X total magnification) was used for diatom identifications and counts. A proportional count of 800 diatom valves (400 frustules) was performed along a vertical transect line across the exact center of the fixed cover slip. The starting point on the top edge was determined with the aid of the microscope's stage micrometer and recorded, and all diatoms observed within a one-field-of-view width were identified and counted. Diatoms were identified to the lowest practical taxonomic level, generally to species-level, although diatoms were identified to subspecies-level when possible.

5.2.3 Data Analysis

5.2.3.1 Non-Diatom Algae Taxonomy

Non-diatom algal data from each site in 2015 is available in Appendix E. Appendix E includes the estimated relative abundance and biovolume rank of each non-diatom algal division by site as well as the same information for the diatom algae in the division Bacillariophyta for comparison. The estimated relative abundance and estimated biovolume rank of each non- diatom algal division were tabulated by site and summarized with stacked histograms to compare results between sites.

5.2.3.2 Diatom Algae Taxonomy

All diatom count and relative abundance data from each site in 2015 is available in Appendix E. The percent relative abundance (PRA) values were based on the proportional count of 800 diatom valves (400 frustules) as described in Section 6.2.2.2. In addition to the diatom count and relative abundance data, Appendix E also includes summaries of diatom metrics and bioindices which will be described in Section 6.2.3.3. Diatom species richness and Shannon diversity values were calculated from the data in Appendix E and those results were summarized with histograms to compare sites.

5.2.3.3 Diatom Bioassessment Indices

5.2.3.3.1 Increaser Taxa

Diatom taxa counts were evaluated to determine the probability of impairment from sediment, nutrients, and metals. Sediment impairment was evaluated by using a list of sediment tolerant diatoms recognized for cold water streams in the Middle Rockies Ecoregion [Teply, 2010a; 2010b]. Sediment increaser taxa identified by Teply [2010a; 2010b] are species with autecological preferences for sediment impaired conditions. To calculate a sediment impairment score at each site, the relative abundance proportion of all identified sediment increaser taxa was combined. If the relative abundance of all combined sediment increaser taxa exceeded 15.34% the site was considered “sediment impaired”. In addition, the relative abundance proportion was transformed following recommendations of Teply [2010a; 2010b] to an impairment probability score. Similarly, Teply and Bahls [2005] proposed lists of diatom taxa that would increase in relative abundance in response to impairment from metals or nutrients in Montana mountain streams. Although these bioindices are informative, the nutrient and metals increaser taxa bioindices of Teply and Bahls [2005] were not adopted as standard operating procedures (SOPs) by MDEQ because the likelihood for meeting performance criteria may be low, and because these bioindices may have limited ability to differentiate between specific causes of impairment. The relative abundance proportions and impairment probabilities of the sediment, nutrient, and metals increaser taxa are summarized with histograms.

5.2.3.3.2 Association Metrics

In addition to the increaser taxa bioindices, we have selected seven diatom association metrics to provide additional assessments of environmental quality at these sites [Table 5-2] as well as an evaluation of overall biointegrity at each site. Results of these metrics from each site were tabulated, and sites with impaired conditions have been highlighted. The following paragraphs describe each metric.

Species richness is a common measure of environmental impairment with greater diversity reflecting more heterogeneous environmental conditions whereas low diversity reflects environmental homogeneity potentially due to impairment from a specific stressor such as metal contamination. Bahls [1979] utilized species richness as a measure of diatom biointegrity.

The diversity index [Bahls, 1993] is based on the Shannon diversity index [Weber, 1979] which includes measures of species evenness and species richness and is sensitive to variation in water quality [Bahls, 1993].

The pollution index [Bahls, 1993] synthesizes the three pollution tolerance groups defined by Lange-Bertalot [1979] with diatom autecological profiles described by Lowe [1974] and unpublished Montana diatom data described in Bahls [2006]. Diatom species are assigned on an ordinal scale from 1-3 with a score of 1 corresponding to “most-tolerant”, 2 corresponding to “less-tolerant”, and 3 corresponding to “sensitive” for tolerance to nutrient enrichment, mineral salts, elevated temperatures, or metal toxicity.

A large number of diatom taxa are motile (i.e., capable of locomotion). The siltation index [Bahls, 1993] is calculated as the total percent abundance of motile diatom taxa which include species belonging to the genera *Navicula, Nitzschia, Surirella* and other closely related taxa. Motility may be an adaptation to siltation, as a mechanism that allows individual diatom cells to avoid inundation by deposited sediment.

The disturbance index [Barbour et al., 1999] considers the percent relative abundance of the diatom *Achnanthidium minutissimum*, which is highly specialized in the post-disturbance recolonization of stream substrates. Elevated numbers may be indicative of recent environmental stress caused by elevated or highly variable stream flows, water velocities, and water temperatures at a site.

In addition to the metrics described [Table 5-2], an overall biointegrity rating was assigned for each monitoring site. This rating essentially provides a summary of the seven metrics from Table 5-2 and is determined in a series of steps. First, at each site, scores were assigned for each diatom association metric [Table 5-2] on an ordinal scale: “excellent” = 3, “good” = 2, “fair” = 1, and “poor” = 0. Second, the mean score of those seven metrics at each site was calculated. The mean score of the seven metrics was then used as the overall biointegrity rating on another ordinal scale: “excellent” >2.7, “good” = 1.7-2.7, “fair” = 0.7-1.7, and “poor” <0.7.

Table 5-2. Diatom association metrics to evaluate biological integrity in mountain streams: references range of values, expected response to increasing impairment or natural stress, and criteria for rating levels of biological integrity.

Metric	Biological Integrity				Range	Expected Response	Reference
	Excellent	Good	Fair	Poor			
	Impairment or Stress						
	None	Minor	Moderate	Severe			
	Use Support						
	Full	Full	Partial	None			
Species Richness[23]	>29	20-29	19-10	<10	0-100+	decrease[24]	Bahls, 1979
Diversity Index[25]	>2.99	2.00-2.99	1.00-1.99	<1.00	0-5+	decrease[26]	Bahls, 1993
Pollution Index[27]	>2.50	2.01-2.50	1.50-2.00	<1.5	1-3	decrease	Bahls, 1993
Siltation Index[28]	<20.0	20.0-39.9	40.0-59.9	>59.9	0-90+	increase	Bahls, 1993
Disturbance Index[29]	<25.0	25.0-49.9	50.0-74.9	>74.9	0-100	increase	Barbour et al., 1999
Dominant Species (%)[30]	<25.0	25.0-49.9	50.0-74.9	>74.9	~5-100	increase	Barbour et al., 1999
Abnormal Valves (%)[31]	0	>0.0, <3.0	3.0-9.9	>9.9	0-30+	increase	McFarland et al., 1997

5.2.3.3.3 Additional Association Metrics

Van Dam et al. [1994] developed specific metrics to evaluate the response of periphyton assemblages to nutrient enrichment. Three of these nutrient enrichment metrics have been applied to the diatom count data these results are summarized in histograms. First, the degree to which the diatom assemblage had been structured by variation in trophic state from nutrient

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[23] Based on a proportional count of 400 cells (800 valves).

[24] May increase somewhat in mountain streams in response to slight to moderate increases in nutrients or sediment

[25] Base 2 [bits] [Weber, 1973].

[26] May increase somewhat in mountain streams in response to slight to moderate increases in nutrients or sediment

[27] Composite numeric expression of the pollution tolerances assigned by Lange-Bertalot [1979] to the common diatom species.

[28] Sum of the percent abundances of all species in the genera Navicula, Nitzschia and Surirella.

[29] Percent abundance of *Achnanthidium minutissimum* (synonym: *Achnanthes minutissima*).

[30] Percent abundance of the species with the largest number of valves in the proportional count.

[31] Valves with an irregular outline, with abnormal ornamentation, or both.

enrichment was determined by assessment of the percent relative abundance of diatom taxa which are tolerant of nutrient enriched conditions.

Second, the degree to which the diatom assemblage had been structured by metabolic nitrogen processes, which determines the degree of organic nitrogen tolerance for those organisms, was evaluated by the percent relative abundance of diatom taxa tolerant of enriched organic nitrogen conditions. Enrichment by organically-derived nitrogen compounds can influence the composition of the algal community. Diatoms exhibit a broad range of tolerance to organic nitrogen. Most diatoms are nitrogen autotrophs that are unable to directly utilize organic nitrogen, and for these organisms elevated nitrogen levels may be toxic. Some diatoms are metabolic specialists and are able to directly assimilate organic nitrogen in addition to, or as an alternative to, inorganic nitrogen (i.e., facultative nitrogen heterotrophs). The presence of nitrogen-heterotrophic diatom species does not necessarily indicate elevated organic nitrogen; however, a scarcity of nitrogen-autotrophic diatom species with a low tolerance to organic nitrogen, relative to more tolerant forms, may indicate the likelihood of organic nitrogen pollution.

Third the degree to which the diatom assemblage had been structured by hypoxic (low dissolved oxygen concentrations) conditions was determined by assessing the percent abundance of taxa intolerant to elevated biochemical oxygen demand (BOD) and hypoxia. Additionally, the relative abundance of diatoms requiring oligosaprobous to ß-mesosaprobous conditions was assessed. Oligosaprobous to ß-mesosaprobous conditions are low to moderately-low levels of organic matter decomposition, moderately-high to high dissolved oxygen concentrations, and predominantly inorganic forms of nitrogen.

5.2.3.4 Ecological Interpretations

Finally, at each site the diatom assemblage data are interpreted, and potential water quality impairments are discussed. These narrative interpretations are based on the taxonomic composition, autecological preferences, and functional organization of non-diatom and diatom components of the periphyton assemblage at each monitoring site.

Varying tolerance to inorganic and organic nutrients has been established among non-diatom and diatom algae; some taxa are sensitive to nutrient enrichment, and other taxa are indifferent to, or tolerant of nutrient enrichment [Prescott, 1962; Wehr and Sheath, 2003; Bahls, 2006].

Many soft-bodied algae are sensitive to dissolved metals, particularly copper. Filamentous green algae (Chlorophyta) generally are more sensitive to copper than are colonial (i.e., mat-forming) blue-green algae (Cyanobacteria). Colonial blue-green algae (e.g., *Nostoc* and *Rivularia*) can tolerate metals due to a protective gelatinous mucilage (i.e., slime coating). However, some green algae (e.g., *Cladophora, Mougeotia, Scenedesmus, Stigeoclonium* and *Ulothrix* sp.) have demonstrated high tolerances to dissolved metals [Shaw, 1990].

Diatom assemblages may also indicate metal contamination. Diatom species that increase in abundance in response to heavy metals pollution were identified by Teply and Bahls [2006] and Stoermer and Smol [1999]. Elevated metals can cause teratological growth forms (i.e., abnormalities in cell walls) in diatoms [Falasco et al., 2009].

5.3 RESULTS

5.3.1 Non-Diatom Algae

A total of 37 genera of non-diatom algae representing five algal divisions were identified from the thirteen CFROU sites monitored in 2015 [Appendix E]. The number of non-diatom algae genera identified at each site monitored in 2015 are presented in Table 5-3 and Figure 5-1. The complete list of non-diatom algae genera identified at each site in 2015, with their estimated relative abundance and biovolume rank, are presented in Appendix E. The relative importance of each algal division, by estimated biovolume, at each site in 2015 is presented in Figure 5-2.

At the tributary sites, the number of non-diatom algae genera ranged from 8-21 [Table 5-3; Figure 5-1]. The fewest number of genera (8) occurred at site MCWC-MWB (Mill-Willow Creek at Frontage Road), and the greatest number (21) occurred at site LBC-CFR-02 (Little Blackfoot River at Beck Hill Road).

At the mainstem Clark Fork River sites, the number of non-diatom algae genera ranged from 12-19 [Table 5-3; Figure 5-1]. The fewest number of genera (12) occurred at site CFR-07D (Clark Fork River at Galen Road) and site CFR-03A (Clark Fork River near Galen). The highest number of genera occurred at site CFR-116A (Clark Fork River at Turah).

Among all sites in 2015, Chlorophyta (green algae) and Cyanobacteria (Cyanophyta; blue-green algae) were most numerous and Phaeophyta (brown algae), Rhodophyta (red algae) and Xanthophyta (yellow-green algae) were relatively scarce [Table 5-3; Figure 5-1]. Chlorophyta were either more common, or at least as common, as Cyanobacteria at most tributary and mainstem sites. No site had more than four genera in the Phaeophyta, Rhodophyta, and Xanthophyta divisions cumulatively. Four of the six mainstem sites, and three of eight tributary sites, had no genera belonging to the Rhodophyta, Xanthophyta, or Phaeophyta divisions [Table 5-3; Figure 5-1].

The relative importance of dominant non-diatom algae divisions, based on estimated biovolume contributed by genera within the divisions, is presented in Figure 5-2. Diatom algae are also included to illustrate their relative importance at each site in 2015.

At five of the eight tributary sites, and four of the six mainstem Clark Fork River sites, Chlorophyta (green algae) comprised the largest portion of the algal biovolume present [Figure 5-2]. Diatom algae generally were second in overall biovolume at sites where green algae were dominant.

Blue-green algae (Cyanophyta) exceeded green algae in estimated biovolume at one tributary location (site MCWC-MWB; Mill and Willow Creek at Frontage Road), and one mainstem site (site CFR-07D; Clark Fork River at Galen Road) [Figure 5-2]. At both of these sites, diatom algae comprised a relatively small portion of the total algal biovolume compared to blue-green and green algae.

At site LBC-CFR-02 (Little Blackfoot River at Beck Hill Road), green algae and blue green algae were similar in estimated biovolume, and diatom algae were of lesser importance. At mainstem site CFR-03A (Clark Fork River near Galen), diatoms, green algae and blue-green algae were similar in estimated biovolume [Figure 5-2].

Blue-green algae comprised the smallest fraction of estimated total biovolume relative to green algae and diatoms in 2015 at three tributary sites (SS-25, LC-7.5, and RTC-1.5) and at one mainstem site (CFR-27H) [Figure 5-2]. Genera from the divisions Xanthophyta (yellow-green algae), Rhodophyta (red algae), or both, comprised a significant portion of total estimated biovolume (relative to blue-green algae) at all of these sites except Silver Bow Creek (SS-25) [Figure 5-2].

Table 5-3. Number of non-diatom algae genera, by algal division, present at Clark Fork River Operable Unit monitoring sites, 2015.

Site ID	Site Location	Algal Division					
		Chlorophyta (Green Algae)	Cyanobacteria [32] (Blue-green Algae)	Phaeophyta (Brown Algae)	Xanthophyta (Yellow-green Algae)	Rhodophyta (Red Algae)	Total Genera
Tributary Sites							
MCWC-MWB	Mill-Willow Creek at Frontage Road	4	4	0	0	0	8
MWB-SBC	Mill-Willow Bypass near mouth	7	4	0	0	0	11
SS-19	Silver Bow Creek at Frontage Road	9	5	0	0	0	14
SS-25	Silver Bow Creek at Warms Springs	8	2	0	0	0	10
WSC-SBC	Warms Springs Creek near mouth	11	4	1	0	1	17
LC-7.5	Lost Creek near mouth	8	2	0	2	2	14
RTC-1.5	Racetrack Creek near mouth	14	3	0	1	2	20
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	12	7	0	2	0	21
Mainstem Sites							
CFR-03A	Clark Fork River near Galen	6	6	0	0	0	12
CFR-07D	Clark Fork River at Galen Road	6	6	0	0	0	12
CFR-11F	Clark Fork River at Gemback Road	8	5	0	0	0	13
CFR-27H	Clark Fork River at Deer Lodge	8	3	0	0	2	13
CFR-34	Clark Fork River at Williams-Tavenner Bridge	11	5	0	0	0	16
CFR-116A	Clark Fork River at Turah	11	7	0	1	0	19

[32] Formerly classified as Cyanophyta.

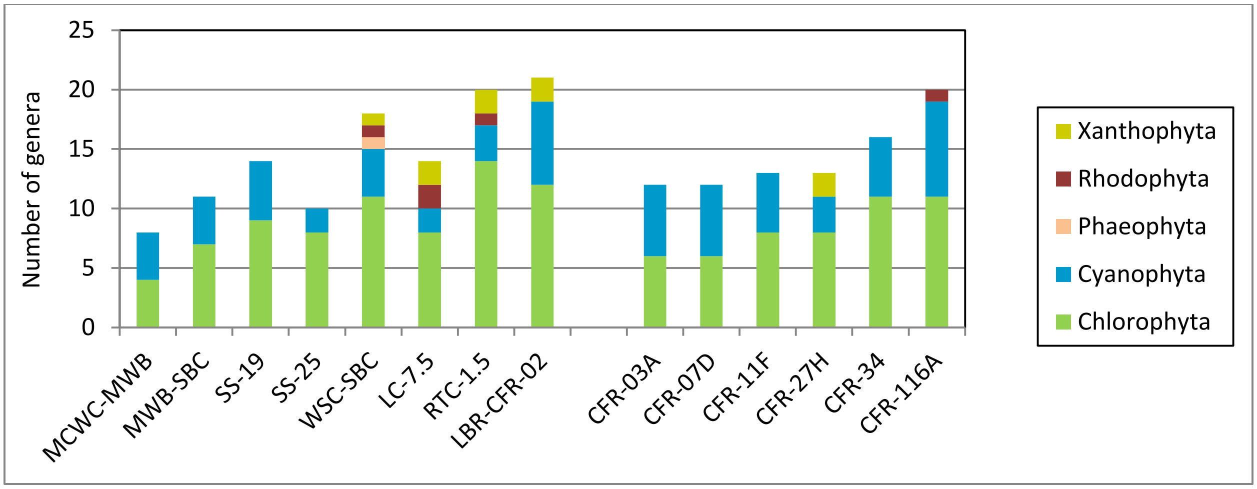

Figure 5-1. Number of non-diatom algae genera, by algal division, present at Clark Fork River Operable Unit sites in 2015.

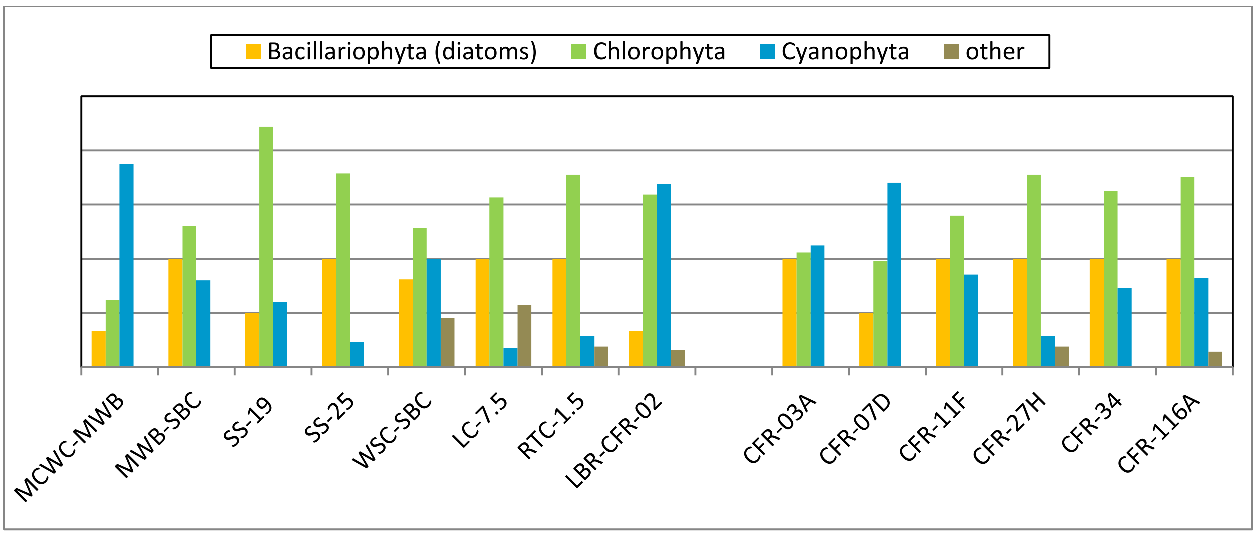

Figure 5-2. Relative importance of non-diatom algal divisions and diatoms, based on estimated biovolume ranking, at Clark Fork River Operable Unit sites in 2015.

5.3.2 Diatom Bioassessment Indices

5.3.2.1 Diatom Increaser Taxa

The percent relative abundance and probability of impairment for diatom increaser taxa are plotted for sediment [Figure 5-3], metals [Figure 5-4], and nutrients [Figure 5-5] at the fourteen sites monitored in 2015.

5.3.2.2 Sediment Increaser Taxa

Sediment increaser diatom taxa [Figure 5-3] were most abundant at site MCWC-MWB (Mill-Willow Creek at Frontage Road), site LBC-CFR-02 (Little Blackfoot River at Beck Hill Road) and site CFR-11F (Clark Fork River at Gemback Road). The probability of impairment by sediment at these three sites exceeded the impairment threshold of 51% (as recommended by Teply [2010a]). Two other sites (MWB-SBC and SS-25) had sediment increaser taxa values that were at the impairment threshold. The remaining four mainstem sites and four tributary sites had moderately low to low sediment increaser taxa values that were below the impairment threshold. Probabilities of sediment impairment ranged from a minimum of 17% at site RTC-1.5 (Racetrack Creek at Frontage Road) to a maximum of 42% at site CFR-34 (Clark Fork River at Williams-Tavenner Bridge) [Figure 5-3].

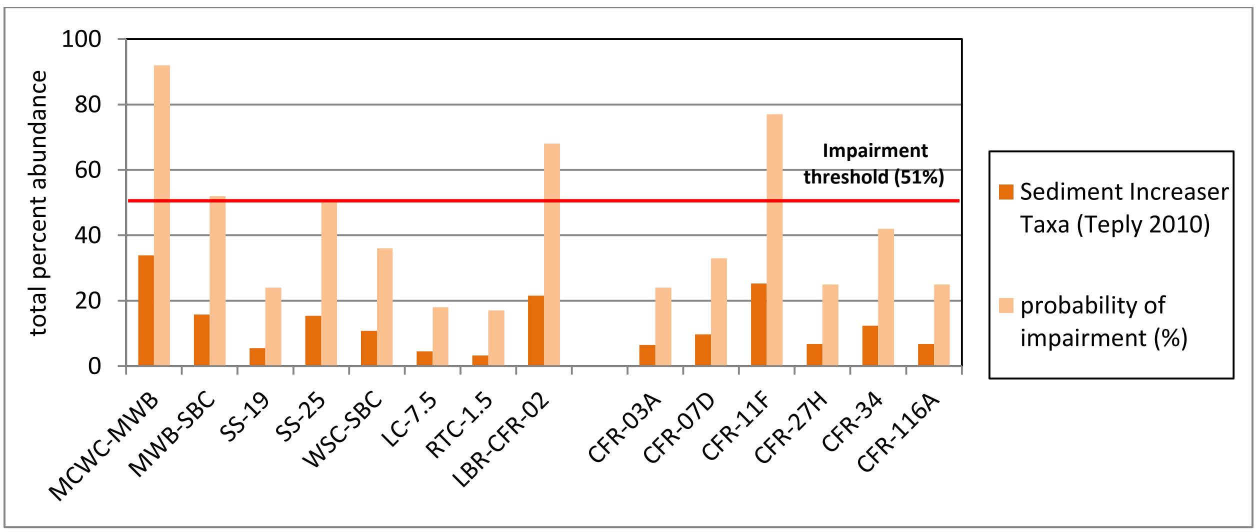

Figure 5-3. Total percent abundance and probability of impairment for diatom sediment increaser taxa bioassessment index [Teply, 2010a] at Clark Fork River Operable Unit sites in 2015.

5.3.2.3 Metals Increaser Taxa

Metals increaser diatom taxa [Figure 5-4] were most abundant at both Silver Bow Creek sites (SS-19 and SS-25), site CFR-03A (Clark Fork River near Galen), and site CFR-11F (Clark Fork River at Gemback Road), with the probability of metals impairment ranging between 84-

96%. The probability of metals impairment was 73% at site LBR-CFR-02 (Little Blackfoot River at Beck Hill Road) 66% at site CFR-07D (Clark Fork River at Galen Road), 54% at site CFR-116A (Clark Fork River at Turah), 48% at site MWB-SBC (Mill-Willow Bypass near mouth), and 35% at site CFR-34 (Clark Fork River at Williams-Tavenner Bridge). The two remaining sites on the Clark Fork River, and the three tributary sites between Warm Springs and Deer Lodge all had probabilities of impairment by heavy metals that was <25%. Site CFR-27H (Clark Fork River at Deer Lodge) had the lowest value for metals increaser diatom taxa determined in 2015, with a probability of heavy metals impairment of 12% [Figure 5-4]. No impairment threshold has been established for metals increaser taxa in the CFROU. This index is provided to allow for comparisons of the relative magnitude of impairment probabilities between sites.

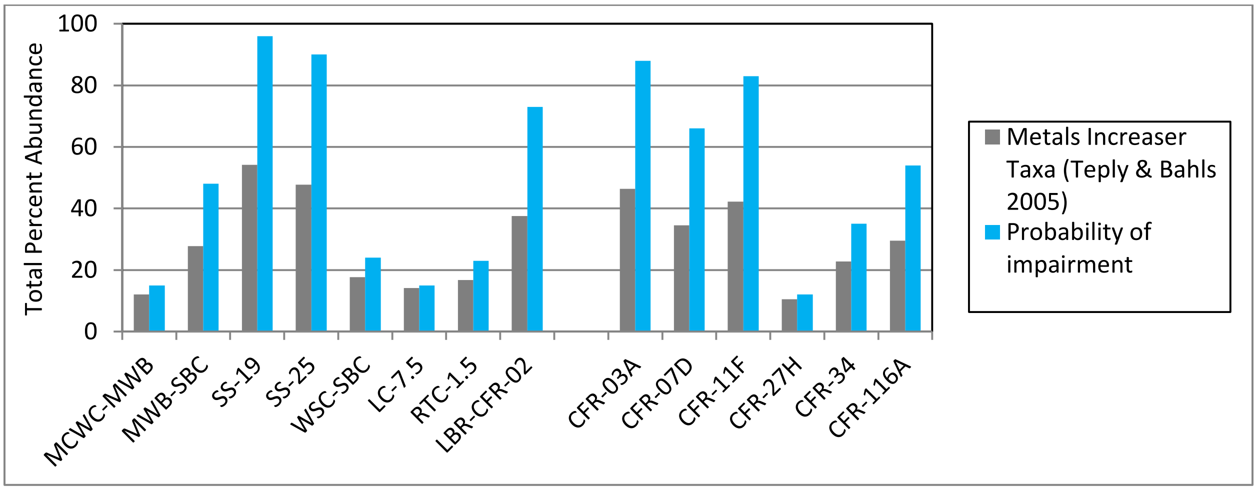

Figure 5-4. Total percent abundance and probability of impairment for diatom metals increaser taxa bioassessment index [Teply and Bahls, 2005] at Clark Fork River Operable Unit sites in 2015.

5.3.2.4 Nutrient Increaser Taxa

Nutrient increaser diatom taxa [Figure 5-5] were most abundant at three mainstem Clark Fork River sites, with a 95% probability of impairment by nutrients at site CFR-03A (Clark Fork River near Galen), site CFR-11F (Clark Fork River at Gemback Road), and site CFR-116A (Clark Fork River at Turah). The probability of impairment by nutrients was 60% at site CFR-27H (Clark Fork River at Deer Lodge), 48% at site CFR-07D (Clark Fork River at Galen Road), and 33% at site CFR-34 (Clark Fork River at Williams-Tavenner Bridge). Tributary sites LBR-CFR-02 (Little Blackfoot River at Beck Hill Road) and SS-25 (Silver Bow Creek at Warm Springs) had impairment probabilities of about 70%. The probability of impairment by nutrients was 64% at site MCWC-MWB (Mill-Willow Creek at Frontage Road) and 57% at site MWB-SBC (Mill-Willow Bypass at mouth). Probability of impairment by nutrients was 48% at LC-7.5 (Lost Creek at Frontage Road), 23% at WSC-SBC (Warm Springs Creek at Warm Springs), and 5% at RTC-1.5 (Racetrack Creek at Frontage Road) based on the percent abundance of nutrient increaser taxa in 2015.

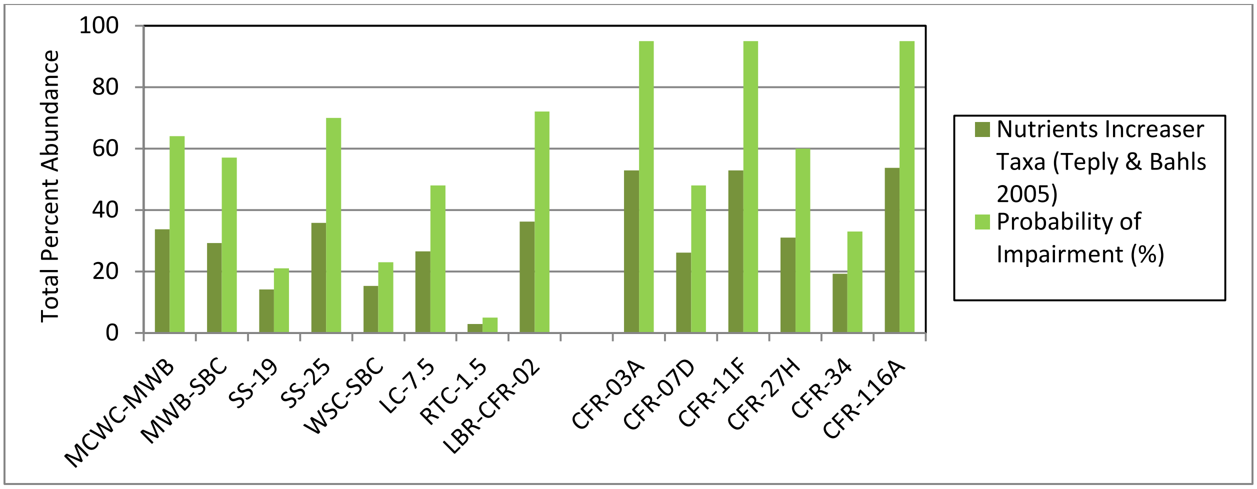

Figure 5-5. Total percent abundance and probability of impairment for diatom nutrient increaser taxa bioassessment index [Teply and Bahls, 2005] at Clark Fork River Operable Unit sites in 2015.

5.3.2.5 Diatom Association Metrics for Montana Mountain Streams

For the CFROU sites monitored in 2015, overall biological integrity was rated "good" at all mainstem sites and at six of eight tributary sites [Table 5-4]. A biological integrity rating of "good" indicates minor impairment to aquatic life. Biological integrity was rated "excellent" at site LBR-CFR-02 (Little Blackfoot River at Beck Hill Road). No site monitored in 2015 received a rating of "fair" or "poor" for biological integrity except SS-19 (Silver Bow Creek at Frontage Road).

At site CFR-03A (Clark Fork River near Galen) the "good" biological integrity rating was due to a slightly depressed Shannon diversity value and slightly elevated values for percent dominant taxon and percent abnormal cells [Table 5-3]. The "good" biological integrity rating at site CFR-07D (Clark Fork River at Galen Road) and at site CFR-11F (Clark Fork River at Gemback Road) was primarily due to an elevated siltation index value in combination with a slightly elevated percentage of abnormal cells. At sites CFR-27H (Clark Fork River at Deer Lodge), CFR-34 (Clark Fork River at Williams-Tavenner Bridge) and CFR-116A (Clark Fork River at Turah), the "good" biological integrity rating was attributable to slightly depressed pollution index values in combination with either depressed Shannon diversity values and elevated percentages of abnormal cells, percent dominant taxon, and siltation index values [Table 5-3].

At tributary sites MCWC-MWB (Mill-Willow Creek at Frontage Road), MWB-SBC (Mill-Willow Bypass near mouth), and SS-25 (Silver Bow Creek at Warm Springs), the rating of "good" for biological integrity was attributable to slightly depressed pollution index values and elevated siltation index values [Table 5-3]. At site WSC-SBC (Warm springs Creek near mouth), elevated values for the siltation index and percentage of abnormal cells resulted in the rating of "good" for biological integrity. At sites RTC-1.5 (Racetrack Creek at Frontage Road) and LC-7.5 (Lost Creek at Frontage Road), depressed values for Shannon diversity and elevated values for percent dominant taxon and percent disturbance taxon combined for a biological integrity rating of “good”. Site LC-7.5 (Lost Creek at Frontage Road) also had an elevated percentage of abnormal cells [Table 5-3].

Table 5-4. Diatom association metrics and biological integrity[33] and impairment ratings[34] for Clark Fork River Operable Unit monitoring sites, 2015 (after Bahls [1993]).

Site ID	Site Location	Diatom Species Richness	Shannon Diversity Index	Pollution Index	Siltation Index	Disturbance Index	Dominant Taxon (%)	Abnormal Cells (%)	Biological Integrity
Tributary Sites									
MCWC-MWB	Mill-Willow Creek at Frontage Road	73	3.38	2.46	35.5	6.38	24.5	1.38	Good
MWB-SBC	Mill-Willow Bypass near mouth	59	3.35	2.44	**41.13**	1.38	11.13	2.00	Good
SS-19	Silver Bow Creek at Frontage Road	34	2.22	**1.69**	**73.75**	0.00	33.13	**8.25**	Fair
SS-25	Silver Bow Creek at Warm Springs	47	3.06	2.46	20.88	0.63	13.13	2.38	Good
WSC-SBC	Warms Springs Creek near mouth	59	3.32	2.57	37.88	16.50	16.50	1.38	Good
LC-7.5	Lost Creek near mouth	50	2.79	2.59	15.75	25.63	25.63	**3.50**	Good
RTC-1.5	Racetrack Creek near mouth	41	2.12	2.76	3.13	34.38	34.38	0.00	Good
LBR-CFR-02	Little Blackfoot River at Beck Hill Road	70	3.44	2.59	35.00	1.75	14.88	0.00	Excellent
Mainstem Sites									
CFR-03A	Clark Fork River near Galen	48	2.72	2.59	17.50	1.00	29.88	2.25	Good
CFR-07D	Clark Fork River at Galen Road	52	3.09	2.59	**55.38**	6.25	16.13	0.25	Good
CFR-11F	Clark Fork River at Gemback Road	59	3.12	2.63	26.63	2.25	19.50	0.63	Good
CFR-27H	Clark Fork River at Deer Lodge	62	2.62	2.45	10.13	28.88	28.88	**4.13**	Good
CFR-34	Clark Fork at Williams-Tavenner Bridge	70	3.64	2.39	32.88	9.38	9.38	2.75	Good
CFR-116A	Clark Fork River at Turah	56	2.62	2.46	16.63	5.25	37.75	**4.00**	Good

[33] Biological integrity rating is based on numerical criteria for each diatom metric.

[34] Impairment rating codes for individual metric values: normal font = no impairment, underlined = minor impairment, **bold font** = moderate impairment, and **bold and underlined** = severe impairment.

5.3.2.6 Additional Diatom Association Metrics

Diatom taxa which are intolerant to inorganic nutrients relative to tolerant forms were in relatively low abundance at all six Clark Fork River mainstem sites in 2015 [Figure 5-6]. The relative abundance of taxa intolerant to elevated inorganic nutrients ranged from about 1% at site CFR-27H (Clark Fork River at Deer Lodge) to about 12% at site CFR-03A (Clark Fork River near Galen) with a mean of about 5%. Similar results were observed at six of the eight tributary sites in 2015 [Figure 5-6]. A notable exception was site RTC-1.5 (Racetrack Creek at Frontage Road) where the relative abundance of nutrient-intolerant diatom taxa was nearly 25%, and nutrient tolerant taxa comprised less than 7% the diatom assemblage [Figure 5-6].

Nitrogen-autotrophic diatoms were dominant at all sites monitored in 2015 [Figure 5-7]. Nitrogen-autotrophic taxa with a higher tolerance to organic nitrogen were more abundant than less tolerant autotrophic forms at all sites. Nitrogen-autotrophic diatom relative abundance ranged from about 50% to 77% with a mean of approximately 60% in Clark Fork River mainstem and tributary sites with the exception of SS-19 which had 39% relative abundance. At Clark Fork River mainstem sites, nitrogen-autotrophic diatom taxa with lower organic nitrogen tolerance ranged in relative abundance from a low of <4% at site CFR-27H (Clark Fork River at Deer Lodge) to a high of about 30% at site CFR-03A (Clark Fork River near Galen), with a mean of about 19% [Figure 5-7]. At tributary sites, the percent abundance of nitrogen autotrophs with low organic nitrogen tolerance ranged from a low of <1%% at SS-19 (Silver Bow Creek at Frontage Road) to a high of about 23% at site LBR-CFR-02 (Little Blackfoot River at Beck Hill Road) [Figure 5-7]. These data indicate that diatom assemblages at CFROU sites in 2015 were predominantly autotrophic forms requiring inorganic nitrogen and had tolerance to relatively high organic nitrogen concentrations. While this suggests the possibility of organic nitrogen inputs to tributary and mainstem sites, it does not indicate that organic nitrogen had adverse impacts or toxic effects on the diatom assemblages.

The percent abundance of diatoms requiring oligosaprobous to ß-mesosaprobous conditions (i.e., low to moderately low levels of organic matter decomposition, moderately-high to high dissolved oxygen concentrations, and predominantly inorganic forms of nitrogen) at CFROU sites monitored in 2015 ranged from about 19% to 69% among the tributary sites, and from about 52% to 84% among the Clark Fork River mainstem sites [Figure 5-8].

Diatoms requiring water that is >75% saturated with dissolved oxygen were dominant at all sites in 2015; relative abundance of these diatoms ranged from about 34% to 55% at tributary sites and 42-66% (mean = 53%) at mainstem sites [Figure 5-8].

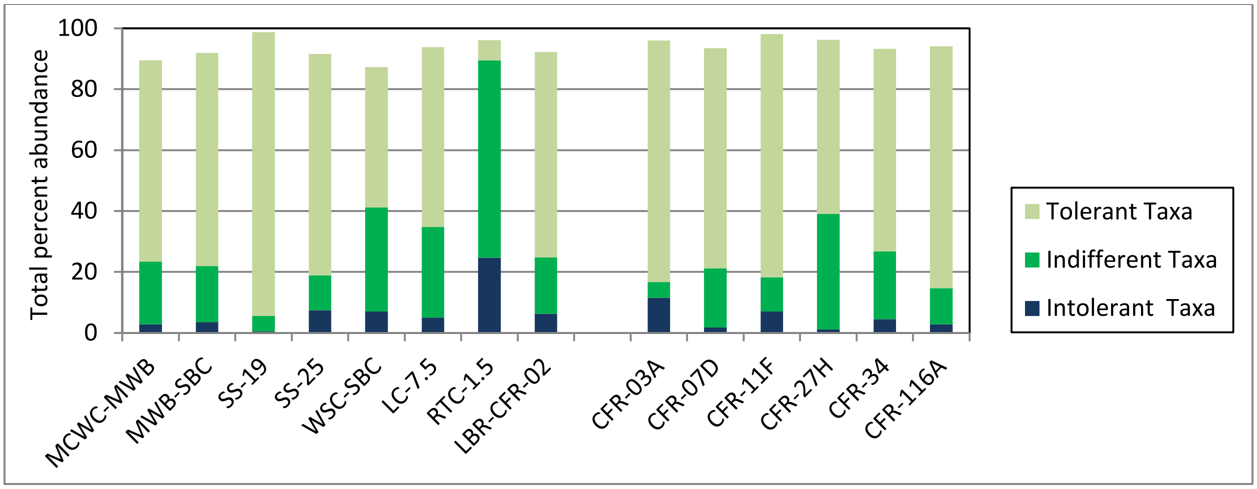

Figure 5-6. Variation in diatom trophic state tolerance among Clark Fork River Operable Unit monitoring sites, 2015; percent abundance of taxa tolerant to elevated inorganic nutrients (after Van Dam et al. [1994]).

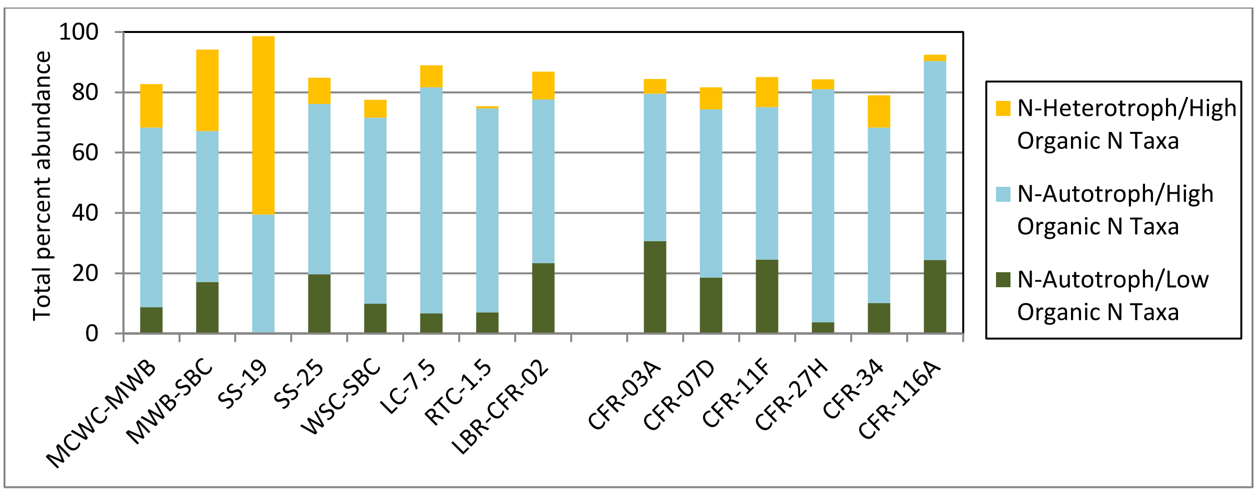

Figure 5-7. Variation in diatom nitrogen metabolism among Clark Fork River Operable Unit monitoring sites, 2015; percent abundance of taxa tolerant of organic nitrogen (after Van Dam et al. [1994]).

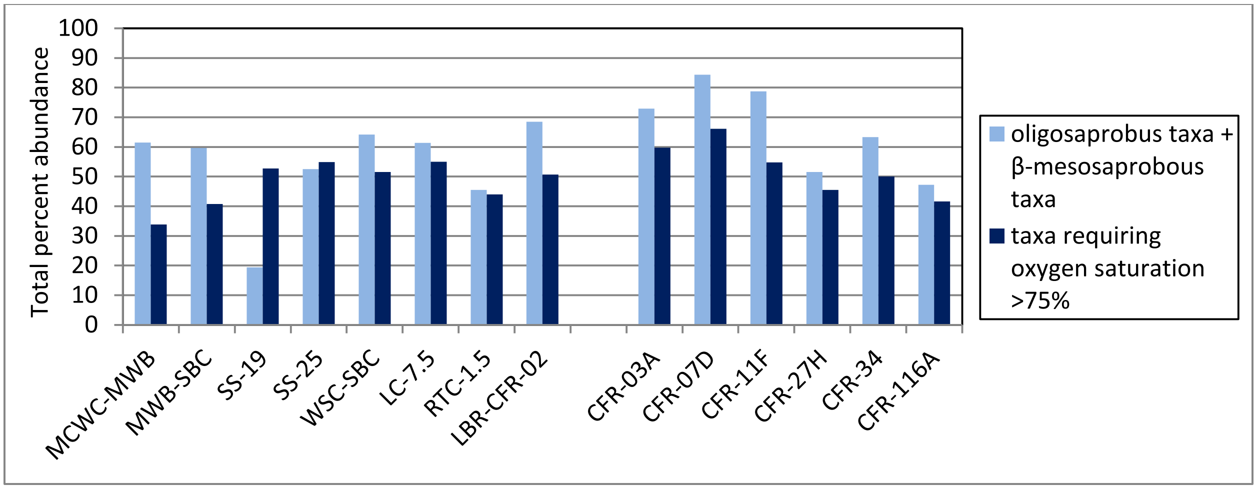

Figure 5-8. Variation in diatom oxygen demand among Clark Fork River Operable Unit monitoring sites, 2015; percent abundance of taxa intolerant to elevated biochemical oxygen demand (BOD) and hypoxia (after Van Dam et al. [1994]).

5.4 DISCUSSION

5.4.1 Ecological Interpretations of Periphyton Assemblages

5.4.1.1 Non-Diatom Algae

From four to fourteen genera of Chlorophyta (green algae) were present at each of the fourteen CFROU monitoring sites in 2015. A total of seventeen genera of microscopic Chlorophyta (green algae) were identified in the 2015 CFROU samples, including most notably: the filamentous genera *Cladophora, Klebsormidium, Microspora, Oedogonium, Stigeoclonium* and *Ulothrix;* the colonial genus *Scenedesmus;* and single-celled genera *Closterium* and *Cosmarium*. These algae are generally indicative of cool, moderately nutrient-rich water. Many of these species are relatively tolerant of elevated nutrients, acidity, metals, or combinations of those conditions. *Stigeoclonium,* and *Ulothrix* have been observed in streams with elevated zinc concentrations [Shaw, 1990]. *Scenedesmus* is known to tolerate elevated copper concentrations, and *Cladophora* and *Ulothrix* are resistant to copper used in paint for watercraft and ship hulls [Shaw, 1990].

Cladophora was an important taxon at thirteen sites in 2015, whereas *Oedogonium* was present at twelve sites. Estimated biovolume for *Cladophora* ranked within the top four taxa (including diatom algae as a whole) at six of eight tributary sites: MWB-SBC (Mill-Willow Bypass near mouth), SS-19 (Silver Bow Creek at Frontage Road), SS-25 (Silver Bow Creek at Warm Springs), WSC-SBC (Warm springs Creek near mouth), RTC-1.5 (Racetrack Creek at Frontage Road) and LC-7.5 (Lost Creek at Frontage Road), and at all six mainstem Clark Fork River sites in 2015. Estimated biovolume for *Oedogonium* ranked with the top four taxa at three tributary sites: MWB-SBC (Mill-Willow Bypass near mouth), SS-25 (Silver Bow Creek at Warm Springs) and WSC-SBC (Warm springs Creek near mouth) and three mainstem sites: CFR-03A

(Clark Fork River near Galen), CFR-11F (Clark Fork River at Gemback Road) and CFR-27H (Clark Fork River at Deer Lodge) in 2015. *Cladophora* forms large masses, often 30 cm or more in length, composed of innumerable microscopic, highly branched filaments that provide extensive surface habitat for attached diatoms and other microalgae. *Oedogonium*. occurs as macroscopic masses of microscopic, unbranched filaments that are frequently colonized by microalgae. Both *Cladophora* and *Oedogonium* prefer cool, flowing water with an alkaline pH and moderately high levels of inorganic nutrients.

From two to seven genera of Cyanobacteria (blue-green algae), were present at each of the fourteen CFROU monitoring sites in 2015. A total of fourteen genera of microscopic Cyanobacteria (blue-green algae) were identified in the 2015 CFROU samples, including most notably: *Chamaesiphon, Heteroleibleinia*, *Homoeothrix, Nostoc, Phormidium* and *Tolypothrix*

Of the Cyanobacteria (blue-green algae), the genus *Nostoc* was an important taxon at eight of fourteen monitoring sites in 2015, including five mainstem Clark Fork River sites. *Nostoc* ranked within the top four taxa in estimated biovolume at all five mainstem sites where it was identified as well as all three tributary stations where it occurred. *Nostoc* is generally indicative of cool, moderately nutrient-rich, relatively unpolluted water. Masses of *Nostoc* trichomes (i.e. filaments composed of individual cells) are encased in a tough colonial mucilage that is resistant to scour and desiccation. More importantly, *Nostoc* possesses specialized cells called heterocytes that permit fixation of atmospheric nitrogen through enzyme reactions. This provides *Nostoc* with a competitive advantage over other non-diatom algae in water with low inorganic nitrogen concentrations.

Phormidium is a cosmopolitan Cyanobacterium that occurs within a relatively broad range of habitats and water quality conditions, and can form extensive macroscopic growths. *Phormidium* occurred at five of the six tributary sites upstream of Deer Lodge, but was absent from SS-25 (Silver Bow Creek at Warm Springs) and all of the Clark Fork River mainstem sites except CFR-116A (Clark Fork River at Turah).

Chamaesiphon, Heteroleibleinia and *Homoeothrix* are microscopic Cyanobacteria that commonly occur as epiphytes (i.e., plants that grow on other plants) on filamentous green algae (e.g., *Cladophora* or *Oedogonium*) in relatively unpolluted waters. The genus *Chamaesiphon*, often occurs in high densities that cover much of the surfaces of the host alga. *Chamaesiphon* often is found on submerged substrates in cold water in mountain streams, and generally prefers low to moderate levels of nutrients and dissolved solids.

Tolypothrix is a filamentous Cyanobacterium that often occurs in relatively unpolluted freshwaters attached to stones, macrophytes or other algae, sometimes forming wooly mats or tufts. *Tolypothrix* also possesses the specialized cells called heterocytes that permit fixation of atmospheric nitrogen. *Tolypothrix* occurred at all six Clark Fork River mainstem sites but was essentially absent from tributary streams in 2015.

The filamentous alga *Audouinella,* a member of the division Rhodophyta (red algae), is a cosmopolitan form that prefers circumneutral (i.e., with a pH of around 7) to slightly basic water that is moderately low in nutrients and dissolved solids. *Audouinella* was identified at some tributary sites and one mainstem site.

Tribonema and *Vaucheria* are filamentous genera of yellow-green algae (division Xanthophyta) that either together or singly were important taxa in 2015 at some tributary sites. Often these taxa occur in cool, nutrient-poor water that is slightly acidic due to elevated levels of dissolved humic substances (e.g., tannins) associated with decaying vegetation and bog environments.

An uncommon filamentous brown alga, *Heribaudiella* (division Phaeophyta), was found only in Warm Springs Creek in 2015. *Heribaudiella* is known to occur in cool water at higher current velocities, often with moderate levels of nutrients and alkalinity [Wehr and Sheath, 2003].

5.4.1.2 Diatom Algae

Diatom algae were dominant components of the periphyton assemblage at all CFROU sites in 2015. Diatoms were ranked first in estimated biovolume relative to non-diatom algae at five of six Clark Fork River mainstem sites and at five of eight tributary sites monitored in 2015. Diatoms were ranked second at one mainstem site and one tributary site and were ranked third in two tributary sites. Nearly 150 species and varieties of diatoms were identified among the CFROU sites in 2015. Several diatoms were of particular interest because of specific autecological preferences and environmental requirements of those organisms.

Achnanthidium minutissimum is a specialist in recolonizing stream substrates that have been subjected to physical disturbance such as scour or impacted by dewatering. The percent relative abundance of *A. minutissimum* is the basis for the disturbance index [Bahls, 1993].

Cocconeis pediculus and C. placentula are cosmopolitan, attached forms that occur in very high densities as epiphytes on larger forms of filamentous algae, particularly the green algae *Cladophora* and *Oedogonium,* and are indicative of moderately nutrient-rich, slightly alkaline water.

Cymbella affinis is an attached, stalk-forming diatom that prefers alkaline water with moderately low levels of nitrogen and phosphorus and moderately high bicarbonate concentrations.

Diatoma moniliformis and *D. vulgaris* are non-motile chain forming diatoms that prefer cool, well oxygenated, moderately alkaline water with relatively low to moderate levels of nutrients.

Epithemia sorex, E. turgid and *Rhopalodia gibba* often harbor single-celled endosymbotic (i.e., internal to the cell wall) nitrogen fixing cyanobacteria, with an assumed benefit to both organisms in nitrogen limited waters. These taxa, considered collectively as the percent Rhopalodiales metric, suggest low levels of inorganic nitrogen relative to phosphorus in the water column.

Melosira varians is a non-motile, centric diatom that forms long ribbons of cells, often entangled with filamentous non-diatom algae. It is indifferent to nutrient concentrations but intolerant of elevated sediment and siltation.

Navicula capitatoradiata, N. caterva and *N. cryptotenella* are motile diatoms that prefer alkaline, moderately hard water with moderately low to moderate levels of nitrogen relative to phosphorus.

Nitzschia dissipata, N. fonticola and *N. paleacea* are highly motile forms that are adapted to elevated levels of deposited sediment and prefer cool, somewhat alkaline water with moderate levels of nitrogen and phosphorus.

Ulnaria acus, U. oxyrhynchus and *U. ulna* (formerly *Synedra*) are attached forms with relatively low tolerance to deposited sediment that prefer alkaline water and variable levels nitrogen and phosphorus.

5.4.2 Site Specific Narratives

The following narratives summarize collective results from analysis of data at each site. Summaries are based on the species counts at each site for non-diatom and diatom algae and the suite of metrics derived from those data. The apparent overall biological integrity and likely degree of impairment of the aquatic biota are assessed for each monitoring site with a focus of each narrative on water quality impairments, specifically the influence of metals, nutrients, and sediment on diatom assemblages.

5.4.2.1 Mill Willow Creek at the Mill-Willow Bypass (MCWC-MWB)

Non-diatom algae at site MCWC-MWB were the least diverse of all sites monitored in 2015. Eight genera were present, equally divided between green algae (order Chlorophyta) and blue-green algae (order Cyanobacteria). However, blue-green algae dominated estimated biovolume. The filamentous blue-green Phormidium and the colonial blue-green *Nostoc* ranked first and second, respectively, in estimated biovolume, ahead of diatom algae. These non-diatom algae indicated relatively unimpaired water quality that was moderately nutrient-rich and likely nitrogen limited.

Diatom algae in the combined Mill and Willow Creeks had the highest species richness and Shannon diversity of the twelve sites monitored in 2015. Dominant diatom taxa included *Achnanthidium minutissimum, Cocconeis placentula, Melosira varians, Navicula caterva, Nitzschia dissipata* and *Planothidium frequentissimum*, which suggest cool, moderately nutrient-rich, alkaline water. Sediment increaser taxa and siltation index scores indicated a high probability of impairment by sediment. Metals increaser taxa and the pollution index suggested a low probability of impairment by metals. Nutrient increaser taxa suggested a moderate probability of impairment by nutrients. A majority of the diatom taxa present were tolerant of elevated levels of inorganic nutrients and organic nitrogen. A majority of diatoms were intolerant of elevated levels of biochemical oxygen demand (BOD), but could tolerate somewhat depressed dissolved oxygen concentrations. Overall biological integrity at site MCWC- MWB was rated “good” with minor impairment related to sediment and possibly toxic effects indicated by abnormal diatom cell walls.

5.4.2.1.1 Mill Willow Bypass near Mouth (MWB-SBC)

Eleven genera of non-diatom algae were identified at site MWB-SBC, with seven genera of green algae and four genera of blue-green algae. Green algae at site MWB-SBC comprised slightly more estimated biovolume than did the diatoms or blue-green algae. The filamentous blue-green *Phormidium* was ranked second in biovolume behind diatoms, but six genera of green algae were ranked third through eighth in estimated biovolume, including the relatively robust filamentous forms *Cladophora, Mougeotia* and *Oedogonium*. Moderate enrichment by inorganic nutrients, particularly nitrogen, was indicated by the non-diatom algae.

Diatom species richness at site MWB-SBC, and to a lesser extent Shannon diversity, decreased from values seen at the upstream site MCWC-MWB. Dominant diatoms at site MWB-SBC included *Cocconeis placentula, Epithemia sorex*, *Navicula capitatoradiata*, *Navicula cryptotenella, Nitzschia dissipata* and *Ulnaria ulna*. These diatom species indicated cool, alkaline water that was moderately rich in nutrients. Sediment increaser taxa abundance and the siltation index indicated a moderately high probability at site MWB-SBC of impairment by sediment. Metals increaser taxa and the Pollution Index indicated a moderately high probability of impairment by metals. Nutrient increaser taxa indicated a moderate probability at site MWB-SBC of impairment by nutrients. A majority of diatoms at site MWB-SBC were tolerant of inorganic nutrients, elevated organic nitrogen, and somewhat depressed levels of DO saturation, but were intolerant of elevated levels of biochemical oxygen demand. Overall biological integrity at site MWB-SBC was rated as "good", with only minor impairments related to sediment and possible toxic effects indicated by abnormal diatom cell walls.

5.4.2.1.2 Silver Bow Creek at Frontage Road (SS-19)

The diverse assemblage of non-diatom algae at site SS-19 suggested relatively high water quality, while the moderately low diatom algae diversity indicated some degree of water quality degradation. High tolerances to elevated concentrations of organic nitrogen, biochemical oxygen demand and heavy metals, and moderately high tolerances to inorganic nutrients and sediment were exhibited by the diatom assemblage. Overall biological integrity at site SS-19 was rated "fair", with moderately high impairment of the aquatic biota by organic nitrogen, heavy metals, inorganic nutrients and sediment.

5.4.2.1.3 Silver Bow Creek at Warm Springs (SS-25)

Ten genera of non-diatom algae were identified at site SS-25 in 2015. The flora was dominated by green algae (eight taxa), with three filamentous genera (*Cladophora, Oedogonium,* and *Stigeoclonium*) and two single-celled desmids (*Cosmarium,* and *Closterium)* responsible for most of the non-diatom algal biovolume at site SS-25. *Chamaesiphon* was one of only two genera of blue-green algae identified at site SS-25. A microalga epiphytic on filamentous green algae, *Chamaesiphon* was common at site SS-25 but did not contribute greatly to the total estimated biovolume. No other algal divisions were represented at site SS-25. The filamentous green algae present were indicative of water relatively rich in nutrients, particularly nitrogen, and are relatively tolerant of metals.

Diatoms ranked first in estimated relative abundance, but were second in estimated biovolume, behind the green algae. Diatom species richness and Shannon diversity values were moderately depressed compared to the upstream site MWB-SBC. A low disturbance index at site SS-25 suggested relatively stable conditions (e.g., little streambed scour). Several dominant diatom taxa were observed which commonly occur as epiphytes or in association with filamentous algae and aquatic macrophytes in alkaline, nutrient-rich streams (i.e., *Cocconeis pediculus*, *C. placentula, Diatoma vulgaris, Epithemia sorex, Gomphonema subclavatum, Navicula capitatoradiata, Nitzschia paleacea*, *Ulnaria acus* and *U. ulna*). Sediment increaser taxa abundance and the siltation index indicated at least a moderate probability of impairment by sediment. Metals increaser taxa abundance, along with a slightly depressed pollution index and slightly elevated abnormal cell percentage, indicated a high probability of impairment due to metals toxicity. Nutrient increaser taxa abundance indicated a moderately high probability of impairment by nutrients. Diatoms intolerant of elevated inorganic nutrients and elevated organic nitrogen, were slightly more abundant at site SS-25 than at upstream site MWB-SBC, but tolerant forms remained dominant and suggested eutrophic conditions in the reach below the Warm Springs Ponds. The percentage of diatoms intolerant of elevated biochemical oxygen demand at site SS-25 decreased slightly from site MWB-SBC, while the percentage of diatoms requiring high dissolved oxygen levels increased at site SS-25. Biological integrity at site SS-25 in 2015 was rated as "good", with minor impairment by toxic metals suggested by the pollution index and high proportion of abnormal diatom cells.

5.4.2.1.4 Warm Springs Creek near Mouth (WSC-SBC)

Seventeen genera of non-diatom algae were identified at site WSC-SBC in 2015, including eleven genera of green algae, four genera of blue-green algae and three genera from "other" divisions. The blue-green algae *Nostoc* and *Phormidium* were ranked second and fourth in estimated biovolume, respectively, below the diatoms. The filamentous green algae *Cladophora* and *Oedogonium* were ranked third and fourth in estimated biovolume, respectively. Chlorophyta, including *Cladophora* and *Oedogonium,* comprised the greatest portion of the total biovolume at site WSC-SBC. The filamentous red alga *Audouinella,* the filamentous yellow-green alga *Vaucheria*, and the filamentous brown alga *Heribaudiella* represented a substantial portion of the periphyton biovolume. All of these algae are indicative of cool, relatively unpolluted water with low to moderate levels of inorganic nutrients. The dominance of *Nostoc* suggests that inorganic nitrogen may have been the limiting nutrient relative to phosphorus. However, the relatively low abundance of green algae suggests the opposite.

Diatom species richness and Shannon diversity at WSC-SBC were moderately high in 2015. Dominant diatoms included *Achnanthidium minutissimum, Diatoma moniliformis, Melosira varians, Navicula caterva,* and *Nitzschia dissipata*. These taxa prefer cool, well-oxygenated, alkaline water of moderate conductivity, with low to moderate inorganic nutrient concentrations. Sediment increaser taxa results indicated a moderately low probability of impairment by sediment although the siltation index was slightly elevated. Metals increaser taxa and the pollution index indicated a moderately low probability of impairment by metals. Nutrient increaser taxa indicated a low probability of impairment by nutrients. A majority of diatom taxa present were tolerant of inorganic nutrients and organic nitrogen, but required a moderately high level of oxygen saturation. Diatoms with a low tolerance of decomposing organic matter (i.e., biochemical oxygen demand) were present at a relatively high percentage. Biological integrity was rated as "good" with minor impairment of the biota indicated by slightly elevated values for the siltation index and percent abnormal diatoms.

5.4.2.1.5 Clark Fork River near Galen (CFR-03A)

Twelve genera of non-diatom algae were identified at Clark Fork River headwaters site CFR-03A. Six genera of green algae and six genera of blue-green algae were present; no other algal divisions were represented. Estimated biovolume was distributed relatively evenly between green and blue-green algae, with the cyanobacteria *Nostoc* and *Tolypothrix* and the filamentous green algae *Cladophora, Oedogonium* and *Stigeoclonium* ranked as the top five non-diatom taxa. These algae suggested moderate nutrient enrichment with somewhat limited levels of nitrogen relative to phosphorus. Several genera of cyanobacteria that are epiphytic on large filamentous green algae were relatively important including *Homoeothrix, Chamaesiphon,* and *Heteroleibleinia.*

Diatom algae ranked first in estimated biovolume at site CFR-03A. Diatom species richness and Shannon diversity values at site CFR-03A were somewhat lower than at major tributary sites such as WSC-SBC and MWB-SBC. However, diatom species richness and Shannon diversity values at site CFR-03A were similar to values at site SS-25 immediately upstream. Dominant diatom taxa included *Diatoma vulgaris, D. moniliformis* and *Epithemia sorex* which are all forms associated with epiphytic on filamentous green algae. All of these taxa suggest cool, alkaline water that is moderately rich in inorganic nutrients but likely limited by nitrogen. Sediment increaser diatom taxa and the siltation index indicated a relatively low probability of impairment by sediment. Metals increaser diatom taxa results indicated a high probability of impairment by metals, although the pollution index did not suggest impairment by metals. Nutrient increaser taxa indicated a high probability of impairment by nutrients. A high percentage of the diatoms present were tolerant of inorganic nitrogen, although the percentage that are intolerant of high levels of inorganic nitrogen was the highest of any mainstem site in 2015. A significant percentage of diatoms were tolerant of organic nitrogen at low levels only. Over 70% of the diatoms observed (by relative abundance) were intolerant of elevated biochemical oxygen demand and 60% required relatively high dissolved oxygen concentrations. Biological integrity was rated “good” with only minor impairment suggested by a slightly depressed Shannon diversity score and slightly elevated dominant taxon and abnormal cell percentages. All other diatom metrics for Montana mountain streams indicated “excellent” biological integrity and an unimpaired biota.

5.4.2.1.6 Clark Fork River at Galen Road (CFR-07D)

Twelve genera of non-diatom algae were identified at Clark Fork River site CFR-07D in 2015. Six genera of green algae and six genera of blue-green algae were present but no other algal divisions were represented. Estimated biovolume was dominated by blue-green algae with *Nostoc* and *Tolypothrix* ranked first and third, respectively. The filamentous green alga *Oedogonium* was ranked fourth in estimated biovolume and the filamentous green algae *Stigeoclonium* and *Mougeotia* ranked ninth and tenth, respectively. The algal assemblage at site CFR-07D differed somewhat from the assemblage at upstream site CFR-03A, most notably by the absence of *Cladophora*. Water moderately rich in inorganic nutrients, but likely limited by inorganic nitrogen, is suggested by the dominance of non-diatom algae at site CFR-07D.

Diatoms were ranked second in estimated biovolume at site CFR-07D relative to non-diatom algae. Diatom species richness and Shannon diversity were only slightly higher at site CFR-07D compared to upstream site CFR-03A. The diatom assemblage at site CFR-07D differed considerably from that at upstream site CFR-03A, and with the exception of *Epithemia sorex,* the dominant taxa had little in common. The diatoms *Achnanthidium minutissimum, Cocconeis placentula, Navicula cryptotenella, Nitzschia dissipata, N. fonticola* and *N. sociabilis* were dominant. The decreased importance of *Diatoma vulgaris, D. moniliformis,* along with the increased abundance of several species of *Navicula* and *Nitzschia,* suggested that sedimentation influenced the diatom assemblage. The diatom assemblage in general indicated cool, somewhat alkaline water with moderately high levels of inorganic nutrients. Sediment increaser diatom taxa suggested a moderately low probability of impairment, while the siltation index indicated moderate impairment by sediment. Metals increaser diatom taxa indicated a moderately high probability of impairment by metals. Nutrient increaser diatom taxa indicated a moderate probability of impairment by nutrients. A high percentage of the diatoms present a were tolerant of elevated inorganic nitrogen and organic nitrogen, required a relatively high level of dissolved oxygen saturation, and were intolerant of elevated biochemical oxygen demand. Biological integrity was considered “good” with only sediment indicated as a possible impairment.

5.4.2.1.7 Lost Creek at Frontage Road (LC-7.5)

Fourteen genera of non-diatom algae were present at site LC-7.5 in 2015 including eight genera of green algae, two genera of blue-green algae, two genera of red algae, and two genera of yellow-green algae. Five genera of filamentous green algae (*Cladophora, Klebsormidium, Oedogonium, Stigeoclonium* and *Mougeotia)* were ranked within the top eight taxa by estimated biovolume contribution. Green algae were strongly dominant. The filamentous yellow-green alga *Vaucheria* and the filamentous red alga *Audouinella* ranked fourth and sixth (respectively) in algal biovolume. The blue-green alga *Phormidium* was ranked tenth in algal biovolume. These taxa are indicative of cool, high quality water that is high in dissolved minerals and moderately rich in nutrients.

Diatom species richness and Shannon diversity values at site LC-7.5 were moderately low, compared to the other tributary streams monitored in 2015. Dominant diatoms included *Achnanthidium minutissimum, Diatoma moniliformis, D. vulgaris, Melosira varians,* and *Nitzschia dissipata.* These taxa prefer cool, well-oxygenated, alkaline water of moderate conductivity, with low to moderate inorganic nutrients. At site LC-7.5 in 2015, 3.5% of *Diatoma moniliformis* frustules had abnormal cell walls (i.e. teratological growth forms). A high proportion of abnormal cells may be an indication of metals toxicity. The moderately high disturbance index suggested some degree of environmental instability or physical disturbance in the recent past. Sediment increaser diatom taxa and the siltation index indicated a low probability of impairment by sediment. Metals increaser diatom taxa indicated a low probability of impairment by metals. Nutrient increaser diatom taxa indicated a moderate probability of impairment by nutrients. A majority of diatoms present were tolerant of inorganic nutrients and organic nitrogen. Diatom taxa intolerant of high biochemical oxygen demand and requiring high dissolved oxygen levels comprised over 40% of total diatom abundance. Biological integrity was rated as “good”, with minor impairment indicated, due to slightly depressed Shannon diversity value, and elevated values for the disturbance index and abnormal cell percentage.

5.4.2.1.8 Clark Fork River at Gemback Road (CFR-11F)

Thirteen genera of non-diatom algae were identified at site CFR-11F with eight genera of green algae and five genera of blue-green algae present. No other algal divisions were represented. The filamentous green algae *Cladophora* and *Oedogonium* were ranked second and third (respectively) in biovolume after the diatoms. The cyanobacteria *Nostoc, Chamaesiphon,* and *Tolypothrix* ranked fourth through sixth in estimated biovolume (respectively). Overall, the green algae dominated the total biovolume. The non-diatom algae assemblage at CFR-11F was dissimilar to that observed at upstream site CFR-07D, but was similar CFR-03A. The non-diatom algae at site CFR-11F suggested water moderately rich in inorganic nutrients, but apparently limited by nitrogen.

Diatom algae ranked first in estimated biovolume at site CFR-11F. Diatom species richness and Shannon diversity were slightly higher than at upstream site CFR-07D. Dominant diatom taxa at site CFR-11F included *Coconeis pediculus, C. placentula, Epithemia sorex, Fragilaria capucina, Nitzschia paleacea*, *Diatoma moniliformis,* and *D. vulgaris*. All of these diatom species prefer water with low to moderate levels of inorganic nitrogen and phosphorus, moderate conductivity, and occur as epiphytes on, or in close association with, filamentous green algae. Sediment increaser diatom taxa indicated high probability of impairment by sediment, whereas the siltation index suggested moderate impairment. Metals increaser diatoms indicated a high probability of impairment by metals, whereas the pollution index suggested only minor impairment. Nutrient increaser taxa indicated a high probability of impairment by nutrients. The percent abundance of diatoms tolerant of inorganic nutrients and organic nitrogen was relatively high. The percent abundance of diatoms requiring high dissolved oxygen saturation and intolerant to conditions of high biochemical oxygen demand was slightly lower than at the two upstream mainstem sites. Biological integrity at site CFR-11F in 2015 was rated "good", with minor impairment indicated by slightly elevated values for the siltation index and abnormal cell percentage. All other diatom association metrics for site CFR-11F indicated "excellent" biological integrity with an unimpaired biota in 2015.

5.4.2.1.9 Racetrack Creek at Frontage Road (RTC-1.5)

A diverse assemblage of twenty non-diatom genera from four algal divisions was present at site RTC-1.5 in 2015. Fourteen genera of green algae were identified, including five filamentous genera (i.e., *Cladophora, Microspora, Oedogonium, Spirogyra* and *Ulothrix*). Green algae dominated the estimated biovolume. The filamentous cyanobacterium *Phormidium* was the only blue-green alga ranked within the top fifteen non-diatom taxa by biovolume. The yellow-green alga *Vaucheria* ranked fifth in estimated biovolume. *Vaucheria* and *Tribonema* (another member of the Xanthophyta division) were observed and are often found in somewhat acidic waters containing dissolved humic compounds. Together these taxa are indicative of cool, high quality water that is moderately high in dissolved solids and moderately rich in nutrients.

Diatom species richness and Shannon diversity values at site RTC-1.5 were the lowest of any CFROU site monitored in 2015. The diatoms *Achnanthidium minutissimum* and *A. pyrenaicum* were dominant with about 34% and 21% relative abundance, respectively. *Encyonema minutum* and *E. silesiacum* accounted for about 13% and 14% relative abundance, respectively. All of these taxa prefer cool, low conductivity water that is relatively low in nutrients. *Achnanthidium minutissimum* is well adapted to recolonizing recently disturbed substrates. The dominance of *Achnanthidium minutissimum* suggests that physical factors such as high current velocities and substrate scour may have impacted the periphyton assemblage at the site. Sediment increaser diatom taxa and the siltation index indicated a very low probability of impairment by sediment. Metals increaser diatom taxa indicated a low probability of impairment by metals. Nutrient increaser diatom taxa indicated a low probability of impairment by nutrients. The diatom assemblage was primarily indifferent or intolerant of inorganic nitrogen, and tolerant of elevated organic nitrogen. Over 40% of diatom species present required high levels of dissolved oxygen, and were intolerant of conditions with elevated biochemical oxygen demand. Overall biological integrity at site RTC-1.5 in 2015 was rated as "good" with minor impairment indicated by a slightly depressed Shannon diversity value, and slightly elevated values for percent dominant taxon and the disturbance index.

5.4.2.1.10 Clark Fork River at Deer Lodge (CFR-27H)

Thirteen genera of non-diatom algae were identified at site CFR-27H in 2015 including eight genera of green algae, three genera of blue-green algae, and two genera of yellow-green algae. The filamentous green algae *Oedogonium* and *Cladophora* were the most abundant non-diatom genera by estimated biomass. *Cladophora* and *Oedogonium* indicate relatively high-quality water moderately rich in inorganic nutrients. The blue-green alga *Nostoc,* important at the three mainstem Clark Fork River sites upstream of site CFR-27H, was conspicuously absent from site CFR-27H. The green algae, followed by the diatoms, were the most common in estimated total algal biovolume. The absence of *Nostoc* and low abundance of other nitrogen-fixing blue-green algae suggests that the periphyton assemblage was largely phosphorus-limited. The low percent abundance of the diatom *Epithemia sorex* supports the conclusion of phosphorus-limitation.

Diatom species richness at site CFR-27H was slightly higher than at the three upstream mainstem Clark Fork River sites, but Shannon diversity at site CFR-27H was the lowest of any mainstem sites. Diatom taxa were dominated by *Achnanthidium minutissimum* and *Diatoma moniliformis,* each with percent relative abundance values of about 29% and 25%, respectively. About 3% of the *Diatoma moniliformis* cells were found to be abnormal. These diatom species prefer cool, somewhat alkaline water with low to moderate levels of inorganic nitrogen and phosphorus, and moderate conductivity. Sediment increaser diatoms and the siltation index indicated a low probability of impairment by sediment. Metals increaser diatoms indicated a low probability of impairment by metals, but the elevated percentage of percent abnormal cells suggested a moderate probability of metals impacts. Nutrient increaser diatom taxa indicated a moderate probability of impairment by nutrients. The diatom assemblage as a whole was relatively tolerant of, or indifferent of, elevated inorganic nitrogen and tolerant of high levels of organic nitrogen. A lower percentage of diatoms present at site CFR-27H were sensitive to elevated biochemical oxygen demand or required high dissolved oxygen levels when compared to upstream Clark Fork River sites. Overall biological integrity at site CFR-27H was rated as "good" with slight impairment indicated by the Shannon diversity index, pollution index, disturbance index, and moderate impairment indicated by the percent of abnormal cells.

5.4.2.1.11 Little Blackfoot River at Beck Hill Road (LBR-CFR-02)

A diverse assemblage of 21 genera of non-diatom algae, representing three algal divisions, was identified at site LBR-CFR-02 including twelve genera of green algae, seven genera of blue-green algae and two genera of yellow-green algae. The blue-green algae *Nostoc* and *Tolypothrix* were ranked first and fourth in estimated biovolume, respectively, and diatom algae ranked third. The filamentous green algae *Spirogyra, Cladophora,* and *Stigeoclonium* ranked second, fifth and sixth, respectively. The total estimated biovolume of green algae and blue-green algae were essentially the same. The yellow-green algae *Vaucheria* and *Tribonema* contributed a relatively minor portion of total estimated biovolume. This diverse non-diatom algae assemblage suggests relatively high quality, nutrient-rich water with little indication of impairment by toxic metals.

Diatom species richness and Shannon diversity values at site LBR-CFR-02 were the highest of any tributary streams in the CFROU, and similar to the highest values observed in the Clark Fork River mainstem. Of the 70 diatom taxa identified, *Cocconeis palcentula* was the dominant diatom taxon with a relative abundance of nearly 15%, and *Navicula capitatoradiata* and *Epithemia sorex* each accounted for about 8%. These diatoms prefer cool, well-oxygenated, alkaline water of moderate conductivity, with low to moderate levels of inorganic nutrients. The importance *of Epithemia sorex*, along with the cyanobacteria *Nostoc*, suggests nitrogen was likely the limiting nutrient. Sediment increaser diatom taxa and the siltation index indicated a moderately high probability of impairment by sediment. Metals increaser diatom taxa indicated a moderate probability of impairment by metals, although the pollution index did not suggest impairment by metals. Nutrient increaser taxa abundance indicated a moderately high probability of impairment by nutrients. A majority of the diatom taxa were tolerant of elevated inorganic nitrogen and organic nitrogen, but were intolerant of elevated levels of biochemical oxygen demand, and required relatively high dissolved oxygen saturation. Biological integrity at LBR-CFR-02 was rated “excellent” in 2015 with an essentially unimpaired biota.

5.4.2.1.12 Clark Fork River at Williams-Tavenner Bridge

Sixteen genera of non-diatom algae were identified at site CFR-34 in 2015. Eleven genera of green algae and five genera of blue-green algae were identified. No other algal divisions were identified. Following the diatoms, the filamentous green alga *Cladophora* was ranked second in estimated biovolume, and the colonial blue-green *Nostoc* was ranked third. The green algae dominated the estimated total algal biovolume followed by diatoms and blue-green algae. *Cladophora* indicates relatively high-quality water moderately rich in inorganic nutrients, while the relative importance of the blue-green *Nostoc* suggests nitrogen may have been the limiting nutrient.

Diatom species richness and Shannon diversity values at site CFR-34 were the highest of the six Clark Fork River mainstem sites monitored in 2015. One diatom species (*Achnanthidium minutissimum*) had a percent abundance that approached 10%, while thirteen diatom taxa had percent abundance values between 3% and 6%. Included in this group were *Cocconeis pediculus* and *C. placentula, Diatoma moniliformis and D. vulgaris, Epithemis sorex, Navicula cryptotenella, Nitzschia dissipata* and *N. fonticola,* and *Ulnaria ulna.* These diatoms prefer cool, well-oxygenated, alkaline water of moderate conductivity, with low to moderate levels of inorganic nutrients. Sediment increaser diatom taxa and the siltation index indicated a moderately high probability of impairment by sediment. Metals increaser diatom taxa indicated a moderate probability of impairment by metals whereas the pollution index and percentage of abnormal cells suggested a moderately low probability of metals impacts. Nutrient increaser diatom taxa indicated a moderately low probability of impairment. A high percentage of the diatoms present were tolerant of elevated inorganic nitrogen and organic nitrogen, required a relatively high level of dissolved oxygen saturation, and were intolerant of elevated biochemical oxygen demand. Overall biological integrity at CFR-34 was rated as “good” with minor impairment, indicated by a slightly depressed pollution index value and a slightly elevated siltation index value.

5.4.2.1.13 Clark Fork River at Turah (CFR-116A)

Nineteen genera of non-diatom algae were identified at site CFR-116A in 2015, including eleven genera of green algae, seven genera of blue-green algae, and one genus of red algae. By biovolume, diatoms were most abundant followed by the filamentous green alga *Cladophora* and *Stigeoclonium,* and the colonial blue-green alga *Nostoc*. Green algae dominated the biovolume. The non-diatom algae assemblage was generally indicative of cool, nutrient-rich water.

Diatom species richness at site CFR-116A was relatively low, and the Shannon diversity value was as low as any Clark Fork River mainstem site in 2015. *Diatoma moniliformis* was dominant with a relative abundance of about 37%. *Cymbella affinis* was the second-highest diatom in terms of relative abundance at about 13%, followed by *Achnanthidium minutissimum* at about 7%, and *Epithemia sorex* at about 5%. These diatom taxa general prefer cool, well-oxygenated, moderately alkaline water with relatively low to moderate levels of nutrients. Sediment diatom increaser taxa and the siltation index indicated a low probability of impairment by sediment. Metals increaser taxa, the pollution index, and the percent of abnormal cells indicated a moderate probability of impairment by heavy metals. Nutrient increaser diatom taxa indicated a high probability of impairment by nutrients. A high percentage of the diatoms were tolerant of elevated inorganic nitrogen, but a significant percentage were intolerant of organic nitrogen. A relatively low percentage (<50%) were intolerant of elevated biochemical oxygen demand or required a high level of dissolved oxygen saturation. Biological integrity at site CFR-116A was rated “good” in 2015, with minor impairment indicated by slightly depressed Shannon diversity and pollution index values, a slightly elevated value for percent dominant taxon, and a moderately high value for percent of abnormal cells.

6.0 MACROINVERTEBRATES[35]

6.1 INTRODUCTION

The Clark Fork River, a major tributary of the Columbia River, has been impacted by mining and mineral operations occurring in its headwaters at the confluence of Warm Springs and Silver Bow Creeks in Deer Lodge County, Montana. In the late 1800's and early 1900's these tributaries carried wastes to the Clark Fork from mining, milling and smelting operations in the Butte and Anaconda areas. Wastes included hazardous substances such as arsenic, cadmium, copper, lead, and zinc that contaminate large areas of the Clark Fork floodplain, river sediments and surface water.

Investigations of the character and extent of the contamination on the Clark Fork River began in 1995, subsequent to the EPA designation of a portion of the river from the Warm Springs ponds on Silver Bow Creek to upstream of Milltown Reservoir as a distinct operable unit of the Milltown Reservoir Superfund Site. These investigations showed that natural resources in and around the river were impacted by the release of hazardous substances, prompting the development of an adaptive, comprehensive long-term monitoring plan for evaluating the success of restoration and remediation activities [DeArment et al., 2010]. The plan will be implemented over the next decade and includes monitoring techniques and remediation goals for surface water, ground water, in-stream sediment, vegetation, and aquatic biota.

Stream benthic macroinvertebrates are major components of the aquatic biota present in the Clark Fork drainage and thus, play an important role in the comprehensive monitoring plan. The overall goal of the plan for macroinvertebrates "is a reduction of acute and chronic risks to aquatic life as measured by…. benthic macroinvertebrate community integrity…… An absence of impacts to macroinvertebrate organisms will be reflected by a balanced, integrated, and adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the regions [Karr and Dudley, 1981]." Attainment of this goal will be reflected by progressive increases in biological integrity [DeArment et al., 2010]. Specifically, the goal for the macroinvertebrate community is "to attain and maintain a 'nonimpaired' bioassessment rating (>80%) based in the metrics subset indicating metals pollution which was established by McGuire [McGuire, 2010]". Although metals pollution will be used as the primary benchmark for evaluation of the condition of the macroinvertebrate community relative to remediation measures, other metrics will also be used to evaluate overall community integrity.

This report describes the analysis of a subset of the benthic macroinvertebrate monitoring program, specifically the samples collected in the Clark Fork drainage in 2015. The benthic invertebrate fauna was analyzed using an index developed specifically for the Clark Fork

[35] Chapter 7 was prepared by Billie Kerans, Wease Bollman, and Jennifer Bowman with Rhithron with minor editing and formatting by RESPEC.

drainage [McGuire, 2010]. This index has been applied over a long course of sampling dating from 1986. The index is divided into three parts: a general subset, an organic pollution subset and a metals subset. In addition, the taxonomic and functional composition of the benthic fauna was investigated to gain information about probable stressors to water quality and habitat integrity. This information is described in a series of site-specific narratives. The results of several other biotic assessment tools are also presented in Appendix G.

6.2 METHODS

6.2.1 Sampling

Benthic macroinvertebrates were sampled at three Clark Fork River headwater sites, five sites on the mainstem Clark Fork River, and three sites on tributaries of the Clark Fork on September 10 and 11, 2015. Four sample replicates were collected at each site, using a Hess sampling device. Sites are described in Table 6-1. Samples were delivered to Rhithron Associates, Inc. (Rhithron) for processing and identification.

Table 6-1. Macroinvertebrate sampling sites in the Clark Fork River basin, September 10-11, 2015.

Site description	Site ID.	Co-located USGS gauge	Latitude (NAD 83)	Longitude (NAD 83)
Mill-Willow Creek at Frontage Road	MCWC-MWB	NA	46.12649	-112.79876
Warm Springs Creek near mouth	WSC-SBC	12323770	46.18041	-112.78592
Silver Bow Creek at Warm Springs	SS-25	12323750	46.18123	-112.77917
Clark Fork River near Galen	CFR-03A	12323800	46.20877	-112.76740
Clark Fork River at Galen Road	CFR-07D	12323800	46.20877	-112.76740
Clark Fork River at Gemback Road	CFR-11F	NA	46.26520	-112.74430
Clark Fork River at Williams-Tavenner Bridge	CFR-34	NA	46.47119	-112.72492
Clark Fork at Turah	CFR-116A	12334550	46.49340	-113.48480
Lost Creek near mouth	LC-7.5	12323850	46.21862	-112.77384
Racetrack Creek near mouth	RTC-1.5	NA	46.28395	-112.74921
Little Blackfoot River near Garrison	LBR-CFR	12324590	46.51964	-112.79312

6.2.2 Laboratory Analysis

Samples were completely picked of organisms, following procedures consistent with previous Clark Fork River Biomonitoring projects processed at Rhithron [Bollman, 2010]. Similar to the most recent studies [Bollman and Sullivan, 2013; Bollman et al., 2014], densities of abundant taxa were not estimated, but actual counts were obtained for all organisms. Caton trays [Caton, 1991] were used to distribute the samples for sorting. Each individual sample was thoroughly mixed in its jar(s), poured out and evenly spread into the Caton tray. Grids were systematically selected, and grid contents were examined under stereoscopic microscopes using 10x-30x magnification (Leica S6E and Leica EZ4 stereoscopic dissecting microscopes). All invertebrates were sorted from the substrate, and placed in 95% ethanol for subsequent identification.

Organisms were individually examined by certified taxonomists, using 10x – 80x stereoscopic dissecting scopes (Leica S8E) and identified to the lowest practical level consistent with previous Clark Fork River biomonitoring projects [McGuire, 2010], using appropriate published taxonomic references and keys. Midges and worms were carefully morphotyped using 10x-80x stereoscopic dissecting microscopes (Leica S8E) and representative specimens were slide mounted and examined at 200x – 1000x magnification under compound microscopes (Olympus BX 51 with Hoffman Contrast and Leica DM1000). Slide mounted organisms were archived at the Rhithron laboratory.

Identification, counts, life stages, and information about the condition of specimens were recorded. Organisms that could not be identified to the taxonomic targets because of immaturity, poor condition, or lack of complete current regionally-applicable published keys were left at appropriate taxonomic levels that were coarser than target levels. To obtain accuracy in richness measures, these organisms were designated as "not unique" if other specimens from the same group could be taken to target levels. Organisms designated as "unique" were those that could be definitively distinguished from other organisms in the sample. Identified organisms were preserved in 95% ethanol in labeled vials, and archived at the Rhithron laboratory.

6.2.3 Data Analysis

Taxa lists and counts for each sample were constructed. Standard metric calculations were made using customized database software. McGuire's indices are ".....specifically designed to evaluate water quality in the Clark Fork River Basin" [McGuire, 2010]. The indices comprise 11 metrics. Two subsets of three metrics each are scored and summed separately to obtain values for organic/nutrient impairment and for metals impairment. Individual metrics and the expected response of each to environmental stress are described in the project sampling and analysis plan [Naughton et al., 2015a].

6.2.4 Quality Assurance Systems

Quality control procedures for macroinvertebrate sample processing involved checking sorting efficiency on three randomly selected quality control samples. These checks were conducted by trained quality assurance technicians who microscopically re-examined 100% of sorted substrate from each quality control sample. Sorting efficiency was evaluated by applying the following calculation:

$$SE = \frac{n_1}{n_1 + n_2} \times 100$$

where: SE is the sorting efficiency, expressed as a percentage, n_1 is the total number of specimens in the first sort, and n_2 is the total number of specimens in the second sort.

Quality control procedures for taxonomic determinations of invertebrates involved checking accuracy, precision and enumeration. Two samples were randomly selected and all organisms were re-identified and counted by an independent taxonomist. Taxa lists and enumerations were compared by calculating a Bray-Curtis similarity statistic [Bray and Curtis, 1957] for each selected sample. The percent taxonomic disagreement (PTD) and percent difference in enumeration (PDE) were also calculated [Stribling et al., 2003].

Quality control and quality assurance results are reported in Appendix F.

6.2.5 Ecological Interpretations: Approach

We use narrative interpretations of taxonomic and functional composition of invertebrate assemblages to reveal the probable stressors in the Clark Fork River Operable Unit. Often canonical procedures are used for stressor identification; however, the substantial data required for such procedures (e.g., surveys of habitat, historical and current data related to water quality, land use, point and non-point source influences, soils, hydrology, geology) were not readily available for this study. Instead our narrative interpretations are based on demonstrated associations between assemblage components and habitat and water quality variables gleaned from the published literature, the writer's own research (especially Bollman [1998]) and professional judgment, and the research (especially Wisseman [1996]) and professional judgment of other expert sources.

We use attributes of invertebrate taxa that are well substantiated in diverse literature, and that are generally accepted by regional aquatic ecologists as evidence of water quality, and instream and reach-scale habitat conditions. The approach to this analysis uses some assemblage attributes that are interpreted as evidence of water quality and other attributes that are interpreted as evidence of habitat integrity. To arrive at impairment classifications, attributes are considered individually, so information is maximized by not relying on a single cumulative score which may mask stress on the biota. Such an approach also minimizes the possibility of using inappropriate assessment strategies when the biota at a site is atypical of "characteristic" sites in a region. Replicate samples were electronically combined into composited samples for this analysis. Below we describe the invertebrate attributes that were used and their relationships to water quality and habitat conditions.

Mayfly taxa richness, the Hilsenhoff Biotic Index (HBI) value [Hilsenhoff, 1987], the richness and abundance of hemoglobin-bearing taxa, and the richness of sensitive taxa are often used as indicators of water quality. Mayfly taxa richness has been demonstrated to be significantly correlated with chemical measures of dissolved oxygen, pH, and conductivity (e.g., Bollman [1998]; Fore et al. [1996]; Wisseman [1996]). The HBI has a long history of use and validation [Cairns and Pratt, 1993; Smith and Tran, 2010; Johnson and Ringler, 2014]. In Montana foothills, the HBI was demonstrated to be significantly associated with conductivity, pH, water temperature, sediment deposition, and the presence of filamentous algae [Bollman, 1998]. Nutrient enrichment in Montana streams often results in large crops of filamentous algae [Watson, 1988]. Thus in these samples, when macroinvertebrates associated or dependent on filamentous algae (e.g., Anderson [1976]; LeSage and Harrison [1980]) are abundant, the presence of filamentous algae and nutrient enrichment are also suspected. Sensitive taxa exhibit intolerance to a wide range of stressors (e.g., Hellawell [1986]; Wisseman [1996]; Friedrich [1990]; Barbour et al. [1999]), including nutrient enrichment, acidification, thermal stress, sediment deposition, habitat disruption, and others. These taxa are expected to be present in predictable numbers in functioning montane and foothills streams (e.g., Bollman [1998]). Although the abundance of invertebrates in Hess samples can be highly variable, reflecting the patchy and dynamic areal distribution of the benthos in stony-bottomed streams, McGuire's thresholds for environmental perturbation [McGuire, 2010] are cited as evidence of enrichment or impairment.

The richness and abundance of cold stenotherm taxa [Clark, 1997] and calculation of the temperature preference of the macroinvertebrate assemblage [Brandt, 2001] can predict the thermal characteristics of the sampled site. Hemoglobin-bearing taxa are also indicators of warm water temperatures [Walshe, 1947], since dissolved oxygen is directly associated with water temperature; oxygen concentrations can also vary with the degree of nutrient enrichment. Increased temperatures and high nutrient concentrations can, alone or in concert, create conditions favorable to hypoxic sediments; habitats preferred by hemoglobin-bearers.

The absence of invertebrate groups known to be sensitive to metals and the Metals Tolerance Index [Bukantis, 1998] are considered signals of possible metals contamination. Metals sensitivity for some groups, especially the heptageniid mayflies, is well-known (e.g., Kiffney and Clements [1994]; Clements [1999]; [2004]; Montz et al. [2010]; Iwasaki et al. [2013]). In the present approach, the absence of these groups in environs where they are typically expected to occur is considered a signal of possible metals contamination, but only when combined with a measure of overall assemblage tolerance of metals. The Metals Tolerance Index ranks taxa according to their sensitivity to metals. Weighting taxa by their abundance in a sample, assemblage tolerance is estimated by averaging the tolerance of all sampled individuals.

Characteristics of the macroinvertebrate assemblages can also reveal the condition of instream and streamside habitats. Stress from sediment is evaluated by caddisfly richness and by "clinger" richness [Kleindl, 1995; Bollman, 1998; Karr and Chu, 1999; Wagenhoff et al., 2012; Leitner et al., 2015]. A newer tool, the Fine Sediment Biotic Index (FSBI) [Relyea et al., 2012] shows promise when applied to the montane and foothills regions. This index and its interpretation are modified in this report, based on the author's professional judgment, to more effectively characterize the Clark Fork River and tributaries in the sampled reaches.

The functional characteristics of macroinvertebrate assemblages are based on the morphology and behaviors associated with feeding, and are interpreted in terms of the River Continuum Concept [Vannote et al., 1980] in the narratives. Alterations from predicted patterns in montane and foothills streams may be interpreted as evidence of water quality or habitat disruption. For example, shredders and the microbes they depend on are sensitive to modifications of the riparian zone [Plafkin et al., 1989].

6.3 RESULTS

6.3.1 Bioassessment

Mean bioassessment scores and their associated impairment classifications are given in Table 6-2. Raw scores for each macroinvertebrate replicate sample are given in Appendix F.

6.3.1.1 Overall Biointegrity Index

Mean scores for McGuire's overall biointegrity index [Table 6-2] indicate unimpaired biological integrity at 4 of the 5 sites on the mainstem Clark Fork River: the sites near Galen (CFR-03A), at Galen Road (CFR-07D), at Gemback Road (CFR-11F) and at the Williams-Tavenner Bridge (CFR-34). All headwaters and tributary sites, and the mainstem Clark Fork River site at Turah (CFR-116A) are classified as slightly impaired using this index. There was moderate variation in overall biological integrity scores among sample replicates. The mean coefficient of variation (CV) among replicates for this index (scores as percent of maximum score) was 7.71%. Mean, maximum and minimum scores, with 95% confidence intervals are graphed in Figure 6-1.

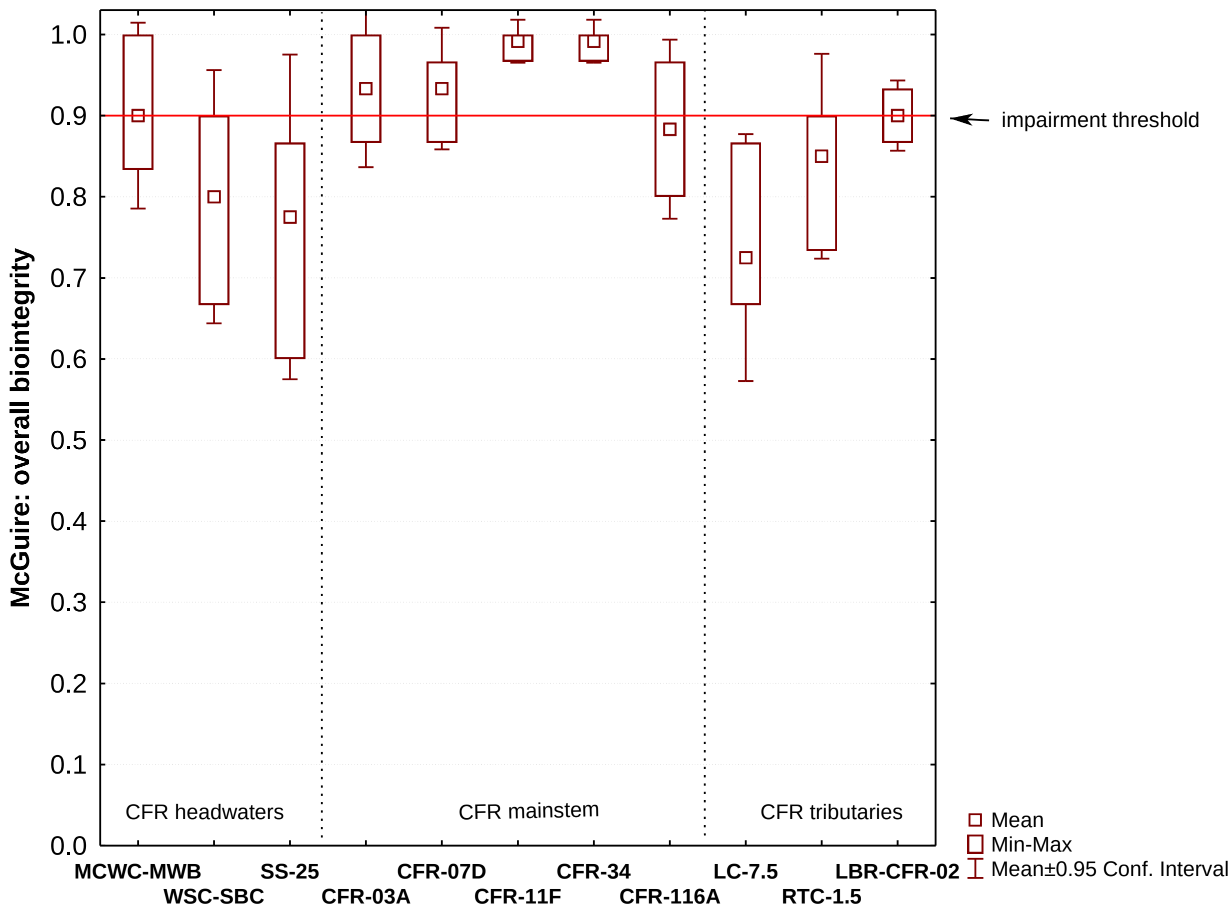

Figure 6-1. Variability among replicates: mean scores, maximum and minimum scores, and 95% confidence intervals for McGuire's overall biointegrity index. Clark Fork River basin, September 10-11, 2015.

6.3.1.2 Metals Subset

Mean scores for McGuire's metals index [Table 6-2] indicate unimpaired conditions at 8 of the 11 sampled sites. Slight metals impairment was indicated at: Warm Springs Creek near mouth (WSC-SBC), Silver Bow Creek at Warm Springs (SS-25), and at Lost Creek at Frontage Road (LC-7.5). The mean CV among replicates for the metals subset index score (scores as percent of maximum score) was 8.7%, suggesting greater variability in these scores compared to the overall biointegrity scores. Mean, maximum and minimum scores, with 95% confidence intervals are graphed in Figure 6-2.

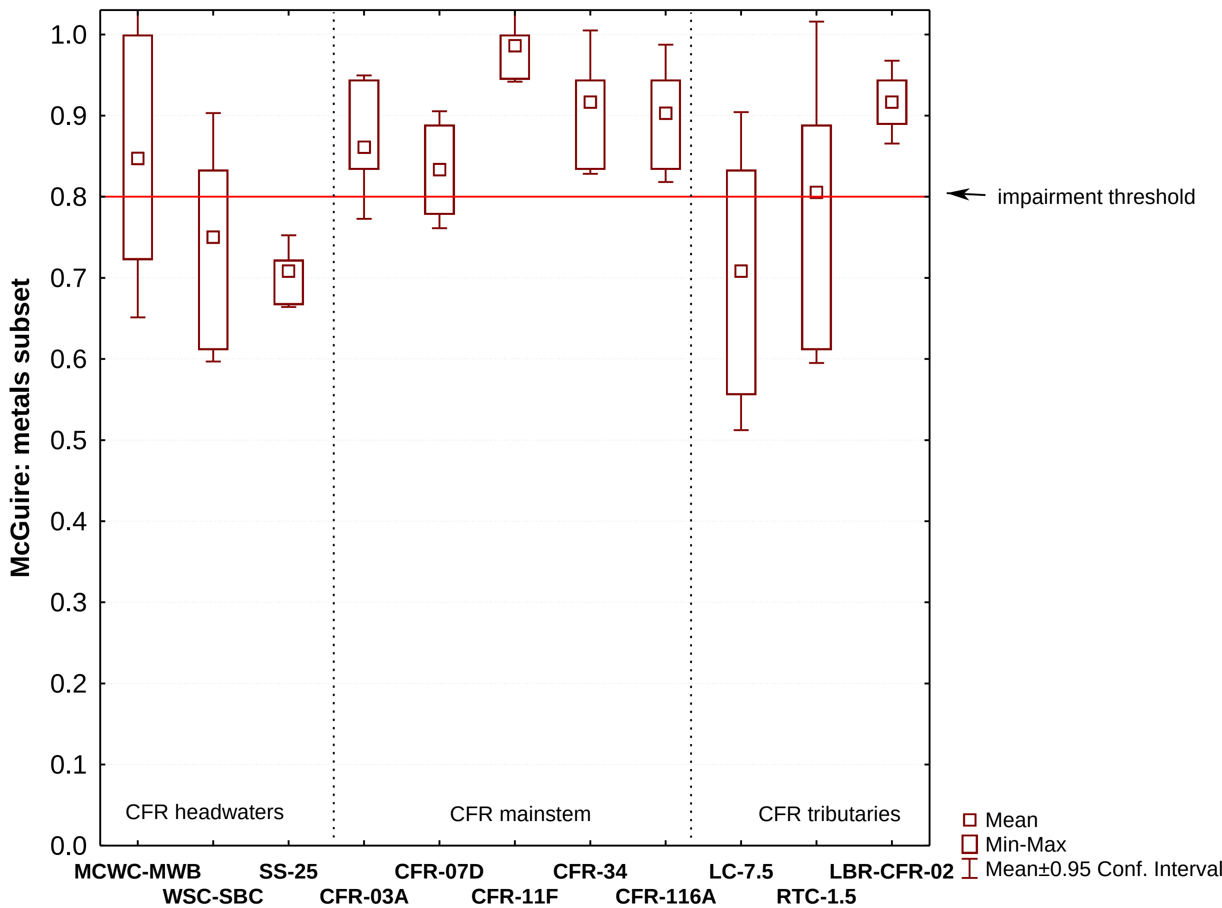

Figure 6-2. Variability among replicates: mean scores, maximum and minimum scores, and 95% confidence intervals for McGuire's metals pollution metric subset. Clark Fork River basin, September 10-11, 2015.

6.3.1.3 Organic and Nutrient Subset

Mean scores for McGuire's organic and nutrient index [Table 6-2] indicate unimpaired conditions at 8 of 11 sampled sites. Slight impairment due to organic/nutrient enrichment was detected by the index at Silver Bow Creek at Warm Springs (SS-25), the mainstem Clark Fork River sites at the Rock Creek Cattle Company Bridge (CFR-34) and at Turah (CFR-116A. The mean CV among replicates for the organic/nutrient subset index score (scores as percent of maximum score) was 6.92%, indicating moderate variation in these scores. Mean, maximum and minimum scores, with 95% confidence intervals are graphed in Figure 6-3.

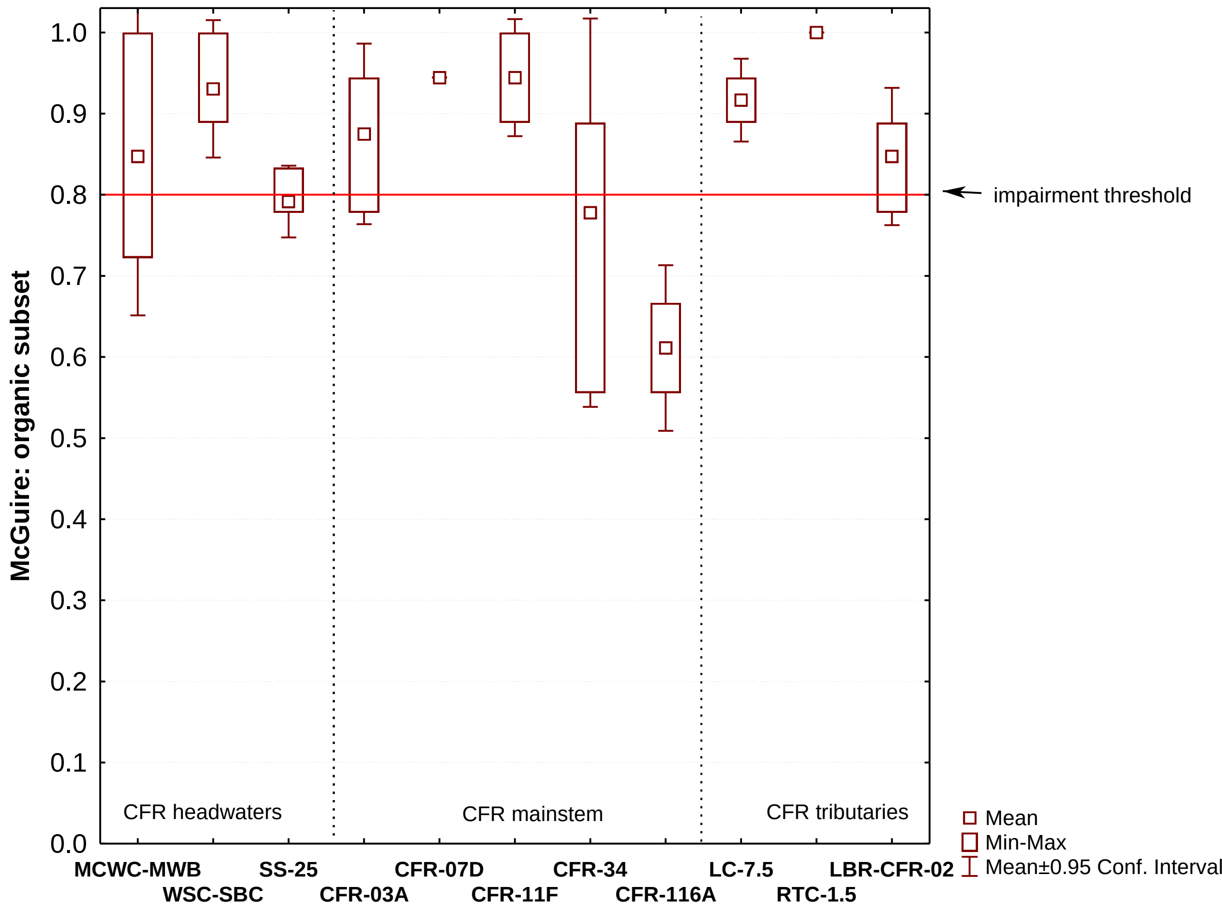

Figure 6-3. Variability among replicates: mean scores, maximum and minimum scores, and 95% confidence intervals for McGuire's organic/nutrient pollution metric subset. Clark Fork River basin, September 10-11, 2015.

Table 6-2. Mean macroinvertebrate bioassessment scores and impairment classifications: McGuire's indices for general biointegrity, nutrient/organic impairment, and metals impairment. Scores are mean values over four replicate samples, and are expressed as the percent of maximum score. Clark Fork River basin, September 10-11, 2015.

Site name	Site identifier	McGuire biointegrity metrics [McGuire, 2010]		McGuire metals-sensitive subset [McGuire, 2010]		McGuire organic/nutrient-sensitive subset [McGuire, 2010]	
		score	impairment class	score	impairment class	score	impairment class
Mill -Willow Creek at Frontage Road	MCWC-MWB	90.0	slight	84.7	none	84.7	none
Warm Springs Creek near mouth	WSC-SBC	80.0	slight	75.0	slight	93.1	none
Silver Bow Creek at Warm Springs	SS-25	77.5	slight	70.8	slight	79.2	slight
Clark Fork River near Galen	CFR-03A	93.3	none	86.1	none	87.5	none
Clark Fork River at Galen Road	CFR-07D	93.3	none	83.3	none	94.4	none
Clark Fork river at Gemback Road	CFR-11F	99.2	none	98.6	none	94.4	none
Clark Fork River at Williams-Tavenner Bridge	CFR-34	99.2	none	91.7	none	77.8	slight
Clark Fork River at Turah	CFR-116A	88.3	slight	90.3	none	61.1	slight
Lost Creek at Frontage Road	LC-7.5	72.5	slight	70.8	slight	91.7	none
Racetrack Creek at Frontage Road	RTC-1.5	85.0	slight	80.6	none	100.0	none
Little Blackfoot River at Beck Hill Road	LBR-CFR-02	90.0	slight	91.7	none	84.7	none

6.4 DISCUSSION

6.4.1 Ecological Interpretation of Aquatic Invertebrate Assemblages

6.4.1.1 Mill-Willow Creek at Frontage Road (MCWC-MWB)

6.4.1.1.1 Water Quality

Although most metric indicators suggested good water quality at this site, some indicators suggested mild impairment. Eight mayfly taxa were collected: three taxa in the family Baetidae, two in the family Ephemerellidae, two in the family Heptageniidae, and one in the family Leptophlebiidae. The HBI (3.56) was within expectations for a low-order valley stream. In addition, two pollution sensitive taxa, the midge *Cricotopus (Nostococladius)* sp. and the mayfly *Drunella grandis*, were found in the composited sample. Hemoglobin-bearing organisms (0.4%) were uncommon, suggesting that the sediments were well oxygenated. However, none of the pollution sensitive taxa and the mayflies were common (all mayflies represented <2% of the total abundance), pollution-tolerant organisms (23.1%, mainly the elmid beetles *Optioservus* sp. and *Zaitzevia* sp.) were a large component of the assemblage, and the dominant organisms in the sample were immature specimens of filter-feeding hydropsychid caddisflies (28.4%), resulting in the dominance of the filter-feeding functional group (54.8%). All three of these characteristics suggest that some slight water quality impairment cannot be ruled out. The MTI (3.82) was higher than the HBI, perhaps suggesting slight contamination by metals; however, such contamination is unlikely because metals intolerant taxa were present (heptageniid mayflies *Rhithrogena* sp. and *Cinygmula* sp.) and even common (the caddisfly *Lepidostoma* sp. (5.4%).

6.4.1.1.2 Thermal Condition

One cold stenotherm taxon (the midge *C. (Nostococladius)* sp., 0.6%) was collected at this site. The estimated thermal preference of the assemblage was 14.6 C.

6.4.1.1.3 Sediment Deposition

It is unlikely that the deposition of fine sediment impeded the colonization of taxa in this reach as 14 caddisfly and 29 “clinger” taxa were found in the sample. The FSBI (4.21) indicated an assemblage that was moderately tolerant of fine sediment.

6.4.1.1.4 Habitat Diversity and Integrity

Overall habitat diversity and integrity appeared to be good at this site. The high taxa richness (60) suggested that instream habitats were diverse and intact. Six stonefly taxa were collected, thus channel morphology, streambanks, and riparian function appear intact. The presence of 10 semivoltine taxa, including some that were very abundant (e.g., the elimid beetle, *Optioservus* sp., 18.3%), suggests a fauna that was not substantially influenced by catastrophic dewatering, thermal extremes, or severe sediment pulses. Filter-feeders (54.8%; common taxa include the caddisflies *Brachycentrus occidentalis* (14.6%), *Hydropsyche occidentalis* (6.9%) and the aforementioned immature hydropsychids (28.4%)) dominated the functional mix. Scrapers

(25.0%) were the second most common functional group. These ecological characteristics suggest that fine particulate organic matter and algal production are important energy pathways in this reach. Other functional groups occurred in expected proportions.

6.4.1.2 Warm Springs Creek near mouth (WSC-SBC)

6.4.1.2.1 Water Quality

The fauna at this site had some characteristics suggestive of impaired water quality and some suggestive of good water quality. The mayflies composed >5% of the assemblage and were divided into five taxa (*Rhithrogena* sp., *Cinygmula* sp.*, Drunella grandis, Diphetor hageni,* and *Baetis tricaudatus* complex), a richness that was somewhat lower than expected. In addition, most of the mayflies were *Baetis tricaudatus* complex (4.7%), among the more tolerant taxa in this insect order. The HBI value (4.43) suggested an assemblage that was mildly tolerant to organic pollution, and pollution tolerant organisms (11.5%) and collector-filterers (25.2%) were common. On the positive side, two pollution sensitive taxa (the mayfly, *Drunella grandis* and the midge, *Cricotopus (Nostococladius)* sp.) were collected. This midge (24.2%) was very abundant and the dominant organism in the assemblage. In addition, the midge is assigned a relatively high HBI tolerance value (6) that may overestimate its tolerance causing at least some of the elevation in the HBI. Nitrogen was likely a limiting nutrient, because abundant *C. (Nostococladius)* sp. suggests a large crop of the blue-green alga *Nostoc* sp. In addition, taxa typically associated with filamentous algae (*Cricotopus spp*. (1.1% not including *C. (Nostocladius)* sp.) and *Orthocladius* spp. (4.7%)) were common, suggesting a high abundance of filamentous algae which is often associated with nutrient enrichment. This combination of characteristics suggests that mild water quality impairment, perhaps through nutrient enrichment, cannot be ruled out. The MTI value (4.55) was higher than the HBI value, but metals-sensitive taxa such as heptageniid mayflies were present and the caddisfly, *Lepidostoma* sp. (2.1%), was common. Based on these findings, metals contamination is probably unlikely here.

6.4.1.2.2 Thermal Condition

The estimated thermal preference of the site was 14.5 C. *Cricotopus (Nostococladius)* sp. was the only cold stenotherm taxon collected; however, as noted above it was very abundant.

6.4.1.2.3 Sediment Deposition

Nine caddisfly taxa were found in this sample. However, the richness of “clingers” (18) was somewhat below the expected number. When combined with an FSBI (4.77) that indicated a moderately sediment tolerant assemblage, it appears that this site may have been impacted by sediment deposition, limiting the colonization of some taxa.

6.4.1.2.4 Habitat Diversity and Integrity

Overall taxa richness (35) was lower than expected: instream habitats may have been monotonous or disrupted. In addition, four stonefly taxa were collected indicating that impacts to channel morphology, streambanks, and riparian function cannot be ruled out. Six semivoltine taxa were counted, suggesting that catastrophes like dewatering or thermal stress probably did not interrupt long life cycles. Indeed, the semivoltine stonefly *Hesperoperla pacifica* was common—almost 2% of the fauna. Shredders (28.2%) were the most abundant of the feeding groups; however, the most abundant shredder was *C. (Nostococladius)* sp. This midge does not respond to riparian inputs of large organic material: this type of material may have been limited in the reach. All other functional groups were present and in similar relative abundances.

6.4.1.3 Silver Bow Creek at Warm Springs (SS-25)

6.4.1.3.1 Water Quality

Water quality appears impaired at this site. Only four mayfly taxa (*Ephemerella excrucians*, *Tricorythodes* sp., *Diphetor hageni*, *Baetis tricaudatus complex*) were found and only the ubiquitous *B. tricaudatus complex* (2.0%) was abundant. The HBI (5.59) was elevated, and pollution tolerant organisms (36.2%), including the elimid beetle *Optioservus* sp. (20.1%: the dominant organism in the sample), the filtering caddisfly *Cheumatopsyche* sp. (5.3%), and the amphipod *Hyalella* sp. (4.4%), were common. In addition, filtering collectors (29.2%) were the most abundant of the functional feeding groups and taxa typically associated with filamentous algae (*Cricotopus* spp. (12.3% not including *C. (Nostocladius)* sp.) and *Orthocladius* spp. (1.1%)) were common. Both of these characteristics are often associated with nutrient enrichment. These results suggest that water quality was impaired, probably by nutrient enrichment. The fact that hemoglobin-bearing organisms (7.0%), mostly the midge *Microtendipes* sp. (6.9%), were common indicates that sediments might be hypoxic and also supports the contention that nutrient enrichment might be a problem in this reach. Metals contamination is probably unlikely in this reach as the MTI (5.06) was lower than the HBI.

6.4.1.3.2 Thermal Condition

Only one cold stenotherm taxon (*Cricotopus (Nostococladius*) sp., only 0.3% of the fauna) was collected at this site. The temperature preference (17.2°C) of the assemblage was the highest of any site in the 2015 study. Several organisms tolerant of warm water temperatures were collected (e.g., the caddisflies *Oecetis* sp. (4.2%) and *Cheumatopsyche* sp.).

6.4.1.3.3 Sediment Deposition

The impact of fine sediment on the colonization of stony substrates in this reach cannot be ruled out. Although the caddisfly taxa richness (13) was high, only 15 “clinger” taxa were collected. The FSBI (3.34) also suggests an assemblage that is tolerant of fine sediment.

6.4.1.3.4 Habitat Diversity and Integrity

Overall taxa richness (50) was somewhat lower than expected, suggesting limited or monotonous instream habitats. In addition, stonefly (0) and semivoltine (3) taxa were under-represented, suggesting that channel morphology, streambanks, and riparian function were impaired and catastrophes such dewatering, scouring sediment pulses, or thermal extremes may have had an impact on the biota. Collector-filterers (29.2%) were the dominant functional group suggesting the importance of fine particulate matter to the energy flow in this reach.

Scrapers (21.0%) and shredders (13.2%) were also common suggesting that instream algal production and inputs from riparian vegetation were also important in the energy budget.

6.4.1.4 Clark Fork River near Galen (CFR-03A)

6.4.1.4.1 Water Quality

Mayfly taxa richness (8) was within expectations for a low-to-mid-order stream in the Valley and Foothill ecoregion. Three taxa in the family Baetidae, two taxa in the family Ephemerellidae, and three taxa in the family Heptageniidae were collected, although only the ubiquitous *Baetis tricaudatus* complex (2.5%) was common. Similar to the samples collected in 2013 and 2014, the midge *Cricotopus (Nostococladius)* sp. dominated collections taken at this site, accounting for 21.1% of the sampled fauna. The relatively high HBI value (6) assigned to this midge may overestimate its tolerance to organic pollution, and resulted in an HBI of 4.61, which is slightly higher than expected. Nitrogen was likely a limiting nutrient, because abundant *C. (Nostococladius)* sp. suggests a large crop of the blue-green alga *Nostoc* sp. Collector-filterers (31.0%) and tolerant organisms (24.7%) were common, but two pollution-sensitive taxa were collected including the midge *C. (Nostococladius)* sp., which as noted above, was abundant. Consequently, most metrics suggest that nutrient enrichment did not substantially influence the macroinvertebrate assemblage here. There was no indication of metals contamination as the MTI (4.31) was lower than the HBI and metals intolerant taxa were common (e.g., the caddisfly *Lepidostoma* sp., 4.9%).

6.4.1.4.2 Thermal Condition

Only one cold stenotherm taxon was collected, *C. (Nostococladius)* sp., which accounted for 21.1% of the fauna in the assemblage. The temperature preference of the assemblage was 15.4 C.

6.4.1.4.3 Sediment Deposition

At least 28 "clinger" taxa and 14 caddisfly taxa were supported at this site, suggesting that stony substrates were largely free of deposited sediment. The FSBI value (3.78) indicated a moderately sediment-tolerant fauna.

6.4.1.4.4 Habitat Diversity and Integrity

Taxa richness (60) was high and at least six stonefly taxa were recorded from this reach. Thus, instream and reach-scale habitat features appear intact and diverse. Eight long-lived taxa were counted in samples, and several of these were abundant, including the elmids *Optioservus* sp. (about 10%) and *Zaitzevia* sp. (about 7%). Catastrophes such as dewatering, scouring sediment pulses, or thermal extremes were probably not influential here. The collector-filterers (31.0%) were the dominant functional group and collector-gatherers (18%) were common suggesting the importance of fine particulate matter to the flow of energy. Shredders (28.4%) were the next most common group; however, this high percentage is probably an overestimate of the role of riparian inputs to the reach because the abundant *C.*

(Nostococladius) sp. is a shredder, but it does not respond to inputs of coarse particulate matter from streamside. Other functional groups were also well represented.

6.4.1.5 Clark Fork River at Galen Road (CFR-07D)

6.4.1.5.1 Water Quality

Eight mayfly taxa were collected from this reach, which was within expectations for a mid-order valley stream. Taxa included three baetids, two ephemerellids, and three heptageniids, none of which were common (even the ubiquitous *Baetis tricaudatus* complex accounted for <1.0% of the assemblage). The HBI (4.03) was only slightly elevated above the level that indicated organic pollution (4.00). Two pollution-sensitive taxa were recorded from this site: *Cricotopus (Nostococladius)* sp. (5.0%) was common, whereas *Drunella grandis* (0.01%) was uncommon. Although both pollution tolerant taxa (35.3%) and collector-filterers (33.3%) were abundant at this site, other macroinvertebrate metrics suggest that water quality was good with little negative impact from nutrient enrichment. There was also no indication of metals contamination as the MTI (4.00) was less than the HBI and the metals sensitive caddisfly *Lepidostoma* sp. (2.3%) was common.

6.4.1.5.2 Thermal Condition

Cricotopus (Nostococladius) sp. was the only cold stenotherm taxon collected, and it accounted for 5% of the total abundance of the sample. The temperature preference of the assemblage was 15.1 C. However, the caddisflies *Oecetis* sp. (1.2%) and *Helicopsyche* sp. (6.8%) were common: these taxa are tolerant of warmer water.

6.4.1.5.3 Sediment Deposition

Sediment deposition probably did not influence colonization of taxa to an appreciable extent: the site supported no fewer than 13 caddisfly taxa and 24 “clinger” taxa. However, the FSBI value (3.48) indicated an assemblage that was sediment-tolerant.

6.4.1.5.4 Habitat Diversity and Integrity

Overall taxa richness (51) and stonefly taxa richness (3) were somewhat lower than expected, suggesting limited instream habitats and disturbed reach-scale habitat features like stream banks and riparian zones. Catastrophes such as dewatering, scouring sediment pulses, or thermal extremes probably did not influence the composition of the benthic fauna, because seven semivoltine taxa were counted in samples. Indeed, the long-lived, elmid beetle *Optioservus* sp. (22.7%) was the most abundant taxon in the sample. Scrapers (42.7%) were the dominant functional group suggesting abundant algal resources and the importance of autochthonous production to the energy balance in this reach. Clearly fine particulate organic matter that is suspended in the water column was also an important energy component as collector-filterers (33.3%) were the next dominant group. All other functional groups were well represented.

6.4.1.6 Clark Fork River at Gemback Road (CFR-11F)

6.4.1.6.1 Water Quality

Although most metrics suggest that water quality was good at this site, there were metrics that indicated some water quality impairment. Mayfly taxa richness (10) was high and included four baetids (*Iswaeon* sp. (3.7%) was the most abundant mayfly), two ephemerellids, three heptageniids, and one leptohyphid. The HBI (3.87) was below the threshold indicating organic pollution. Indeed, the grazing caddisfly *Protoptila* sp. (25.4%) was the dominant organism in the sample and it has an HBI index value of 1 indicating that it is sensitive to organic pollution. In addition, three pollution sensitive taxa were collected (the dipterans, *Potthastia longimanus* Gr. and *Cricotopus (Nostococladius)* sp., and the mayfly, *Drunella grandis*), although none of them were common. However, pollution tolerant taxa composed 29.4% of the assemblage, and hemoglobin-bearing organisms (7.5%, mostly the midge *Microtendipes* sp.) and collector-filterers (31.6%) were both common. The presence of so many hemoglobin-bearing organisms suggest hypoxic sediments, which when combined with the high percentage of collector-filterers (mostly filtering caddisflies in the family Hydropsychidae) suggests that mild nutrient enrichment cannot be ruled out here. Metals contamination is unlikely as the MTI (3.33) was lower than the HBI, metals sensitive heptageniid mayflies were present and the caddisfly *Lepidostoma* sp. (1.4%) was common.

6.4.1.6.2 Thermal Condition

Only one cold stenotherm taxon, *Cricotopus (Nostococladius)* sp*.,* was collected from this reach. However, in contrast to the two upstream sites, the midge was not very abundant here (0.3%). Although the estimated temperature preference of the assemblage was only 15.6 C, several organisms tolerant of warm water temperatures were abundant (e.g., the caddisflies *Oecetis* sp. (7.8%), *Cheumatopsyche* sp. (2.6%) and *Helicopsyche* sp. (5.2%)).

6.4.1.6.3 Sediment Deposition

Fourteen caddisfly and 28 “clinger” taxa were collected suggesting that sediment deposition did not impede the colonization of stony sediments in this reach. However, the FSBI value (3.61), indicated a moderately sediment-tolerant assemblage.

6.4.1.6.4 Habitat Diversity and Integrity

Instream habitats appear to be diverse as 62 taxa were found in this sample. Only four stonefly taxa were recorded, which is somewhat lower than expected perhaps indicating that reach-scale habitat features like stream banks and riparian zones were disturbed. Semivoltine taxa were well-represented: nine such taxa were counted in samples and the elmids, *OptioservusI*(10.2%) and *Zaitzevia* sp. (2.5%), were common. Catastrophic dewatering or thermal extremes did not appear to be influential. Scrapers (43.3%) dominated the functional composition, which is not unexpected given that the scraping caddisfly *Protoptila* sp. was the dominant organism in the sample. Filterers (31.6%), especially among the hydropsychid caddisflies (22.3%, including *Ceratopsyche cockerelli*, *Cheumatopsyche* sp., and *Hydropsyche occidentalis*) were also common. These metrics suggest that algal production and fine organic particulates in suspension are important to the energy flow in this reach. Although most other feeding groups were represented, shredders (2.5%) were not abundant. Riparian inputs of large organic material such as leaves and woody debris may have been limited in the reach.

6.4.1.7 Clark Fork River at Williams-Tavenner Bridge (CFR-34)

6.4.1.7.1 Water Quality

Water quality may have been slightly impaired by mild nutrient enrichment at this site. Although 11 mayfly taxa were collected (four baetids, three ephemerellids, two heptageniids, one leptophlebiid, and one leptohyphid), the HBI (4.71) was somewhat elevated over expectations. Pollution tolerant organisms composed almost 50% of the assemblage, and collector-filterers (54.3%) dominated the functional composition: the pollution tolerant filtering caddisfly *Cheumatopsyche* sp. (14.3%) was the dominant taxon in the sample. In addition, hemoglobin-bearing organisms (6.9%), mainly *Microtendipes* sp., were common. Even though three pollution sensitive taxa were found in the sample (*Potthastia gaedii* Gr., *Cricotopus (Nostococladius)* sp. and *Drunella grandis*) none of them were common. There was also no indication of metals contamination as the MTI (4.31) was lower than the HBI and the metals sensitive caddisfly *Lepidostoma* sp. (1.3%) was common.

6.4.1.7.2 Thermal Condition

The water temperature metrics calculated for this site were very similar to the site CFR-11F. Only one cold stenotherm taxon, *Cricotopus (Nostococladius)* sp., was collected and it was not very abundant (0.1%). Several warm-water loving taxa were abundant, including the caddisflies *Oecetis* sp. (4.8%), *Cheumatopsyche* sp. (14.3%) and *Helicopsyche* sp. (2.8%). The calculated temperature preference of the assemblage was 15.9 C.

6.4.1.7.3 Sediment Deposition

It appears that fine sediment deposition did not influence the biota in this reach because 14 caddisfly and 26 “clinger” taxa were sampled from this site. The FSBI value (3.48), however, indicated a moderately sediment-tolerant assemblage.

6.4.1.7.4 Habitat Diversity and Integrity

Overall the habitat characteristics of this site appear to be good. Sixty-seven total taxa were collected, including five stonefly taxa and 10 semivoltine taxa. The long-lived elmid taxa *Optioservus* sp. (13.0%) and *Zaitzevia* sp. (2.6%) were common. Thus, instream habitats appear diverse; reach-scale habitat features like stream banks and riparian zones appear undisturbed and catastrophic dewatering or thermal stress appear unlikely. Collector-filterers (54.3%), the dominant functional group, and collector-gatherers (9.2%) were common suggesting the importance of fine particulate organic matter to the food web here. All other functional groups were well represented.

6.4.1.8 Clark Fork River at Turah (CFR-116A)

6.4.1.8.1 Water Quality

Eight mayfly taxa were supported at this site including two baetids (the ubiquitous *Baetis tricaudatus* complex (2.9%) was the most abundant), three ephemerellids, two heptageniids, and one leptohyphid. The HBI value (4.72) indicated an assemblage that was mildly tolerant of organic pollution, which seems appropriate for a higher-order riverine system in the Valley and Foothill ecoregion. Three pollution sensitive taxa were collected (*Potthastia gaedii* Gr, *Cricotopus (Nostococladius)* sp. and *Drunella grandis*), but only *D. grandis* (1.5%) was common. Pollution tolerant organisms (35.0%) were abundant. Collector-filterers (73.1%) strongly dominated the functional composition of the assemblage, which is not surprising given that the filtering caddisflies *Hydropsyche occidentalis* (37.6%) and *Cheumatopsyche* sp. (21.9%) were the two most abundant organisms in the sample. These metrics suggest that nutrient enrichment is mild at this site. No metals contamination was indicated: the MTI (4.47) was lower than the HBI and heptageniid mayflies were common (2.1%).

6.4.1.8.2 Thermal Condition

The water temperature metrics of this site were very similar to the site CFR-11F. Only one cold stenotherm taxon, *Cricotopus (Nostococladius)* sp.*,* was collected and it was not very abundant (0.4%)   The estimated temperature preference of the assemblage was 15.6 C and several organisms tolerant of warm water temperatures were abundant including the caddisflies *Oecetis* sp. (2.8%) and *Cheumatopsyche* sp. (21.9%).

6.4.1.8.3 Sediment Deposition

The site supported at least 12 caddisfly taxa and 25 “clinger” taxa, suggesting that colonization of stony substrates was not inhibited by deposited sediment. The FSBI value (3.32) indicated a sediment-tolerant assemblage.

6.4.1.8.4 Habitat Diversity and Integrity

Overall taxa richness (51) was slightly below expectations, suggesting some slight disturbance to instream habitats. The stonefly fauna (7) and long-lived taxa (8) were diverse, thus, it appears that reach-scale habitat features like stream banks and riparian zones were undisturbed and that catastrophic dewatering or thermal stress probably did not influence the biota in this reach. As mentioned previously, collector-filterers dominated the functional mix and collector-gatherers (8.5%) were common suggesting that fine particulate organic matter dominates the energy flow in this reach. Shredders (1.9%) associated with leafy and woody debris from riparian sources were uncommon; however, other functional groups were well represented.

6.4.1.9 Lost Creek at Frontage Road (LC-7.5)

6.4.1.9.1 Water Quality

Only three mayfly taxa were collected at this site including the ubiquitous *Baetis tricaudatus* complex, *Diphetor hageni*, and *Paraleptophlebia* sp., and none of them were common. The HBI value (4.54) was elevated over expectations and indicated an invertebrate assemblage that was tolerant of organic pollution. Impaired water quality seems to be indicated. Pollution tolerant taxa were extremely abundant (75.5%): among these were included large numbers of the dipteran *Caloparyphus* sp. (14.6%). In addition, other pollution tolerant taxa were present: among these were the amphipod *Gammarus* sp., the snail *Physella* sp., and the leech *Helobdella stagnalis*. Some of these taxa (e.g., Hydroptilidae) are associated with filamentous algae, large crops of which may be an indication of nutrient enrichment. Only one pollution sensitive taxon was collected: the midge *Cricotopus (Nostococladius*) sp. was represented by only one specimen. Interestingly, the functional composition of this site was not dominated by collector-filterers (6.7%) but by scrapers (43.6%) and collector-gatherers (33.8%). There was no discernible evidence of metals contamination as the MTI (3.99) was lower than the HBI.

6.4.1.9.2 Thermal Condition

Only one cold stenotherm taxon *Cricotopus (Nostococladius*) sp. was found in the sample and as mentioned previously it was represented by only one individual. The calculated thermal preference of the fauna was 16.9 C, which is the second highest value found in the study in 2015. Several warm water tolerant taxa were common here including the caddisflies *Helicopsyche* sp. (17.3%) and *Oecetis* sp. (4.4%).

6.4.1.9.3 Sediment Deposition

Although 12 caddisfly taxa were recorded from this site, the number of “clinger” taxa (12) was lower than expectations. These findings suggest that sediment deposition may have compromised stony substrate habitats. The FSBI value (3.51) supports this contention and indicates that the fauna was moderately tolerant of deposited sediment.

6.4.1.9.4 Habitat Diversity and Integrity

Overall taxa richness (48) was somewhat lower than expected, indicating that instream habitats may be monotonous or disturbed. Only two stonefly taxa were collected and neither were common, perhaps indicating that reach-scale habitat features like stream banks and riparian zones were also disturbed. It is unlikely that catastrophes such as dewatering or scour disrupted the life cycles of long-lived organisms because five semivoltine taxa were counted in samples and some, like the elmid *Optioservus* sp. (25.7%), were abundant. All expected functional groups were present: scrapers (43.6%) and collector-gatherers (33.8%) dominated the functional mix, indicating the importance of autochthonous algal production and deposited fine particulate organic matter to the energy flow in this reach. However, shredders (2.3%) were not well represented, thus inputs of allochthonous material like leaves and twigs from the riparian zone were probably not important in the energy flow. Other functional groups were well represented.

6.4.1.10 Racetrack Creek at Frontage Road (RTC-1.5)

6.4.1.10.1 Water Quality

High mayfly taxa richness (10) and low HBI value (3.50) suggest that nutrient enrichment was not influential here. The diverse mayfly fauna (10 taxa) included one taxon in the family Ameletidae, three taxa in the family Baetidae, three in the family Ephemerellidae, two in the family Heptageniidae, and one in the family Leptophlebiidae. Indeed, the pollution sensitive mayfly *Drunella grandis* (10.1%) was one of the four dominant organisms in the sample and the most abundant mayfly. The other pollution sensitive taxon was the limnephilid caddisfly *Ecclisomyia* sp. (0.4%), which was not very abundant. In addition, pollution tolerant organisms only composed about 8.3% of the fauna. On the other hand, the abundance of taxa typically associated with filamentous algae (*Cricotopus* spp. (3.4%) and *Orthocladius spp.* (13.2%)) does suggest the possibility of some mild nutrient enrichment. The MTI (3.95) was higher than the HBI; however, it was below the threshold value that indicates metals contamination. Also, the heptageniid mayflies, *Cinygmula* sp. and *Heptagenia* sp. are intolerant of metals pollution and were common, accounting for around 5% of the assemblage. Unlike 2014, there was little evidence for the fauna being impacted by metals in 2015.

6.4.1.10.2 Thermal Condition

The limnephilid caddisfly *Ecclisomyia* sp. (0.4%) was the only cold stenotherm taxon in the sample. The calculated thermal preference for the assemblage was 15.1 C.

6.4.1.10.3 Sediment Deposition

Ten caddisfly taxa and 26 “clinger” taxa were collected, suggesting that sediment deposition did not appreciably limit colonization of stony substrates. The FSBI value (4.44) indicated a fauna that was moderately tolerant of fine sediment.

6.4.1.10.4 Habitat Diversity and Integrity

Instream and reach-scale habitats appear intact as overall taxa richness (59) and stonefly (7) richness were high. It also seems unlikely that the site was influenced by catastrophic dewatering, thermal extremes or scouring sediment pulses because seven long-lived taxa were collected at this site and the elmid beetle *Optioservus* sp. (4.5%) was common. The functional composition of the assemblage was dominated by collector-gatherers (39.9%), indicating the importance of deposited fine particulate organic matter to the energy flow in this reach. All other functional groups were well represented except for the collector-filterers (1.1%).

6.4.1.11 Little Blackfoot River at Beck Hill Road (LBR-CFR-02)

6.4.1.11.1 Water Quality

Although seven mayfly taxa were counted in samples collected at this site, none were common (even the most abundant mayfly, the ubiquitous *Baetis tricaudatus* complex, was only 0.8% of the entire assemblage). The midge *Cricotopus (Nostococladius)* sp. dominated collections taken at this site, accounting for 43.2% of the sampled fauna. The HBI (5.04) was higher than expected; however, the relatively high tolerance value (6) assigned to this midge may overestimate its tolerance to organic pollution. Taxa typically associated with filamentous algae (e.g., *Cricotopus spp*. (3.4%) *Eukiefferiella spp*. (2.4%) and *Tvetenia spp*. (2.4%)) were common, which suggests the possibility of some mild nutrient enrichment. On the other hand, pollution tolerant taxa composed 14.9% and collector-filterers only 18.2% of the fauna. In addition, four pollution sensitive taxa were collected here, although only the midge *C. (Nostococladius)* sp. was common. Thus, some, but not all, metrics suggest mild water quality impairment through nutrient enrichment. There was no evidence of metals contamination as the MTI was 4.59 and lower than the HBI. Also, the metals sensitive caddisfly *Lepidostoma* sp. (4.0%) was common.

6.4.1.11.2 Thermal Condition

Only one cold stenotherm, the midge *C. (Nostococladius)* sp., was found in this sample; however, because it was very abundant, cold stenotherms (43.2%) were very abundant as well. The calculated temperature preference of the assemblage was 15.6 C.

6.4.1.11.3 Sediment Deposition

Eighteen caddisfly and 30 "clinger" taxa, the highest numbers of these taxa among all the sites in 2015, were collected at this site. These metrics suggest that the deposition of fine sediments did not influence the colonization of stony substrates in this reach. The FSBI (4.09) indicates a fauna that was moderately tolerant of fine sediment.

6.4.1.11.4 Habitat Diversity and Integrity

Overall taxa richness (72) was high, the highest of all the sites in 2015, suggesting diverse and intact instream habitats. Six stonefly taxa were collected, suggesting that reach-scale habitat features were also intact. In addition, 10 long-lived taxa were counted and the elmids *Optioservus* sp. (4.3%) and *Zaitzevia* sp. (3.1%) were common; year-round surface flow and absence of events that would interrupt long life cycles are indicated. The shredders (51.5%) were the dominant functional group; however, this high percentage is probably an overestimate of the role of riparian inputs to the reach because the abundant *C. (Nostococladius)* sp. is a shredder, but it does not respond to inputs of coarse particulate matter from streamside. All other expected functional groups were represented.

6.5 CONCLUSIONS

In the CFROU in 2015, three sites had metals pollution subset scores <80%: Warm Springs Creek near mouth (WSC-SBC) with a mean score of 75.0%, Silver Bow Creek at Warm Springs (SS-25) with a mean score of 70.8%, and Lost Creek at Frontage Road (LC-7.5) with a mean score of 70.8%. All sampled sites on the Clark Fork River had metals pollution subset scores >80%. On the basis only of the taxonomic composition of the macroinvertebrate fauna and the performance of the Metals Tolerance Index (MTI), as described in the ecological narratives, the influence of metals contamination could not be detected with confidence at any site in 2015.

Table 6-3 summarizes the probable stressors suggested by the taxonomic and functional composition of macroinvertebrate assemblages at each site.

Table 6-3. Clark Fork River basin sites and probable stressors as suggested by the composition of macroinvertebrate assemblages. Clark Fork River basin, September 10-11, 2015.

Site name	Site ID	Low abundance	Nutrient and/or organic pollution	Metals	Sediment deposition	Thermal extremes	Habitat instability
Mill -Willow Creek at Frontage Road	MCWC-MWB		?				
Warm Springs Creek near mouth	WSC-SBC		?		?		?
Silver Bow Creek at Warm Springs	SS-25		+		?		+
Clark Fork River near Galen at Perkins Lane	CFR-03A						
Clark Fork River at Galen Road	CFR-07D						?
Clark Fork River at Gemback Road	CFR-11F		?				
Clark Fork River at Williams-Tavenner Bridge	CFR-34		+				
Clark Fork River at Turah	CFR-116A		?				
Lost Creek at Frontage Road	LC-7.5		+		?		?
Racetrack Creek at Frontage Road	RTC-1.5						
Little Blackfoot River at Beck Hill Road	LBR-CFR-2		?				

+ Composition of the assemblage suggests stress.

? Evidence from the assemblage was contradictory or inconclusive.

7.0 FISH[36]

7.1 INTRODUCTION

Decades of mining and mineral processing activities in the Butte and Anaconda areas have impacted the upper Clark Fork River and altered its fishery. These alterations include changes in the fish species community and reduced trout numbers. As a result of these negative impacts, angling use of the Clark Fork River is lower than other streams in western Montana. Remediation and restoration activities are ongoing and aim to mitigate historical mining and smelting damage to natural resources in the upper Clark Fork River basin.

The primary goal for aquatic restoration in mainstem Silver Bow Creek and the upper Clark Fork River is to restore the fishery and angling resources to levels of similar rivers not impacted by mining contamination [Saffel et al., 2011; Geum, 2015]. To directly achieve this goal, remediation and restoration in the mainstem are being completed cooperatively by the Montana Department of Environmental Quality (DEQ) and the Natural Resource Damage Program (NRDP). Caged fish studies have been used to monitor baseline survival and metals concentrations of juvenile brown trout (*Salmo trutta*) prior to restoration [Cook et al., 2015]. Restoration activities are underway on the upper Clark Fork River, and caged fish studies are now being conducted to monitor for potential acute effects of construction activities themselves. Because these activities often involve removing vegetation and disturbing stream banks, these disturbances have the potential to temporarily increase inputs of metal laden sediments into the Clark Fork River.

Concurrent with mainstem remediation and restoration, the NRDP is directing restoration efforts on tributaries in the upper Clark Fork River basin. The goals of tributary restoration are to improve trout recruitment to the mainstem and offset mainstem fishery damage by improving native and recreational fisheries in tributaries. The NRDP recognized the need to monitor the effectiveness of tributary projects and the contribution of tributary restoration to the recovery of the mainstem fisheries [Geum, 2015].

Because of the scale and scope of remediation and restoration efforts in the basin, fisheries monitoring will require building upon existing data collected through established sampling methods (i.e., fish population estimates) and new information on factors such as movement, recruitment, and population structure. Fisheries monitoring data was gathered sporadically in past decades. In 2009, Montana Fish, Wildlife and Parks (MFWP) initiated a more extensive monitoring plan on the upper Clark Fork River. This program included completing population estimates for the entire reach of the upper Clark Fork River from Warm Springs Ponds to the mouth of Rock Creek. This effort replicated work completed by MFWP in 1987 and provided new data to assess the current state of the Clark Fork River fishery. MFWP biologists also used this data to establish long term monitoring sections that were representative of the Clark Fork River. MFWP has completed population estimates in these reaches each of the subsequent years. Unlike the abundance data, data on the age structure of mainstem trout populations is

[36] Chapter 7 was prepared by Nathan Cook, Tracy Elam, Jason Lindstrom, Brad Liermann, and Pat Saffel of Montana Fish, Wildlife, and Parks with minor editing and formatting by RESPEC.

just beginning to be gathered. These data can be used to determine growth and mortality rates, which are critical to understanding the population dynamics of mainstem populations.

Multiple tributaries have been identified as priorities for restoration in the upper Clark Fork River basin [Saffel et al., 2011]. Data on species composition and distribution have been collected in multiple watersheds in the upper Clark Fork River basin [Lindstrom et al., 2008; Liermann et al., 2009]. In addition, population estimate sections have been established in most of these priority tributaries in order to monitor changes in these fisheries as restoration efforts are implemented. However, the frequency and spatial resolution of these population surveys need to be comprehensive if restoration-induced changes are to be detected. Although information on trout abundance is valuable, this information does not account for the complexity of trout life histories. Freshwater salmonids tend to migrate between different habitats to complete requirements of different life stages. For instance, adults may move long distances to habitats that are suitable for spawning. Young fish that are produced may swim or drift to habitats that promote growth and survival during the first years of life. Successful spawning and the production and survival of juveniles (typically referred to as recruitment) will largely determine the abundance of adult trout in later years. Thus, knowing the location of important spawning and rearing habitats used by a salmonid population is critical to managing and restoring these populations.

A radio-tracking study indicated that brown trout in the upper Clark Fork River make spawning related movements to both mainstem and tributary habitats [Mayfield, 2013]. However, just because a fish is in an area during spawning season does not guarantee that the fish will successfully spawn or that resulting offspring will survive to recruit to the fishery. Determining sources of recruitment requires that individual fish be assigned to these sources through genetics or other techniques such as hard part (bony tissue) microchemistry. Hard part microchemistry can determine the chemical signatures of a fish bony structure as those structures incorporate chemical changes in the fish's environment over a its lifetime. More specifically, this technique has been used in several studies to determine a fish's natal stream and to identify key migrations that occurred during a fish's life [Pracheil et al., 2014]. One of the primary microchemistry markers used to assess freshwater fish migrations is strontium (Sr). Otolith strontium isotope (^{87}Sr:^{86}Sr) ratios and strontium to calcium ratios (Sr:Ca) have been found to discriminate between habitats of interest because these chemical markers are directly related to the chemistry of the water in which fish are living [Clarke et al., 2007; Gibson-Reinemer et al., 2008].

7.1.1 Objectives

To gather baseline fisheries data in the upper Clark Fork River basin, an intensive monitoring program funded by NRDP and DEQ and implemented by MFWP was initiated in 2015. This program will be conducted for at least three years and has four objectives:

1. Describe baseline trout population abundances and species composition of fish communities in the upper Clark Fork River and priority tributaries.
2. Determine growth and mortality rates of brown trout in the mainstem through aging of fin rays and otoliths.

3. Investigate the natal origins and sources of recruitment for brown trout in the mainstem Clark Fork River.
4. Monitor mortality and metals uptake of fish in cages upstream and downstream of remediation sites in the upper Clark Fork River as well as at the outflow of Pond 2.

7.1.2 Study Area

Silver Bow Creek originates from Blacktail Creek which flows from the continental divide northeast to the town of Butte. Silver Bow Creek flows through the town of Butte, downstream of which it is joined by two major tributaries, Browns Gulch and German Gulch. A fish barrier was constructed downstream of Durant Canyon to prevent nonnative brown trout and rainbow trout *Oncorhynchus mykiss* downstream of the barrier from negatively interacting with the genetically pure westslope cutthroat trout *Oncorhynchus clarkii lewisi* upstream of the barrier. Silver Bow Creek flows into a series of set of settling ponds near Warm Springs. These ponds were constructed to trap sediments contaminated with mining waste and reduce the toxicity of metals such as copper and zinc. Remediation activities, including extensive tailings removal, have been completed on Silver Bow Creek between Butte and Warm Springs.

Warm Springs Creek joins Silver Bow Creek downstream of the Warm Springs Ponds to become the Clark Fork River. Meyers Dam, located 5.5 km upstream of Anaconda is a barrier to fish migrating upstream in Warm Springs Creek. Tributaries of the upper Warm Springs Drainage originate from the south slope of the Flint Creek Range and the north slope of the Anaconda Range. Tributaries of interest in this study were the West Fork of Warm Springs, Storm Lake, Twin Lakes, Foster, and Barker creeks.

Lost and Racetrack Creeks flow east from the Flint Creek Range and join the Clark Fork River between the towns of Warm Springs and Deer Lodge. Cottonwood Creek flows out of the Boulder Mountains where it joins the Clark Fork River on the east side of Deer Lodge. The lower reaches of Lost, Racetrack, and Cottonwood creeks are impacted by dewatering during the irrigation season.

The Little Blackfoot River flows into the Clark Fork River near Garrison. The Little Blackfoot River adds significant flow to the Clark Fork River and reduces concentrations of suspended sediment and metal contaminants through dilution [Sando et al., 2014]. Downstream of the Little Blackfoot River, Warm Springs Creek (different than the Warm Springs Creek near Anaconda) and Gold Creek enter the Clark Fork.

Flint Creek starts at the outflow of Georgetown Lake. It is joined by Boulder Creek near the town of Maxville. The lower reaches of Flint Creek are heavily dewatered during the irrigation season. Harvey Creek is a small tributary that originates in the John Long Mountain Range. A barrier near the mouth of Harvey Creek isolates native westslope cutthroat trout and bull trout *Salvelinus confluentus,* but also prevents nonnative species present in the Clark Fork River from moving upstream and interacting with the native species.

Rock Creek is a major tributary to the upper Clark Fork River and supports a robust brown trout fishery in the lower reaches and populations of westslope cutthroat trout and bull trout in headwaters and tributary streams. Rainbow trout are also present in the Rock Creek watershed, as well as mountain whitefish *Prosopium williamsoni*, longnose sucker *Catostomus*

catostomus, largescale sucker *Catostomus commersonii,* northern pikeminnow *Ptychocheilus oregonensis,* and sculpin *Cottus spp*.

7.2 METHODS

7.2.1 Population Monitoring

7.2.1.1 Mainstem

In spring 2015, trout population estimates were conducted at six established sections on the Clark Fork River that are sampled annually. MFWP refers to these stations as Bearmouth, Morse Ranch, Phosphate, Williams-Tavenner, Below Sager Lane, and pH Shack. Fish were collected using aluminum drift boats with a mounted electrofishing unit and two front boom anodes and one netter. Estimates were made using one or two mark runs and one or two recapture runs. Recapture runs were completed roughly one week after marking runs. All captured trout were identified to species, weighed (g), measured (mm), and marked with a small fin clip. Population estimates for fish ≥ 175 mm (~7 in) were generated using the Chapman modification [Chapman, 1951] of the Petersen method provided in MFWP's Fisheries Information System. Estimates were calculated for trout species that had a minimum of four marked fish that were recaptured.

Fin rays were collected from a subsample of brown trout during annual population estimates in 2013-1015. We attempted to collect 100 fin rays from remedial reaches A, B, and C (as defined in Mayfield [2013]) each year. These 100 samples were divided equally among four length classes (25 samples per length class): 175-249 mm, 250-324 mm, 325-399 mm, and ≥ 400 mm. Because of the lack of fish in some length classes, not all 25 fin rays could be collected in some remedial reaches. Fin rays were sent to the fish aging lab at the University of Idaho for sectioning and aging. Resulting data were used to calculate mean length at age, von Bertalanffy growth curves, and catch curves (for mortality estimation) following standard methods [Isely and Grabowski, 2007; Miranda and Bettoli, 2007]. Mean length at age was compared among sampling sections and remedial reaches A, B, and C using pairwise t-tests with Bonferroni corrected p-values.

In addition to the annual population estimates, MFWP conducted population estimates on the entire upper Clark Fork River from the Warm Springs Ponds to the confluence with Rock Creek. This survey was a repeat of surveys conducted in 1987 and 2009. Methods for this continuous sampling were similar to those described above except that only one mark and one recapture run were conducted on most continuous sampling sections. Descriptions of section lengths and locations can be found in Appendix H.

7.2.1.2 Tributaries

Population estimates were conducted in 18 tributaries in the upper Clark Fork River basin identified as high priority in Saffel et al. [2011] [Figure 7-1]. Population estimates were generated either by mark-recapture or depletion methods. Mark-recapture estimates consisting of one mark and one recapture run were conducted on larger waters (Flint Creek, lower Little Blackfoot River, and lower Warm Springs Creek). Two- or three- pass depletion estimates [Zippin, 1958] were conducted at other sections. Fish were collected at most tributary sections using one or two backpack electrofishing units. In larger streams, a barge mounted electrofishing unit was used to collect fish. Descriptions of sampling methods, section lengths, and locations of sampling sections can be found in Appendix H.

7.2.2 Microchemistry

In order to determine whether there is sufficient variation in $^{87}Sr{:}^{86}Sr$ and Sr:Ca between tributaries and the mainstem to facilitate an otolith microchemistry study, a preliminary study of water chemistry was conducted. Water samples were collected at four sites in the mainstem Clark Fork River and 12 tributary sites [Figure 7-1]. Mainstem sites were located near the downstream boundaries of remedial reaches A, B, and C. An additional mainstem site was located upstream of the confluence of Racetrack Creek. Tributary water collection sites were located near tributary mouths. In Rock Creek, Flint Creek, Warm Springs Creek, and the Little Blackfoot River, additional water samples were collected approximately halfway between the mouth and the headwaters to provide additional spatial resolution of strontium ratios. Water samples were extracted by pumping 50 ml of stream water through a 0.2 µm syringe filter. Water samples were preserved by adding a nitric acid solution and refrigerated until they were shipped to the Woods Hole Oceanic Institute for analyses. Water samples were analyzed for elemental ratios (i.e., Sr:Ca) using a Thermo Scientific ELEMENT 2, rapid scanning, magnetic sector, single collector inductively-coupled plasma mass spectrometer (ICPMS). Strontium isotope ratios ($^{87}Sr{:}^{86}Sr$) were determined by a Thermo Scientific NEPTUNE, large format, magnetic sector, multicollector ICPMS. Ratios of $^{87}Sr{:}^{86}Sr$ versus Sr:Ca were plotted (isoscape plot; Muhlfeld et al. [2012]) to determine if there was sufficient variation in these chemical markers to conduct a brown trout otolith microchemistry study.

7.2.3 Caged Fish Monitoring

Caged fish monitoring in 2015 had two objectives. The first objective was to monitor springtime discharge of Warm Springs Pond #2 (Pond 2). This discharge monitoring was centered on a potential pulse of ammonia from the pond shortly after ice out. Three fish cages were placed at three sites. One site was located at the Pond 2 outlet [Table 7-1]. This site served as the primary site of interest. One site was located upstream of the Warm Springs Ponds to represent the water quality coming into the ponds. This site is referred to as SS-19 [Table 7-1]. The third site was located in Mill-Willow Bypass [Table 7-1] near the mouth. Caged fish site locations were co-located with surface water sampling sites (see Section 2.2.1).

Twenty-five brown trout were placed in each cage on February 23, 2015. Fish cages were checked biweekly for mortalities between February 27 and May 7, 2015. Checks of the fish cages followed standard protocols for upper Clark Fork River fish cage studies (i.e., Cook et al. [2015]). Water samples were collected 5-7 times a week at fish cage sites from February 23 to April 17, 2015. A subsample of these water samples were analyzed for total ammonia nitrogen (NH_3-N).

The second objective was to monitor potential impacts of construction activities between Racetrack and Galen. In mid-April, 2015, additional fish cages were added to the Clark Fork River at Galen Road (Galen), Racetrack bridge (Racetrack), and Kohrs Bend Fishing Access Site. Three cages at each site were each stocked with 25 brown trout. Fish cages were checked twice a week from April 20 to October 13, 2015. Any fish mortalities were collected and frozen. Three live fish were collected at each site during the last week of every month of the study. These live fish were submitted to the Montana Department of Health and Human Services Environmental Laboratory (Helena, Montana) for determination of whole-fish metal concentrations.

Table 7-1. Caged fish locations in the upper Clark Fork River Basin, 2015.

Site ID	General Location	Coordinates (NAD 83)	
		Latitude	Longitude
Pond 2	Silver Bow Creek below Warm Springs Pond 2 outlet	46.17834	-112.78194
SS-19	Silver Bow Creek at Frontage Road	46.12237	-112.79917
Mill-Willow	Mill-Willow Bypass near confluence	46.17754	-112.78331

7.2.4 Water Quality

Water quality parameters were recorded in the Clark Fork River at caged fish sites with continuously recording multiparameter water quality probes (Hydrolab ® MS5). Water quality parameters recorded include pH and dissolved oxygen (DO) at all sites, with the addition of total ammonia (NH_4 + NH_3) at MWB-SBC, SS-19, and Pond 2. Hydrolabs were calibrated periodically during the field season. The precision with which the Hydrolab records total ammonia levels has been questionable in the past [T. Selch, MFWP, *personal communication*]. As a result of the questionable reliability of the ammonia sensors, ammonia data as recorded by the Hydrolabs are not presented in this report. Daily mean values are presented for pH and DO as well as minimum daily values for DO.

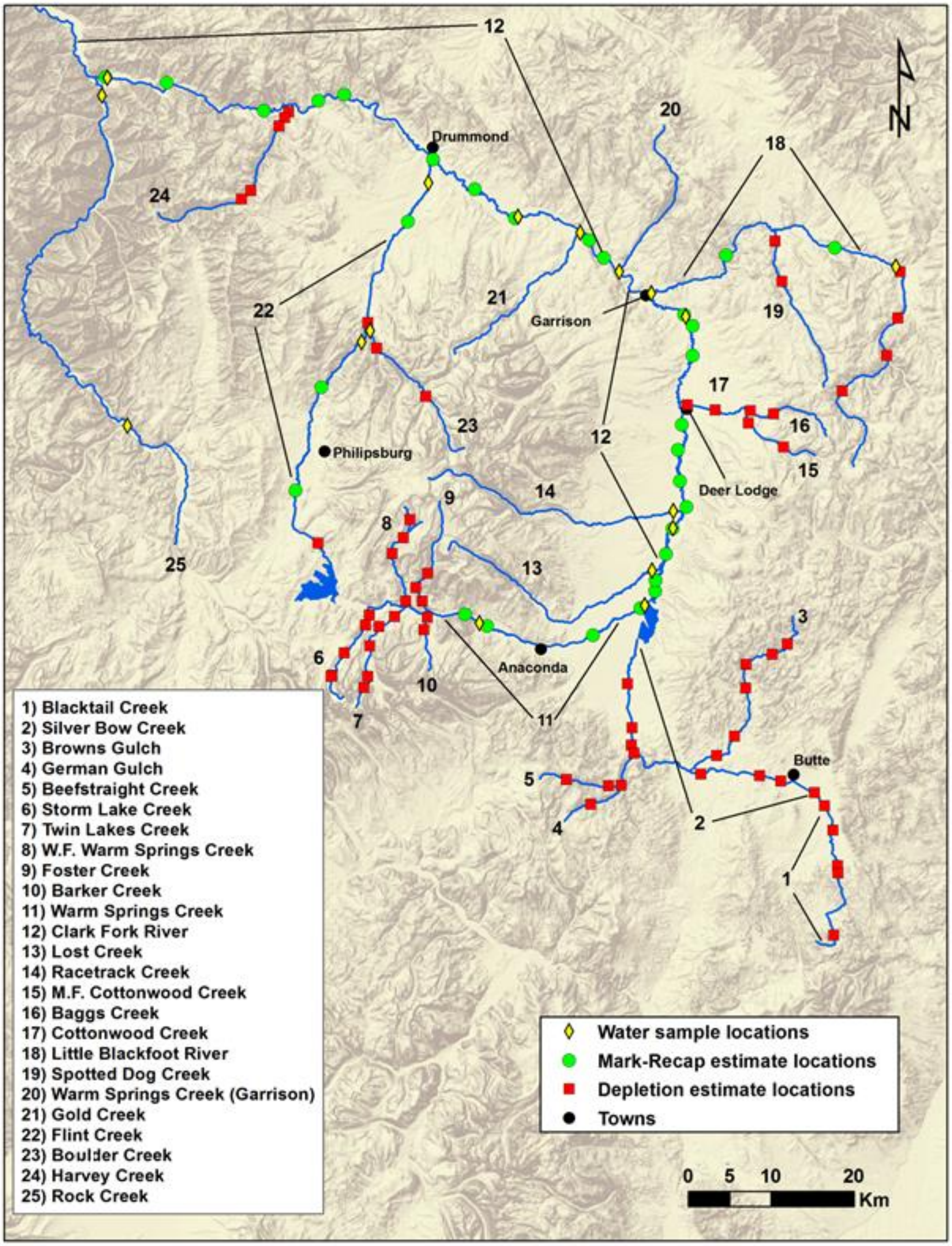

Figure 7-1. Map of 2015 electrofishing sections and water sampling sites in the upper Clark Fork River basin. Numbers refer to specific streams.

7.3 RESULTS

7.3.1 Population Monitoring

7.3.1.1 Mainstem

7.3.1.1.1 Abundance

Brown trout population estimates at the annual sampling sections ranged from 25 fish/km at Bearmouth, to 267 fish/km at Williams-Tavenner [Table 7-2]. Combined estimates of rainbow and cutthroat trout were 25 fish/km at Bearmouth and 3 fish/km at Morse Ranch. *Oncorhynchus* estimates could not be generated for other sections because fewer than four marked fish were recaptured. Brown trout population estimates in 2015 were generally lower than estimates from 2013-2014 at all sections [Figure 7-2]. The largest decrease took place at the pH Shack section. Brown trout numbers decreased from 1,167 (95% confidence interval: 991-1,383) in 2013, to 732 in 2014, to 175 in 2015 at the pH Shack site.

Results from continuous population estimates conducted in 1987, 2009, and 2015 indicate spatial patterns in brown trout numbers [Figure 7-3]. Across all sampling years, brown trout estimates ranged from 64-1,212 fish/km from sampling that took place in remedial reach A. The highest estimates occurred in the most upstream reaches in 1987. Brown trout population estimates ranged from 90-175 fish/km from sampling events in remedial reach B. The highest estimates in remedial reach B all occurred in 2009. Estimates ranged from 5-52 fish/km in remedial reach C.

Table 7-2. Electrofishing data collected in 2015 from annual sampling sections on the upper Clark Fork River. Population estimates (95% confidence interval) are for trout greater than 175 mm (~ 7") in total length. Asterisks indicate species were combined for the population estimate.

Section	Species	Population Estimate (fish/km)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
pH Shack	Brown Trout	175 (116-274)	165	342	102-483	97
	Rainbow Trout	NA	5	364	295-460	3
	Westslope Cutthroat Trout	NA	0	NA	NA	0
	Bull Trout	NA	0	NA	NA	0
Below Sager Lane	Brown Trout	205 (97-470)	158	358	125-457	100
	Rainbow Trout	NA	0	NA	NA	0
	Westslope Cutthroat Trout	NA	0	NA	NA	0
	Bull Trout	NA	0	NA	NA	
Williams-Tavenner	Brown Trout	267 (208-348)	399	371	123-546	98
	Rainbow Trout	NA	8	375	340-397	2
	Westslope Cutthroat Trout	NA	0	NA	NA	0
	Bull Trout	NA	0	NA	NA	0
Phosphate	Brown Trout	163 (107-262)	167	334	194-460	98
	Rainbow Trout	NA	4	288	200-347	2
	Westslope Cutthroat Trout	NA	0	NA	NA	0
	Bull Trout	NA	0	NA	NA	0
Morse Ranch	Brown Trout	65(54-80)	401	360	151-484	94
	Rainbow Trout	3 (2-5)*	16	320	240-413	4
	Westslope Cutthroat Trout	NA	7	326	225-440	4
	Bull Trout	NA	1	502	502	<1
Bearmouth	Brown Trout	25 (20-33)	157	378	151-535	55
	Rainbow Trout	25 (18-37)*	107	322	195-446	38
	Westslope Cutthroat Trout	NA	18	347	192-393	6
	Bull Trout	NA	3	516	308-674	1

NA Not applicable due to insufficient data.

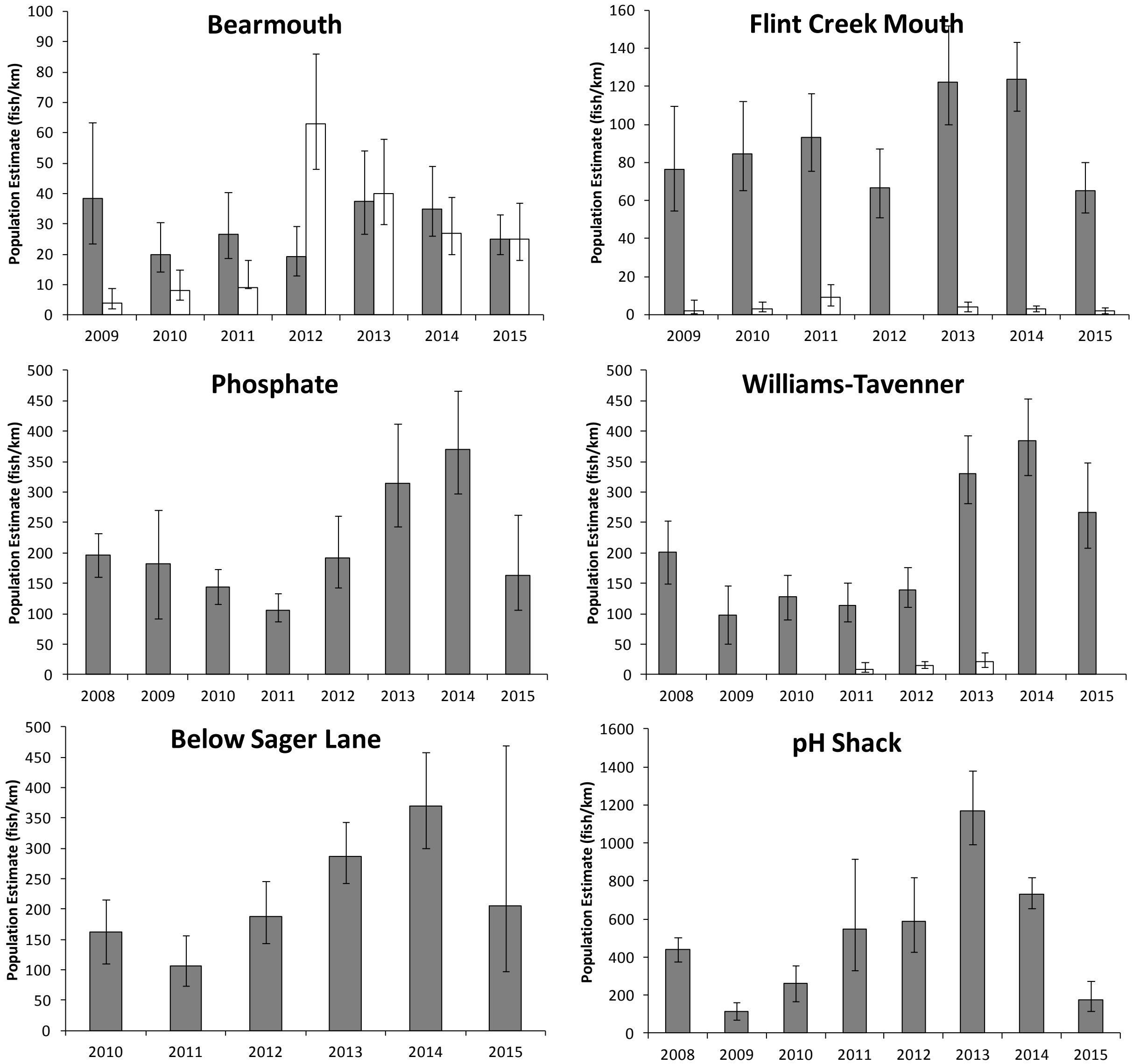

Figure 7-2. Clark Fork River brown trout (grey bars) and *Oncorhynchus sp.* (white bars) population estimates from 2008-2015 by sample reach. Sample reaches are displayed from downstream to upstream, left to right then top to bottom. Please note that axis values are not the same for every sample reach.

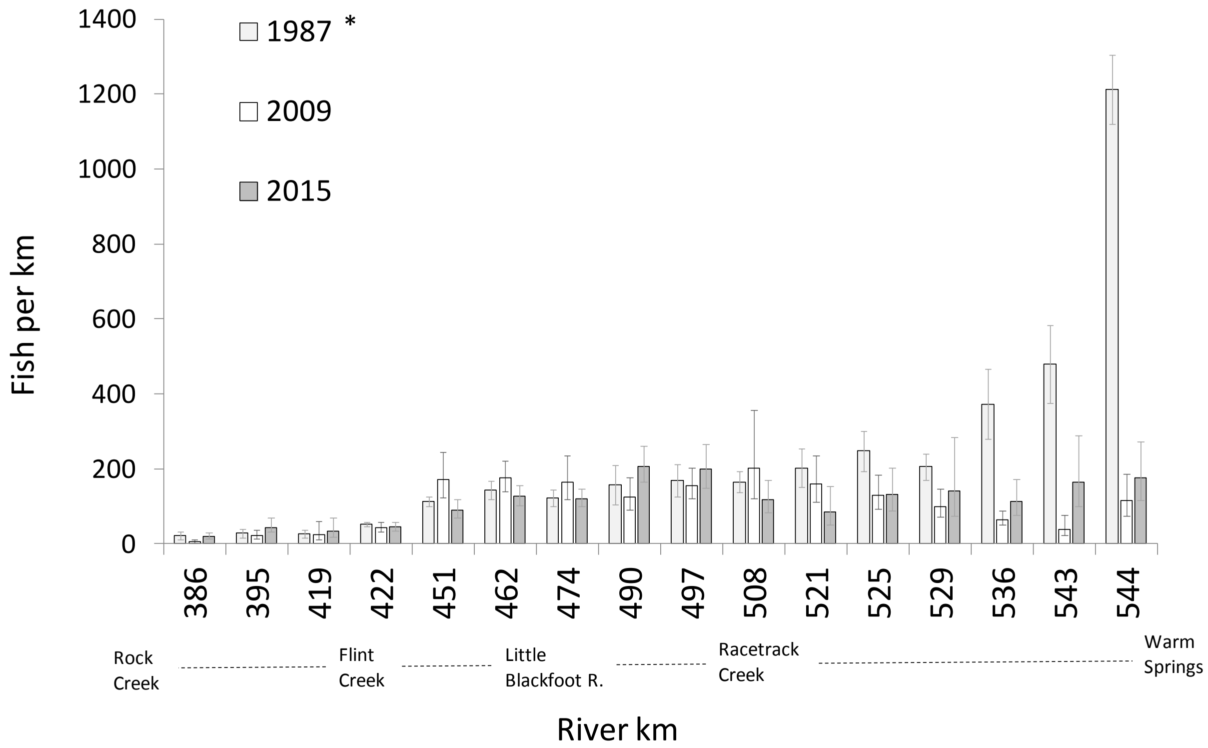

Figure 7-3. Brown trout population estimates and 95% confidence intervals from continuous electrofishing surveys in the upper Clark Fork River. Section boundaries were at slightly different locations in 1987 than in other years.

7.3.1.1.2 Brown Trout Age, Growth and Mortality

Mean length at age varied between sampling sections and remedial reaches [Table 7-3]. However, the variation in length at age also varied significantly between individual fish, limiting the significance of most statistical comparisons between sections or remedial reaches. Age-3 fish sampled from the Bearmouth section were longer on average than any other section, but the difference was statistically significant only when compared to Sager, Phosphate, and Morse. Age-6 fish from the pH Shack section were on average >30 mm longer than any other section, but the differences were not significant due to considerable variation in length at age-6 within the pH Shack section itself [Table 7-3]. When pooling data into remedial reaches A, B, and C, length at age-3 was significantly greater for remedial reach C compared to both A and B [Table 7-4]. No other comparisons were significantly different.

Plots of von Bertalanffy growth curves for different sample sections indicate different growth patterns in the different sampling sections [Table 7-4]. The pH Shack and Sager sections showed relatively slow growth at the younger age classes, but relatively high growth at ages beyond age-5. Conversely, brown trout from the Bearmouth section displayed rapid growth to age-3, but slower growth compared to other sections after age-5. When growth data was pooled into remedial reaches A, B, and C, the von Bertalanffy curves indicated that brown trout had higher growth at age-3 in remedial reach C [Table 7-5]. The growth curve for remedial reach A exceeded the other remedial reaches after age-5.

The brown trout population in remedial reach A is primarily composed of age-3 and age-4 fish [Figure 7-6]. Fish in these two age classes comprise 74% of the fish captured. For comparison, age-3 and age-4 fish were 63% and 58% of fish captured in remedial reaches B and C, respectively. Total annual mortality estimates from catch curves [Figure 7-7] were 0.65, 0.46, and 0.32 for remedial reaches A, B, and C, respectively [Table 7-5].

Table 7-3. Mean length (mm) at age for brown trout captured from 2013-2015 at six electrofishing sections in the upper Clark Fork River. Standard deviations are in parentheses. Different lowercase letters within each age class indicate statistically significant differences in pairwise *t*-tests.

Section	Age								
	2	3	4	5	6	7	8	10	11
pH Shack	212 (23)	287 (44)[ab]	353 (51)	396 (43)	450 (80)		457 (40)		482 (2)
Below Sager Lane	185 (34)	265 (57)[b]	350 (41)	402 (49)	410 (39)	458 (65)			
Williams-Tavenner	250 (101)	273 (47)[ab]	346 (46)	394 (59)	417 (48)				
Phosphate	230 (54)	276 (53)[b]	335 (58)	399 (37)	402 (27)	418 (29)			
Morse Ranch	224 (31)	273 (49)[b]	345 (67)	380 (49)	410 (28)	419 (31)			
Bearmouth	227 (40)	306 (58)[a]	348 (56)	384 (50)	401 (42)	402 (46)	424 (36)	393 (NA)	

NA Not applicable due to insufficient data.

Table 7-4. Mean length (mm) at age for brown trout captured in 2013 and 2014 by remedial reach [Figure 2-1] in the upper Clark Fork River. Standard deviations are in parentheses. Different lowercase letters within each age class indicate statistically significant differences in pairwise *t*-tests.

Remedial Reach	Age								
	2	3	4	5	6	7	8	10	11
A	232 (83)	276 (49)[b]	350 (46)	396 (51)	421 (52)	458 (65)	457 (40)		482 (2)
B	227 (44)	275 (51)[b]	339 (61)	389 (44)	407 (27)	418 (29)			
C	227 (40)	306 (58)[a]	348 (56)	384 (50)	401 (42)	402 (46)	424 (36)	393 (NA)	

NA Not applicable due to insufficient data.

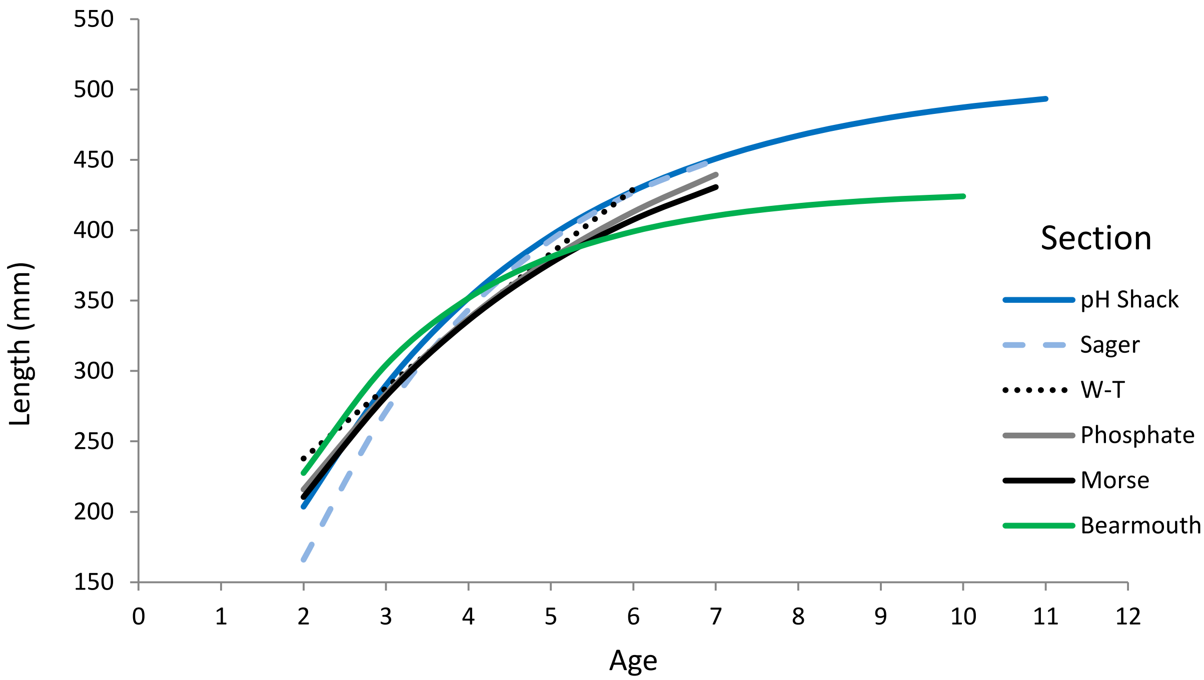

Figure 7-4. Brown trout von Bertalanffy growth curves for six sampling sections in the upper Clark Fork River. Curves were plotted up to the oldest age observed at each section.

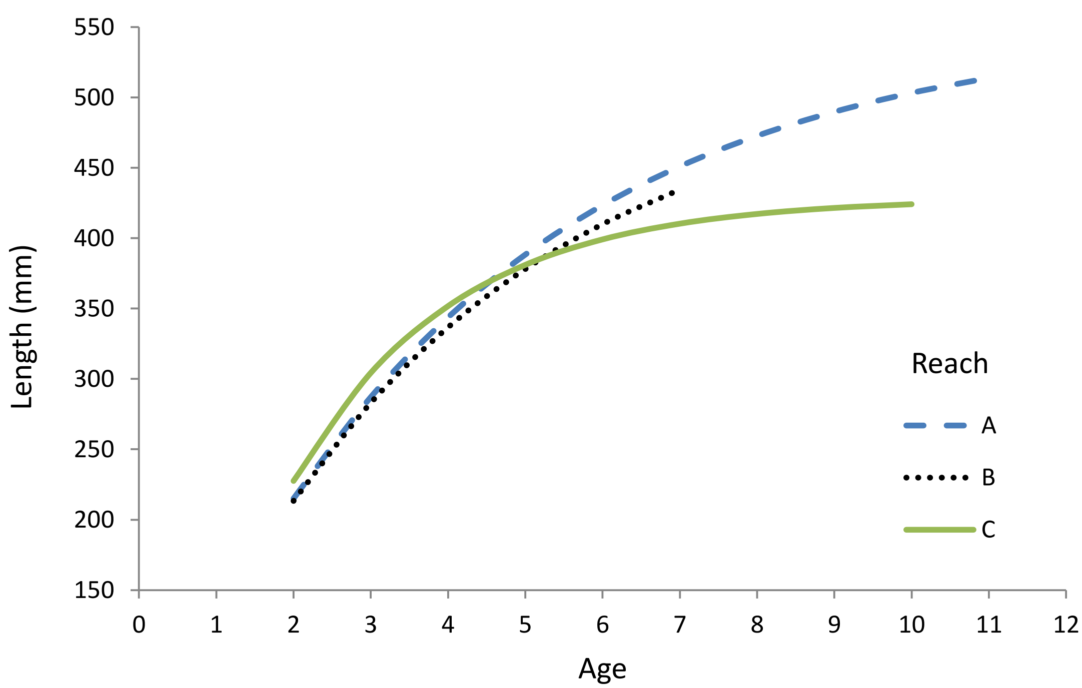

Figure 7-5. Brown trout von Bertalanffy growth curves for remedial reaches A, B, and C in the upper Clark Fork River. Curves were plotted up to the oldest age observed at each remedial reach.

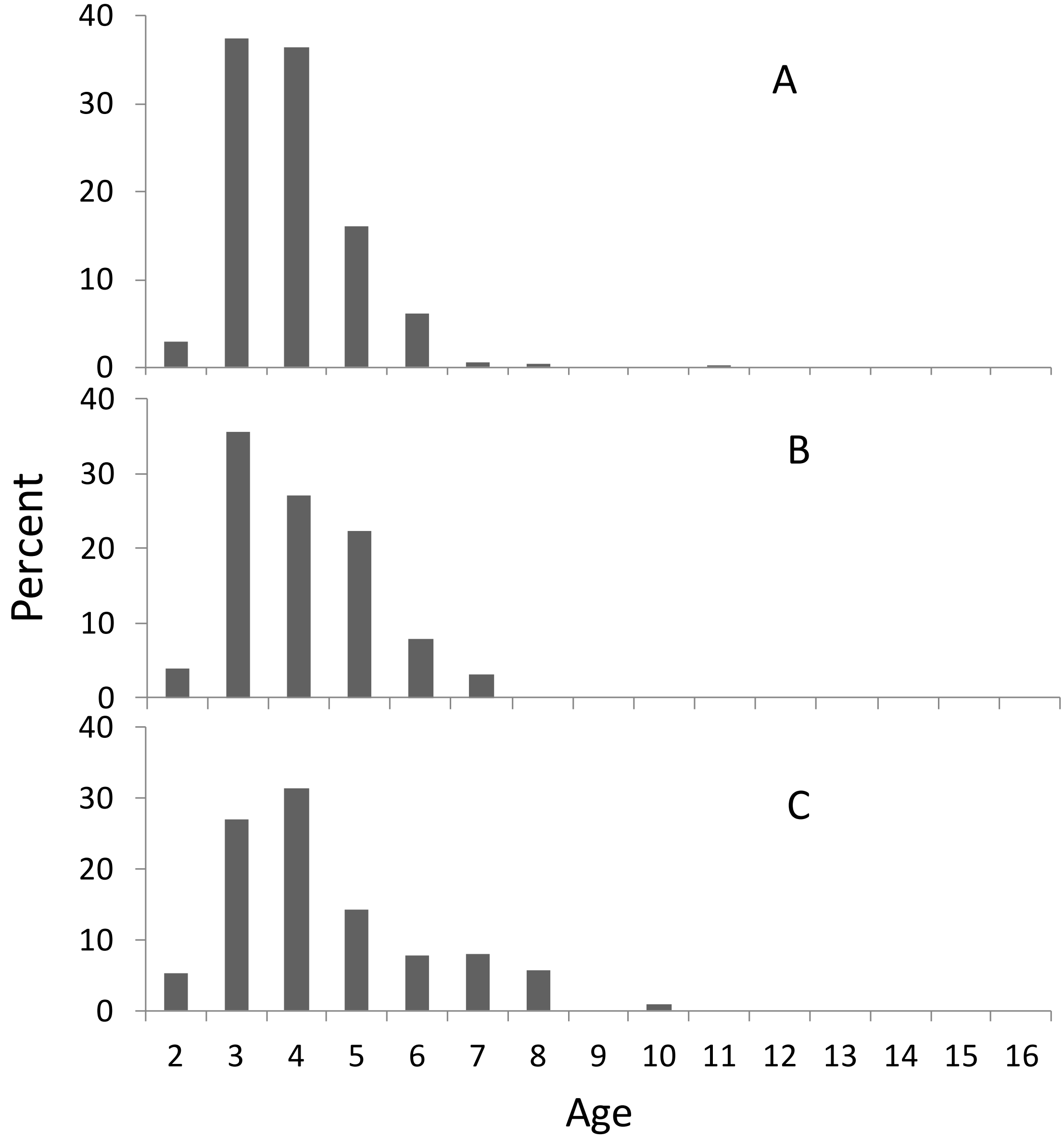

Figure 7-6. Percent of different age classes of brown trout collected during 2013-2015 population estimates in three remedial reaches of the upper Clark Fork River.

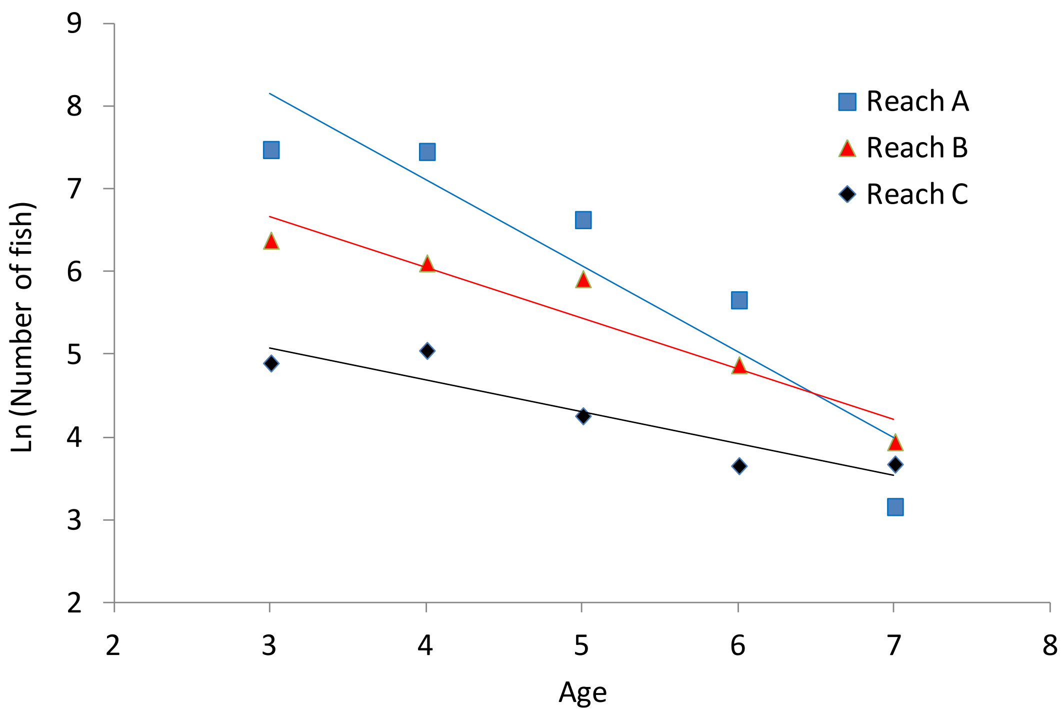

Figure 7-7. Catch curves for the three remedial reaches [Figure 2-1] of the upper Clark Fork River.

Table 7-5. Catch curve derived mortality and survival estimates for three remedial reaches [Figure 2-1] of the upper Clark Fork River.

Remedial reach	Total Annual Mortality	Annual Survival
A	0.65	0.35
B	0.46	0.54
C	0.32	0.68

7.3.1.2 Tributaries

Between July 6 to October 14, 2015, a total of 76 sections comprising 18.6 km of stream were sampled in tributaries of the upper Clark Fork River and Silver Bow Creek. Sixty-four depletion and nine mark-recapture population estimates were conducted on these waters. Electrofishing data are presented for each watershed below.

7.3.1.2.1 Silver Bow Creek Watershed

Twenty-four depletion estimates were done on Silver Bow Creek and four of its tributaries [Table 7-6 through Table 7-10]. In Blacktail Creek, brook trout were the most abundant trout species in the lower four sections and westslope cutthroat trout were most abundant in the upper two sections. In the sections where brook trout were most abundant, they accounted for 56-90% of the fish captured in the section. Westslope cutthroat trout made up 63-64% of the catch in the sections where they were dominant. Brook trout were present in all six sections while westslope cutthroat trout were only present in the upper four. Non-trout species (longnose sucker, sculpin [unidentified species], and central mudminnow *Umbra limi*) were observed in the lower three reaches.

Six estimate sections were conducted in Browns Gulch with brook trout being the dominant species throughout. In the lower three sections, brook trout accounted for 59-65% of the species present. Sculpin and longnose sucker were the next most abundant fish species in the lower three sections. In the upper three sections, brook trout accounted for 83-96% of the fish present. Sculpin and longnose sucker were absent in the upper three sections. Westslope cutthroat trout were present in five of six sections but in very low numbers compared to brook trout.

German Gulch had three estimate sections with westslope cutthroat trout being the dominant species in all sections and making up 63-100% of the species present. Sculpin were the only non-trout fish captured and only one was captured in the lowest section. One rainbow trout and one rainbow trout-cutthroat trout hybrid was also captured. Brook trout were present in the two lower sections but absent in the upper section.

Beefstraight Creek had two estimate sections with westslope cutthroat trout being the dominant species in both, and accounting for 75-89% of fish captured. Fewer brook trout were present in the upper section. No non-trout species were observed.

Population estimates were attempted at seven sections on Silver Bow Creek. Trout population estimates could be computed for four sections (Fairmont, Below German Gulch, Ramsay, and Father Sheehan). Population estimates for longnose sucker were generated for the Ramsay and Rocker sections, and for central mudminnow at the Rocker section. At the other sites, insufficient fish numbers or poor capture efficiency prevented the calculation of estimates.

At the two sections downstream of the fish barrier at Durant Canyon (Hwy 1 Bridge and Fairmont), brook trout were the most common trout species. Rocky Mountain sculpin were the most abundant fish making up 67-77% percent of fish captured in these two sections. Longnose sucker were also present in the sections, but in low numbers. In four sections located above the barrier to the downstream end of Butte (Below German Gulch, Ramsay, Rocker, and LAO), there were low numbers of brook trout and westslope cutthroat trout in each section. Non-trout species accounted for the majority of the fish in these four sections. Of these four sections, Rocky Mountain sculpin were the most abundant fish species in the lower and upper sections, and longnose sucker were the most abundant in the middle two sections. The lower six sections on Silver Bow Creek had relatively small populations of trout. The upstream-most section near Father Sheehan Park had the most trout of any of the seven Silver Bow Creek sections, with brook trout being the only trout species captured. Longnose sucker and sculpin were also captured in this section.

Table 7-6. Electrofishing data collected on Blacktail Creek in 2015. Population estimates (95% CI) are for trout greater than 75 mm (~ 3”) in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Golf Course Butte C.C.	Brook Trout	128 (127-131)	154	165	56-420	89
	Central Mudminnow	NA	1	90	90	<1
	Longnose Sucker	13 (13-13)	13	215	173-250	7
	Sculpin	NA	6	83	60-113	3
Above Blacktail Loop	Brook Trout	75 (72-81)	119	106	52-240	90
	Central Mudminnow	NA	1	84	84	<1
	Longnose Sucker	12 (11-17)	12	116	72-170	9
Below 9 Mile	Brook Trout	42 (41-45)	58	120	51-262	60
	Longnose Sucker	12 (12-14)	12	164	131-205	13
	Westslope Cutthroat Trout	26 (26-28)	26	168	88-235	27
Above 9 Mile	Brook Trout	43 (42-45)	58	114	38-210	56
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	NA	1	125	125	1
	Westslope Cutthroat Trout	33 (33-34)	45	109	62-216	43
Upper Forest Service	Brook Trout	12 (10-21)	10	118	75-157	37
	Westslope Cutthroat Trout	15 (15-17)	17	91	53-145	63
Upper Thompson	Brook Trout	28 (28-30)	30	126	46-194	36
	Westslope Cutthroat Trout	52 (46-62)	53	107	68-286	64

NA Not applicable because data insufficient.

Table 7-7. Electrofishing data collected on Brown's Gulch in 2015. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Lower Ueland (RM 2.6)	Brook Trout	21 (21-22)	25	188	85-290	42
	Longnose Sucker	11 (11-12)	13	138	78-177	22
	Rocky Mountain Sculpin	NA	21	unk	39-124	35
	Westslope Cutthroat Trout	NA	1	240	240	1
Upper Ueland (RM 5.3)	Brook Trout	NA	15	130	70-249	65
	Longnose Sucker	NA	3	97	87-108	13
	Sculpin	NA	5	84	71-103	22
Brothers Ranch (RM 9.7)	Brook Trout	34 (34-35)	41	132	50-211	59
	Longnose Sucker	21 (19-28)	19	142	115-167	28
	Sculpin	NA	6	94	77-125	9
	Westslope Cutthroat Trout	NA	3	137	35-226	4
Balentine (RM 11.5)	Brook Trout	103 (100-109)	109	119	50-215	83
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	NA	2	156	154-158	2
	Westslope Cutthroat Trout	22 (22-23)	20	113	77-245	15
Lower Forest Service (RM 13.8)	Brook Trout	42 (42-44)	53	119	44-203	87
	Westslope Cutthroat Trout	8 (8-10)	8	126	76-204	13
Upper Forest Service (RM 15.3)	Brook Trout	104 (102-108)	140	110	41-183	96
	Westslope Cutthroat Trout	NA	6	137	69-170	4

NA Not applicable because data insufficient.
unk Unknown.
RM River mile; measured upstream from river mouth.

Table 7-8. Electrofishing data collected on German Gulch in 2015. Population estimates (95% CI) are for trout greater than 75 mm (~ 3”) in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
RM 0.2	Westslope Cutthroat Trout	52 (51-55)	96	193	70-400	63
	Brook Trout	22 (22-23)	53	174	56-207	35
	Rainbow Trout	NA	1	207	207	<1
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	NA	1	322	322	<1
	Rocky Mountain Sculpin	NA	1	74	74	<1
RM 3.0	Westslope Cutthroat Trout	28 (28-29)	33	133	45-236	67
	Brook Trout	6 (6-7)	16	96	51-264	33
RM 6.0	Westslope Cutthroat Trout	NA	11	157	65-188	100

NA Not applicable because data insufficient.

RM River mile; measured upstream from river mouth.

Table 7-9. Electrofishing data collected on Beefstraight Creek in 2015. Population estimates (95% CI) are for trout greater than 75 mm (~ 3”) in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Above lower bridge (RM 1.3)	Brook Trout	22 (22-23)	39	103	46-163	25
	Westslope Cutthroat Trout	54 (51-58)	114	133	57-309	75
Below Spring Creek Trail Crossing (RM 4.5)	Brook Trout	NA	7	115	75-226	11
	Westslope Cutthroat Trout	56 (55-59)	55	122	79-176	89

NA Not applicable because data insufficient.

RM River mile; measured upstream from river mouth.

Table 7-10. Electrofishing data collected on Silver Bow Creek in 2015. Population estimates (95% CI) are for fish greater than 75 mm (~ 3”) in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Above Hwy 1 Bridge	Rocky Mountain Sculpin	NA	47	74	29-115	77
	Brook Trout	NA	4	168	136-245	7
	Longnose Sucker	NA	9	116	54-224	15
	Rainbow Trout	NA	1	89	89	1
Fairmont	Brook Trout	7 (6-10)	22	156	86-401	17
	Longnose Sucker	NA	13	189	103-260	10
	Rocky Mountain Sculpin	NA	88	73	36-142	67
	Westslope Cutthroat Trout	3 (3-4)	9	264	103-398	6
Below German Gulch	Brook Trout	NA	7	114	95-144	7
	Longnose Sucker	NA	11	89	50-117	11
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	NA	1	175	175	1
	Rocky Mountain Sculpin	NA	68	70	40-123	70
	Westslope Cutthroat Trout	3 (3-4)	11	209	70-420	11
Ramsay	Brook Trout	7 (7-8)	26	174	110-258	19
	Central Mudminnow	NA	1	109	109	<1
	Longnose Sucker	24 (21-27)	80	152	62-266	58
	Rocky Mountain Sculpin	NA	10	104	85-118	7
	Westslope Cutthroat Trout	6 (5-7)	20	264	119-393	15
Rocker	Brook Trout	NA	2	165	146-184	<1
	Central Mudminnow	10 (9-11)	25	105	93-130	9
	Longnose Sucker	90 (85-95)	246	119	48-236	88
	Rocky Mountain Sculpin	NA	4	103	98-106	1
	Westslope Cutthroat Trout	NA	2	268	152-383	<1
LAO	Brook Trout	NA	5	350	300-405	5
	Longnose Sucker	NA	10	60	48-105	10
	Rocky Mountain Sculpin	NA	82	90	43-129	84
	Westslope Cutthroat Trout	NA	1	200	200	1
Father Sheehan	Brook Trout	148 (139-157)	325	148	58-380	94
	Longnose Sucker	NA	18	134	55-257	5
	Sculpin	NA	4	84	65-115	1

NA Not applicable because data insufficient.

7.3.1.2.2 Warm Springs Creek Watershed

Nineteen depletion estimates and four mark-recapture estimates were conducted in the Warm Springs Creek watershed [Table 7-11 through Table 7-15]. Five electrofishing sections were sampled on Storm Lake Creek with westslope cutthroat trout being the most abundant species in all sections ranging from 56% in the lower section to 94% in the upper section. Brook trout, bull trout and rainbow trout were also present. There were no non-trout species captured in any section of Storm Lake Creek.

Five sections were sampled on Twin Lakes Creek with westslope cutthroat trout being the most common trout species throughout making up 52-73% of all fish species. Brook trout and bull trout were present in all but one section. Sculpin were observed in all sections and both Rocky Mountain sculpin and slimy sculpin were found in Twin Lakes Creek. Slimy sculpin were found in all but the most upstream section and Rocky Mountain sculpin were found in all but the most downstream section.

Foster Creek had three estimate sections with westslope cutthroat trout being the most abundant species in all sections and accounting for 68-98% of fish present. Brook trout were present in all sections. Bull trout were present in two sections, but in low numbers. There were bull trout-brook trout hybrids present in the lowest section. Sculpin were also captured in the lowest section but were not identified to species.

Barker Creek had two estimate sections with bull trout accounting for 63-66% percent of the fish. Westslope cutthroat trout were present in both sections and one brook trout was captured in the lower section. No sculpin were captured.

Warms springs Creek (including the West Fork) had eight estimate sections with brown trout comprising 73-92% of fish in the lower three sections below Myers Dam and westslope cutthroat trout accounting for 32-100% of fish in the five sections above Myers Dam. Brook trout were present in five sections. Bull trout were present in all but the lower two sections and second most upstream section. In all sections where both bull trout and brook trout were found, hybrids between these two species were also found. Rocky Mountain sculpin were present in the lowest section. Sculpin were also observed in the two sections just upstream of Meyers Dam, but were only identified to species (slimy sculpin) in the Veronica Trail section.

Table 7-11. Electrofishing data collected on Storm Lake Creek in 2015. Population estimates (95% CI) are for trout greater than 75 mm (~ 3”) in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Lower (RM 0.6)	Brook Trout	13 (12-18)	12	147	110-210	38
	Bull Trout	NA	2	163	160-165	6
	Westslope Cutthroat Trout	18 (18-19)	18	148	110-230	56
Above First Crossing (RM 1.4)	Brook Trout	15 (13-23)	13	152	107-235	33
	Bull Trout	NA	4	163	150-582	10
	Westslope Cutthroat Trout	19 (19-21)	22	128	62-192	57
Lower Meadow (RM 4.2)	Brook Trout	NA	1	238	238	2
	Rainbow Trout	6 (6-7)	6	181	154-220	13
	Westslope Cutthroat Trout	38 (38-39)	40	137	62-214	85
Below upper Storm Lake road crossing (RM 6.3)	Brook Trout	NA	6	132	114-182	8
	Bull Trout	4 (4-5)	4	204	192-216	5
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	NA	7	114	69-198	10
	Westslope Cutthroat Trout	44 (44-46)	57	98	37-195	77
Above upper Storm Lake road crossing (RM 6.3)	Brook Trout	NA	3	119	97-131	5
	Bull Trout	NA	1	214	214	1
	Westslope Cutthroat Trout	69 (56-88)	60	127	65-215	94

NA Not applicable because data insufficient.

RM River mile; measured upstream from river mouth.

Table 7-12. Electrofishing data collected on Twin Lakes Creek in 2015. Population estimates (95% CI) are for trout greater than 75 mm (~ 3”) in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Lower (RM 1.3)	Brook Trout	NA	4	148	137-158	11
	Bull Trout	NA	5	123	84-168	14
	Slimy Sculpin	NA	1	104	104	2
	Westslope Cutthroat Trout	28 (27-33)	27	153	63-245	73
Meadow (RM 2.8)	Brook Trout	32 (30-37)	30	157	106-244	34
	Bull Trout	NA	1	196	196	1
	Rocky Mountain Sculpin	NA	1	90	90	1
	Sculpin	NA	2	48	40-55	3
	Slimy Sculpin	NA	7	83	70-117	8
	Westslope Cutthroat Trout	54 (46-68)	46	147	75-239	53
Upstream of old bridge (RM 4.6)	Brook Trout	8 (8-9)	8	152	68-237	15
	Rocky Mountain Sculpin	NA	8	unk	82-110	15
	Slimy Sculpin	NA	7	unk	71-113	14
	Westslope Cutthroat Trout	30 (28-36)	29	128	115-193	56
Downstream of lower lake (RM 7.2)	Bull Trout	NA	1	166	166	3
	Rocky Mountain Sculpin	NA	24	unk	57-109	70
	Slimy Sculpin	NA	2	116	67-82	6
	Westslope Cutthroat Trout	NA	7	112	46-177	21
Upstream of upper lake (RM 8.5)	Brook Trout	NA	2	280	150-410	3
	Bull Trout	13 (13-15)	17	123	60-207	24
	Rocky Mountain Sculpin	NA	15	unk	60-115	21
	Westslope Cutthroat Trout	38 (34-47)	36	107	69-155	52

NA Not applicable because data insufficient.
unk Unknown.
RM River mile; measured upstream from river mouth.

Table 7-13. Electrofishing data collected on Foster Creek in 2015. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Lower (RM 1.0)	Brook Trout	NA	1	166	166	1
	Brook Trout x Bull Trout phenotypic hybrid	NA	2	223	220-225	2
	Bull Trout	NA	1	66	66	1
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	NA	1	164	164	1
	Sculpin	NA	5	69	45-91	6
	Westslope Cutthroat Trout	79 (78-82)	79	144	60-294	89
Middle (RM 2.3)	Brook Trout	6 (6-8)	19	82	45-140	31
	Bull Trout	NA	1	186	186	1
	Westslope Cutthroat Trout	41 (39-46)	42	102	66-194	68
Upper (RM 3.8)	Brook Trout	NA	3	169	128-193	2
	Westslope Cutthroat Trout	105 (102-110)	138	122	62-223	98

NA Not applicable because data insufficient.

RM River mile; measured upstream from river mouth.

Table 7-14. Electrofishing data collected on Barker Creek in 2015. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Lower (RM 0.5)	Brook Trout	NA	1	265	265	3
	Bull Trout	38 (21-98)	21	155	109-212	66
	Westslope Cutthroat Trout	9 (9-12)	10	169	74-206	31
RM 1.5	Bull Trout	21 (19-25)	27	138	95-428	63
	Westslope Cutthroat Trout	11 (11-12)	16	169	81-292	37

NA Not applicable because data insufficient.

RM River mile; measured upstream from river mouth.

Table 7-15. Electrofishing data collected on Warm Springs Creek in 2015. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Wildlife Management Area (RM 3.3)	Brook Trout	NA	1	277	277	<1
	Brown Trout	60 (50-74)	331	193	55-462	73
	Mountain Whitefish	24 (17-34)	116	310	94-484	26
	Rainbow Trout	NA	1	264	264	<1
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	NA	2	326	293-358	<1
	Redside Shiner	NA	1	87	87	<1
	Rocky Mountain Sculpin	NA	2	75	60-90	<1
Below Airport Road (RM 9.0)	Brown Trout	86 (73-104)	344	174	60-427	92
	Mountain Whitefish	NA	29	206	87-376	8
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	NA	2	277	238-298	<1
Below Meyers Dam	Brook Trout	2 (1-3)	14	183	129-250	2
	Brook Trout x Bull Trout phenotypic hybrid	NA	4	436	180-522	<1
	Brown Trout	118 (107-131)	789	210	58-415	85
	Bull Trout	NA	14	384	180-605	2
	Rainbow Trout	3 (2-6)	23	190	98-451	2
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	10 (8-15)	67	188	80-396	7
	Westslope Cutthroat Trout	NA	13	218	94-374	1
Garrity WMA (Above Meyers Dam)	Westslope Cutthroat Trout	48 (40-59)	286	169	68-395	48
	Brook Trout	2 (1-4)	14	132	102-177	2
	Brook Trout x Bull Trout phenotypic hybrid	NA	2	324	274-373	<1
	Brown Trout	5 (4-9)	40	210	56-385	7
	Bull Trout	5 (3-8)	33	216	55-384	6
	Rainbow Trout	3 (2-5)	23	244	125-376	4
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	23 (20-28)	200	153	81-428	33
	Sculpin	NA	unk	unk	52-90	unk
Above Veronica Trail (RM 26.0)	Brook Trout	8 (8-10)	8	179	101-341	17
	Brook Trout x Bull Trout phenotypic hybrid	NA	1	180	180	3
	Bull Trout	NA	5	131	109-157	11

	Rainbow Trout	NA	3	92	72-125	6
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	NA	3	129	86-173	6
	Slimy Sculpin	NA	3	89	78-95	unk
	Westslope Cutthroat Trout	28 (27-34)	27	145	71-293	57
Below Upper Bridge (RM 27.4)	Brook Trout	12 (12-13)	12	194	136-311	39
	Brook Trout x Bull Trout phenotypic hybrid	NA	1	249	249	3
	Bull Trout	8 (8-9)	8	246	202-291	26
	Westslope Cutthroat Trout	10 (10-10)	10	174	127-213	32
Below Confluence of Upper Forks	Westslope Cutthroat Trout	52 (52-54)	52	163	89-236	100
West Fork	Westslope Cutthroat Trout	50 (47-57)	50	133	58-201	94
	Bull Trout	NA	3	236	128-314	6

NA Not applicable because data insufficient.

unk Unknown.

RM River mile; measured upstream from river mouth.

7.3.1.2.3 Cottonwood Creek Watershed

Six depletion estimates were conducted on Cottonwood Creek and one of its tributaries, Baggs Creek [Table 7-16; Table 7-17]. In Cottonwood Creek, brown trout were the most abundant species in the lower two sections, making up 75-83% of all fish captured. In the lower section, several young-of-year brown trout were captured. The section at river mile 3.0 was generally depauperate of fish, probably due to dewatering. Westslope cutthroat trout and brook trout were captured in similar numbers in the upper section accounting for 41% and 39% of fish, respectively. Sculpin were captured in the three mainstem sections but were only identified to species in the lower section. No sculpin were captured in the Middle Fork of Cottonwood Creek.

Two sections were sampled on Baggs Creek with westslope cutthroat trout and brook trout making up similar percentages of fish in both sections. Westslope cutthroat trout were slightly more abundant accounting for 57% and 55% of the fish while brook trout made up 43% and 45%. The lowest section had very few fish which is probably due to low stream flows resulting from water diversion for irrigation. No non-trout species were captured in either section.

Table 7-16. Electrofishing data collected on Cottonwood Creek in 2015. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
School (RM 0.8)	Brook Trout	NA	1	137	137	2
	Brown Trout	48 (46-52)	54	134	68-305	83
	Rocky Mountain Sculpin	NA	10	unk	95-112	15
Middle (RM 3.0)	Brown Trout	NA	3	66	65-68	75
	Sculpin	NA	1	65	65	25
Upper (RM 6.9)	Brook Trout	31 (31-32)	52	102	45-220	39
	Sculpin	NA	27	47	34-85	20
	Westslope Cutthroat Trout	52 (51-55)	55	128	68-258	41
Middle Fork	Brook Trout	22 (21-26)	21	130	85-165	11
	Westslope Cutthroat Trout	160 (155-167)	169	125	62-212	89

NA Not applicable because data insufficient.

unk Unknown.

RM River mile; measured upstream from river mouth.

Table 7-17. Electrofishing data collected on Baggs Creek in 2015. Population estimates (95% CI) are for trout greater than 75 mm (~ 3”) in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
RM 0.4	Brook Trout	NA	3	115	78-188	43
	Westslope Cutthroat Trout	NA	4	102	31-136	57
RM 2.4	Brook Trout	40 (38-44)	70	112	52-228	45
	Westslope Cutthroat Trout	81 (76-87)	86	135	77-252	55

NA Not applicable because data insufficient.

RM River mile; measured upstream from river mouth.

7.3.1.2.4 Little Blackfoot River Watershed

Two mark-recapture estimates and six depletion estimates were conducted on the Little Blackfoot River and one of its tributaries [Table 7-18; Table 7-19]. In the lower two sections of the Little Blackfoot River, brown trout were the most abundant trout species, accounting for 91-100% of fish captured. Many mountain whitefish were observed in the lower two sections, but were not netted due to time constraints. Sculpin were also present in the lower section. Brown trout numbers were lower in the upper four sections than the lower two. Westslope cutthroat trout were the most abundant trout species in the upper three sections making up 44-61% of fish present. Brook trout were present in all but the lowest section. Mountain whitefish were present in all sections but there were fewer present in the upper sections.

Two depletion estimates were done on Spotted Dog Creek. Brown trout were the most abundant species in the lower section, making up 94% of fish. Similar numbers of brown trout and westslope cutthroat trout were captured at the upper section, but an estimate was not done for brown trout because the majority of the fish were less than 75 mm in length. Sculpin were present in both sections.

Table 7-18. Electrofishing data collected on the Little Blackfoot River in 2015. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Rest Area -FWP FAS	Brown Trout	57 (46-72)	340	286	68-471	100
Above North Trout Creek Confluence	Brook Trout	NA	13	180	99-211	5
	Brown Trout	36 (31-44)	255	232	72-395	91
	Westslope Cutthroat Trout	NA	12	268	170-340	4
Above Hwy 12 Bridge near Elliston (RM 26.7)	Brook Trout	NA	7	123	45-204	4
	Brown Trout	14 (14-16)	41	198	100-353	22
	Mountain Whitefish	42 (37-48)	112	306	160-385	60
	Westslope Cutthroat Trout	10 (9-14)	26	219	80-351	14
Above Sunshine Camp	Brook Trout	NA	2	66	63-69	3
	Brown Trout	8 (8-9)	24	185	93-356	40
	Mountain Whitefish	3 (3-3)	8	293	234-333	13
	Westslope Cutthroat Trout	9 (8-12)	27	148	68-290	44
Below Ontario Creek (RM 34.9)	Brook Trout	NA	1	112	112	<1
	Brown Trout	10 (10-11)	14	163	87-296	19
	Mountain Whitefish	NA	12	225	114-315	17
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	NA	1	148	148	<1
	Sculpin	NA	unk	unk	75-150	unk
	Westslope Cutthroat Trout	43 (34-59)	44	139	74-241	61
Above Kading Campground (RM 40.1)	Brook Trout	10 (10-11)	21	138	44-205	22
	Brown Trout	8 (8-9)	16	132	74-235	17
	Mountain Whitefish	6 (6-7)	11	195	130-285	11
	Westslope Cutthroat Trout	24 (23-25)	48	157	62-273	50

NA Not applicable because data insufficient.
unk Unknown.
RM River mile; measured upstream from river mouth.

Table 7-19. Electrofishing data collected on Spotted Dog Creek in 2015. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
RM 1.1	Brown Trout	23 (23-24)	34	257	128-375	94
	Sculpin	NA	2	65	49-80	unk
	Westslope Cutthroat Trout	NA	2	120	118-121	6
RM 4.6	Brook Trout	NA	5	84	51-163	7
	Brown Trout	NA	29	74	45-391	40
	Longnose Sucker	NA	4	138	86-177	6
	Mountain Whitefish	NA	1	66	66	1
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	NA	1	130	130	1
	Sculpin	NA	3	75	56-107	5
	Westslope Cutthroat Trout	18 (17-23)	29	99	73-129	40

NA Not applicable because data insufficient.

unk Unknown.

RM River mile; measured upstream from river mouth.

7.3.1.2.5 Flint Creek Watershed

Three mark-recapture and four depletion estimates were conducted on Flint Creek and Boulder Creek [Table 7-20; Table 7-21]. Flint Creek had four estimate sections with brown trout comprising 80-99% of captured fish. Abundant mountain whitefish were observed in the three lowest sections, but were not netted. Westslope cutthroat trout were captured in the lower two sections, brook trout in the middle two sections and rainbow trout in the upper three sections. Rocky Mountain sculpin were observed in only the lowest section.

Boulder Creek had three estimate sections with brown trout being the most abundant fish in the lower two sections, accounting for 68% and 60% of fish. Bull trout was the most abundant species in the upper section making up 71% of fish captured. One adult bull trout was captured in the lowest section. Westslope cutthroat trout were present in all three sections. Phenotypic rainbow trout-cutthroat trout hybrids and sculpin were observed in the lower two sections.

Table 7-20. Electrofishing data collected on Flint Creek in 2015. Population estimates (95% CI) are for trout greater than 175 mm (~ 7") in total length for the Hall, Johnson Tuning Fork and Chor sections. Estimate is for trout greater than 75 mm (~3") for the Dam section.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Hall	Brown Trout	175 (151-208)	214	278	152-45	99
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	NA	1	353	353	<1
	Westslope Cutthroat Trout	NA	1	334	334	<1
Johnson Tuning Fork	Brook Trout	NA	2	236	230-241	<1
	Brown Trout	416 (376-470)	419	281	159-452	97
	Rainbow Trout	NA	9	264	198-400	2
	Westslope Cutthroat Trout	NA	1	268	268	<1
Chor	Brook Trout	NA	6	241	193-272	<2
	Brown Trout	277 (251-310)	327	296	160-470	98
	Rainbow Trout	NA	1	225	225	<1
Dam (Above Campground)	Brown Trout	51 (46-56)	49	290	186-460	80
	Rainbow Trout	12 (11-13)	12	195	124-238	20

NA Not applicable because data insufficient.
unk Unknown.

Table 7-21. Electrofishing data collected on Boulder Creek in 2015. Population estimates (95% CI) are for trout greater than 75 mm (~ 3”) in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
USGS Gauge (RM 0.4)	Brown Trout	15 (14-16)	28	124	60-370	68
	Bull Trout	NA	1	225	225	3
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	NA	5	189	108-336	12
	Westslope Cutthroat Trout	16 (12-31)*	7	188	78-352	17
RM 2.0	Brown Trout	26 (25-30)	41	127	62-395	60
	Rainbow Trout x Westslope Cutthroat Trout phenotypic hybrid	30 (26-44)*	16	149	46-305	24
	Slimy Sculpin	NA	unk	unk	35-91	unk
	Westslope Cutthroat Trout	NA	11	129	91-225	16
Copper Lakes Trailhead	Bull Trout	20 (20-21)	24	159	55-355	71
	Westslope Cutthroat Trout	10 (10-12)	10	176	83-271	29

NA Not applicable because data insufficient.

unk Unknown.

RM River mile; measured upstream from river mouth.

7.3.1.2.6 Harvey Creek

There were six estimate sections on Harvey Creek [Table 7-22]. Westslope cutthroat trout were the most abundant trout species in all six sections. Westslope cutthroat trout made up 100% of trout in the lower three sections. Westslope cutthroat trout abundance was highest at the RM 2.3 section and generally declined at sections farther upstream and downstream from RM 2.3. Bull trout were present in the upper three sections and accounted for 3%, 26% and 48% of trout in those sections. Sculpin were present in the lower four sections.

Table 7-22. Electrofishing data collected on Harvey Creek in 2015. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length.

Section	Species	Population Estimate (fish/100 m)	Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
RM 0.6	Rocky Mountain Sculpin	NA	8	unk	75-98	19
	Westslope Cutthroat Trout	26 (25-30)	34	109	55-216	81
RM 1.2	Slimy Sculpin	NA	22	unk	60-97	28
	Westslope Cutthroat Trout	46 (45-47)	56	145	90-305	72
RM 1.6	Slimy Sculpin	NA	18	unk	66-101	14
	Westslope Cutthroat Trout	121 (114-130)	114	123	75-339	86
RM 2.3	Bull Trout	NA	2	285	144-426	3
	Westslope Cutthroat Trout	65(61-72)	61	144	80-311	97
Below 8 Mile	Bull Trout	13 (14-23)	28	94	42-326	26
	Westslope Cutthroat Trout	63 (55-74)	78	145	42-470	74
Above FS Road	Bull Trout	27 (27-29)	33	113	49-266	48
	Westslope Cutthroat Trout	33 (32-36)	36	113	60-220	52

NA Not applicable because data insufficient.
unk Unknown.
RM River mile; measured upstream from river mouth.

7.3.2 Microchemistry

Strontium isotope ratios (^{87}Sr:^{86}Sr) from water samples collected in the upper Clark Fork River basin ranged from 0.707446 to 0.727524 [Table 7-23]. Water samples from Rock Creek had the highest isotope ratios, whereas samples from the Little Blackfoot River had the lowest ratios. Isoscape plots indicate clear separation of the mainstem and most tributary waters [Figure 7-8]. Exceptions were water samples taken from Lower Flint Creek and Lost Creek, which clustered close together. The sample from Racetrack Creek was within the cluster of mainstem samples taken upstream of the Little Blackfoot River and just upstream of Racetrack Creek. With the possible exception of Racetrack Creek, there appears to be sufficient variation in strontium signatures between waters of the upper Clark Fork River basin for movements between the mainstem Clark Fork River and tributaries to be apparent in the future otolith microchemistry study.

Table 7-23. Strontium isotope ratios ($^{87}Sr:^{86}Sr$) for water samples collected in the upper Clark Fork River Basin. Samples are listed from highest to lowest values.

Site	$^{87}Sr:^{86}Sr$
Rock Creek #1 (Near Mouth)	0.727524
Rock Creek #2 (Above Stony Creek)	0.724798
Warm Springs Creek #2 (Above Myers Dam)	0.715863
Flint Creek #2 (Above Boulder Creek)	0.714373
Warm Springs Creek #1 (Near Mouth)	0.712644
Flint Creek #1 (Near Mouth)	0.711860
Lost Creek (Near Mouth)	0.711203
Clark Fork River #4 (Above Racetrack Creek)	0.710381
Warm Springs Creek-Garrison (Near Mouth)	0.710240
Racetrack Creek (Near Mouth)	0.710203
Clark Fork River #3 (Above Little Blackfoot)	0.709699
Clark Fork River #1 (Above Rock Creek)	0.709664
Clark Fork River #2 (Above Flint Creek)	0.709529
Gold Creek (Near Mouth)	0.708735
Little Blackfoot #1 (Near Mouth)	0.708529
Little Blackfoot #2 (Above Dog Creek)	0.707446

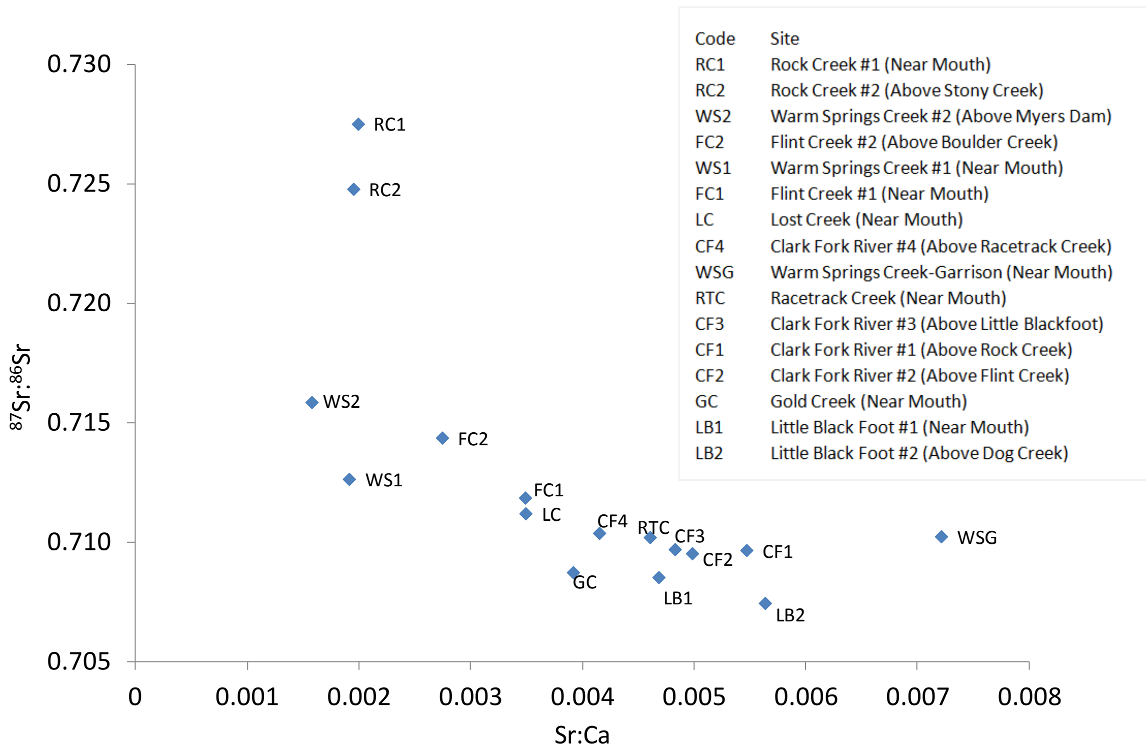

Figure 7-8. Water ^{87}Sr:^{86}Sr and Sr:Ca values for streams in the upper Clark Fork River Basin.

7.3.3 Caged Fish Monitoring

No pulse of ammonia was detected in daily water sampling at the Pond 2 outflow. There were three caged fish mortalities at the outflow of Pond 2 compared to 14 mortalities at SS-19, and 36 mortalities at Mill-Willow. Most of the mortalities at Mill-Willow were in the first week of the study and were probably related to acclimation to new environmental conditions [Figure 7-9]. Given the low mortality, and no detection of an acute mortality event at Pond 2, there was no evidence of a lethal ammonia pulse in the Pond 2 discharge.

In the fish cages used for construction monitoring, there were 20 mortalities at the Galen site, 13 mortalities at the Pond 2 site, 11 mortalities at Kohrs Bend, and five mortalities at Racetrack. Mortalities tended to occur shortly after fish were placed in cages and on the descending limb of the hydrograph [Figure 7-10 through Figure 7-13]. Water temperatures exceeded the upper critical temperature (19 C) for 74 days at Pond 2, 63 days at Galen, 53 days at Racetrack, and 83 days at Kohrs Bend. Water temperatures exceeded the upper incipient lethal temperature (24.7 C) for 4 days at Pond 2, 0 days at Galen, 0 days at Racetrack, and 10 days at Kohrs Bend.

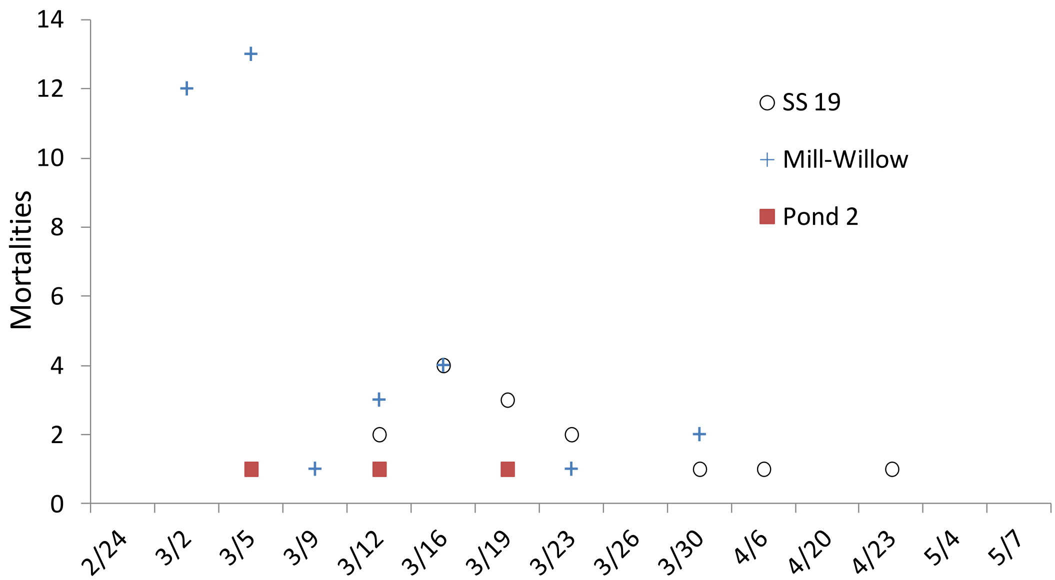

Figure 7-9. Brown trout mortalities over time at three caged fish sites used to monitor potential ammonia discharge from Pond 2 in spring, 2015.

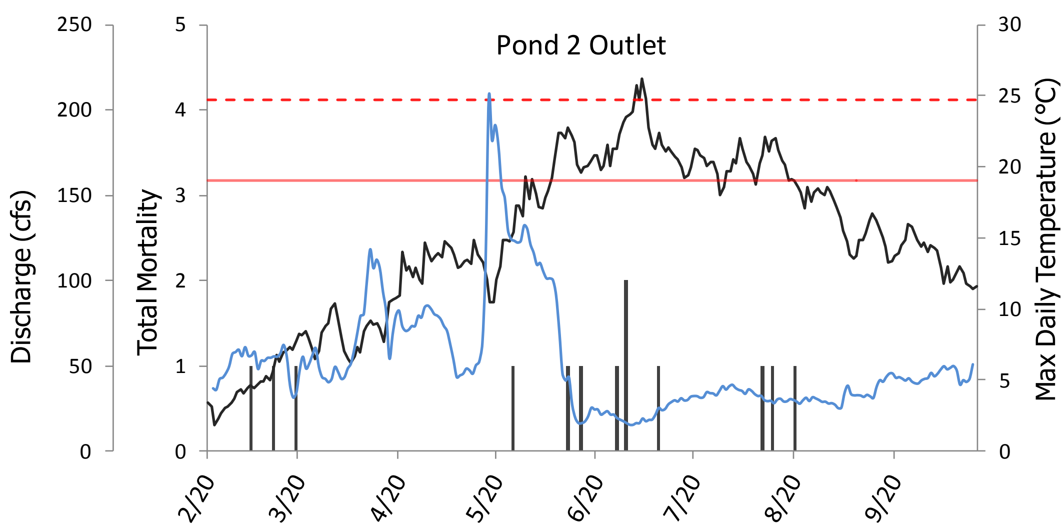

Figure 7-10. Total fish mortalities, maximum daily water temperature (black line), and mean daily discharge (blue line) for Silver Bow Creek at the outlet of Pond 2. The solid red line indicates the upper critical temperature threshold and the dashed red line represents the upper incipient lethal temperature for brown trout.

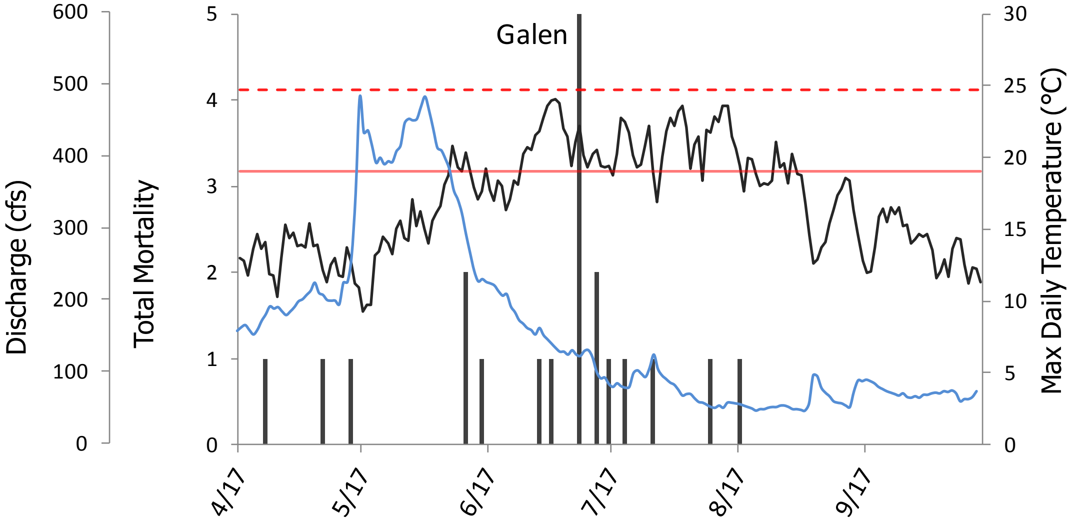

Figure 7-11. Total fish mortalities, maximum daily water temperature (black line), and mean daily discharge (blue line) for the Galen Site. The solid red line indicates the upper critical temperature threshold and the dashed red line represents the upper incipient lethal temperature for brown trout.

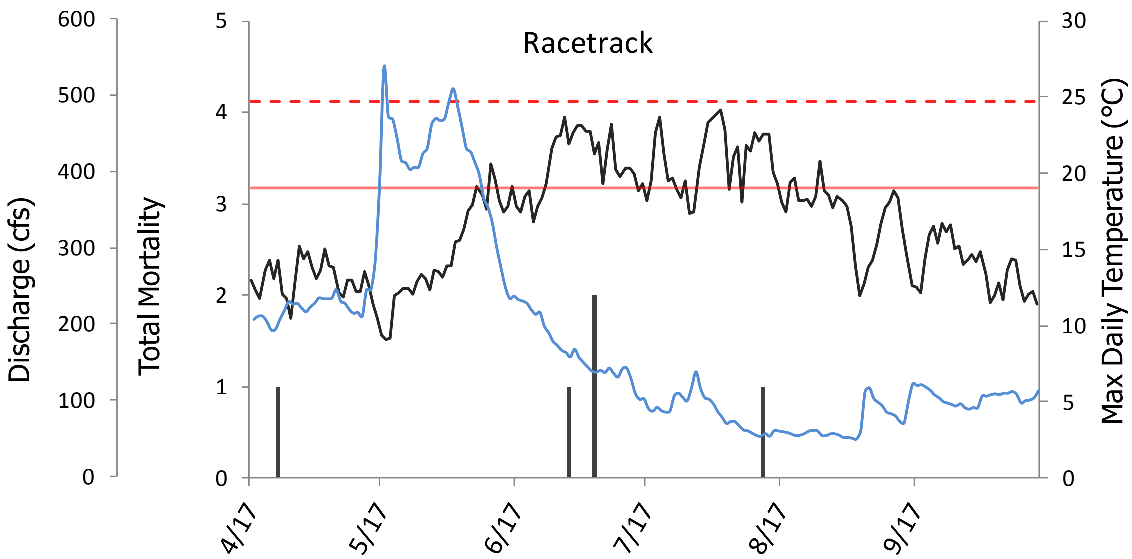

Figure 7-12. Total fish mortalities, maximum daily water temperature (black line), and mean daily discharge (blue line) for the Racetrack site. The solid red line indicates the upper critical temperature threshold and the dashed red line represents the upper incipient lethal temperature for brown trout.

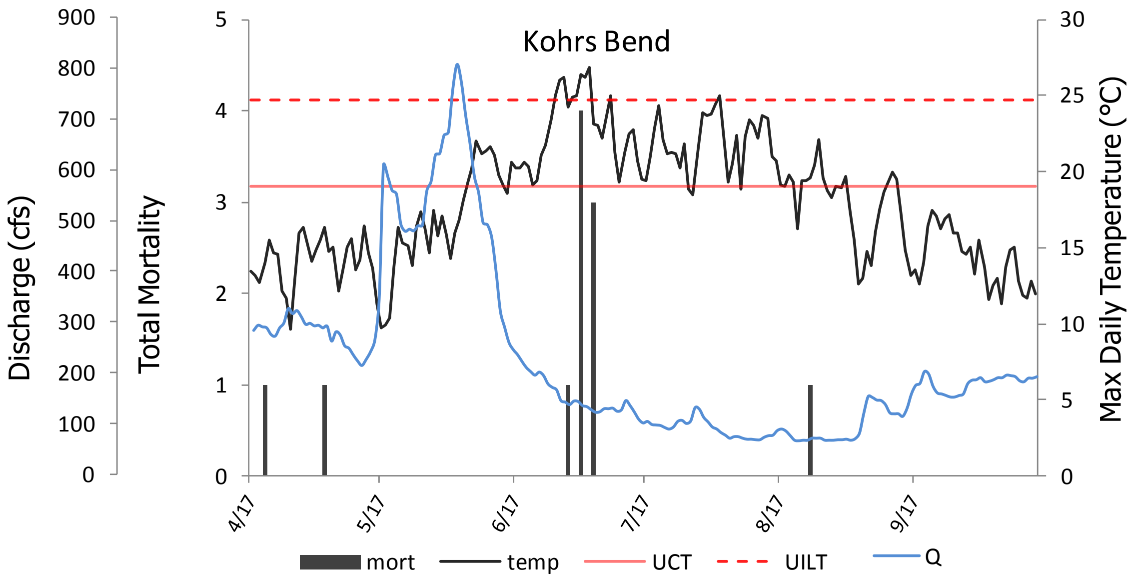

Figure 7-13. Total fish mortalities, maximum daily water temperature (black line), and mean daily discharge (blue line) for the Kohrs Bend site. The solid red line indicates the upper critical temperature threshold and the dashed red line represents the upper incipient lethal temperature for brown trout.

7.3.4 Water Quality

At the Pond 2 outlet, pH rapidly increased from early June to August and exceeded 10 for at least 53 days [Figure 7-14]. The Hydrolab probe at Pond 2 was removed for maintenance for five days in early September. Based on pH readings >10, both before and after the maintenance, the pH would likely have been over 10 during this time period as well. Daily mean pH measurements were between 7.8 and 9.2 at other sites. Mean dissolved oxygen ranged from 6.5-10.9 mg/L at the four sites, with the lowest DO occurring during the summer months [Figure 7-15]. Although minimum DO concentrations approached 4 mg/L at Pond 2, Galen, and Racetrack, only the Racetrack site actually reached DO concentrations below 4 mg/L during a night in August [Figure 7-16].

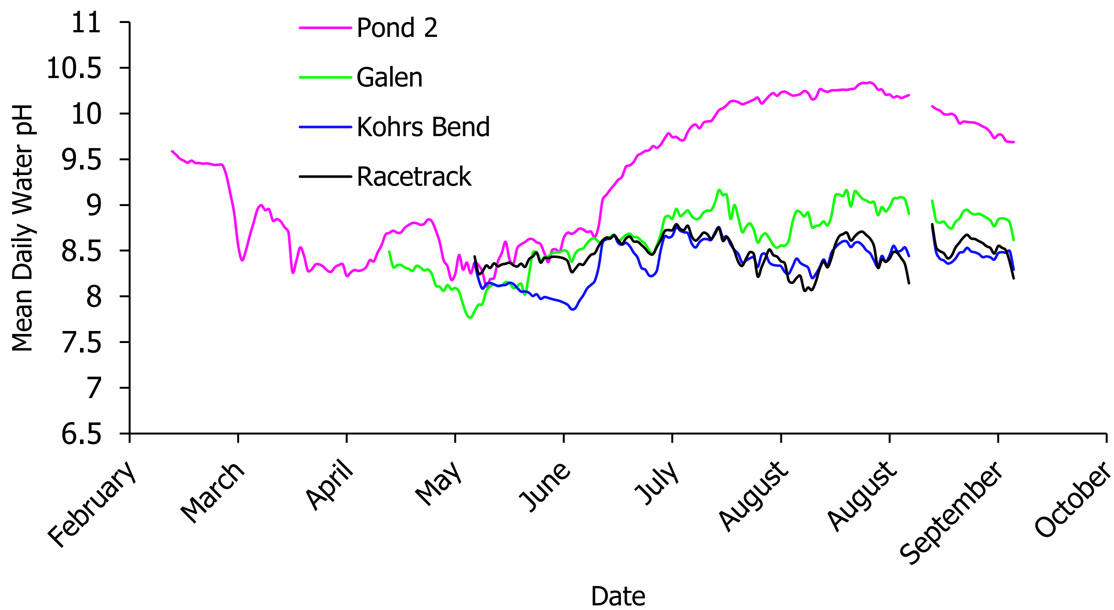

Figure 7-14. Mean daily water pH at 2015 caged fish sites.

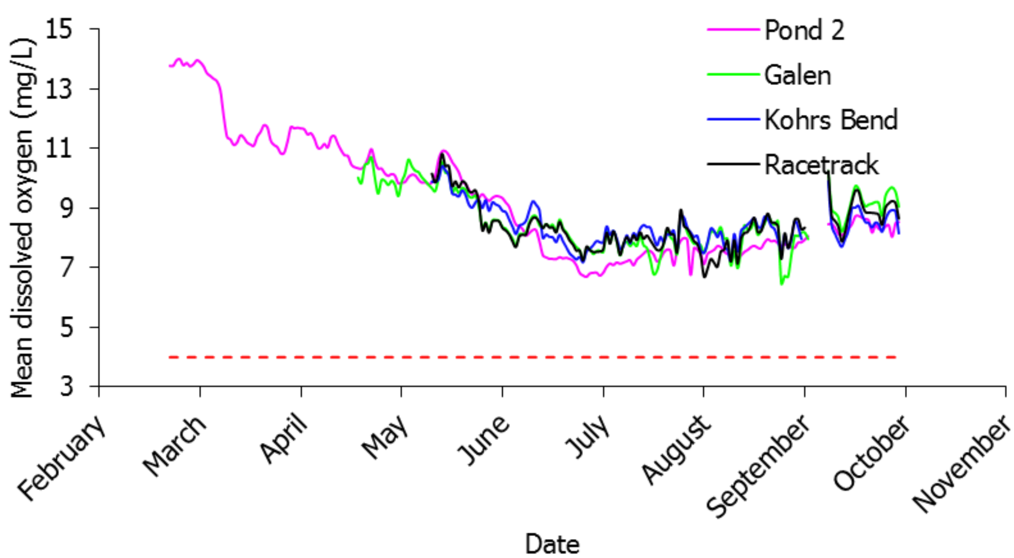

Figure 7-15. Mean daily dissolved oxygen concentrations at 2015 caged fish sites. The red dashed horizontal line denotes the freshwater ALS one day minimum.

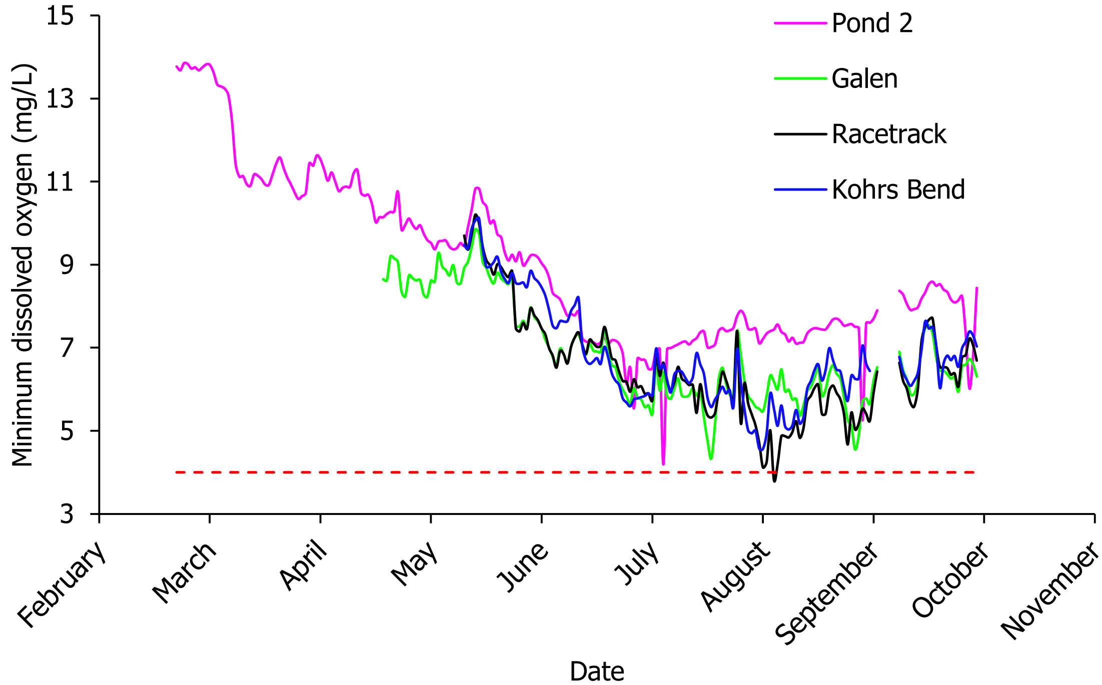

Figure 7-16. Minimum daily dissolved oxygen concentrations at 2015 caged fish sites. The red dashed horizontal line denotes the freshwater ALS one day minimum.

7.4 DISCUSSION

At sections of the Clark Fork River sampled annually, brown trout population estimates were lower in 2015 than they had been since at least 2012 at all sites. Brown trout in the upper Clark Fork River are not fully vulnerable to electrofishing until age-3 [Figure 7-6]. The increase in brown trout numbers in 2013 and 2014 is largely due to increases in numbers of three and four year old fish. These strong year classes are from 2010 and 2011, which were good water years [Figure 7-17]. The higher flows during these years may have provided additional spawning habitats, rearing habitats, or both, that were not are not available at lower flows. Conversely, 2012 was more of a drought year and these lower flows likely contributed to reduced recruitment, and lower population estimates in 2015.

Like the mainstem brown trout populations, brown trout estimates were relatively low in some tributary populations in 2015. Brown trout population estimates have been conducted on two sections of the Little Blackfoot River and one section of Warm Spring Creek since 2007. Data collected from all these sections indicate that brown trout populations were lower in 2015 than in any other year that these sections were surveyed [Figure 7-18]. Synchronous declines in mainstem and tributary brown trout suggest that similar environmental conditions may affect these populations. Many brown trout that reside most of the year in the mainstem Clark Fork River move into tributaries such as the Little Blackfoot and Warm Springs Creek to spawn [Mayfield, 2013], so it makes sense that population trends in the tributaries and mainstem would be linked. The otolith microchemistry project that is currently underway will provide data on fish movement between tributaries and the mainstem and shed light on the primary sources of brown trout recruitment in the upper Clark Fork River basin. Information from the microchemistry project will provide more insight into the prevalence of fluvial life histories and the exchange of individual brown trout between populations or metapopulations in the upper Clark Fork River basin.

Continuous (entire river) population estimates were conducted on the Clark Fork River in 1987, 2009, and 2015. Population estimates from annual sections indicate brown trout numbers were relatively low throughout the Clark Fork River in both 2009 and 2015. Population estimates from the upper reaches of the Clark Fork River were relatively high in 1987. For example, there were 1,212 brown trout/km at the most upstream section in 1987. The brown trout population in the most upstream sections of the Clark Fork River is more variable from year to year compared to other sections of the Clark Fork River. The coefficient of variation (standard deviation/mean) of brown trout population estimates conducted 2008 through 2015 is 0.68 at pH Shack compared to 0.27-0.52 at other reaches during the same time period. The reason for this variability is not well understood, but could be related to metals contamination from banks, sediment, and groundwater inputs, water quality of the discharge of Pond 2, warm summer water temperatures, or low summer flows in either the mainstem or important spawning tributaries. More than likely, the brown trout population in the upper sections of the Clark Fork River is impacted by a complex interaction of these factors.

Age-3 fish from Bearmouth (the only annual sampling section in remedial reach C) were significantly longer on average than age-3 fish from other sections or remedial reaches. There was considerable variation in length at age of individual fish, even within the same sampling sections. This variation limited the power of statistical comparisons. However, von Bertalanffy growth curves indicated some differences between remedial reaches and sampling sections that are likely biologically relevant even though the differences are not statistically significant. Generally, fish in remedial reach C (Bearmouth sampling section) grew faster to age-3, but growth appeared to slow down compared to other parts of the Clark Fork River from age-5 on. Brown trout from the most upstream sampling sections (pH Shack and Sager Lane) were generally longer than fish from other sections from age-5 on. Interestingly, age-2 fish from these sections were shorter on average compared to downstream sections. It is possible that older brown trout in the upper sections of the Clark Fork River are able to use different resources than younger fish, allowing for an increase in growth once they reach a certain size. Larger brown trout do not have the gape limitations of smaller fish, which allows larger fish to eat larger prey items.

Mortality estimates indicate that brown trout in remedial reach A of the Clark Fork River have higher mortality rates compared to remedial reaches B and C. This result was consistent to a telemetry study that directly measured mortality of individual fish in the upper Clark Fork River [Mayfield, 2013]. Mayfield [2013] attributed the increased mortality in remedial reach A primarily to elevated copper concentrations. Estimates of annual mortality from the telemetry study were 0.75 for remedial reach A, 0.68 for remedial reach B, and 0.50 for remedial reach C. These estimates were higher than those generated by catch curves in this study. However, the pattern of high mortality in remedial reach A, intermediate mortality in remedial reach B, and low mortality in remedial reach C was consistent between the catch curves and telemetry studies. The mortality estimate for remedial reach A is among the highest reported in studies of lotic brown trout populations [Table 7-24].

One of the assumptions of catch curves is that mortality is constant between age classes [Miranda and Bettoli, 2007]. If this assumption is met, a catch curve will be perfectly linear with the log-transformed numbers of fish captured fitting perfectly on the regression line. It is clear that the number of age-7 fish in remedial reach A is well below the value predicted by the catch curve for this remedial reach [Figure 7-7]. Simple annual mortality calculations (Nt+1/Nt) indicate that older age classes in remedial reaches A and B experience higher mortality than younger age classes [Table 7-25]. This pattern of increasing mortality with age does not appear to be the case in remedial reach C. One possible explanation for this pattern is the emigration of older trout from remedial reaches A and B into remedial reach C. Catch curve analysis does not account for immigration or emigration when calculating mortality. However, the telemetry study conducted 2009-2011 indicated that movement between remedial reaches of the upper Clark Fork River was rare for brown trout [Mayfield, 2013].

Some of the tributary monitoring sections sampled in 2015 have been sampled repeatedly in the past, some have only been sampled for species composition, and some had never been sampled before. The same tributary monitoring sections will be repeated for at least the next two years. These data will be critical in revealing any population trends or changes in fish communities following restoration activities.

In previous surveys of streams in the upper Clark Fork River basin, sculpin either were not identified to species or were thought to be slimy sculpin. In 2015 surveys, we identified sculpin to species in most sampling sections where they were found and detected a number of Rocky Mountain sculpin populations. Rocky Mountain sculpin are generally found in the lower reaches of tributaries to large rivers or streams. Slimy sculpin are generally found upstream of Rocky Mountain sculpin can tolerate colder water temperatures [Adams et al., 2015]. Interestingly, Twin Lakes Creek shows the opposite pattern with Rocky Mountain sculpin residing higher up in the steam than slimy sculpin. It is possible that the species was introduced into the upper Twin Lakes Creek system, perhaps through a bait bucket transfer into one or both of the Twin Lakes.

Metals cleanup activities on Silver Bow Creek are nearing completion. MFWP has been monitoring the fishery response to cleanup for several years. This monitoring has been done through single-pass electrofishing. While single-pass electrofishing allows for examinations of species composition and relative abundance, population estimates were not available (except for the Father Sheehan section). In 2015, we were able to generate population estimates for four fish species at four additional sections. These population estimates will be crucial for monitoring future colonization and establishment of various fish species in Silver Bow Creek. Based on the 2015 trout population estimates and overall low number of trout captured, it appears that the trout populations in Silver Bow Creek downstream of Butte are currently small. In contrast to trout, Rocky Mountain sculpin and longnose sucker are present in relatively high numbers in most Silver Bow Creek sections. In streams that are rehabilitated from mining impacts, sculpin typically colonize habitats after trout, either because sculpin are less mobile than trout [Mebane et al., 2015] or because sculpin are more sensitive to metals contaminants such as copper [Besser et al., 2007]. However, Rocky Mountain sculpin far outnumber either brook trout or westslope cutthroat trout at the Above Hwy 1 Bridge and LAO sampling sections. The reason for the high abundance of sculpin in sections with low trout numbers is unclear, but future fish community monitoring may shed light on the factors limiting different fish taxa in Silver Bow Creek.

Strontium isotope ratios were highest in Rock Creek and lowest in the Little Blackfoot River. Variation in strontium isotope ratios from water samples collected the upper Clark Fork River basin indicate this chemical marker holds promise for evaluating natal origins and movement of fish in the basin. The range of $^{87}Sr{:}^{86}Sr$ in the 16 samples collected in the upper Clark Fork River basin was 0.707446-0.727524. This range is smaller than the range of 0.71131-0.74679 in $^{87}Sr{:}^{86}Sr$ of 41 water samples collected in streams of the Flathead River basin in Montana [Muhlfeld et al., 2012]. The range of $^{87}Sr{:}^{86}Sr$ in the upper Clark Fork River basin may have been larger if more sites in more tributaries been sampled. When $^{87}Sr{:}^{86}Sr$ data is combined with Sr:Ca, most waters sampled in the upper Clark Fork River basin was clearly separated in isoscape plots. The separation of waters and sampling sites by strontium values suggest that otolith strontium profiles will be good markers for examining fish movements and recruitment sources in the upper Clark Fork River basin.

The temporal pattern of caged fish mortality in 2015 was similar to patterns in previous Clark Fork River caged fish studies (e.g., Cook et al. [2015]). Most mortality occurred during low summer flows and high water temperatures. There were no spikes in mortality at Racetrack that would indicate impacts of excessive runoff or other input of contaminated sediments from construction activities in Phase 5 or 6.

The pH at the outflow of Pond 2 was elevated for nearly two months, probably because of liming activities. The discharge of high pH water from the Warm Springs Ponds appears to elevate pH at least as far downstream as the Galen Site, which is approximately 13 stream km from the outlet of Pond 2. Racetrack (approximately 19 km from Pond 2) and Kohrs Bend (approximately 58 km from Pond 2) had similar pH, suggesting that influence of the high pH water discharged from Pond 2 is minimal at these sites.

Mean daily DO concentrations were well above the 4-day minimum aquatic life standard (4.0 mg/L; MDEQ [2012b]) at all sites. However, DO did approach or dip below 4 mg/L several times at night at all sites. The dips in DO took place on summer nights when, presumably, biological oxygen demand was high and no photosynthesis was taking place. There were not specific mortality events that took place during these dips in DO, but mortality was generally elevated during periods of high water temperatures.

Remediation of the upper Clark Fork River basin has the potential to permanently benefit the fish and aquatic ecosystem of the Clark Fork River and its tributaries. Remediation and restoration activities will take years to complete and fish communities of the upper Clark Fork River basin may take decades to fully respond to aquatic habitat enhancements. Monitoring fisheries changes due to remediation in the upper Clark Fork River basin requires an intensive sampling effort and a wide array of techniques. Population estimates, research on vital rates and water quality, and microchemistry data on fish movement and recruitment will be invaluable for understanding changes in fish populations over time. However, there still may gaps in our understanding of some aspects of the upper Clark Fork River basin aquatic community. For example, more understanding is needed of non-trout species, amphibians, invertebrates and the complex interactions of these organisms and their environments. Monitoring changes in the upper Clark Fork River basin ecosystem will require an adaptive approach and need to take place at multiple spatial scales including the basin as whole, within individual watersheds and streams, and at specific remediation projects.

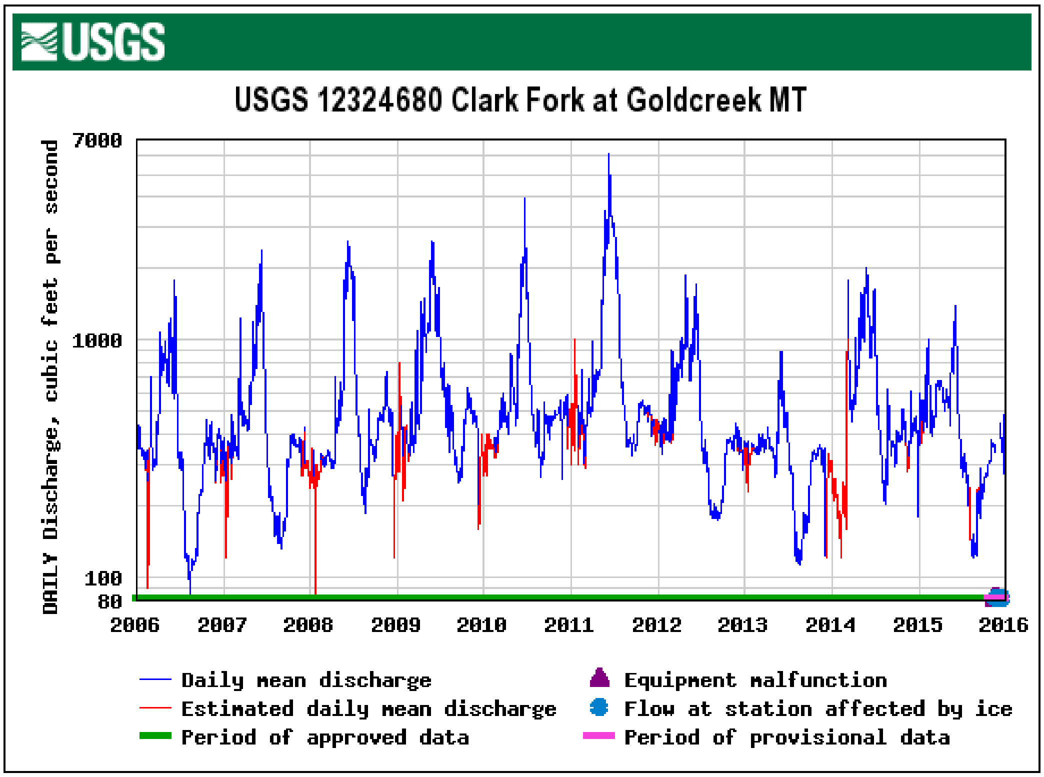

Figure 7-17. USGS hydrograph from the Clark Fork River gauge near Goldcreek.

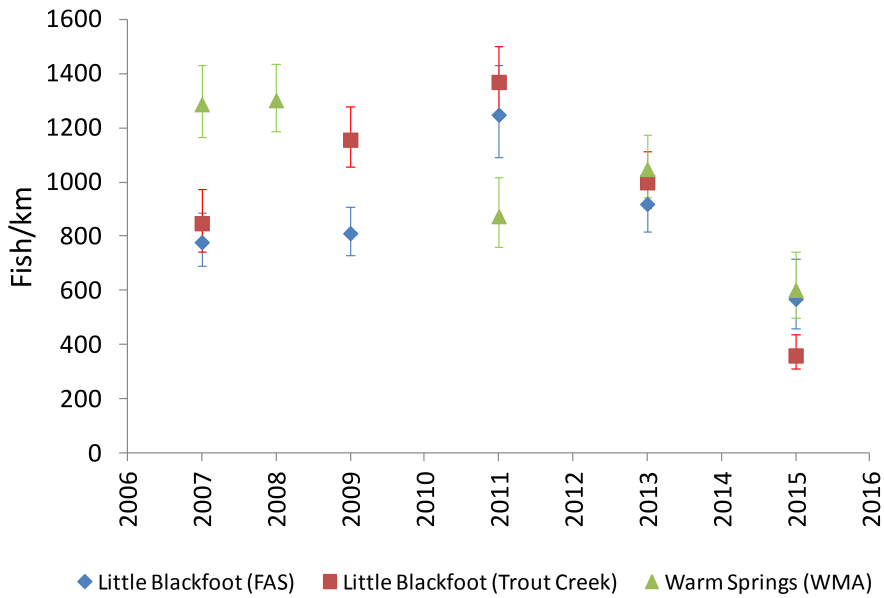

Figure 7-18. Brown trout population estimates and 95% CI from two sampling sections on the Little Blackfoot River and one section of Warm Springs Creek. Section names are in parentheses.

Table 7-24. Catch curve derived brown trout total annual mortality estimates from various studies.

Location	Max Age	Total Annual Mortality	Reference
Viau River, France	8	0.55	Pauly et al. [1994]
Vébre River, France	7	0.74	
Green River, WY	6	0.56	Wiley and Dufek [1980]
Cedar Run Creek, PA	4	0.31	McFadden and Cooper [1962]
Spring Creek, PA	4	0.54	
Spruce Creek, PA	7	0.39	
Young Woman Creek, PA	4	0.23	
Kettle Creek, PA	4	0.54	
Shaver Creek, PA	8	0.31	
Madison River, MT	>4	0.56	Vincent [1987]
Clark Fork River			
Remedial Reach A	11	0.65	This study
Remedial Reach B	7	0.46	
Remedial Reach C	10	0.32	

Table 7-25. Age specific mortality estimates for brown trout in three reaches of the upper Clark Fork River.

Remedial Reach	Age			
	3	4	5	6
A	2.3	56.1	62.1	91.8
B	24.0	17.4	64.7	60.6
C	-16.4	54.7	45.3	-2.0

8.0 BIRDS[37]

8.1 INTRODUCTION

Three areas along the river were surveyed in 2015. Each area had three point counts that were conducted weekly for a total of 13 surveys. One site was post-remediation, and the other two sites were pre-remediation. In all 84 species were observed between April 1 and June 30. More species were found within the pre-remediation sites than the one year post remediation site. Twenty-five species were migrant song birds, and 31 (37%) of the species found were found on all three sites. It is hoped that over time post-remediation sites will have as many species as pre-remediation sites. It is possible that even more species will be found with improved riparian habitat in the post-remediation sites in the future.

A summary of results include the following:

- Total: 84 species observed,
- Phase 1: 50 species observed,
- Phase 7: 63 species observed,
- Phase 15: 57 species observed.

Figure 8-1. Marsh wren seen along Clark Fork River riparian area.

[37] Chapter 8 was completed by Gary Swant (GoBirdMontana LLC) with minor editing and formatting by RESPEC.

8.2 METHODOLOGY

With the assistance of B. Bartkowiak (MDEQ), three sites were chosen for bird surveys. All three sites are riparian sites along the river corridor.

8.2.1 Survey Sites

8.2.1.1 Phase 1 (Headwaters)

This was the first site to be remediated. It begins at the confluence of Warm Springs and Willow Creek with the treated effluent water from the treatment of Silver Bow Creek in the Warm Springs Ponds. Where these three streams join is the origin of the Clark Fork River. The Phase 1 site begins at this confluence.

Phase 1 was completed in the fall of 2014. Phase 1 is approximately 1.5 miles of stream reach. Three point counts were conducted within Phase 1. One was near the pond that was created as part of the remediation (N 46^0 11’38.94”; W 112^0 46’22.52”). The second point count is on the west side of the river (N 46^0 11’38.09”; W 112^0 46’08.70”). The third point count was on the east side of the river (N 46^0 11’37.37”; W 112^0 35’35.19”).

Figure 8-2. Phase 1 pond site.

Phase 2 construction began in late mid-June and the Phase 1 pond site was impacted with heavy equipment, the digging of a ditch near the pond, and lowering the water in the ponds by pumps in preparation of remediation work in Phase 2 immediately adjacent to Phase 1. It is unclear how this activity may have affected the last two point counts in June.

Figure 8-3. Phase 1 west river site.

Figure 8-4. Phase 1 east river site, March 28, 2014.

Figure 8-5. Phase 1 east river site, July 14, 2014.

Looking at these pictures [Figure 8-4; Figure 8-5] of the Phase 1 east river point count site, shows the extent of revegetation that has taken place in 94 days. This successful reestablishment of a healthy riparian area should be reflected in bird species numbers and densities in the future. The possibility exists that the diversity and density might even be greater in the future.

8.2.1.2 Phase 7 (Racetrack Pond Area)

Phase 7 includes the Racetrack Pond site (N 46^0 16'07'.51"; W 112^0 44'35.44") which is adjacent to the river on the west, and two areas north of the pond. The two areas north of the pond include one on the west side of the river (N 46^0 16'29'.23"; W 112^0 44'12.58") and one on the east side of the river (N 46^0 16'29'.23"; W 112^0 44'12.58").

Figure 8-6. Phase 7 Racetrack Pond.

Figure 8-7. Phase 7 west river site.

Figure 8-8. Phase 7 east river site.

8.2.1.3 Phase 15 (Grant Kohrs Ranch National Historic Site)

Phase 15 point count sites include an old oxbow of the river (N 46^0 24’25’.48”; W 112^0 44’55.48”), and a south point count on the west side of the river (N 46^0 24’34’.77”; W 112^0 ^{4}44’45.79”), and a north point count on the west side of the river (N 46^0 24’40’.65”; W 112^0 ^{4}44’46.34”).

Figure 8-9. Phase 15 oxbow site.

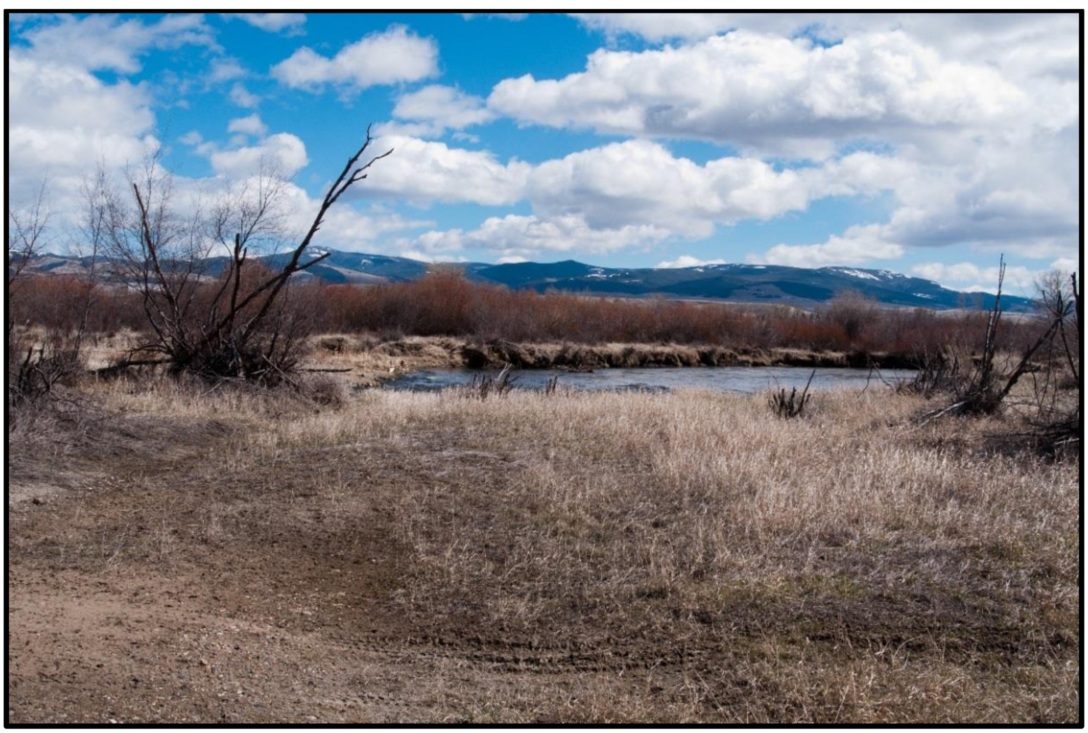

Figure 8-10. Phase 15 southwest site.

Figure 8-11. Phase 15 northwest site.

Appendix I has a more complete pictorial view of these nine sites with pictures taken from north, south, east and west directions. You will be able to see in some of the pictures slickens and vegetation affected by heavy metals contamination. The bare spot in the Phase 15 northwest Site is a large slicken.

8.2.2 Point Count Method

Bird monitoring data consisted of standardized bird species counts at each point count site. At each point count site a white plastic tube marker with the location code on it was driven in the ground to mark the site. Counts were conducted after a two-minute period following the surveyor arrival at each site. This period allowed birds to become accustomed to the surveyor presence.

Upon conducting each survey at each site, the GPS coordinates, date, time of survey start, and weather conditions were noted. Each survey was 10 minutes in duration. During the survey, each observed bird species was recorded based on a 4-letter ALPA abbreviation code system. The ALPA abbreviation code system is available in Appendix J. Surveyors counted all observed birds within an estimated 40 m radius from the point count site marker. For those species observed within 40 m, the abundance of each species was made based on a count of individuals of each species during the 10-minute survey period. For those species that were heard (by call or song), but not seen, the species was counted but an abundance estimate was not made. Species that flew through the 40-m site radius but did not stop within it were identified as having passed through the site. The estimated height at which these species passed was also noted as either above or below 20 m. In addition, species clearly identified but not observed within the 40-m site radius were noted accordingly.

8.3 GENERAL CONCLUSIONS

Eighty-four species were observed in total among all nine point count sites distributed in the three phases. The Phase 1 site had a total of 50 species. Phase 7 had a total of 63 species. Phase 15 had a total of 57 species. The list of bird species for each phase is found in Appendix J which includes the common name, scientific name and ALPA Code.

Birds are listed on the sheets in American Ornithological Union (AOU) 2014 order, not alphabetically. The AOU order is by family and genetic similarities.

Figure 8-12 shows the number of species in Phase 15 (Grant-Kohrs), versus Phase 7 (Racetrack) and Phase 1 (Headwaters). The headwaters site has two conditions that need to be considered. The last two weeks of observations was the beginning of construction for Phase 2. Although not a lot of dirt moving was being done, equipment and people were in the area of the pond, and may have reduced bird use. Secondly, there were a lot of "fly through" and "fly over" observations that led to high number of birds in the Phase 1 counts. Phase 1 is next to the Warm Springs Wildlife Management Area, and birds leaving and coming to the Warm Springs Wildlife Management Area were counted in flight and may lead to an artificially high count for Phase 1. Figure 8-13 shows total count of species within the circle versus total count of all birds seen from the point count. This graph gives a more realistic view of the number of species using Phase 1.

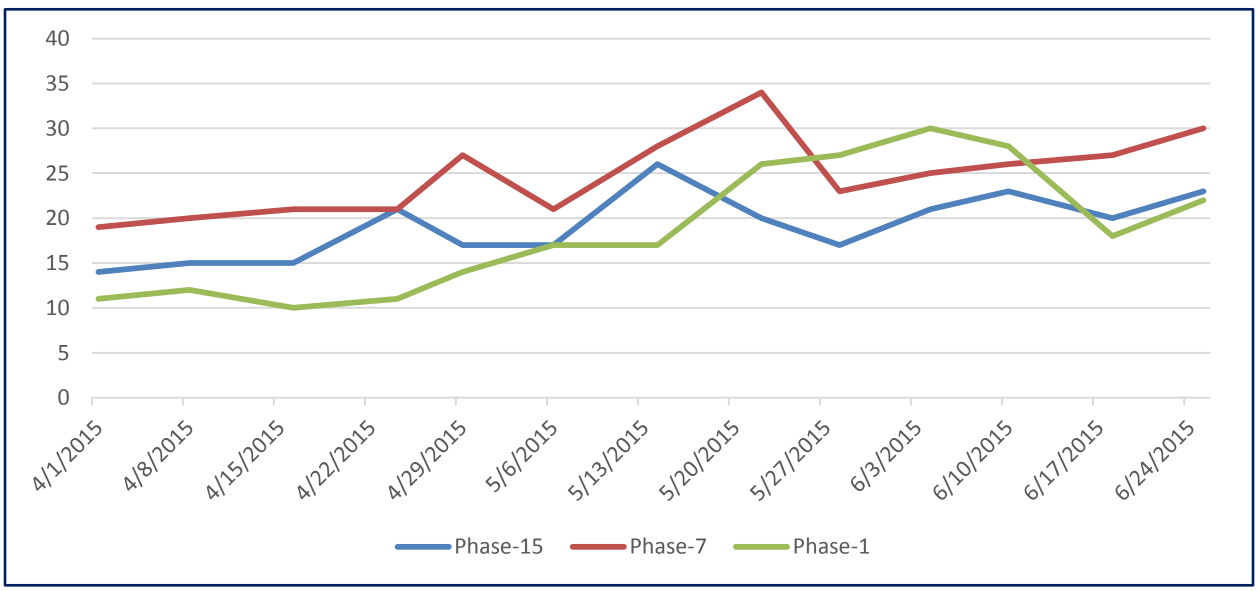

Figure 8-12. Number of species per site by date.

Conclusions from Figure 8-12:

- Phase 7 (Racetrack) consistently has more species over the 13 samples. The average number of species per week was 25.
- Phase 15 (Grant-Kohrs) had an average number of species present per point count of 20.
- Phase 1 (Headwaters) had an average count of 18 species per count.
- As the season progressed more bird species were seen at each site. The average number of species seen at all three sites on April 1 was 15. In the middle of the count period on May 14 the count was 23 and at the end of the season the count was 25.
- All sites had more species at the end of the count period than at the beginning.

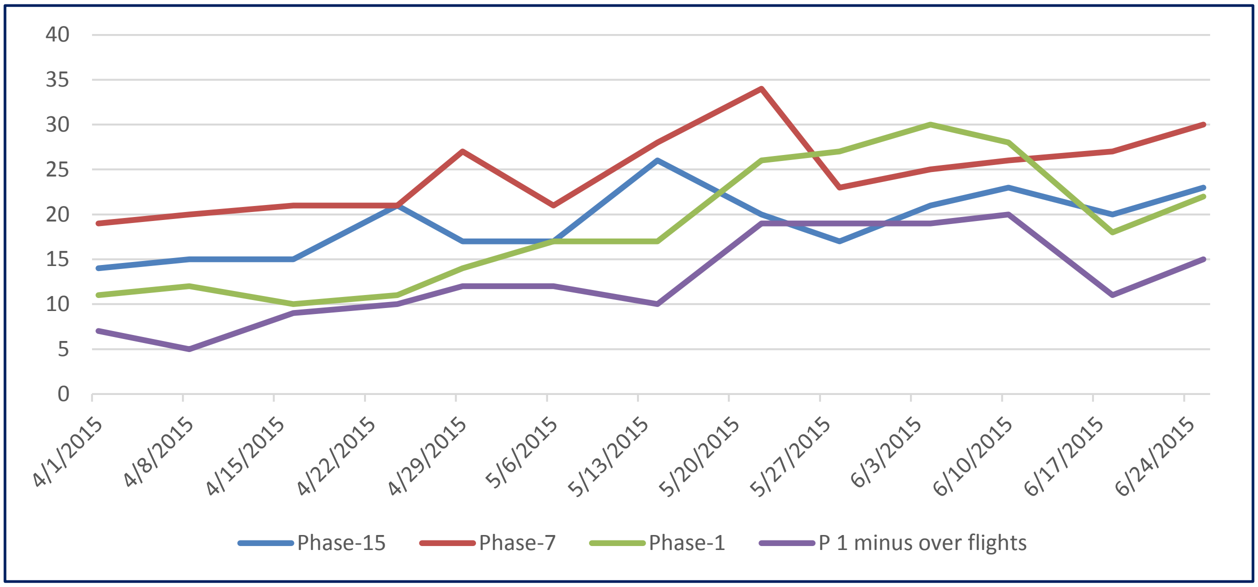

Figure 8-13. Number of species per site by date adjusted for over flight in Site 1.

Conclusions from Figure 8-13:

- The "P 1 minus overflights" line was the number of species observations in Phase 1 (Headwaters) adjusted to eliminate over flight counts. This line is most likely a truer representation of bird species moving back into the area after remediation.
- The average number of birds moving back into Phase 1 is 13 or 48% of Phase 7 and 65% of Phase 15.
- Phase 1 is only one year post remediation, and it would be expected that the number of species using the area will increase yearly.
- As other phases are completed such as Phase 5 and 6, which are currently undergoing remediation and are further from Warm Springs Wildlife Management Area, a more accurate picture of the reestablishment of bird species in the area can be established.
- It is speculation, but with better habitat in the area due to lack of slickens, and heavy metals, revegetation, and the stream lowered for more natural spring stream flows, point counts may show increased species or at least increased density of species along the riparian areas of the upper Clark Fork River.
- Yearly point count studies for several years into the future should be done.

Figure 8-14 was generated by taking the total number of individuals of all species for each point count date. This would be nine point counts in total. Species density is one index of a site's health for birds. The number of species is another indicator and is addressed in Figure 8-14. As an example, if an area has 16 species and 35 individual birds, it may not be as healthy as an area with 10 species and 185 individual birds.

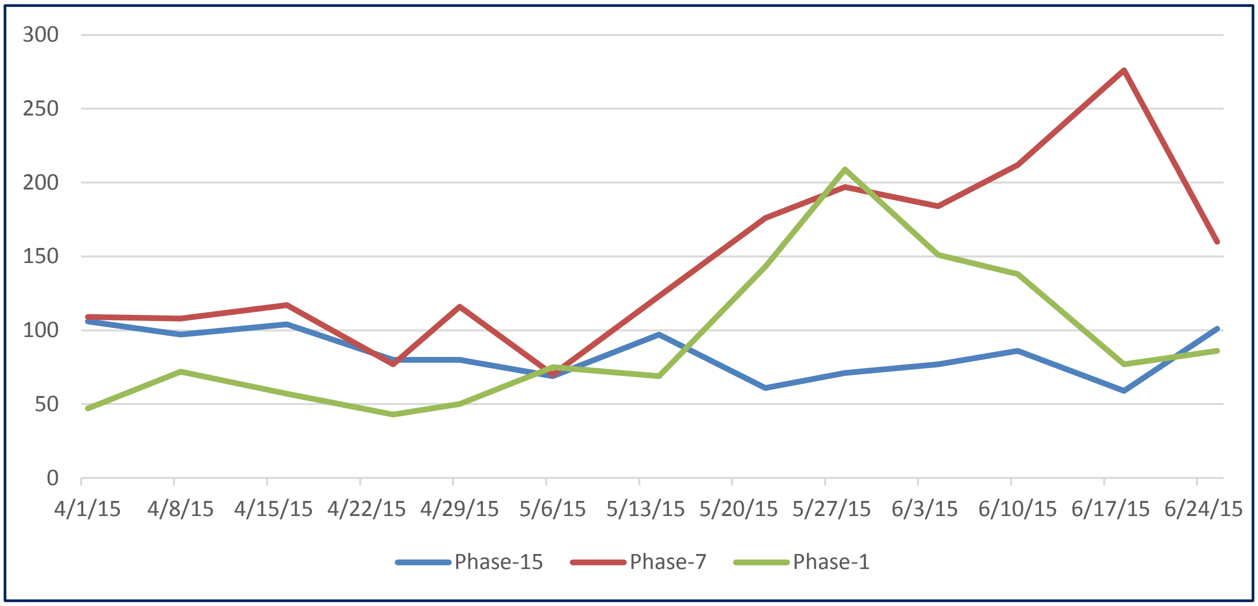

Figure 8-14. Density of all bird species per site by date.

Conclusions from Figure 8-14:

- Phase 7 (Racetrack) has had an increasing number of individuals as the season lengthened. The number of individuals on June 17 was 276 compared to 109 on April 1.
- The average number of individuals over the three months of the study in Phase 7 was 148 compared to 84 for Phase 15 and 94 for Phase 1.
- Phase 7 also had the most number of species of the three sites (refer to Figure 8-12).
- Phase 7 had an average of 10 more individuals per point count than did Phase 15. This is typical of sites with ponds. An influx of waterfowl at a pond can drastically affect an average density count. The spike on May 28 on Phase 1 was due to a large number of ring-billed gulls (37 individuals) and California gulls (65 individuals) feeding on the pond and flying over the pond. These two species breed on an island within the Warm Springs Wildlife Management Area.

Figure 8-15 shows the total number of species found for all nine point counts within the three sites for each date. The river mileage from Phase 1 to Phase 15 is between 15 to 17 river miles. Figure 8-15 shows the total number of species using the riparian corridor along the Clark Fork River during the April through June season. This is the period of time that transients move through, such as the Western tanager, to their breeding areas further north or at higher elevations in the valley. It is also the period of time that locally breeding birds such as the northern flicker and migrant breeders such as mountain bluebirds, and osprey arrive from climes further south, as far away as Ecuador, and set up territories, breed, nest, and fledge young. At the beginning of the point count (April 1) season few species were present. As the season continued, birds were on territory and singing, and by the end of the point count season (June 30), young of the year were being observed.

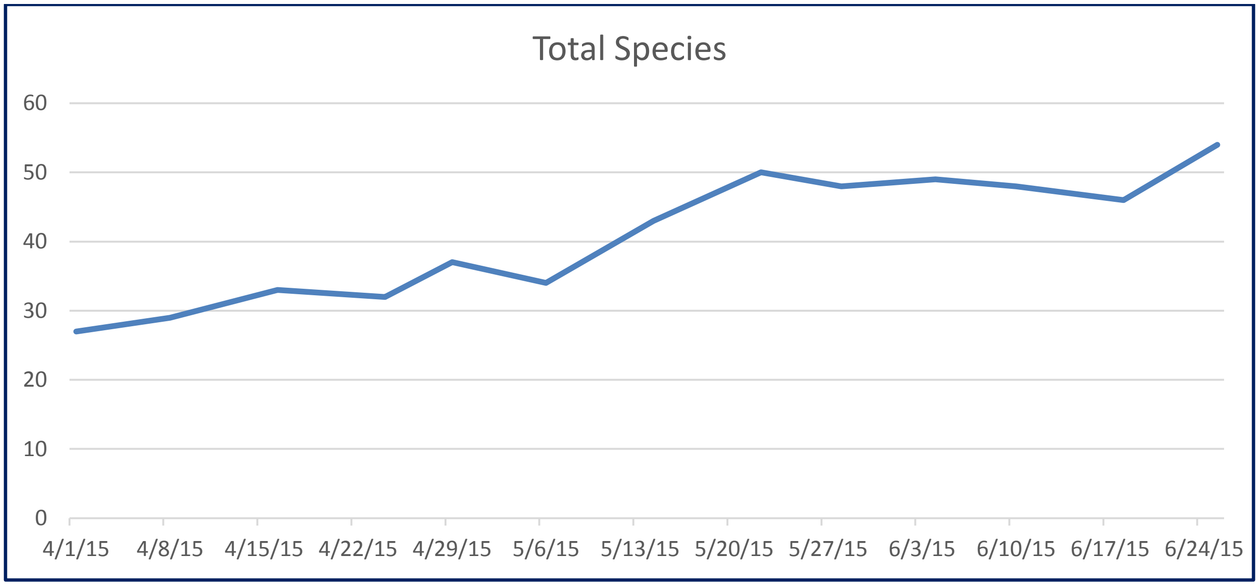

Figure 8-15. Number of species from Phase 1 to Phase 15. The nine point counts were combined in each of the three sites for this species count.

Conclusions from Figure 8-15:

- Species continue to increase through the entire time of the point counts.
- The number of species levels off in late May and continues to level until a spike on the final date of the study. No new species from May 20 to June 17 would indicate that most species that are present are being seen.
- Some of the transient species that were found in April such as the yellow-rump warbler were not found later in June.
- The highest count for bird species was 54 on June 25. Total species seen over the three month period was 84, thus the June 25 count saw 65% of the total species seen.

Overall conclusions from Figure 8-12 through Figure 8-15:

- Phase 7 (Racetrack) has the highest number of species and individuals of the three sites.
- Phase 15 (Grant-Kohrs) has the most stable number of species per point count as well the least fluctuation of total individuals per point count.
- Phase 1 is quickly being repopulated with bird species. As was noted earlier, a more accurate representation of bird reestablishment will take place as project phases further from the Warm Springs Wildlife Management Area undergo remediation. Phase 1 species and density of birds is greatly influenced by its proximity to the Warm Springs Wildlife Management Area.

Table 8-1. Birds observed in Phase 1, 7, and 15 in 2015.

Species (common name)	Species (common name)	Species (common name)
Canada goose	*Green-winged teal*	Osprey
Gadwall	Ring-billed gull	**Black-billed magpie**
American wigeon	Mourning dove	**American crow**
Red-tailed hawk	Eastern kingbird	**Common raven**
Killdeer	Clay-colored sparrow	Tree swallow
Spotted sandpiper	Savannah sparrow	**Red-winged blackbird**
Northern rough-winged swallow	Song sparrow	Western meadowlark
Black-capped chickadee	*Lesser scaup*	Yellow-headed blackbird
American robin	Double-crested cormorant	Brown-headed cowbird
Cinnamon teal	**Great blue heron**	
Northern shoveler	Turkey vulture	

Thirty-seven percent of the species (31 species) were found in all three phases [Table 8-1]. Conclusions from Table 8-1:

- Of these 31 species, seven are waterfowl that can be found year around in the area, and are marked in italics.
- Another eight species, of which 3 are song birds, are indicated in bold and are year around residents and breeders.
- The 15 year round species, which are highlighted (**bold** and *italicized*), make up 48% of the total species that were found on all three sites.
- The two underlined species are shorebirds which extensively use the mudflats and shallow areas of the river.
- The remaining 14 species are breeding migrants to the area; two are raptors, one is a gull, two are swallows, and the remaining nine are migrant song birds.

Another 31 species were only found on one of the phase sites [Table 8-2]. This can best be explained by the fact that the species is either rare, or has specific habitat needs that were only represented by one of the three sites.

Table 8-2. Birds observed in only one phase in 2015.

Species (common name)	Species (common name)	Species (common name)
Northern pintail	Sandhill crane	Rudy-crowned kinglet
Ring-necked duck	*Wilson phalarope*	**Orange-crowned warbler**
Bufflehead	*Bonaparte's gull*	Yellow warbler
Barrow's goldeneye	*Franklin's gull*	*American tree swallow*
Hooded merganser	**Herring gull**	**Lark sparrow**
Rudy duck	*Belted kingfisher*	White-crowned sparrow
Common loon	Downy woodpecker	Bobolink
Horned grebe	Western wood-pewee	Bullock's oriole
Western grebe	**Bank swallow**	American goldfinch
Sharp-shinned hawk	**Cliff swallow**	
American coot	**Barn swallow**	

Conclusions from Table 8-2:

- Five species, indicated by italics, were only found in the Phase 1 (Headwaters) site. Two were gulls that probably spilled over from the Warm Springs Wildlife Management Area to the Phase 1 pond. The Barrow's goldeneye is rather rare and found at the Warm Springs Wildlife Management Area as a transient in early spring. The belted kingfisher is common at the Warm Springs Wildlife Management Area, and rarer downstream. The American tree sparrow is a winter resident of the Warm Springs Wildlife Management Area and was only found in April. Even though these five species may have been spill over from the Warm Springs Wildlife Management Area, they were still using the Phase 1 site and will probably continue to use the site in the future because of good habitat remediation.
- Fourteen species, indicated by bold letters, were only found in the Phase 7 (Racetrack) site. Nine were associated with water. All four duck species are diving ducks, rather than dabbling ducks, and prefer deep water, not swallow ponds. The Racetrack Pond is a rather deep pond. During remediation, if Racetrack Pond was made even deeper it would enhance the use of Racetrack Pond by other species of diving ducks. Grebes and loons need deep water for their food sources such as mollusks that prefer deep, cold water. The herring gull is a rare to uncommon transient to the valley, and was probably just present when the point count was conducted.
- The remaining 10 species were found in Phase 15 (Grant-Kohrs). The sharp-shinned hawk because of its nature of hunting by flight could be found in all three phases. The sharp-shinned hawk is relatively uncommon and was simply not seen in more than one phase, but could be expected to be in all three phases. The northern pintail could be found at Phase 7 and was not, due to lack of enough observations. The downy woodpecker, western wood-pewee, ruby-crowned kinglet, yellow warbler, white-crowned sparrow, Bullock's oriole, and American goldfinch could be found in the Phase 7 east river point count as it is proper habitat, but small in area. Phase 15 has large areas of proper habitat for these species. The sandhill crane would only be expected at Phase 15

as it is the only site with proper habitat of extensive wet meadows. The same is true for the bobolink. The bobolink requires rather large, undisturbed, wet meadows and the Stuart field provides that habitat.

The remaining 22 species were found in two phases. The three combinations are: Phase 1 and 7 [Table 8-3], Phase 1 and 15 [Table 8-4], and Phase 7 and 15 [Table 8-5]. I suspect that these 22 species were found in all three riparian habitats, and if more point counts would have been done, they would have been observed in all three phases.

Table 8-3. Birds observed in Phases 1 and 7 in 2015.

Species (common name)	Species (common name)	Species (common name)
Common goldeneye	*American avocet*	**Mountain bluebird**
Red-breasted merganser	*California gull*	Swainson's hawk
American white pelican		

Conclusions from Table 8-3:

- Both Phase 1 and Phase 7 have large ponds and all five of the italics species are habitat specific to a pond environment.
- The oxbow habitat of Phase 15 would not match the habitat needs of the American white pelican, American avocet, red-breasted merganser or California gull. The common goldeneye could be expected to be seen in the oxbow and was probably not recorded due to lack of enough observations.
- All hawks and eagles could be expected to be found in flight over and through all of the riparian habitats, and the fact that the Swainson's hawk was not recorded in all three phases is due to insufficient observations.
- The mountain bluebird would not be expected to be seen at Phase 15 as they prefer a drier environment than what is found at Grant-Kohrs.

Table 8-4. Birds observed in Phases 1 and 15 in 2015.

Species (common name)	Species (common name)	Species (common name)
Northern harrier	Red-naped sapsucker	Vesper sparrow

Conclusions from Table 8-4:

- There is no particular reason for the northern harrier and red-naped sapsucker being found in Phase 1 and 15. Both of these species occur along the entire corridor. This is especially true of the northern harrier. The most likely explanation is lack of sufficient point count observations.
- The Vesper sparrow is a grasslands species and there are grasslands near or in all three phases, thus again probably more observations would place them in all three phases.

Table 8-5. Birds observed in Phases 7 and 15 in 2015.

Species (common name)	Species (common name)	Species (common name)
Blue-winged teal	Northern flicker	European starling
American kestrel	**Willow flycatcher**	**Common yellowthroat**
Wilson's snipe	**Gray catbird**	**Brewer's blackbird**

Conclusions from Table 8-5:

- Phase 7 and 15 both have well developed riparian willow environments and the birds in bold print require that type of habitat. Where you have proper habitat the bird species will occupy the area.
- Note: As remediation activities continue during the upcoming years, it will be interesting to observe if the bolded species above increase in density (number of individuals) and are found in all of the reaches of the river.
- The blue-winged teal is the least common duck in the valley, and the last to arrive in the spring. Its habitat requirements are best met in the oxbow in Phase 15, and the backwater shallow ponds at Phase 7 east. These same requirements are needed by the Wilson's snipe.
- It was surprising that the American kestrel, northern flicker, and European starling were not seen in all phases monitored, and is probably a function of the number of point counts conducted.

8.4 INDIVIDUAL SPECIES, NATURAL HISTORY, AND SPECIES STATUS CODE

Bird distribution is mapped in Montana by latilongs, that is one degree of latitude by one degree of longitude. Phases 1, 7, and 15 are in quarter latilong 27C. Following the common name of the species, are one letter codes for local occurrence in quarter latilong 27C as established by the Montana Bird Distribution 7th Edition, 2012 Guide.

Table 8-6. Bird species observed in the Clark Fork River Operable Unit in 2015.

Species found[38]	Codes[39]	Species of concern[40]	Remarks
Ducks, Geese, and Swans			
Canada goose	B, C, Y		Non-songbird; resident breeder.
Gadwall	B, C		Non-songbird; migrant breeder.
American wigeon	B, C		Non-songbird; migrant breeder.
Mallard	B, C, Y		Non-songbird; resident breeder.
Blue-winged teal	B, U		Last waterfowl of the year to appear in late April; non-songbird migrant breeder.
Cinnamon teal	B, C		Non-songbird; migrant breeder.
Northern shoveler	B, C		Non-songbird; migrant breeder.
Northern pintail	b, U		First waterfowl of the year to appear in early March.
Green-winged teal	B, C		Non-songbird; migrant breeder.
Ring-necked duck	b, C		Non-songbird; migrant breeder.
Lesser scaup	B, C		Non-songbird; migrant breeder.
Bufflehead	B, C		Non-songbird; migrant breeder.
Common goldeneye	B, C, Y		Non-songbird; resident breeder.
Barrow's goldeneye	B, U		Non-songbird; resident breeder; most continue further north to breed.
Hooded merganser	T, U		Typically seen spring and fall.
Common merganser	T, U		Typically seen spring and fall.
Red-breasted merganser	R, T		Only found in Racetrack Pond. 14% of Montana is breeding range for this species, and Montana contains 1% of the global breeding range.
Rudy duck	B, C		Non-songbird; migrant breeder.
Loons and Grebes			
Common loon	T, U	G5 S3	Only found in Racetrack Pond. 14% of Montana is breeding range for this species, and Montana contains 1% of the global breeding range.
Horned grebe	T, U		Early spring, late fall. Only found in Racetrack Pond.
Western grebe	B, C		Does not breed in the Clark Fork riparian zone.
Cormorants and Pelicans			

[38] Bold font indicates migrant songbird species.

[39] Codes: B = direct evidence of breeding established; b = indirect evidence of breeding, probably does not breed in area yearly; T = transient/migrant spring, fall or both; Y = year round; W = winter only; w = occasionally overwinters; C = common in the area; U = uncommon in the area; R = rare in the area; S = non-breeding summer resident; SOC - Species of Concern by Montana Natural Heritage Program.

[40] See: http://fieldguide.mt.gov/statusCodes.aspx#msrc:rank.

Double-crested cormorant	B, C		Does not breed in the Clark Fork riparian zone.
American white pelican	C, S	G4 S3B	6% of Montana is breeding range for this species, and Montana contains 1% of the global breeding range. Only juveniles found along the Clark Fork River. Only three breeding colonies in the state.
Herons			
Great blue heron	B, C, w	G5 S3	Small breeding population size. Recent declines caused by declining regeneration of riparian cottonwood forest. 6% of Montana is breeding range for this species, and Montana contains 1% of the global breeding range. Currently no breeding rookeries along the Clark Fork River, but have been in the past.
Vultures and Hawks			
Turkey vulture	T, U		Roost in the area occasionally.
Osprey	B, C		Non-songbird, migrant breeder, active nest site at Racetrack Pond (Phase 7).
Bald eagle	B, C, Y		Non-songbird, resident breeder, no active nest in current phases. Four active nests occur along the river between Warm Springs and Garrison.
Northern harrier	B, C, Y		Non-songbird, resident breeder, breeds on ground along the riparian zone.
Sharp-shinned hawk	b, U		Non-songbird, resident breeder, only observed once.
Swainson's hawk	B, C		Non-songbird, migrant breeder, no nests observed in Phases 1, 7, or 15.
Red-tailed hawk	B, C, Y		Non-songbird, resident breeder, nest in Phase 15.
Falcons			
American kestrel	B, C		Non-songbird, migrant breeder, nest in Phases 7 and 15.
Rails and Cranes			
American coot	B, C		Non-songbird, migrant breeder, nest in Phases 7 and 15.
Sandhill crane	B, C		Non-songbird, migrant breeder, nest in Phase 15.
Shorebirds			
Killdeer	B, C		Non-songbird; migrant breeder all along the Clark Fork River.
American avocet	B, C		Non-songbird; migrant breeder in Phase 1.
Spotted sandpiper	B, C		Non-songbird, migrant breeder, most common shorebird along the Clark Fork River.
Wilson's snipe	B, C, w		Non-songbird, migrant breeder in Phases 7 and 15; uncommon in the winter.
Wilson's phalarope	B, C		Non-songbird; migrant breeder in Phases 1 and 7.
Gulls			
Bonaparte's gull	b, T, U		Juveniles have been observed at the Warm Springs Wildlife Management Area.
Franklin's gull	T, U	G4 S3	48% of Montana is breeding range for this species, and Montana contains 7% of the global breeding range. Found mostly at the Warm Springs Wildlife Management Area and spill over to Phase 1.
Ring-bill gull	B, C		Breeding colony at the Warm Springs Wildlife Management Area.
California gull	B, C		Non-songbird, migrant breeder. Breeding colony at the Warm Springs Wildlife Management Area and spills over to Phase 1 and 7.
Herring gull	T, U		Rarely seen, but was at the Phase 1 pond.
Doves			

Mourning dove	B, C		Non-songbird; migrant breeder all along the Clark Fork River.
Kingfishers			
Belted kingfisher	B, C, Y		Non-songbird, resident breeder all along the Clark Fork River
Woodpeckers			
Red-naped sapsucker	B, C		Non-songbird, migrant breeder in cottonwood trees.
Downy woodpecker	B, C, Y		Non-songbird, migrant breeder in cottonwood trees.
Northern flicker	B, C, Y		Non-songbird, migrant breeder in cottonwood trees.
Flycatchers			
Western wood-pewee	B, C		Migrant breeding songbird in cottonwood trees.
Willow flycatcher	B, C		Migrant breeding songbird in riparian willows.
Eastern kingbird	B, C		Migrant breeding songbird in riparian willows; very common.
Corvids			
Black-billed magpie	B, C, Y		Resident breeding songbird; very common.
American crow	B, C, w		Elevational-migrant breeding songbird, occasional overwinters, or stays late into the fall.
Common raven	B, C, Y		Resident breeding songbird, very common.
Swallows			
Tree swallow	B, C		Migrant breeding songbird along the riparian zone.
Northern rough-winged swallow	B, C		Migrant breeding songbird along the riparian zone.
Bank swallow	B, C		Migrant breeding songbird along the riparian zone.
Cliff swallow	B, C		Migrant breeding songbird along the riparian zone.
Barn swallow	B, C		Migrant breeding songbird along the riparian zone. Last to appear in the spring, last to leave and is the least common of the swallows.
Chickadees			
Black-capped chickadee	B, C, Y		Resident breeding songbird, very common.
Kinglets			
Ruby-crowned kinglet	B, C		Migrant breeding songbird.
Mountain bluebird	B, C		Migrant breeding songbird in Phase 7 and 15.
American robin	B, C, w		Migrant breeding songbird along the riparian zone; occasionally individuals may overwinter.
Mimics			
Gray catbird	B, C		Migrant breeding songbird along the riparian zone.
European starling	B, C, Y		Non-native, resident breeding songbird.
New World Warblers			
Orange-crowned Warbler	B, U		Migrant breeding songbird along the riparian zone.
Common Yellowthroat	B, C		Migrant breeding songbird along the riparian zone.

Yellow Warbler	B, C		Migrant breeding songbird along the riparian zone.
			Sparrows
American tree sparrow	C, W		Seen early in April and not again.
Clay-colored sparrow	B, C		Migrant breeding songbird along the riparian zone.
Vesper sparrow	B, C		Migrant breeding songbird along the riparian zone.
Lark sparrow	T, U		Transient/migrant breeding songbird along the riparian zone, only seen once.
Savannah sparrow	B, C		Migrant breeding songbird along the riparian zone.
Song sparrow	B, C, W		Resident breeding songbird along the riparian zone.
White-crowned sparrow	B, C		Migrant breeding songbird, but breeds in the coniferous forest above the valley. A spring and fall bird in the valley.
			Blackbirds
Bobolink	B, C	G5 S3	Migrant breeding songbird at Phase 15. Species has undergone recent large population declines in Montana. 100% of Montana is breeding range for this species, and Montana contains 9% of the global breeding range.
Red-winged blackbird	B, C, Y		Resident breeding songbird along the riparian zone.
Western meadowlark	B, C		Migrant breeding songbird along the riparian zone.
Yellow-headed blackbird	B, C		Migrant breeding songbird along the riparian zone.
Brewer's blackbird	B, C		Migrant breeding songbird along the riparian zone.
Brown-headed cowbird	B, C		Migrant breeding songbird along the riparian zone.
Bullock's oriole	B, U		Migrant breeding songbird along the riparian zone.
			Finches
American goldfinch	B, C, Y		Resident breeding songbird along the riparian zone.

Conclusions from Table 8-6:

- Of the 84 species:
  - 23 families of birds were represented on the three sites;
  - 68 species breed in the riparian area, or near it;
  - 46 species are non-songbird breeders;
  - 16 species are resident breeders;
  - 25 species are migrant songbird breeders;
  - four species have only indirect evidence of breeding (juveniles observed, no nest);
  - 65 species are common to the area;
  - 13 species are uncommon to the area;
  - one species is a summer resident only, and does not breed;
  - one species is a winter resident only;
  - 16 species are year around residents;
  - five species were classified as "species of concern".

Table 8-7. Number of families by phase.

Family	Phase 1	Phase 7	Phase 15	All
Ducks and geese	11	16	11	18
Loons and Grebes	0	3	0	3
Cormorants and Pelicans	2	2	1	2
Herons	1	1	1	1
Vultures and Hawks	6	5	5	6
Falcons	0	1	1	1
Rails and Cranes	0	1	2	2
Shorebirds	4	4	3	5
Gulls	4	3	1	5
Doves	1	1	1	1
Kingfishers	1	0	0	1
Woodpeckers	1	1	2	3
Flycatchers	2	2	3	3
Corvids	3	3	3	3
Swallows	5	5	3	5
Chickadees	1	1	1	1
Kinglets	0	0	1	1
Thrushes	2	1	1	2
Mimics	2	2	2	2
New World Warblers	3	1	2	3
Sparrows	7	4	5	7
Blackbirds	7	5	7	7
Finches	1	0	1	1
Total (families)	**19**	**20**	**21**	**23**
Total (species)	**50**	**63**	**57**	**84**

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