Fisheries Monitoring in the Upper Clark Fork River Basin
2022 Report

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Abbreviations for fish species present in the Upper Clark Fork River.

Species	Species abbreviation
Brook Trout	EB
Brook Trout X Bull Trout Hybrid	EBxBULL
Brown Trout	LL
Brook Trout X Brown Trout Hybrid	EBxLL
Bull Trout	BULL
Central Mud Minnow	CM MN
Kokanee	KOK
Lake Trout	LT
Largemouth Bass	LMB
Largescale Sucker	LS SU
Longnose Sucker	LN SU
Longnose Dace	LN DC
Mountain Whitefish	MWF
Northern Pike Minnow	N PMN
Rainbow Trout	RB
Rainbow Trout X Westslope Cutthroat Trout	RBxWCT
Redside Shiner	RS SH
Rocky Mountain Sculpin	RM COT
Sculpin (unidentified)	COT
Slimy Scuplin	SL COT
Westslope Cutthroat Trout	WCT
Yellow Perch	YP

Introduction

The Upper Clark Fork River (UCFR) was subject to extensive mining and mineral processing activities during the late 19th and early 20th centuries. Metal contamination has reduced habitat quality and altered the fishery in the UCFR. Fishery changes include reduced trout numbers and changes in species composition. Because of these negative impacts, angling use of the Clark Fork River is lower comparable to other rivers in western Montana. Extensive remediation and restoration efforts are underway, and these efforts aim to mitigate historical mining and smelting damage to natural resources in the Upper Clark Fork River Basin (UCFRB). Effects of these actions have been dramatic in Silver Bow Creek, where remedial activities have allowed the return of trout after being extirpated for more than a century (Naughton 2013). The Silver Bow Creek fishery may continue to change in response to improvements in water quality, maturation of riparian vegetation, natural changes in river morphology, tributary restoration projects, flow enhancements, etc. Remedial efforts on the mainstem of the Clark Fork River are more recent and the area slated for restoration projects is vast (see Saffel et al. 2018). Thus, monitoring fisheries responses to restoration needs to be done at multiple spatial and temporal scales (Geum Environmental 2015).

In the past, fisheries data collection was conducted sporadically in the UCFRB. From 2008 to 2010, FWP biologists established long term monitoring sections on the mainstem UCFR. FWP has completed population estimates in these sections each of the subsequent years. These mainstem population surveys provide a dataset that can be used to evaluate the mainstem Clark Fork River fishery before, during, and after restoration and remediation actions. Annual fisheries surveys in Silver Bow Creek began as early as 2002 when the first suckers and sculpin were detected at the Rocker section. Silver Bow Creek surveys initially consisted of one-pass electrofishing conducted in the fall. In 2014, more sections were added, and sampling occurred in both spring and fall. In 2015, the first fish population estimates were attempted on Silver Bow Creek, both in spring and fall. The spring sampling was shifted to summer from 2016-2018 and population estimates were conducted in summer and fall at six sections. The summer sampling is conducted during low flows and high-water temperatures. Low dissolved oxygen has been documented in the past during the summer and hypoxic areas of Sliver Bow Creek tend to be devoid of trout during this period (Naughton 2013). Fall sampling is focused on evaluating fish numbers and distribution when water temperatures have cooled, and dissolved oxygen concentrations are more favorable to fish.

Multiple tributaries have been identified as priorities for restoration in the UCFRB (Saffel et al., 2018). Preliminary data on species composition and distribution were collected in multiple watersheds during the late 2000s (Lindstrom et al. 2008, Liermann et al. 2009). Population estimate sections were established in priority tributaries and these sections were sampled every year from 2015-2017. Larger streams (Warm Springs Creek, Little Blackfoot River, and Flint Creek) are now sampled semi-annually, while smaller tributaries are sampled periodically.

As restoration projects have been completed in the tributaries, there has been increased opportunities to evaluate these projects and their fisheries benefits. However, due to the sheer number of restoration projects in the UCFRB, not all projects can be specifically monitored. This limitation requires the careful

prioritization of project-level monitoring effort. To date, project monitoring has focused on getting pre- and post- project fisheries data on large projects (i.e., the Allendale Canal), gathering data on different restoration approaches, or evaluating the potential for projects to provide benefits to fish. In this report, we describe project level monitoring in Spotted Dog Creek, Cottonwood Creek and at the Allendale Canal fish screen project.

Clark Fork River Mainstem

Population surveys

Trout population estimates are conducted in spring at seven established sections on the Clark Fork River. These sections are sampled annually by FWP and are referred to as Bearmouth, Morse Ranch, Phosphate, Williams Tavenner, Below Sager Lane, PH Shack to Perkins Lane, and PH Shack (Figure 1). In addition to the annual sampling sections, we were scheduled to complete population estimates for the entire river from Warm Springs to Rock Creek in 2020. Due to the pandemic, this "all river" sampling was not completed. Instead, we chose to conduct targeted sampling in three sections of reach A in areas of recent or upcoming remediation (Map 1). The Perkins to Galen section was added in 2019 to provide additional baseline trout population in phases 3 and 4, which are currently being remediated. Perkins to Galen is also the section where a fish kill was documented in fall of 2019 (Cook and Elam 2019). The Grant-Kohrs and Galen to Racetrack sections were added in 2018 and 2019, respectively, to provide additional post-remediation data in phases 5, 6, 15 and 16. Perkins to Galen and Galen to Racetrack were sampled in the spring and Grant Kohrs was sampled in the fall in 2018 and 2020. All three sections are now sampled in the spring.

Fish were collected using aluminum drift boats with a mounted electrofishing unit, two front boom anodes and one netter. Estimates were made using two marking runs and two recapture runs. Recapture runs were completed 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 Montana Fish, Wildlife and Park's Fisheries Information System. Estimates were calculated for trout species that had a minimum of 4 marked fish recaptured (B. Liermann, Montana, Fish, Wildlife, and Parks, personal communication, 2014).

<u>Annual Sections</u>

The brown trout estimate at the PH Shack section in 2022 was 80 fish/km. The 2022 estimate was well below the 15-year average for this section of 324 fish/km. The highest estimate during the last 15 years at PH Shack occurred in 2013 when the brown trout population was at 1,167 fish/km. The brown trout population at PH Shack declined by 85% from 2013 to 2015 and has remained under 200 fish/km since 2017. At the PH-Shack-to-Perkins Lane section, the 2022 brown trout estimate was 83 fish/km, which is down from 93 fish/km in 2021. At the Below Sager Lane section, the 2022 estimate was 76 fish/km, similar to the 84 fish/km in 2021. At the Williams-Tavenner section, the 2022 brown trout estimate was 197 fish/km, the highest estimate since 2017 after four straight years of declines. The westslope cutthroat estimate for 2022 was 19 fish/km, an increase from 2021 and the third consecutive year with an estimate. Estimates for westslope were unable to be produced from 2014-2019 due to low capture

and recapture numbers. The 2022 brown trout estimate is above the long-term average of 186 fish/km. Brown trout numbers at Phosphate were 165 fish/km in 2022, which is an increase from 2021 but still below the section average of 199 fish/km. The 2022 brown trout estimate at the Morse Ranch section was 92 fish/km, which is an increase from 2021 and above the long-term average of 83 fish/km. The 2022 combined *Oncorhynchus* (westslope cutthroat trout, rainbow trout, and hybrids) estimate at Morse Ranch was 6 fish/km, which is within the historical range of *Oncorhynchus* estimates for this section. At the Bearmouth section, the 2022 brown trout estimate was 52 fish/km, which is above the average estimate of 31 fish/km and double the 2021 estimate. The 2022 *Oncorhynchus* estimate at Bearmouth was 56 fish/km, double the long-term average of 27 fish/km. It should be noted that sampling conditions were less than favorable in the Morse Ranch and Bearmouth sections with low, clear water. Confidence intervals of the estimates for these two sections were very large, although the pattern of increasing brown trout numbers is the same at the lower four sections. Most sections are below the long-term averages, but all sections were either near or above the five-year average. The five-year average is below the long-term average at all sites except for Bearmouth (Table 1).

Targeted Sampling

Targeted sampling has been conducted at two sites since 2009 and at a third site since 2018.
The Perkins to Galen section has been sampled six times since 2009 and annually since 2019(Figure 2). It was sampled again in 2022 to continue monitoring the area where the fish kill occurred in 2019 and where erosion control measures were installed on some slickens to help avoid future fish kills. There is also a need to continue monitoring this section to assess the remediation that began in 2021. The 2022 brown trout estimate for this section was 146 fish/km, which is about triple the estimate from 2021, and the highest estimate on record for this section (Table 2).

Remediation in the Galen to Racetrack section was completed in 2016. This section has been monitored six times since 2009 and annually since 2019 (Figure 2). The 2022 brown trout population estimate for this section was 55 fish/km which is up slightly from 41 fish/km in 2021. Low sampling efficiency and low numbers of recaptured fish continue to complicate statistical comparisons to past estimates at this section, but brown trout numbers do appear down since 2015 (Table 2).

The section in the Grant Kohrs Ranch was sampled in 2018 prior to remediation and 2020 during the late stages of remediation. This section has been done annually since 2020 (Figure 2). The 2018 brown trout estimate was 154 fish/km and the 2020 estimate was 402 fish/km. The 2020 estimate should be interpreted with caution due to low capture efficiency and recapture rate. As a result of low sampling efficiency, the 95% confidence interval for the 2020 estimate at Grant Kohrs is 166-638 fish/km. For 2021, extra mark and recapture events were used to improve capture efficiency and recapture rate. The estimate for brown trout in 2021 was 67 fish/km with a 95% confidence interval of 48-97 fish/km. It should be noted that the 2018 and 2020 estimates were done in the fall while the 2021 and 2022 estimates were done in the spring. The estimate in 2022 was 132 fish/km which is double the estimate from 2021 (Table 2).

Discussion

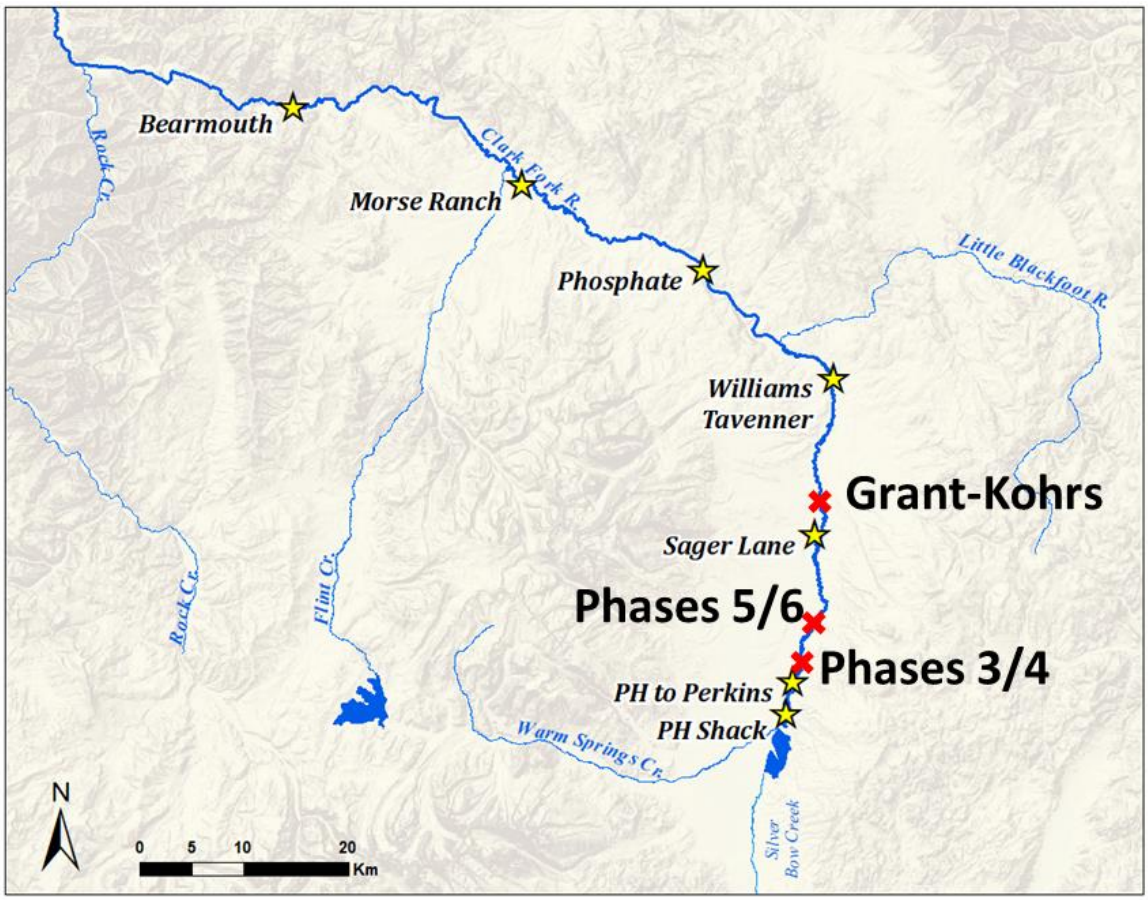
The brown trout population in the upper reaches of the Clark Fork River are near historic lows. The decline in brown trout numbers is particularly pronounced in sampling reaches upstream of Deer Lodge. It was noted in 2020 that estimates were closer to long term averages in lower reach B and reach C compared to reach A. But in 2021 estimates at Williams-Tavenner, Phosphate, and Morse Ranch were also below average. At those same sites in 2022, brown trout estimates increased and surpassed the long-term average in all but the Phosphate section. Estimates in all four sections were above the five-year average and all increased from 2021. The estimates for brown trout at the upper three sites, Below Sager Lane, pH Shack to Perkins Lane and pH shack, all remained below the long-term average and were lower than 2021. All three however were at or above the five-year average. The cause for the population crash is not fully understood. Based on an otolith microchemistry study (Cook et al. 2017), the brown trout population upstream of Deer Lodge is heavily dependent on recruitment of fish that were spawned and reared in the mainstem Clark Fork River. Historically, variations in the brown trout population in the upper reaches of the Clark Fork River were tied to flows. Prior to the last few years, the number of age 3 fish captured during electrofishing (an index of recruitment) at the pH Shack Section was strongly related to flow conditions three years prior. Minimum flow during the brown trout's first year of life apparently had a significant effect on their survival. From 2002 to 2017, recruitment of age 3 brown trout could be predicted based on previous flow conditions with high precision (r^2=0.85). However, since 2018 previous flow conditions are no longer a strong predictor of brown trout numbers in the UCFR.

Several recent developments could be impacting trout numbers in the upper reaches of the Clark Fork River. Reaches of the river above Deer Lodge have extensive slickens and the erosion of these slickens into the river has accelerated in recent years (MTFWP and Clark Fork Coalition 2020). The increased input of metal-laden slicken material into the river is likely having deleterious effects on the population. The documented fish kill in 2019 confirmed the lethality of slicken material, not only to trout, but also to mountain whitefish and suckers. Erosion control measures that were installed in 2020 should help to buy time until mine tailings can be removed from the floodplain and banks. However, eroding slickens exist outside of phases 3 and 4 and remediation will not reach some of them for years. High risk slickens should continue to be monitored and mitigation measures should be considered to buy time until cleanup is completed.

Another recent development in the Clark Fork River above Deer Lodge is the remediation itself. Along with removing tailings material, remediation also removes most of the overhanging vegetation and undercut banks. Overhanging vegetation and undercut banks provide cover for brown trout and other fish species. These habitat features will eventually reform after remediation, but it is possible that habitat simplification is contributing to the decline in trout numbers in the UCFR. FWP has started doing more targeted sampling to understand changes in trout numbers in remediated and unremediated parts of the river. Our data show that declines in brown trout numbers have occurred in both remediated and unremediated reaches of the river. Brown trout estimates over the last several years seem to have stabilized at all monitoring sections. All sections are at or above the five-year average, although most are still below the long-term average except for Bearmouth, Morse Ranch and Williams-Tavenner. In 2022 Bearmouth, Morse Ranch, Phosphate, and Williams-Tavenner all had brown trout estimates

increase compared to 2021 while Sager Lane, pH Shack to Perkins, and pH Shack all declined. While habitat simplification will affect fish, particularly at a local scale, it is apparent that other factors have contributed to a more widespread decline.

It is also possible that disease, changing environmental conditions, or a combination of other factors could be responsible for the decline in trout numbers in the UCFR. Brown trout declines have also recently been reported on the Big Hole, Beaverhead, Ruby, Jefferson, and Madison rivers. FWP does not currently understand why brown trout declines are occurring at a regional, or even state-wide scale, but conducted a statewide study to investigate factors such as drought, disease, angling pressure, high temperatures and other culprits. None of the variables evaluated in this study were found to be strong predictors of recent brown trout population trends at a statewide or regional scale (Cline et al. 2022). Whatever factors are affecting other Montana brown trout fisheries, some challenges such as acute metal contamination and remedial habitat simplification are unique to the UCFR.



Map 1. Map of sections of the Upper Clark Fork River sampled in 2020. Established annual sections are denoted by the yellow stars and sections targeting remediation by the red Xs. The Perkins to Galen section is within phases 3/4, the Galen to Racetrack section is within 5/6, and the Grant Kohrs Ranch is within 15/16.

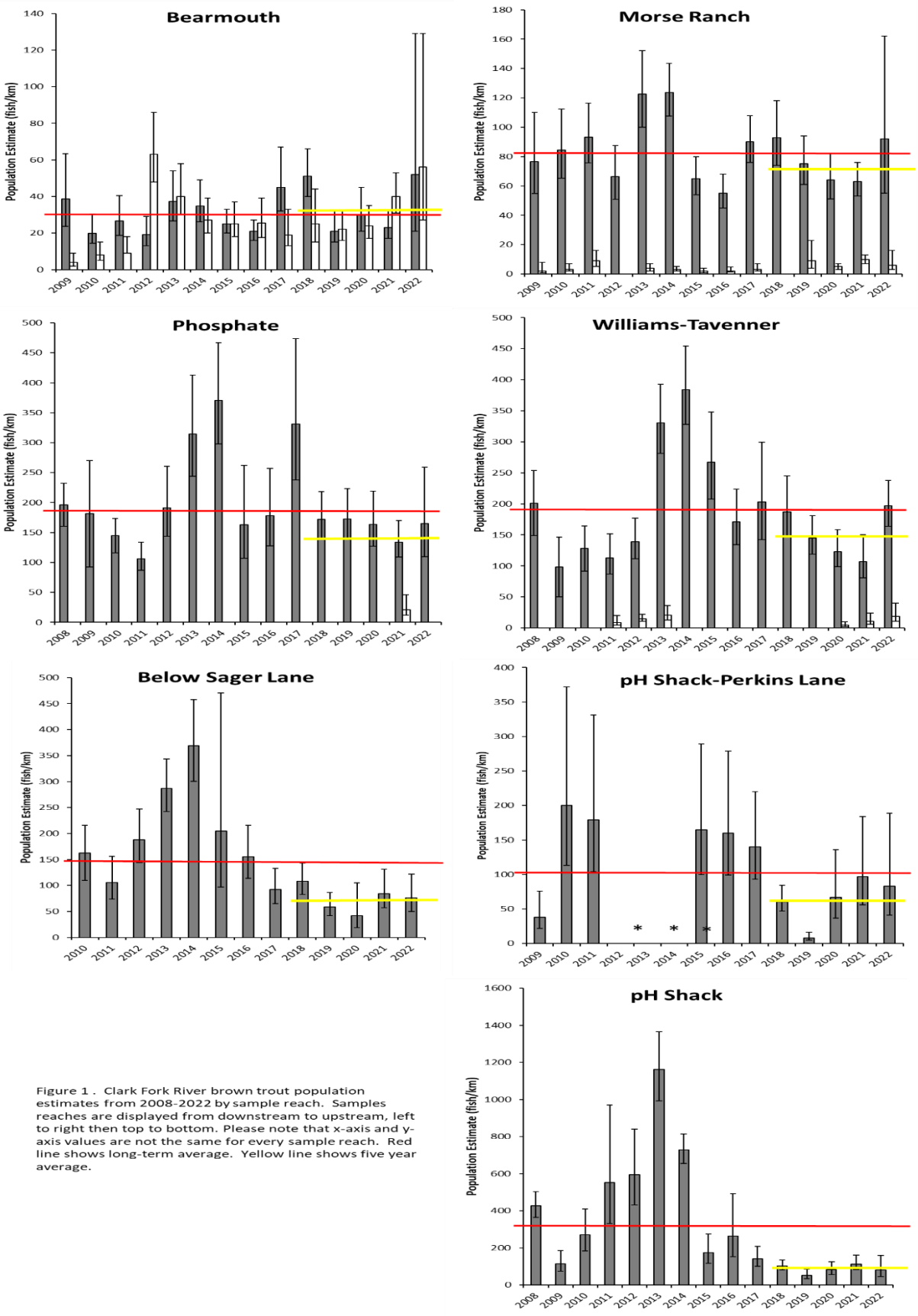


Figure 1 . Clark Fork River brown trout population estimates from 2008-2022 by sample reach. Samples reaches are displayed from downstream to upstream, left to right then top to bottom. Please note that x-axis and y-axis values are not the same for every sample reach. Red line shows long-term average. Yellow line shows five year average.

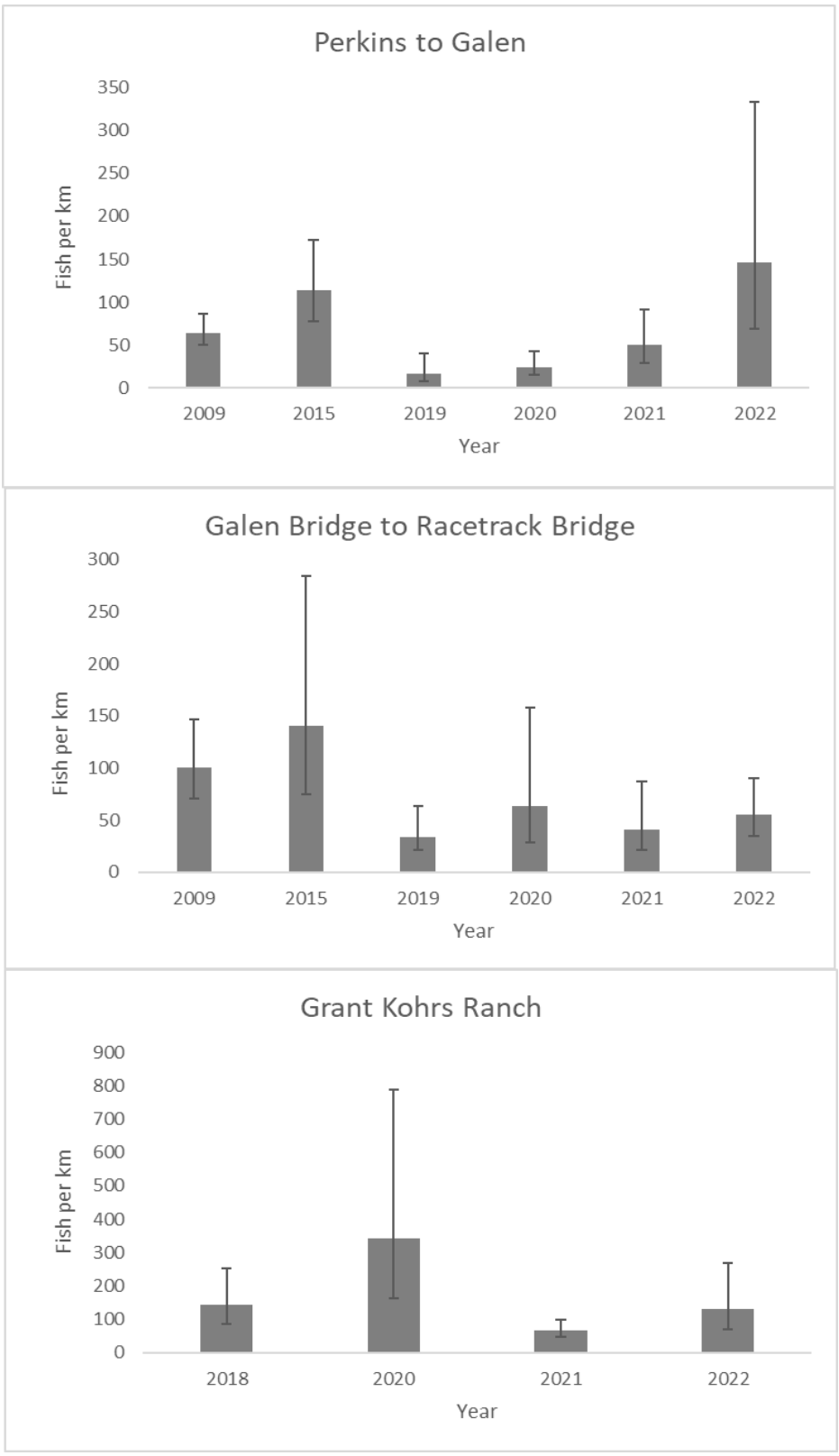


Figure 2. Brown trout population estimates at three sampling reaches targeting remediation in the Upper Clark Fork River.

Table 1. Electrofishing data collected in Spring 2022 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. Estimates for mountain whitefish greater than 175 mm were done at three sites. Species abbreviations: LL = Brown Trout, WCT = Westslope Cutthroat Trout, RB = Rainbow Trout, BULL = Bull Trout, RBXWCT = phenotypic hybrid between Rainbow Trout and Westslope Cutthroat Trout, LS SU = Large Scale Sucker, MWF = Mountain Whitefish.

Section	Species	Population Estimate (fish/Km)	# Fish Handled	Mean Length (mm)	Length Range (mm)
Bearmouth	BULL		1	460	460
RM 254-260	LL	52(21-129)	89	346	188-560
	RB	29(9-58)	49	332	186-453
	RBXWCT		19	358	250-443
	WCT	23(11-56)	45	329	180-402
	LS SU		3	271	157-473
	MWF	482(295-835)	540	350	147-485
Morse Ranch	BULL		1	275	275
RM 274-280	LL	92(55-162)	217	337	177-532
	RB		2	393	367-419
	WCT	6(3-16)	23	329	215-420
Phosphate	BULL		1	442	442
RM 287-289	LL	165(110-259)	190	316	100-474
	RBXWCT		1	367	367
	WCT		9	335	255-422
	MWF	576(464-722)	639	327	191-464
Williams	LL	197(164-238)	447	361	128-520
Tavenner	EB		4	266	239-292
RM 306-308	RB		1	204	204
	RBXWCT		1	379	379
	WCT	19(11-40)	37	343	276-416
Below Sager	LL	76(50-122)	166	327	100-514
Lane	EB		2	243	212-273
RM 315-318	MWF	536(465-622)	1110	326	150-475
PH Shack to	BULL		1	411	411
Perkins Ln.	LL	83(41-189)	63	323	112-487
RM 337-338	RB		1	405	405
	WCT		1	347	347
pH Shack	LL	80(45-158)	82	328	87-665
RM 338-339.5	RB		7	417	380-451
	WCT		1	479	479

Table 2. Electrofishing data collected in Spring 2022 from three targeted sampling sections on the Upper Clark Fork River. Population estimates (95% confidence interval) are for trout greater than 175 mm (~ 7") in total length. Species abbreviations: LL = Brown Trout, WCT = Westslope Cutthroat Trout, BULL = Bull Trout.

Section	Species	Population Estimate (fish/Km)	# Fish Handled	Mean Length (mm)	Length Range (mm)
Perkins to Galen RM 333-336	LL	146(69-333)	298	222	82-521
	WCT		1	322	322
Galen to Racetrack RM 329-332	BULL		1	333	333
	LL	55(35-90)	174	299	100-541
	EB		1	272	272
Grant Kohrs Ranch RM 312-314	LL	132(71-267)	135	378	141-537
	WCT		2	355	322-387

CPUE Sites

Catch Per Unit Effort (CPUE) surveys have been conducted at three monitoring sites in the upper Clark Fork River. All sections are approximately one mile long and are done within the long-term monitoring sites at Bearmouth, Phosphate and Below Sager Lane. Two sites (Phosphate and Below Sager Lane) have CPUE data from 2014-2019 while the Bearmouth site has continued to be surveyed yearly. For the CPUE surveys, a portion of the mark/recapture section is surveyed, and all fish species are netted and recorded. This data can be used to determine species composition in the Clark Fork River, however, it should be noted that even though a certain fish species is not captured doesn't mean it isn't present. In Table 3 below, species composition is shown as a percentage of fish captured. A 0% should be interpreted as low abundance or low capture efficiency as opposed to not present. Mountain whitefish are the most captured fish in all three sections. Brown trout are the most captured trout in all three sections.

Table 3. Percentage of fish captured at three CPUE sections on the Upper Clark Fork River. These sections are long-term mark/recapture estimate sections. All fish species are netted in a portion of each section to determine species composition.

Section	Species	2014	2015	2016	2017	2018	2019	2020	2021	2022	Average
Bearmouth CPUE	BULL	n/a	0%	0%	1%	0%	0%	0%	0%	0%	**0%**
	LL	n/a	11%	8%	8%	4%	2%	6%	7%	13%	**7%**
	LN SU	n/a	1%	1%	0%	0%	0%	0%	0%	0%	**0%**
	LS SU	n/a	16%	8%	3%	19%	7%	10%	8%	4%	**9%**
	MWF	n/a	63%	83%	84%	74%	85%	80%	72%	70%	**76%**
	N PMN	n/a	1%	0%	1%	1%	0%	0%	1%	0%	**0%**
	RB	n/a	6%	1%	3%	3%	3%	0%	3%	6%	**3%**
	RBXWCT	n/a	0%	0%	0%	0%	1%	3%	2%	0%	**1%**
	RM COT	n/a	1%	0%	0%	0%	0%	0%	1%	0%	**0%**
	RS SH	n/a	0%	0%	0%	0%	1%	0%	4%	0%	**1%**
	WCT	n/a	1%	0%	1%	0%	1%	1%	3%	7%	**2%**
Jens CPUE	LL	29%	n/a	17%	20%	19%	19%	n/a	n/a	n/a	**21%**
	LN DC	0%	n/a	1%	0%	0%	0%	n/a	n/a	n/a	**0%**
	LN SU	0%	n/a	0%	1%	0%	1%	n/a	n/a	n/a	**0%**
	LS SU	5%	n/a	4%	3%	10%	2%	n/a	n/a	n/a	**4%**
	MWF	64%	n/a	76%	76%	70%	77%	n/a	n/a	n/a	**73%**
	RBXWCT	0%	n/a	0%	0%	0%	0%	n/a	n/a	n/a	**0%**
	RM COT	0%	n/a	0%	0%	1%	1%	n/a	n/a	n/a	**0%**
	RS SH	0%	n/a	0%	0%	0%	0%	n/a	n/a	n/a	**0%**
	WCT	0%	n/a	1%	2%	1%	1%	n/a	n/a	n/a	**1%**
Above Deer Lodge CPUE	EB	0%	n/a	0%	0%	0%	0%	n/a	n/a	n/a	**0%**
	LL	14%	n/a	5%	13%	16%	14%	n/a	n/a	n/a	**13%**
	LN DC	0%	n/a	0%	0%	0%	1%	n/a	n/a	n/a	**0%**
	LN SU	0%	n/a	0%	0%	0%	0%	n/a	n/a	n/a	**0%**
	LS SU	15%	n/a	40%	34%	32%	39%	n/a	n/a	n/a	**32%**
	MWF	70%	n/a	55%	52%	52%	46%	n/a	n/a	n/a	**55%**

Silver Bow Creek

Sampling strategy

Fisheries monitoring in Silver Bow Creek began in earnest when the first fish (suckers and sculpins) were documented near Rocker in 2002. As fish populations expanded in response to remediation, fish monitoring efforts also expanded. Over the years most fish surveys have occurred during the fall. However, spring surveys were conducted at the Father Sheehan Section in 2005 and 2007-2014 and in the summer of 2015. Both spring and fall surveys were conducted at multiple sections in 2014 and 2015. Spring sampling was moved to summer starting in 2016. Summer sampling was done to document fish numbers and distribution during the period of warm water temperatures. The fall sampling was designed to represent a period when high water temperatures were no longer limiting to trout. Since 2015, sampling was conducted using two backpack electrofishers. From 2015-2018, we attempted to get population estimates (Zippin 1958) in both summer and fall, but this proved difficult in some sections due to low fish densities and deep water. Instead, we report counts of fish captured, standardized by electrofishing time (referred to as Catch Per Unit of Effort or CPUE). CPUE during fall through time can be found in Table 6. Starting in 2019, fish sampling was further complicated by an increase in water conductivity caused by releases of treated mine water in Butte. The high conductivity is due to the addition of lime during the treatment process and this increase was significant enough to reduce the

efficacy of using electrofishing to capture fish. Thus, fish capture data from 2019 on may not be directly comparable to previous years for sections downstream of Butte. To increase capture efficiency in 2020, a generator-powered, barge-mounted electrofishing unit was used on the German Gulch and Fairmont sections instead of backpack electrofishers. These two sections have especially fast water and deep pools that, combined with increased water conductivity, were very difficult to sample with backpack units.

Sampling summary

For the 2022 monitoring year, six sections were sampled in Silver Bow creek. Single pass backpack electrofishing samples were conducted at HWY 1, Ramsay, Rocker and LAO. In the past these sections have been done in both the summer and fall. In 2022, due to low flows and elevated water temperatures, CPUE surveys on these sections were only conducted in the fall (Table 6). Mark recapture estimates were done at the Fairmont and German Gulch sections in the fall as well using the barge-mounted electrofisher. The most downstream section is just above the HWY 1 bridge (Map 2).

The HWY 1 section is characterized by consistently low trout densities, comprised of rainbow trout, westslope cutthroat trout, and brook trout. Longnose and largescale suckers, rocky mountain sculpin, and redside shiners have also been captured at this section. Rainbow trout, longnose suckers, and sculpin were first detected at his section in 2008. Westslope cutthroat were first detected in 2010 at HWY 1. CPUE rates were about average for most species in the fall of 2022. Catch rates for brook trout and rocky mountain sculpin were slightly higher than the past several years.

The Fairmont Section was first sampled in 2014. The trout population in this section is comprised of westslope cutthroat trout, rainbow trout, and brook trout. Longnose and largescale suckers, rocky mountain sculpin, and redside shiners have also been captured at this section. A mark-recapture estimate was done in September 2020 in an expanded section at Fairmont. This sampling yielded a westslope cutthroat estimate of 108 fish/km of fish greater than 150 mm. Only 13 brook trout greater than 150 mm were captured and 29 brook trout less than 150 mm were captured. There were too few recaptures to obtain valid estimates. The Fairmont mark/recapture estimate was repeated in 2022 and it was possible to estimate the number of both brook trout and westslope cutthroat. For brook trout and westslope greater than 150mm, the sampling yielded a brook trout estimate of 68 fish/km and a westslope estimate of 70 fish/km. Unlike 2020, many more brook trout were captured in all size classes in 2022. In 2022, 270 brook trout less than 150 mm and 89 brook trout greater than 150 mm were captured. After analyzing the data, fish greater than 100 mm can effectively be captured by the electrofishing gear being used. Moving forward, fish estimates will be done for fish greater than 100 mm when possible. The 2022 estimate for brook trout greater than 100 mm was 527 fish/km and the estimate for westslope greater than 100 mm was 74 fish/km (Table 5).

The German Gulch section has the highest densities of westslope cutthroat trout during the summer of all Silver Bow Creek sampling sections. Catch rates of both westslope and brook trout in the fall tend to be lower in the German Gulch Section compared to summer. This fall reduction in trout catch rates can be attributed to fish redistributing to other parts of Silver Bow Creek as water temperatures cool down. Other species captured in the German Gulch Section of Silver Bow Creek include longnose suckers, rocky

mountain sculpin, and central mudminnow. A mark-recapture estimate was done in September 2020 in an expanded section below German Gulch. This sampling yielded a westslope cutthroat estimate of 152 fish/km and a brook trout estimate of 51 fish/km for fish greater than 150 mm for both species. Estimates of other species could not be generated due to low numbers of recaptures. The German Gulch section was not sampled in 2021. The German Gulch mark/recapture estimates were repeated in 2022 and estimates for westslope were 77 fish/km and estimates for brook trout were 28 fish/km for fish greater than 150 mm. As with the Fairmont section, we will transition to estimating fish greater than 100 mm when possible. The 2022 brook trout estimate was 32 fish/km and the westslope estimate was 100 fish/km for fish greater than 100 mm (Table 5).

Suckers and sculpin were first found in the Ramsay section in 2005 and trout were first captured in fall 2007. Summer sampling at Ramsay was started in 2016. The Ramsay section was characterized by moderately high trout densities during the fall and low densities during the summer through 2020. Trout catch rates during the fall (2016-2019) at Ramsay are like catch rates at the sampling section below German Gulch (Figure 3). However, during summer sampling trout catch rates at Ramsay go down while catch rates go up at German Gulch. Although these sites are still sampled, the catch rate data is no longer comparable since the sampling technique was changed at the German Gulch section in 2020. One brown trout was captured in the Ramsay section in fall of 2016, which is the only documented occurrence of brown trout in the Silver Bow basin upstream of the fish barrier. The increase in water conductivity following the discharge of treated Berkeley Pit water began in 2019 brings into question whether electrofishing efficiency is affecting fish capture rates. Although the Ramsay section has held relatively high numbers of westslope cutthroat trout in the past during the fall, westslope CPUE was down dramatically in fall of 2020 and no westslope were captured in the section in 2021. This trend continued in 2022 and no westslope were captured in the Ramsay section. Capture rates for brook trout and longnose suckers increased in 2022 so it appears that electrofishing efficiency may not be to blame for the lack of westslope captures.

At the Rocker section, low numbers of trout are typically captured in both the spring and fall sampling. Westslope cutthroat trout were first captured at the Rocker section in 2010 and brook trout were first captured in 2011. However, no trout were captured at Rocker in the fall of 2021. No westslope cutthroat trout were captured here in 2022, but many more brook trout were captured than in previous years. Capture rates of longnose suckers continue to be low compared to previous years and rocky mountain sculpin continue to be the most abundant.

Longnose suckers, sculpin, and central mudminnow were captured during the first survey of the LAO section in 2005. Brook trout were first captured at LAO in 2007 and westslope cutthroat trout in 2009. Brook trout tend to outnumber westslope in this section. Trout catch rates are higher during the fall sampling compared to summer sampling, suggesting trout move in and out of this part of Silver Bow Creek as conditions change with the seasons. Catch rates of brook trout, westslope cutthroat, longnose suckers, and rocky mountain sculpin in the fall of 2022 were within range of previous years' surveys.

Discussion

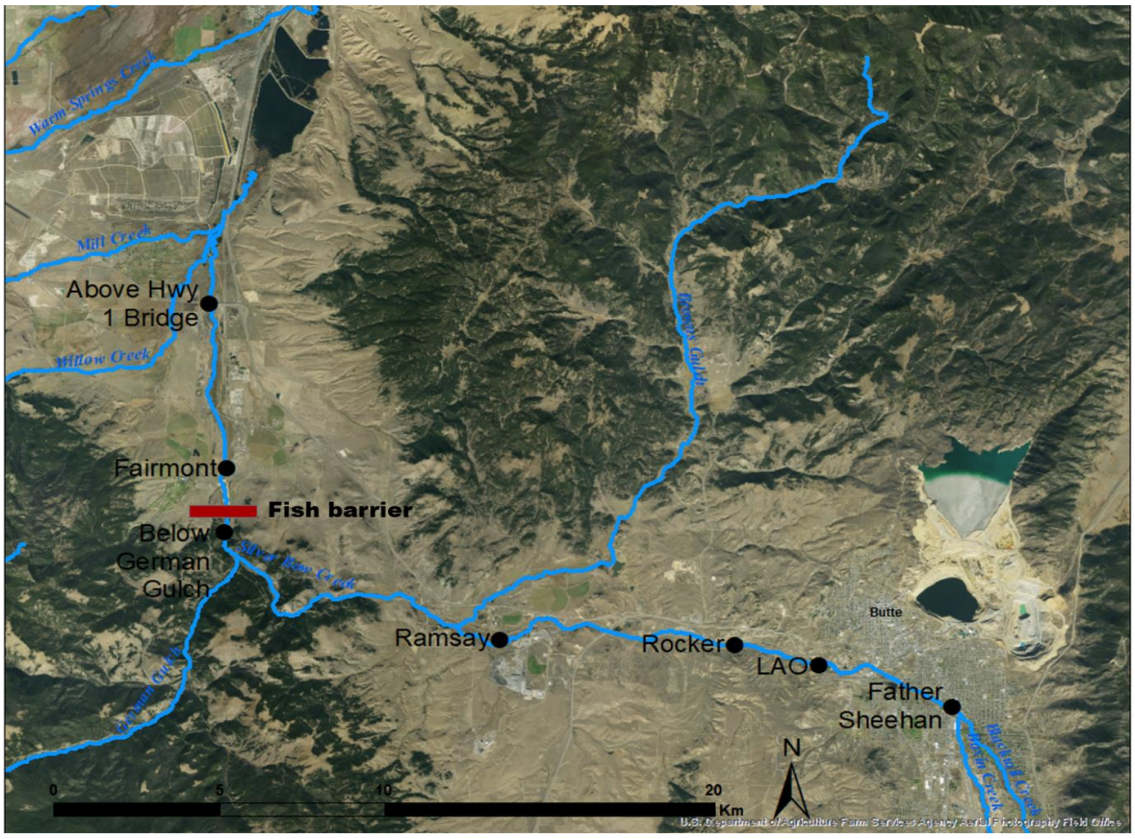
Prior to the start of remedial actions in 1999, Silver Bow Creek was considered fishless. Suckers and sculpin first recolonized Silver Bow Creek followed by brook trout and westslope cutthroat trout. Tributaries were less impacted by mine waste and metals contamination and have served as a source of fish recruitment to mainstem Silver Bow Creek. German Gulch is a critical spawning stream for westslope cutthroat and brook trout. Given the high numbers of brook trout in the Father Sheehan section, it is likely that Blacktail Creek is a source of trout to the upper reaches of Silver Bow Creek. Blacktail Creek is also a potential source of westslope cutthroat trout, which are common in the upper reaches of the tributary. Compared to Father Sheehan, the LAO section holds far fewer trout, even though it is only about 3 miles downstream. At the Rocker section, which is about 2 miles downstream of LAO, trout are even less abundant. Cleanup of metals contamination has allowed fish to become established throughout Silver Bow Creek and enabled the establishment of substantial trout populations in certain parts of the creek (i.e., immediately downstream of German Gulch). However, habitat and water quality (i.e. temperature and dissolved oxygen) conditions in much of Silver Bow Creek within and immediately downstream of Butte are not conducive to supporting trout fisheries year-round.

The Silver Bow Creek trout fishery is characterized by fish that concentrate near the mouths of German Gulch and Blacktail Creek. Westslope cutthroat trout especially concentrate in Silver Bow Creek near German Gulch in the summer because this tributary is a primary source of cold water. Westslope disperse away from German Gulch into areas such as Ramsay as water cools off during the fall. In the past, areas of Silver Bow Creek downstream of Butte have had low dissolved oxygen during hot summer nights (Naughton 2013), although DO conditions appear to have improved since the Butte wastewater treatment plant was improved in 2015 and 2016 (Nagisetty et al. 2019). However, nighttime DO concentrations are still dipping below water quality standards for typical trout bearing streams (i.e., 8 mg/L for class B streams: MT DEQ 2017). Limiting conditions in mainstem Silver Bow Creek should be investigated and eventually addressed to maximize the benefits of tributary restoration efforts on the mainstem fishery.

At the Ramsay section, fall catch rates of westslope cutthroat trout and brook trout in 2020 and 2021 were well below average. In fact, no westslope were captured in 2021, which was the first fall sampling at Ramsay without westslope since 2007. This trend continued in 2022 with no westslope being captured. This section has had high trout numbers during previous fall sampling periods, approaching numbers of the section below German Gulch (Figure 3). Sampling below German Gulch was changed to a mark/recapture estimate so the CPUE's are no longer comparable. It is unclear if reduced electrofishing efficiency due to a 2-3X increase in specific conductivity is responsible for the reduction in CPUE. It is also possible that trout are avoiding this part of Silver Bow Creek due to changes in water chemistry. During baseflow conditions, flows in this part of Sliver Bow Creek are approximately 50% treated water, much of which is treated Berkley Pit water. The effects of the Berkley Pit effluent, as well as effluent from municipal wastewater treatment should be thoroughly investigated.

Migratory fish, especially westslope cutthroat trout, provide a significant portion of the overall trout fishery in Silver Bow Creek. The importance of German Gulch as a source of migratory fish has been well established by tagging studies and population sampling. However, contributions of migratory individuals

from other tributaries are not as well understood. As restoration efforts progress on Brown's Gulch, Basin Creek, and Blacktail Creek, monitoring could be conducted to determine the prevalence of migratory fish from these tributaries and identify remaining impediments to fish passage.



Map 2. Map of seven annual fish sampling sections on Silver Bow Creek.

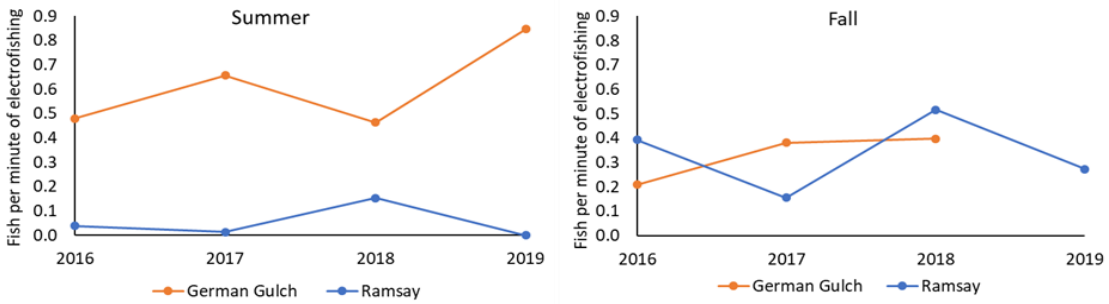


Figure 3. Catch rates (trout captured per minute of electrofishing) at the German Gulch and Ramsay sections of Silver Bow Creek. Catch rates of Westslope Cutthroat trout and Brook trout are combined. The German Gulch section was not sampled in fall 2019.

Table 4. Electrofishing data collected in Fall 2022 from annual sampling sections on Silver Bow Creek. Species composition for all sites. Single pass backpack electrofisher surveys at four sites. Data for Fairmont and German Gulch are fist pass with tote barge electrofisher. Species abbreviations: WCT = Westslope Cutthroat Trout, EB = Eastern Brook Trout, RB = Rainbow Trout, RBXWCT = phenotypic hybrid between Rainbow Trout and Westslope Cutthroat Trout, LS SU = Large Scale Sucker, LN SU = Longnose Sucker, RM COT = Rocky Mountain Sculpin, RS SH = Redside Shiner, CM MN = Central Mudminnow.

Section	Species	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Above Hwy 1	EB	9	115	92-141	9
Bridge	LN SU	3			3
RM 8.0	LS SU	33	151	52-250	31
	RB	2	258	236-279	2
	RM COT	36	65	29-101	34
	RS SH	22	89	67-111	21
Fairmont M/R	EB	191	155	77-467	43
RM 12.0	LN SU	42	190	92-288	9
	RB	5	223	100-376	1
	RBXWCT	1	217	217	<1
	RM COT	111	83	40-126	25
	RS SH	47	101	72-129	11
	WCT	44	220	58-395	10
German	EB	14	213	76-408	21
Gulch M/R	LN SU	9	124	91-186	13
RM 13.0	RM COT	21	79	40-102	31
	WCT	24	196	107-336	35
Ramsay	EB	6	198	89-333	8
RM 20.5	LN SU	28	125	50-199	37
	RM COT	41	81	41-121	55
Rocker	CM MN	1	100	100	<1
RM 25.5	EB	13	128	109-148	13
	LN SU	12	153	110-196	12
	RM COT	76	88	47-129	75
LAO	CM MN	1	114	114	1
RM 27.4	EB	9	163	101-263	12
	LN SU	1	67	67	1
	RM COT	64	73	39-106	83
	WCT	2	257	257-258	3

Table 5. Electrofishing data collected in Fall 2022 from annual sampling sections on Silver Bow Creek. Mark/recapture population estimates (95% confidence interval) at two sites are for trout greater than 100 mm (~4") in total length. Species abbreviations: EB = Eastern Brook Trout, WCT = Westslope Cutthroat Trout.

Section	Species	Population Estimate (fish/Km)	# Fish Handled	Mean Length (mm)	Length Range (mm)
Fairmont M/R RM 12.0	EB	527(413-688)	317	155	100-485
	WCT	74(52-118)	70	235	100-423
German Gulch M/R RM 13.0	EB	32(20-62)	28	191	100-408
	WCT	100(64-167)	61	194	100-413

Table 6. Fish captured per minute of electrofishing in seven sampling sections on Silver Bow Creek during fall surveys. Although it is not sampled in the fall and it is not within Silver Bow Creek, data from the Father Sheehan section of Blacktail Creek is included in this table to allow for comparison to other long-term datasets. Surveys at Father Sheehan were in done in spring prior to 2015 (spring data in grey) but were more recently conducted during August (bold) and October in 2022. Catch rates at the Ramsay section were likely reduced in 2020 due to high water conductivity (~1200 µc/cm).

Section	Species	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Father Sheehan	WCT	n/a	n/a	n/a	0	n/a	0	0	0	0	0	0	0.054	0	**0**	**0.012**	**0.012**	**n/a**	**0**	**0.029**	**n/a**	0
2002-2014 Spring	EB	n/a	n/a	n/a	1.140	n/a	1.398	2.154	3.528	3.876	3.438	7.080	7.621	3.337	**3.194**	**2.386**	**1.485**	**n/a**	**3.190**	**2.942**	**n/a**	2.889
After 2015 Summer	LN SU	n/a	n/a	n/a	0.600	n/a	1.290	0.306	0.042	0.408	0.186	0.192	0.027	0	**0.132**	**0.136**	**0.344**	**n/a**	**0.394**	**0.108**	**n/a**	0.141
	RM COT	n/a	n/a	n/a	2.280	n/a	2.910	2.154	1.548	1.122	1.242	1.440	0.403	0.303	**0.015**	**0.049**	**0.196**	**n/a**	**1.241**	**0.902**	**n/a**	0.294
	CM MN	n/a	n/a	n/a	0	n/a	0.852	0.408	0.258	0.168	0.078	0.030	0	0	**0**	**0.037**	**0.012**	**n/a**	**0.197**	**0.039**	**n/a**	0.071
	GDF	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**0.020**	**n/a**	0
LAO	WCT	n/a	n/a	n/a	0	0	0	0	0.030	0	0.042	0	0	0.037	0.026	0.081	0.083	0	0.071	0.102	0.049	0.045
	EB	n/a	n/a	n/a	0	0	0.060	0	0.066	0.570	0.438	0.198	0.117	0.225	0.103	0.190	0.083	0.092	0.024	0.102	0.073	0.200
	LN SU	n/a	n/a	n/a	7.200	1.860	0.846	0.996	0.618	0.258	0.042	1.512	0.381	0.037	0	0.027	0.111	0.642	0	0	0.024	0.022
	RM COT	n/a	n/a	n/a	0.444	4.140	4.668	2.772	2.256	0.858	0.120	2.778	2.490	0	1.806	1.520	0.473	0.275	0.686	1.223	1.168	1.425
	CM MN	n/a	n/a	n/a	0.096	0.084	0.204	0.144	0.228	0	0.042	0	0	0.037	0	0	0	0	0.024	0	0.073	0.022
Rocker	WCT	0	0	0	0	0	0	0	0	0.120	0.072	0	0.064	0	0.037	0	0.058	0.030	n/a	n/a	0	0
	EB	0	0	0	0	0	0	0	0	0	0.138	0	0	0.048	0.037	0.045	0.019	0.060	n/a	n/a	0	0.301
	LN SU	2.940	1.800	0.720	2.820	5.220	2.610	5.352	1.362	8.238	6.564	13.038	2.708	3.033	3.164	3.048	0.637	0.060	n/a	n/a	0.450	0.277
	RM COT	0.060	0.036	0.036	0	0.096	0.120	0	0.036	0.060	0	0.186	0	0	0.037	0	0.039	0.360	n/a	n/a	1.520	1.757
	CM MN	0	0	0	0	0	0	0	0	0	0	0	0	0	0.389	0.045	0	0	n/a	n/a	0	0.023
Ramsay	WCT	n/a	0	0	n/a	0	0	0.078	0.174	0.312	0.624	0.360	0.692	0.460	0.214	0.284	0.155	0.387	0.234	0.048	0	0
	EB	n/a	0	0	n/a	0	0.030	0.036	0	0.036	0	0	0.099	0.276	0.300	0.109	0	0.129	0.039	0.097	0.018	0.110
	LL	n/a	0	0	n/a	0	0	0	0	0	0	0	0	0	0	0.000	0	0	0	0	0	0
	LN SU	n/a	0	0	n/a	4.320	1.206	1.212	0.300	0.156	0.228	0.450	0.395	0.046	0.815	0.327	0.291	0	0.098	0.072	0.328	0.511
	RM COT	n/a	0	0	n/a	0.060	0.084	0.192	0.042	0	0	0.048	0.049	0.092	0.129	0.851	0.310	0.022	0.176	0.387	1.493	1.151
	CM MN	n/a	0	0	n/a	0	0	0	0	0	0	0	0	0.046	0	0	0	0	0	0	0	0
German	WCT(w/RB)	n/a	0	0	0	0	0.048	0.066	0.042	0.072	0.078	0.564	n/a	0.499	0.081	0.146	0.362	0.280	n/a	0.796	n/a	0.335
	EB	n/a	0	0	0	0.030	0.906	0.066	0.126	0.570	0.360	0.390	n/a	0.160	0.067	0.063	0.019	0.117	n/a	0.470	n/a	0.195
	LN SU (w/LS)	n/a	0	0	0.030	0.300	1.068	1.128	0.192	1.278	0.150	0.486	n/a	0.120	0.054	0	0	0	n/a	0.039	n/a	0.126
	RM COT	n/a	0	0	0.090	0.084	0.420	0.126	0	0.180	0.036	1.356	n/a	0.619	0.364	0.335	0.133	0.280	n/a	0.313	n/a	0.293
Fairmont	RB	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0.147	0.016	0	n/a	0.043	n/a	0.050
	WCT	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.402	0.091	0.213	0.441	0.221	n/a	0.745	n/a	0.442
	EB	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.369	0.195	0.213	0.063	0.080	n/a	0.292	n/a	1.921
	LN SU(w/LS)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.168	0.052	0.295	0.409	0	n/a	0.140	n/a	0.422
	RM COT	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.067	0.507	0.950	0.063	0.080	n/a	1.696	n/a	1.116
	RS SH	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.110	0	n/a	0.119	n/a	0.473
HWY 1	RB	n/a	n/a	n/a	n/a	n/a	n/a	0.072	0.108	0.192	0.042	0.048	0.272	0.036	0.019	0.116	0.083	0.068	n/a	n/a	0.040	0.040
(new section in 2012)	WCT	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0.048	0	0	0	0.109	0	0.116	0.062	0	n/a	n/a	0	0
	EB	n/a	n/a	n/a	n/a	n/a	n/a	0	0.036	0	0.078	0.198	0.194	0	0.057	0.070	0.041	0	n/a	n/a	0.040	0.178
	LN SU (w/LS)	n/a	n/a	n/a	n/a	n/a	n/a	0.420	0.036	0	0.078	0.048	0	0.036	0.057	0.046	0.021	0	n/a	n/a	1.943	0.711
	RM COT	n/a	n/a	n/a	n/a	n/a	n/a	0.534	0.216	1.998	0.312	1.080	0.155	0.253	0.439	0.279	0.021	0.045	n/a	n/a	0.341	0.711
	RS SH	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0	0	0	0	0	0.023	0	0	n/a	n/a	0.561	0.434

Blacktail Creek

Five sections were survey in Blacktail Creek in 2022 (Table 7). The most downstream site is located near Father Sheehan Park. A single pass electrofishing survey was conducted here, and the fish community was dominated by brook trout. Central mud minnow, longnose sucker and Rocky Mountain sculpin were also captured. Westslope cutthroat trout have been captured in past years, but none were captured in 2022. Depletion estimates on fish greater than 75 mm in length were conducted at the remaining four locations. At the golf course section at the Butte Country Club, the brook trout estimate was 395 fish/100 m. This is over double the previous estimate that was conducted in 2017. Estimates were not possible on other species. One westslope was captured here in 2022. At the three uppermost sites, estimates were possible on brook trout and westslope cutthroat trout. The brook trout estimate at the Above 9 Mile site was 26 fish/100 m and the westslope estimate was 32 fish/100 m. At the Upper Thompson site, the brook trout estimate was 26 fish/100 m and the westslope estimate was 37 fish/100 m. In the Upper Forest section, the brook trout estimate was 19 fish/100 m and the westslope estimate was 15 fish/100 m.

Table 7. Electrofishing data collected on Blacktail Creek in 2022. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = Westslope cutthroat trout, EB = Eastern Brook trout, RM COT = Rocky Mountain Sculpin, CM MN = Central Mud Minnow, LN SU = Longnose Sucker.

Section	Species	Population Estimate (Fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Father	CM MN		6	101	91-112	2
Sheehan Park	EB		246	140	73-386	85
Single Pass	LN SU		12	164	123-205	4
	RM COT		25	45	44-108	9
Golf Course	CM MN		2	112	92-131	<1
Butte C.C.	EB	395(377-413)	416	102	66-279	97
	LN SU		2	129	114-143	<1
	RM COT		7	65	32-97	2
	WCT		1	183	183	<1
Above 9 Mile	EB	26(25-28)	91	123	46-192	70
	WCT	32(31-33)	39	106	77-187	30
Upper	EB	26(24-28)	32	117	46-182	45
Thompson	WCT	37(35-39)	39	99	72-184	55
Upper Forest	EB	19(9-29)	29	85	42-132	39
	WCT	15(14-16)	46	79	55-163	61

Figure 4. First pass fish captures, and brook trout estimates at the Father Sheehan section of Blacktail Creek. First pass fish captures are for fish of all sizes. Brook trout estimates are for fish greater than 75 mm in length.

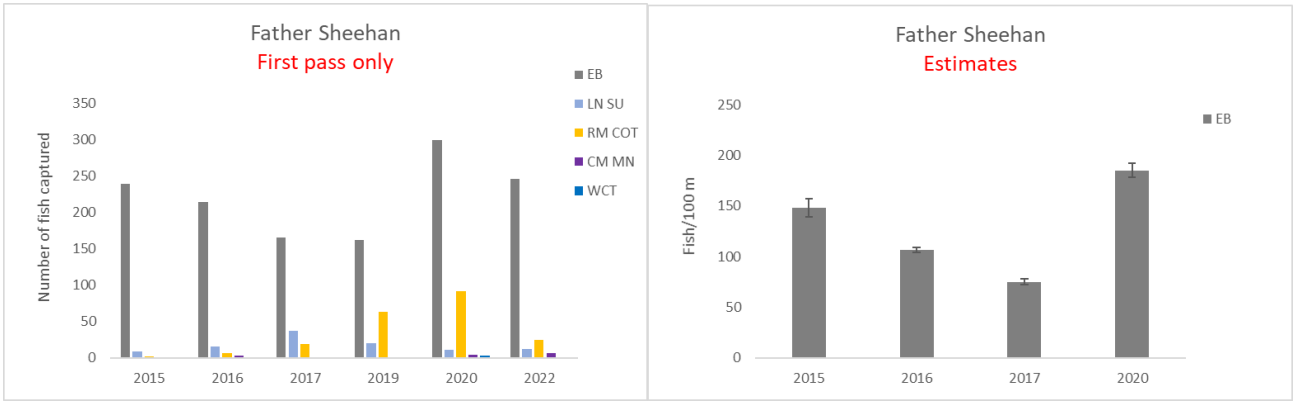
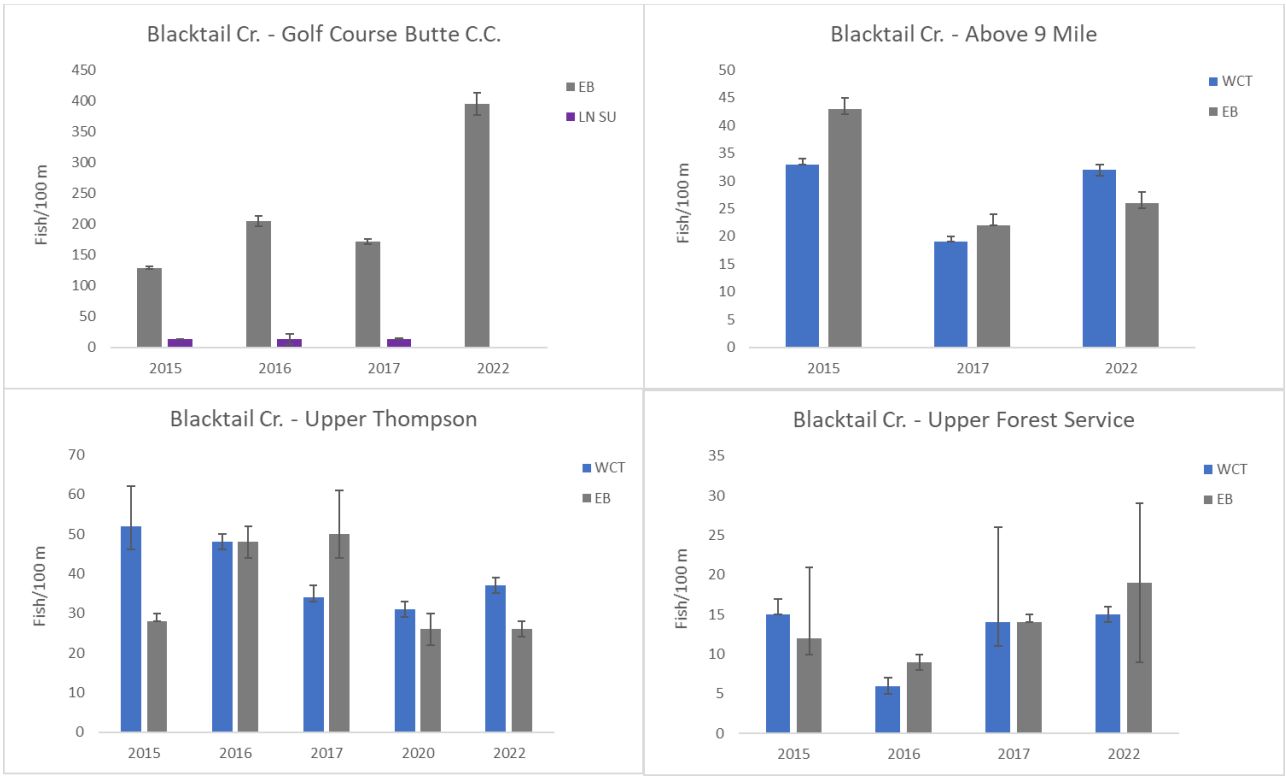


Figure 5. Westslope cutthroat trout and brook trout estimates at four sections of Blacktail Creek.



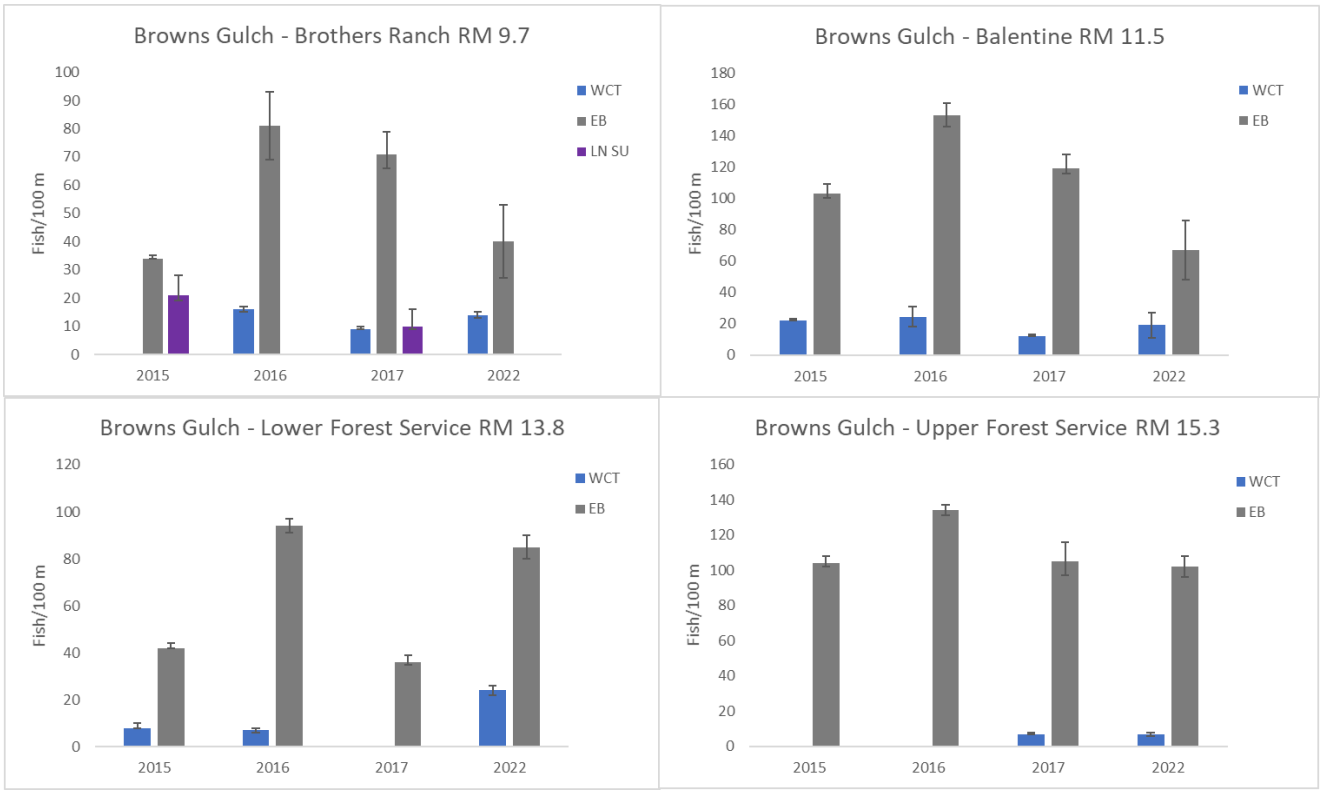
Browns Gulch

Depletion estimates were conducted for fish greater than 75 mm in length at four sites on Browns Gulch in 2022 (Table 8). The brook trout estimate at the Brothers Ranch RM 9.7 was 40 fish/100m and the westslope cutthroat trout estimate was 14 fish/100 m. At the Balentine RM 11.5 section, the brook trout estimate was 67 fish/100m and the westslope estimate was 19 fish/100m. The Lower Forest Service RM 13.8 site had a brook trout estimate of 85 fish/100m and a westslope estimate of 24 fish/100 m. The brook trout estimate at the Upper Forest Service RM 13.8 site was 102 fish/100 m and the westslope estimate was 7 fish/100 m. Brook trout numbers appear to be in decline at the lower two sections and stable or increasing at the upper two sites. Westslope cutthroat trout seem to be stable or increasing at all sites. Rocky Mountain sculpins were present at the lower two sites. Longnose suckers were only detected at the lowest site.

Table 8. Electrofishing data collected on Browns Gulch in 2022. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = Westslope cutthroat trout, EB = Eastern Brook trout, RM COT = Rocky Mountain Sculpin,LN SU = Longnose Sucker.

Section	Species	Population Estimate (Fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Brothers Ranch RM 9.7	EB	40(27-53)	39	124	48-236	43
	LN SU		15	109	90-128	16
	RM COT		23	89	62-116	25
	WCT	14(13-15)	15	137	74-185	16
Balentine RM 11.5	EB	67(48-86)	50	115	84-182	69
	RM COT		8	80	62-98	11
	WCT	19(11-27)	15	162	94-297	20
Lower Forest Service RM 13.8	EB	85(80-90)	87	110	41-192	73
	WCT	24(22-26)	33	101	61-166	27
Upper Forest Service RM 15.3	EB	102(96-108)	137	105	52-187	95
	WCT	7(6-8)	7	137	98-166	5

Figure 6. Westslope cutthroat trout and brook trout estimates at four sections on Browns Gulch.



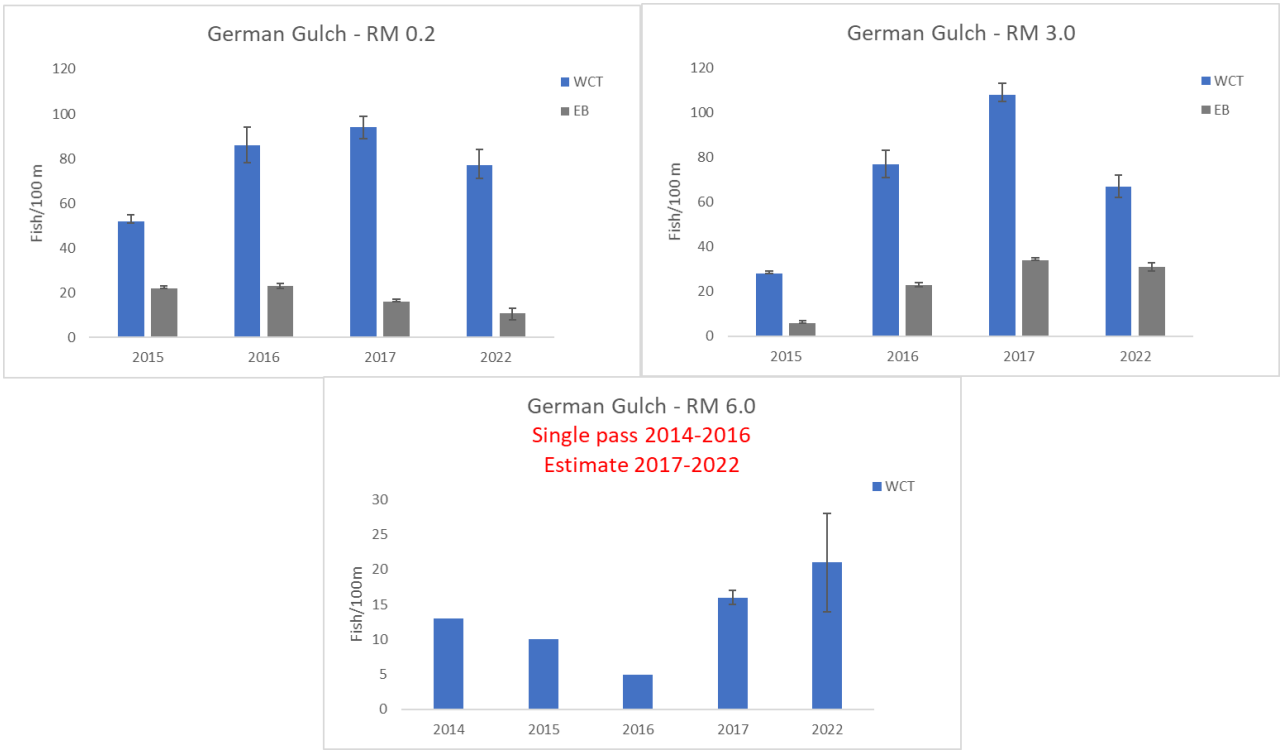
German Gulch

Three sections were surveyed on German Gulch in 2022 (Table 9). Estimates were possible for westslope cutthroat trout and brook trout greater than 75 mm in length at the lower two sites. Only westslope cutthroat trout are present at the upper site. Rocky Mountain sculpins were only captured at the lowest site. At the RM 0.2 site, the brook trout estimate was 11 fish/100 m and the westslope estimate was 77 fish/100 m. The middle section at RM 3.0 had a brook trout estimate of 31 fish/100m and a westslope estimate of 67 fish/100 m. The uppermost site at RM 6.0 had a westslope estimate of 21 fish/100 m. Estimates for both species were down a little from the last time estimates were done in 2017 but still near the long-term average. The westslope numbers at the upper site appear to be increasing since 2016.

Table 9. Electrofishing data collected on German Gulch in 2022. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = Westslope cutthroat trout, EB = Eastern Brook trout, RM COT = Rocky Mountain Sculpin,LN SU = Longnose Sucker.

Section	Species	Population Estimate (Fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
RM 0.2	EB	11(8-13)	28	123	43-278	13
	RM COT		45	105	56-153	22
	WCT	77(71-84)	135	122	73-310	65
RM 3.0	EB	31(29-33)	50	135	45-223	42
	WCT	67(62-72)	69	117	66-239	58
RM 6.0	WCT	21(14-28)	20	129	63-174	100

Figure 7. Westslope cutthroat trout and brook trout estimates at three sites on German Gulch.



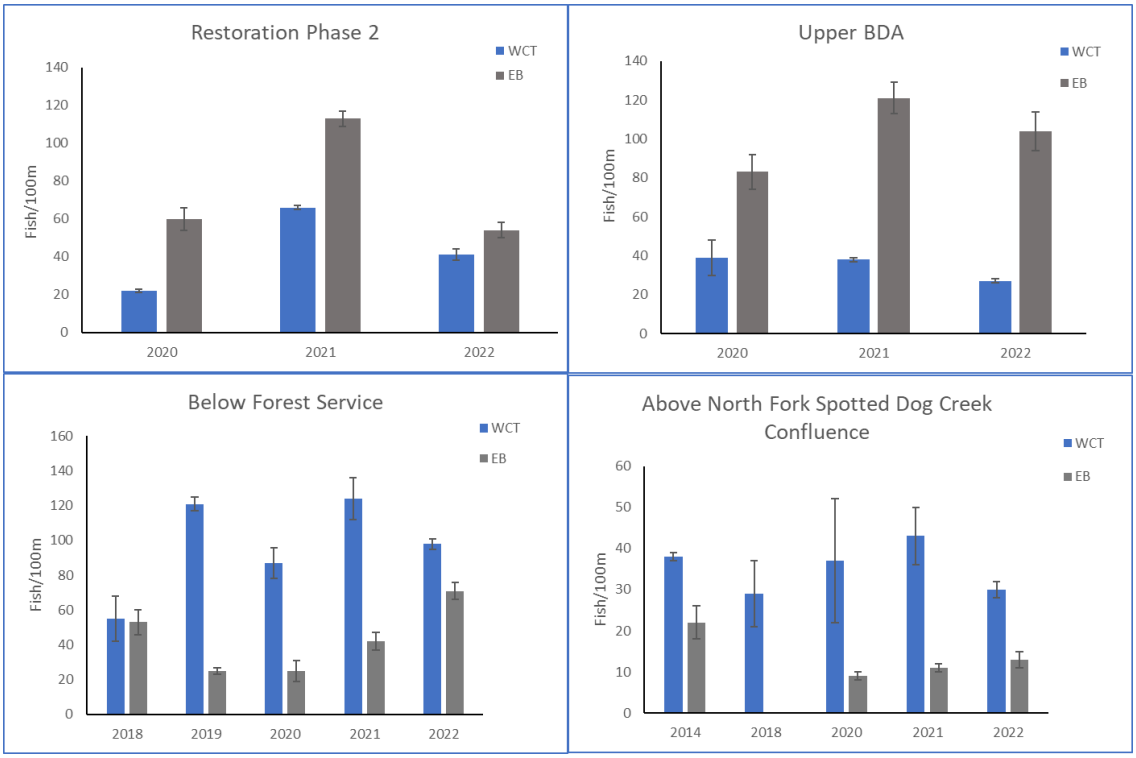
Spotted Dog Creek

In 2022, four sections were sampled on Spotted Dog Creek (Table 10). The lower two sections are in two areas of restoration work and have been sampled yearly since 2020 to monitor fish response to restoration efforts. The upper two sites have been monitored consistently since 2018 and are being used as controls for the restoration reaches. At the Restoration Phase 2 site, the brook trout estimate was 54 fish/100 m and the westslope cutthroat trout estimate was 41 fish/100 m. At the Upper BDA site, the brook trout estimate was 104 fish/100 m and the westslope estimate was 27 fish/100 m. No other species were captured in these two sections. Longnose suckers and slimy sculpin have been captured here in past surveys. At the Below Forest Service site, the brook trout estimate was 71 fish/100 m and the westslope estimate was 98 fish/ 100 m. The upper most site above the North Fork confluence had a brook trout estimate of 13 fish/100 m and a westslope estimate of 30 fish/100 m. Slimy sculpins were also present at both upper sites.

Table 10. Electrofishing data collected on Spotted Dog Creek in 2022. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = Westslope cutthroat trout, EB = Eastern Brook trout, SL COT = Slimy Sculpin.

Section	Species	Population Estimate (Fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Restoration Phase 2 RM 8.0	EB	54(52-56)	63	133	45-303	61
	WCT	41(38-44)	40	135	77-245	39
Upper BDA RM 8.4	EB	104(94-114)	120	127	43-315	82
	WCT	27(26-28)	27	153	78-252	18
Below Forest Service RM 9.8	EB	71(66-76)	71	112	32-235	34
	SL COT		15	68	51-84	7
	WCT	98(95-101)	123	104	60-218	59
Above North Fork Confluence RM 11.3	EB	13(11-15)	16	88	73-143	24
	SL COT		3	74	72-76	4
	WCT	30(28-32)	48	88	54-165	72

Figure 8. Westslope cutthroat trout and brook trout estimates at four sites on Spotted Dog Creek.



Boulder Creek

Four sections of Boulder Creek were sampled in 2022 (Table 11). Three of these sections were established monitoring sections that have been surveyed periodically since 2014-2016, depending on the section. The other section is a new monitoring site established in 2020 to evaluate areas of Boulder Creek that underwent restoration projects competed in 2017. Although baseline fish surveys were not done prior to restoration, we can still compare fish population data from the restoration sections to that of other parts of Boulder Creek.

The most downstream section is River Mile 0.4. The westslope cutthroat trout population estimate in 2022 was 36 fish/100 m, which is the highest number of westslope that has been estimated at this section (Figure 9). The brown trout estimate was 58 fish/100 m in 2022 which is also the highest estimate for this section and almost double the estimate from 2020. One bull trout, 4 rainbow X westslope hybrids, and 15 slimy sculpins were also captured in 2022. Twenty-four westslope, 4 rainbow X westslope hybrids and 1 bull trout were also PIT tagged in this section to assess Boulder Creeks contribution to the fish population in Flint Creek and the Clark Fork River. Four westslope from this section were detected at PIT antennas in Flint Creek, one of which was detected on the PIT array near the mouth of Flint Creek on October 19. It is assumed that this fish entered the Clark Fork River.

At the RM 2.0 Section, the brown trout estimate was 38 fish/100 m and the westslope cutthroat trout estimate was 36 fish/100 m in 2022. Six bull trout, 1 mountain whitefish, and 18 slimy sculpins were also captured. The westslope estimate is down a little from 2020 and the brown trout estimate is more than double the estimate from 2020. Twenty-four westslope and 4 bull trout were PIT tagged in this section.

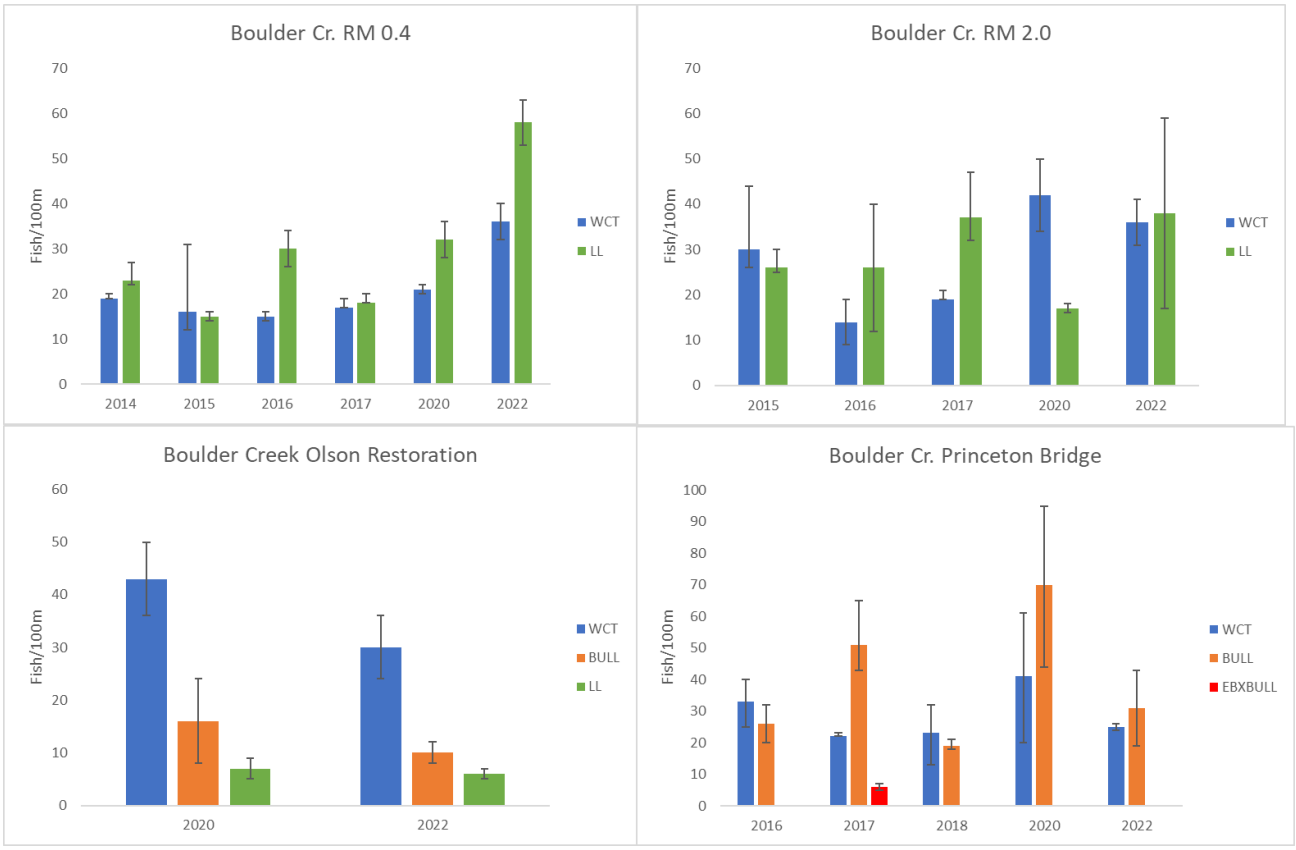
At the Olson restoration section at river mile 5.0, the westslope cutthroat trout estimate was 30 fish/100 m, the brown trout estimate was 6 fish/100 m, and the bull trout estimate was 10 fish/100 m in 2022. The estimates for all three species were down compared to 2020. One brook trout X bull trout hybrid, one rainbow trout and 10 slimy sculpins were also captured. Twenty-four westslope and 10 bull trout were PIT tagged in this section.

At the RM 6.5 (Princeton Bridge) Section, the westslope cutthroat trout estimate was 25 fish/100 m, and the bull trout estimate was 31 fish/100 m in 2022. One brook trout, one brown trout and one slimy sculpin was also captured. Estimates for both westslope and bull trout were much lower than in 2020 but about average over the long term. Seventeen west slope and 21 bull trout were PIT tagged in this section.

Table 11. Electrofishing data collected on Boulder Creek in 2022. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = westslope cutthroat trout, BULL = bull trout, LL = brown trout, SL COT = Slimy Sculpin, EBxBULL = phenotypic hybrid between Eastern brook trout and bull trout, RBXWCT = photypic hybrid between westslope cutthroat trout and rainbow trout.

Section	Species	Population Estimate (Fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
USGS Gauge	BULL		1	250	250	1
RM 0.4	LL	58(53-63)	56	159	82-321	50
	RBXWCT		4	246	182-338	4
	SL COT		15	77	64-89	13
	WCT	36(32-40)	36	155	43-382	32
RM 2.0	BULL		6	187	53-287	6
	EBXBULL		1	215	215	1
	LL	38(17-59)	33	143	42-320	35
	MWF		1	357	357	1
	SL COT		18	68	41-94	19
	WCT	36(31-41)	35	154	73-314	37
Olson	BULL	10(8-12)	11	182	57-288	19
Restoration	EBXBULL		1	263	263	2
RM 5.0	LL	6(5-7)	6	122	87-229	10
	RB		1	209	209	2
	SL COT		10	69	36-102	18
	WCT	30(24-36)	28	219	75-360	49
Princeton	BULL	31(19-43)	22	171	102-298	45
Bridge RM 6.5	EB		2	141	109-172	4
	LL		1	276	276	2
	SL COT		1	129	129	2
	WCT	25(24-26)	23	170	71-271	47

Figure 9. Trout estimates at four sections on Boulder Creek.



Flint Creek

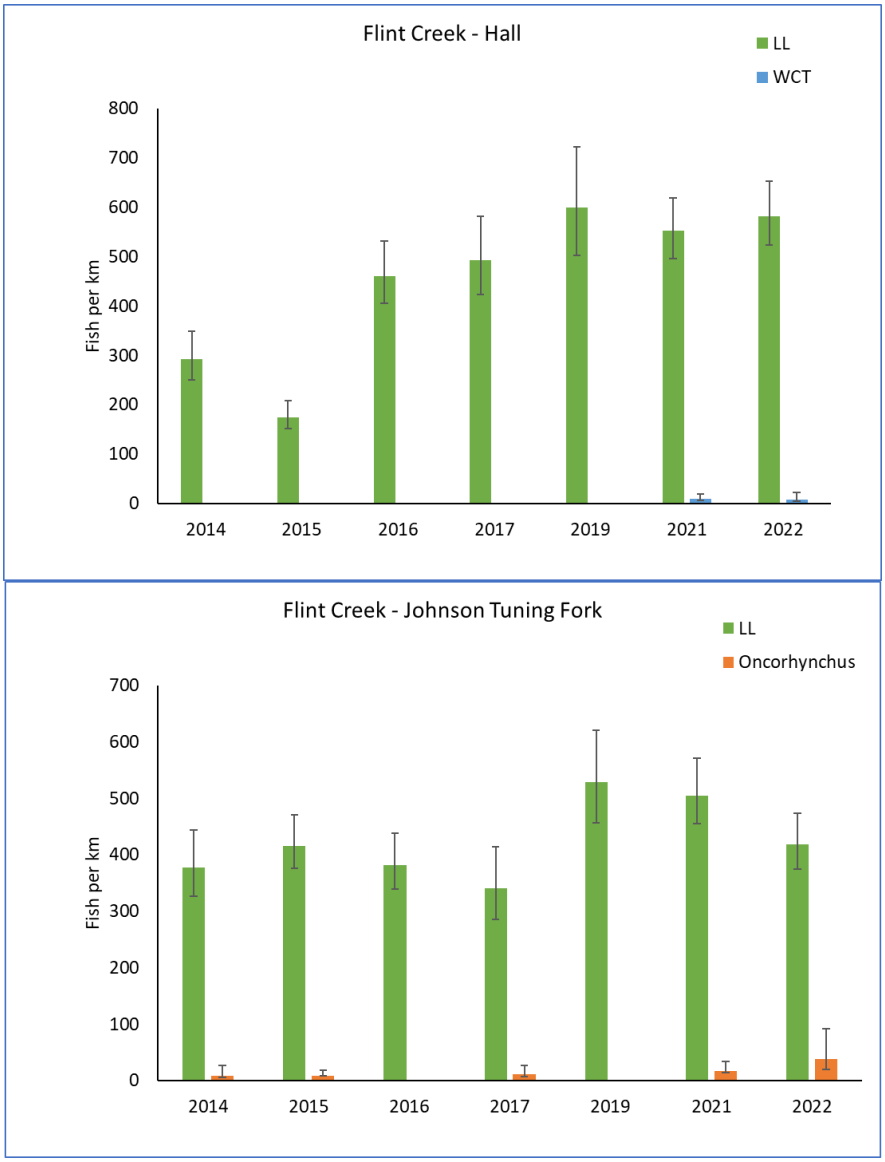
Three Sections were sampled on Flint Creek in 2022, two long term sites and a new site that is directly upstream of the Allendale Canal (Table 12). There have been seven sampling events conducted at the long-term sites since 2014. In general, there has been an increase in the population estimates for both brown trout and Oncorhynchus Sp./westslope cutthroat trout at the two long term sites completed in 2022 (Figure 10). The most downstream site near the town of Hall had a brown trout estimate of 581 fish/km. The brown trout population at Hall has been stable for the past several years. The westslope cutthroat trout estimate for this section was 8 fish/km. Numbers of westslope in this section continue to be low but stable. The most upstream section that was sampled in 2022 was the Johnson Tuning Fork section. The brown trout estimate was 418 fish/km which is a little down from the previous two sampling events, but still higher than the four years prior to that. The Oncorhynchus in this section are dominated by rainbow trout and there were an estimated 38 fish/km. This is the highest estimate for rainbow trout in this section. The third section sampled in 2022 is between Hall and Johnson Tuning for and immediately upstream of the Allendale Canal Diversion. This section has been named the Byrne Creek section because the section begins where Byrne Creek enters Flint Creek. This section was added to get a better idea of how many fish are near the Allendale Canal and therefore have a greater chance of interacting with the diversion structure and possibly being entrained. The brown trout estimate for this section was 966 fish/km and the westslope cutthroat trout estimate was 68 fish/km. These are

extremely high estimates compared to the other sections and are likely elevated because of the influence of cold water input from Boulder Creek. With this estimate data, we will be PIT tagging a proportion of these fish in the spring of 2023 and monitoring their interaction with the Allendale and Private Users diversions and fish screens through the spring, summer, and fall to get an idea of how many fish are being bypassed by the screens and back into Flint Creek.

Table 12. Electrofishing data collected on Flint Creek in 2022. Population estimates (95% CI) are for trout greater than 150 mm (~ 6") in total length for the Hall, Byrne Creek, and Johnson Tuning Fork sections. Species abbreviations: WCT = westslope cutthroat trout, LL = brown trout, EB = Eastern brook trout, RB = rainbow trout, BULL = bull trout. All sections had combined estimates for Oncorhynchus species.

Section	Species	Population Estimate (Fish/Km)	# Fish Handled	Mean Length (mm)	Length Range (mm)
Hall	EB		1	275	275
RM 6.6-7.6	LL	581(524-653)	605	265	151-500
	RBXWCT		1	366	366
	WCT	8(5-22)	8	318	227-392
Byrne Creek	BULL		1	282	282
RM 12.6-13.3	EB		3	250	210-277
	LL	966(872-1081)	739	249	61-470
	RB		3	280	275-282
	RBXWCT		3	322	233-388
	WCT	68(50-112)	44	291	204-384
Johnson	BULL		2	246	208-284
Tuning Fork	LL	418(374-474)	412	265	62-487
RM 23.9-24.6	RB	38(20-92)	22	302	194-390
	WCT		2	387	385-388

Figure 10. Trout estimates at 2 sites on Flint Creek.



Flint Creek/Allendale Fish Screen PIT Study

To assess fish interactions with the Allendale Canal, the adjacent Private User's Diversions, and fish movement throughout lower Flint Creek, it was decided to employ the use of Radio-frequency identification (RFID) using Passive Integrated Transponder (PIT) technology. This will allow us to characterize fish interactions with the irrigation structures, fish screens and understand other fish movements in Flint Creek. The arrays consisted of readers from Oregon RFID powered by 12v deep cycle batteries which were charged by 2 solar panels. The antennas were built with 10-gauge speaker wire encapsulated in ¾ to 2 inch PVC pipe, depending on the antenna configuration. PIT antennas were set up at multiple sites in Flint Creek as well as in the Allendale Canal and on the bypass pipes that returned water and fish from the ditches back to the creek. Antennas were set up in Flint Creek near the mouth (Map 3) and near the town of Hall (Map 4) at the beginning of May. At the same time antennas were put in the Allendale Canal near the headgate and at the upstream end of the fish screen. Antennas were also installed on the bypass pipes from both Allendale Canal and the Private User's Diversion. When flows in Flint creek dropped, antennas were added to the diversion dam sills of both the Allendale diversion and the Private User's Diversion (Maps 5 & 6). PIT readers were downloaded weekly to monitor fish movement and ensure the readers were working properly.

Map 3. Location of the antenna pair near the mouth of Flint Creek. Multiple antennae are used to gain directionality of fish movement. These antennae are used to monitor fish interaction between Flint Creek and the Clark Fork River.

Map 4. Location of the PIT antenna pair near the town of Hall. Multiple antennae are used to gain directionality of fish movement. This site was used as a midway check point between the Allendale and Private Users fish screens and the mouth.

Map 5. Locations of PIT antennae around the Private Users Diversion structure. Bypassed water from all three Private Users ditches return to Flint Creek through a single pipe so only one antenna was used to monitor bypassed tagged fish.

Map 6. Locations of PIT antennae around the Allendale diversion structure.

Tagging

Two sizes of PIT tags were implanted in fish. Fish over 200 mm received a 23 mm tag and fish under 200 mm received a 14 mm tag. The read range of the two different size tags was very similar on all antennas. Fish were captured by boat electrofishing, barge electrofishing, backpack electrofishing or angling and then tagged and released. There were several tagging events throughout the year and were mostly done when long term monitoring was already being conducted. Fish were tagged in the Clark Fork River and several different sites in Flint Creek and Boulder Creek to assess fish movement across the watershed and fish interaction with the Allendale and Private User's diversions.

The tagging events in the Clark Fork coincided with the annual population estimates conducted in April at the Bearmouth and Morse Ranch sites. These two sites bracket Flint Creek and only westslope cutthroat trout and bull trout were tagged to assess native fish movement from the Clark Fork River into Flint Creek. In May, fish were also captured and tagged downstream of the Hall diversion and downstream of the Private User Diversion. At the Hall diversion, all fish over 100 mm captured were tagged and released upstream of the diversion. At the Private User diversion, all fish over 100 mm captured were tagged and released downstream of the diversion (Table 13).

	Tagging Location				
Species	CFR Bearmouth	CFR Morse Ranch	Flint Below Hall diversion	Flint Below Private User Diversion	
Bull trout	1	1	0	0	
Brown trout	0	0	47	85	
Westslope Cutthroat trout	44	22	1	3	
Rainbow trout	0	0	0	1	
Mountain Whitefish	0	0	8	3	
Longnose sucker	0	0	1	0	
Total	**45**	**23**	**57**	**92**	**217**

Table 13. Number of PIT tagged fish from two sections in the Clark Fork River and two sections in Flint Creek.

From May through August, traps were designed to capture fish that were being bypassed through the diversions (Table 14). The efficiency of these traps was dependent on stream flows and the amount of water that was coming through the headgate. The objective was to estimate the number of fish being bypassed at different times of the year. With the constant change in stream flows and irrigation needs, it was difficult to have the traps work consistently. In total, 68 fish were captured and tagged between all four screens and released back into Flint Creek downstream of the Private User diversion.

	Tagging Location				
Species	Anderson Ditch (19 days)	Conn Ditch (16 days)	McGowan Ditch (15 days)	Allendale Bypass (7 days)	
Brown trout	14	12	7	21	
Westslope Cutthroat trout	2	0	0	2	
Rainbow trout	0	0	0	1	
Rainbow X Westslope	1	0	0	0	
Longnose Sucker	2	1	4	0	
Longnose Dace	0	0	1	0	
Total	**19**	**13**	**12**	**24**	**68**

Table 14. Number of fish PIT tagged after being trapped in fish screen bypass structures. Number of days that the traps were run is noted by each trap location

In August, four angling events were conducted upstream of the Allendale diversion. The focus was to capture and tag as many westslope cutthroat trout as possible. A total of 21 westslope, ranging in size from 221 mm to 360 mm were captured, tagged, and released where they were captured.

Depletion estimates were conducted at four sites on Boulder Creek in August. Along with the estimates, all Bull trout and westslope cutthroat trout over 100 mm captured were implanted with PIT tags (Table 15). Four fish that were identified as possibly being rainbow X westslope hybrids were also tagged, but no genetic samples were collected.

	Tagging Location				
Species	RM 0.4	RM 2.0	Olson	RM 6.5	
Bull trout	1	4	10	21	
Westslope Cutthroat trout	24	24	24	17	
Rainbow X Westslope	4	0	0	0	
Total	**29**	**28**	**34**	**38**	**129**

Table 15. Number of fish PIT tagged at four sites in Boulder Creek.

In September, three mark/recapture estimates were conducted on Flint Creek at two long term sites and at one new site just upstream of the Allendale diversion. All bull trout and westslope cutthroat trout that were captured in each section were PIT tagged (Table 16). There were also three fish identified as rainbow X westslope hybrids tagged. It appears that the influence of Boulder Creek may be providing cold water refuge for westslope cutthroat trout between its confluence with Flint Creek and the Allendale Diversion since there is a greater number of westslope cutthroats here than in other reaches of Flint Creek.

	Tagging Location			
Species	Flint Hall	Flint Byrne Creek	Flint Johnson Tuning Fork	
Bull trout	0	1	2	
Westslope Cutthroat trout	8	33	2	
Rainbow X Westslope	1	2	0	
Total	**9**	**36**	**4**	**49**

Table 16. Number of fish PIT tagged at 3 sites in Flint Creek.

A passage study of the Private User Diversion was also conducted in September where fish were captured in the Byrne Creek section and transported downstream of the Private User Diversion. 181 fish were tagged as part of the passage study (Table 17).

	Tagging Location
Species	Flint Creek - Byrne
Brown trout	159
Westslope Cutthroat trout	11
Mountain Whitefish	10
Rainbow trout	1
Total	**181**

Table 17. Number of fish PIT tagged for the Private Users Diversion passage study.

In total, 672 fish were tagged in 2022 to assess fish interactions with the Allendale and Private User diversions (Table 18).

Species	**Number of Tags**
Bull trout	41
Brown trout	351
Longnose Dace	1
Longnose sucker	8
Mountain Whitefish	21
Rainbow trout	3
Rainbow X Westslope	8
Westslope Cutthroat trout	239
Total	**672**

Table 18. Total number of fish PIT tagged in 2022.

Results

Allendale Diversion

With the orientation of the PIT antennae around the Allendale diversion structure it was possible to get an idea of how many tagged fish interacted with the headgate and how many tagged fish ended up entering the Allendale Canal. A fish was considered to have interacted with the diversion structure if it was detected on the antenna on the diversion sill or the antenna in the canal. If a fish entered the canal, there was also an antenna about 1000 m down the canal at the front end of the Allendale fish screen. There was also an antenna on the bypass pipe that returns water from the Allendale canal back to Flint Creek downstream of the Private Users Diversion. This antenna will show how many tagged fish are successfully bypassed back to Flint Creek.

The Allendale screen prevented a minimum of 14 tagged fish from being entrained in the Allendale Canal. Those 14 fish either exited the canal through the bypass pipe, the headgate, or were rescued during 1 of 2 fish salvage events after the headgate was closed. In total, 174 tagged fish interacted with the Allendale diversion and headgate (Table 19). Of those, 20 entered the canal. After entering the canal, only 14 fish made it to the antenna at the front end of the Allendale screen. Only 3 fish that entered the canal successfully returned to Flint Creek via the bypass pipe. Seven brown trout were detected on the diversion antenna after being detected on the canal antenna meaning these fish exited the canal back through the headgate. After the Allendale headgate was closed for the season, two fish salvage events were conducted from the Allendale screen to the Allendale headgate. Three tagged brown trout and 1 tagged westslope cutthroat trout were salvaged and returned to Flint Creek. Of the fish that entered the Allendale canal, we are unable to account for 3 brown trout, 2 westslope cutthroat trout and 1 Longnose sucker. It is possible that these fish exited through the headgate, were missed during the fish salvage, or fell victim to predation.

Species	Interacted with diversion	Entered Ditch	Dectected at screen	Bypassed	Exited headgate	Salvaged	Unknown
Brown trout	133	13	9	0	7	3	3
Westslope Cutthroat trout	31	5	3	2	0	1	2
Longnose sucker	5	2	2	1	0	0	1
Bull trout	1	0	0	0	0	0	0
Mountain Whitefish	1	0	0	0	0	0	0
Rainbow trout	1	0	0	0	0	0	0
Rainbow X Westslope	1	0	0	0	0	0	0
Large Scale sucker	1	0	0	0	0	0	0
Total	174	20	14	3	7	4	6

Table 19. Number of PIT tagged fish detected in relation to the Allendale diversion and canal.

Private Users Diversion

With the orientation of the antennae around the Private Users Diversion it was possible to get a known number of tagged fish that interacted with the diversion structure. Because of equipment limitations, it was not possible to set up an antenna on all three headgates associated with the Private Users ditches. However, the bypass system for all three ditches ends up returning to Flint Creek through the same pipe, so a single antenna was placed so that any tagged fish that returned to Flint Creek would be detected.

The Private User's fish screens prevented the entrainment of 22 tagged fish in the Private User's ditches. All those fish exited the Private User's ditches through the bypass pipe. In total, 184 tagged fish

interacted with the Private Users Diversion structure (Table 20). Of those, 22 tagged fish were detected at the bypass pipe and returned to Flint Creek. Since there are no antennae directly below the headgates, it is not possible to say if this was the total number of fish to enter the ditches and if it is possible for fish to swim back out through the headgate once they enter the ditch.

Species	Interacted with diversion	Bypassed
Brown trout	157	17
Westslope Cutthroat trout	17	3
Longnose sucker	4	2
Mountain Whitefish	4	0
Bull trout	1	0
Rainbow X Westslope	1	0
Total	184	22

Table 20. Number of PIT tagged fish detected in relation to the Private Users Diversion and ditches.

Discussion

In 2016, a similar study was performed around the Allendale Canal. A total of 219 brown trout and 4 westslope cutthroat trout were captured below the Private Users Diversion and transported upstream of the Allendale diversion. There was not an antenna on the diversion structure itself, so it was hard to know for sure how many fish interacted with the diversion structure. There was an antenna in the canal and one about 100 m downstream of the diversion. In total, 45 brown trout interacted with the two antennae. Twenty-four entered the canal and 21 were detected on the antenna below the diversion. This data suggests that approximately 53% of fish that encountered the diversion structure were entrained in the Allendale canal.

In the 2022 study, after the orientation of the headgate in relationship to Flint Creek was changed, we were able to set up PIT antennae in a manner that allowed us to better see how many tagged fish were interacting with the diversion structure. Ideally, there would be an antenna in Flint Creek directly above and below the headgate. However, we are limited with the amount of equipment available, so we were only able to place an antenna on the sill of the diversion directly downstream of the headgate. Only 11.5% (20/174) of fish that interacted with the diversion structure were entrained in the canal. Similar numbers were seen at the Private Users Diversion where 12% (22/184) of fish that interacted with the diversion structure were bypassed back to Flint Creek. Even though the two studies (2016 & 2022) at the Allendale diversion were not identical, it appears that the reorientation of the headgate may have reduced the number of fish that are entering the canal.

In the spring of 2023, it is planned to tag a proportion of the fish population upstream of the Allendale canal and run the PIT antennae through high water, especially when the headgate is initially opened, to see if we can get a better idea of the percentage of fish that are entering the canal. This will be the first time PIT antennae will be in place during high water when there is greater potential for out migrating fish to be encountering the diversion structure.

Private Users Diversion Upstream Fish Passage Study

Fall 2022

Installation of fish screens at the Allendale Canal and Private Users diversions was completed in 2021. The rock and tarp diversions were replaced with notched concrete dams that included low flow, fish passage channels leading downstream from the dam notch through a constructed rock riffle. Fish passage of the new Private Users diversion was assessed in the fall of 2021. Flint Creek experienced a near bank full flow event in the spring of 2022 and the constructed riffle moved and settled. This created a change in the low flow channel and increased the drop at the notch in the concrete dam. In 2021, fish were able to simply swim through the notch. After the spring flows in 2022, there is a big enough drop over the notch to require fish to jump to pass the diversion. The fish passage study from 2021 was repeated in 2022 to see if fish passage was affected by the physical change in the constructed riffle.

To assess upstream fish passage, three Positive Integrated Transponder (PIT) antennas were installed on the constructed riffle and diversion. One antenna was installed on the top of the diversion, one was located near the bottom of the constructed riffle in the low flow channel, and one was installed in the sluice gate channel (Map 7). The sluice channel antenna was added for the 2022 study because there was enough water getting to the sluice channel from the constructed riffle to allow fish to move up the riffle. In 2021 only the low flow channel and notch were monitored. A control riffle was also added for the 2022 study. The control riffle was located just downstream of the constructed riffle. A fourth antenna was constructed at the bottom of the control riffle. This was done to give a baseline of what should be expected for fish passage on a natural riffle. The control riffle was 50 m long, and the constructed riffle is 30 m long. In comparison, the control riffle is lower gradient and has a smaller substrate than the constructed riffle. On September 9th, 2022, 181 fish were captured upstream of the Allendale canal diversion using a tote barge electrofisher. Fish were divided into two groups with one group being released below the control riffle and one group being released below the constructed riffle (Table 21).

	Release Location		
Species	Control Riffle	Constructed Riffle	
Brown trout	78	81	
Westslope Cutthroat trout	5	6	
Mountain Whitefish	6	4	
Rainbow trout	1	0	
Total	**90**	**91**	**181**

Table 21. Number of PIT tagged fish and release location of fish for the Private User's Diversion passage study.

Map 7. Location of PIT antennae used to assess fish passage over the Private User's Diversion.

All fish were implanted with 23 mm or 14mm PIT tags depending on the size of fish. Fish length of 200mm was used as the cutoff for tag size. For the constructed riffle, we considered fish detected at either the low flow or sluice channel antenna to have attempted to pass the diversion. We considered a fish to have completely moved up and over the diversion if it was last detected at the upper antenna (and not moved back downstream to show up at the lower antenna). For the control riffle we considered fish detected at the lower antenna to have attempted to pass the riffle. We considered a fish to have passed the control riffle if it was detected on either the low flow or sluice channel antenna.

Control Riffle

The purpose of releasing fish below the control riffle was to get an idea of how fish can pass through a natural stream environment. If movement is not impaired by the constructed riffle, we would expect similar percentages of fish to be able to pass both riffles. Of the 90 fish released below the control riffle, 79 attempted to pass the control riffle and were included in the analysis. Of the 79 fish that attempted, 73 fish successfully navigated and passed the control riffle. Overall, fish had a passage success rate of

92% (Table 22 Control). Since swimming ability is related to fish size, results were further broken down into 50 mm length groups by species to compare the passage success rate of fish in different size classes (Figure 11). Only brown trout under 150 mm and mountain whitefish 200-249 mm were below the 92% passage rate. It should be noted that the 0% for mountain whitefish in that length group was only one fish. Brown trout made up 87% of the fish in the study so the other species are a relatively small sample size.

Constructed Riffle

Of the 91 fish that were released directly below the constructed riffle, 85 attempted to pass and 72 fish successfully navigated the constructed riffle and passed over the diversion. Overall, this is a passage success rate of 85% (Table 22 Test #1). Since swimming ability is related to fish size, results were further broken down into 50 mm length groups by species to compare the passage success rate of fish in different size classes (Figure 11). Percentages of brown trout that were able to pass the constructed riffle were very similar to brown trout that were able to pass the control riffle. Westslope cutthroat trout were less successful at passing the constructed riffle, but it was a small sample size. No mountain whitefish successfully passed the diversion. This was also a small sample size, but we would expect to see some mountain whitefish pass the diversion if they are able to move as they did through the control riffle.

Control Riffle fish Passing Constructed Riffle

Since the control riffle and constructed riffle were connected, we were able to use the fish that passed the control riffle as a second test for the constructed riffle. All 73 fish that passed the control riffle were considered to have attempted the constructed riffle since they were all detected on the low flow or sluice channel antennae. Of those 73 fish, 65 successfully navigated the constructed riffle and passed the diversion. Overall, this is a passage success rate of 89% (Table 22 Test #2). Since swimming ability is related to fish size, results were further broken down into 50 mm length groups by species to compare the passage success rate of fish in different size classes (Figure 11). Although the sample size is still small, no mountain whitefish from this group successfully passed the diversion.

Control

Species	# Released	# attempted to pass	# that passed	% that passed
Brown trout	78	69	64	93%
Westslope Cutthroat trout	5	4	4	100%
Mountain Whitefish	6	5	4	80%
Rainbow trout	1	1	1	100%
Total	**90**	**79**	**73**	**92%**

Test #1

Species	# Released	# attempted to pass	# that passed	% that passed
Brown trout	81	77	68	88%
Westslope Cutthroat trout	6	6	4	67%
Mountain Whitefish	4	2	0	0%
Total	**91**	**85**	**72**	**85%**

Test #2

Species	# attempted to pass	# that passed	% that passed
Brown trout	64	60	94%
Mountain Whitefish	4	0	0%
Rainbow trout	1	1	100%
Total	**73**	**65**	**89%**

Table 22. Results of the Private User's Diversion study for the control riffle and the two tests on the constructed riffle. Test #1 are fish released directly below the constructed riffle. Test #2 are fish that successfully passed the control riffle and attempted the constructed riffle.

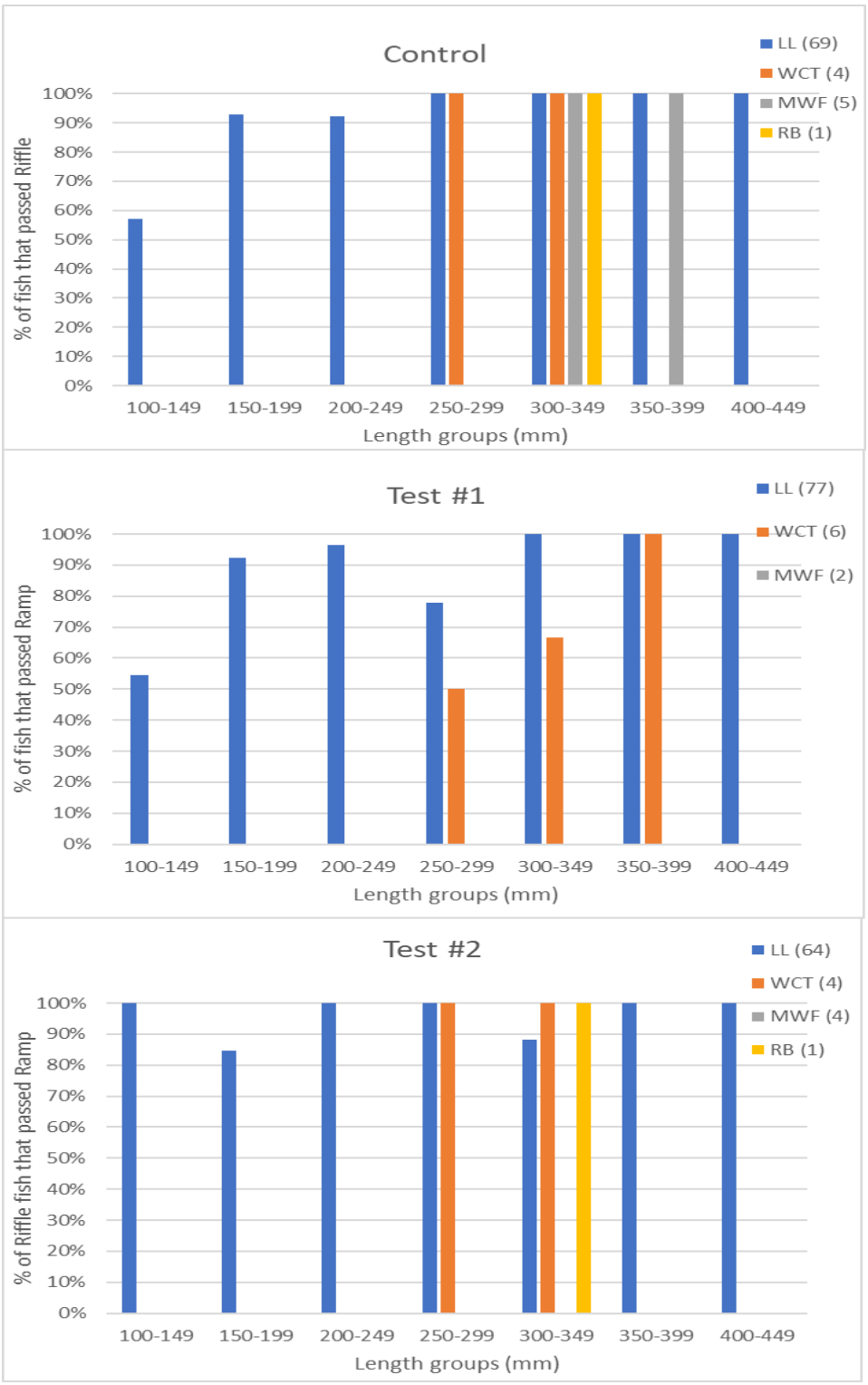


Figure 11. Control shows the percentage of fish that successfully passed the control riffle. Test #1 shows the percentage of fish that successfully passed the constructed riffle. Test #2 shows the percentage of fish that successfully passed the constructed riffle after passing the control riffle. The legend shows the number of fish that attempted to pass by species. Brown trout (LL), Westslope Cutthroat trout (WCT), Mountain Whitefish (MWF) and Rainbow trout (RB).

Statistical Comparison

A Two Proportion Z-test at significance level $\alpha=0.05$ was used to see if there was a significant difference between the proportion of fish that were able to successfully pass the Control Riffle and the proportion of fish that were able to successfully pass the Constructed Riffle. The fish that successfully passed the Control Riffle were also used as a second sample for the Constructed Riffle which was also compared to the Control Riffle. The proportion of fish that successfully passed the Control Riffle serves as the proportion of fish expected to be able to successfully pass the Constructed Riffle. When comparing the proportion from the Control Riffle to the proportion from the Constructed Riffle there was no statistically significant difference between the two groups ($p=0.16$). When comparing the proportion from the Control Riffle to the proportion of the second sample for the Constructed Riffle there was again no significant difference ($p=0.53$). When comparing the two groups that successfully passed the Constructed Riffle there was again no significant difference ($p=0.46$). In summary, there were no significant differences in fish passage observed between the control riffle and constructed riffle demonstrating that fish passage in the low flow channel is functioning acceptably for all size groups and species, except for mountain whitefish.

Future Maintenance of the Constructed Riffle and Associated Low Flow Channel:

A near bankfull event occurred in Flint Creek in 2022 and this event was substantial enough to cause significant adjustments in both constructed riffles. While these adjustments did not appear to affect fish passage at the Allendale Diversion, a small hydraulic jump was created at the Private Users Diversion during the 2022 event. While this hydraulic jump was not substantial enough to create fish passage issues for any species other than mountain whitefish based on our tagging results, observing significant channel changes within the first two years of project completion suggests that further monitoring of the low flow channels at both the Private Users Diversion and Allendale Diversion is necessary. This is particularly evident as a bankfull event is a routine event (appx. a 1.5 year recurrence interval) and events that exceed bankfull will likely occur in the coming decade and may cause more severe channel changes in the low flow channels or in the entirety of the constructed riffles on both diversions. NRDP will be continuing to monitor channel cross-sections at both constructed riffles to assess channel morphology changes as part of their permitting requirements, but MFWP and NRDP should continue to monitor the status of fish passage through the low flow channels via annual visits to the site post runoff, particularly in years when flows exceed bankfull.

Cottonwood Creek

Diversion upgrade and screening effort evaluation

Cottonwood Creek has been evaluated to be an important tributary for maintaining and improving westslope cutthroat trout population in the mainstem Clark Fork River. Chronic dewatering and connectivity within the drainage and to the Clark Fork River are key issues to address for optimizing westslope cutthroat trout recruitment from Cottonwood Creek. Many of the irrigation structures known to be an impediment to migrating westslope cutthroat trout in Cottonwood Creek have been addressed over the past few years. However, several irrigation structures that are likely key to overall success in the drainage remain impediments for migrating fish.

To assess the success of completed projects and identify future projects that are key to overall success in the drainage, FWP instigated a positive integrated transponder (PIT) tag study in the drainage in early summer 2022. PIT antennas were placed at four locations on Cottonwood Creek and near the mouth of Baggs Creek, a tributary to Cottonwood Creek. The most upstream site on Cottonwood Creek was at the recently rebuilt and screened McQueary Diversion at RM 5.8 (Map 8). This location is at the lower end of the cutthroat stronghold in Cottonwood Creek and what is believed to be the likely spawning habitat for fish migrating from the river. The reader was set up to read fish migrating in the stream or being bypassed by the screen. The next most upstream reader was placed in Baggs Creek just upstream of its confluence with Cottonwood Creek, this reader was set up to evaluate fish moving into and out of Baggs Creek and to evaluate fish passage at a structure completed at the mouth of Baggs Creek. The next reader was placed at the recently rebuilt and screened Applegate diversion located at RM 3.0 in Cottonwood Creek (Map 9). This diversion also marks the upstream extent of a large section of Cottonwood Creek that is dewatered for much of the year due to irrigation and natural sub-surface flows. This reader was set up to evaluate fish migrating past this point in the stream and being bypassed by the screen. The final two readers were placed in Cottonwood Creek at its confluence with the Clark Fork River. One reader was placed just upstream of the point where the Kohrs-Manning Ditch intersects Cottonwood Creek, the final reader was placed about 10m downstream just below where the ditch intersects the creek (Map 10). These two readers are intended to assess the impact of the Kohrs-Manning ditch and its diversion on Cottonwood Creek to fish migrating to and from the Clark Fork River. We hypothesize that this ditch crossing, and diversion structure represent a barrier to migrating fish throughout much of, or all year and may be critical to address to realize benefits of upstream projects to the Clark Fork River.

Map 8. Location of PIT antennae on Baggs Creek, Cottonwood Creek and McQueary diversion bypass pipe.

Map 9. Location of PIT antennae on Cottonwood Creek and Applegate diversion bypass pipe.

Map 10. Location of PIT antennae near the mouth of Cottonwood Creek.

Fish were then tagged in Cottonwood Creek at several locations. Much of the tagging effort occurred upstream of the Mcqueary Diversion around RM 6.9 where 133 westslope cutthroat trout were tagged. Twenty-four cutthroats were also tagged just below the McQueary diversion at RM 5.6. Seven cutthroats were tagged in lower Baggs Creek around RM 0.3 in a spawning reach identified by a telemetry tagged cutthroat trout from the Clark Fork River (Mayfield 2013). To increase observed interactions with the Kohrs-Manning infrastructure, 22 and 57 brown trout were also tagged in lower Cottonwood Creek at RM 0.3 and 0.9 respectively.

Very little fish movement was detected between when fish were initially tagged in early summer and when readers were removed on October 19, 2022. Two fish were detected on the reader at the McQueary ditch moving downstream. One of those fish then moved into Baggs Creek and the other was not encountered again. The third fish was tagged below the McQueary ditch and encountered as it moved into Baggs Creek.

Fish interactions were likely limited in 2022 due to readers being deployed and tagging efforts occurring after much of the spring migration had subsided. Now that sites have been identified and fish have been tagged readers will be installed in early spring of 2023 to capture movements at higher water when cutthroat are more likely to be migrating and Cottonwood Creek is hydraulically connected to the Clark Fork River. There were also equipment malfunctions that occurred at various points through the study period in 2022 that could have inhibited our ability to detect fish movements. Going forward, an effort will be made to tag fluvial adult cutthroat in the Clark Fork River and more juveniles in upper Cottonwood Creek.

References

Chapman, D. G. 1951. Some properties of the hypergeometric distribution with applications to zoological censuses. University of California Publications on Statistics 1:131-160.

Cline, T.J. et al. 2022. *An assessment of brown trout status and trends for rivers across Montana between 1980 and 2021*

Cook, N. A., and T. Elam. 2019. Monitoring in the Upper Clark Fork River Basin: 2019 Report. Montana Fish Wildlife and Parks, Helena, Montana.

Geum Environmental. 2015. Upper Clark Fork River Basin Aquatic Resources Restoration Plan Monitoring and Maintenance Plan. Prepared for the Natural Resource Damage Program, Montana Department of Justice, Helena, Montana.

Mayfield, M.P. 2013. Limiting factors for trout populations in the upper Clark Fork River Superfund site, Montana. M.S. Thesis, Montana State University, Bozeman, Montana. Available: http://etd.lib.montana.edu/etd/view/item/1883.

MTFWP and Clark Fork Coalition. 2020. Upper Clark Fork River Slicken Assessment. Draft report.

MT DEQ, 2017. Circular DEQ -7 Montana Numeric Water Quality Standards. Available online at http://deq.mt.gov/Portals/112/Water/WQPB/Standards/ SB235Rulemaking/DEQ-7_Final_April2017.pdf.

Nagisetty, R. M., K. F. Flynn, and D. Uecker. 2019. Dissolved oxygen modeling of effluent-dominated macrophyte-rich Silver Bow Creek. Ecological Modeling 393:85-97.

Naughton, J.P. 2013. Salmonid response to superfund remediation in Silver Bow Creek, Montana. M.S. Thesis, Montana State University, Bozeman, Montana.

Liermann, M, J. Lindstrom, and R. Kreiner. 2009. An Assessment of Fish Populations and Riparian Habitat in Tributaries of the Upper Clark Fork River Basin: Phase II. Montana Fish Wildlife and Parks, Helena, Montana.

Lindstrom, J., B. Liermann, and R. Kreiner. 2008. An assessment of fish populations and riparian habitat in tributaries of the upper Clark Fork River Basin. Montana Fish Wildlife and Parks, Helena, Montana.

Saffel, P., N. Cook, B. Liermann, J. Lindstrom, L. Knotek, D. Martin, and B. Downing. 2018. Prioritization of Areas in the Upper Clark Fork River Basin for Fishery Enhancement. Montana Fish, Wildlife and Parks, Missoula, MT and Natural Resource Damage Program, Helena, MT.

Zippin, C. 1958. The removal method of population estimation. Journal of Wildlife Management 22: 82-90.