

2021 Silver Lake Release Evaluation and Assessment

NRDP Task Order No. 90024.13.1



Clark Fork River at Sager Lane July 30, 2021



Clark Fork River at Sager Lane August 12, 2021



Submitted by Morgan Case
Trout Unlimited Western Water and Habitat Program
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Abbreviations

BSB	City-County Government of Butte Silver Bow
CFC	Clark Fork Coalition
FWP	Montana Department of Fish, Wildlife and Park
NRDP	Montana Natural Resource Damage Program
TIFID	Tax Increment Financing Industrial Board
TU	Trout Unlimited
CFR	Clark Fork River
UCFRB	Upper Clark Fork River Basin
USGS	US Geological Survey
WCT	Westslope Cutthroat Trout
WSC	Warm Springs Creek

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Executive Summary

Warm Springs Creek (WSC) and the upper Clark Fork River (CFR) between Warm Springs and Deer Lodge have flows that are below the minimum flow targets and are considered inadequate for supporting healthy fish populations. Water temperatures also regularly exceed thermal thresholds of 15°C for healthy bull trout habitat and 20°C for westslope cutthroat trout. In addition to flow and temperature, the CFR has elevated metal and arsenic concentrations from historic mining and smelting as well as other limiting factors impacting aquatic life. Silver Lake provides a unique opportunity to utilize high quality, cold water stored in the reservoir to partially address the flow and temperature issues downstream. Increases to instream flows in WSC and the CFR will improve fish habitat, moderate water temperatures, and dilute nutrient and metal loads.

The Montana Natural Resource Damage Program (NRDP) tasked Trout Unlimited with coordinating, monitoring, and evaluating a release of water from Silver Lake, in the headwaters of WSC, near Anaconda. The purpose of the release was to add critically needed flows to WSC and the CFR in the summer of 2021 during a severe drought and to build upon previous efforts to characterize the WSC and CFR hydrologic systems.

Butte Silver Bow (BSB) released approximately 32 cfs from Silver Lake between August 2 and September 20, 2021. A total of 3,120 AF was released into WSC, dropping the surface elevation of Silver Lake 11.7 ft. The temperature of the water pumped from Silver Lake slowly increased from an initial temp of 9.5 °C to a high of 14.4 °C.

Flows in WSC and the CFR increased in the days following the start of the release. Synoptic measurements collected on August 12, 2021 characterized the increase to be as much as 32.2 cfs from Cable Creek to the USGS gage in Anaconda, 27.4 cfs between Anaconda and the Gardiner Ditch, and 24.1 cfs from the Gardiner Ditch to USGS gage near Warm Springs. In the upper CFR, the synoptic measurements showed increases of 21.4 cfs through the USGS gage near Galen and 20.2 cfs downstream to Deer Lodge. Those increases, in addition to some precipitation, raised flows in WSC above the 40 cfs flow target for the duration of the release and raised the CFR above the 40 cfs and 90 cfs flow targets at Galen and Deer Lodge, respectively. The informal flow targets of 50 cfs and 60 cfs at Gemback Bridge and Sager Lane were not reached early in the release, but additional flows from rain and release from the Warm Springs Ponds resulted in exceeding the targets later in the release.

The relatively cool water temperatures in Warm Springs Creek were maintained with the addition of the Silver Lake Water, which was consistently less than the 15°C threshold for healthy bull trout habitat. There was no obvious cooling effect of the additional flow in the Clark Fork River, but the additional mass may have prevented additional heating.

The timing and volume of the third pilot release demonstrated that water stored in Silver Lake can be used to increase flows to meet or partially meet minimum flow targets in WSC and the CFR. A long-term agreement to set aside up to 3,200 AF of Silver Lake stored water annually to address drought conditions in WSC and the CFR could be beneficial to the CFR trout fishery. In addition, additional investigations into the relationship between flow and temperature in the CFR are recommended. TU also recommends monitoring reservoir levels and installing and maintaining real time stream gage stations on WSC below the Gardiner Ditch and on the CFR near Sager Lane.

I. Introduction

Warm Springs Creek and the upper Clark Fork River between Warm Springs Creek and Deer Lodge have flows that are below the minimum flow targets and are considered inadequate for supporting healthy fish populations. FWP established flow targets for the UCFRB as a part of the *Application for Reservation of Water in the Upper Clark Fork River Basin* (Nov. 1986) filed with the Montana Department of Natural Resources and Conservation (DNRC). Flows often fall below the targets of 40 cfs at Galen and Warm Springs and 90 cfs at Deer Lodge. Water temperatures also regularly exceed thermal thresholds of 15°C for healthy bull trout habitat (Fraley and Shepard 1998; Dunham et al. 2003) and 20°C for westslope cutthroat trout (Bear et al. 2007). In addition to flow and temperature, the upper CFR has elevated metal and arsenic concentrations from historic mining and smelting as well as other limiting factors impacting aquatic life. Silver Lake provides a unique opportunity to use the high quality, large quantity, cold water in the reservoir to partially address the flow and temperature issues downstream. Benefits of increases to instream flows to WSC and the upper CFR will improve fish habitat, moderate water temperatures, and dilute nutrient and metal loads.

NRDP along with project partners (WRC, CFC and TU) contacted water-users on WSC and CFR to notify them of the release and requested they not divert additional water than currently being diverted. Overall, the majority of water-users made an attempt to not increase their water use.

In 2021, the Montana Natural Resource Damage Program tasked Trout Unlimited with coordinating, monitoring, and evaluating a third and larger release of water from Silver Lake, in the headwaters of WSC, near Anaconda. The purpose of this third release was to demonstrate the effects of the flow release during the typical period of low flows in WSC and the upper CFR and build upon previous efforts to characterize the WSC and upper CFR hydrologic systems. This knowledge can be used to support development and implementation of a long-term project to lease water stored in Silver Lake to address flow limitations in lower WSC and the CFR. The project will partially implement Proposed Action 1, Flow Quantity, for the Warm Springs Creek watershed identified in section 3.2.2.14 and Group 1 projects described in section 3.2.1 of the Upper Clark Fork River Basin Aquatic and Terrestrial Resources Restoration Plans (Restoration Plans).

In addition, the project will partially address the Restoration Plans goals for the mainstem fishery of 1.) restoring the mainstem UCFR trout fishery by improving recruitment of fish from tributaries, 2.) replacing lost trout angling in the mainstem by improving trout populations in the tributaries and 3.) maintaining or improving native trout populations in the UCFRB to preserve rare and diverse gene pools and improve the diversity and resiliency of the trout fishery.

II. Materials and Methods

TU, NRDP, and the Clark Fork Coalition identified the inflow and outflow locations between Silver Lake and the CFR near Deer Lodge, reviewed existing flow and temperature monitoring locations, and discussed available equipment and staffing before preparing the 2021 Silver Lake Release Monitoring Plan.

In accordance with the monitoring plan, the final monitoring locations are listed in Tables 1 and 2 and shown on the map in Figure 1. Stream discharge measurements were collected following USGS protocols using either a Marsh McBirney Flo-mate or Hach Portable Flow Meter. Solinst Levelloggers, Onset Hobo

Water Level Loggers, and TruTrack Data Loggers were installed in PVC housings attached to metal posts sunk into the streambed. The loggers recorded water depth and temperature at regular intervals. A Solinst Barologger installed in the housing with the water level recorder on WSC below the Gardiner diversion and a Barologger on Dry Creek Ranch were used to adjust records to compensate for ambient air pressure. Temperature loggers were attached to rebar or concrete form posts, which were sunk into the stream bed in areas with shade and moving water. All monitoring instrumentation was installed by July 14th, 2021.

Table 1. Flow monitoring locations during 2021 Silver Lake release.

Location Name	Device/Method	Equipment Owner	Latitude	Longitude
Ditch below Silver Lake dam	Parshall Flume	BSB	46.16589	-113.21239
Ditch below Silver Lake dam	Solinst Levellogger	WCE	46.16576	-113.21070
Cable Creek above WSC	Manual Flow Measurement	TU	46.16873	-113.15412
Twin Lakes Creek above WSC	Manual Flow Measurement	TU	46.16777	-113.15395
WSC below confluence with Cable Creek	Manual Flow Measurement	TU	46.16862	-113.15312
WSC above Meyers Dam	Solinst Levellogger	TU	46.15390	-113.04011
Foster Creek	Manual Flow Measurement	TU	46.16469	-113.12061
Barker Creek	Manual Flow Measurement	TU	46.16249	-113.11686
WF Barker Creek	Flow Estimate	TU	46.16235	-113.11725
Small Diversion	Flow Estimate	TU	46.16316	-113.06469
WSC near Anaconda	USGS Gage 12323760	USGS	46.13367	-112.90315
Gardiner Ditch	Parshall Flume		46.13750	-112.89259
WSC below Gardiner Ditch	Solinst Levellogger	TU	46.13750	-112.89202
Opportunity Pond Drain	Manual Flow Measurement	TU	46.16487	-112.81852
WMA diversion	Manual Flow Measurement	TU	46.17164	-112.80465
WSC below WMA	Solinst Levellogger	TU	46.17189	-112.80418
WSC at Warm Springs	USGS Gage 12323770	USGS	46.18038	-112.78508
Mill Creek at Opportunity	USGS Gage 12323700	USGS	46.11438	-112.81978
Willow Creek at Opportunity	USGS Gage 12323720	USGS	46.10716	-112.81061
SBC at Opportunity	USGS Gage 12323600	USGS	46.10776	-112.80528
SBC at Warm Springs	USGS Gage 12323750	USGS	46.17950	-112.78056
CFR nr Galen (Perkins Lane)	USGS Gage 12323800	USGS	46.20824	-112.76735
Lost Creek near Anaconda	USGS Gage 12323840	USGS	46.16133	-112.89380
Lost Creek near Galen	USGS Gage 12323850	USGS	46.21866	-112.77396
Lost Creek nr Confluence	Onset HOBO Water Level Logger	CFC	46.22663	-112.75989
CFR at Galen Road	Onset HOBO Water Level Logger	CFC	46.23745	-112.75315
Alvi-Beck Ditch	Manual Flow Measurement	CFC	46.24516	-112.75137
Modesty Creek	Manual Flow Measurement	CFC	46.25509	-112.75469
Westside/Whalen Ditch	Manual Flow Measurement	NA	46.26091	-112.75242
CFR at Gemback Bridge	Onset HOBO Water Level Logger	CFC	46.26522	-112.74477
CFR below Racetrack Creek	Onset HOBO Water Level Logger	CFC	46.28937	-112.72409
Valiton Ditch	Manual Flow Measurement	CFC	46.29423	-112.72344
CFR at Sager Lane	Onset HOBO Water Level Logger	CFC	46.31741	-112.73612
CFR at Deer Lodge	USGS Gage 12324200	USGS	46.39765	-112.74254

Table 2. Temperature monitoring locations during 2021 Silver Lake release.

Location Name	Device	Equipment Owner	Latitude	Longitude
Ditch below Silver Lake dam	Solinst Levelogger	WCE	46.16576	-113.21070
WSC below Sub	Onset Hobo Pro V2	FWP	46.22598	-113.18185
WSC above Foster Cr	Onset Hobo Pro V2	FWP	46.16195	-113.12893
WSC above Meyers Dam	Solinst Levelogger	TU	46.15390	-113.04011
WSC below Meyers Dam	Onset Hobo Pro V2	TU	46.15382	-113.03683
WSC near Anaconda*	Onset Hobo Pro V2	FWP	46.14174	-112.98315
WSC below Gardiner Ditch	Solinst Levelogger	TU	46.13750	-112.89202
WSC near Mouth	Onset Hobo Pro V2	FWP	46.18042	-112.78529
Mill Creek at Opportunity Park	Onset Hobo Pro V2	FWP	46.11360	-112.82642
Willow Creek at Opportunity Road	Onset Hobo Pro V2	FWP	46.10749	-112.81020
SBC below WS Ponds	Onset Hobo Pro V2	TU	46.17828	-112.78182
Mill Willow Bypass	Onset Hobo Pro V2	FWP	46.17378	-112.78519
SBC above WSC	Onset Hobo Pro V2	TU	46.18081	-112.77979
Silver Bow Creek near Opportunity	Onset Hobo Pro V2	FWP	46.10710	-112.80496
CFR in WMA	Onset Hobo Pro V2	FWP	46.19612	-112.76772
Lost Creek nr Confluence	Onset HOBO Water Level Logger	CFC	46.22624	-112.76059
CFR at Gemback Bridge	Onset HOBO Water Level Logger	FWP	46.26514	-112.74480
CFR at Sager Lane	Onset HOBO Water Level Logger	CFC	46.31741	-112.73612
CFR at Deer Lodge*	Onset Hobo Pro V2	FWP	46.37827	-112.73734

* Temperature loggers deployed, but lost or stolen.

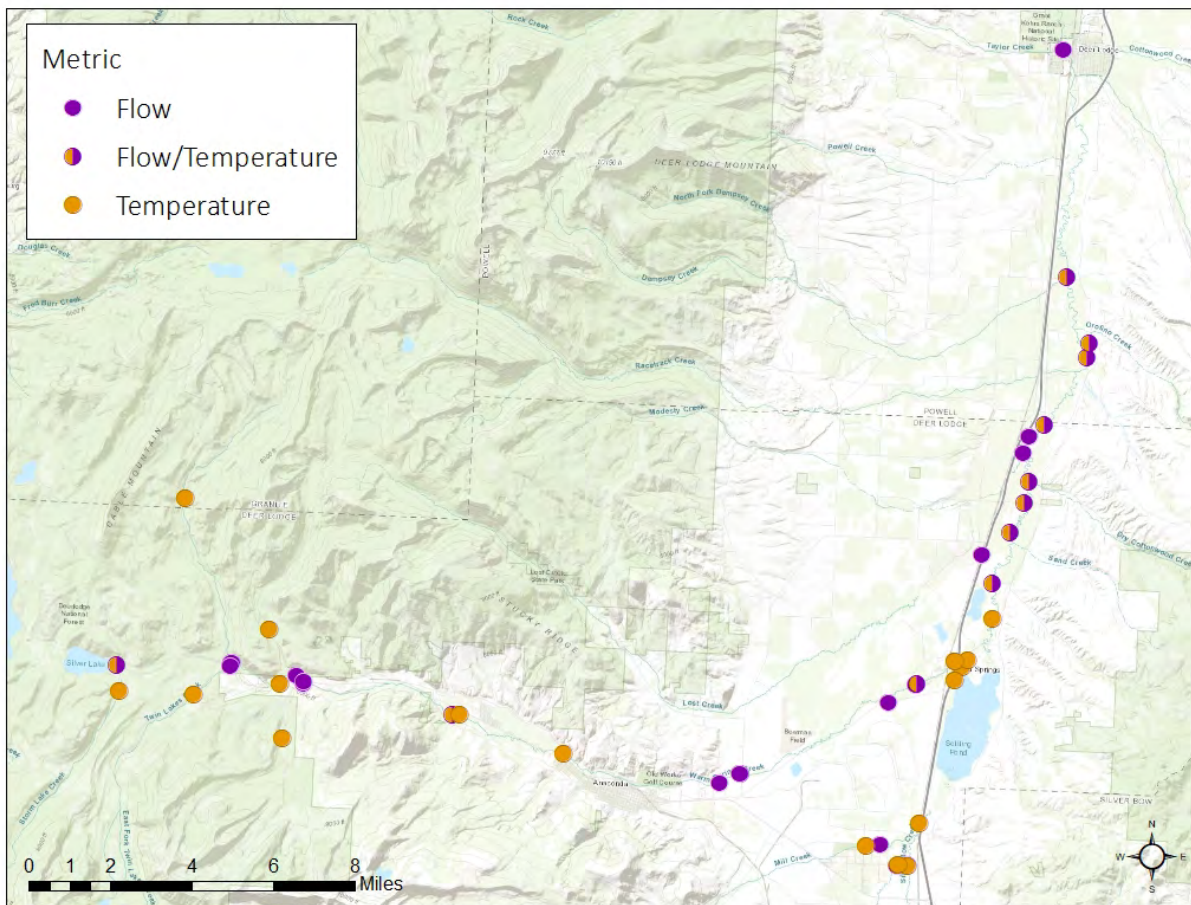


Figure 1. Flow and temperature monitoring locations for 2021 Silver Lake Release.

The monitoring plans called for low flow measurements prior to the release and synoptic measurements during the release. The synoptic measurements are a series of discharge measurements along the project reach within a short period of time. The results are intended to identify the location and magnitude of stream losses or gains due to interaction with groundwater or unmetered surface water. TU and project partners conducted pre-release low flow measurements on July 28, 2021, and one mid-release synoptic measurement event on August 12, 2021. Additional discharge measurements were collected throughout the summer to further characterize the hydrology and develop stage-discharge relationships for data loggers. Due to the inherent error in measurement (the USGS considers a +/- 5% error acceptable for the highest quality measurement), the discharge figures within this report are most informative when considered in terms of relative change over the period of the test release. Major irrigation diversions were also monitored during the release, with communication efforts focused on holding the diversion to no more than they were diverting prior to the release.

Results

Pre-release conditions

Prior to the Silver Lake release, flows at the four USGS stream gages between Silver Lake and Deer Lodge were lower than the mean historic flow (see Appendix A). On August 1, 2021, the day before the release, the mean daily discharge at the USGS gage on WSC at Warm Springs was 28.6 cfs, 11.4 cfs lower than the 40 cfs flow target and 15.4 cfs lower than the mean of 44 cfs. Mean daily discharges at that site were near or below the 40 cfs target beginning in mid-July. At the USGS gage near Galen, the mean daily discharge was 40.8 cfs, meeting the 40 cfs flow target, but 61.2 cfs lower than the 102 cfs mean for that day. At the USGS gage near Deer Lodge, the mean daily flow was 85 cfs, 5 cfs lower than the 90 cfs flow target and 32 cfs less than the mean of 117. Of greater concern, the CFC measured only 9.9 cfs at the Gemback Bridge, 16.5 cfs below Racetrack Creek, and 7.7 cfs at Sager Lane, well below the informal flow targets of 50 cfs at Gemback Bridge and 60 cfs at Sager Lane.

Maximum daily stream temperatures prior to the release were below the 20°C threshold for healthy westslope cutthroat trout habitat at all WSC locations except near the mouth, where maximum daily flows exceeded 20°C the three days prior to the start of the release. Maximum daily stream temperatures along the Clark Fork River exceeded the threshold as early as late June, with water temperatures as high as 26.6°C in the Clark Fork at Gemback Bridge on July 30, 2021. (See Appendix B).

Release conditions

BSB began pumping water from Silver Lake on the morning of August 2, 2021 and continued pumping water (approximately 32 cfs, as measured in the Parshall flume in the outlet ditch) through the morning of September 20, 2021 (Figure 2). Approximately 3,120 AF of water stored in Silver Lake was released. The surface elevation of the lake decreased 11.7 ft, which corresponds with a calculated storage loss of 3,339 AF. Evaporation and seepage losses likely account for the difference. The mean and maximum daily temperature of the water released via gravity were all under the 15°C threshold for healthy bull trout habitat (Figure 2). See Appendix C.

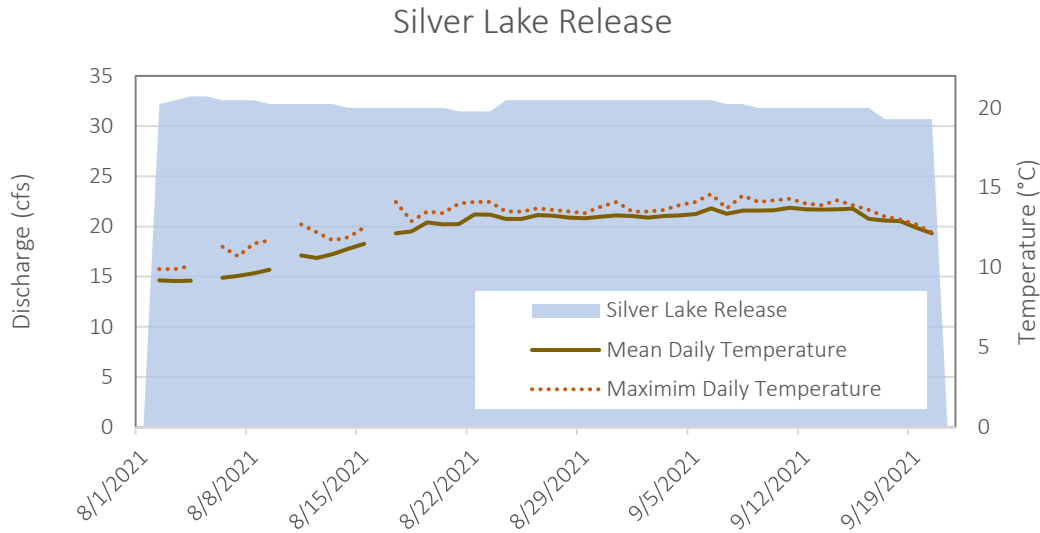


Figure 2. Silver Lake release discharge and water temperature, as measured by Parshall flume and Solinst Levelogger located in the Silver Lake ditch.

Discharge Response

Warm Springs Creek

The measured response of discharges in WSC and the CFR varied in timing and magnitude, with the more immediate, and therefore easier to correlate, increases in flow occurring closer to Silver Lake and attenuating with distance from the lake (see Appendixes A and D). All flow monitoring sites on WSC had changes in flow which followed the pattern of the release, with increases of 16.4-30.6 cfs between August 1 and August 4, 2021, and decreases of 13.0-32.7 cfs between September 19 and September 26, 2021 when pumping stopped (Table 3 and Figure 3). The Silver Lake water raised flows in WSC above the 40 cfs flow target for the duration of the release.

Table 3. Warm Springs Creek mean daily discharge values before, during, and after Silver Lake Release.

Location	Beginning of Release			End of Release		
	8/1/2021 Mean Daily Discharge (cfs)	8/4/2021 Mean Daily Discharge (cfs)	Change (cfs)	9/19/2021 Mean Daily Discharge (cfs)	9/26/2021 Mean Daily Discharge (cfs)	Change (cfs)
Silver Lake Release	0	33.0	+32.2	30.7	0	-30.7
WSC abv Meyers Dam	57.0	87.6	+30.6	76.1	50.1	-26.0
WSC near Anaconda	85.7	116.0	+30.3	104.0	71.3	-32.7
WSC blw Gardiner Ditch	39.2	55.6	+16.4	60.9	47.9	-13.0
WSC blw WMA Ditch	28.6	48.7	+20.1	51.4	33.7	-17.7
WSC at Warm Springs	27.6	54.6	+27.0	55.3	30.5	-24.8

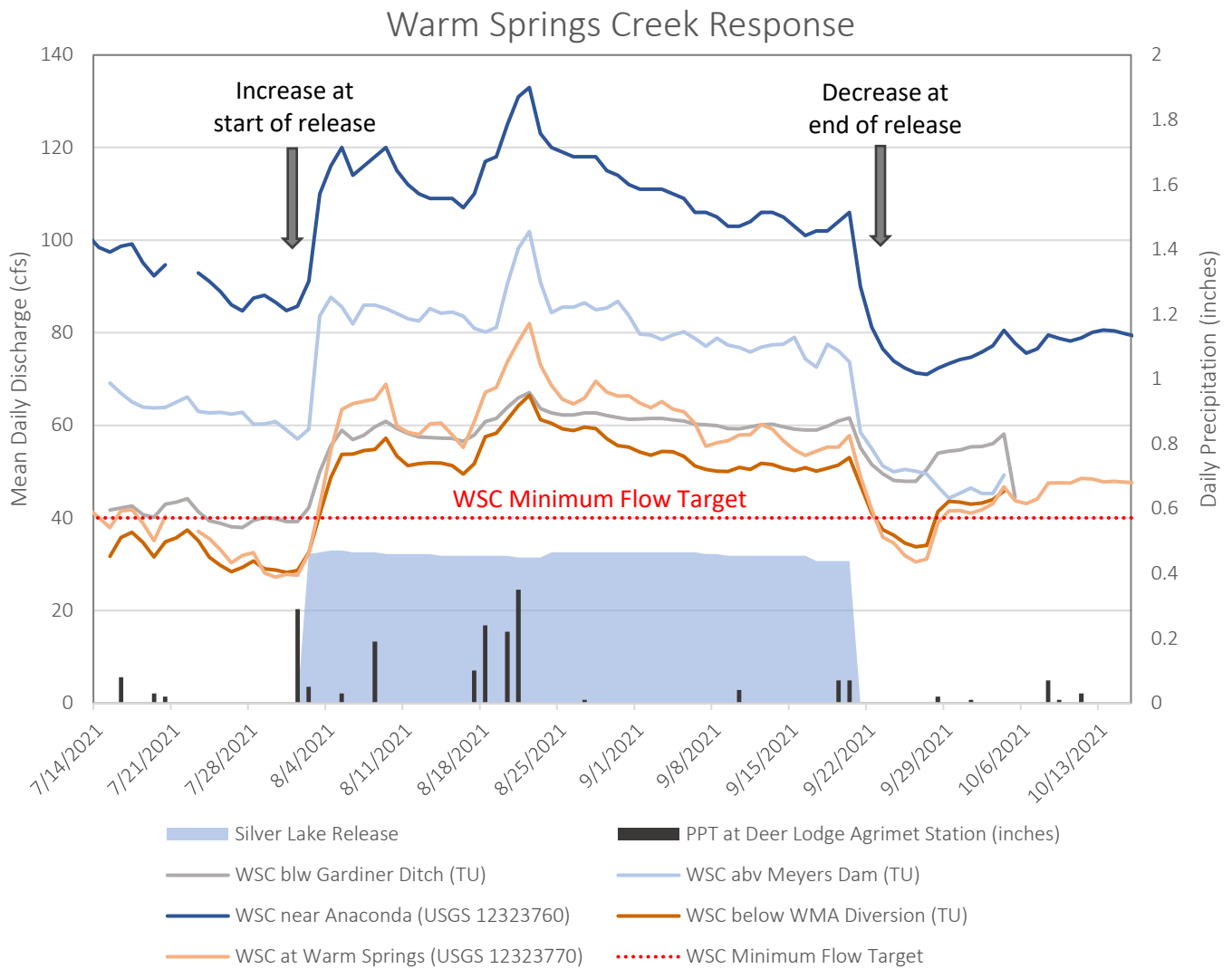


Figure 3. Mean daily discharge at Warm Springs Creek stream gages and daily precipitation at Deer Lodge, MT Agrimet Weather Station.

Trout Unlimited and BSB monitored major diversions at Meyers Dam, the Gardiner Ditch, and the FWP Wildlife Management Area (WMA) Ditch during the release (See Figure 4). The diversion at Meyers dam fluctuated between 3.3-5.8 cfs during the release, while the diversions from Gardiner Ditch and the WMA ditch held a mostly steady diversion of 29.5 and 4.5 cfs, respectively.

The TU gage below the Gardiner Ditch reflected the smallest increase 3 days after release began. The initial lower value could be attributed to reach losses and an increase in diversion into the ditch, due to the increased head from higher flows. TU staff measured 33 cfs being diverted into the ditch before the release on the morning of August 2, 2021 and 40 cfs on the afternoon of August 3, 2021. The Gardiner Ditch users adjusted the headgate to maintain a diversion of less than 33 cfs soon after being contacted about the passive increase at the headgate.

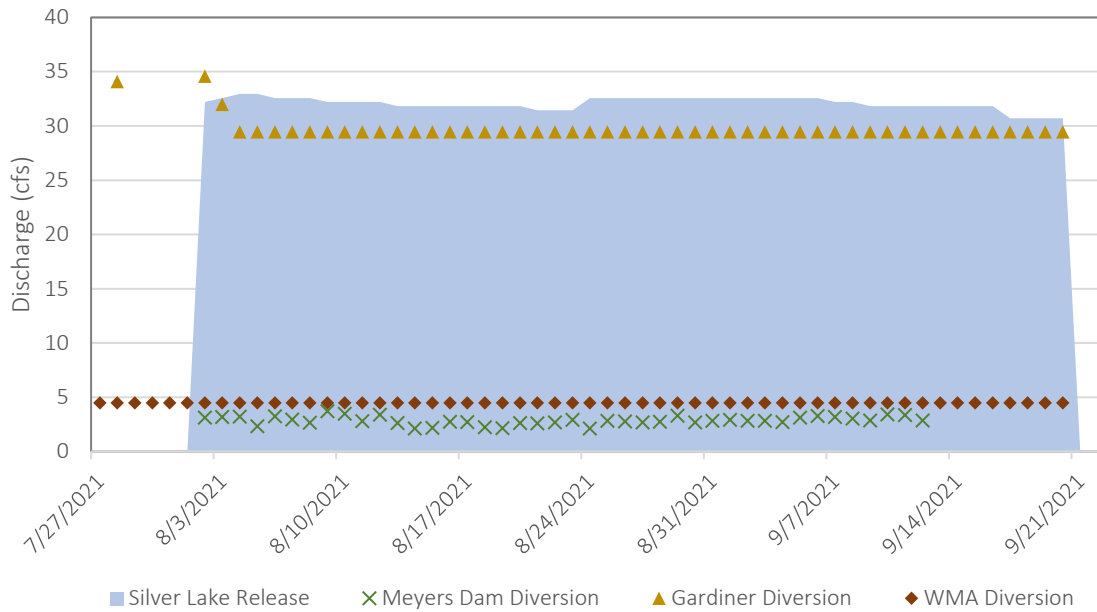


Figure 4. Warm Springs Creek diversions (cfs) during Silver Lake release. * Meyers dam diversion estimated using BSB TIFID influent measurements. ** WMA ditch estimated at a constant 4.5 cfs based on several discharge measurements.

The reach gain and loss characterization from the synoptic measurements collected on August 12, 2021, aligned with previous results from 2017 and 2019. Warm Springs Creek gained 15.6 cfs (29.1 %) from Cable Creek to the Meyers dam and an additional 32.2 cfs (39.2%) between Meyers Dam and the USGS gage in Anaconda. Below the gage in Anaconda, WSC lost 16.8 cfs (15.4%) through the Gardiner Ditch and an additional 7.3 cfs (11.5%) between the Gardiner Ditch and the Wildlife Management Area (WMA) ditch. Lower WSC showed an increase in flow in the lowest reach between the WMA Ditch and the USGS gage at Warm Springs, gaining 6.0 cfs (11.7%). Assigning loss of the storage water released from Silver Lake the percentage of reach loss, we estimate that 24.1 cfs was entering the upper CFR. (See Table 4 and Figure 5.)

Table 4: Reach characterization based on August 12, 2021 synoptic measurements.

Reach	Reach Gain-Loss (cfs)	Percent Gain-Loss	Silver Lake water remaining (cfs)
Silver Lake Release	32.2	NA	32.2
WSC blw Cable to abv Meyers	15.6	29.1%	32.2
WSC abv Meyers to Anaconda	32.2	39.2%	32.2
WSC Anaconda to blw Gardiner	-16.8	-15.4%	27.4
WSC blw Gardiner to blw WMA	-7.3	-11.5%	24.1
WSC blw WMA to Warm Springs	6.0	11.7%	24.1
Lower SBC + WSC gages to CFR at Galen (Perkins Lane)	-10.6	-11.0%	21.4
CFR Galen (Perkins Lane) to Galen Rd	-5.2	-6.1%	20.2
CFR Galen Rd to Gemback Bridge	16.0	19.9%	20.2
CFR Gemback Bridge to below Racetrack	11.1	21.3%	20.2
CFR blw Racetrack to Sager Lane	0.6	1.0%	20.2
CFR Sager Lane to Deer Lodge	37.2	69.3%	20.2

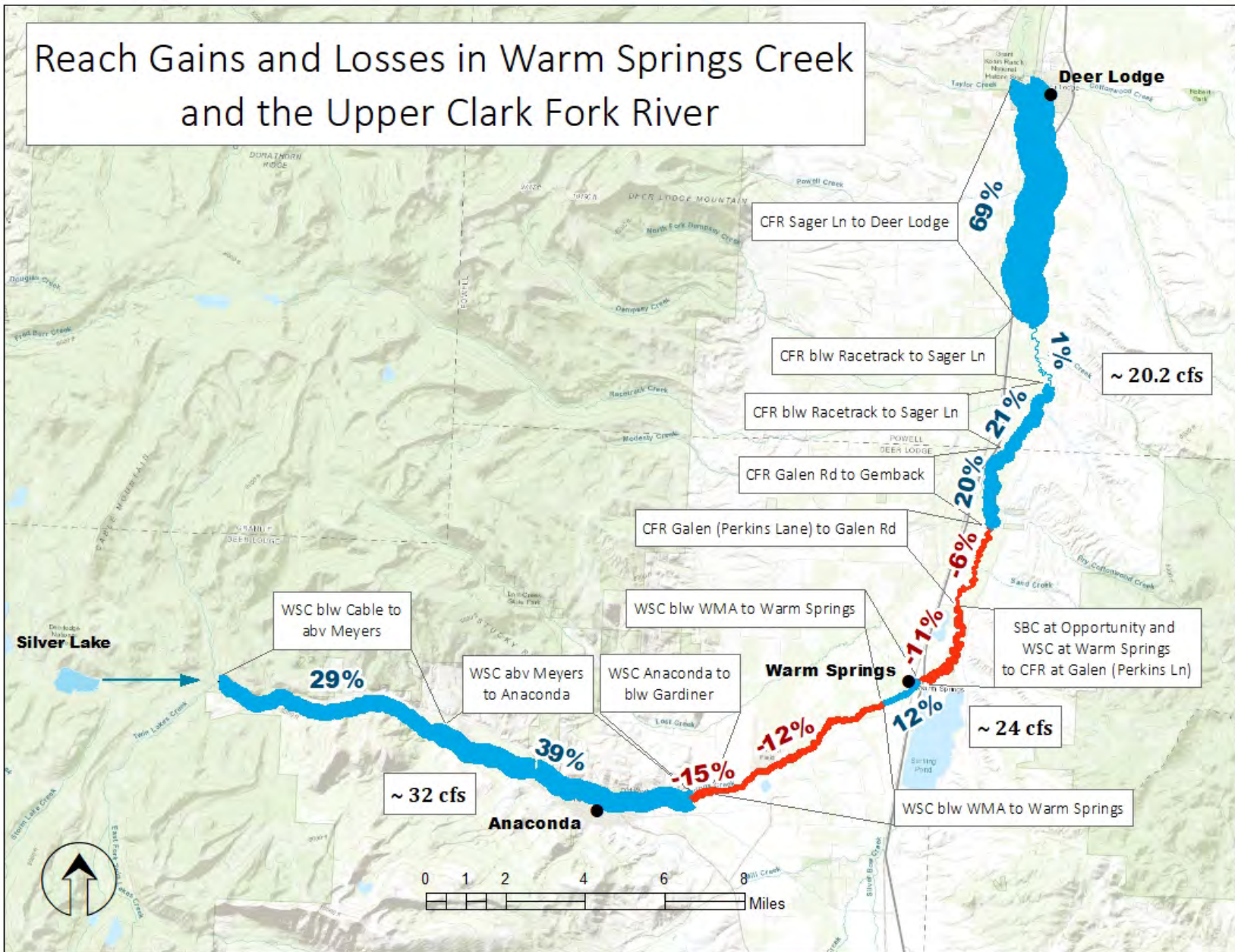


Figure 5. Reach gains and losses as determined by synoptic measurements taken on August 12, 2021.

Clark Fork River

In the Clark Fork River below WSC, there were large increases in flow after the start of the release, with gains of 31.9 cfs to 41.4 cfs along the system between August 1 and August 6, 2021 (Table 5 and Figure 6). The increases in flow along the CRF were only partially the result of Silver Lake releases. The area received 0.34 inches of rain (Deer Lodge Agrimet station) between August 2 and August 3, 2021, which contributed an unknown amount of water to the system. Flows in Silver Bow Creek, which were unaffected by the release, increased 5.2 cfs between August 1 and August 3, 2021 (Figure 7). There was also an increase of 36.6 cfs in SBC below the Warm Springs Ponds between August 10 and August 13, 2021 (Figure 7), which appears to be attributable to increased releases from the Warm Springs Pond system as Mill and Willow Creeks did not significantly increase during that period (See details in Appendix B.) At the end of the release, flows dropped between 15.7 cfs and 3.4 cfs between September 19 and September 24, 2021, with a decrease of 15.7 cfs at the USGS gage near Galen and 11.0 cfs at Deer Lodge (Table 5 and Figure 6). The increases raised flows in the CFR above the 40 cfs and 90 cfs flow targets at Galen and Deer Lodge, respectively. The informal flow targets of 50 cfs and 60 cfs at Gemback Bridge and Sager Lane were not reached early in the release, but additional flows from rain and release from the Warm Springs Ponds resulted in exceeding the targets by mid-August.

Table 5. Clark Fork River mean daily discharge values before, during, and after Silver Lake Release.

Location	Beginning of Release			End of Release		
	8/1/2021 Mean Daily Discharge (cfs)	8/6/2021 Mean Daily Discharge (cfs)	Change (cfs)	9/19/2021 Mean Daily Discharge (cfs)	9/24/2021 Mean Daily Discharge (cfs)	Change (cfs)
Silver Lake Release	0	32.6	+32.6	30.7	0	-30.7
CFR near Galen (USGS)	40.8	82.2	+41.4	89.4	73.7	-15.7
CFR at Galen Rd (CFC)	46.8	78.7	+31.9	101.2	87.7	-13.5
CFR at Gemback Bridge (CFC)	12.1	46.0	+33.9	97.8	89.1	-8.7
CFR blw Racetrack Creek (CFC)	13.4	53.9	+40.5	92.1	86.6	-5.5
CFR at Sager Ln (CFC)	5.0	42.2	+37.2	89.3	85.9	-3.4
CFR at Deer Lodge (USGS)	35.7	83.2	+47.5	158.0	147	-11.0

Clark Fork River Response

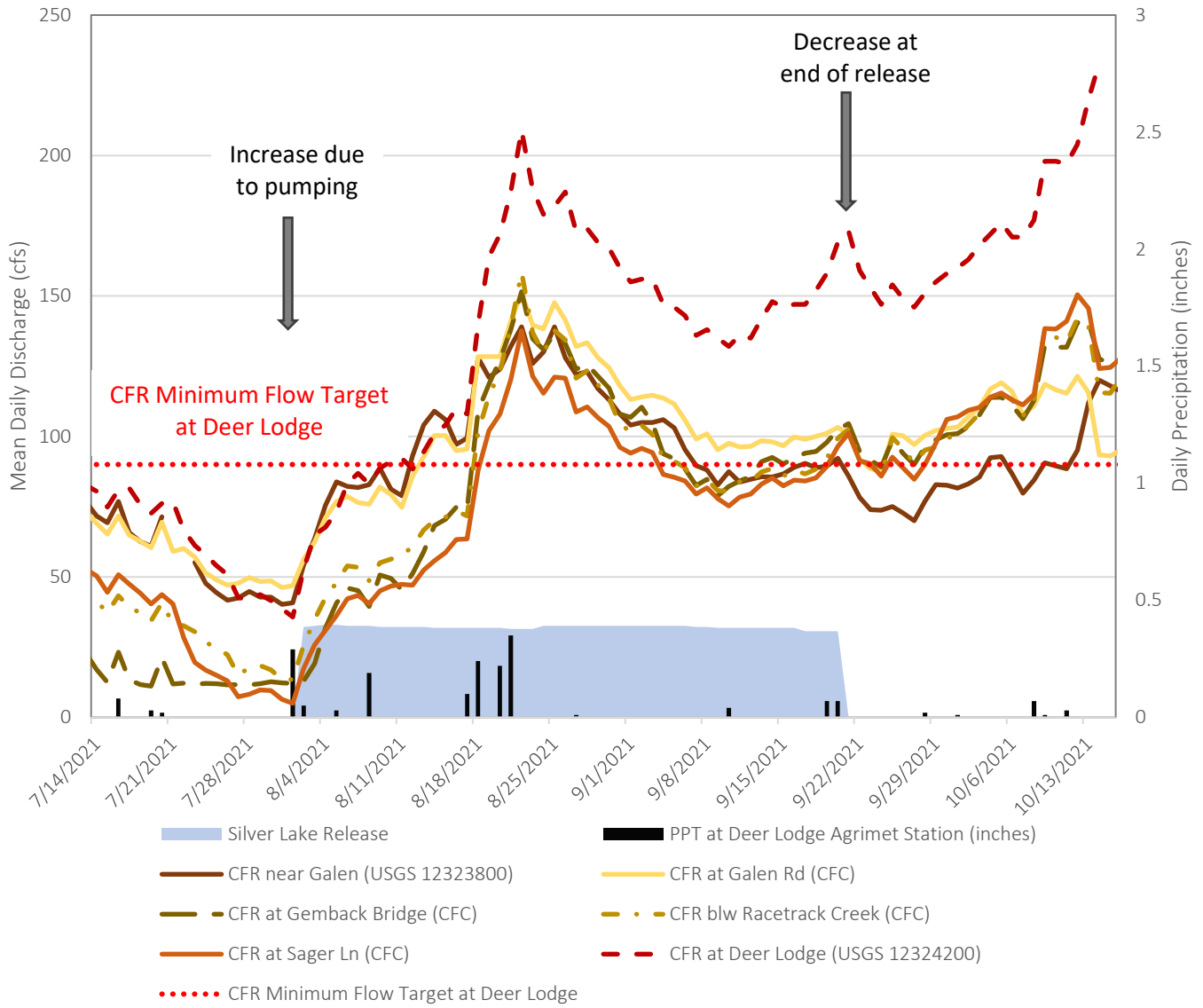


Figure 6. Mean daily discharge at Clark Fork River stream gages and daily precipitation at Deer Lodge, MT Agrimet Weather Station.

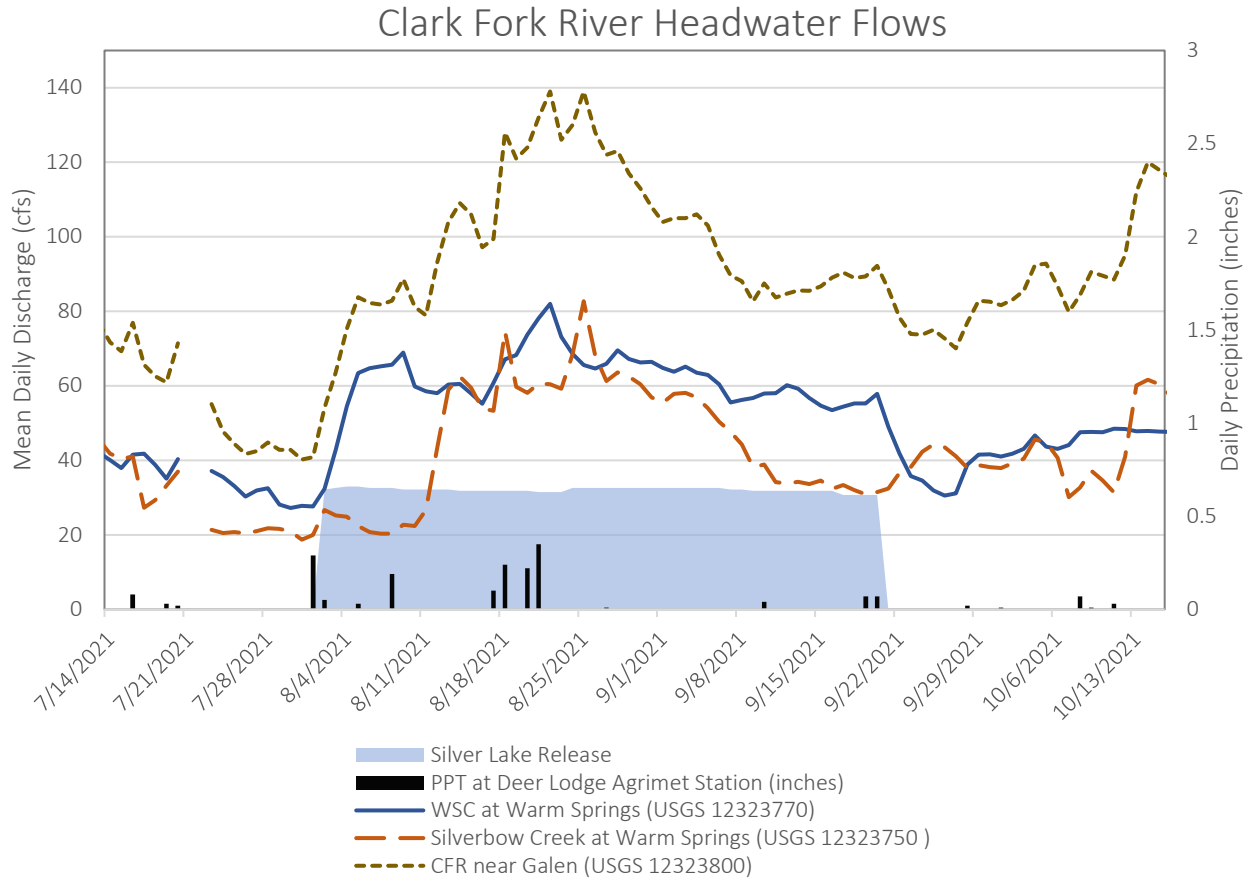


Figure 7. Mean daily discharge of Clark Fork River headwater streams.

The 2021 reach gain and loss characterization for the CFR synoptic measurements also aligned with the data from 2017 and 2019, except for the reach between the lowest WSC and SBC USGS stream gages and the USGS CFR near Galen gage. In 2019, that reach gained 1% -8%, during synoptic measurements, compared to the 11% loss measured in 2021. Approximately 15.8 cfs was lost between the lowest stream gages on WSC and SBC and the CFR at Galen Rd, with 10.6 cfs (11.0%) lost between the SBC and WSC gages and the CFR at Galen (Perkins Lane) and 5.2 cfs (6.1%) lost between the USGS gage near Galen (Perkins Lane) and CFC gage at Galen Road (Table 4 and Figure 5). The CFR gained 64.3 cfs between Galen Rd. and Deer Lodge, with 16.0 cfs (19.9%) gained between Galen Road and Gemback Bridge, 11.1 cfs (21.3%) gained between Gemback Bridge and below Racetrack Creek, 0.6 cfs (1.0%) gained below Racetrack to Sager Lane, and 37.2 cfs (69.3%) gained between Sager Lane and Deer Lodge (Table 4 and Figure 5). Return flows at the lower end of the Anaconda and Deer Lodge valley likely account for a portion of those significant reach gains. Assigning loss of the storage water released from Silver Lake the percentage of reach loss, we estimate that 21.4 cfs was in the upper reach above Galen and 20.2 cfs remained instream down to Deer Lodge (Table 4).

Temperature

Determining the effect of the release on stream temperature in WSC and the CFR is challenging. The water released from Silver Lake was consistently below the 15°C threshold for healthy bull trout habitat, so it was protective of the fish habitat in WSC. Water temperatures near Warm Springs had been exceeding the 20°C threshold for healthy WCT habitat in the 3 days before the Silver Lake release. After the release, maximum temperatures were consistently below the threshold (Figure 8 and Appendix B). The biggest drop in temperature coincided with rain and a drop of more than 10°C mead daily air temperatures.

Warm Springs Creek Maximum Daily Temperature

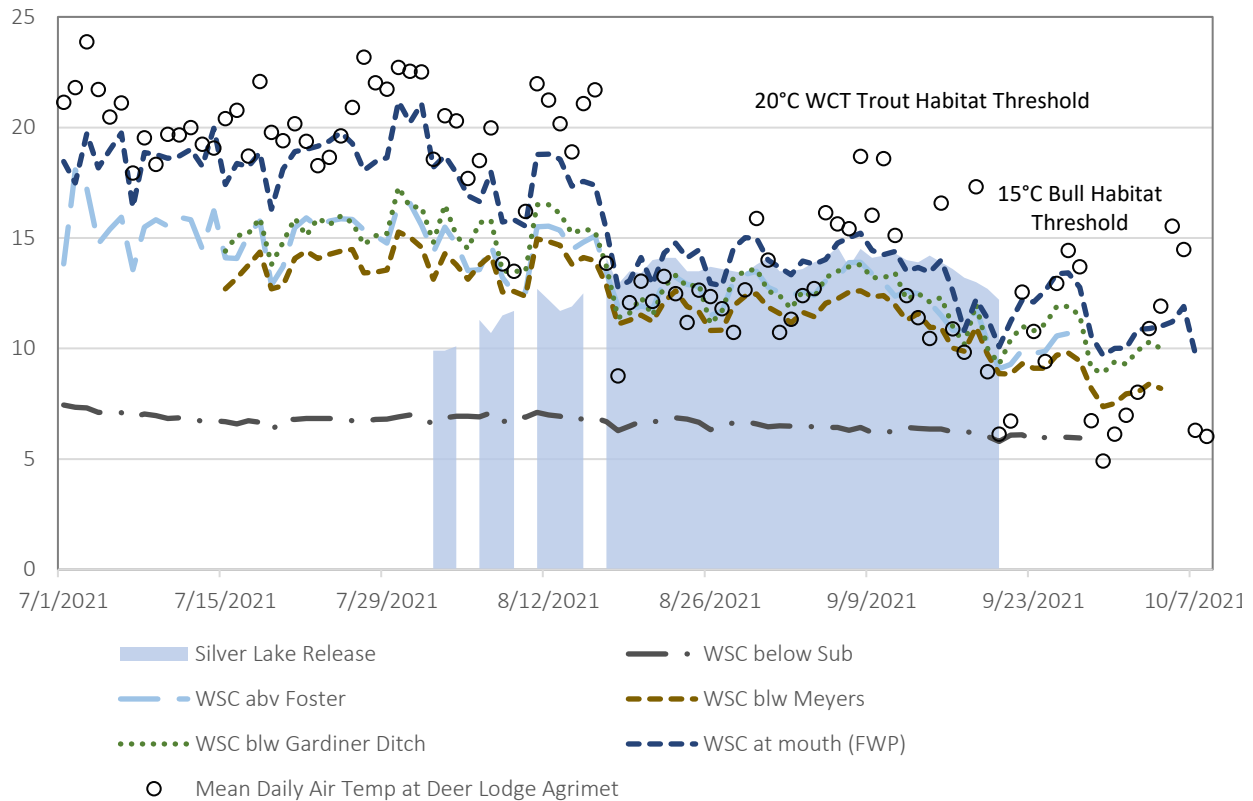


Figure 8. Warm Springs Creek Maximum Daily water temperatures and mean daily air temperature at Deer Lodge Agrimet station.

There did not appear to be a cooling effect of the Silver Lake water in the CFR. Maximum water temperatures continued to exceed the 20°C threshold for healthy WCT through mid-August (Figure 9 and Appendix B), when rain and cooling air temperatures decreased water temperatures in reference streams like SBC above WSC, the Mill-Willow Bypass, and Lost Creek (Figure 10). However, the water mass added to the CFR may prevent additional warming. It is not within the current monitoring protocol and technical expertise of Trout Unlimited to evaluate this aspect of the Silver Lake release.

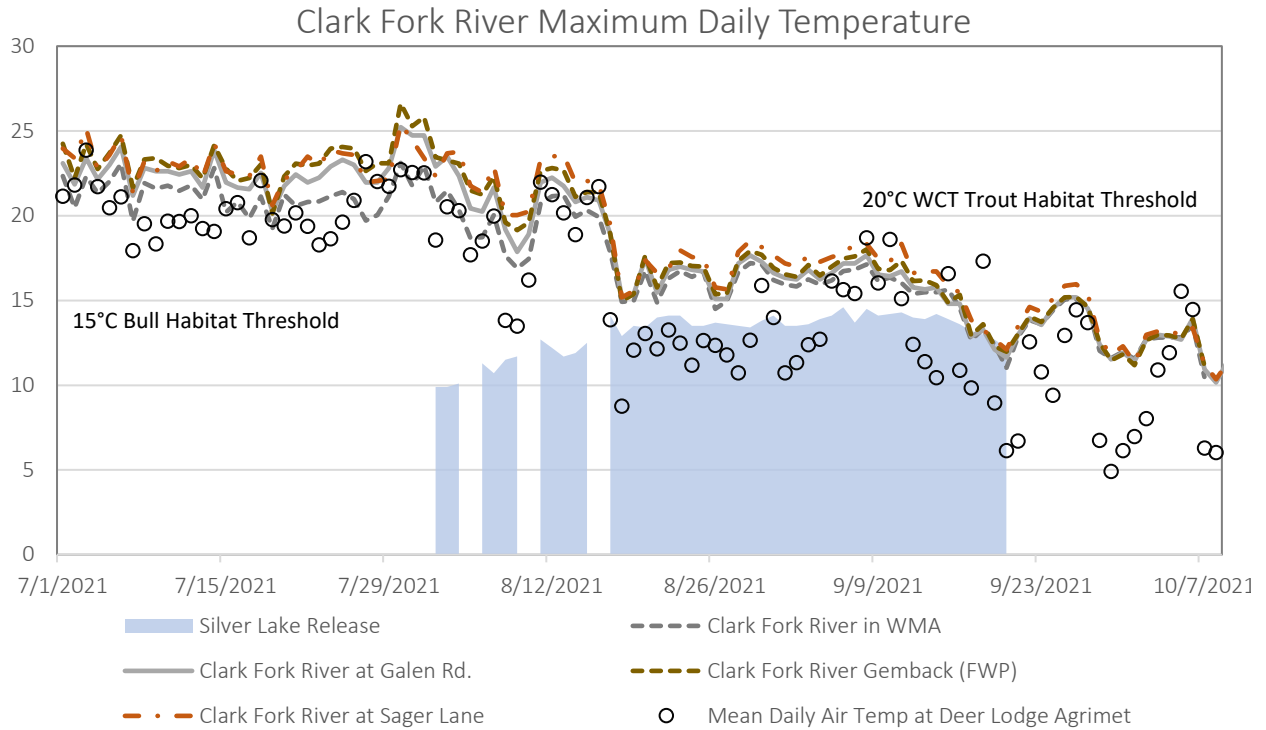


Figure 9. Clark Fork River maximum daily water temperatures and mean daily air temperature at Deer Lodge Agrimet station.

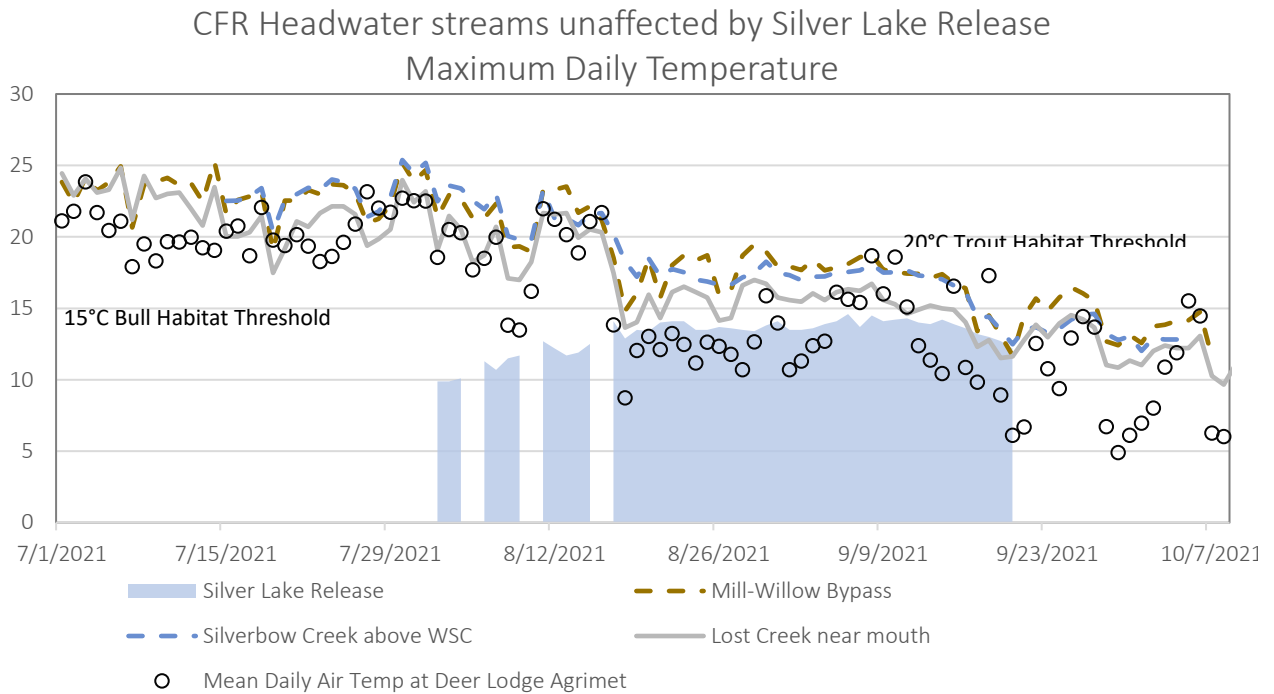


Figure 10. Clark Fork River headwater stream maximum daily temperatures unaffected by Silver Lake release and mean daily air temperature at Deer Lodge Agrimet station.

III. Conclusions and Recommendations

The timing of the third pilot release, during a severe drought, demonstrated that water stored in Silver Lake can be used to increase flows to meet or partially meet minimum flow targets in WSC and the CFR. TU recommends a long-term agreement to set aside up to 3,200 AF of Silver Lake stored water annually to address drought conditions in WSC and the CFR. TU also recommends monitoring reservoir levels and installing and maintaining real time stream gage stations on WSC below the Gardiner Ditch and on the CFR near Sager Lane.

Release of cold water from Silver Lake maintained stream temperatures under the 20°C threshold for Westslope cutthroat trout in WSC but did not appear to have an obvious cooling effect in the CFR. The additional water may have prevented additional warming in the river, but TU does not have the technical expertise to effectively evaluate the impacts. TU recommends that NRDP investigate further the relationship between flow and temperature in the CFR. Using the temperature and flow data available from monitoring of the stream that make up the CFR headwaters to run predictions of temperature changes in the upper CFR W3T model could be one place to start.

IV. References

Bear, E.A., T.E. McMahon, and A.V. Zale. 2007. Comparative thermal requirements of westslope cutthroat trout and rainbow trout: Implications for species interactions and development of thermal protection standards. *Transactions of the American Fisheries Society* 136: 1113-1121.

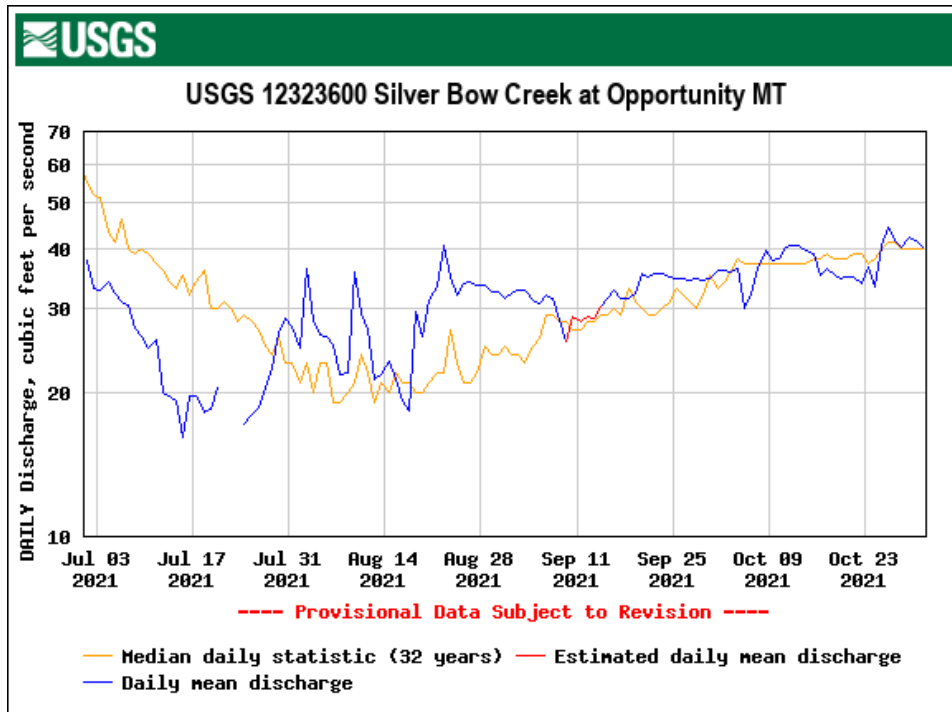
Dunham, J.B., B.E. Rieman, and G.L. Chandler. 2003. Influences of temperature and environmental variables on the distribution of bull trout within streams at the southern margin of its range. *North American Journal of Fisheries Management* 23:894-904.

Fraley, J.J., and B.B. Shepard. 1989. Life history, ecology, and population status of migratory bull trout (*Salvelinus confluentus*) in the Flathead Lake and River System, Montana. *Northwest Science* 63:133-143.

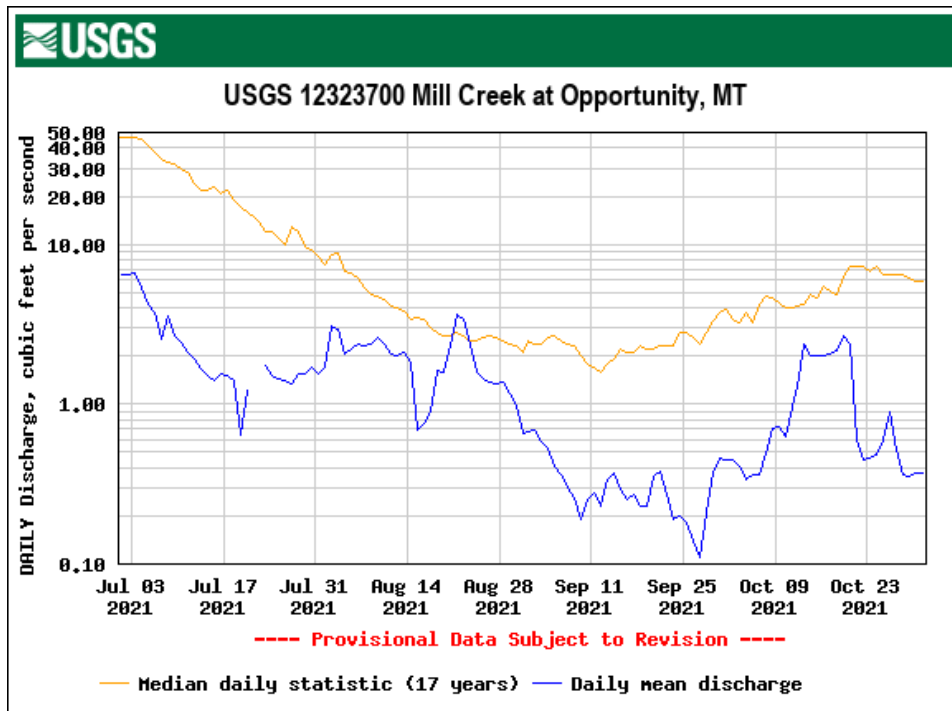
Montana Department of Fish, Wildlife & Parks. 1986. *Application for Reservations of Water in the Upper Clark Fork River Basin*. Helena, MT: Montana Department of Fish, Wildlife & Parks, November 1986.

Trout Unlimited. 2021. Silver Lake Release Monitoring Plan, prepared for Montana Department of Justice Natural Resource Damage Program, July 2021.

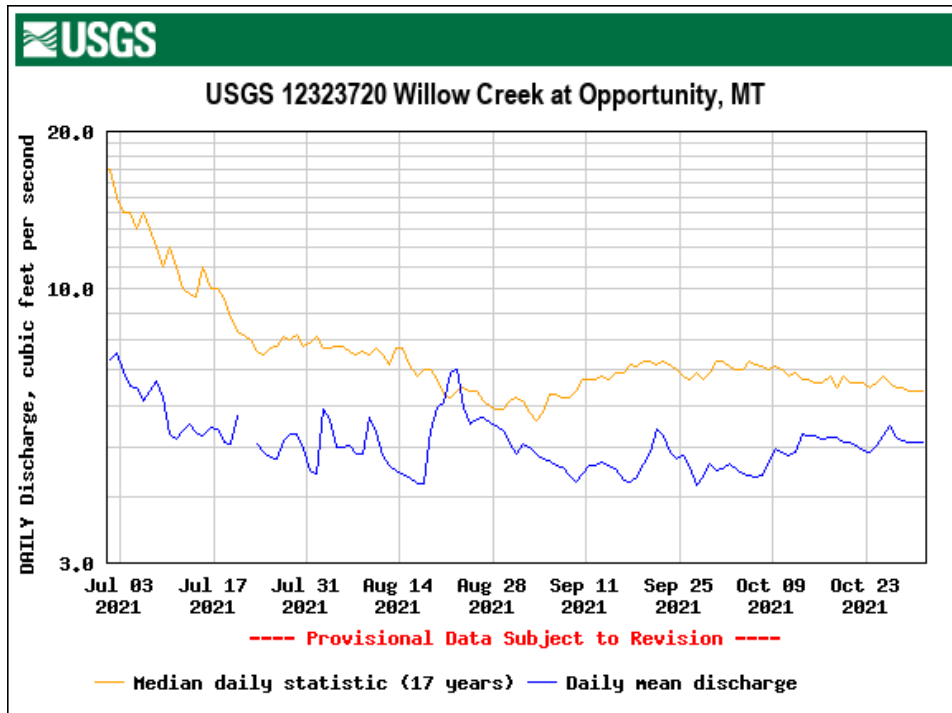
Appendix A: USGS Stream Gage Hydrographs



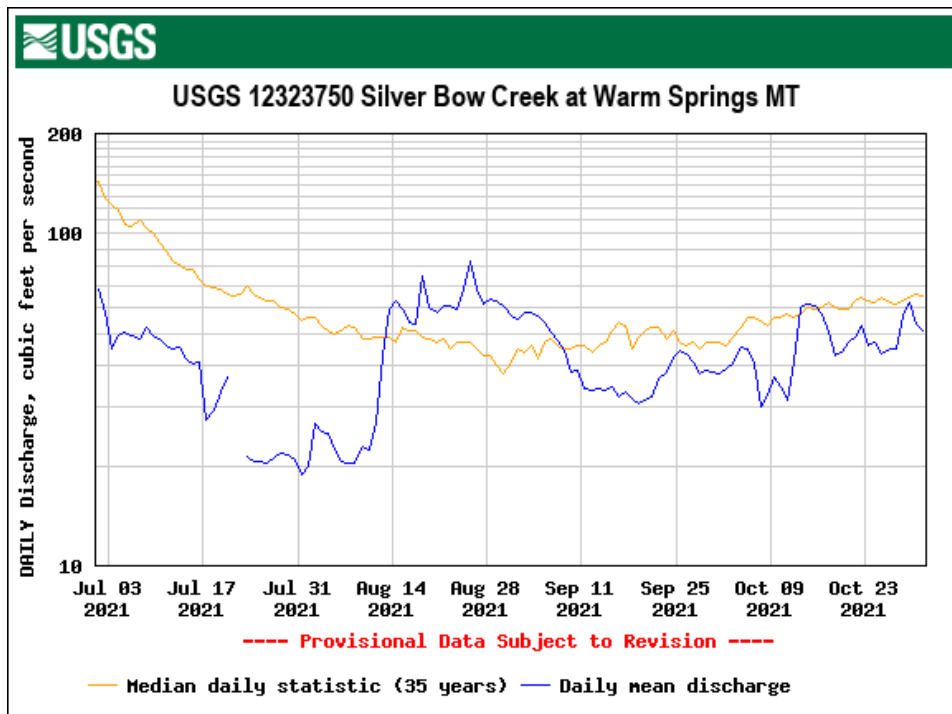
USGS Gage 12323600 Silver Bow Creek at Opportunity, MT mean and 32-year median daily discharge, July 1 to October 31, 2021.



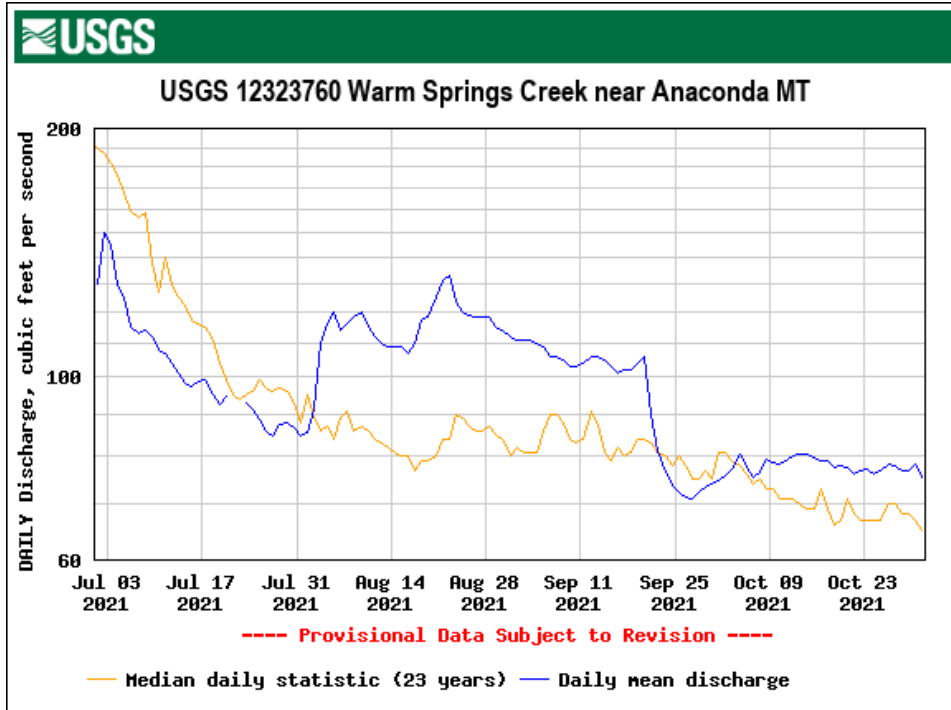
USGS Gage 12323700 Mill Creek at Opportunity, MT mean and 17-year median daily discharge, July 1 to October 31, 2021.



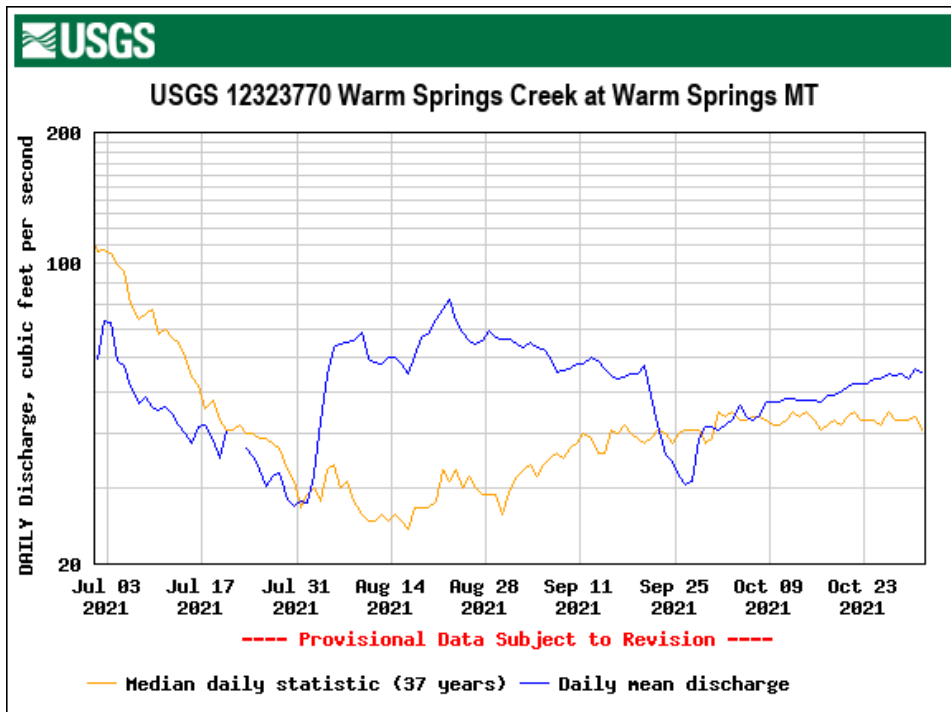
USGS Gage 123237200 Willow Creek at Opportunity, MT mean and 17-year median daily discharge, July 1 to October 31, 2021.



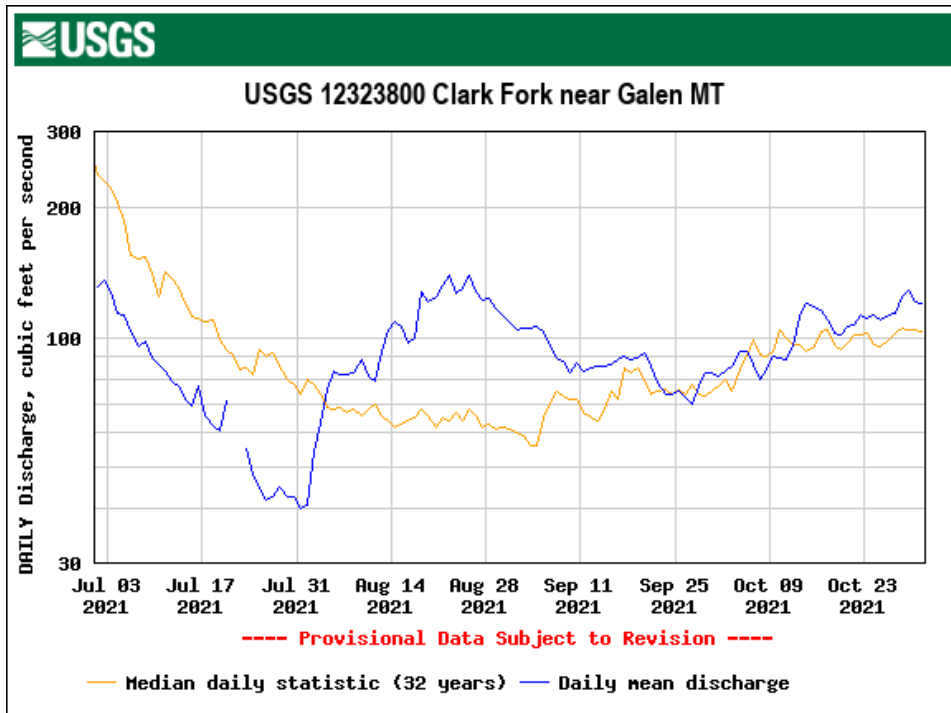
USGS Gage 12323750 Silver Bow Creek at Warm Springs, MT mean and 35-year median daily discharge, July 1 to October 31, 2021.



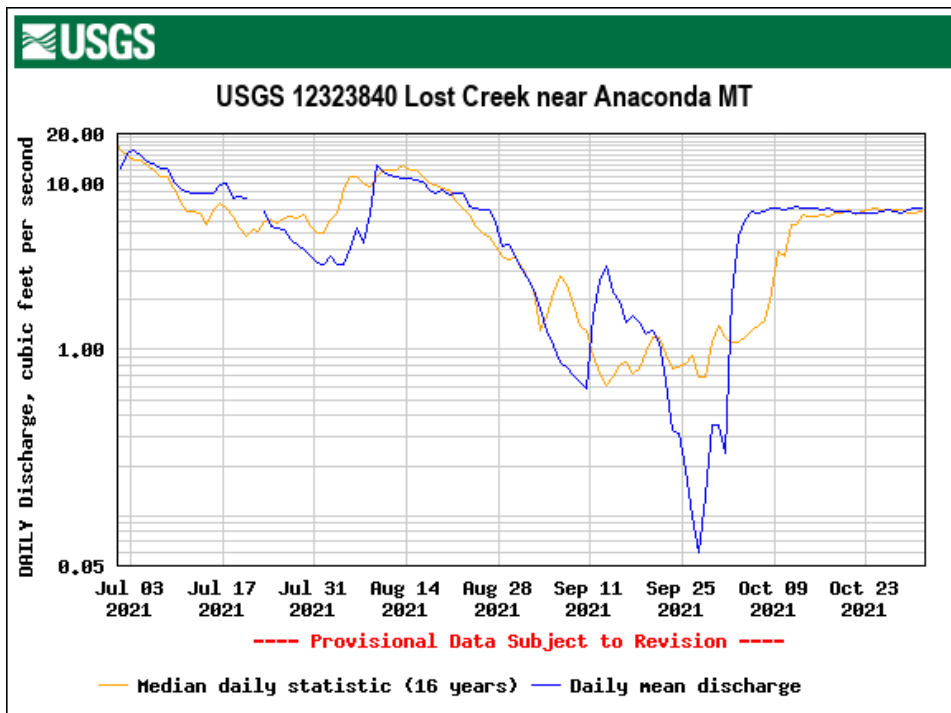
USGS Gage 12323760 Warm Springs Creek near Anaconda, MT daily mean and 23-year median daily discharge, July 1 to October 31, 2021.



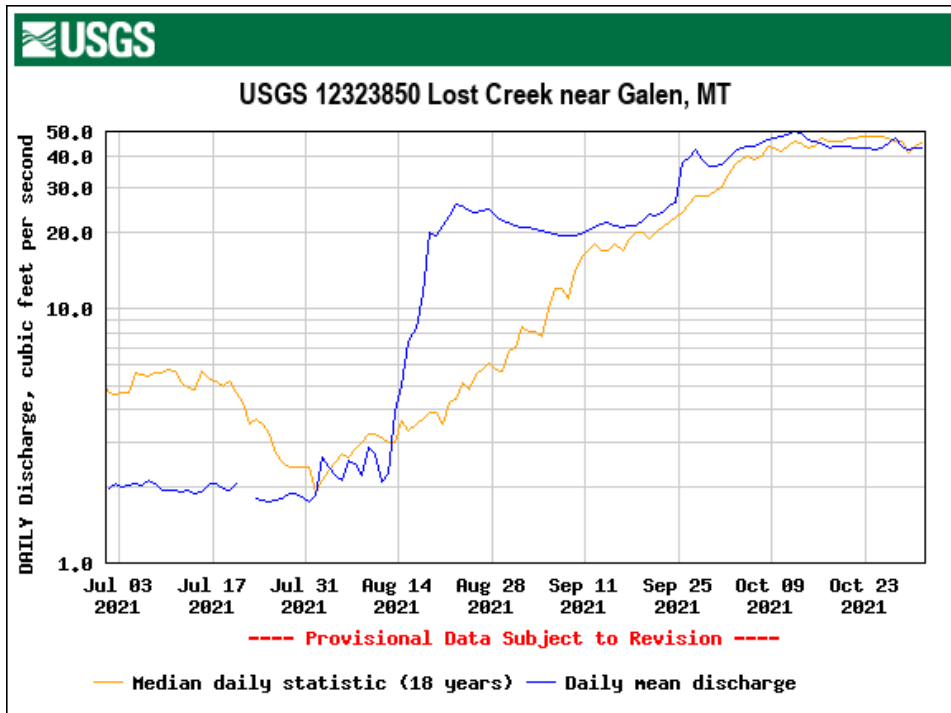
USGS Gage 12323770 Warm Springs Creek at Warm Springs, MT daily mean and 37-year median daily discharge, July 1 to October 31, 2021.



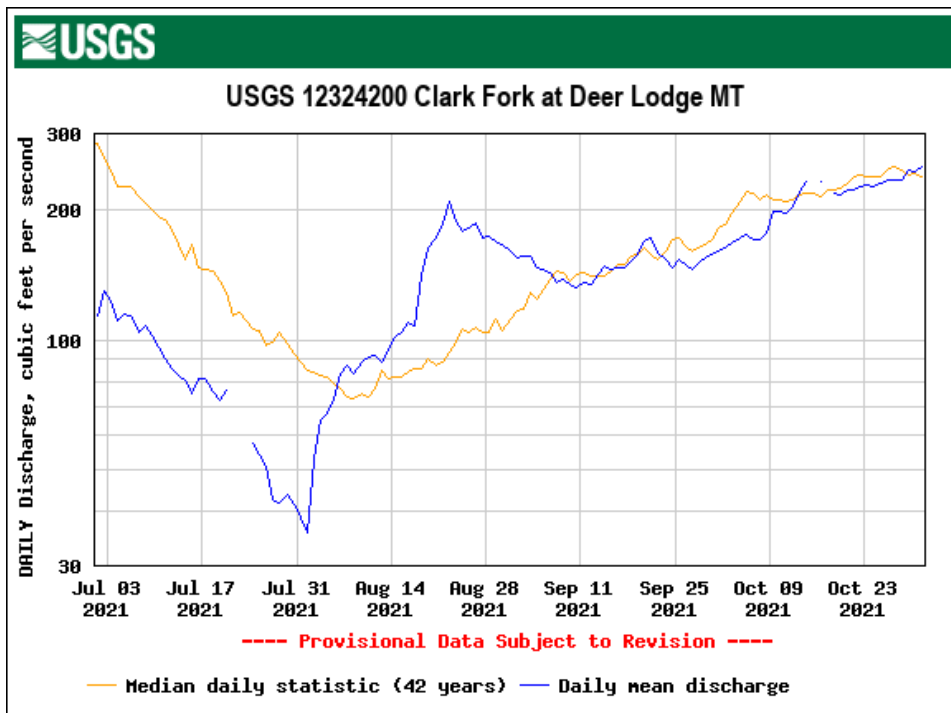
USGS Gage 12323800 Clark Fork River near Galen, MT mean and 32-year median daily discharge, July 1 to October 31, 2021.



USGS Gage 12323840 Lost Creek near Anaconda, MT mean and 16-year median daily discharge, July 1 to October 31, 2021.

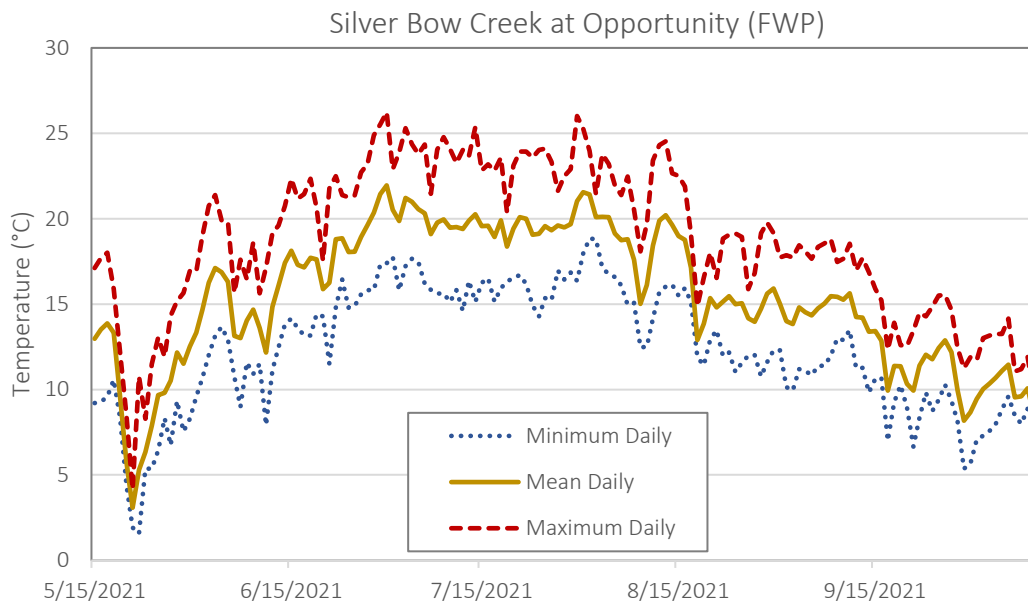


USGS Gage 12323850 Lost Creek near Galen, MT mean and 18-year median daily discharge, July 1 to October 31, 2021.

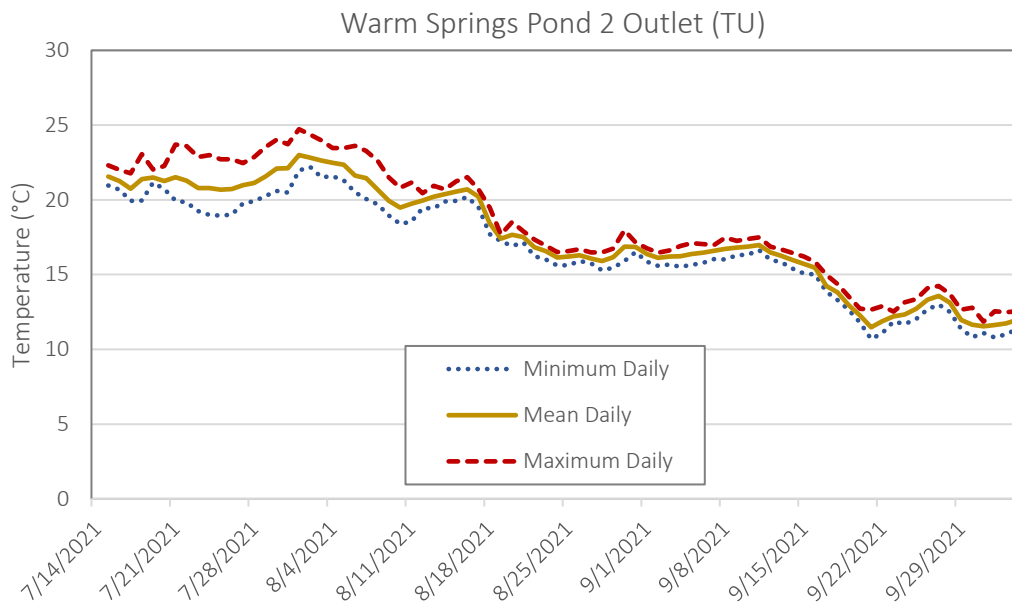


USGS Gage 12324200 Clark Fork River at Deer Lodge mean and 42-year median daily discharge, July 1 to October 31, 2021.

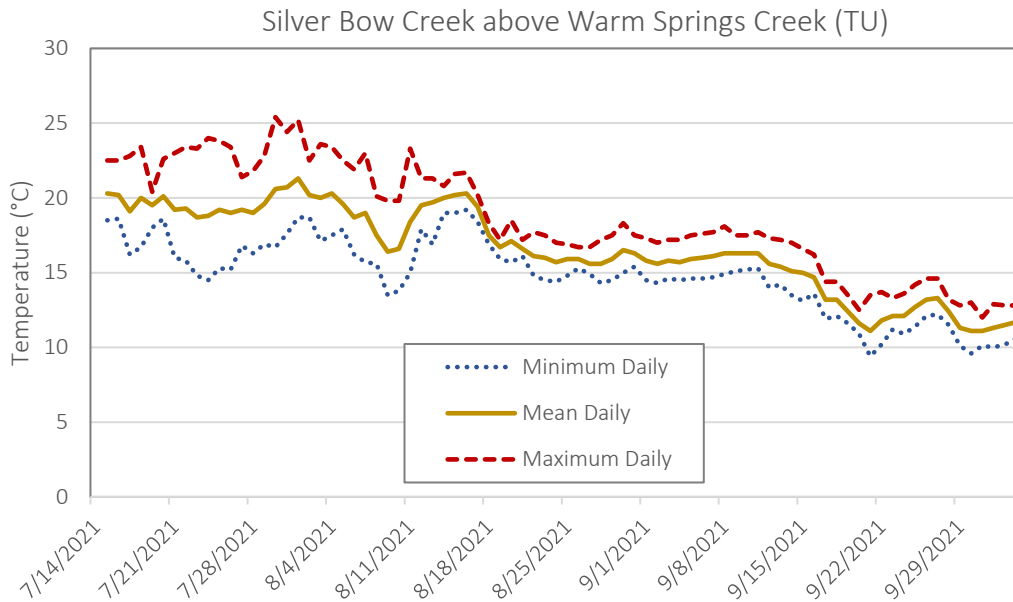
Appendix B: Temperature Monitoring Results



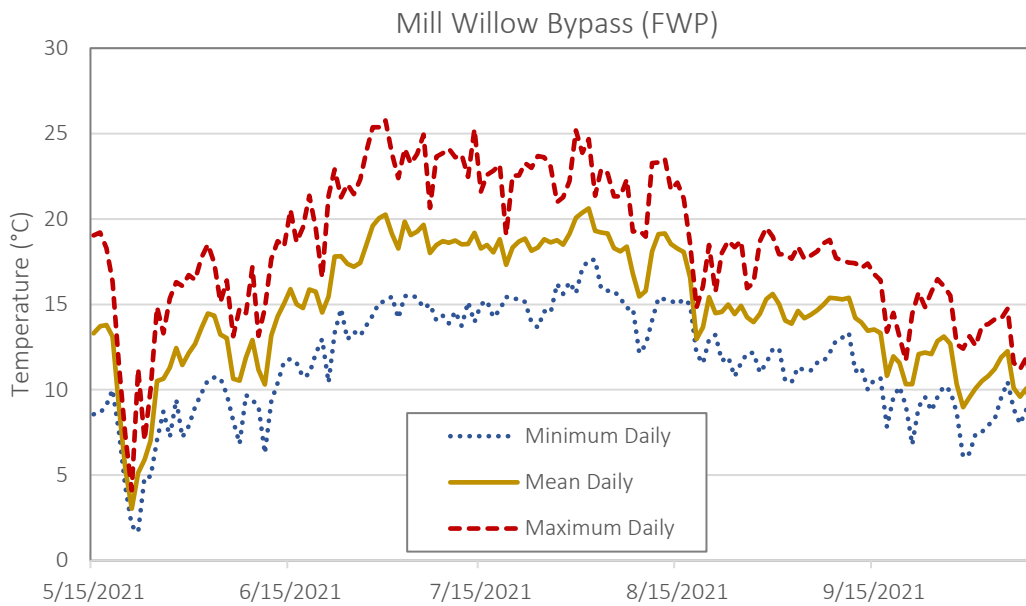
Silver Bow Creek temperature (°C) near Opportunity, as measured by FWP Onset Hobo ProV2 temperature probe.



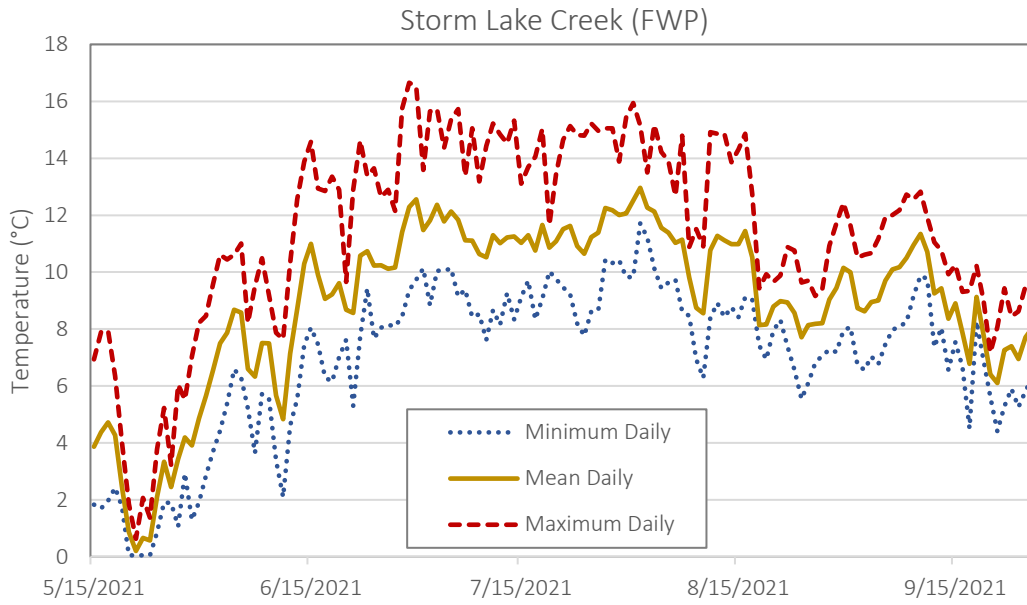
Silver Bow Creek temperature (°C) in Warm Springs Pond 2 outlet, as measured by FWP Onset Hobo Pendant temperature probe.



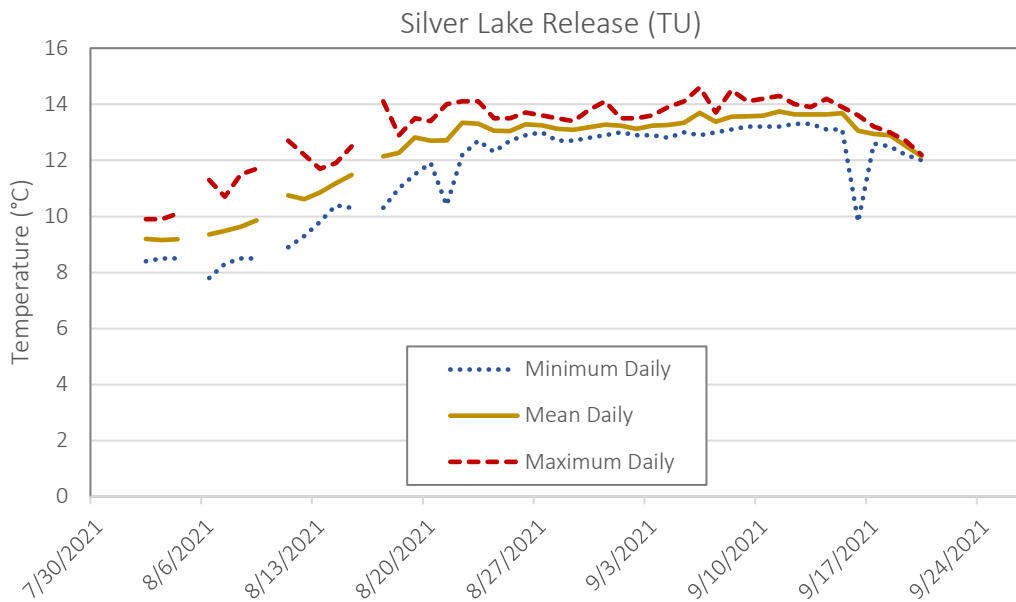
Silver Bow Creek temperature (°C) above confluence with Warm Springs Creek, as measured by Onset Hobo ProV2 temperature probe.



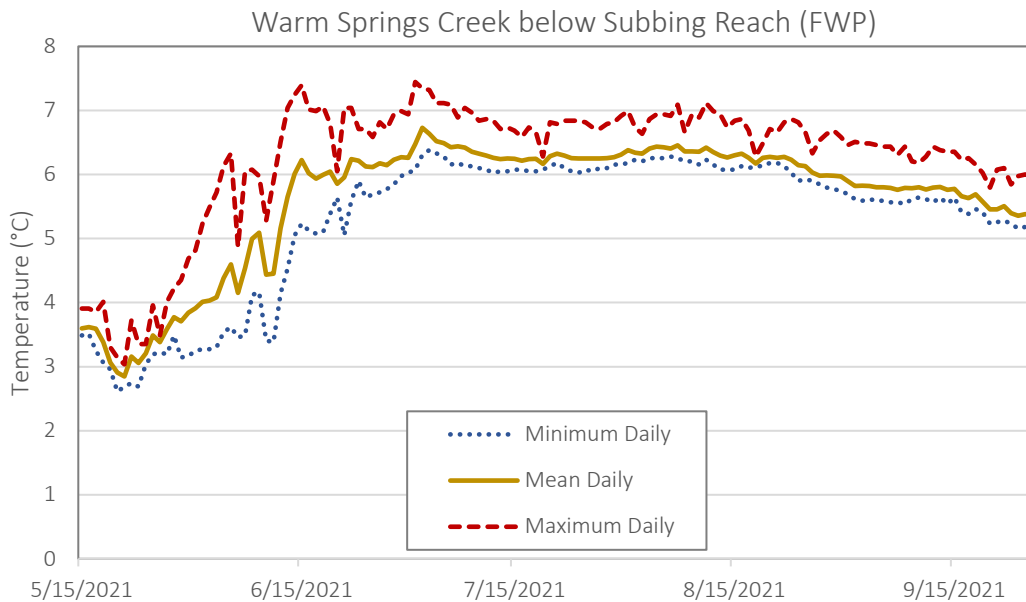
Mill-Willow Bypass temperature (°C) near confluence with Silver Bow Creek, as measured by Onset Hobo ProV2 temperature probe.



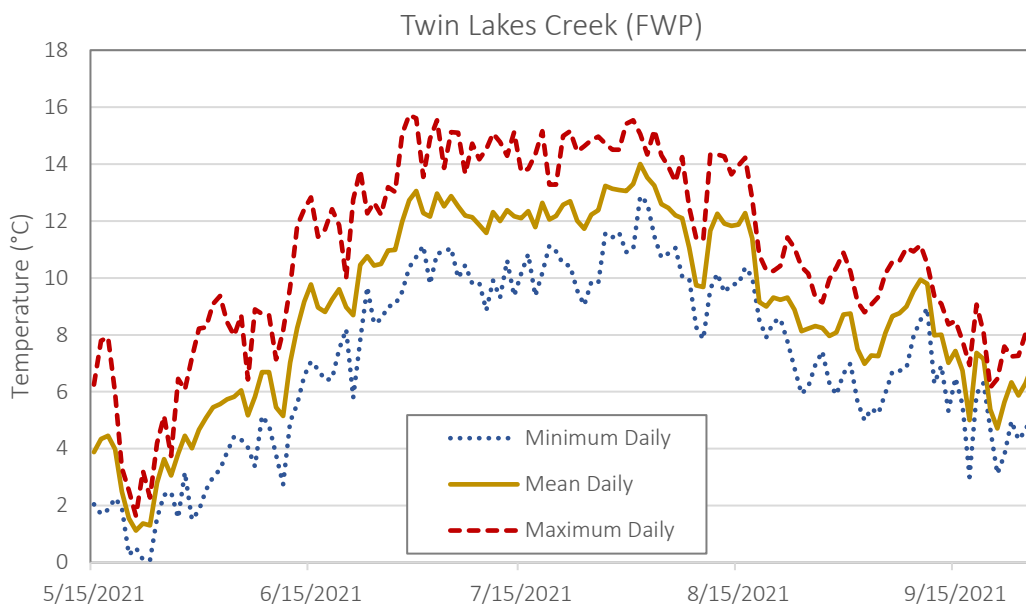
Storm Lake Creek temperature (°C), as measured by MT Fish, Wildlife and Parks Onset Hobo ProV2 temperature probe.



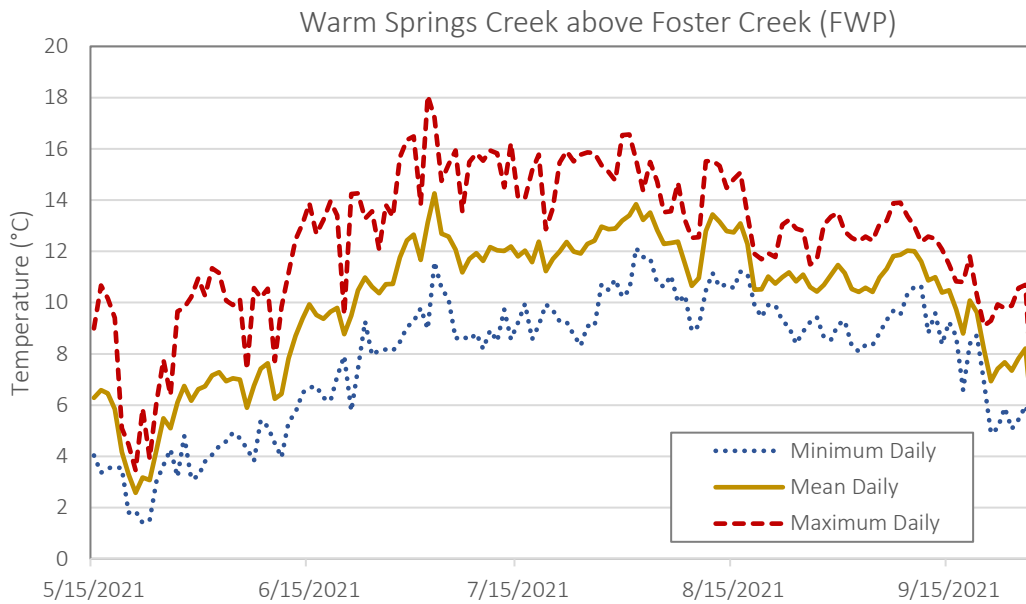
Temperature (°C) of Silver Lake release water, as measured by Solinst stage logger downstream of Parshall Flume.



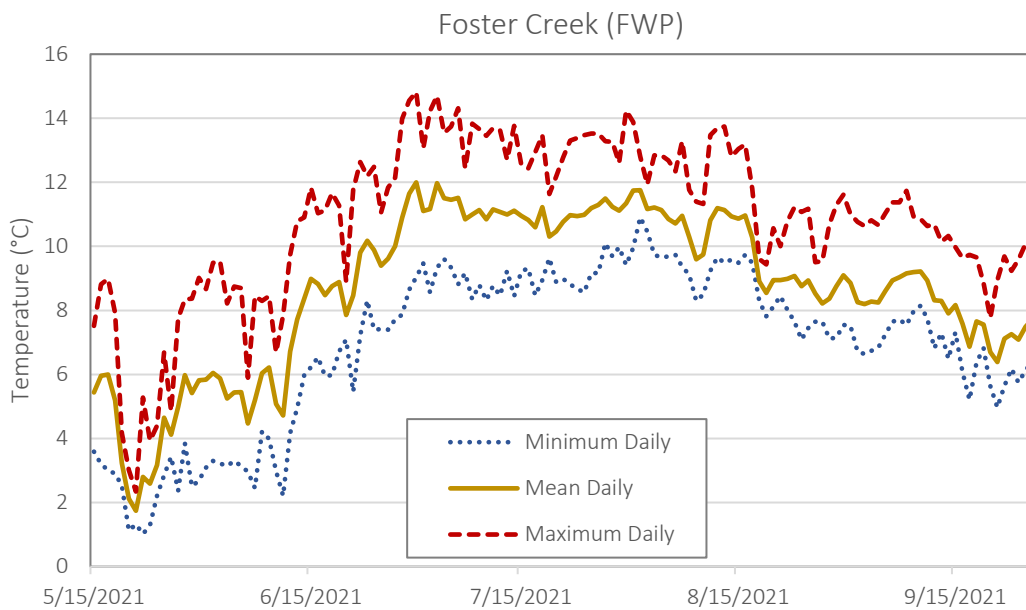
Warm Springs Creek temperature (°C) below a reach where flows go subsurface, as measured by MT Fish, Wildlife and Parks Onset Hobo ProV2 temperature probe.



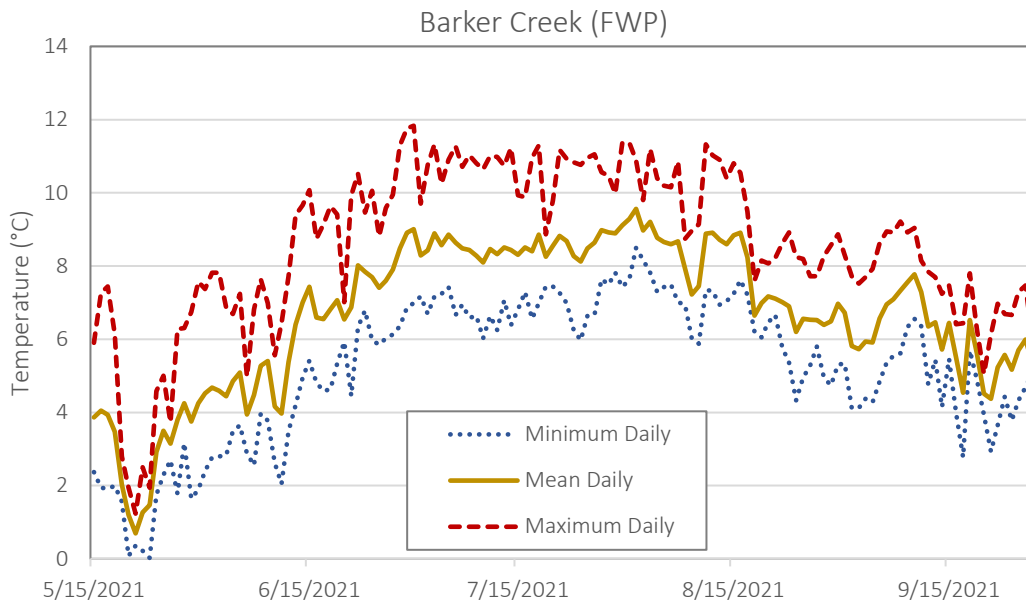
Twin Lakes Creek temperature (°C) near the confluence with Warm Springs Creek, as measured by Onset Hobo ProV2 temperature probe.



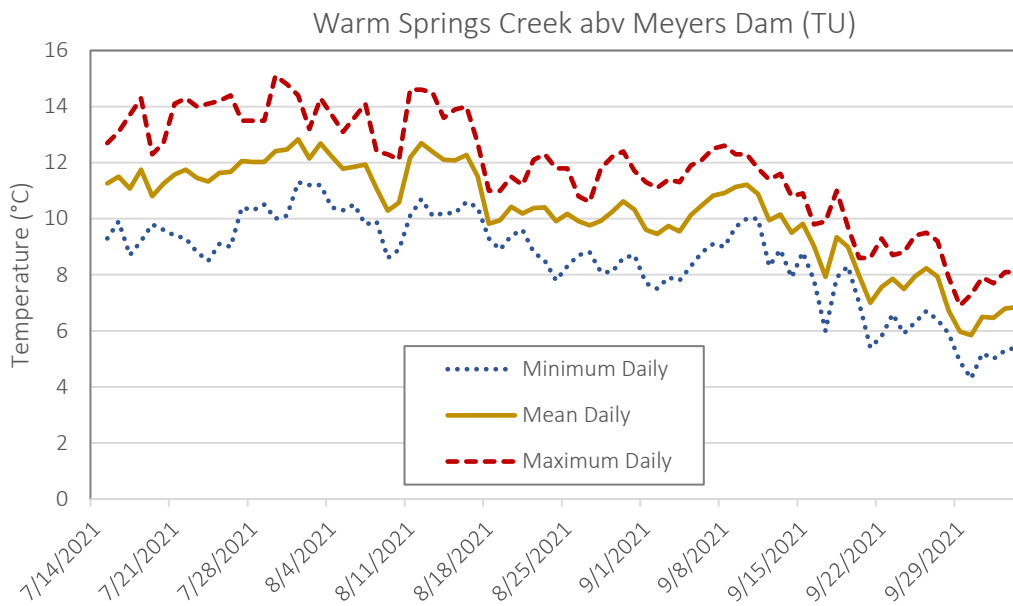
Warm Springs Creek temperature (°C) below Foster Creek, as measured by FWP Onset Hobo ProV2 temperature probe.



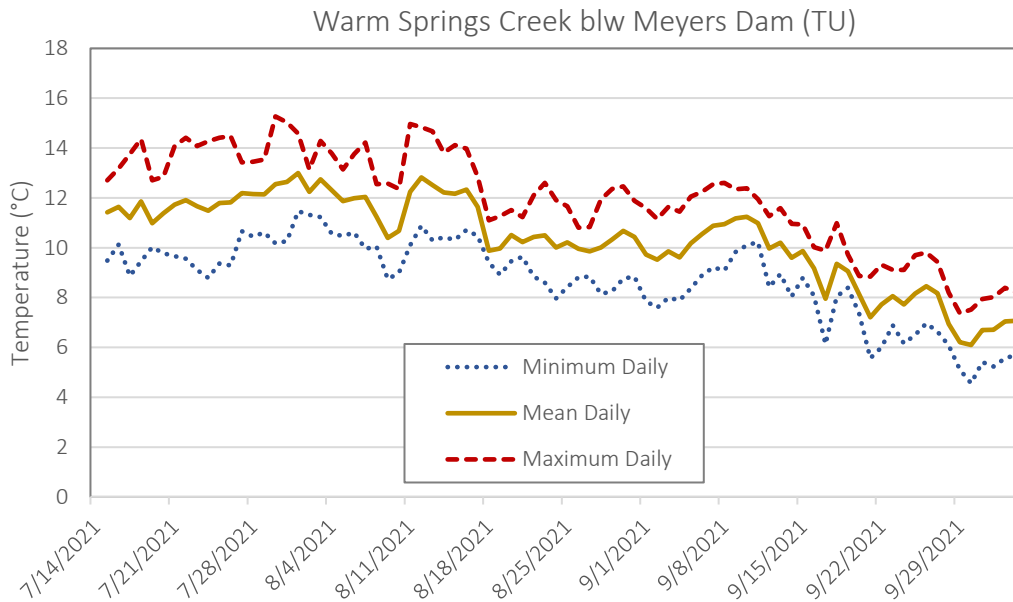
Foster Creek temperature (°C), as measured by FWP Onset Hobo ProV2 temperature probe.



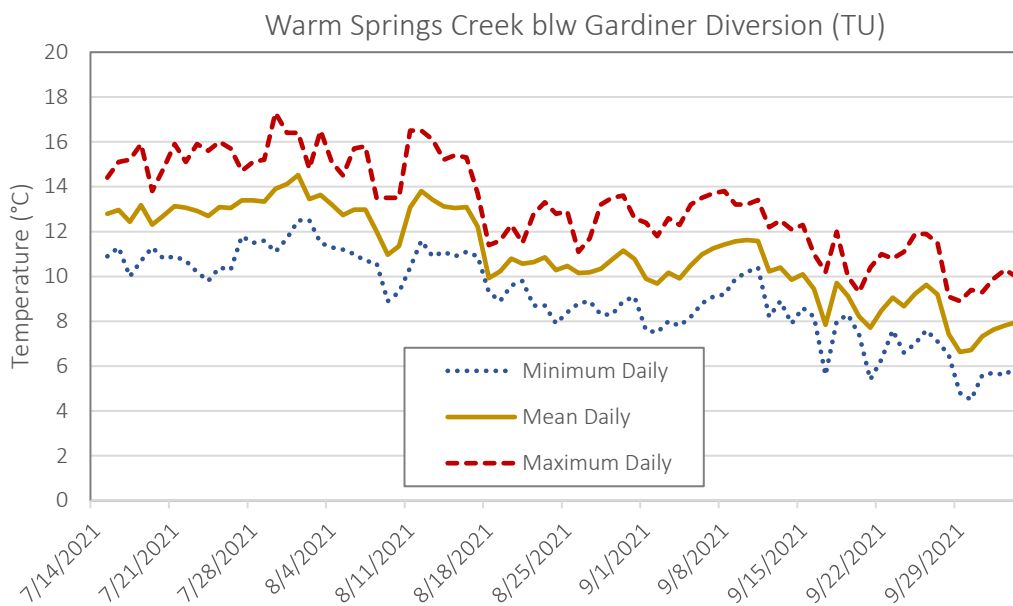
Barker Creek temperature (°C), as measured by FWP Onset Hobo ProV2 temperature probe.



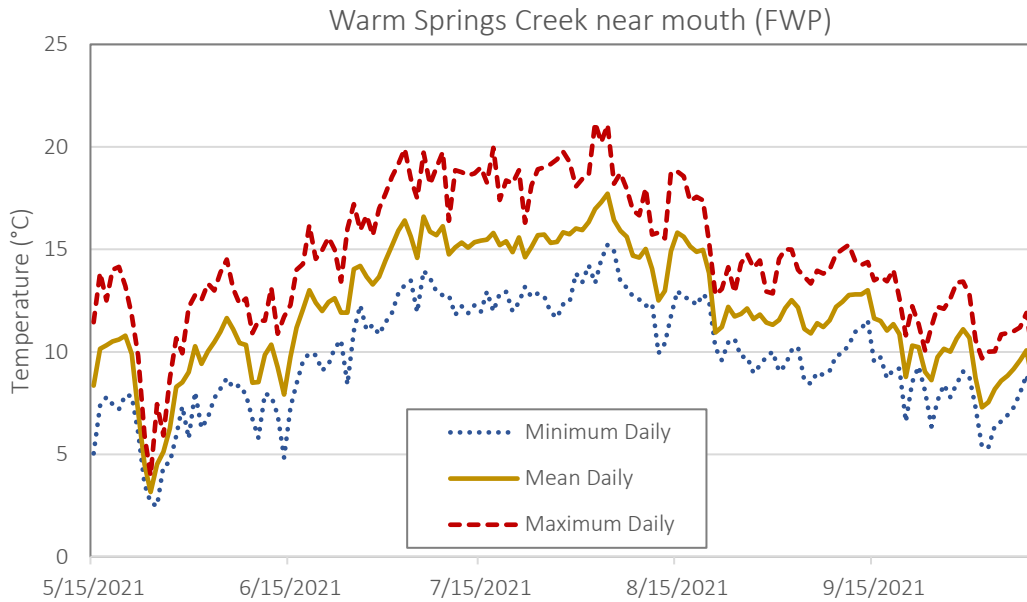
Warm Springs Creek temperature (°C) above Meyers Dam, as measured by Solinst stage logger.



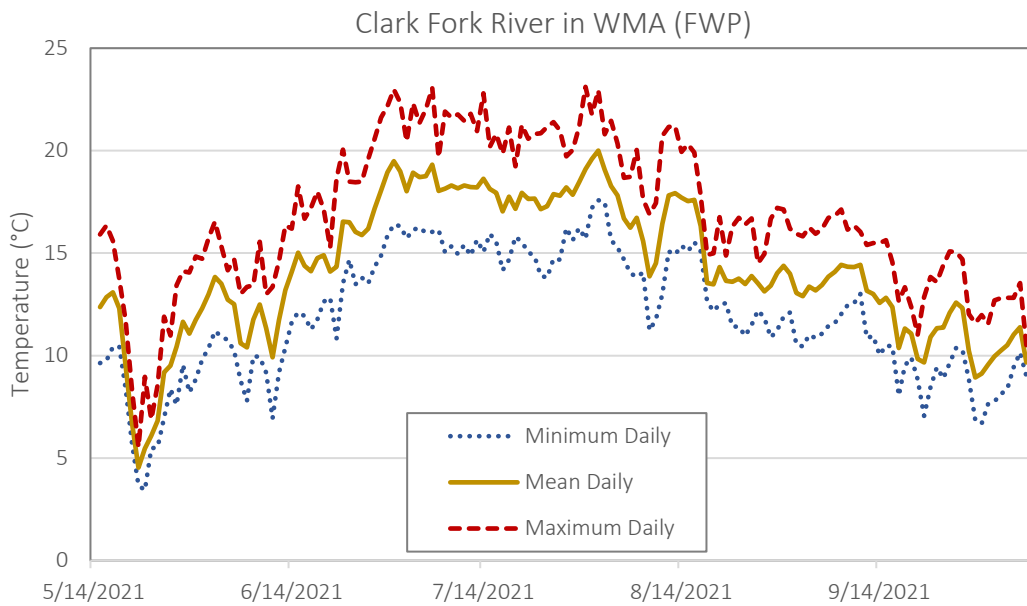
Warm Springs Creek temperature (°C) below Meyers Dam, as measured by Hobo ProV2 temperature probe.



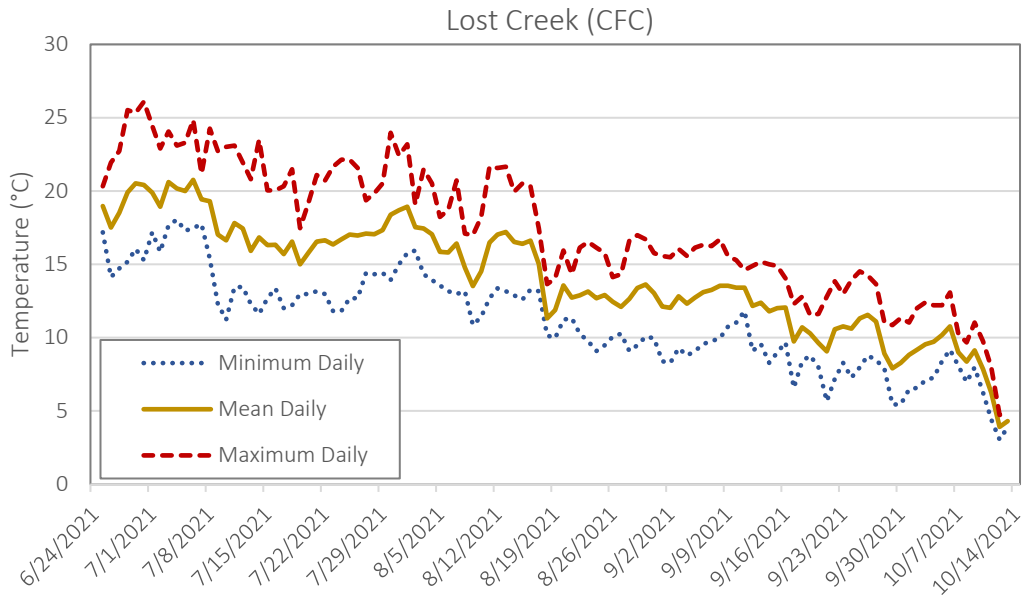
Warm Springs Creek temperature (°C) below Gardiner Ditch, as measured by Solinst stage logger.



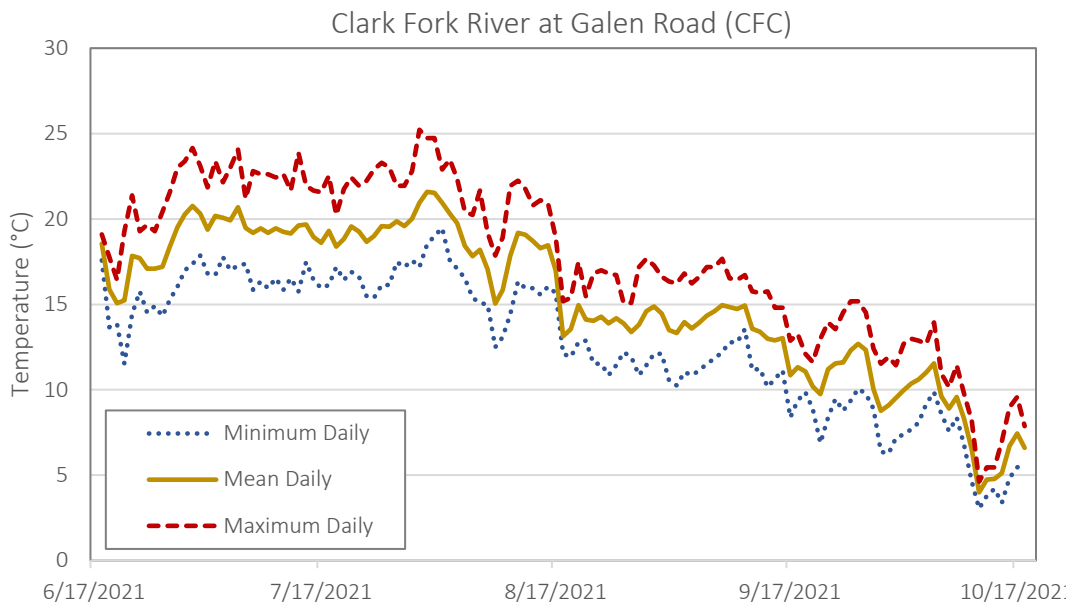
Warm Springs Creek temperature (°C) near confluence with Silver Bow Creek, as measured by FWP Onset Hobo ProV2 temperature probe.



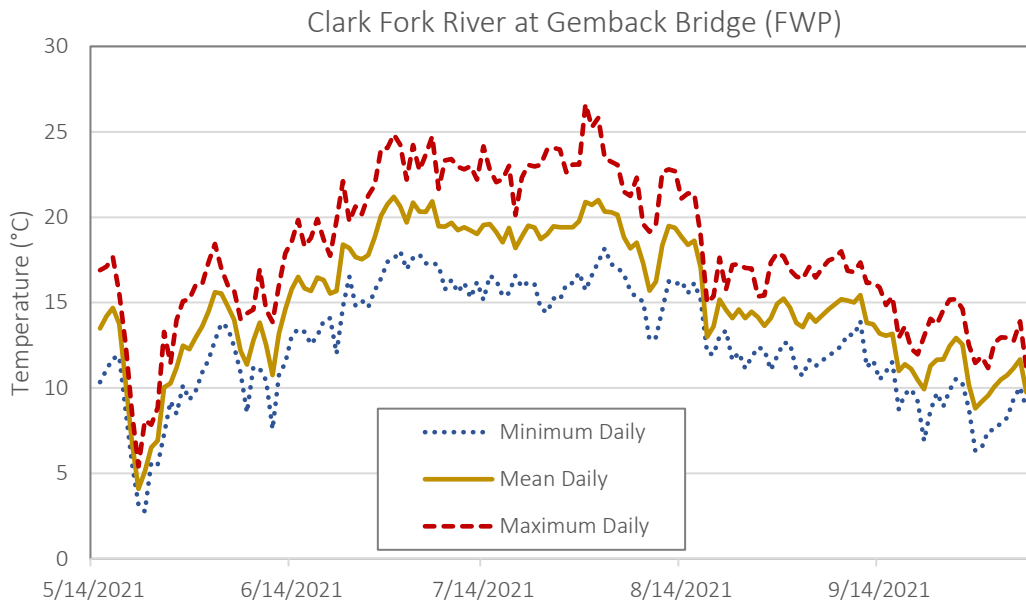
Clark Fork River temperature (°C) in Wildlife Management Area, as measured by FWP Onset Hobo ProV2 temperature probe.



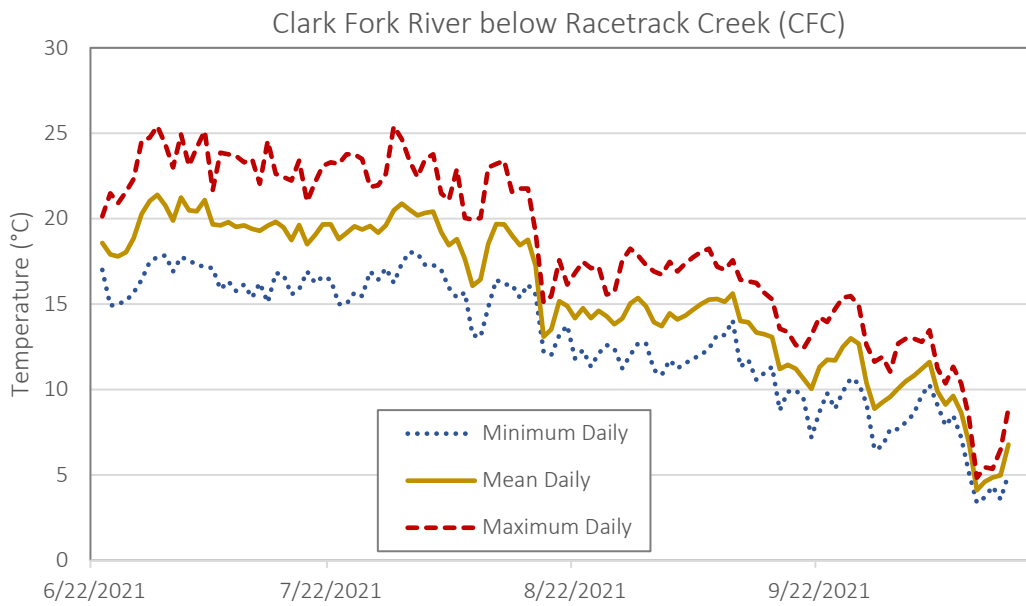
Lost Creek temperature (°C) near confluence with Clark Fork River, as measured by CFC Onset Hobo Water Level Logger.



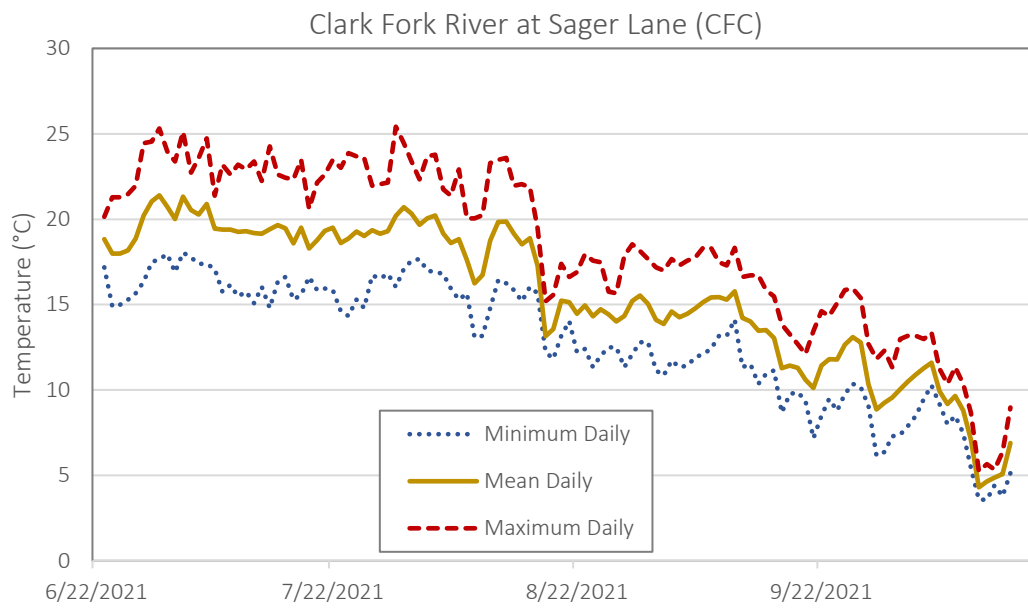
Clark Fork River temperature (°C) at Galen Rd., as measured by CFC Onset Hobo Water Level Logger.



Clark Fork River temperature (°C) at Gemback Bridge, as measured by FWP Onset Hobo ProV2 temperature probe.



Clark Fork River temperature (°C) below Racetrack Creek, as measured by CFC Onset Hobo Water Level Logger.



Clark Fork River temperature (°C) at Sager Lane, as measured by CFC Onset Hobo Water Level Logger.

Appendix C: Butte Silver Bow 2021 Silver Lake release records.

**Butte Silver
Water Utility Division**

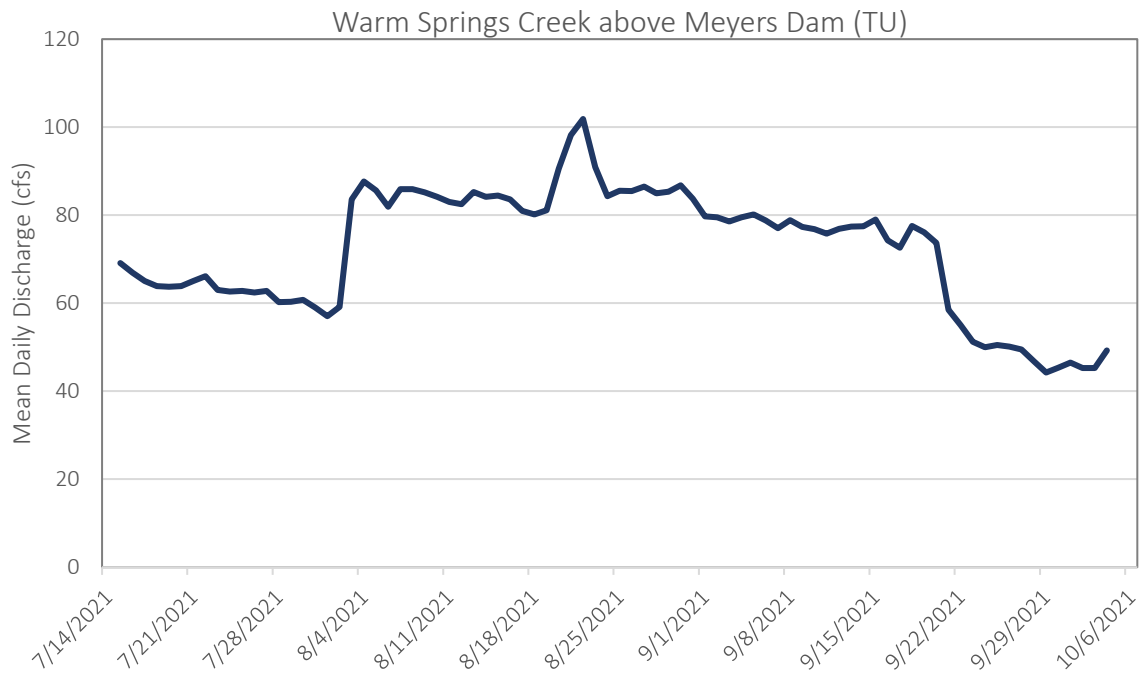
Silver Lake Discharge/Release - 2021

Date	Time	Lake Elevation	Volume		5' Parshall Flume				Water Temp. F	Gardner Ditch 8' Parshall Flume				Water Temp. F	TIFD 34" Inflow MGD
			Acres ft	MG	Time	Reading	cfs	MGD		Time	Reading	cfs	MGD		
2-Aug-21	9:40 AM	6430.75	16,102	5,247		1.35	32.20	20.82	49.50		1.05	34.61	22.37		3.11
3-Aug-21	10:00 AM	6430.45	15,979	5,208		1.36	32.58	21.06	49.10		1.00	32.00	20.68		3.21
4-Aug-21	12:30 PM	6430.14	15,888	5,177		1.37	32.96	21.31	50.40		0.95	29.47	19.04	56.6	3.22
5-Aug-21	10:00 AM	6429.86	15,826	5,157		1.37	32.96	21.31	49.20		0.95	29.47	19.04	52.6	3.24
6-Aug-21	10:30 AM	6429.57	15,735	5,127		1.36	32.58	21.31	49.50		0.95	29.47	19.04	52.7	3.27
7-Aug-21	11:00 AM	6429.20	15,614	5,088		1.36	32.58	21.31	50.30		0.95	29.47	19.04	52.6	2.95
8-Aug-21	11:00 AM	6429.00	15,554	5,068		1.36	32.58	21.31	49.70		0.95	29.47	19.04	53.4	2.67
9-Aug-21	9:30 AM	6428.79	15,494	5,049		1.35	32.20	20.82	49.10		0.95	29.47	19.04	51.4	3.74
10-Aug-21	12:30 PM	6428.47	15,404	5,019	1:30 PM	1.35	32.20	20.82	57.10	2:24 PM	0.95	29.47	19.04	55.2	3.48
11-Aug-21	10:15 AM	6428.24	15,314	4,990	10:00 AM	1.35	32.20	20.82	49.90	9:30 AM	0.95	29.47	19.04	51.8	2.80
12-Aug-21	9:45 AM	6427.97	15,255	4,971	9:36 AM	1.35	32.20	20.82	52.00	9:10 AM	0.95	29.47	19.04	53.2	3.39
13-Aug-21	9:15 AM	6427.75	15,195	4,951	9:05 AM	1.35	32.20	20.82	51.10	8:40 AM	0.95	29.47	19.04	51.8	2.64
14-Aug-21	11:15 AM	6427.33	15,048	4,903	10:50 AM	1.34	31.82	20.57	52.10	12:00 PM	0.95	29.47	19.04	52.7	2.15
15-Aug-21	11:30 AM	6427.05	14,989	4,884	12:00 PM	1.34	31.82	20.57	53.10	11:00 AM	0.95	29.47	19.04	53.3	2.19
16-Aug-21	10:23 AM	2426.88	14,931	4,865	10:12 AM	1.34	31.82	20.57	54.20	9:45 AM	0.95	29.47	19.04	52.6	2.75
17-Aug-21	9:46 AM	2426.60	14,843	4,837	9:35 AM	1.34	31.82	20.57	54.50	9:08 AM	0.95	29.47	19.04	52.1	2.73
18-Aug-21	10:10 AM	6426.35	14,786	4,818	10:00 AM	1.34	31.82	20.57	54.40	9:30 AM	0.95	29.47	19.04	49.5	2.26
19-Aug-21	10:00 AM	6426.09	14,699	4,790	11:05 AM	1.34	31.82	20.57	55.40	2:00 PM	0.95	29.47	19.04	52.6	2.18
20-Aug-21	9:50 AM	6425.75	14,613	4,762	9:30 AM	1.34	31.82	20.57	56.30	9:00 AM	0.95	29.47	19.04	49.6	2.63
21-Aug-21	9:30 AM	6425.52	14,527	4,734	9:30 AM	1.33	31.45	20.33	57.00	10:20 AM	0.95	29.47	19.04	50.7	2.61
22-Aug-21	10:05 AM	6425.32	14,471	4,715	10:00 AM	1.33	31.45	20.33	56.60	9:30 AM	0.95	29.47	19.04	48.4	2.70
23-Aug-21	9:30 AM	6425.06	14,414	4,697	10:00 AM	1.33	31.45	20.33	56.50	11:20 AM	0.95	29.47	19.04	49.6	2.94
24-Aug-21	9:45 AM	6424.86	14,358	4,679	11:00 AM	1.36	32.58	21.06	56.50	9:15 AM	0.95	29.47	19.04	46.6	2.15
25-Aug-21	9:30 AM	6424.61	14,373	4,651	9:15 AM	1.36	32.58	21.06	56.10	8:50 AM	0.95	29.47	19.04	47.5	2.85
26-Aug-21	9:30 AM	6424.36	14,217	4,633	9:15 AM	1.36	32.58	21.06	56.50	8:50 AM	0.95	29.47	19.04	48.3	2.79
27-Aug-21	1:40 PM	6424.21	14,162	4,615	2:15 PM	1.36	32.58	21.06	56.40	3:00 PM	0.95	29.47	19.04	51.9	2.69
28-Aug-21	10:45 AM	6424.01	14,106	4,596	10:30 AM	1.36	32.58	21.06	56.10	10:00 AM	0.95	29.47	19.04	47.8	2.76
29-Aug-21	10:00 AM	6423.68	14,023	4,569	9:45 AM	1.36	32.58	21.06	56.20	9:45 AM	0.95	29.47	19.04	47.4	3.31
30-Aug-21	11:00 AM	6423.39	13,941	4,543	11:00 AM	1.36	32.58	21.06	56.30	12:15 PM	0.95	29.47	19.04	51.4	2.69
31-Aug-21	12:45 PM	6423.09	13,858	4,516	1:30 PM	1.36	32.58	21.06	56.60	1:45 PM	0.95	29.47	19.04	52.5	2.85
1-Sep-21	9:40 AM	6422.96	13,831	4,507	10:20 AM	1.36	32.58	21.06	56.50	11:40 AM	0.95	29.47	19.04	48.0	2.93
2-Sep-21	9:10 AM	6422.86	13,803	4,498	9:00 AM	1.36	32.58	21.06	56.20	10:00 AM	0.95	29.47	19.04	48.2	2.84
3-Sep-21	10:15 AM	6422.59	13,722	4,471	9:45 AM	1.36	32.58	21.06	56.50	9:15 AM	0.95	29.47	19.04	46.9	2.85
4-Sep-21	11:30 AM	6422.53	13,694	4,462	11:00 AM	1.36	32.58	21.06	56.40	10:30 AM	0.95	29.47	19.04	47.6	2.74
5-Sep-21	1:00 PM	6422.15	13,613	4,436	1:30 PM	1.36	32.58	21.06	57.90	2:00 PM	0.95	29.47	19.04	52.5	3.15
6-Sep-21	11:30 AM	6422.04	13,559	4,418	11:45 AM	1.36	32.58	21.06	57.60	12:15 PM	0.95	29.47	19.04	50.9	3.30
7-Sep-21	11:00 AM	6421.71	13,478	4,392	11:30 AM	1.35	32.20	20.82	56.70	12:45 PM	0.95	29.47	19.04	52.3	3.19
8-Sep-21	9:45 AM	6421.51	13,424	4,374	9:30 AM	1.35	32.20	20.82	56.80	8:30 AM	0.95	29.47	19.04	48.9	3.06
9-Sep-21	1:00 PM	6421.30	13,371	4,357	12:45 PM	1.34	31.82	20.57	57.10	12:00 PM	0.95	29.47	19.04	52.1	2.86
10-Sep-21	11:00 AM	6421.13	13,317	4,339	11:30 AM	1.34	31.82	20.57	56.80	8:35 AM	0.95	29.47	19.04	50.7	3.42
11-Sep-21	11:15 AM	6420.95	13,290	4,331	11:30 AM	1.34	31.82	20.57	57.80	12:00 PM	0.95	29.47	19.04	52.4	3.37
12-Sep-21	11:00 AM	6420.77	13,237	4,313	11:30 AM	1.34	31.82	20.57	57.40	12:00 PM	0.95	29.47	19.04	49.6	2.88
13-Sep-21	10:35 AM	6420.51	13,157	4,287	10:20 AM	1.34	31.82	20.57	57.30	9:50 AM	0.95	29.47	19.04	48.6	
14-Sep-21	10:50 AM	6420.31	13,104	4,270	9:35 AM	1.34	31.82	20.57	56.90	9:05 AM	0.95	29.47	19.04	46.5	
15-Sep-21	10:20 AM	6420.16	13,078	4,261	10:15 AM	1.34	31.82	20.57	57.50	9:35 AM	0.95	29.47	19.04	48.1	
16-Sep-21	9:30 AM	6419.91	12,999	4,236	9:50 AM	1.34	31.82	20.57	56.10	10:45 AM	0.95	29.47	19.04	47.2	
17-Sep-21	9:10 AM	6419.66	12,946	4,218	10:00 AM	1.31	30.70	19.85	55.70	10:15 AM	0.95	29.47	19.04	47.3	
18-Sep-21	10:30 AM	6419.46	12,894	4,202	10:30 AM	1.31	30.70	19.85	55.80	10:00 AM	0.95	29.47	19.04	47.1	
19-Sep-21	10:15 AM	6419.21	12,815	4,176	10:00 AM	1.31	30.70	19.85	55.00	9:30 AM	0.95	29.47	19.04	47.3	
20-Sep-21	9:25 AM	6419.01	12,763	4,159	9:10 AM	1.31	30.70	19.85	54.30	8:40 AM	0.95	29.47	19.04	45.6	
Total		11.74	3,339	1,088.00			1,604.41	1,037.95				1,481.17	956.97		120.66
Max									57.90					56.60	
Min									49.10					45.60	
Avg									54.80					50.28	

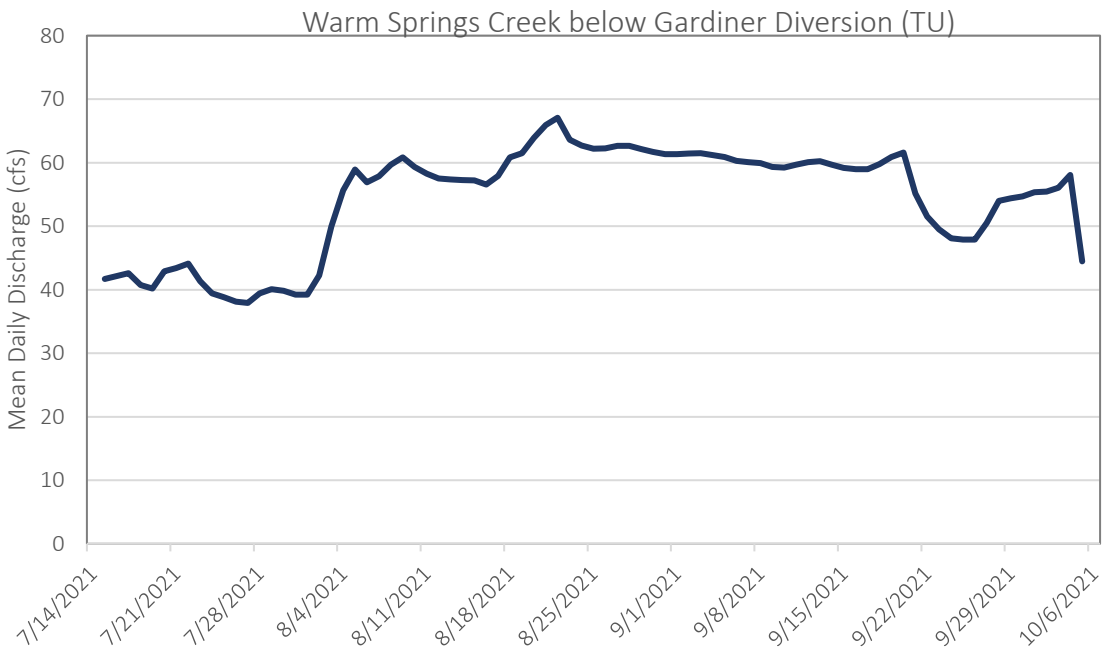
Notes:

Started Silver Lake Pumps @ approximately 9:40 AM on Aug. 2nd - 32 cfs.
 Power outage (lightning) Aug. 6th, Pump # 1 off line for 2 hours
 Pump # 2 shut down, high vibration ?? for approximately 3 hours, Ed restarted pump at 11:00 am Sept. 10th
 Pump # 2 shut down, high vibration ?? for approximately 3 hours, Ed started Pump #1 at 9:00 am Sept. 16th
 Silver Lake Pumps shut down @ 9:40 AM on September 20th

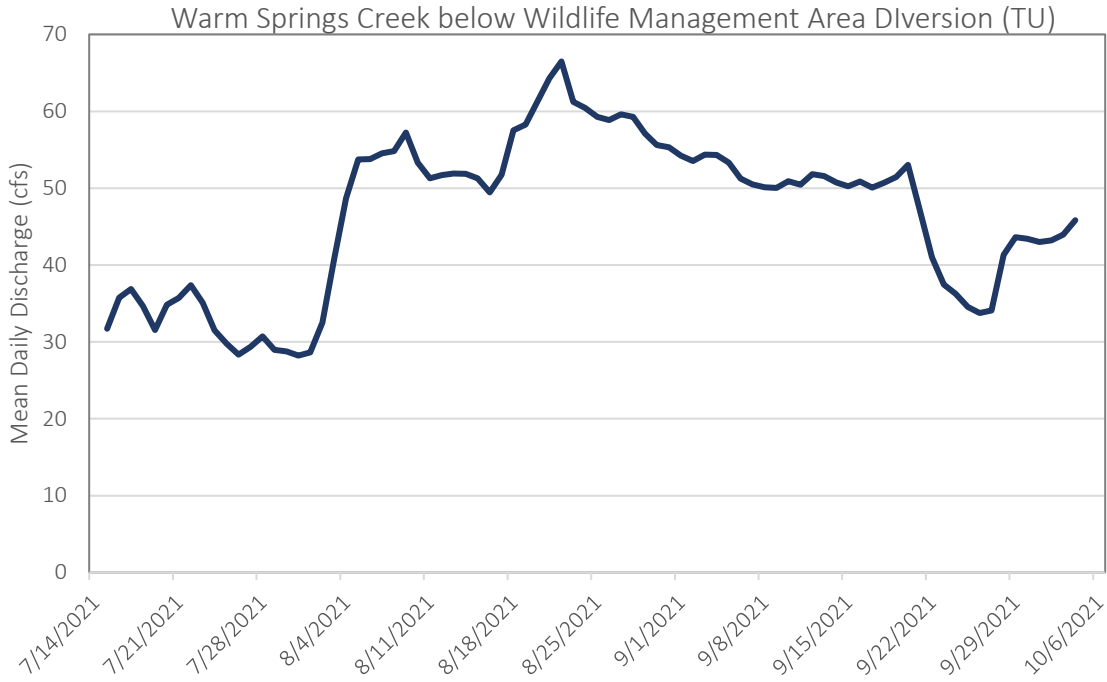
Appendix D: Trout Unlimited and Clark Fork Coalition Hydrographs



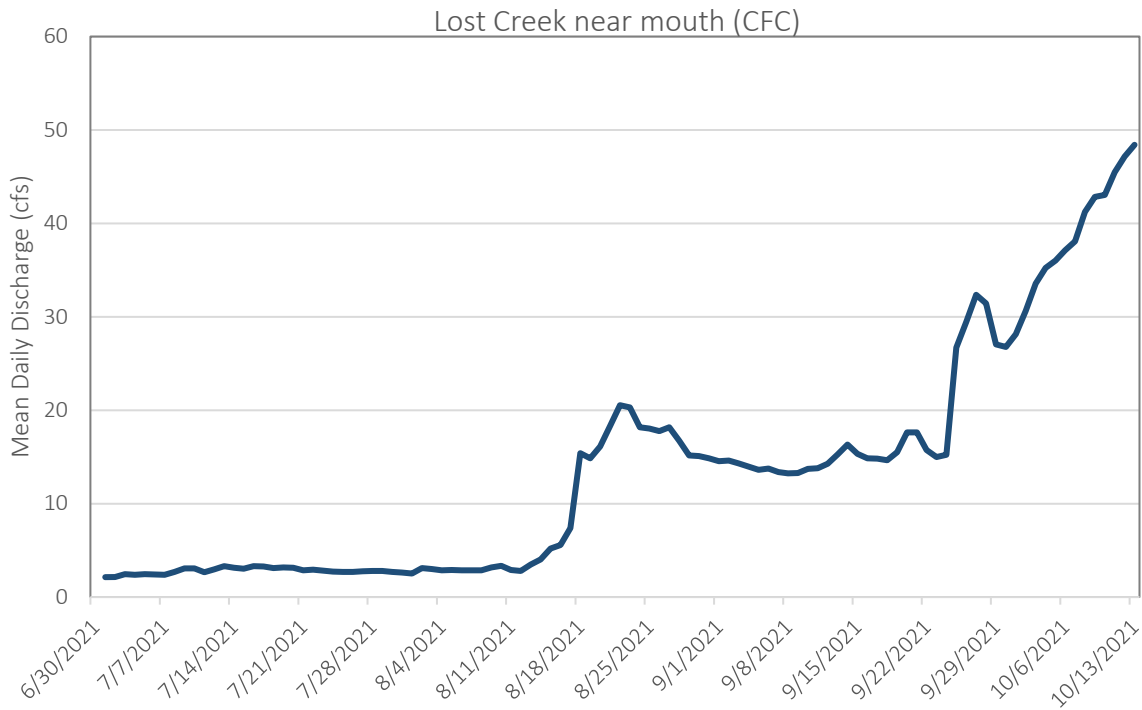
Mean daily discharge in Warm Springs Creek above Meyers Dam (TU).



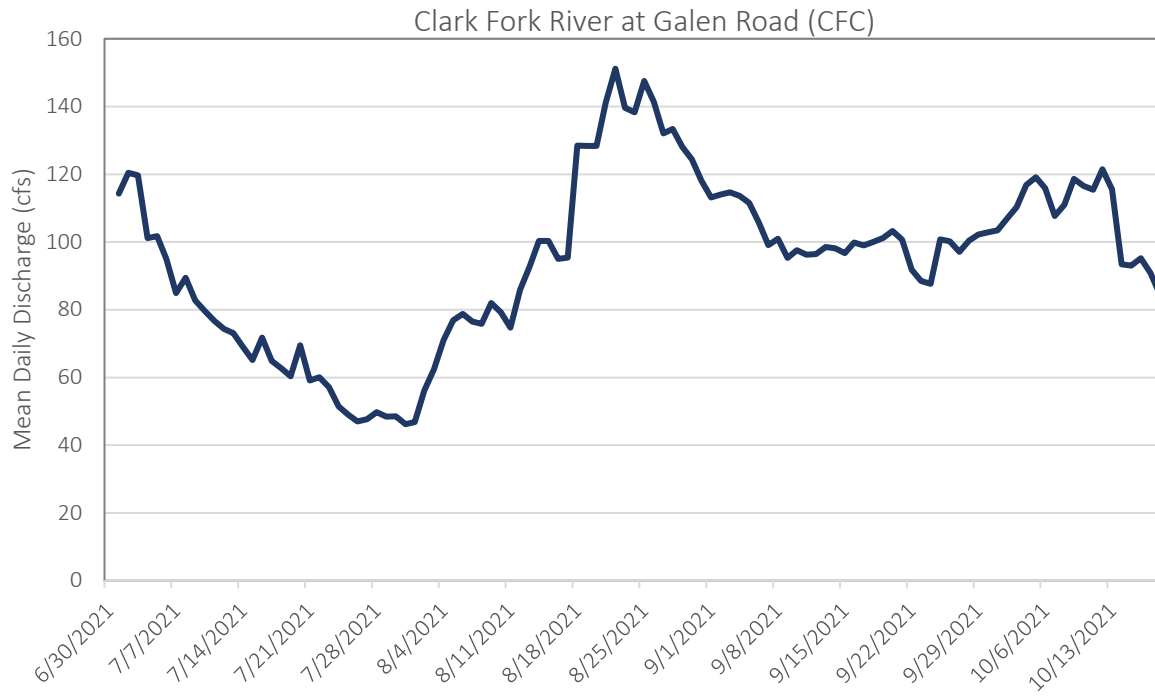
Mean daily discharge in Warm Springs Creek below Gardiner Ditch (TU).



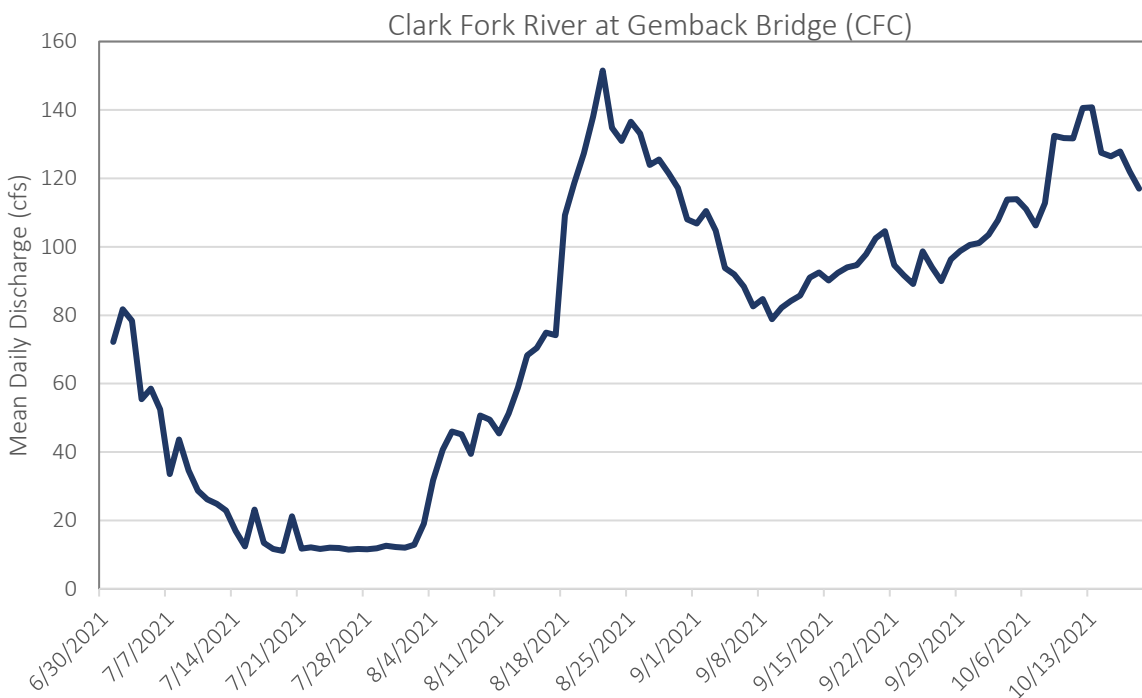
Mean daily discharge in Warm Springs Creek below the Wildlife Management Area diversion (TU).



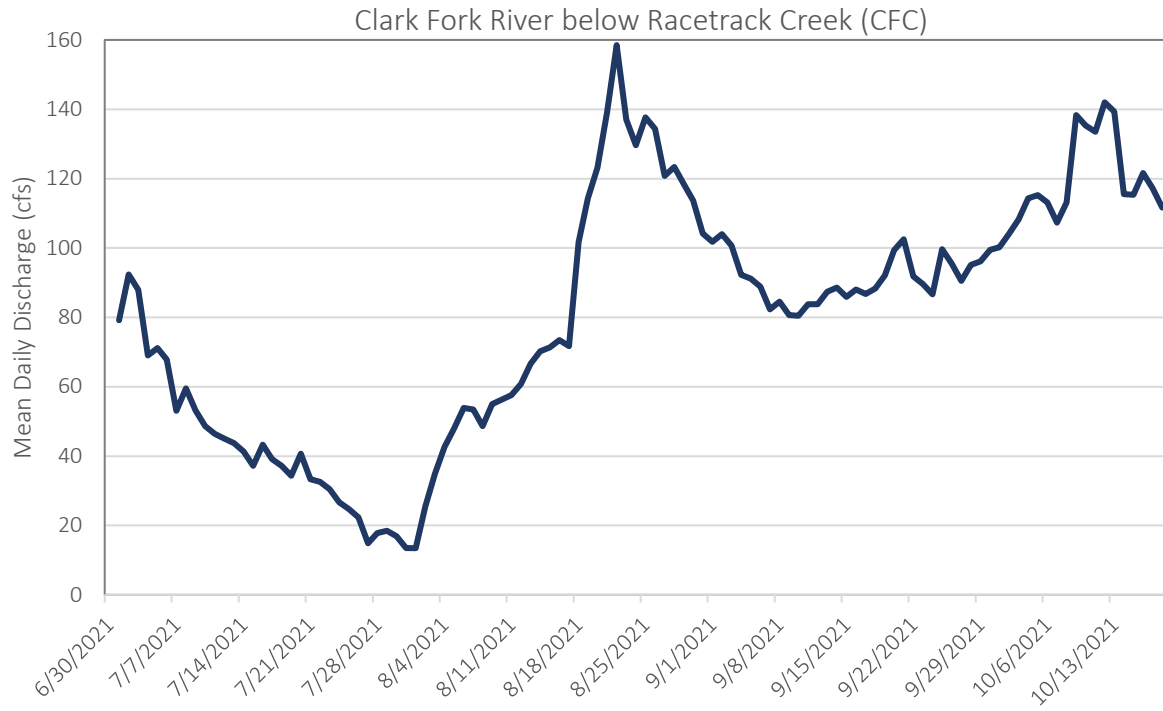
Mean daily discharge in Lost Creek near mouth (CFC).



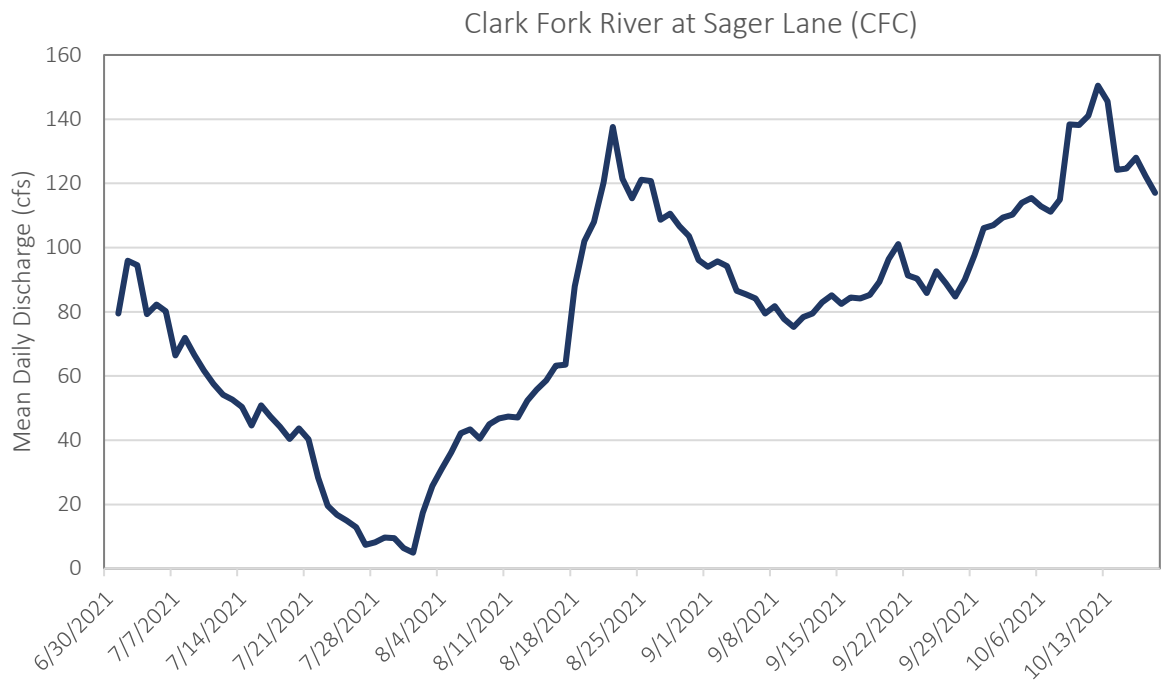
Mean daily discharge in Clark Fork River at Galen Road (CFC).



Mean daily discharge in Clark Fork River at Gemback Road (CFC).



Mean daily discharge in Clark Fork River below Racetrack Creek (CFC).



Mean daily discharge in Clark Fork River at Sager Lane (CFC).

Appendix D: August 12, 2021 Synoptic Flow Measurement Results

Location	8/12/2021 Discharge (cfs)	Distance (mi)	Change/mi
Silver Lake Release	322		
Cable Creek	385		
WSCblwCable	515		
+Twin Lakes Creek	8.7		
+Foster Creek	3.6		
+Barker Creek	4.0		
+WF Barker Creek	15		
-Small Irrigation Diversion	13		
=Calculated Flow at WSCabv Meyers	66.4		
Difference WSC Cable to abv Meyers	29.1%	62	4.7%
WSCab Meyers	82.1		
-TIFID influent (proxy for diversion at Meyers)	52		
=Calculated Flow at WSCnr Anaconda	76.8		
Difference WSCabv Meyers to Anaconda	39.2%	80	4.9%
USGS WSCnr Anaconda	1090		
-Gardiner Ditch	285		
=Calculated Flow at WSCbl Gardiner	805		
Difference Anaconda to blw Gardiner	-15.4%	06	-25.7%
WSCblw Gardiner Ditch	1070		
+Opportunity Drain	19		
-Johnson Diversion	20		
-WMA Ditch	48		
=Calculated Flow WSCblw WMA Ditch	588		
Difference Above Gardiner to WSCblw WMA	-11.5%	66	-8.8%
WSCbelow WMA Ditch	515		
Difference Between WSCblw WMA and Warm Springs	11.7%	13	90%
USGS WSCat Warm Springs	575		
USGS WSCat Warm Springs	59.7		
Silver Bow Creek abv WS	37.1		
Calculated flow CFS at Galen (Perkins Lane)	96.8		
Difference between lower SBC + WSC gages to CFR at Galen (Perkins Lane)	-11.0%		
CFR at Galen (Perkins Lane)	862		
+Lost Creek nr Confluence	24		
-Lampert/Logan Pumps	30		
=Calculated Flow at Galen Rd	856		
Difference between CFR at Galen (Perkins Lane) and Galen Rd	-6.1%	40	-1.5%
CFR at Galen Road	804		
+Dry Cottonwood Creek	0		
-Am Beck Ditch	35		
+Modesty Creek	13		
-Whalen Ditch	7.1		
-Westside Ditch	35.1		
=Calculated Flow CFR at Gemback Bridge	360		
Difference between CFR at Galen Rd Gemback Bridge	199%	4.1	4.9%
CFR at Gemback Bridge	520		
+Racetrack Creek	05		
=Calculated Flow blw Racetrack	525		
Difference between CFR at Gemback Bridge and below Racetrack	21.3%	29	7.3%
CFR blw Racetrack Creek	63.6		
-Valiton Ditch	55		
Broken Circle and Sager Lane Pumps	50		
=Calculated CFR at Sager Lane	53.1		
Difference between UCFR blw Racetrack and at Sager Lane	10%	3.1	0.3%
UCFR at Sager Lane	53.7		
Difference between UCFR at Sager Lane and at Deer Lodge	69.3%	86	8.1%
UCFR at Deer Lodge	909		

*Color Legend: Measured Discharge, Estimated Discharge, Calculated Discharge, Reach Loss, Reach Gain