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Photo Credit: Park County

Park County Flood History

Upper Yellowstone Hydrology

Park County, Montana

April 29, 2024

Prepared For:
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1 INTRODUCTION

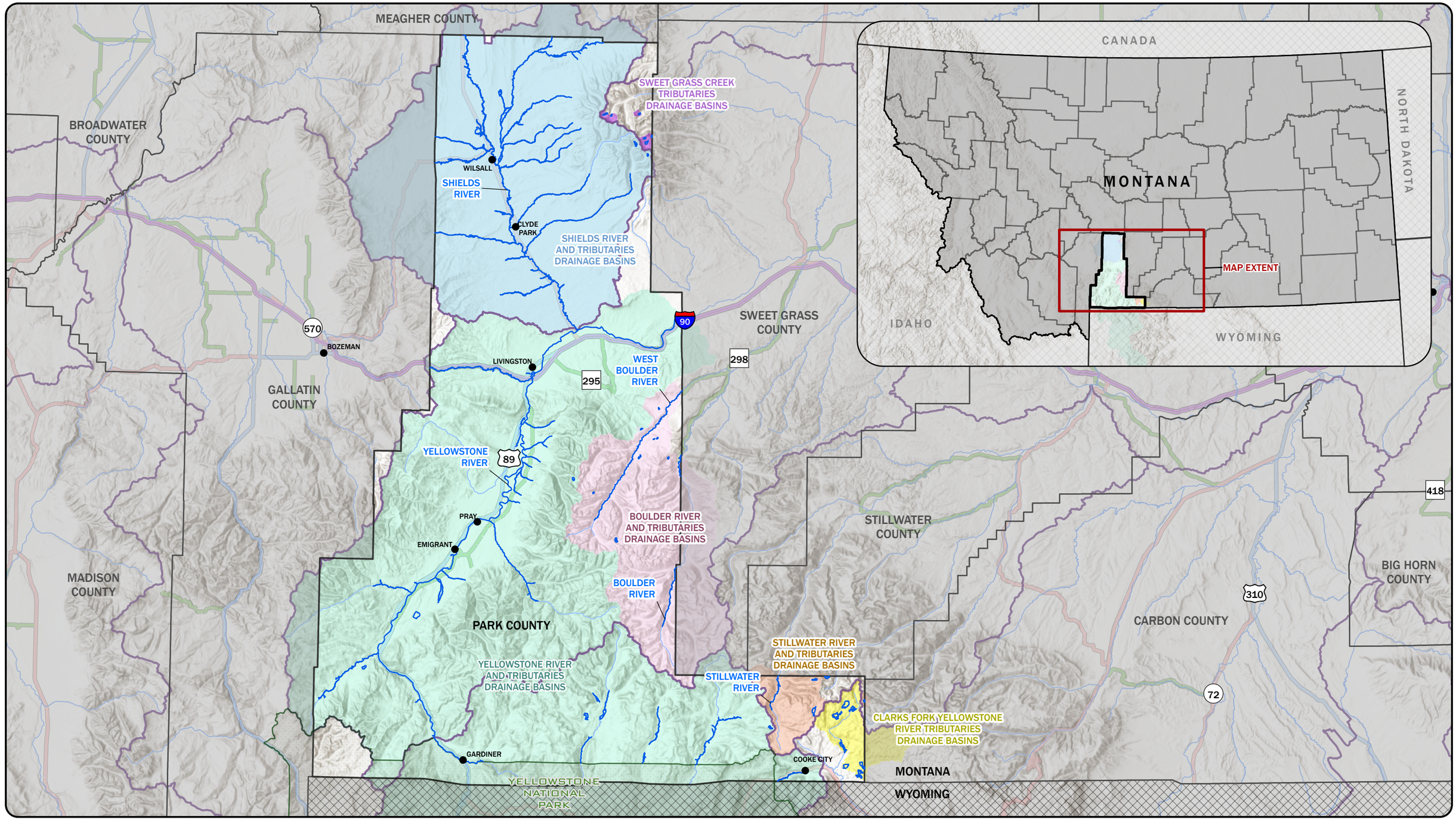
As part of the Upper Yellowstone Hydrologic Analysis project, the Montana Department of Natural Resources and Conservation (DNRC) contracted Pioneer Technical Services, Inc. (Pioneer) to complete a comprehensive peak flow hydrologic analysis for Park County and compile supplemental flood history. Major study reaches included in the hydrologic analysis and flood history investigation were the Yellowstone River and tributaries and Shields River and tributaries. Smaller study areas included reaches located in the Crazy Mountains, the Sweet Grass Creek water bodies, and the Absaroka – Beartooth Mountains including the Boulder River and tributaries, the Stillwater River and tributaries, and water bodies at the headwaters of the Clarks Fork Yellowstone River. For this flood history report, the Boulder River and Tributaries and the Stillwater River and tributaries were discussed as part of the Yellowstone River basin. Due to the remote location of the Clarks Fork Yellowstone River water bodies and the limited flood impact they have had on Park County communities, the flood history of these water bodies was not included. This flood history report encompasses a look into relevant past flooding in the Yellowstone and Shields River basins within Park County, Montana. The Park County study area is shown on Figure 1-1.

The purpose of this report is to provide the Park County community with flood history information through previous hydrologic studies, USGS gage station data, and historical and photographic flood documentation. The report is intended to be supplemental to and complement the Upper Yellowstone Hydrologic Analysis Report Park County, Montana (Pioneer, 2024).

Flood history information was compiled from the following sources:

- U.S. Geological Survey (USGS) published studies and gage station information.
- Previous Flood Insurance Study (FIS) reports.
- Park County.
- Park County Conservation District.
- DNRC.
- Local newspapers, news stations, etc. reporting on flood events.

The Upper Yellowstone Hydrologic Analysis Report included Annual Exceedance Probability (AEP) peak flow estimates for the 50%, 10%, 4%, 2% ,1%, 0.2%, and 1%-plus annual chance (AC) flood events. The AEP peak flow estimates are determined using historically measured flow data, typically collected at USGS gage sites, to provide a statistical expected chance of a peak flow occurring each year. For example, there is a 1% chance every year that the 1% AEP event may occur. The 1% AEP estimate is the flood event selected and used by the National Flood Insurance Program to regulate floodplains. Statistically there is a 26% chance of the 1% AEP event occurring during a 30-year mortgage. Over time, as more measured flow data are collected, AEP peak flow estimates are updated to better represent flow probability. The Upper Yellowstone Hydrologic Analysis study used flow data through water year 2022 (Pioneer, 2024).



LEGEND

- PARK COUNTY STUDY REACH
- HUC8 BOUNDARIES
- SWEET GRASS CREEK TRIBUTARIES DRAINAGE BASIN
- SHIELDS RIVER AND TRIBUTARIES DRAINAGE BASIN
- YELLOWSTONE RIVER AND TRIBUTARIES DRAINAGE BASIN
- BOULDER RIVER AND TRIBUTARIES DRAINAGE BASIN
- STILLWATER RIVER TRIBUTARIES DRAINAGE BASIN
- CLARKS FORK YELLOWSTONE RIVER TRIBUTARIES DRAINAGE BASIN

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PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD 1983
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FIGURE 1-1

PARK COUNTY STUDY AREA DRAINAGE BASINS

PIONEER TECHNICAL SERVICES, INC.

DATE: 4/29/2024

1.1 Basin Characteristics

The study area terrain within Park County is diverse. Park County is surrounded by four mountain ranges, the Absaroka, Gallatin, Bangtail, and Crazy mountains, and features the highest peak in Montana, Granite Peak, at an elevation of 12,807 feet. Many water bodies and stream headwaters in this study are located at high mountain elevations. Central Park County is dominated by the Paradise and Shields valleys; these valleys encompass many of Park County's study reaches. Agriculture and recreational pursuits are common land uses. Most of the heavily farmed land in Park County is found along the floodplains of the Shields and Yellowstone rivers.

The major drainage basins of Park County are the Yellowstone River and the Shields River drainage basins. Additional substantial streams that have drainage basins originating in Park County are Sweet Grass Creek, the Boulder River, Stillwater River, and Clarks Fork Yellowstone River. These streams eventually converge with the Yellowstone River outside of Park County in Sweet Grass, Stillwater, and Carbon Counties.

The largest community within the study area is the city of Livington, Montana, located near the confluence of the Shields and Yellowstone Rivers. Other communities located in the study area are Wilsall, Clyde Park, Gardiner, and Cooke City.

2 PARK COUNTY HYDROLOGIC FLOOD STUDIES

Multiple flood studies have been conducted on Park County streams, encompassing the Yellowstone River and tributaries and the Shields River and tributaries. The following sections outline the relevant hydrologic analyses that include peak flow frequency analyses within or near Park County. Historically, studies related to mining impacts, water management, fisheries management, and sediment management have incorporated hydrologic analysis. This report focuses on the Federal Emergency Management Agency (FEMA) (including FIS reports), USGS, and DNRC contracted hydrologic analyses related to Park County.

2.1 Flood Insurance Studies

The Park County FIS Report was initially issued on May 19, 1987, and revised on October 18, 2011 (FEMA, 2011). Prior to the FIS studies, hydrologic and hydraulic analyses for the Yellowstone River in the City of Livingston were performed by the U.S. Army Corp of Engineers, Omaha District, in 1974. Dames & Moore performed the hydrologic analysis for the 1987 FIS report in 1985, which covers the incorporated areas of the City of Livingston, Park County (FEMA, 1987). The FIS reports are summarized in Table 2-1. The AEP peak discharge estimates determined by the studies are discussed in Section 3.

Table 2-1 Park County FEMA FIS Summary

Existing Study	Community	Date Issued	Study Details			
			Detailed Studied Streams[1]	Approx[2] (mi)	Detailed (mi)	Total (mi)
Flood Insurance Study	City of Livingston	05/19/1987	Yellowstone River	520	2.3	522
Flood Insurance Study	Park County, Unincorporated Areas; City of Livingston; Town of Clyde Park	10/18/2011	Yellowstone River	470	52	522

Approx: Approximate. mi: miles.
1. Detailed studied streams are streams with a hydrologic analysis performed on them.
2. Approximate value includes Approximate Zone A reaches to be studied in this hydrologic analysis report. The FIS studies do not list length for Approximate Zone A reaches.

Between FIS report releases, Letter of Map Changes (LOMC) are published when an area of the effective FIS is reevaluated or restudied. There are two types of LOMCs, Letter of Map Revisions (LOMR) and Letter of Map Amendments (LOMA). There are no active LOMRs for Park County, but there are 67 LOMAs and 18 revalidated LOMAs. A LOMA revalidation occurs after the FIS Flood Insurance Rate Maps (FIRMs) are updated, but the LOMA determination is still correct. A table of LOMAs is included in Appendix A.

2.2 USGS Flood Studies

The USGS collects peak flow data throughout the year at select gaging stations. The USGS performs hydrologic analyses and flood frequency analyses on USGS gage stations peak flow data regularly to incorporate hydrologic methodology changes and large flood events to account for increased gage period of record and to assist floodplain mapping studies. Five different studies conducted by the USGS were reviewed.

Although a hydrologic analysis published date lists the year the analysis was published, the water year through which gage data extend typically is different. This is due to the length in which hydrologic analyses are performed and the extensive review processes the analyses go through. Table 2-2 provides the study release data, the water year the data were studied through, and the methodology used in the study.

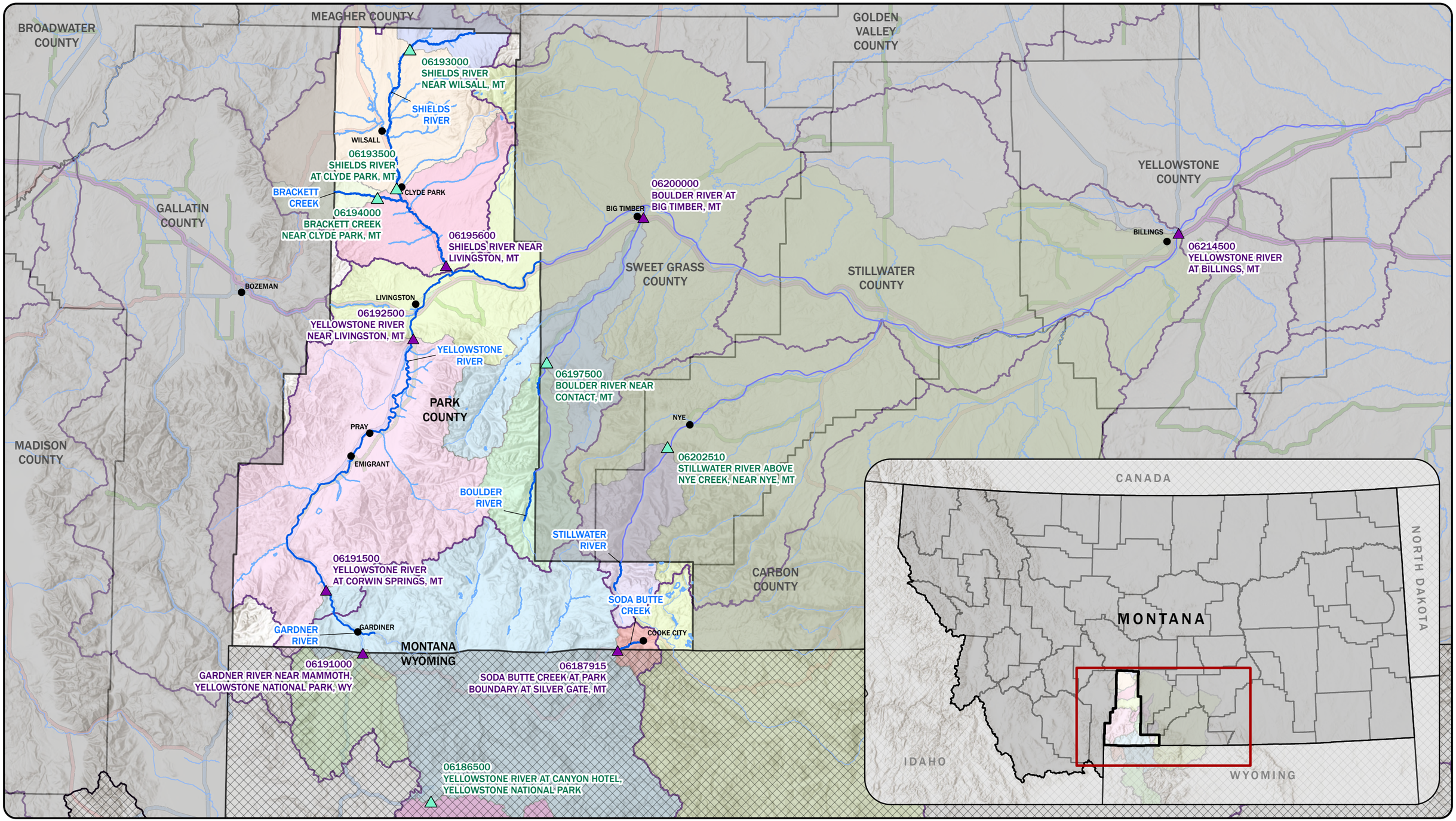
Table 2-2 USGS Gage Station Hydrologic Investigations and Studies

USGS Hydrologic Study	Study Release Year	Water Year of Data	Study Methodology
WRIR 92-4048	1992	1988	Bulletin 17B
WRIR 03-4308	2003	1998	Bulletin 17B
SIR 2015-5019-C	2015	2011	Bulletin 17B
SIR 2018-5046	2018	2015	Bulletin 17C
wymt_ffa_2022Yellowstone	2023	2022	Bulletin 17C

FFA: Flood Frequency Analysis. SIR: Scientific Investigations Report. WRIR: Water Resource Investigations Report. WYMT: Wyoming Montana.

As shown in Table 2-2, two overarching methodologies were used for the USGS studies: Bulletin 17C and Bulletin 17B. Bulletin 17C methodology was released in March of 2018 (England, et al., 2018) and replaced the Bulletin 17B methodology that was released by the Interagency Advisory Committee on Water Data (IACWD) in 1982 (IACWD, 1982).

Various gages on, upstream of, or downstream of Park County reaches were included in the USGS flood studies. The relevant USGS gages from the studies are provided on Figure 2-1.



LEGEND

- ACTIVE USGS GAGE STATIONS
- INACTIVE USGS GAGE STATIONS
- HUC8 BOUNDARY
- GAGE ASSOCIATED STUDY REACH
- GAGED ASSOCIATED REACH OUTSIDE OF PARK COUNTY
- NON-GAGED STUDY REACH

NOTE: THE GARDNER RIVER NEAR MAMMOTH, YELLOWSTONE NATIONAL PARK, WY GAGE STATION (06191000) WAS NOT STUDIED BY THE USGS IN 2023. HOWEVER, PIONEER CONDUCTED A PEAKFQ ANALYSIS ON THE GAGE STATION PEAK FLOW DATA TO BE USED IN THE HYDROLOGIC ANALYSIS ON THE GARDNER RIVER FLOW NODE.

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DATUM: NAD 1983
UNITS: INT'L FEET
SOURCE: ESRI/PIONEER

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FIGURE 2-1

PARK COUNTY
USGS GAGE STATIONS

PIONEER TECHNICAL SERVICES, INC.

DATE: 4/29/2024

2.2.1 USGS Hydrologic Investigations

Pioneer reviewed four previous USGS hydrologic investigations that included gage stations within and near Park County, Montana. The USGS Water Resource Investigations Report (WRIR) 92-4048 (Omang, 1992), USGS WRIR 03-4308 (Parret & Johnson, 2004), Scientific Investigations Report (SIR) 2015-5019-C, and USGS SIR 2018-5046 (Sando & McCarthy, 2018) each document prior flood frequency analyses used to determine AEP peak discharge estimates at the gage stations.

The gages studied in WRIR 92-4048, WRIR 03-4308, and SIR 2016-5019-C were analyzed using Bulletin 17B flood frequency methodology and At-Site peak flow data. The gages studied in SIR 2018-5046 were analyzed using Bulletin 17C flood frequency methodology and used both At-Site peak flow data and additional methods designed to improve At-Site peak flow estimates: Regional Regression Equation Weighted (RRE wtd), and Maintenance of Variance Extension Type III (MOVE.3). The RRE wtd weights the At-Site value with an estimate based on general equations developed for the region, and MOVE.3 incorporates measured peak flow data from other gage locations on the study reach or on nearby streams to extend the period of record.

Table 2-3 lists the USGS flood frequency analysis studies and relevant gages in and near Park County included in the studies.

Table 2-3 Summary of Park County USGS Gage Studies

USGS Station Number	USGS Station Name	WRIR 92-4048	WRIR 03-4308	SIR 2015-5019-C	SIR 2018-5046
		Years of Record	Years of Record	Years of Record	Years of Record
Shields River Basin					
06194000	Brackett Creek near Clyde Park, MT	27	27	27	--
06193000	Shields River near Wilsall, MT	22	22	22	--
06193500	Shields River at Clyde Park, MT	41	41	41	--
06195600	Shields River near Livington, MT	--	20	33	--
Yellowstone River Basin					
06197500	Boulder River near Contact, MT	34	34	34	--
06200000	Boulder River at Big Timber, MT	41	51	64	--
06191000	Gardner River near Mammoth, Yellowstone National Park, WY	39	65	78	--
06187915	Soda Butte Creek at Park Boundary at Silver Gate, MT	--	--	13	--

USGS Station Number	USGS Station Name	WRIR 92-4048	WRIR 03-4308	SIR 2015-5019-C	SIR 2018-5046
		Years of Record	Years of Record	Years of Record	Years of Record
06202510	Stillwater River above Nye Creek, near Nye, MT	--	12	12	--
06187000	Yellowstone River near Canyon Hotel, Yellowstone National Park, WY	--	37	37	37[1]
06191500	Yellowstone River at Corwin Springs, MT	--	92	105	109[1]
06192500	Yellowstone River near Livingston, MT	--	74	87	91[1]
06214500	Yellowstone River near Billings, MT	--	73	86	90[1]

SIR: Scientific Investigations Report. USGS: U.S. Geological Survey. WRIR: Water Resource Investigations Report.
-- Indicates gage station was not studied in corresponding USGS hydrology study.
1. Gage was analyzed using At-Site and MOVE.3 methods. At-Site peak flow records were reported.

2.2.2 2023 USGS Flood Frequency Gage Analysis

After the record breaking 2022 flooding event across southwest Montana, the USGS was contracted by the DNRC, as part of the Upper Yellowstone Hydrologic Analysis project, to perform a flood frequency analysis for select stream gages in the Upper Yellowstone Basin with water data through 2022 (Siefken, et al., 2023). Using Bulletin 17C, the USGS determined peak flow using At-Site recorded flow values and two additional methods designed to improve At-Site estimates. The first additional method is RRE wtd, and the second method is MOVE.3. The peak flow estimate determined to be most appropriate for floodplain mapping was used to estimate peak discharges for the Upper Yellowstone Hydrologic Analysis for Park County, Montana report (Pioneer, 2024). Table 2-4 lists the gages from the 2023 USGS gage analysis used in the hydrologic analysis performed by Pioneer.

Table 2-4 USGS Gage Stations Used in the Park County Hydrologic Analysis

USGS Station Number	USGS Station Name	Regulation Status	Recorded Peak Flow Years at Gage	Number of Recorded Peak Flows	2022 Status
Shields River Basin					
06194000	Brackett Creek near Clyde Park, MT	U	1921-1923, 1934-1957	27[1]	Inactive
06193000	Shields River near Wilsall, MT	U	1936-1957	22[1]	Inactive
06193500	Shields River at Clyde Park, MT	U	1921-1923, 1929-1932, 1934-1967	41[1]	Inactive

USGS Station Number	USGS Station Name	Regulation Status	Recorded Peak Flow Years at Gage	Number of Recorded Peak Flows	2022 Status
06195600	Shields River near Livingston, MT	U	1979-2022	44[1]	Active
Yellowstone River Basin					
06200000	Boulder River at Big Timber, MT	U	1947-1953, 1955-2022	75[2]	Active
06197500	Boulder River near Contact, MT	U	1910-1916, 1929, 1951-1969, 1971-1975, 1982,1983, 2022	35[2]	Inactive
06187915	Soda Butte Creek at Park Boundary at Silver Gate, MT	U	1999-2022	24	Active
06202510	Stillwater River above Nye Creek, near Nye, MT	U	1980-1991, 2022	13[2]	Inactive
06187000	Yellowstone River near Canyon Hotel, Yellowstone National Park, WY	U	1913-1918, 1921-1951	37[2]	Inactive
06191500	Yellowstone River at Corwin Springs, MT	U	1890-1893, 1911-2022	116[2]	Active
06192500	Yellowstone River near Livingston, MT	U	1897-1905, 1929-1932, 1938-2022	98[2]	Active
06214500	Yellowstone River at Billings, MT	U	1904, 1905, 1918, 1929-2022	97[2]	Active

U: unregulated. USGS: U.S. Geological Survey.
1. Gage was analyzed using At-Site and RRE wtd methods.
2. Gage was analyzed using At-Site and MOVE.3 methods. At-Site peak flow records reported.

2.3 2024 Upper Yellowstone Hydrologic Analysis Report Park County

Pioneer was contracted by the DNRC as part of the Upper Yellowstone Hydrology project to conduct a hydrologic analysis on 151 streams and 41 water bodies in Park County (Pioneer, 2024). This hydrologic analysis will be used to update the Park County FIS report.
The hydrologic analysis was performed using the most current methodologies and aligned with FEMA standards for floodplain mapping. The analysis was completed using the 2023 USGS Upper Yellowstone Flood Frequency Analysis on USGS gages through water year 2022 (Siefken, et al., 2023).

3 REACH SPECIFIC FLOOD HISTORY

Park County's major floods tend to follow high snowpack years. Spring weather conditions, such as above average temperatures and/or precipitation, exacerbate snowmelt and lead to flooding. In the past few years, Park County saw significant flooding throughout the entire county from both the Yellowstone River basin and the Shields River basin. This section outlines the past and recent flooding events throughout the county, details how estimated AEP peak flow AC events have changed since previous FIS and USGS releases, and documents some of the

major Park County flood events and how they impacted communities. Additional photographs of flooding in Park County are included in Appendix B.

3.1 Yellowstone River Basin

The Yellowstone River, a major tributary to the Missouri River, originates south of Park County in Yellowstone National Park, Wyoming, and is the longest undammed river in the lower 48 states. The river flows 700 miles before its confluence with the Missouri River in North Dakota. The entire Yellowstone River watershed basin encompasses approximately 70,000 square miles, with roughly 4,700 of those feeding the Yellowstone River within the Park County study reach.

3.1.1 Yellowstone River

In Park County, the Yellowstone River flows from south to north through the Paradise Valley between the Absaroka Range and the Gallatin Range. At Livingston, Montana, the Yellowstone River bends eastward. East of Livingston, a major Yellowstone River tributary in Park County, the Shields River, joins the Yellowstone River. The river continues east before entering Sweet Grass County near Springdale, Montana. The Yellowstone River in Park County basin elevations range from 12,143 feet to 4,201 feet at the Sweet Grass County border.

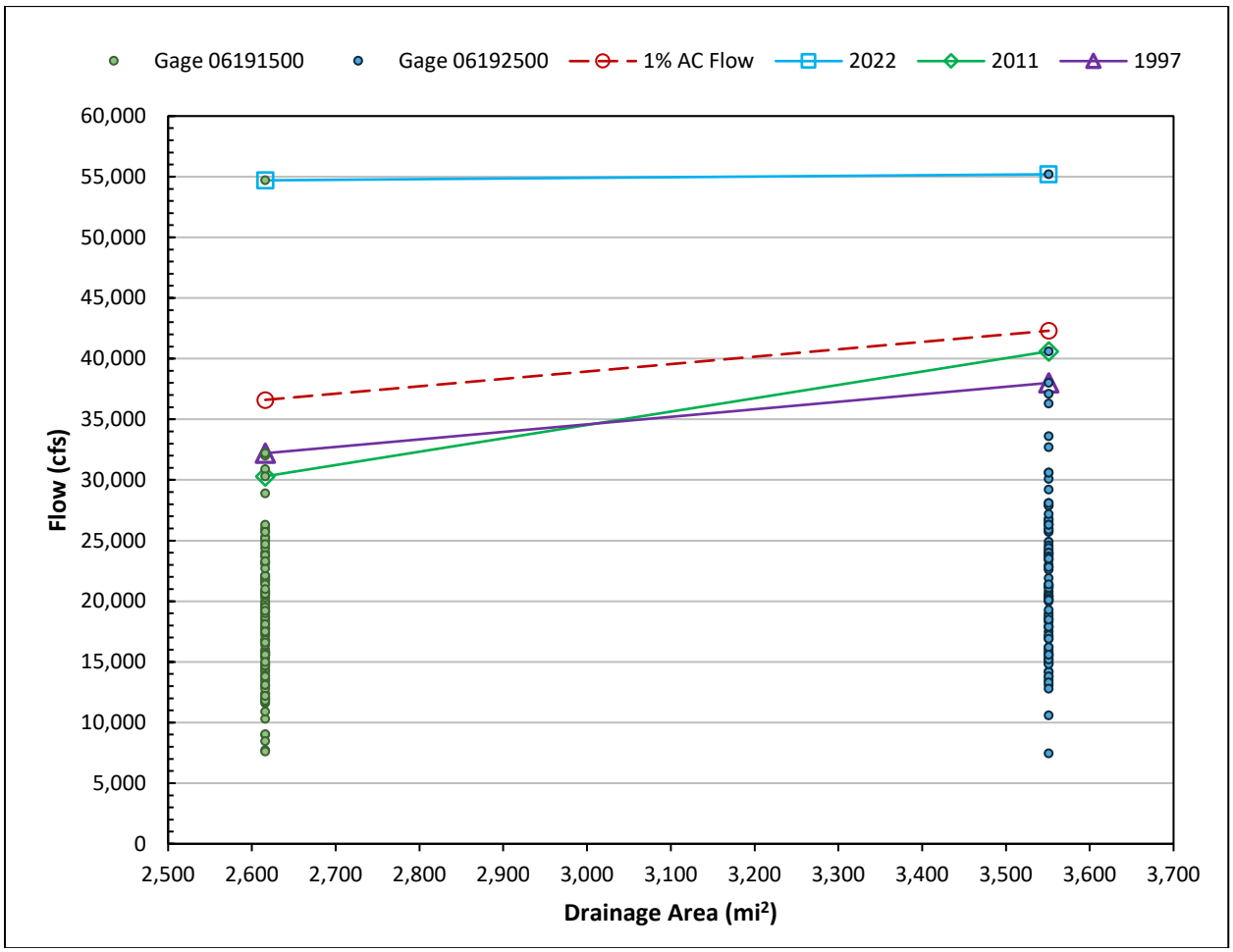
The Park County study reach is over 88 miles long and flows through the communities of Gardiner, Emigrant, Pray, and Livingston, Monana. Two Yellowstone River USGS stream gages are located within Park County, and two USGS gages are located outside of the study area in Yellowstone National Park and Yellowstone County, Montana. The two gage stations located in the Park County study area were used for flood history.

3.1.1.1 Yellowstone River USGS Gage Peak Discharge Comparison

The USGS publishes a peak flow for each water year a gage station is in operation. The two gage stations evaluated for flood history on the Yellowstone River in Park County are 06192500 Yellowstone River near Livingston, MT and 06191500 Yellowstone River at Corwin Springs, MT. Both gage stations are active; the Yellowstone River near Livingston, MT gage has flow data dating back to 1897 with a period of record from 1897 through 1905, 1929 through 1932, and 1938 through 2022, and the Yellowstone River at Corwin Springs, MT gage has data dating back to 1890 with a period of record of 1890 through 1893 and 1911 through 2022.

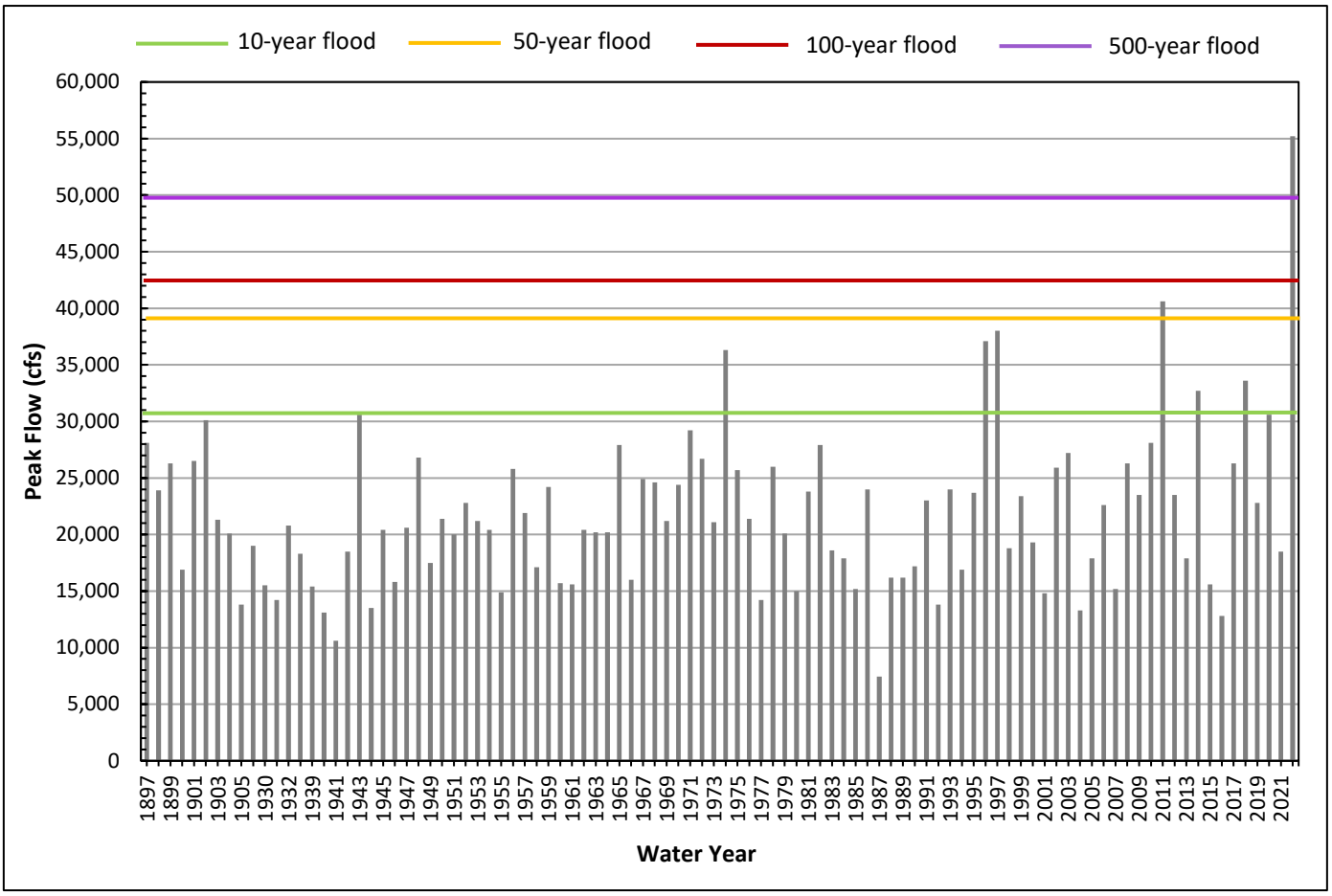
Figure 3-1 illustrates the measured peak flow history on the Yellowstone River at the two gage stations. Select extreme flooding events are highlighted, and the USGS estimated 1% AC peak discharge (Siefken, et al., 2023) for each gage location is shown in red.

Figure 3-1 Yellowstone River Gage Station Peak Flows



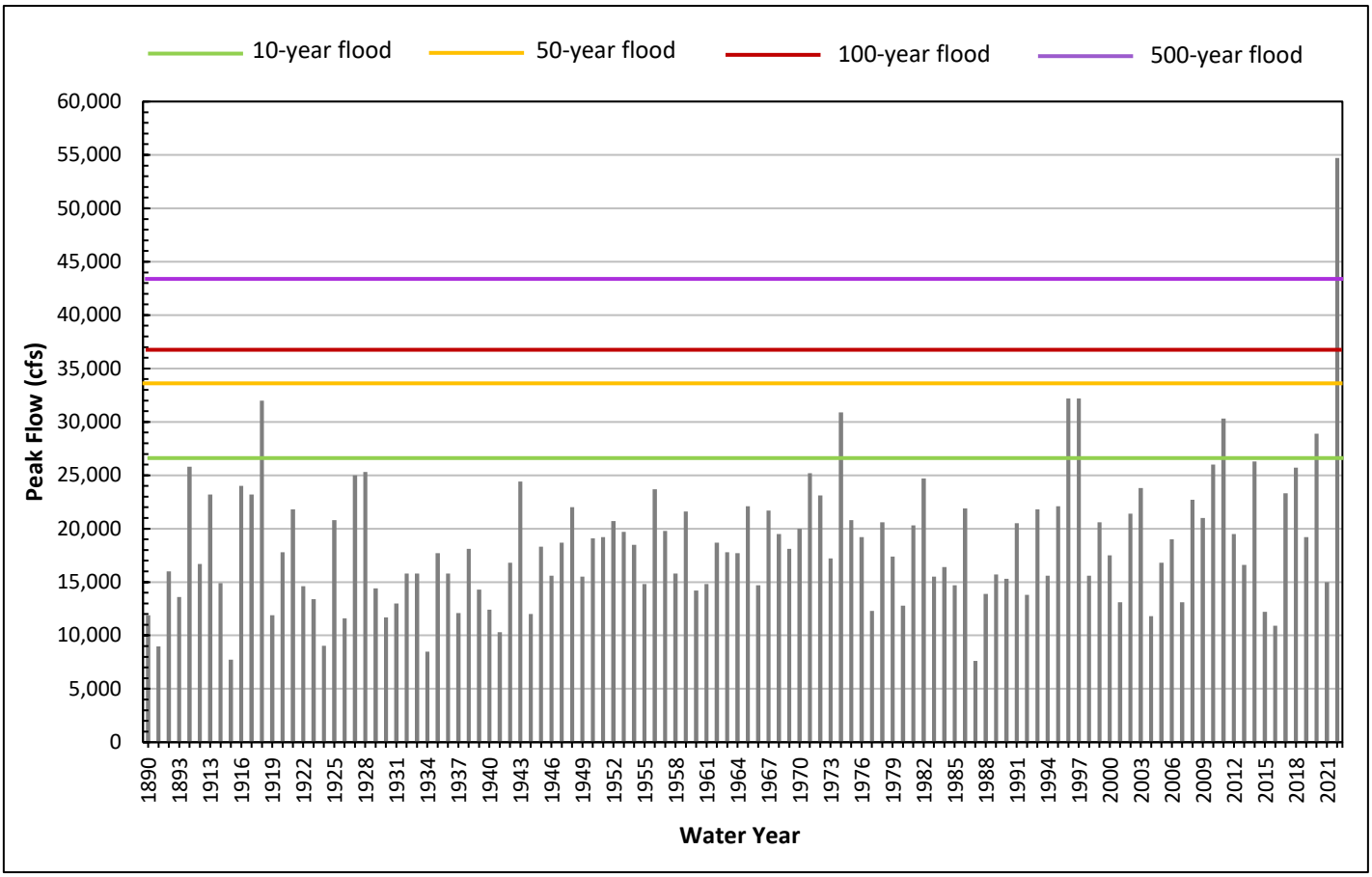
Peak flows were compared to different recurrence intervals at each stream gage. Figure 3-2 and Figure 3-3 show measured peak flow data at both gages by year in comparison to the 10-year (10% AC), 50-year (2% AC), 100-year (1% AC), and 500-year (0.2% AC) recommended USGS values (Siefken, et al., 2023).

Figure 3-2 Yellowstone River near Livingston, MT (06192500)



Note: The figure only shows years with measured Yellowstone River peak flows at the Yellowstone River near Livingston, MT gage station. The years shown include 1897 through 1905, 1929 through 1932, and 1938 through 2022. Years with no peak flow data (1906 through 1928 and 1933 through 1937) are not shown.

Figure 3-3 Yellowstone River at Corwin Springs, MT (06191500)



Note: The figure only shows years with measured Yellowstone River peak flows at the Yellowstone River at Corwin Springs, MT gage station. The years shown include 1890 through 1893 and 1911 through 2022. Years with no peak flow data (1894 through 1910) are not shown.

3.1.1.2 Yellowstone River Recommended Peak Discharge Comparison to Past Values

Comparing effective and historical peak flow estimates at specific flow locations can be used as tool to visualize how and why flood extents will change with new floodplain mapping. Table 3-1 compares the estimated 1% AEP peak discharges from the 2011 FIS report (FEMA, 2011) and the Upper Yellowstone Hydrologic Analysis Park County report (Pioneer, 2024).

Table 3-1 Yellowstone River Peak Discharge Estimates vs Existing FIS Flow Estimates

Flooding Source and Location	Peak Flood Frequency Source	Drainage Area (mi^2)	Date of Study	1% AEP (100-year) (cfs)	Percent Change[1]
Yellowstone River at confluence with Big Creek	Park County FIS Report	2,900	2011	34,000	--
	Upper Yellowstone Hydrologic Analysis	2,857	2024	38,160	12.2

Flooding Source and Location	Peak Flood Frequency Source	Drainage Area (mi^2)	Date of Study	1% AEP (100-year) (cfs)	Percent Change[1]
Yellowstone River at confluence with Mill Creek	Park County FIS Report	3,060	2011	35,100	--
	Upper Yellowstone Hydrologic Analysis	3,124	2024	39,810	13.4
Yellowstone River at confluence with Trail Creek	Park County FIS Report	3,400	2011	37,300	--
	Upper Yellowstone Hydrologic Analysis	3,412	2024	41,510	11.3
Yellowstone River at Carter Bridge+	Park County FIS Report	3,551	2011	38,300	--
	Upper Yellowstone Hydrologic Analysis	3,551	2024	42,300	10.4
Yellowstone River at confluence with Shields River[2]	Park County FIS Report	4,576	2011	42,000	--
	Upper Yellowstone Hydrologic Analysis	4,716	2024	49,520	17.9

AEP: Annual Exceedance Probability. cfs: cubic feet per second. mi^2: square miles.
+ Indicates the location is a USGS gage station.
1. "Percent Change" is the percent change of 1% AEP discharge of the Upper Yellowstone Hydrologic Analysis Park County discharge values (Pioneer, 2024) from past effective FIS discharge.
2. Upper Yellowstone Hydrologic Analysis Park County Report lists this location as "Yellowstone River on Sweet Grass County border"; the flow change node is located downstream of the effective FIS flow node, but no significant tributaries enter the Yellowstone River between the two locations.

As shown in Table 3-1, the estimated 1% AEP increased by approximately 4,000 to 7,000 cubic feet per second (cfs) at each flow change node location on the Yellowstone River in Park County. Both the effective Park County FIS report and the Upper Yellowstone Hydrologic Analysis Park County report used USGS gages to estimate peak flow discharges at the flow change nodes. The increase can be attributed to the increased gage stations period of record, large peak flow flood events in the extended period of record, and the change in methodology for estimating peak flow events.

The two USGS gage stations on the Yellowstone River in Park County have an extensive period of record. Previously estimated peak discharges from USGS studies show changes in flow estimates as a period of record increases and/or as methodology changes. Table 3-2 provides a comparison of 1% AEP USGS peak flow estimates at the Yellowstone River gage stations within Park County.

Table 3-2 Yellowstone River USGS Gage Peak Flow Comparison

USGS Station Number	USGS Station Name	Peak Flood Frequency Source	Year of Study	1% AEP (100-year) (cfs)
06192500	Yellowstone River near Livingston, MT	WRIR 03-4308	2003	38,300
		SIR 2015-5019-C	2015	39,500
		SIR 2018-5046	2018	39,200[1]
		wymt_ffa_2022Yellowstone	2023	42,300[1]
06191500	Yellowstone River at Corwin Springs, MT	WRIR 03-4308	2003	32,100
		SIR 2015-5019-C	2015	32,600
		SIR 2018-5046	2018	32,600[1]
		wymt_ffa_2022Yellowstone	2023	36,600[1]

AEP: Annual Exceedance Probability. cfs: cubic feet per second. ffa: Flood Frequency Analaysis. SIR: Scientific Investigations Report. USGS: U.S. Geological Survey. WRIR: Water Resource Investigations Report. WYMT: Wyoming Montana.

Shaded row represents the current USGS flood frequency analysis and corresponding 1% AEP peak flow value.

1. 1% AEP peak flow estimate was determined using MOVE.3 to extend the period of record and synthesize data for peak flow years where the gage station was inactive.

As shown in Table 3-2, the 1% AEP peak discharges determined in the 2023 USGS flood frequency analysis were greater than the previously determined 1% AEP peak discharges at the two Yellowstone River gage stations. When comparing the current 2023 USGS estimated 1% AEP (Siefken, et al., 2023) to the most recent past study, SIR 2018-5046 (Sando & McCarthy, 2018), the current estimates had a 7% change at the Yellowstone River near Livingston, MT gage and a 12% change at the Yellowstone River at Corwin Springs, MT gage. Methodology between the 2018 study and the 2023 study remained the same; therefore, the increase in estimated peak discharge can be attributed to the increased period of record and the large measured peak flow values from 2022, 2020, and 2018.

3.1.1.3 Yellowstone River Flood History Documentation

Yellowstone River flooding has greatly impacted Park County residents multiple times throughout history. The most recent significant flood event occurred in 2022; other large flood events, which have surpassed the estimated 25-year peak discharge at either Yellowstone River Park County gage station, occurred in 1918, 1974, 1996, 1997, and 2011. These are the largest six floods on record in Park County, and each has been the result of rapid spring snow melt. Although not as widespread, flooding on the Yellowstone River has also resulted from ice jams.

In early June 2022, a large rain on snow event in the Absaroka and Beartooth Mountains led to flooding on many of southwest Montana's streams; this is the flood of record for the Yellowstone River and many of its tributaries with headwaters in the Absaroka – Beartooth Mountains. This flood event surpassed the 0.2% AC event (500-year), and peak discharge was 136% of the previous flood of record (2011 flood) at the Yellowstone River near Livingston, MT gage station and 170% of the flood of record (1996 and 1997) at the Yellowstone River at Corwin Springs, MT gage station. The measured peak flows at the Yellowstone River near

Livingston, MT and Yellowstone River at Corwin Springs, MT gage stations were 55,200 and 54,700 cfs, respectively. The flood stage for the Yellowstone River near Livingston, MT gage station (at Carter Bridge) is 10.0 feet, and the 2022 flood peaked at 11.63 feet. The flood stage at the Yellowstone River at Corwin Springs, MT gage is 11 feet, and the 2022 flood peaked at 14.72 feet.

The Yellowstone River in Park County saw banks drastically eroded, towns isolated, and bridges and houses washed away in 2022. The Point of Rocks bridge on Highway 89 South sustained substantial damage while other stretches of Highway 89, including near the Emigrant Rest Stop and through Yankee Jim Canyon, were underwater. The Carbella Bridge near Carbella, Montana was washed out. Numerous houses and businesses throughout the Paradise Valley and Livingston, Montana, were inundated with floodwaters. Though not designed to withstand a flood of this magnitude, nor holding FEMA certification, the levees near the Livingston, Montana, 9th Street Island and Sacajawea Lagoon, reinforced with countless sandbags, prevented major flooding in that region of Livingston, Montana. Although no lives were lost during the June 2022 flood, the Park County community is still, even 1.5 years later, feeling the impact. Millions of dollars of damage occurred throughout Park County and surrounding counties; for fiscal year 2024, the Federal Highway Administration (FHWA) has allocated over $28 million to reimburse and support repair costs throughout Montana as a result of the 2022 flooding as part of the FHWA's Emergency Relief program (USDOT FHWA, 2024). Photograph 3-1 through Photograph 3-12 document only a portion of the significant 2022 Yellowstone River flood. Prior significant flooding events are discussed beneath the 2022 flooding photographs.

Photograph 3-1 Yellowstone River Flooding 2022 – Gardiner, MT

Caption: A house was undercut and fell into the Yellowstone River as the bank eroded away during the 2022 flood. Image on left is from June 14, 2022. Image on right is from 2019. Source: Google Earth Imagery.

Photograph 3-2 Yellowstone River Flooding 2022 – 989 US Highway 89 South Gardiner, MT

Caption: The Yellowstone River undercut a structure along Highway 89 S near Gardiner, MT during the June 2022 flooding. The structure was still hanging over the edge when the photograph was taken one month after flood waters receded. Source: Pioneer.

Photograph 3-3 Yellowstone River Flooding 2022 – Yankee Jim Canyon

Caption: Highway 89 South overtopped by the Yellowstone River at the Yankee Jim Canyon River Access site. Source: Park County.

Photograph 3-4 Yellowstone River Flooding 2022 – Carbella Bridge

Caption: Carbella Bridge during the 2022 Yellowstone River flood before and during being washed away. Source: Park County.

Photograph 3-5 Yellowstone River Flooding 2022 – Emigrant, MT

Caption: Residences and structures just east of the Emigrant Bridge crossing of the Yellowstone River are inundated. Source: Pioneer.

Photograph 3-6 Yellowstone River Flooding 2022 – Mallard's Rest, Paradise Valley

Caption: Mallard's Rest fishing access site and campground are inundated by the Yellowstone River. Much of the bank of the Yellowstone River sloughed off, leading to the closure of the site even after flood waters receded. Mallard's Rest was photographed during the 1997 flood and is shown on Photograph 3-17. Source: Park County.

Photograph 3-7 Yellowstone River Flooding 2022 – Evergreen Lane near Carter Bridge

Caption: A residence built along Evergreen Lane off of Highway 89 South near Carter Bridge during and after the 2022 flooding. The residence is located on the banks of the Yellowstone River and avoided inundation due to being built on stilts. Source: Park County.

Photograph 3-8 Yellowstone River Flooding 2022 – 5024 Highway 89 South Livingston, MT

Caption: A house just north of Carter Bridge off Highway 89 South is shown after floodwaters receded from the 2022 flood events on June 15, 2022. This home was also photographed during the 1996 flood and is shown on Photograph 3-16. Source: Park County.

Photograph 3-9 Yellowstone River Flooding 2022 –
Southern Portion of 9th Street Island Livingston, MT

Caption: 9th Street Island floods residences on June 13, 2022. Source: DNRC – Still Taken from DNRC Sacagawea to Interstate Bridge video.

Photograph 3-10 Yellowstone River Flooding 2022 – East Side of 9th Street Island Livingston, MT

Caption: A residence on 9th Street Island is inundated and in direct path of the Yellowstone River on June 13, 2022. Source: DNRC – Still Taken from DNRC Sacagawea to Interstate Bridge video.

Photograph 3-11 Yellowstone River Flooding 2022 – Veterans Bridge Livingston, MT

Caption: Flood waters rise to almost low chord at Veterans Bridge in Livingston, MT. Source: DNRC's Veterans Bridge Video.

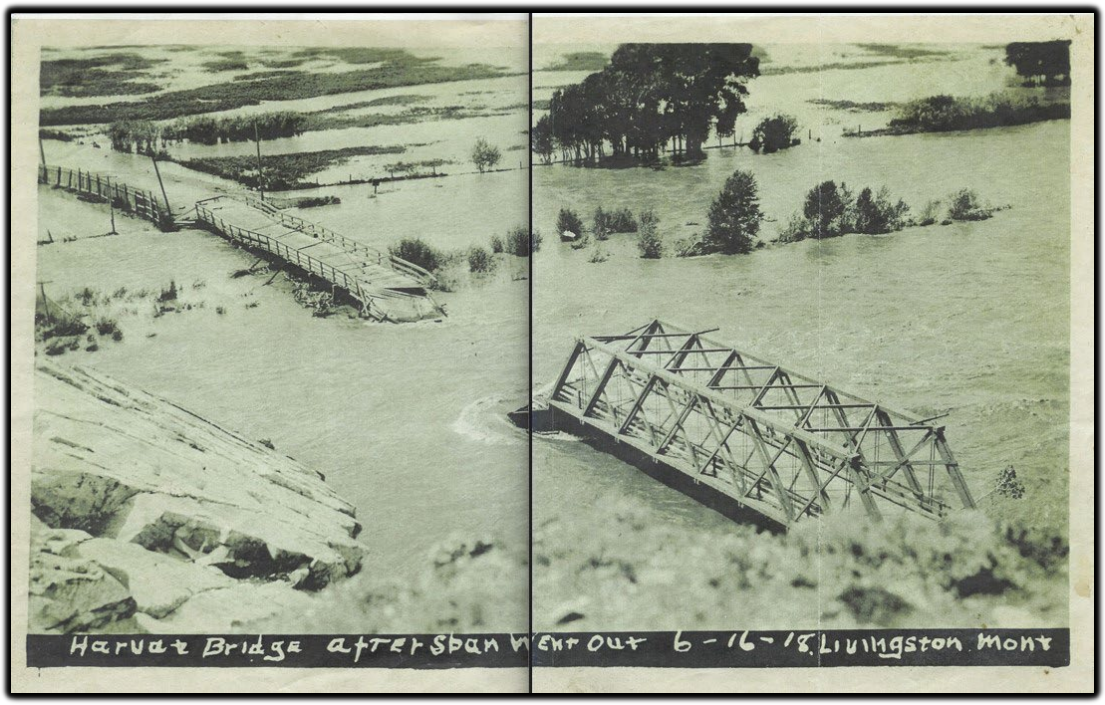
Photograph 3-12 Yellowstone River Flooding 2022 – Livingston, MT Aerial Image

Caption: The Yellowstone River inundates part of Livingston, Montana, on June 13, 2022. In the bottom right of the photograph, Mayor's Landing Fishing Access Site is under water. The hospital is shown near the top of the photograph with flood water surrounding the building. Residences and structures in the bottom left of the photograph between Highway 89 and East Lewis Street see flooding as well. Source: Park County.

Additional significant past flooding along the Yellowstone River in Park County occurred in 1918, 1974, 1996, 1997, and 2011. These floods, including the 2022 flood, are the top six floods on record at the two Yellowstone River gage stations in Park County.

In 1918 at USGS gage stations 06192500 Yellowstone River near Livingston, MT and 06191500 Yellowstone River at Corwin Springs, MT, the peak flow was 37,600 cfs and 32,000 cfs, respectively. The 1918 peak flow value at the Yellowstone River near Livingston, MT gage was synthesized by the USGS because the gage was inactive during the 1918 flood. The 1918 flood would be considered between a 25-year and 50-year event based on current estimated AEP peak flood discharges. This flood was caused by a rapid snow melt. In Livingston, Montana, the flood led to the collapse of the 9th Street Island bridge and inundated the island with 2 to 3 feet of water (FEMA, 2011). Photographic documentation of this flood also shows the destruction of the Horvat Bridge which connected Mayor's Landing to the Horvat Ranch, as shown on Photograph 3-13 and Photograph 3-14.

Photograph 3-13 Yellowstone River Flooding 1918 – Horvat Bridge in Livingston, MT



Caption: A span of Horvat bridge connecting present day Mayor's Landing to Horvat Ranch was washed out during the 1918 flood. Source: DNRC.

Photograph 3-14 Yellowstone River Flooding 1918 – Horvat Bridge Going Out in Livingston, MT

Caption: Horvat Bridge was washed away and floated down the Yellowstone River during the 1918 flood. Source: DNRC.

In 1974, the peak flows at gage stations 06192500 Yellowstone River near Livingston, MT and 06191500 Yellowstone River at Corwin Springs, MT were 36,300 and 30,900 cfs, respectively. The peak flows exceeded the current estimated 10-year event at the Livingston gage location, and the 25-year event at the Corwin Springs gage location. The flooding in Livingston inundated much of 9th Street Island and the school football field and track; the 9th Street Island bridge and Vista View Road from the Main Street bridge to the golf course were closed (RESPEC, 2018). An aerial image taken one day after the peak of the 1974 flood event is shown on Photograph 3-15.

Photograph 3-15 Yellowstone River Flooding 1974 – Livingston, MT

Caption: The Yellowstone River inundated parts of Livingston, Montana, in 1974. Shown on the photograph are the interstate bridges and inundation of both 9th Street Island and Siebeck Island. Source: Park County.

In 1996 and 1997, the peak flows at USGS gage 06191500 Yellowstone River near Livingston, MT were measured at 37,100 and 38,000 cfs, respectively. At the time, the floods were considered nearly 100-year events. However, when compared to current AEP peak flood event discharges, these floods were both between a 25-year and 50-year event. The 1996 flood event was the flood of record when it occurred; then a year later, the 1997 flood became the new flood of record. Although the 1997 flood was slightly higher than the 1996 flood, according to Bozeman Daily Chronicle, the 1997 flood led to less damage due to community members preparing for potential flood events. Some of the residents worked together to build temporary dikes to help keep water out of their homes or properties and others cleaned out ditches and filled sandbags (McMillion, 1997). Both floods, despite the flood preparation efforts, led to numerous homes being inundated with floodwater in consecutive years (FEMA, 2021). Flooding of a home during the 1996 flood is shown on Photograph 3-16 and flooding from the 1997 event is shown on Photograph 3-17 and Photograph 3-18.

Photograph 3-16 Yellowstone River Flooding 1996 – 5024 Highway 89 South, Livingston, MT

Caption: A house just north of Carter Bridge off Highway 89 South is shown during the 1996 flood. This home was also inundated during the 2022 flood and is shown on Photograph 3-8. after the floodwaters receded. Source: Park County.

**Photograph 3-17 Yellowstone River Flooding 1997 –
Mallard's Rest Fishing Access Site**

Caption: Mallard's Rest Fishing Access Site is inundated with floodwaters during the 1997 Yellowstone River Flooding. A similar photograph was taken during the June 2022 flooding and is shown on Photograph 3-6. Source: Park County.

**Photograph 3-18 Yellowstone River Flooding 1997 –
9th Street Island Drive to Siebeck Island**

Caption: The road to Siebeck Island via 9th Street Island Drive was overtopped and washed out during the 1997 flood. Source: Park County.

The peak flow from the 2011 flood was measured at 40,600 cfs at the Yellowstone River near Livingston, MT gage station. This flood was determined to be between a 50-year and a 100-year event based on current AEP peak flood discharges. At the time, the 2011 flood was the flood of record and exceeded the previous flood of record (1997) at the Yellowstone River near Livingston, MT gage by 2,600 cfs. Despite it being such a significant peak flow, minimal damage in Livingston, Montana, was reported compared to previous floods of less magnitude. Flood waters knocked down a power line, overtopped the 9th Street Island Drive, and caused damage to many roads across Park County, but in general catastrophic losses were avoided (Person, 2011).

Although not as common as flooding due to rain on snow events, flooding due to ice jams on the Yellowstone River are known to occur. The most recent significant flooding due to an ice jam occurred on January 17, 2007. According to the Cold Regions Research and Engineering Laboratory (CRREL), the flooding inundated one house and prompted warnings from south of Livingston, Montana, to Pine Creek to be prepared for flooding (CRREL, 2007).

Additional Park County Yellowstone River flooding photographs are provided in a geodatabase included in Appendix B.

3.1.2 Yellowstone River Tributaries

The tributaries of the Yellowstone River throughout Park County have seen significant flooding. Many of the tributaries pass by Park County communities and flooding has greatly impacted those communities. The studied Park County tributaries of the Yellowstone River, not including the Shields River basin, are in the southern portion of Park County and originate in the Gallatin or Absaroka Mountain ranges. The Shields River basin is discussed in Section 3.2.

As part of the Upper Yellowstone Hydrologic Analysis Park County study, 90 Yellowstone River tributaries were analyzed. The flood history for each tributary was investigated. Table 3-3 lists the Yellowstone River tributaries where flood history documentation was found and the corresponding level of analysis for the Park County hydrologic analysis study. These tributaries are discussed in the following sections. The complete list of reaches investigated is included in Appendix C.

Table 3-3 Yellowstone River Tributaries Flood History Reach Summary

Stream Name	Analysis Approach	Total Length (miles)
Boulder River	BLE Zone A	10.7
Fleshman Creek	Enhanced Zone AE with Floodway	1.1
Gardner River	Enhanced Zone AE	0.2
Mill Creek A	Enhanced Zone AE, BLE Zone A	12.0

Stream Name	Analysis Approach	Total Length (miles)
Miller Creek[1]	Enhanced Zone AE with Floodway	0.3
Mulherin Creek	Enhanced Zone AE	0.8
Sheep Creek B[1]	Enhanced Zone AE with Floodway	0.1
Soda Butte Creek	Enhanced Zone AE with Floodway	4.7
Stillwater River	BLE Zone A	4.9
Woody Creek[1]	Enhanced Zone AE with Floodway	0.1

1. Reach flood history addressed in Soda Butte Creek Flood History Documentation section.

3.1.2.1 Boulder River

The Boulder River and its tributaries originate in the northern portion of the Absaroka Range near the Park – Sweet Grass County border. The watershed for Park County study reaches and water bodies in the Boulder River basin encompasses 333 square miles. The Boulder River converges with Yellowstone River in Sweet Grass County at Big Timber, Montana. The small community of Contact, Montana lies on the Park – Sweet Grass County border.

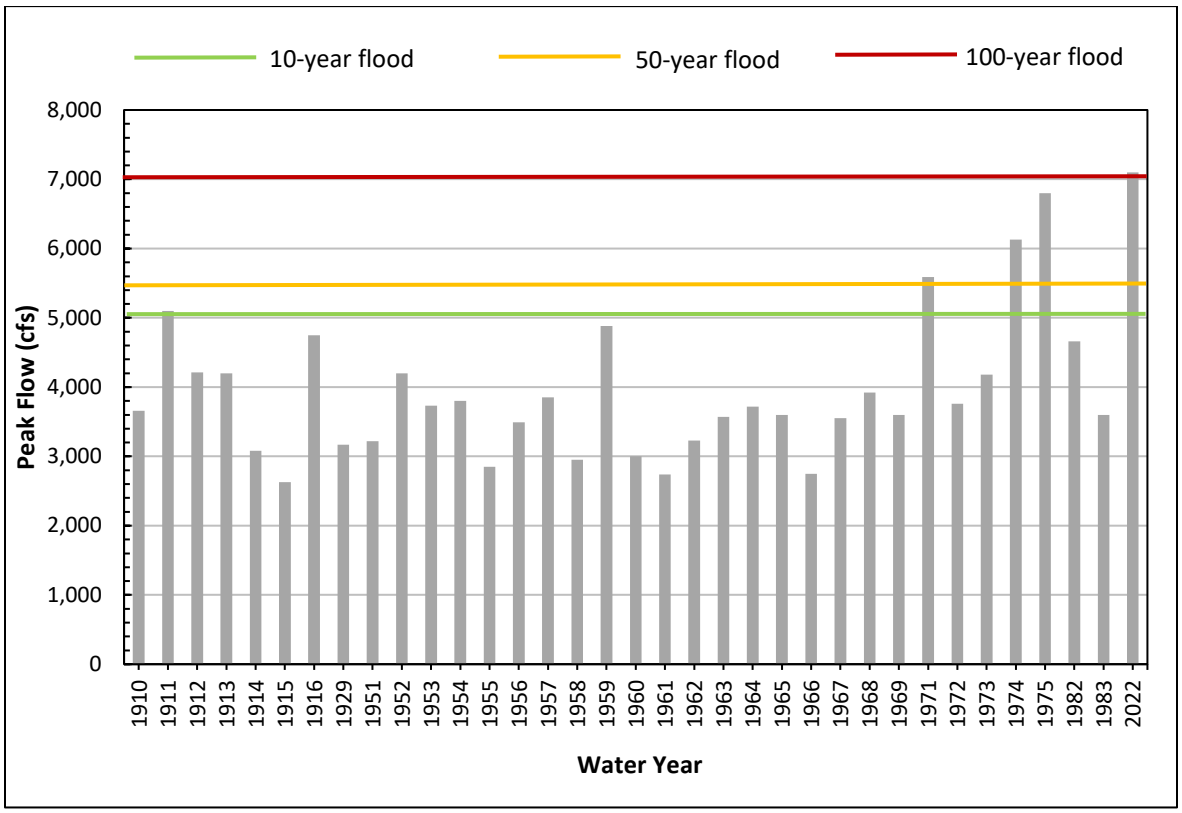
The AEP peak discharges for the Boulder River and tributaries were not included in the effective FIS report. Two USGS gage stations are located on the Boulder River. The gage station located nearest to the study reach, 06197500 Boulder River near Contact, MT, was used for flood history.

3.1.2.1.1 Boulder River USGS Gage Peak Discharge Comparison

The USGS publishes a peak flow for each water year a gage station is in operation. The gage station evaluated for flood history on the Boulder River was 06197500 Boulder River near Contact, MT. The Boulder River gage has a sporadic period of record including 1910 through 1916, 1929, 1951 through 1969, 1971 through 1975, 1982, 1983, and 2022.

Peak flows were compared to different recurrence intervals at the gage. Figure 3-4 shows measured peak flow data at the gage by year in comparison to the 10-year (10% AC), 50-year (2% AC), and 100-year (1% AC) recommended USGS values (Siefken, et al., 2023).

Figure 3-4 Boulder River near Contact, MT (06197500)



Note: The figure only shows years with measured Boulder River peak flows at the Boulder River near Contact, MT gage station. The years shown include 1910 through 1916, 1929, 1951 through 1969, 1971 through 1975, 1982, 1983, and 2022. Years with no peak flow data (1917 through 1928, 1930 through 1950, 1970, 1976 through 1981, and 1984 through 2021) are not shown.

3.1.2.1.2 Boulder River Recommended Peak Discharge Comparison to Past Values

The Boulder River hydrology was not studied as part of the effective FIS. However, the Boulder River gage station, 06197500, was studied as part of three prior USGS studies. A comparison of these studies and the current 1% AEP peak discharge estimates are shown in Table 3-4.

Table 3-4 Boulder River USGS Gage Peak Flow Comparison

USGS Station Number	USGS Station Name	Peak Flood Frequency Source	Year of Analysis	1% AEP (100-year) (cfs)
06197500	Boulder River near Contact, MT	WRIR 92-4048	1992	6,900
		WRIR 03-4308	2003	6,980
		SIR 2015-5019-C	2015	6,890
		wymt_ffa_2022Yellowstone	2023	7,040[1]

AEP: Annual Exceedance Probability. cfs: cubic feet per second. FFA: Flood Frequency Analysis. SIR: Scientific Investigations Report. USGS: U.S. Geological Survey. WRIR: Water Resource Investigations Report. WYMT: Wyoming Montana.
Shaded row represents the current USGS flood frequency analysis and corresponding 1% AEP peak flow value.
1. 1% AEP peak flow estimate was determined using MOVE.3 to extend the period of record and synthesize data for peak flow years where the gage station was inactive.

As shown in Table 3-4, the 1% AEP peak discharge determined in the 2023 USGS flood frequency analysis was higher than the previously determined 1% AEP peak discharge at the Boulder River gage station. When comparing the current 2023 USGS estimated 1% AEP (Siefken, et al., 2023) to the most recent past study, SIR 2015-5019-C (Sando, et al., 2015), the current estimate resulted in a 2% change at the Boulder River near Contact, MT gage. Methodology between the 2015 study and the 2023 study was updated. Therefore, the increase in estimated peak discharge can be attributed to the change in methodology, the increased period of record, and the large annual peak discharges from 2020 and 2022. The 2020 peak discharge value was synthesized using MOVE.3; MOVE.3 is used to extend the gage station's period of record.

3.1.2.1.3 Boulder River Flood History Documentation

The flood of record at the Boulder River near Contact, MT gage station occurred on June 13, 2022. Prior significant flooding events during the period of record at the Boulder River near Contact, MT gage station occurred in 1971, 1974, and 1975; these events each exceeded the estimated 50-year flood event. No historical or photographic records of the prior Boulder River floods were found during the flood history investigation.

The 2022 peak discharge was measured at 7,100 cfs and the next largest measured flood occurred in 1975 and had a measured peak discharge of 6,800 cfs. Due to the remoteness of the Boulder River reach in Park County, few structures are in the floodplain and were damaged during the 2022 flooding. The structures that are in the floodplain are in the rural town of Contact, Montana. No photographic records were found of the 2022 flood event.

3.1.2.2 Gardner River

The Gardner River originates in the northern portion of Yellowstone National Park and flows along the previous Highway 89 before flooding washed away portions of the highway. Upstream of Gardiner, Montana, the confluence of the Gardner River and Yellowstone River occurs. The Gardner River watershed encompasses 207 square miles.

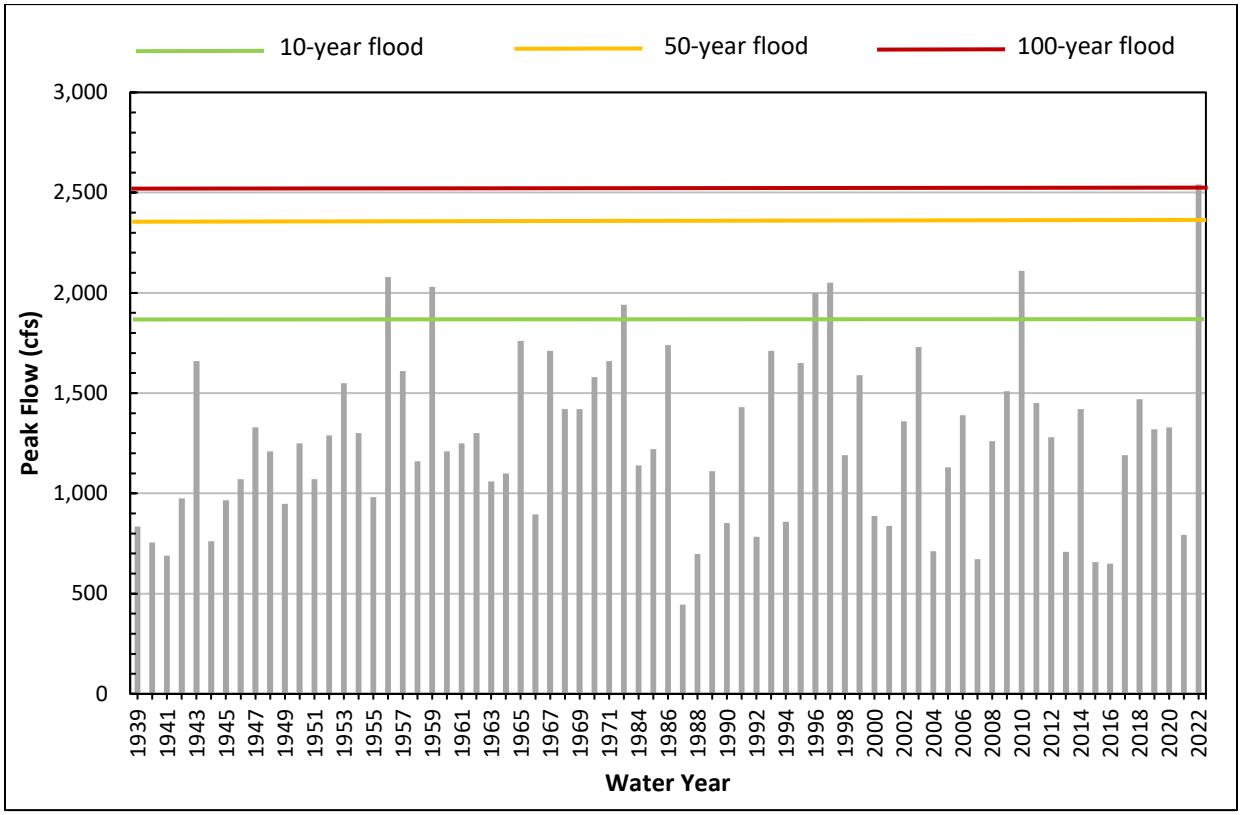
The AEP peak discharges for the Gardner River were not included in the effective FIS report. A USGS gage station is located upstream of the study reach.

3.1.2.2.1 Gardner River USGS Gage Station Peak Discharge Comparison

The USGS publishes a peak flow for each water year a gage station is in operation. The gage station evaluated for flood history on the Gardner River was 06191000 Gardner River near Mammoth, Yellowstone National Park, WY. The Gardner River gage station has a period of record from 1939 through 1972 and 1984 to present.

Peak flows were compared to different recurrence intervals at the gage. Figure 3-5 shows measured peak flow data at the gage by year in comparison to the 10-year (10% AC), 50-year (2% AC), and 100-year (1% AC) recommended values (Pioneer, 2024).

Figure 3-5 Gardner River near Mammoth, Yellowstone National Park, WY (06191000)



Note: The figure only shows years with measured Gardner River peak flows at the Gardner River near Mammoth, Yellowstone National Park, WY gage station. The years shown include 1939 through 1972, and 1984 through 2022. Years with no peak flow data (1973 through 1983) are not shown.

3.1.2.2.2 Gardner River Recommended Peak Discharge Comparison to Past Values

The Gardner River hydrology was not studied as part of the effective FIS. However, the Gardner River gage station, 06191000, was studied as part of three prior USGS studies. A comparison of these studies and the current 1% AEP peak discharge estimates are shown in Table 3-5.

Table 3-5 Gardner River USGS Gage Peak Flow Comparison

USGS Station Number	USGS Station Name	Peak Flood Frequency Source	Year of Analysis	1% AEP (100-year) (cfs)
06191000	Gardner River near Mammoth, Yellowstone National Park, WY	WRIR 92-4048	1992	2,320
		WRIR 03-4308	2003	2,450
		SIR 2015-5019-C	2015	2,450
		Pioneer 2024[1]	2024	2,520

AEP: Annual Exceedance Probability. cfs: cubic feet per second. SIR: Scientific Investigations Report. USGS: U.S. Geological Survey. WRIR: Water Resource Investigations Report.
Shaded row represents the current USGS flood frequency analysis and corresponding 1% AEP peak flow value.
1. A PeakFQ flood frequency analysis was performed by Pioneer because the Gardner River gage station was not included in the most recent USGS hydrologic analysis.

As shown in Table 3-5, the 1% AEP peak discharge determined in the 2024 Upper Yellowstone Hydrologic Analysis (Pioneer, 2024) was greater than the previously determined 1% AEP peak discharge at the Gardner River gage station. When comparing the current 2024 estimated 1% AEP to the most recent past study, SIR 2015-5019-C (Sando, et al., 2015), the current estimate resulted in a 3% increase at the Gardner River near Mammoth, Yellowstone National Park, WY gage. Methodology between the 2015 study and the 2023 study was updated. Therefore, the increase in estimated peak discharge can be attributed to the change in methodology, the increased period of record, and the large annual peak flow from 2022.

3.1.2.2.3 Gardner River Flood History Documentation

The flood of record occurred on June 13, 2022; this flood event was nearly equivalent to the current 100-year flood event. Other significant peak discharge events recorded at the Gardner gage station occurred in 1956 and 2010; these two events were near the estimated 25-year peak discharge, but no historical or photographic records of the flooding were found.

During the 2022 flood the measured peak flow value of 2,540 was 20 cfs over the estimated 1% AEP peak discharge of 2,520 cfs. The 2022 peak discharge was 120% of the 2010 peak discharge, which was the previous flood of record. In early June 2022, a large rain on snow event in the Absaroka and Beartooth mountains led to flooding on many of southwest Montana's streams. The Gardner River between Mammoth, Yellowstone National Park, Wyoming, and Gardiner, Montana, severely damaged Highway 89/North Entrance Road, as shown on Photograph 3-19 and Photograph 3-20. An estimate determined by the U.S. Army Corps of Engineers in 2022 put the cost and time of repairing the 2-mile stretch of Highway 89 near $1 billion and nearly 5 years (Vigliotti, 2022). It is still undecided if the road will be reconstructed along the same route or along a new route. Currently, a temporary road has been constructed on Old Gardiner Road that serves at the entrance into Yellowstone National Park. Photographs of some of the Northeast Entrance Road repair progress can be found on the Yellowstone National Park Service's (NPS) Flickr here: Improvement Project: Old Gardiner Road | Flickr. The Yellowstone NPS Flickr page has an album of the 2022 flood and recovery efforts and can be found here: Event: 2022 Flood & Recovery Efforts | Flickr.

The closure of the North Entrance to Yellowstone National Park as a result of the destruction of the North Entrance Road drastically impacted the town of Gardiner, Montana, economically. As a gateway community to Yellowstone National Park, the town and the businesses rely on the tourism industry. The park entrance closure resulted in a 65% decrease in tax revenue for the community of Gardiner (Sindelar, 2023).

Photograph 3-19 Gardner River Flooding 2022 – Highway 89

Caption: Highway 89 South between Gardiner, Montana, and Mammoth, Yellowstone National Park, Wyoming, at the 45th parallel is washed away by the 2022 Gardner River flood. The image on the left is from 2019 and the image on the right is from 2022. Source: Google Earth Imagery.

Photograph 3-20 Gardner River Flooding 2022 – Highway 89 near Gardiner, MT

Caption: Highway 89 S between Gardiner, Montana, and Mammoth, Yellowstone National Park, Wyoming, south of Rescue Creek trailhead is washed away by the Gardner River 2022 flood. The image on the left is from 2019 while the image on the right is from 2022.

3.1.2.3 Soda Butte Creek

Soda Butte Creek and its tributaries originate in the Absaroka Mountains near the northeast entrance of Yellowstone National Park. It is a tributary to the Lamar River, which flows into the Yellowstone River near Tower Junction, Yellowstone National Park. The Soda Butte Creek watershed, within the Park County study area, encompasses 27.4 square miles. The Park County communities of Cooke City and Silver Gate are located along Soda Butte Creek.

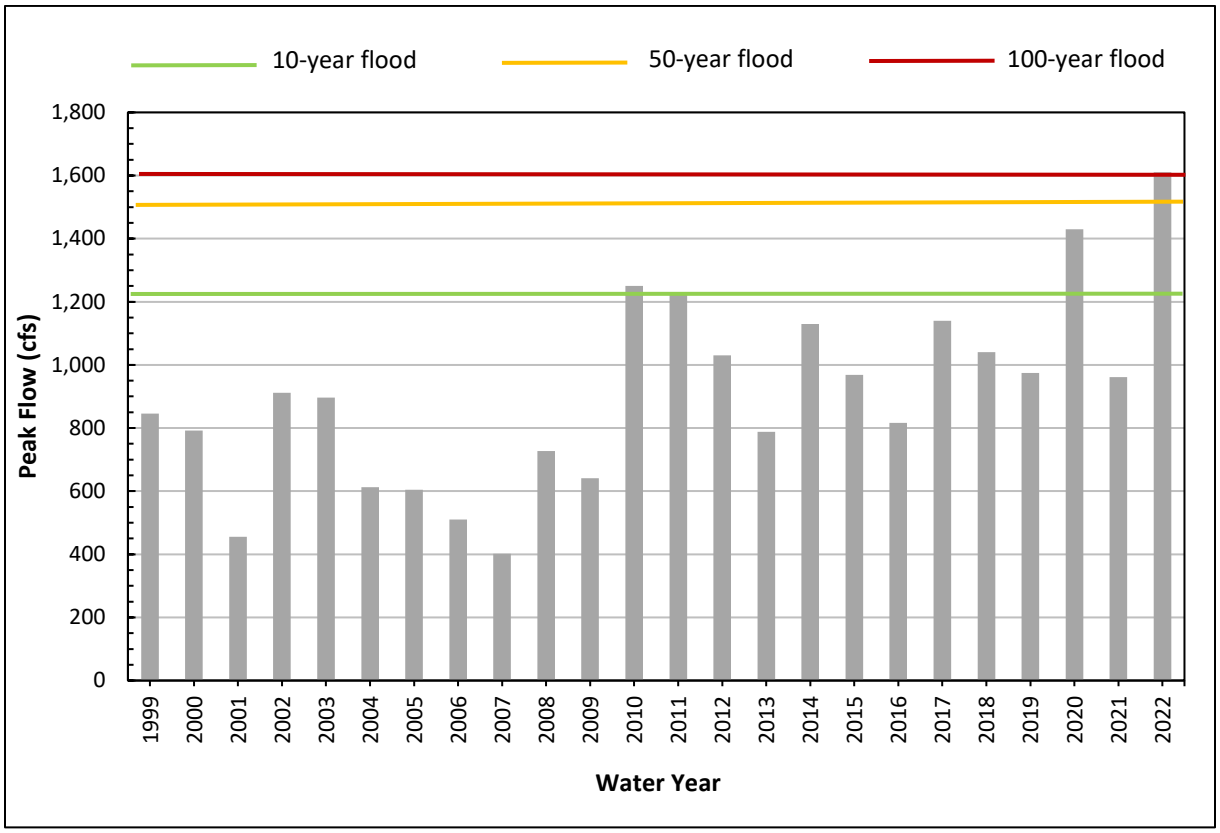
The AEP peak discharges for Soda Butte Creek were not included in the effective FIS report. One USGS gage station is located downstream of the study reach.

3.1.2.3.1 Soda Butte Creek USGS Gage Station Peak Discharge Comparison

The USGS publishes a peak flow for each water year a gage station is in operation. The gage station evaluated for flood history on Soda Butte Creek was 06187915 Soda Butte Creek at Park Boundary, at Silver Gate, MT. This gage became active in 1999.

Peak flows were compared to different recurrence intervals at the gage. Figure 3-6 shows measured peak flow data at the gage by year in comparison to the 10-year (10% AC), 50-year (2% AC), and 100-year (1% AC) recommended USGS values (Siefken, et al., 2023).

Figure 3-6 Soda Butte Creek at Park Boundary at Silver Gate, MT (06187915)



3.1.2.3.2 Soda Butte Creek Recommended Peak Discharge Comparison to Past Values

Soda Butte Creek hydrology was not studied as part of the effective FIS. However, the Soda Butte gage station, 06187915, was studied as part of two prior USGS studies. A comparison of these studies and the current 1% AEP peak discharge estimates are shown in Table 3-6.

Table 3-6 Soda Butte Creek USGS Gage Peak Flow Comparison

USGS Station Number	USGS Station Name	Peak Flood Frequency Source	Year of Analysis	1% AEP (100-year) (cfs)
06187915	Soda Butte Creek at Park Boundary at Silver Gate, MT	SIR 2015-5019-C	2015	1,650
		wymt_ffa_2022Yellowstone	2023	1,600

AEP: Annual Exceedance Probability. cfs: cubic feet per second. FFA: Flood Frequency Analysis. SIR: Scientific Investigations Report. USGS: U.S. Geological Survey. WYMT: Wyoming Montana
Shaded row represents the current USGS flood frequency analysis and corresponding 1% AEP peak flow value.

As shown in Table 3-6, the 1% AEP peak discharge determined in the 2023 USGS flood frequency analysis was slightly lower than the previously determined 1% AEP peak discharges at the Soda Butte Creek gage station. When comparing the current 2023 USGS estimated 1% AEP (Siefken, et al., 2023) to the most recent past study, SIR 2015-5019-C (Sando, et al., 2015a), the current estimate resulted in a 3% decrease at the Soda Butte Creek at Park Boundary at Silver Gate, MT gage. Methodology between the 2015 study and the 2023 study was updated. Therefore, the decrease in estimated peak discharge can be attributed to changing methodology and increased period of record. Despite most gage stations in the Absaroka Mountain Range seeing an increase in 1% AEP peak discharge estimates, the Soda Butte Creek gage became active in 1999 and has a relatively low period of record. At the time of the 2015 study, the Soda Butte Creek gage was studied using only 11 years of record; the current study used 24 years of record. As the period of record increases, the estimated AEP peak discharges become more accurate.

3.1.2.3.3 Soda Butte Creek Flood History Documentation

The Soda Butte Creek flood of record was recorded on June 12, 2022; this flood event was nearly equivalent to the current 100-year flood event. Prior USGS recorded peak flood events occurred in 2010, 2011, and 2020. The 2010 and 2011 events met or exceeded the estimated 10-year peak discharge, and the 2020 event exceeded the estimated 25-year peak discharge. Prior USGS gage station historical reports indicate flooding in 1996 (Boughton, 1999), and historical photographs indicate flooding on Soda Butte Creek in 1997.

In early June 2022, a large rain on snow event in the Absaroka and Beartooth mountains led to flooding on many of southwest Montana's streams. The measured peak flow value of 1,610 was 10 cfs over the estimated 1% AEP peak discharge of 1,600 cfs at the Soda Butte Creek at Park Boundary, at Silver Gate, MT gage station. The 2022 peak discharge was 113% of the 2020 peak discharge, which was the previous flood of record. Soda Butte Creek peaked at a gage height of 4.94 feet in 2022, and the 2020 gage height was 3.67 feet.

In June of 2022, near Cooke City, Montana, and Silver Gate, Montana, the Soda Butte tributaries of Miller Creek, Sheep Creek (B), and Woody Creek also experienced large flood events. Soda Butte Creek and Sheep Creek, located between Silver Gate and Cooke City, saw dangerously high water levels and severely eroded banks and damaged bridges and roadways, such as Bannock Trail Road, though Cooke City, Montana, and Silver Gate, Montana (Shelly, 2022). Troy Wilson, the fire chief of Cooke City/Silver Gate stated both Miller Creek and Woody Creek, located on either end of Cooke City, were dangerously high and the Woody Creek bridge had been wiped out (Weber, 2022).

Further downstream, Soda Butte Creek severely damaged the Northeast Entrance Road/ Highway 212. Due to the significant and widespread flooding in southwest Montana and northern Wyoming, Cooke City and Silver Gate, Montana, were isolated for over a day until the Chief Joseph Highway (Highway 296) toward Cody, Wyoming, was opened when flood water receded. The other two routes out of town were closed for an extended period of time. The Beartooth Highway toward Red Lodge, Montana, damaged by Rock Creek flooding in Carbon County, opened toward the end of July (Rossi, 2022) while Highway 212/Northeast Entrance Road, damaged by Soda Butte Creek and the Lamar River, did not open until the middle of October, 4 months after the flood (National Park Service, 2023). Photographs of some of the Northeast Entrance Road damage and repair progress can be found the Yellowstone NPS's Flickr here: Improvement Project: Northeast Entrance Road Flood Repairs | Flickr. The Yellowstone NPS Flickr page has an album of the 2022 flood and recovery efforts, which can be found here: Event: 2022 Flood & Recovery Efforts | Flickr.

The closure of the Northeast Entrance to Yellowstone National Park as a result of the destruction of the Northeast Entrance Road drastically impacted Cooke City and Silver Gate, Montana, economically. Both communities are gateway communities to Yellowstone National Park, and the towns and the businesses rely on the tourism industry. The park entrance closure resulted in a 60% decrease in revenue for the summer of 2022, as reported by a hotel manager in Cooke City, Montana, and the hotel manager also stated that for the businesses in these communities, the only time the businesses make money is in the summer time (Sindelar, 2023).

No historical or photographic documentation of the recorded 2010, 2011, or 2020 Soda Butte Creek flooding was found during the flood history investigation. Limited documentation of flooding occurring along Soda Butte Creek in Cooke City and Silver Gate, Montana, in both 1996 and 1997 was found; however, the Soda Butte Creek USGS gage station was not active during the floods. Therefore, a peak flow value is not associated with the flooding. Photographs from the 1997 flood event are shown on Photograph 3-21 through Photograph 3-24.

Photograph 3-21 Soda Butte Creek Flooding 1997 – Grizzly Lodge Silver Gate, MT

Caption: Grizzly Lodge surrounded by June 1997 floodwaters in Silver Gate, Montana. Source: Park County.

Photograph 3-22 Soda Butte Creek Flooding 1997 – Silver Gate, MT

Caption: Silver Gate, Montana, welcome sign surrounded by ponding from the 1997 floodwaters. Source: Park County.

Photograph 3-23 Soda Butte Creek Flooding 1997 – Convenience Store Silver Gate, MT

Caption: Convenience store in Silver Gate, Montana, is surrounded by 1997 floodwaters. Source: Park County.

Photograph 3-24 Soda Butte Creek Flooding 1997 – Cooke City, MT

Caption: Flooding near Colter Pass outside of Cooke City in 1997. Source: Park County.

3.1.2.4 Stillwater River

The Stillwater River originates in the high mountain peaks of the Absaroka Mountains. Within Park County, the Stillwater River basin encompasses 48.6 square miles, but by the time it joins the Yellowstone River in Stillwater County at Columbus, Montana, the watershed basin is over 1,000 square miles. There are no communities along the Stillwater River in Park County.

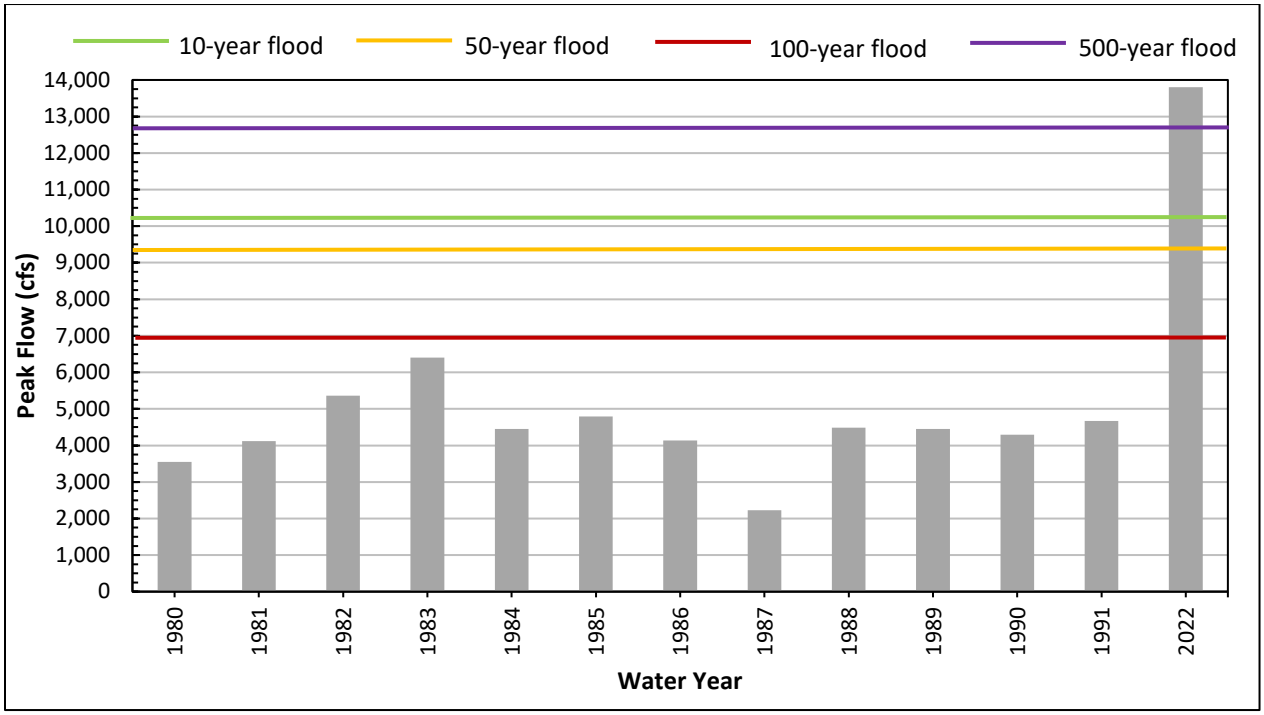
The AEP peak discharges for the Stillwater River and tributaries were not included in the effective FIS report. There are two USGS gage stations on the Stillwater River, but only one gage station is located near the study reach. The gage station located nearest to the study reach was evaluated for flood history.

3.1.2.4.1 Stillwater River USGS Gage Peak Discharge Comparison

The USGS publishes a peak flow for each water year a gage station is in operation. The gage station evaluated for flood history on the Stillwater River was 06202510 Stillwater River above Nye Creek, near Nye, MT and has a period of record of 1980 through 1991 and 2022.

Peak flows were compared to different recurrence intervals at the gage. Figure 3-7 shows measured peak flow data at the gage by year in comparison to the 10-year (10% AC), 50-year (2% AC), 100-year (1% AC), and 500-year (0.2% AC) recommended USGS values (Siefken, et al., 2023).

Figure 3-7 Stillwater River above Nye Creek, near Nye, MT (06202510)



Note: The figure only shows years with measured Stillwater River peak flows at the Stillwater River above Nye Creek near Nye, Montana, gage station. The years shown include 1980 through 1991, and 2022. Years with no peak flow data (1992 through 2021) are not shown.

3.1.2.4.2 Stillwater River Recommended Peak Discharge Comparison to Past Values

The Stillwater River hydrology was not studied as part of the effective FIS. However, the Stillwater River gage station, 06202510, was studied as part of two prior USGS studies. A comparison of these studies and the current 1% AEP peak discharge estimates are shown in Table 3-7.

Table 3-7 Stillwater River USGS Gage Peak Flow Comparison

USGS Station Number	USGS Station Name	Peak Flood Frequency Source	Year of Analysis	1% AEP (100-year) (cfs)
06202510	Stillwater River above Nye Creek, near Nye, MT	WRIR 03-4308	2003	6,820
		SIR 2015-5019-C	2015	6,820
		wymt_ffa_2022Yellowstone	2023	10,200[1]

AEP: Annual Exceedance Probability. cfs: cubic feet per second. FFA: Flood Frequency Analysis. SIR: Scientific Investigations Report. USGS: U.S. Geological Survey. WRIR: Water Resource Investigations Report.
Shaded row represents the current USGS flood frequency analysis and corresponding 1% AEP peak flow value.
1. 1% AEP peak flow estimate was determined using MOVE.3 to extend the period of record and synthesize data for peak flow years where the gage station was inactive.

As shown in Table 3-7, the 1% AEP peak discharge determined in the 2023 USGS flood frequency analysis was higher than the previously determined 1% AEP peak discharges at the Stillwater River gage station. When comparing the current 2023 USGS estimated 1% AEP (Siefken, et al., 2023) to the most recent past study, SIR 2015-5019-C (Sando, et al., 2015a), the current estimate resulted in a 50% increase at the Stillwater River above Nye Creek, near Nye, MT gage. Methodology between the 2015 study and the 2023 study was updated. Therefore, the increase in estimated peak discharge can be attributed to changing methodology, increased period of record, and the large annual peak flows from 2022 and 2020. The 2020 peak discharge value was synthesized using MOVE.3, which is used to extend the gage station's period of record.

3.1.2.4.3 Stillwater River Flood History Documentation

The flood of record occurred on June 13, 2022. In early June 2022, a large rain on snow event in the Absaroka and Beartooth Mountains led to flooding on many of southwest Montana's streams. This flood event exceeded the current 500-year flood event on the Stillwater River. The measured peak flow value of 13,800 cfs was 1,100 cfs over the estimated 0.2% AEP peak discharge of 12,700 cfs at the Stillwater River above Nye Creek, near Nye, MT gage station. The 2022 peak discharge was 216% of the 1983 peak discharge, the previous flood of record. The 2022 peak discharge was 150% of the synthesized flood of record corresponding to the 1967 flood. The synthesized peak flow value was estimated using gage information from the downstream Stillwater near Absarokee, MT gage station.

There was limited to no damage from the Stillwater River flooding in Park County. However, downstream on the Stillwater River in Stillwater County, severe damage was reported and is

shown on Photograph 3-25. No flood photographs of the Stillwater River in Park County were found corresponding to flood events.

Photograph 3-25 Stillwater River Flooding 2022 – Nye Road

Caption: Nye Road at the Sibanye – Stillwater Mine was washed away by the Stillwater River in June 2022.
Sources: Left: Esri Imagery post 2022 flooding. Right: 2015 Google Earth.

3.1.2.5 Ungaged Park County Yellowstone River Tributaries

Many smaller tributaries throughout Park County pose a flood risk to communities and rural or remote areas but are ungaged and do not have measured peak flow values associated with them. The following sections discuss flooding associated with Fleshman and Mill creeks but do not provide a comprehensive flood history of all flooding of streams in Park County; many floods in remote or rural areas are not well documented.

3.1.2.5.1 Fleshman Creek Flood History Documentation

Fleshman Creek, a smaller ungaged tributary to the Yellowstone River, flows through Livingston, Montana. Due to the route of the stream, it has the potential to greatly impact Livingston when flooding. The watershed area of Fleshman Creek encompasses 23.9 square miles.

Significant flooding of Fleshman Creek, in conjunction with an irrigation ditch flooding, occurred in March 2014. The combined flooding was due to rapid snowmelt due to warm weather in the hills north of Livingston, Montana. The flooding led to an evacuation of 70 people from their homes. Crews were required to work through the night pumping water from the irrigation ditch into a nearby field and water from Fleshman Creek into the Yellowstone River. Fleshman Creek overtopped Park Street/Highway 89 through town, and roadways were turned into “small rivers” (Maschmedt, 2014). According to NBC Montana, the flooding prompted a state of

emergency and the most impacted areas from the flooding were South 9th Street to South 12th Street and Park Street down to the Yellowstone River (Staff, 2014).

Previous substantial flooding of Fleshman Creek occurred in June 1937 and June 1950 due to heavy rain in the Bangtails, and in May 1951 due to rapid snow melt. The costs of the floods during their respective years were $80,000, $60,000, and $60,000, (Storey, 2014). Those costs, using the American Institute for Economic Research's cost calculator, would equate to $1.6 million, $730,000, and $675,000 in today's dollars. The 1937 flood was reported in 2018 as the most damaging Fleshman Creek flood on record. The floodwaters, backed up to the railroad tracks, flowed along the railroad corridor, and overtopped the tracks in the business district of Livingston, inundating homes and businesses (RESPEC, 2018). The 1950 and 1951 Fleshman Creek floods inundated similar areas in consecutive years, flooding approximately nine city blocks. Resulting damage to foundations, lawns, streets, and sewage facilities was reported (RESPEC, 2018).

3.1.2.5.2 Mill Creek Flood History Documentation

Mill Creek originates in the Absaroka Mountain Range. Although Mill Creek had an operable USGS gage station from 1951 through 1956, the stream is considered ungaged due to the short period of record. The Mill Creek watershed is a popular area for hunting, fishing, and recreation. The creek flows from the high mountain peaks, down through the Absaroka Mountains foothills, and into the Yellowstone River in the Paradise Valley. The Mill Creek watershed encompasses approximately 171 square miles.

Mill Creek, like many of the streams and rivers in southwest Montana, flooded during June 2022. Near the Mill Creek - Yellowstone River confluence, the Park County Sheriff's Office reported flooding of Burnside [Lane] along Mill Creek the day of the flooding (Park County Sheriff's Office, 2022). In the foothills, Mill Creek overflowed its banks upstream of East River Road, but it was not reported to have overtopped East River Road. Mill Creek at East River Road is shown on Photograph 3-26. Higher in the mountains, the bridge connecting Snowbank Campground in the Absaroka Mountains to Mill Creek Road was washed out, and damage to Mill Creek Road West Fork was reported due to West Fork Mill Creek flooding (Miller & Rosenbaum, 2023). West Fork Mill Creek is a major tributary to Mill Creek.

Photograph 3-26 Mill Creek Flooding 2022 – East River Road

Caption: Mill Creek spills over its banks on June 13, 2022, but does not overtop East River Road. Source: Park County.

3.1.2.5.3 Mulherin Creek Flood History Documentation

Mulherin Creek, a tributary to the Yellowstone River near Corwin Springs, Montana, originates in the Gallatin Mountains on the west side of the Yellowstone River. There are small communities, such as the Church Universal and Triumphant, located along Mulherin Creek. The entire watershed encompasses 52.1 square miles.

Although there was little to no documentation of flooding history along Mulherin Creek found during the flood history investigation. The National Weather Service reported that during the disastrous flooding of southwest Montana in June 2022, Mol Heron Creek Road bridge was closed due to water overtopping the road and a downed tree. The closure made the upper half of the Cinnabar Basin inaccessible (NWS NOAA, 2022).

3.2 Shields River Basin

The Shields River basin, settled between the Crazy Mountains and the Bridger/Bangtail ranges, is a major Yellowstone River tributary. The river generally flows from north to south before its confluence with the Yellowstone River east of Livingston, Montana. The Shields River tributaries typically originate in the Crazy Mountain Range to the east and in the Bridger/Bangtail ranges to the west before entering the Shields River. In total, the Shields River basin encompasses over 850 square miles.

3.2.1 Shields River

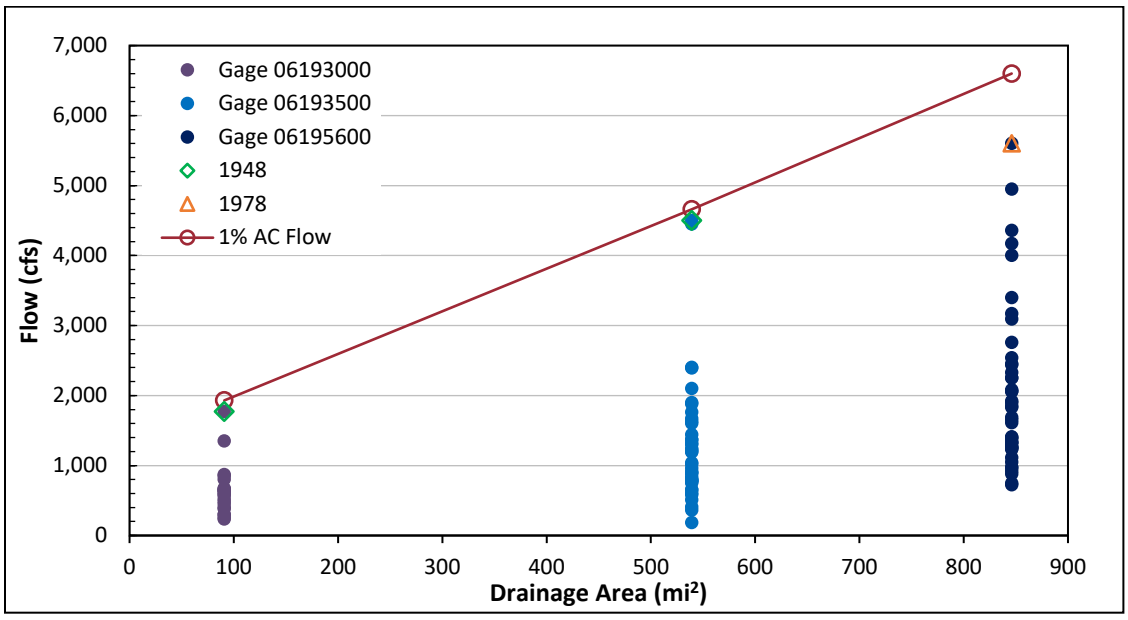
The Shields River originates in the Crazy Mountains in the northeastern portion of Park County. The Shields River study reach extends from the confluence of the Shields River, near Livingston, Montana, north 62.5 miles through the Shields Valley. Drainage basin elevations range from 10,915 feet to 4,383 feet at the Shields River - Yellowstone River confluence.

Four USGS gage stations are located on the Shields River, although only three of the gage stations have a period of record over 10 years. The newest USGS Shields River gage has a period of record of 4 years (through water year 2022) and became active in 2019. The three gages with a period of record of over 10 years were used for flood history; the new gage was not analyzed.

3.2.1.1.1 Shields River USGS Gage Station Peak Discharge Comparison

The USGS publishes a peak flow for each water year a gage station is in operation. The gage stations evaluated for flood history on the Shields River were 06193000 Shields River near Wilsall, MT, 06193500 Shields River at Clyde Park, MT, and 06195600 Shields River near Livingston, MT. The Shields River near Wilsall, MT gage station was active from 1936 through 1957. The Shields River at Clyde Park, MT was active from 1921 through 1923, 1929 through 1932, and 1934 through 1967. The Shields River near Livingston, MT gage has been active since 1979 and does not have an overlapping period of record with the two upstream gages. Figure 3-8 illustrates the measured peak flow history on the Shields River at the gage stations. Select extreme flooding events are highlighted, and the USGS estimated 1% AC peak discharges (Siefken, et al., 2023) are shown in red.

Figure 3-8 Shields River Gage Station Peak Flows



Note: Gage 06195600 Shields River near Livingston, MT was not active during the 1948 peak flow event. Gages 06193000 Shields River near Wilsall, MT and 06193500 Shields River at Clyde Park, MT were not active during the 1979 peak flow event.

Peak flows were compared to different recurrence intervals at the gage. Figure 3-9 through Figure 3-11 show measured peak flow data at the gage by year in comparison to the 10-year (10% AC), 50-year (2% AC), and 100-year (1% AC) recommended USGS values (Siefken, et al., 2023).

Figure 3-9 Shields River near Wilsall, MT (06193000)

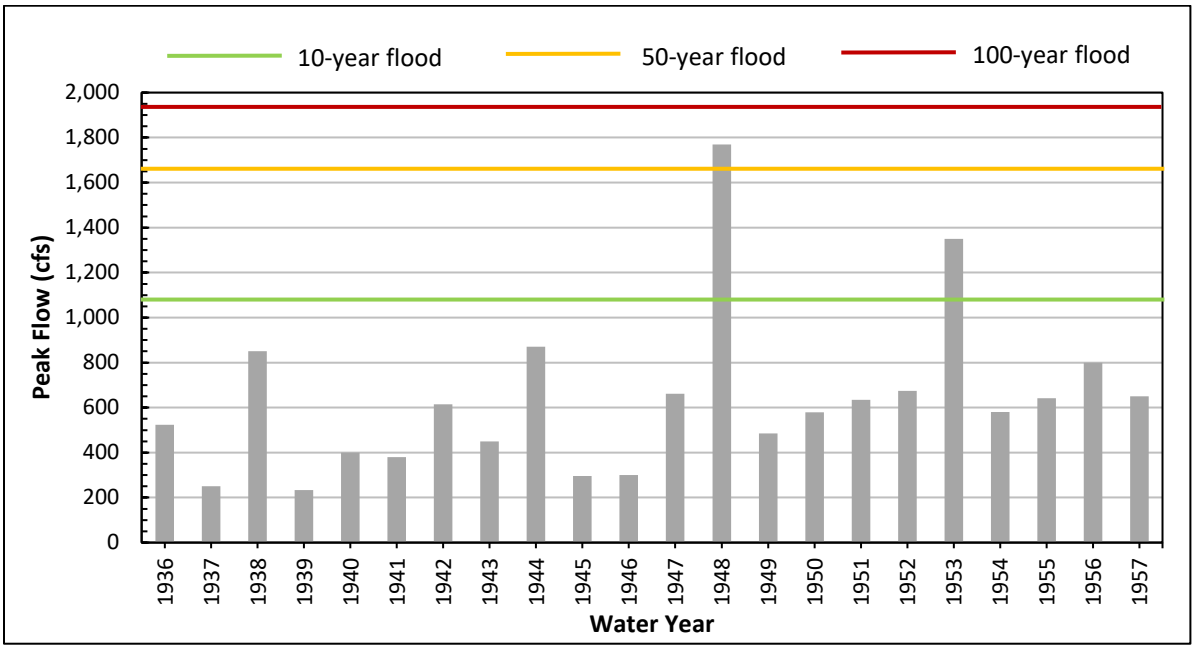
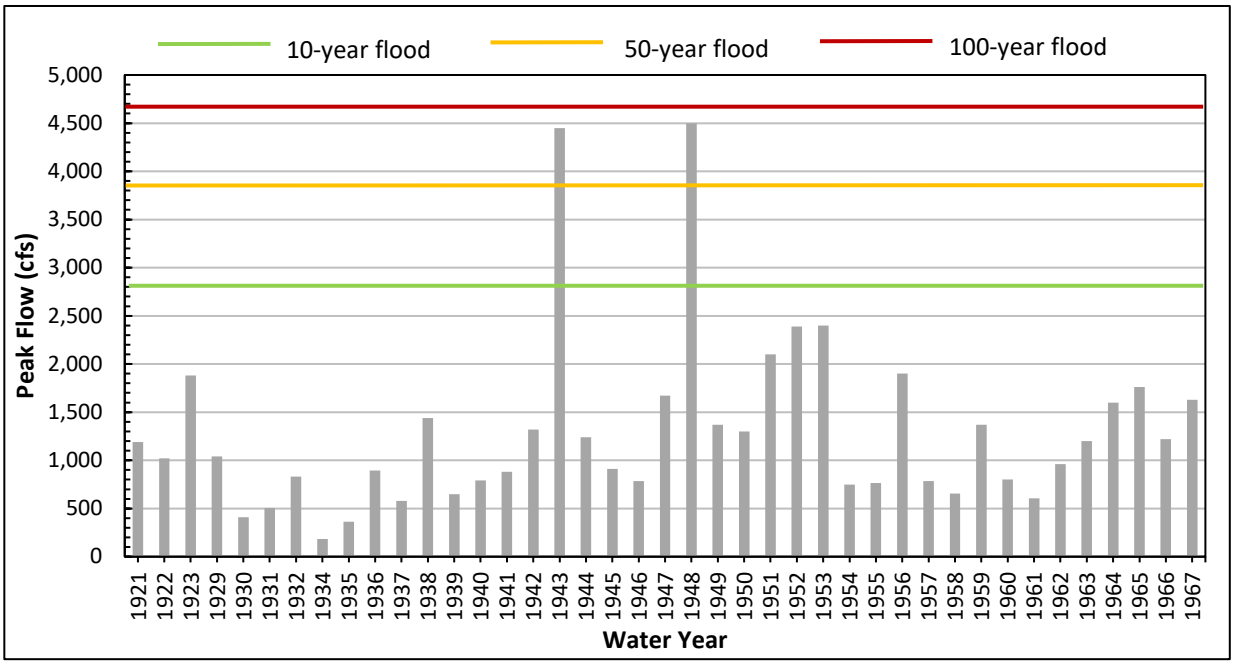
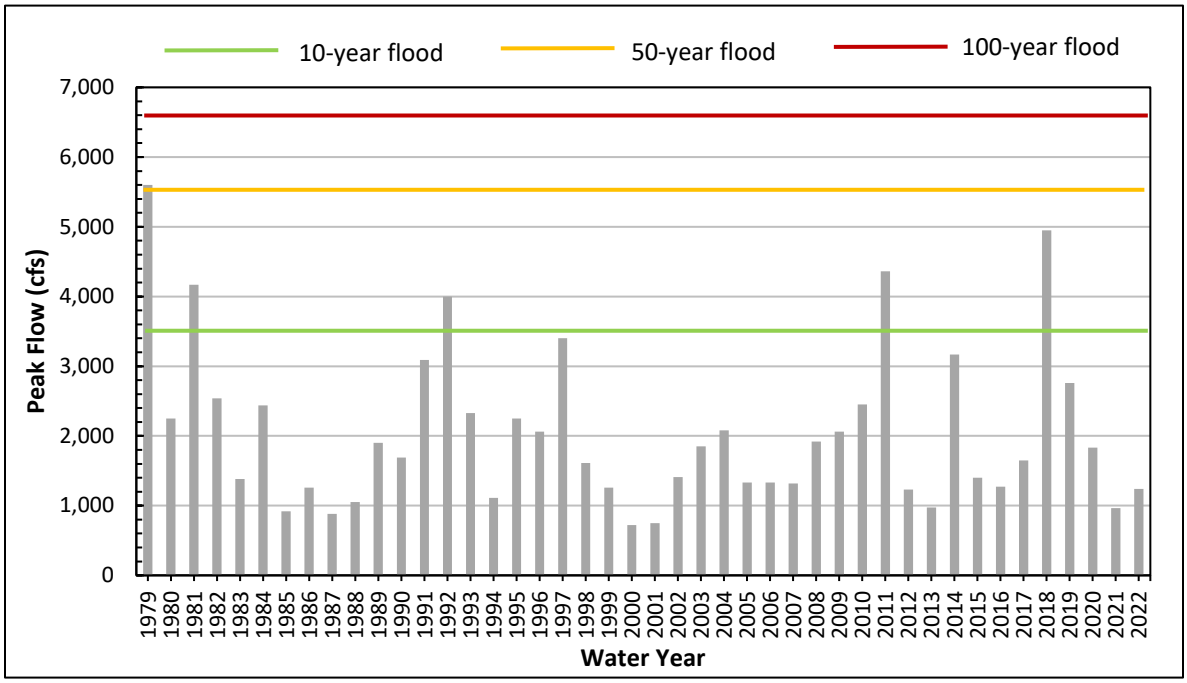


Figure 3-10 Shields River at Clyde Park, MT (06193500)



Note: The figure only shows years with measured Shields River peak flows at the Shields River at Clyde Park, MT gage station. The years shown included 1921 through 1923, 1929 through 1932, and 1934 through 1967. Years with no peak flow data (1924 through 1928 and 1933) are not shown.

Figure 3-11 Shields River near Livingston, MT (06195600)



3.2.1.1.2 Shields River Recommended Peak Discharge Comparison to Past Values

The Shields River hydrology was not studied as part of the effective FIS. However, the Shields River gage stations were studied as part of prior USGS studies. A comparison of these studies and the current 1% AEP peak discharge estimates are shown in Table 3-8.

Table 3-8 Shields River USGS Gage Peak Flow Comparison

USGS Station Number	USGS Station Name	Peak Flood Frequency Source	Year of Analysis	1% AEP (100-year) (cfs)
06193000	Shields River near Wilsall, MT	WRIR 92-4048	1992	2,060
		WRIR 03-4308	2003	1,960
		SIR 2015-5019-C	2015	1,960
		wymt_ffa_2022Yellowstone	2023	1,930
06193500	Shields River at Clyde Park, MT	WRIR 92-4048	1992	4,810
		WRIR 03-4308	2003	4,730
		SIR 2015-5019-C	2015	4,750
		wymt_ffa_2022Yellowstone	2023	4,660
06195600	Shields River near Livingston, MT	WRIR 03-4308	2003	7,140
		SIR 2015-5019-C	2015	6,470
		wymt_ffa_2022Yellowstone	2023	6,600

AEP: Annual Exceedance Probability. cfs: cubic feet per second. FFA: Flood Frequency Analysis. SIR: Scientific Investigations Report. USGS: U.S. Geological Survey. WRIR: Water Resources Investigation Report. WYMT: Wyoming Montana.
Shaded row represents the current USGS flood frequency analysis and corresponding 1% AEP peak flow value.

As shown in Table 3-8, the 1% AEP peak discharges determined for each gage station in the 2023 USGS flood frequency analysis were similar to previously determined 1% AEP peak discharges. When comparing the current 2023 USGS estimated 1% AEP (Siefken, et al., 2023) to the most recent past study, SIR 2015-5019-C (Sando, et al., 2015a), the current estimates resulted in a 2% decrease at the Shields River near Wilsall, MT and the Shields River at Clyde Park, MT gages, and a 2% increase at the Shields River near Livingston, MT gage. Between the 2015 and 2023 USGS studies, methodology was updated. The changes in estimated peak discharges for the Shields River near Wilsall and at Clyde Park gages can be attributed to changing methodology; the period of record at these gages did not change as both gages were inactive prior to the USGS studies. The slight increase seen at the Shields River near Livingston, MT gage can be attributed to the updated methodology, increased period of record, and the large annual peak flow value from 2018. Although the Shields River near Livingston, MT gage is active, the 2023 flood event was not measured due to gage malfunction; additionally, the 2023 USGS study (Siefken, et al., 2023) only included flow values through water year 2022.

3.2.1.1.3 Shields River Creek Flood History Documentation

The Shields River has impacted Park County residents multiple times, most recently in April 2023. Other peak floods, according to the USGS gage stations, occurred in 1943, 1948, 1979, 1992, 2011, and 2018. The Shields River did not see above average flows for 2022, a year much of southwestern Montana experienced record flooding. This was perhaps due to near drought conditions for the Shields River watershed and flows at 60% of normal in May of 2022 (Wright, 2022). Additional localized flooding has occurred on the Shields River due to ice jams.

The 2023 flooding of the Shields River and its tributaries overtopped roads, inundated and damaged homes, bridges, and agricultural lands as a result of low elevation rapid snow melt. The Park County Public Works Director, Matt Whitman, estimated the cost of damages near $240,000 (Batura, 2023). Although extreme flooding occurred in the Shields River Valley in 2023, the only active USGS gage, the Shields River near Livingston, MT gage station on the Shields River was damaged or malfunctioned, and discharge at the time of the flooding was not able to be measured. However, according to the Park County, Montana, Facebook page, the Shields River peaked at 6.02 feet on April 12, 2023 (Park County, 2023a) and the USGS has a provisional estimated daily mean average of 3,830 cfs at the Shields River near Livingston gage station listed for April 12, 2023. When comparing the peak height of 6.02 feet and the estimated daily average mean of 3,830 cfs, the 2023 flood peak discharge was likely around 4,000 cfs. An estimated peak discharge of 4,000 cfs would put the 2023 Shields River flooding event between a 10-year and a 25-year event, below the flood of record, which was recorded in 1979 and had a peak gage height of 6.8 feet and peak discharge of 5,600 cfs. Three aerial photographs from the 2023 Shields River flood are shown on Photograph 3-27 through Photograph 3-29.

Photograph 3-27 Shields River Flood 2023 – Fiddle Creek Road

Caption: Shields River overtops Fiddle Creek Road in 2023 and inundated structures. Source: Lawson Moorman, Park County.

Photograph 3-28 Shields River Flood 2023 – 618 US Highway 89 North Livingston, MT

Caption: Shields River 2023 flooding inundates structures and agricultural land. Source: Lawson Moorman, Park County.

Photograph 3-29 Shields River Flood 2023 – 548 US Highway 89 North Livingston, MT

Caption: Shields River 2023 flooding inundates land and structures. Source: Lawson Moorman, Park County.

The 1943 flood occurred on March 30, 1943, and was the result of rapid snowmelt of a larger than average snowpack. The peak discharge was between a 50-year and 100-year event at the Shields River at Clyde Park gage station when compared to current AEP peak discharge estimates. The flood was not recorded as a significant flood event in the upper portion of the Shields Valley (above Wilsall, Montana); the recorded peak flow at the Shields River near Wilsall,

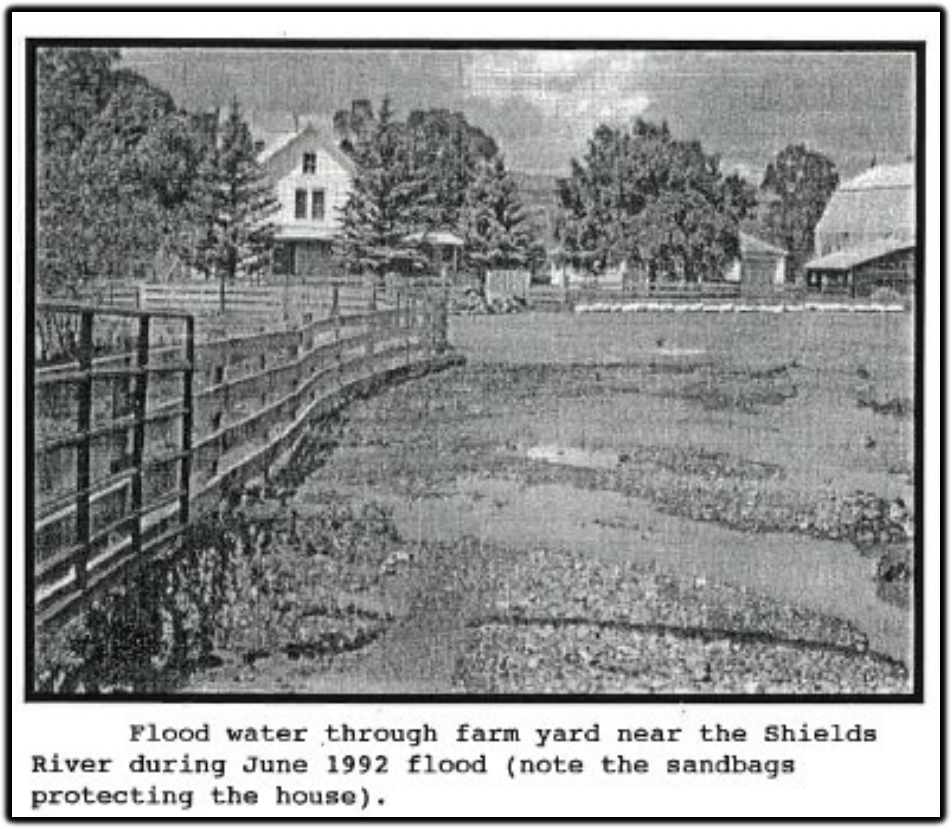
MT gage station was considered less than a 10-year event. The 1994 Shields River Floodplain Management Study (USDA SCS, 1994) reported livestock was lost and several families were evacuated.

The 1948 flood occurred on June 5, 1948, and was the result of heavy rains. The rains led to flooding on other streams in the region as well. Damages included farm equipment and vehicles that were swept into the stream (USDA SCS, 1994). The peak discharge was between a 50-year and 100-year event at the Shields River near Wilsall, MT and Shields River at Clyde Park, MT gage stations when compared to current AEP peak discharge estimates.

The 1979 flood is the largest recorded flood at the Shields River near Livingston, MT gage station and surpassed the current estimated 50-year peak discharge. The flood was the result of over 4 inches of rain falling in a short period of time. The flood reportedly closed seven bridges and flooded fields along the Shields River (USDA SCS, 1994).

The 1992 flood surpassed the current 10-year peak discharge. It was only recorded at the active Shields River near Livingston, MT gage station. Photographic documentation of the 1992 flood is shown on Photograph 3-30 through Photograph 3-33.

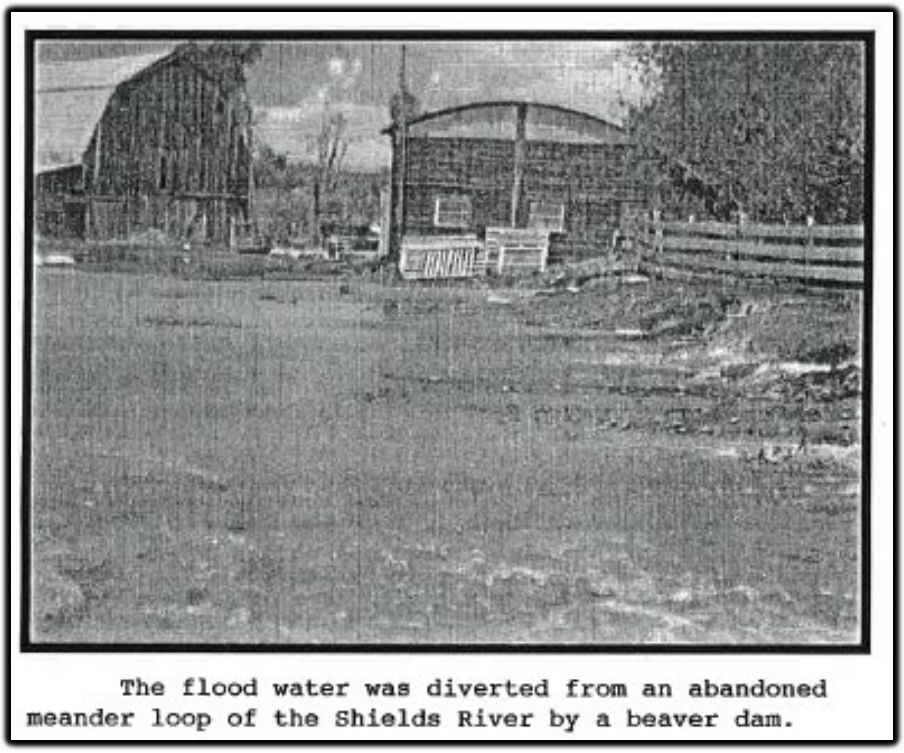
Photograph 3-30 Shields River Flooding 1992 – Ponding near Residence



Flood water through farm yard near the Shields River during June 1992 flood (note the sandbags protecting the house).

Source: (USDA SCS, 1994)

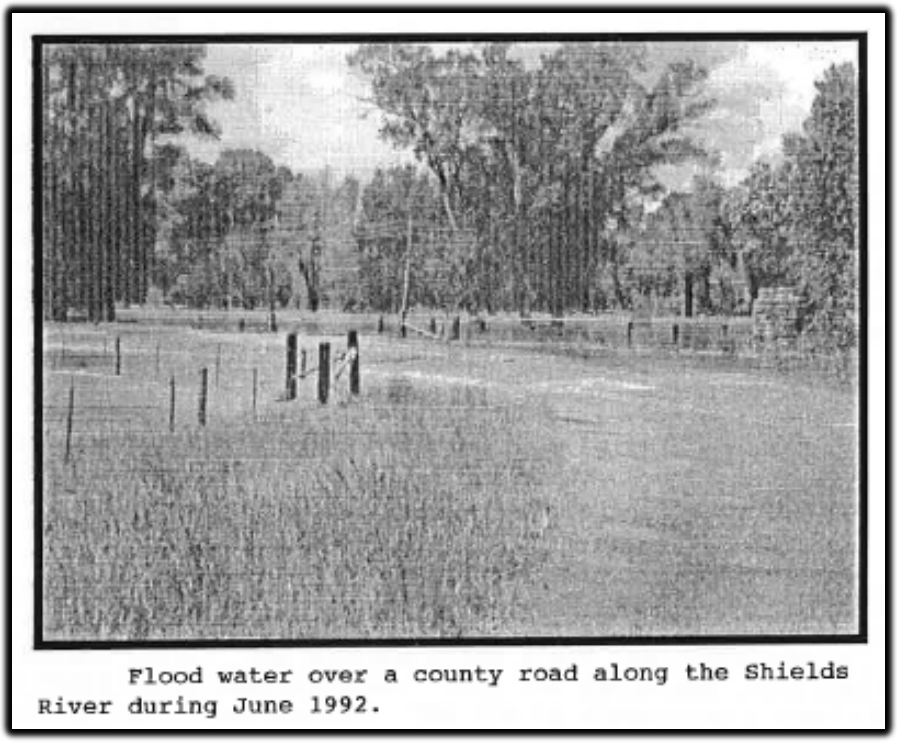
Photograph 3-31 Shields River Flooding 1992 – Ponding near Structures



The flood water was diverted from an abandoned meander loop of the Shields River by a beaver dam.

Source: (USDA SCS, 1994)

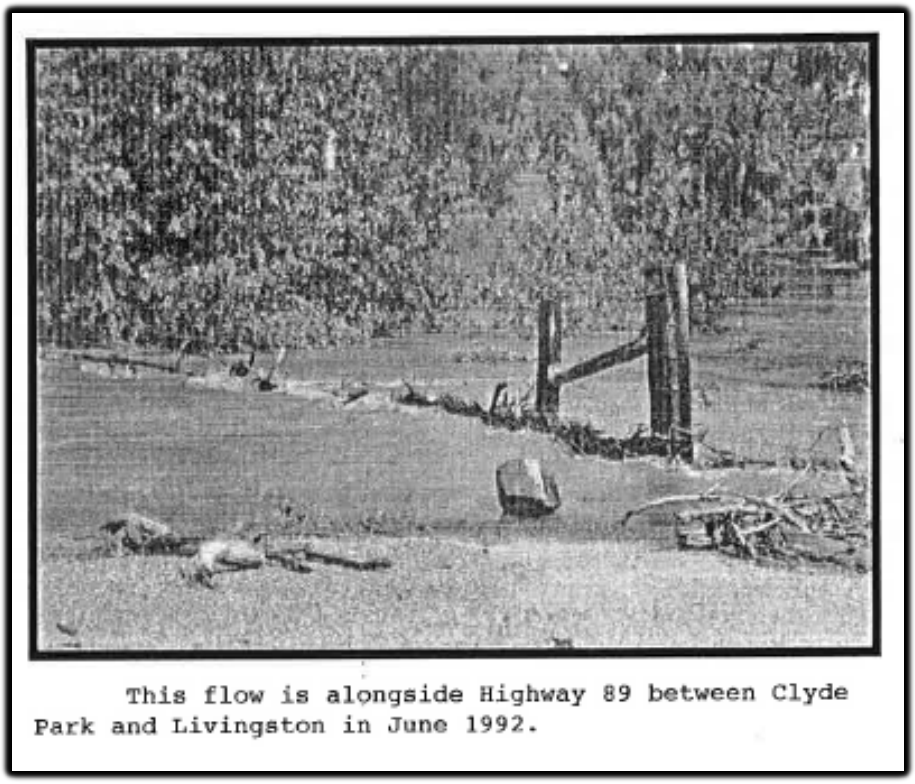
Photograph 3-32 Shields River Flooding 1992 – Road Inundation



Flood water over a county road along the Shields River during June 1992.

Source: (USDA SCS, 1994)

Photograph 3-33 Shields River Flooding 1992 – Field Inundation



This flow is alongside Highway 89 between Clyde Park and Livingston in June 1992.

Source: (USDA SCS, 1994)

The peak discharge in 2018 was 4,950 cfs and the peak discharge in 2011 was 4,360 cfs at the Shields River near Livingston, MT gage station. Comparing both of those to current AEP peak discharge values, the 2018 event was between a 25-year and 50-year event, and the 2011 event was approximately a 25-year event. Across the three Shields River gage stations, both active and inactive gages, the 100-year (1% AEP) discharges have not been exceeded. A video showing the extent of the 2018 flooding along Highway 89 through the Shields Valley can be found here: Flooding Along Highway 89 (youtube.com).

Additional Park County Shields River flooding photographs are provided in a geodatabase included in Appendix B.

Although the peak discharge was not significant compared to other years, the 2019 peak flow event on the Shields River washed out a temporary bridge installed over the Shields River on Convict Grade Road. The destruction of this bridge led to a 26-mile detour for residents east of Livingston, Montana (Just, 2019). The USGS recorded peak flow at the Shields River near Livingston, MT gage station was 2,760 cfs.

Additional flooding in the Shields Valley has occurred during the winter months due to ice jams. One reported ice jam flooded the Grannis School in 1996 (CRREL, 2007).

3.2.2 Shields River Tributaries

The tributaries of the Shields River throughout Shields Valley have seen significant flooding. Many of the tributaries are in rural areas of Park County but also near the communities of Clyde Park and Wilsall, Montana. Tributary flooding tributaries typically occurs while the Shields River is flooding and has significantly impacted residents of the Shields Valley. The Shields River tributaries typically originate in the Crazy Mountain Range to the east and in the Bridger/Bangtail ranges to the west before entering the Shields River. One Shields River tributary, Brackett Creek, is a gaged stream. Tributaries with significant flood history are discussed in the following sections.

As part of the Upper Yellowstone Hydrologic Analysis Park County study, 61 Shields River tributaries were analyzed. The flood history for each tributary was investigated. Table 3-9 lists the Shields River tributaries where flood history documentation was found and the corresponding level of analysis for the Park County hydrologic analysis study. These tributaries are discussed in the following sections. The complete list of reaches investigated is included in Appendix C.

Table 3-9 Shields River Tributaries Flood History Reach Summary

Stream Name	Analysis Approach	Total Length (miles)
Brackett Creek	Enhanced Zone AE	14.3
Cottonwood Creek B	Enhanced Zone AE	3.3
Flathead Creek	Enhanced Zone AE, Enhanced Zone AE with Floodway	16.2
Horse Creek B	Enhanced Zone AE	16.1
Looking Glass Creek	Enhanced Zone AE	2.8
Potter Creek	Enhanced Zone AE, BLE Zone A	27.1

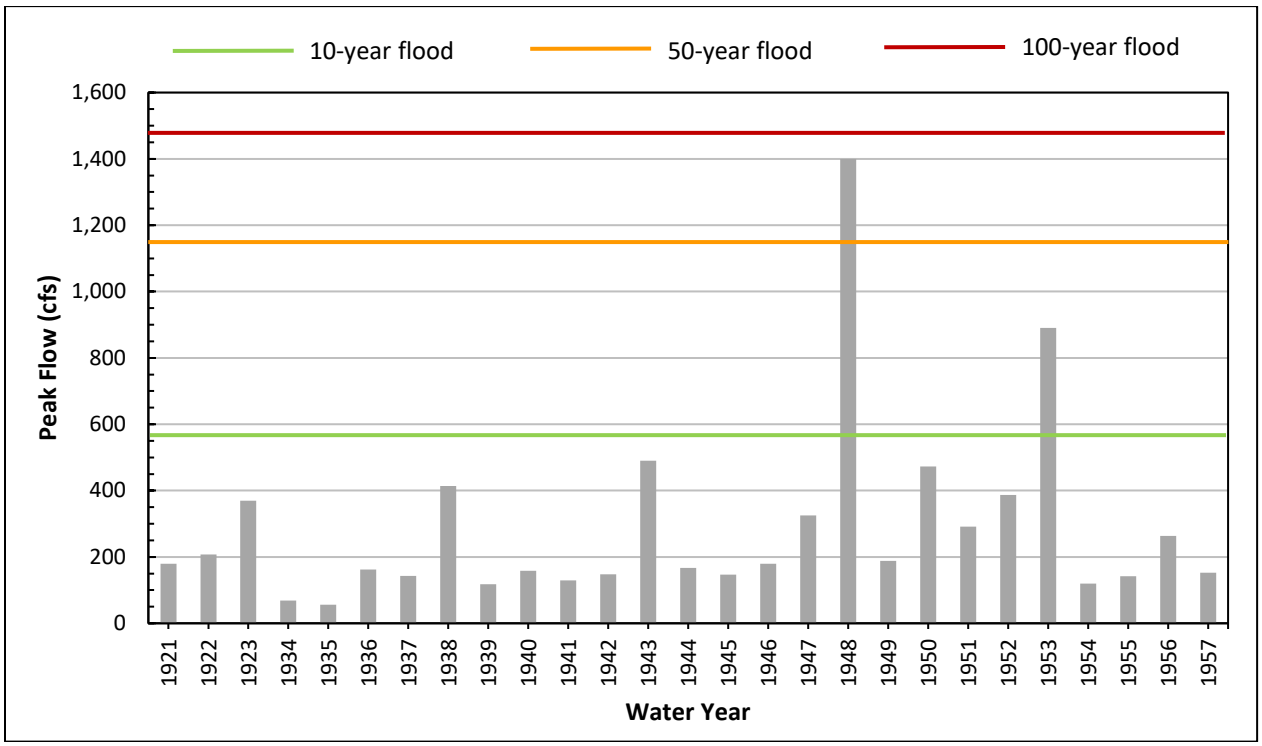
3.2.2.1 Brackett Creek

Brackett Creek originates in the Bridger Mountains near the Park – Gallatin County border. The confluence of Brackett Creek and the Shields River occurs downstream of Clyde Park, Montana. The watershed encompasses 65.5 square miles. Upstream of the Brackett Creek - Shields River confluence, one inactive USGS gage station is located on Brackett Creek.

3.2.2.1.1 Brackett Creek USGS Gage Station Peak Discharge Comparison

The USGS publishes a peak flow for each water year a gage station is in operation. The gage station evaluated for flood history on Brackett Creek was 06194000 Brackett Creek near Clyde Park, MT. The Bracket Creek gage station was active from 1921 through 1923 and 1934 through 1957. Peak flows were compared to different recurrence intervals at the gage. Figure 3-12 shows measured peak flow data at the gage by year in comparison to the 10-year (10% AC), 50-year (2% AC), and 100-year (1% AC) recommended USGS values (Siefken, et al., 2023).

Figure 3-12 Brackett Creek near Clyde Park, MT (06194000)



Note: The figure only shows years with measured Shields River peak flows at the Shields River at Clyde Park, MT gage station. The years shown include 1921 through 1923 and 1934 through 1957. Years with no peak flow data (1924 through 1933) are not shown.

3.2.2.1.2 Brackett Creek Recommended Peak Discharge Comparison to Past Values

Brackett Creek hydrology was not studied as part of the effective FIS. However, the Brackett Creek gage station, 06194000, was studied as part of three prior USGS studies. A comparison of these studies and the current 1% AEP peak discharge estimates are shown in Table 3-10.

Table 3-10 Brackett Creek USGS Gage Peak Flow Comparison

USGS Station Number	USGS Station Name	Peak Flood Frequency Source	Year of Analysis	1% AEP (100-year) (cfs)
06194000	Brackett Creek near Clyde Park, MT	WRIR 92-4048	1992	1,440
		WRIR 03-4308	2003	1,480
		SIR 2015-5019-C	2015	1,480
		wymt_ffa_2022Yellowstone	2023	1,470

AEP: Annual Exceedance Probability. cfs: cubic feet per second. FFA: Flood Frequency Analysis. SIR: Scientific Investigations Report. USGS: U.S. Geological Survey. WRIR: Water Resource Investigations Report. WYMT: Wyoming Montana.
Shaded row represents the current USGS flood frequency analysis and corresponding 1% AEP peak flow value.

As shown in Table 3-10, the 1% AEP peak discharge determined in the 2023 USGS flood frequency analysis was similar to the previously determined 1% AEP peak discharge at the Brackett Creek gage station. When comparing the current 2023 USGS estimated 1% AEP (Siefken, et al., 2023) to the most recent past study, SIR 2015-5019-C (Sando, et al., 2015), the current estimate resulted in a 1% decrease at the Brackett Creek near Clyde Park, MT gage. Between the 2015 and the 2023 studies, methodology was updated. Therefore, the slight decrease in estimated peak discharge can be attributed to the change in methodology. The period of record at the gage did not change between the studies as the gage has been inactive since 1957.

3.2.2.1.3 Brackett Creek Flood History Documentation

The flood of record occurred in 1948 on Brackett Creek, however the Brackett Creek gage station only has a 27-year period of record spanning years from 1921 through 1957. The flood, using current AEP peak discharges, fell between a 50-year and a 100-year event. An additional significant flood event occurred in 1953; the peak discharge exceeded a 25-year event.

Agricultural land as well as multiple residences and structures are in and near the Brackett Creek floodplain, however there is limited documentation of previous flooding on Brackett Creek.

3.2.2.2 Ungaged Park County Shields River Tributaries

Many smaller tributaries throughout Park County in the Shields Valley pose a flood risk to communities and rural or remote areas but are ungaged and do not have peak flow values associated with them. The following sections discuss flooding associated with Cottonwood Creek (B), Flathead Creek, and Looking Glass Creek but do not provide a comprehensive flood history of all flooding of streams in the Shields Valley; many floods in remote or rural areas are not well documented.

3.2.2.2.1 Cottonwood Creek B Flood History Documentation

Two Shields River tributaries are named Cottonwood Creek. Cottonwood Creek A originates in the Crazy Mountains and flows through Clyde Park, Montana. Cottonwood Creek B is a tributary to Potter Creek, which in turn, flows into Flathead Creek. It originates in the Bridger Mountains on the west side of the Shields River. Cottonwood Reservoir is situated along Cottonwood Creek B upstream of its confluence with Potter Creek. Although flooding can occur on both streams, documentation of flooding was only found for Cottonwood Creek B.

In April 2023, when much of the Shields River Valley was inundated with floodwaters, there were unconfirmed reports that Cottonwood Dam on Cottonwood Creek B was overtopped with floodwaters. There is a spillway on Cottonwood Dam that has been used in the past when the reservoir is at or above capacity; the most recent confirmed usage occurred in 2018 (IntoTheLittleBelts, 2018). Flood footage from the 2018 flooding on Cottonwood Creek B and other streams in the Shields Valley along Highway 89 is linked here: Flooding Along Highway 89

- YouTube. Photograph 3-34 shows the inundation of Cottonwood Creek B near the Wilsall Airport upstream of Cottonwood Dam.

**Photograph 3-34 Cottonwood Creek B Flooding 2023 –
West of Wilsall Airport along US Highway 89**

Caption: Cottonwood Creek B floods in April 2023 along US Highway 89 near the Wilsall Airport. The upper portion of Cottonwood Reservoir is shown in the bottom left of photograph. Source: Lawson Moorman, Park County/ DNRC.

3.2.2.2.2 Flathead Creek Flood History Documentation

Flathead Creek and most of its tributaries originate in the Bridger Mountains near the Park - Gallatin County border. The Flathead Creek - Shields River confluence occurs upstream of Wilsall, Montana, near the intersection of Highway 89 North and Flathead Creek Road. Flathead Creek at the Shields River confluence has an ungaged basin of nearly 220 square miles.

In April of 2023, Flathead Creek flooded along with other Shields River tributaries. Flathead Creek floodwaters scoured behind the Shields River Road bridge crossing over Flathead Creek and forced the closure of the road. Vehicles were asked to detour using Potter Creek Road to access part of the upper Shields River Valley (Park County, 2023b). A photo showing the damage and repairs to the Shields River Road bridge over Flathead Creek can be found here: Shields River Road bridge repaired, opened after flooding | News | livingstonenterprise.com.

Additional photographs that exemplify the severity of the Flathead Creek flooding are shown on Photograph 3-34 and Photograph 3-35.

Photograph 3-35 Flathead Creek Flooding 2023 – North of Horse Creek Road

Caption: Flood waters from Flathead Creek in April 2023 inundate farmland and structures north of Horse Creek Road. Source: Lawson Moorman, Park County/ DNRC.

Photograph 3-36 Flathead Creek Flooding 2023 – Unnamed Road

Caption: An unnamed road off Flathead Creek Road is overtopped and the culvert is at capacity during the April 2023 flooding. Source: Lawson Moorman, Park County/ DNRC.

3.2.2.2.3 Horse Creek B Flood History Documentation

Horse Creek B originates in the Crazy Mountain range east of the Shields River. Downstream of Wilsall, Montana, Horse Creek B flows into the Shields River. The creek mainly flows through agriculture land in a predominantly rural area and does not have many residences and structures along its banks.

Although there is limited documented flooding history on Horse Creek B, there is photographic documentation of Horse Creek B flooding in April 2023 when the Shields River Valley saw rapid snowmelt in the valley. Two photographs, Photograph 3-37 and Photograph 3-38, are shown below.

Photograph 3-37 Horse Creek B Flooding 2023 – Indian Creek Road

Caption: Rapid snowmelt in the Horse Creek B drainage resulted in high water in April 2023.
Source: Lawson Moorman, Park County/ DNRC.

Photograph 3-38 Horse Creek B Flooding 2023 – Horse Creek Road

Caption: Rapid snowmelt in the Horse Creek B drainage resulted in high water in April 2023 and in some locations the water overflowed the Horse Creek B banks. Source: Lawson Moorman, Park County/ DNRC.

3.2.2.2.4 Looking Glass Creek Flood History Documentation

Looking Glass Creek originates in the Bridger Mountain Range on the west side of the Shields River. Two back-to-back reservoirs are situated along Looking Glass Creek and are dammed by the O'Halloran Dams; O'Halloran Dam is downstream, and O'Halloran Dam #1 is upstream.

There is limited flood history documentation of flooding on Looking Glass Creek and O'Halloran dams. However, the DNRC provided photographs from the early 1990s where Looking Glass Creek near the O'Halloran dams was out of banks. These photographs, where the exact location is unknown, are provided on Photograph 3-39 through Photograph 3-41.

Photograph 3-39 Looking Glass Creek Flooding in Early 1990s – Near O'Halloran Road

Caption: Water ponds on Looking Glass Creek near O'Halloran Road. Source: Park County.

Photograph 3-40 Looking Glass Creek Flooding Early 1990s – Ponding

Caption: Looking Glass Creek overflows its banks. Source: Park County.

Photograph 3-41 Looking Glass Creek Flooding Early 1990s – Creek Swelling

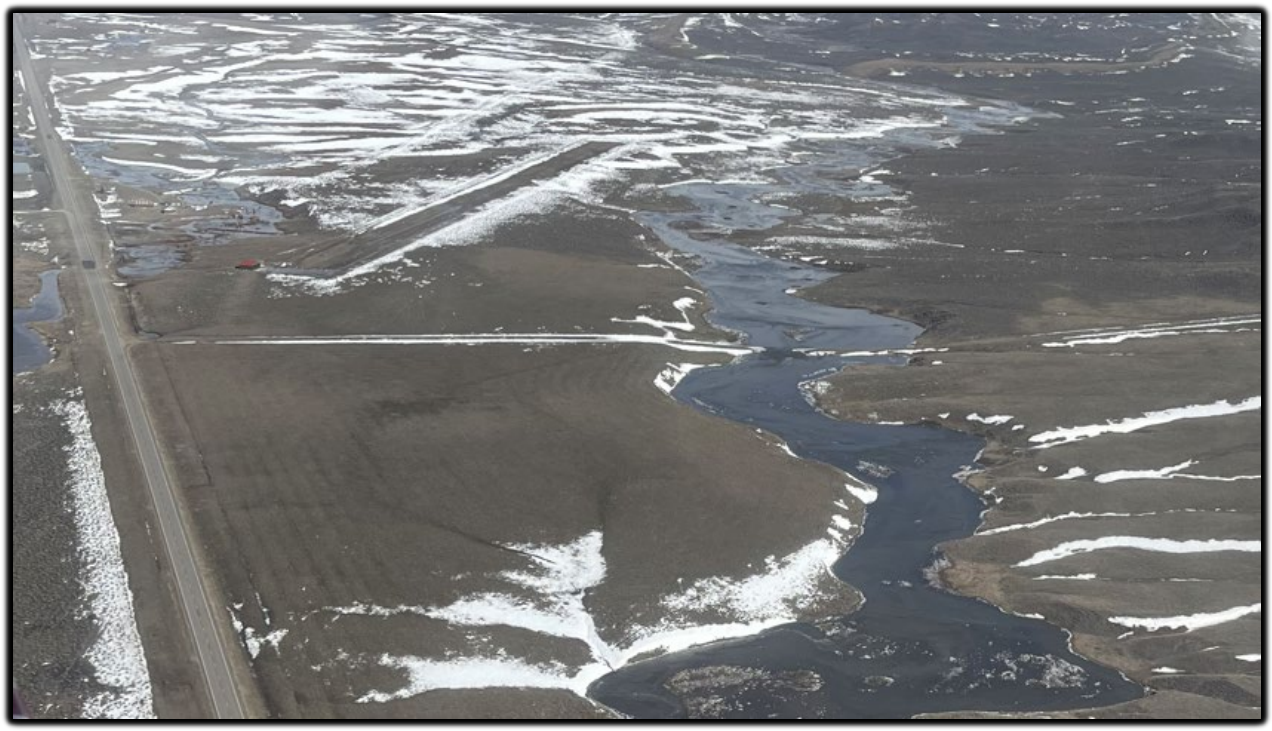
Caption: Looking Glass Creek overflows its banks. Source: Park County.

3.2.2.2.5 Potter Creek Flood History Documentation

Potter Creek originates in Meagher County on the west side of the Shields River. The creek mainly flows through agricultural land in Park County before its confluence with Flathead Creek near Wilsall, Montana.

There is limited flood history documentation of flooding on Potter Creek however, in April 2023, when much of the Shields River Valley was inundated with floodwaters, Potter Creek also flooded. The flooding was due to rapid snowmelt in the Shields Valley. Photograph 3-42 shows Potter Creek overflowing its banks near the Wilsall, Montana Airport.

Photograph 3-42 Potter Creek Flooding 2023



Caption: In April 2023, flooding of Potter Creek overtopped and unnamed road near the Wilsall Airport. On the left side of the photograph flooding of Cottonwood Creek B is also shown. Source: Lawson Moorman, Park County/ DNRC.

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Appendix A
Letter of Map Amendment Table

Appendix B
Additional Park County Flood Photographs

Appendix C
Park County Study Reaches