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Mineral County Modernization Project, Phase II
Clark Fork River Tributaries Study Area
Hydrologic Analysis Report

Montana DNRC

March 1, 2018

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Mineral County Modernization Project Phase II

Clark Fork River Tributaries Study Area Hydrologic Analysis Report

Prepared for:

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Clark Fork River Tributaries Study Area

Hydrologic Analysis Report

March 1, 2018

I hereby certify that all work products (maps, reports, etc.) prepared for this project were done so under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Montana.

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EXECUTIVE SUMMARY

Flood flow frequency calculations were conducted for tributaries along the mainstem Clark Fork River. The study reach extends from the Missoula County/Mineral County border downstream to the Mineral County/Sanders County border. Information gathered from this analysis will be used for future floodplain studies and mapping projects.

The hydrology of the basin is primarily snowmelt driven, although significant flows can result from precipitation events. Land use in the Clark Fork River basin is primarily agricultural with irrigated farming and ranching operations.

The Clark Fork River tributaries contribute streamflow to the Clark Fork River located west of the continental divide in western Montana. The study watershed basin area is approximately 1,217 square miles and is located in the Middle Clark Fork watershed (HUC-8 area). Clark Fork River tributaries' basin elevations within the study area range from approximately 7,800 feet in the headwaters of Trout Creek to approximately 2,600 feet at the confluence of Tamarack Creek and the Clark Fork River. The watershed terrain varies from a high alpine environment in its headwaters to narrow inter-mountain valleys.

The primary cause of flooding on the Clark Fork River tributaries is spring snowmelt. Ice jams and precipitation events can also contribute to flooding. There are historical records from several discontinued U.S. Geological Survey (USGS) stream gages on the tributaries that date back to 1959 documenting basin flood history. Past flood studies for the Clark Fork River tributaries are limited. Within the tributaries, there are no Federal Emergency Management Agency (FEMA) Flood Insurance Studies. The USGS Report *Peak Flow Analysis and Results based on Data through Water Year 2011 for Selected Stream Flow Gaging Stations in or near Montana*, (Sando et al., 2015a) was an important study, which included flood frequency analyses for the Clark Fork River tributaries.

Flood flow frequency analysis was conducted to develop peak flow discharge estimates for the 50-, 10-, 4-, 2-, 1-, and 0.2-percent annual chance events. The 1%+ (plus) annual chance event was also calculated. Peak flow estimates were calculated at 13 locations (flow nodes) within the 7 Clark Fork River tributaries (1 gaged site and 12 ungaged sites). Estimates at the Dry Creek near Superior, Montana gaged site were conducted using Bulletin #17C methodologies (USGS, 2016). Peak flow estimates at the 13 flow nodes were calculated using the Regional Regression Equation method. This method conforms to standard engineering practice.

Comparison of the regional regression peak flow estimates with the USGS stream gage on Negro Gulch near Alberton, Montana (23-years of record), and Thompson Creek near Superior, Montana (20-years of record), indicate good agreement with the gage based flood frequency analysis. Comparison of the regional regression peak flow estimates with the Dry Creek near Superior, Montana gage produced a poor comparison, with the regional regression 1% AEP estimate being over 6 standard errors greater than the gage Bulletin 17C estimate.

Due to the Dry Creek near Superior gage short period of record (10-years) it was determined regional regression equations provided more accurate peak flow estimates.

The hydrologic analysis documented in this report conforms to FEMA standards for detailed/enhanced level studies, and the recommended flows of this analysis are deemed reliable and suitable for future floodplain studies and hydraulic analyses.

1 INTRODUCTION

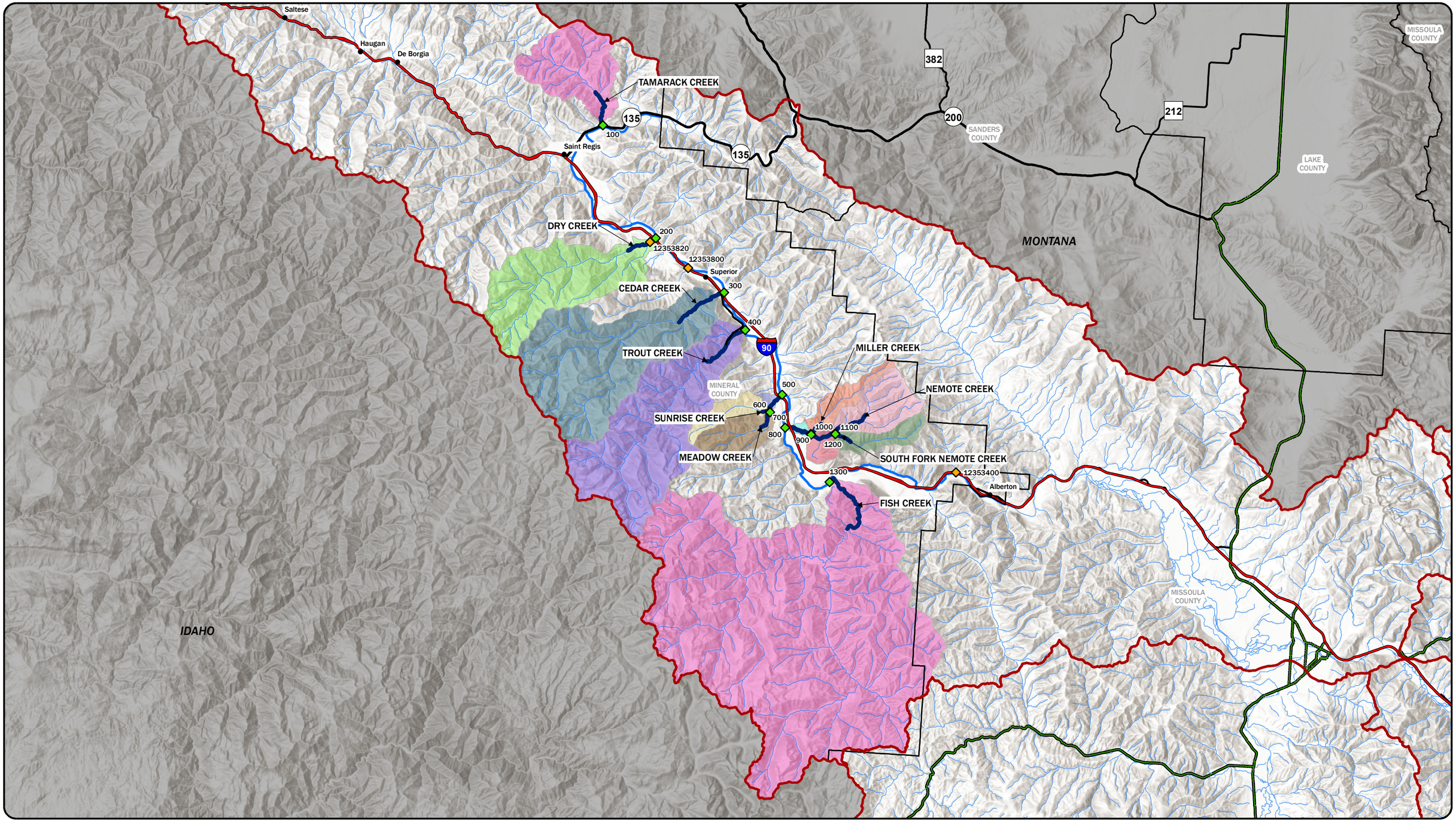
As part of the Mineral County Modernization Phase II Clark Fork River Study activities, the Montana Department of Natural Resources and Conservation (DNRC) contracted Pioneer Technical Services, Inc. (Pioneer) to complete a comprehensive peak flow hydrologic analysis for seven Clark Fork River tributaries in the study reach. Pioneer completed flood flow frequency calculations for seven tributaries that report to the mainstem Clark Fork. The Clark Fork River tributary study reach extends from the Clark Fork river intersection with the Sanders/Mineral County line northwest of St. Regis upstream to the river intersection with the Missoula/Mineral County line east of Alberton. The study area encompasses approximately 1,217 square miles. The study area hydrologic analysis reports for the Clark Fork River (Pioneer, 2017a) and the St. Regis River (Pioneer, 2017b) detailed the hydrologic analyses that were previously completed on each mainstem. Information gathered from this analysis will be used in conjunction with the mainstem Clark Fork River Hydrologic Analysis for both enhanced analysis and base level hydraulic analyses and floodplain mapping. Figure 1 shows the project study reach.

1.1 Background Information

FEMA administers the National Flood Insurance Program (NFIP). As part of this program, FEMA supports flood hazard studies and prepares flood hazard maps and related documents. The Clark Fork River tributaries in the Mineral County study area are sparsely populated with a predominantly rural environment. The existing floodplain mapping for the mainstem Clark Fork River tributaries includes Approximate Zone A. These existing floodplain mapping studies typically date back to the early 1990s, and do not include any floodway information.

Approximate Zone A flood maps are developed using approximate methodologies and are not based on detailed hydraulic analysis. This level of flood mapping is often used in rural areas with low populations. Base Flood Elevations (BFEs) or flood depths are not identified in Approximate Zone A mapping (a BFE is the computed elevation to which floodwater is estimated to rise during the base flood). As a result, areas designated with Approximate Zone A flood mapping are difficult for local communities to manage and administer.

Enhanced analysis and base level mapping are similar in that both use standard hydrologic and hydraulic modeling methods to estimate BFEs and flood inundation areas. Both require the same topographic accuracy. However, base level mapping does not include floodway delineation, may not include a 500-year floodplain delineation, and may allow some flexibility in the acquisition and modeling of bathymetric and structure survey data.



LEGEND

- INACTIVE USGS GAGE
- FLOW NODES
- TOWNS
- HUC 8 BOUNDARIES
- MONTANA COUNTY BOUNDARIES
- NHS INTERSTATE
- NHS NON-INTERSTATE
- PRIMARY
- SECONDARY
- CLARK FORK TRIBUTARIES
- CLARK FORK RIVER STUDY REACH
- NHD HYDROGRAPHY

FLOW CHANGE NODE

- 100
- 200
- 300
- 400
- 500
- 600
- 700
- 800
- 900
- 1000
- 1100
- 1200
- 1300

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD 1983
UNITS: INT'L FEET
SOURCE: PIONEER, MSL, USGS

0 3 6 12
Miles

FIGURE 1

PIONEER TECHNICAL SERVICES, INC.

DATE: 2/27/2018

CLARK FORK RIVER TRIBUTARIES STUDY AREA

Path: G:\DNRC\Mineral -Beaverhead County\Mineral County Tributaries\CAD-GIS\GIS\CLKFK-GI-HYD-001-18.mxd

The DNRC, in partnership with FEMA, Mineral County, and other stakeholders, initiated work to produce new floodplain studies on the Clark Fork River tributaries. This Clark Fork River Tributaries Floodplain Study will provide the groundwork for completing floodplain mapping projects along the Clark Fork River tributaries. This report documents the hydrologic analysis methodology and results for the study, and includes calculation of peak discharge estimates for the 50-, 10-, 4-, 2-, 1-, and 0.2-percent annual chance events at key flow change locations (such as significant tributary confluences, stream gages, and population centers) along the study reach. The hydrologic analysis also included calculation of the 1% + (plus) annual chance discharge estimates, and conformed to FEMA standards for detailed/enhanced level studies (FEMA, 2017).

1.2 Basin Description

The seven primary Clark Fork River tributaries in the study area report to the Clark Fork River, which is a major tributary to the Pend Oreille River and upper headwaters of the Columbia River located west of the continental divide in western Montana. The river is formed by the confluence of Silver Bow Creek and Warm Springs Creek. The river tributaries originate in the Deerlodge National Forest near the continental divide. The watershed is formed by the Bitterroot Mountains to the west, Deer Lodge Mountains to the east, and the Pintler and Highland Ranges to the south. The mainstem Clark Fork River begins at Warm Springs, Montana, and flows north for approximately 20 miles through the Deer Lodge Valley before tuning west. The Blackfoot and Bitterroot Rivers join the Clark Fork River near Missoula. Approximately 213 miles downstream of Missoula, the Clark Fork River terminates at Lake Pend Oreille. The entire Clark Fork watershed area encompasses approximately 22,905 square miles. The study watershed basin area from the Missoula County border to the Sanders County border is approximately 1,217 square miles.

The Clark Fork River tributaries' basin elevations within the study area range from approximately 7,800 feet in the mountains to approximately 2,570 feet at St. Regis. The overall basin elevations range from over 10,000 feet at the continental divide to 2,060 feet near the confluence with Pend Oreille Lake (USACE, 1967). The terrain varies from a high alpine environment in its headwaters to a heavily cultivated landscape in the Deer Lodge valley with expansive irrigated pasture lands, bracketed by rolling foothills. The hydrology of the basin is primarily snowmelt driven.

Land use in the Clark Fork River basin is primarily agricultural with irrigated farming and ranching operations. Most of the intensely farmed land is in the Deer Lodge Valley within the Clark Fork River floodplain.

1.3 Flood History

There are historical records from three tributary USGS stream gages within the study area that document flooding history. The gages are listed below:

1. Dry Creek near Superior, MT (12353820).
2. Thompson Creek near Superior, MT (12353800).
3. Negro Gulch near Alberton, MT (12353400).

The USGS stream gage Dry Creek near Superior, MT (12353820) has a 10-year period of record (1981-1991). The annual peak flow record for the Dry Creek gage is shown in Figure 2. The Dry Creek drainage is one of the 7 tributary drainage basins being evaluated in this report.

The USGS stream gage Thompson Creek near Superior, MT (12353800) has a 20-year period of record (1961-1977,1978, 1979, 1982). The annual peak flow record for the Thompson Creek gage is shown in Figure 3. The Thompson Creek drainage is not one of the 7 tributary basins being evaluated in this report.[1]

The USGS stream gage Negro Gulch near Alberton, MT (12353400) has a 23-year period of record (1959-1973, 1984-1991). The annual peak flow record for the Negro Gulch gage is shown in Figure 4. The Negro Gulch drainage is not one of the 7 tributary basins being evaluated in this report.[1]

Peak flow recurrence intervals shown in Figure 2, Figure 3, and Figure 4 are based on previously published flood frequency analysis through Water Year 2011 (Scientific Investigations Report [SIR] 2015-5019-C) (Sando et al., 2015b).

There are no records that document the flooding mechanisms on the Clark Fork River tributaries. Since the primary cause of flooding on the Clark Fork River mainstem is spring snowmelt and ice jams, it can be inferred that tributary flooding occurs by similar mechanisms.

Figure 2 shows that the peak flood of record on Dry Creek occurred in water year 1991 with a flow of 560 cubic feet per second (cfs), exceeding the 10% (10-year) chance annual flow of 508 cfs. Aside from water year 1991, the 10% chance annual flow was not exceeded. All the annual peak flows occurred during the months of May and June.

[1] There are limited gages on the study tributaries; consequently, while Thompson Creek and Negro Gulch gages are not on basins evaluated for this study, they are near the study area and the data from these gages were used to validate using regional regression equations.

Figure 2 Dry Creek near Superior, MT (12353820)

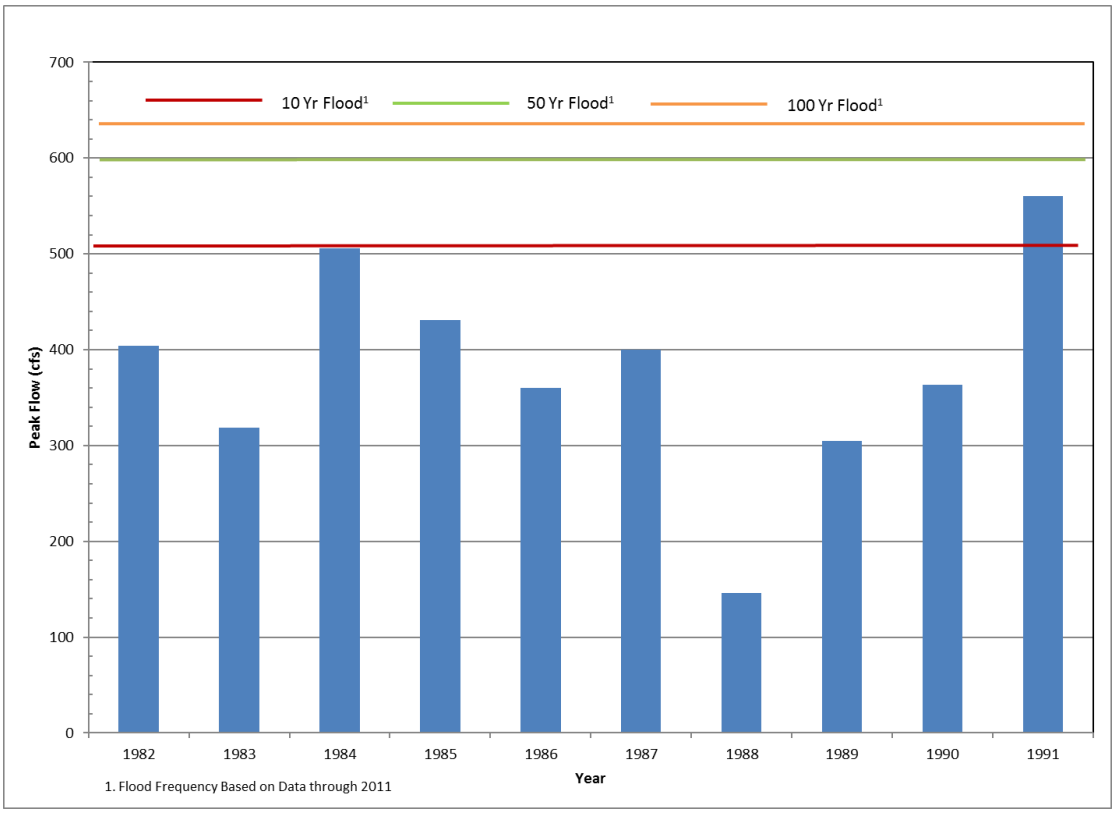
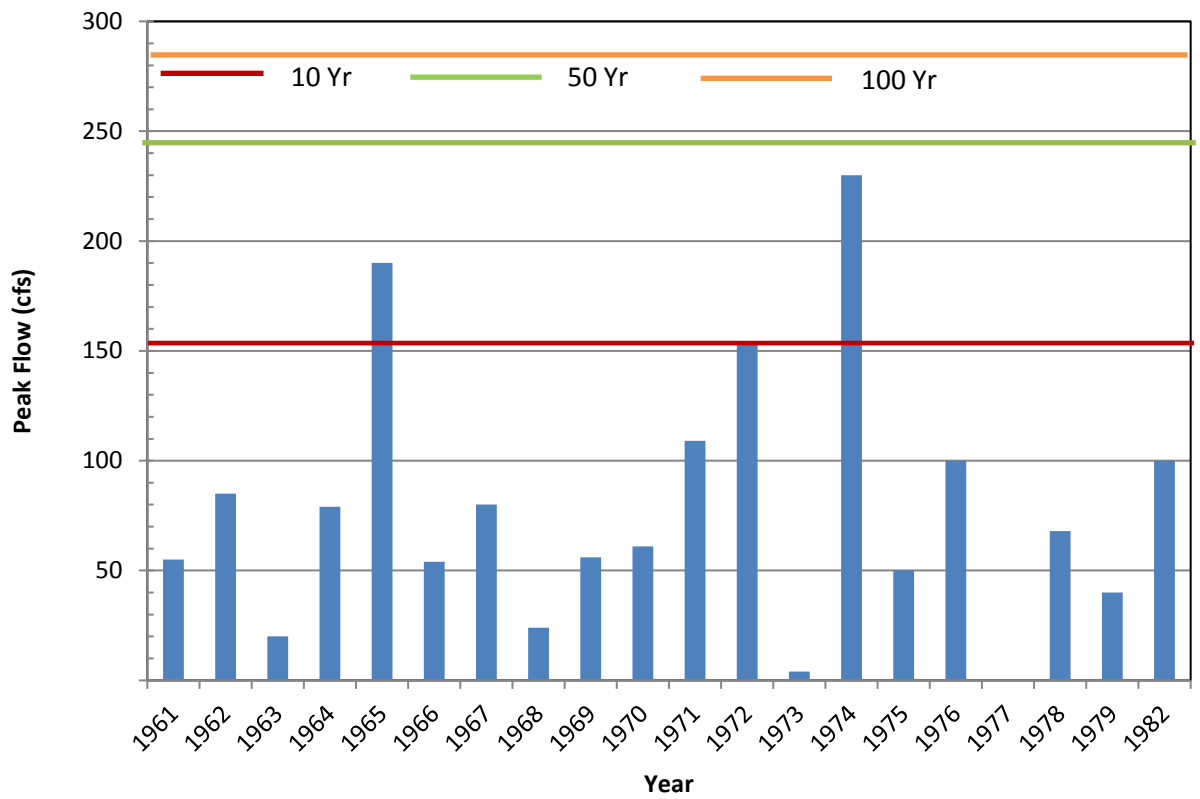


Figure 3 shows that the peak flood of record on Thompson Creek occurred in water year 1974 with a flow of 230 cfs, exceeding the 10% (10-year) chance annual flow of 154 cfs. In the 20-year gage period of record, the 10% chance annual flow has been equaled or exceeded 3 times (in 1965, 1972 and 1974). All the annual peak flows in Thompson Creek occurred during the months of April and May except for the peak flow of record that occurred on January 16, 1974.

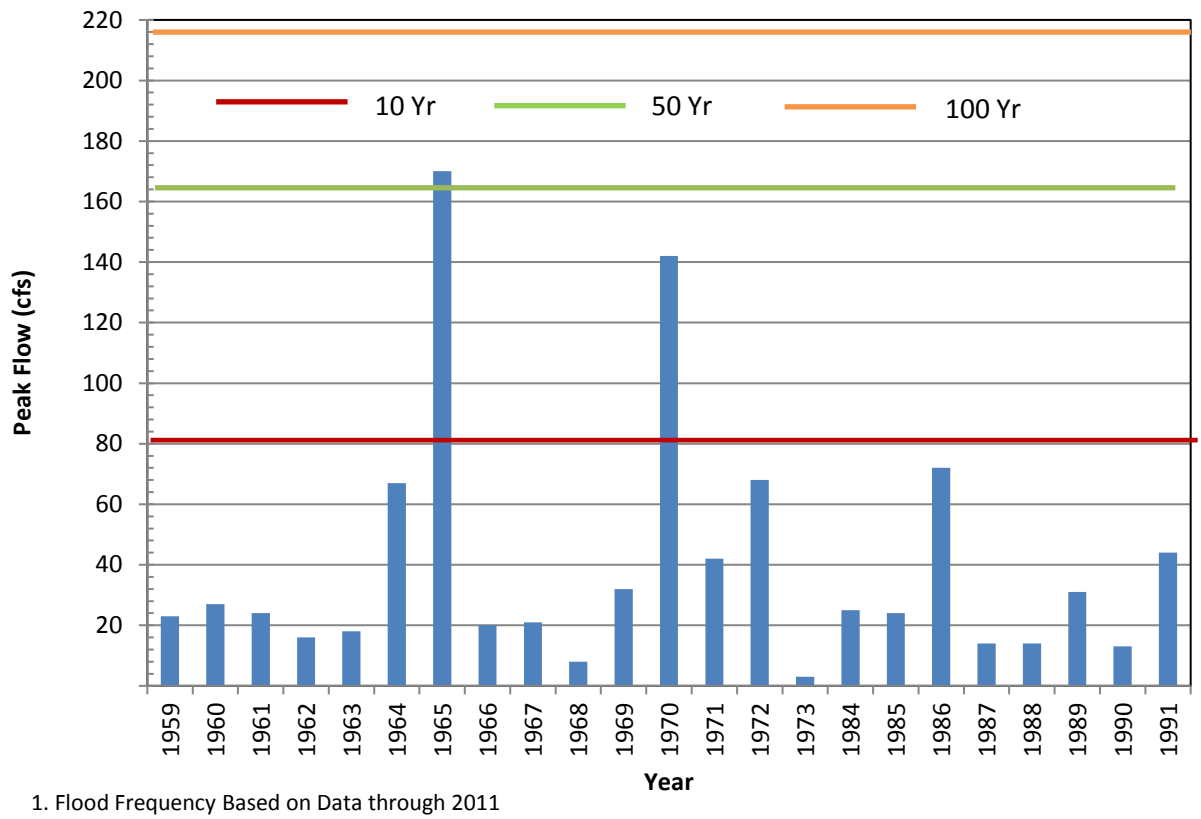
Figure 3 Thompson Creek near Superior, MT (12353800)



1. Flood Frequency Based on Data through 2011

Figure 4 shows that the peak flood of record on Negro Gulch occurred in water year 1965 with a flow of 170 cfs, exceeding the 2% (50-year) chance annual flow of 165cfs. In the 23-year gage period of record, the 10% chance annual flow has been equaled or exceeded twice (1965, 1970). Most of the annual peak flows in Negro Gulch occurred during the months of April through June. The third and fourth highest peak flows for the period of record occurred on February 26, 1986, and March 17, 1972.

Figure 4 Negro Gulch near Alberton, MT (12353400)



1. Flood Frequency Based on Data through 2011

2 Past Studies And Existing Flood Data

Past flood studies for the mainstem Clark Fork River tributaries are limited. Studies relevant to this hydrologic study are those that include peak flow frequency analyses. There are no FEMA Flood Insurance Studies within the Clark Fork River basin in Mineral County. Table 1 shows a summary of the Clark Fork River Tributaries floodplain mapping.

Table 1 Clark Fork River Tributaries Floodplain Mapping Summary

County	Map Panel Summary					Study Details			
	Community	# of FIRM Panels	# of FBFM Panels	FIRM Panel Effective Date	FIS Date	Streams	Approx (mi)	Detailed (mi)	Total (mi)
Mineral	Mineral Co.	4	0	11/1/1996	none	Fish Creek, Nemote Creek, Miller Creek, South Fork Nemote Creek, Meadow Creek, Sunrise Creek, Trout Creek, Cedar Creek, Dry Creek, Tamarack Creek	31	NA	NA

Source: FEMA Map Service Center.
FIRM: Flood Insurance Rate Map. FBFM: Flood Boundary and Floodway Map. FIS: Flood Insurance Study.

SIR 2015-5019-C (Sando et al., 2015b) provides flood frequency analysis on three Clark Fork River tributary gage stations within the study reach. These studies and investigations are discussed in more detail in the following sections.

2.1 Scientific Investigations Report 2015-5019

The USGS SIR 2015-5019-C report updated annual peak discharges with annual exceedance probabilities (AEPs) of 66.7, 50, 42.9, 20, 10, 4, 2, 1, 0.5, and 0.2 percent (return intervals of 1.5, 2, 2.33, 5, 10, 25, 50, 100, 200, and 500 years, respectively) for 725 gaged sites in or near Montana, based on data through Water Year 2011 (Sando et al., 2015b). Flood-frequency data typically were determined by fitting a log-Pearson Type III probability distribution using methods described by the Interagency Advisory Committee on Water Data (IACWD), Bulletin #17B (IACWD, 1982). The study was part of a larger study to develop an online StreamStats application for Montana, in conjunction with computing streamflow characteristics at gage stations, and estimate peak flow flood frequency at ungaged sites. Table 2 provides the SIR 2015-5019-C discharge summary for the Clark Fork River gages.

The USGS SIR 2015-5019-F (Sando et al., 2015a) selected 537 gaging stations from the gage study. The 537 gaging stations were segregated based on the following criteria: contributing drainage area less than about 2,750 square miles, peak-flow records unaffected by major regulation, small redundancy with nearby stations, and representation of peak-flow frequencies at sites within Montana. The study used regression analyses to develop equations relating AEP flows to various basin and climatic characteristics. The relationships developed for this study resulted in lower mean standard errors of prediction than previous regression analyses (Sando et al., 2015a).

Table 2 SIR-2015-5019-C Clark Fork River Tributary Peak Discharge Summary

USGS Station Number	USGS Station Name	Drainage Area (mi^2)	Years of Record	Peak Discharge (cfs), indicated return interval (years)								
				1.5	2	5	10	25	50	100	200	500
12353820	Dry Creek near Superior, Montana	44.8	10	352	386	462	508	561	599	635	670	714
12353800	Thompson Creek near Superior, Montana	12.0	20	50	67	117	154	204	244	284	326	383
12353400	Negro Gulch near Alberton, Montana	8.1	23	20	28	55	81	124	165	215	276	375

Based on systematic data through 2011.

2.2 Additional Previous Studies

Additional related previous studies conducted on the Clark Fork River tributaries involve water management, fisheries management, sediment management or environmental remediation:

- *Fish Creek Wildlife Management Area and Fish Creek State Park Draft Preliminary Management Plan* (Montana FWP, 2009).
- *Flat Creek Watershed Summary Technical Memorandum* (MMI, 2012).

3 Hydrologic Analyses and Results

The purpose of the hydrologic analyses conducted as part of this project was to develop peak flow discharge estimates for the 50-, 10-, 4-, 2-, 1-, and 0.2-percent AEP events at key flow change locations (such as at significant tributary confluences, stream gages, and population centers) within the study reach. The analysis is organized into three sections:

1. Stream Gage Analysis;
2. Flow Node Locations; and
3. Ungaged Flow Node Analysis.

Within the study area, 13 locations (flow change nodes) on 7 Clark Fork River tributaries were identified as having significant changes in streamflow or being at a critical location. Out of the 13 flow change nodes on the Clark Fork River tributaries, 1 node was located at a discontinued USGS stream gage site, and 12 were located within ungaged basins. The study tributaries in this report were based on the Mineral County Modernization Phase II Clark Fork River Study Area

Map provided by the DNRC. Detailed profile baselines and river stationing for each tributary were developed as part of this report. The Clark Fork River Tributaries Study area begins at the border of Mineral and Sanders counties. The upstream extent of the study reach ends at the border of Mineral and Missoula counties.

3.1 Stream Gage Analysis

There is 1 discontinued USGS stream gage located within the 7 Clark Fork River study area tributaries: USGS gaging station 12353820 Dry Creek near Superior, Montana. The gage has a 10-year period of record with peak flows being recorded continuously from 1982 to 1991. Figure 1 shows the study reach and the location of the USGS gaging station used in the hydrologic analysis. Table 3 is a summary of the USGS Dry Creek stream gage. FEMA guidance documents (FEMA, 2017) indicate that gage station records equal or exceeding 10-years in length are applicable to all types of studies. The Dry Fork Creek meets this minimum requirement.

As discussed previously, annual peak discharges with AEPs were updated for 725 gaged sites in or near Montana, based on data through Water Year 2011 (Sando et al., 2015b). Flood-frequency data were determined using methods described by the IACWD Bulletin #17B (IACWD, 1982). The study was part of a larger study to develop an online StreamStats application for Montana. USGS gaging station 12353820 Dry Creek near Superior, Montana, was included in this analysis.

In 2016 the USGS began implementing Bulletin 17C guidelines to provide estimates for selected stream gages operated by the WY-MT Water Science Center (WSC) (USGS, 2016). As part of the Mineral County Modernization Phase I flood mapping activities, USGS completed flood frequency analysis for the mainstem Clark Fork River USGS gages using Bulletin 17C methods on gage data through 2016. Pioneer performed a flood frequency analysis for the Dry Creek gage using Bulletin 17C methods, to update the previous gage peak flow analysis to be consistent with the main stem flood frequency analyses. The calculations were conducted using the USGS PEAK FQ flood frequency analysis software (USGS, 2014). Calculations are provided in Appendix A.

For the Dry Creek gage, the 1%+ (plus) AEP event was calculated to provide a confidence range that the 1% flood frequency peak flow estimates are likely to fall within. For gage analyses, the 1%+ (plus) AEP event is equal to the 1% AEP flow plus 1-standard error. For a normally distributed error function, 1 standard error is equal to 34.1%. A 68% confidence interval is approximately equal to ± 1-standard error. The upper limit of the 68% confidence interval (84% confidence limit, or plus one standard error) was used to determine the 1%+ (plus) flood frequency peak flow estimates. Appendix A provides the 1%+ (plus) flood frequency calculations for the Dry Creek Gage.

Results for the Dry Creek gage flood frequency analysis using Bulletin 17C methods are shown in Table 4. Table 5 compares flood frequency estimates between the SIR 2015-5019-C analysis (Sando et al., 2015b) using Bulletin 17B and this study's Bulletin 17C analysis.

Table 3 Clark Fork River Tributary Flow Change Node USGS Gage Summary

Station Number	Station Name	Drainage Area[1] (mi^2)	Period of Systematic Record[2]	Number of Annual Peaks[2]	River Station (miles)
12353820	Dry Creek near Superior, Montana	44.8	1982–1991	10	0.7

1. Source: National Water Information System (NWIS).
2. Data from SIR 2015-5019-C, Table 1-1 (Sando et al., 2015b).

Table 4 Clark Fork River Tributary USGS Gage Summary Bulletin 17C Results

Station Number	Station Name	Analysis Period of Record	Peak Discharge (cfs), for indicated exceedance probability (%)									
			66.67	50	20	10	4	2	1	0.5	0.2	1%+
			Peak Discharge (cfs), for indicated return interval (years)									
					5	10	25	50	100	200	500	100+
12353820	Dry Creek near Superior, MT	1982-1991	348	384	463	510	565	603	639	674	719	783

Table 5 Gage Flood Frequency Estimate Comparison Bulletin 17B and Bulletin 17C

Station Number	Station Name	Peak Discharge, for Return Interval (years) (cfs)																	
		2		5		10		25		50		100		200		500		1%+	
		17B	17C	17B	17C	17B	17C	17B	17C	17B	17C	17B	17C	17B	17C	17B	17C	17B	17C
12353820	Dry Creek near Superior, MT	386	384	462	463	508	510	561	565	599	603	635	639	670	674	714	719	675	783

3.2 Flow Node Locations

Future flood studies will use hydraulic models that are composed of geometric data and streamflow data. To accurately model the Clark Fork River tributaries, the locations of major tributary confluences and other flow change locations must be identified. The results of this hydrologic analysis will be used as the streamflow data input for the hydraulic modeling of the tributary basins. A detailed review of the study area was performed to identify all potential flow change locations (flow nodes) for the study area tributaries. At each flow node, a drainage basin area was delineated, and peak flow values were calculated for the required recurrence interval floods. Generally, the hydraulic models simulate flood events using steady-state conditions, and, therefore, the peak flow rate calculated at a flow node is projected to the next upstream flow node. This method was followed for the hydrologic analysis calculations. Flow nodes were assigned immediately upstream of tributary junctions; this method of locating the flow nodes was employed so that the additional flow resulting from the tributary confluence was accurately reflected to the reach downstream of the confluence.

Using ArcGIS (Esri's Geographic Information System [GIS] mapping software), 7 flow nodes were located just upstream of each tributary confluence with the mainstem Clark Fork River. On 2 of the 7 tributaries (Meadow Creek and Nemote Creek), additional flow nodes were located where study reach sub-tributaries joined the tributary mainstem. A total of 6 additional flow nodes were added for a total of 13 flow nodes. Table 6 summarizes the 13 flow nodes used in the study.

Figure 5 through Figure 11 map the flow node locations from Table 6.

Due to their drainage area size, these ungaged flow nodes do not have a Geographic Names Information System (GNIS) hydrographic feature name. Therefore, a location description was developed for each ungaged flow node.

To address the issue of coincident peaks between the study tributaries and the Clark Fork River mainstem FEMA guidance requirements assuming coincident peaks were referenced. For the assumption of coincident peaks to be appropriate FEMA guidance documents (FEMA, 2016b) require the following criteria be met:

1. The ratio of the drainage areas lies between 0.6 and 1.4;
2. The arrival times of flood peaks are similar for the two combining watersheds; and
3. The likelihood of both watersheds being covered by the storm is high.

The study tributaries do not meet these drainage area ratio criteria. Except for Dry Creek, study tributaries and the Clark Fork mainstem are not gaged at the tributary's\main stem confluence. Therefore, data to determine criteria No. 2 is not available. The Clark Fork river mainstem drainage area at the tributary confluences are orders of magnitude greater than the tributary basin areas, therefore there is a low likelihood that both watersheds would be covered by the

same storm. Consequently, we have determined that the tributaries do not meet the FEMA criteria for coincident peaks.

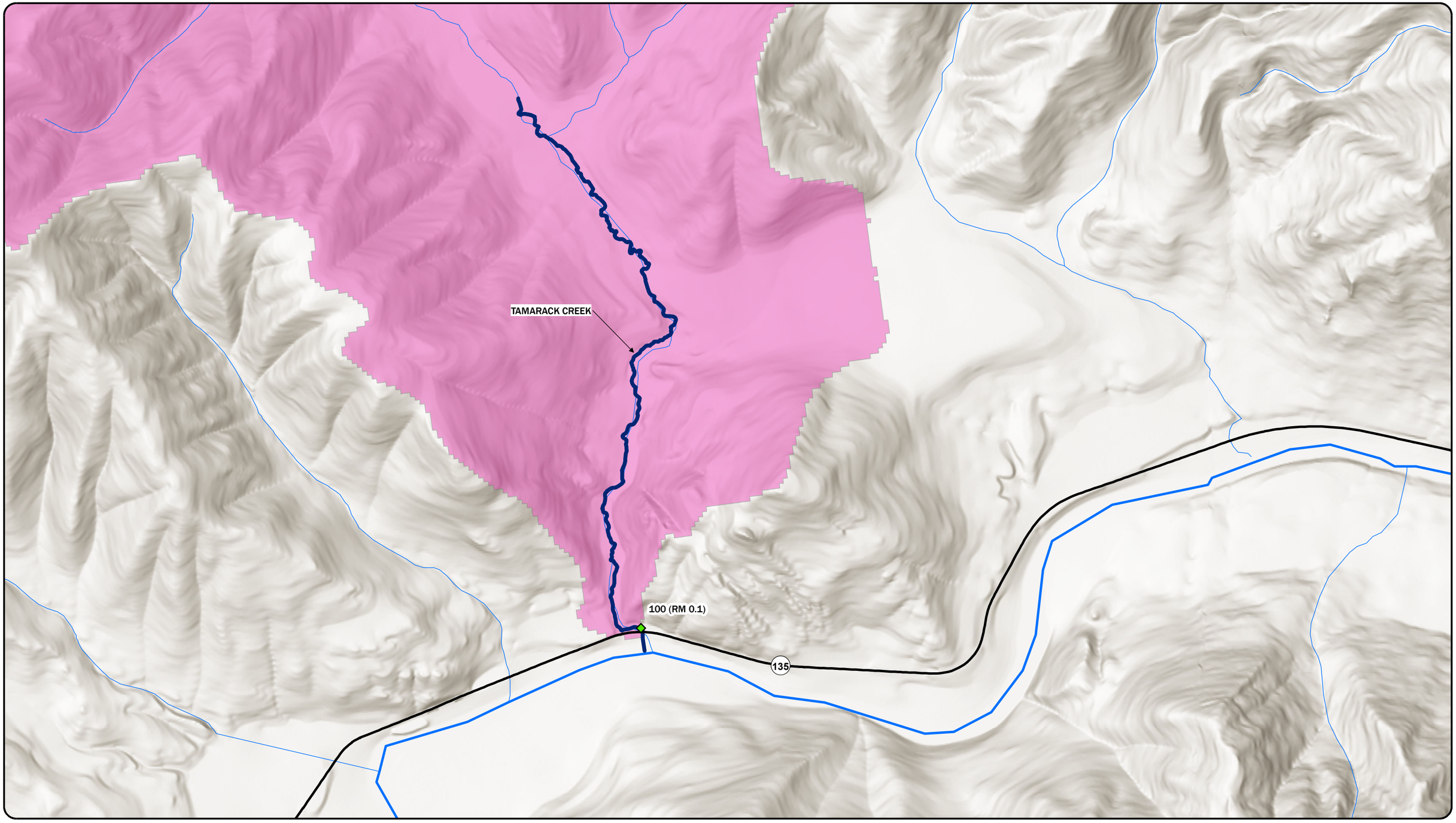
Table 6 Flow Node and USGS Gage Station Information Used in Hydrologic Analyses

Node/USGS Station ID	Location Description	County	River Station[1] (mi)	Stream Stats Calculated Basin Area[2] (mi^2)
100	Tamarack Creek at junction with Clark Fork River	Mineral	0.1	27.6
200	Dry Creek at junction with Clark Fork River	Mineral	0.7	44.8
300	Cedar Creek at junction with Clark Fork River	Mineral	0.1	71.0
400	Trout Creek at junction with Clark Fork River	Mineral	0.1	71.4
500	Meadow Creek at junction with Clark Fork River	Mineral	0.1	18.7
600	Meadow Creek upstream of Sunrise Creek junction	Mineral	2.0	11.1
700	Sunrise Creek at junction with Meadow Creek	Mineral	0.1	6.5
800	Nemote Creek at junction with Clark Fork River	Mineral	0.0	35.1
900	Nemote Creek upstream of Miller Creek junction	Mineral	2.5	26.6
1000	Miller Creek at junction with Nemote Creek	Mineral	0.0	7.5
1100	Nemote Creek upstream of South Fork Nemote Creek junction	Mineral	4.9	15.1
1200	South Fork Nemote Creek at junction with Nemote Creek	Mineral	0.0	7.7
1300	Fish Creek at junction with Clark Fork River	Mineral	0.0	260.4

1. Primary tributary profile baseline river miles.
2. Source: USGS Stream Stats.

Table 7 USGS and GIS Model Watershed Comparison

USGS Gage Station	Station Name	USGS Published Drainage Area (mi^2)	Stream Stats Basin Area[2] (mi^2)	Percent Change	Relative Accuracy of Areas
12353820	Dry Creek near Superior, MT	44.8	44.8	0.00%	100.0%



LEGEND

- FLOW NODES
- HUC 8 BOUNDARIES
- PRIMARY
- CLARK FORK TRIBUTARIES
- CLARK FORK RIVER STUDY REACH
- NHD HYDROGRAPHY

FLOW CHANGE NODE

- 100

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD 1983
UNITS: INT'L FEET
SOURCE: PIONEER, MSL, USGS

0 1,000 2,000 4,000
Feet

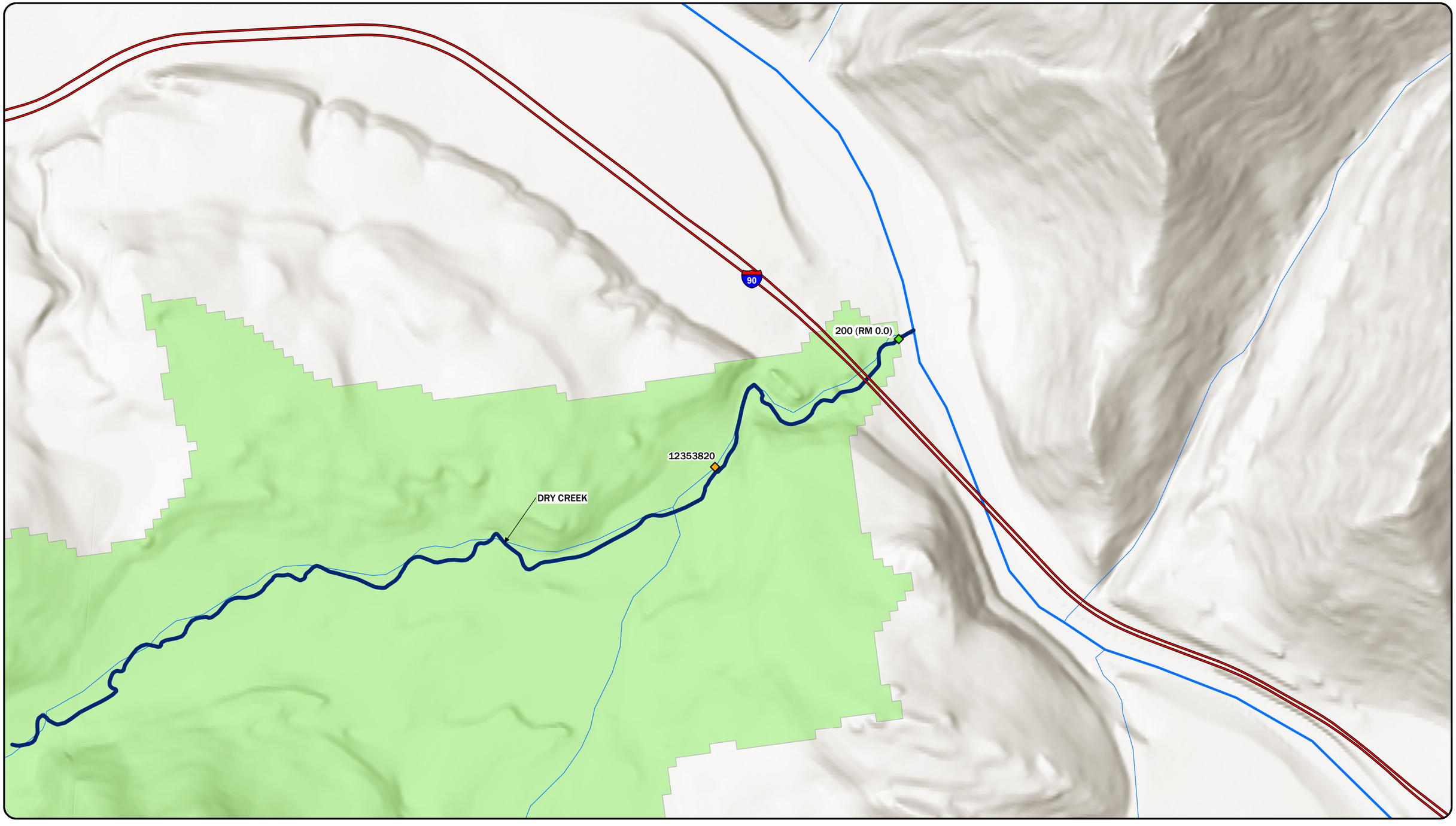
FIGURE 5

PIONEER TECHNICAL SERVICES, INC.

DATE: 2/27/2018

TRIBUTARY BASIN
TAMARACK CREEK
FLOW NODE LOCATION

Path: G:\DNRC\Mineral -Beaverhead County\Mineral County Tributaries\CAD-GIS\GIS\CLKFK-GI-HYD-005-18.mxd



LEGEND

- INACTIVE USGS GAGE
- FLOW NODES
- HUC 8 BOUNDARIES
- NHS INTERSTATE
- CLARK FORK TRIBUTARIES
- CLARK FORK RIVER STUDY REACH
- NHD HYDROGRAPHY

FLOW CHANGE NODE

- 200

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD 1983
UNITS: INT'L FEET
SOURCE: PIONEER, MSL, USGS

0 500 1,000 2,000
Feet

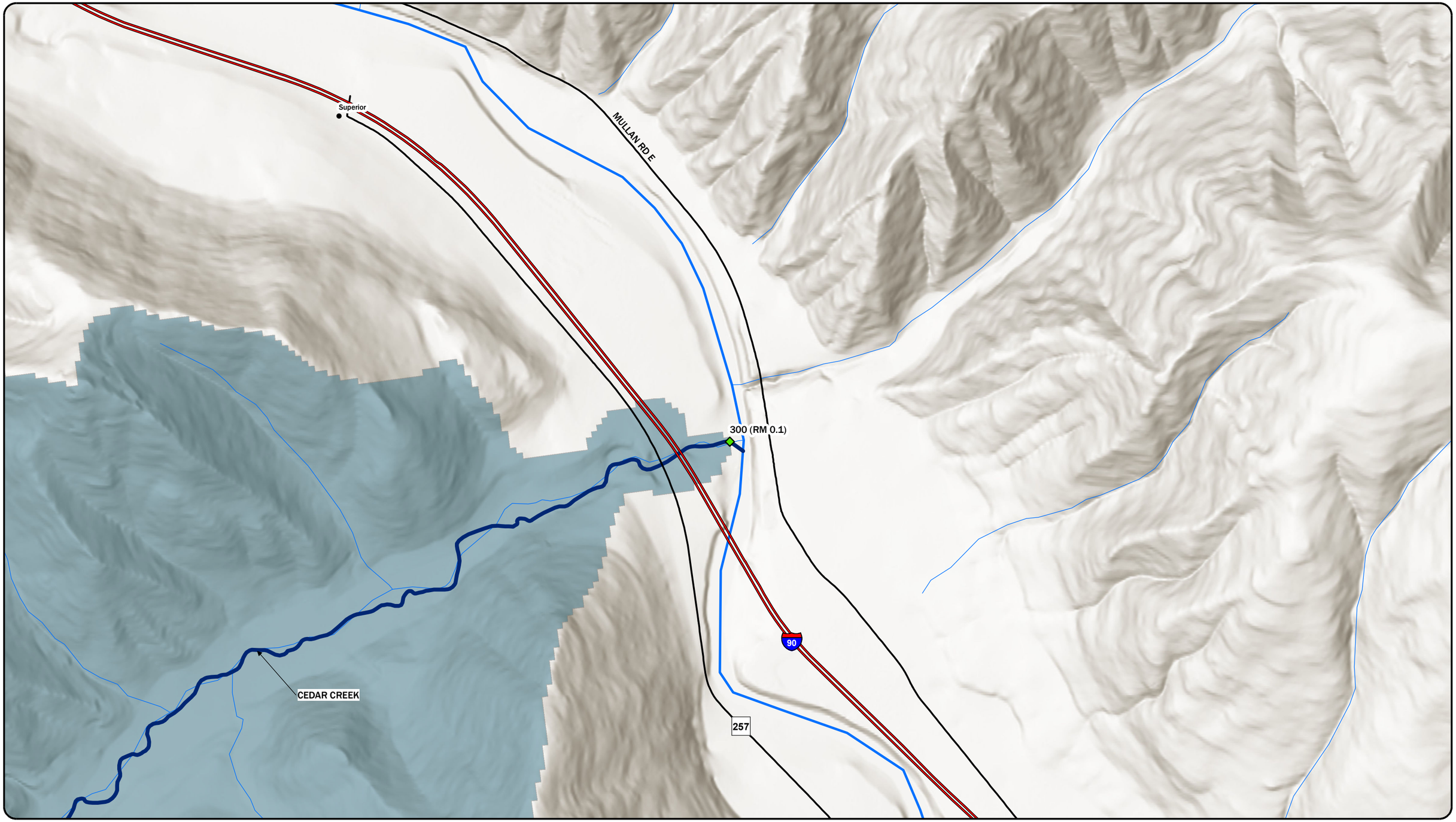
FIGURE 6

PIONEER TECHNICAL SERVICES, INC.

TRIBUTARY BASIN
DRY CREEK
FLOW NODE LOCATION

DATE: 2/27/2018

Path: G:\DNRC\Mineral -Beaverhead County\Mineral County Tributaries\CAD-GIS\GIS\CLKFK-GI-HYD-006-18.mxd



LEGEND

- FLOW NODES
- TOWNS
- HUC 8 BOUNDARIES
- NHS INTERSTATE
- SECONDARY
- CLARK FORK TRIBUTARIES
- CLARK FORK RIVER STUDY REACH
- NHD HYDROGRAPHY
- FLOW CHANGE NODE
- 300

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD 1983
UNITS: INT'L FEET
SOURCE: PIONEER, MSL, USGS

0 750 1,500 3,000
Feet

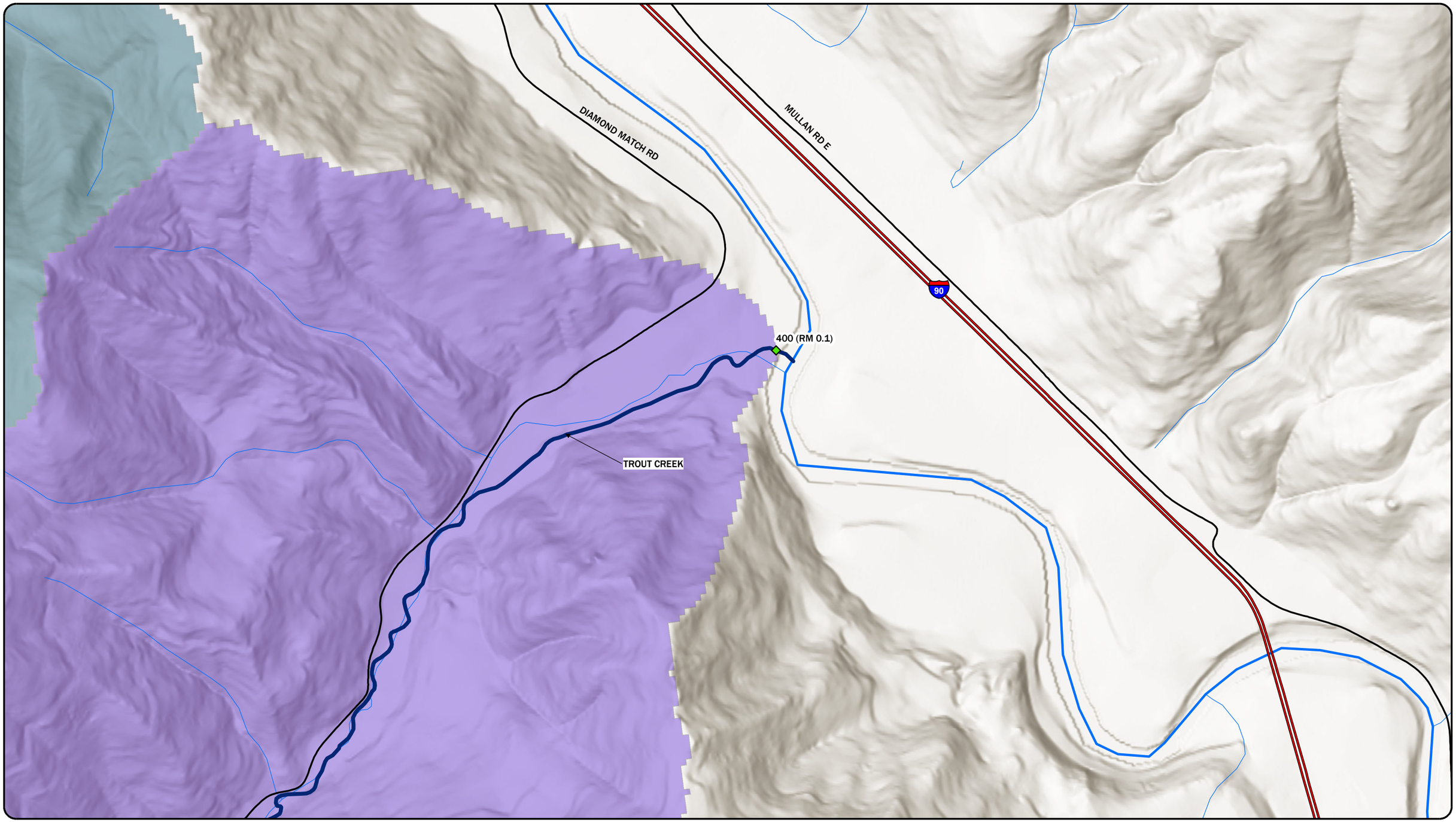
FIGURE 7

PIONEER TECHNICAL SERVICES, INC.

DATE: 2/27/2018

TRIBUTARY BASIN
CEDAR CREEK
FLOW NODE LOCATION

Path: G:\DNRC\Mineral -Beaverhead County\Mineral County Tributaries\CAD-GIS\GIS\CLKFK-GI-HYD-007-18.mxd



LEGEND

- FLOW NODES
- HUC 8 BOUNDARIES
- NHS INTERSTATE
- SECONDARY
- CLARK FORK TRIBUTARIES
- CLARK FORK RIVER STUDY REACH
- NHD HYDROGRAPHY

FLOW CHANGE NODE

- 300
- 400

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD 1983
UNITS: INT'L FEET
SOURCE: PIONEER, MSL, USGS

0 750 1,500 3,000
Feet

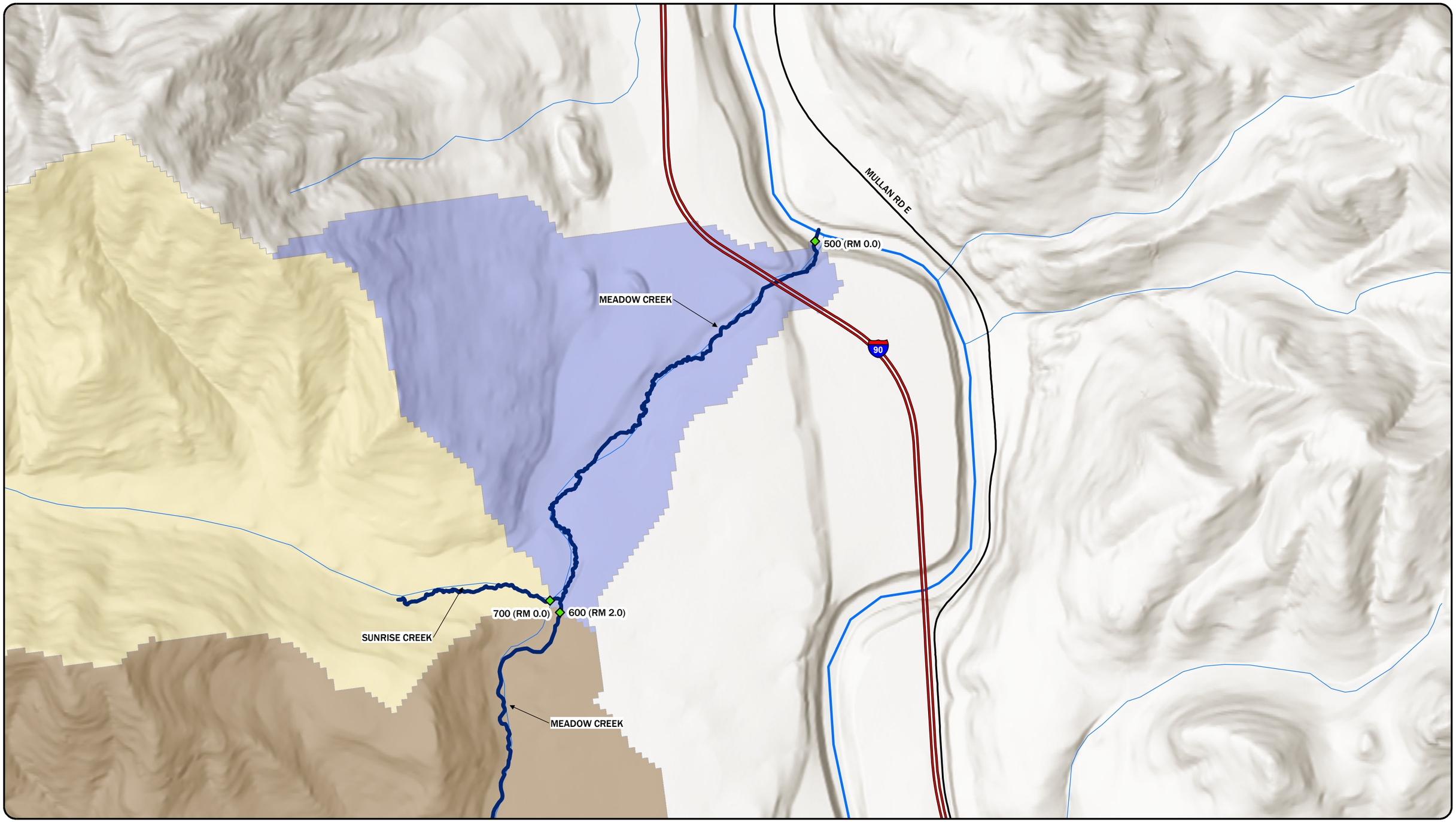
FIGURE 8

PIONEER TECHNICAL SERVICES, INC.

DATE: 2/27/2018

TRIBUTARY BASIN
TROUT CREEK
FLOW NODE LOCATION

Path: G:\DNRC\Mineral -Beaverhead County\Mineral County Tributaries\CAD-GIS\GIS\CLKFK-GI-HYD-008-18.mxd



LEGEND

- FLOW NODES
- HUC 8 BOUNDARIES
- NHS INTERSTATE
- SECONDARY
- CLARK FORK TRIBUTARIES
- CLARK FORK RIVER STUDY REACH
- NHD HYDROGRAPHY

FLOW CHANGE NODE

- 500
- 600
- 700

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD 1983
UNITS: INT'L FEET
SOURCE: PIONEER, MSL, USGS

0 750 1,500 3,000
Feet

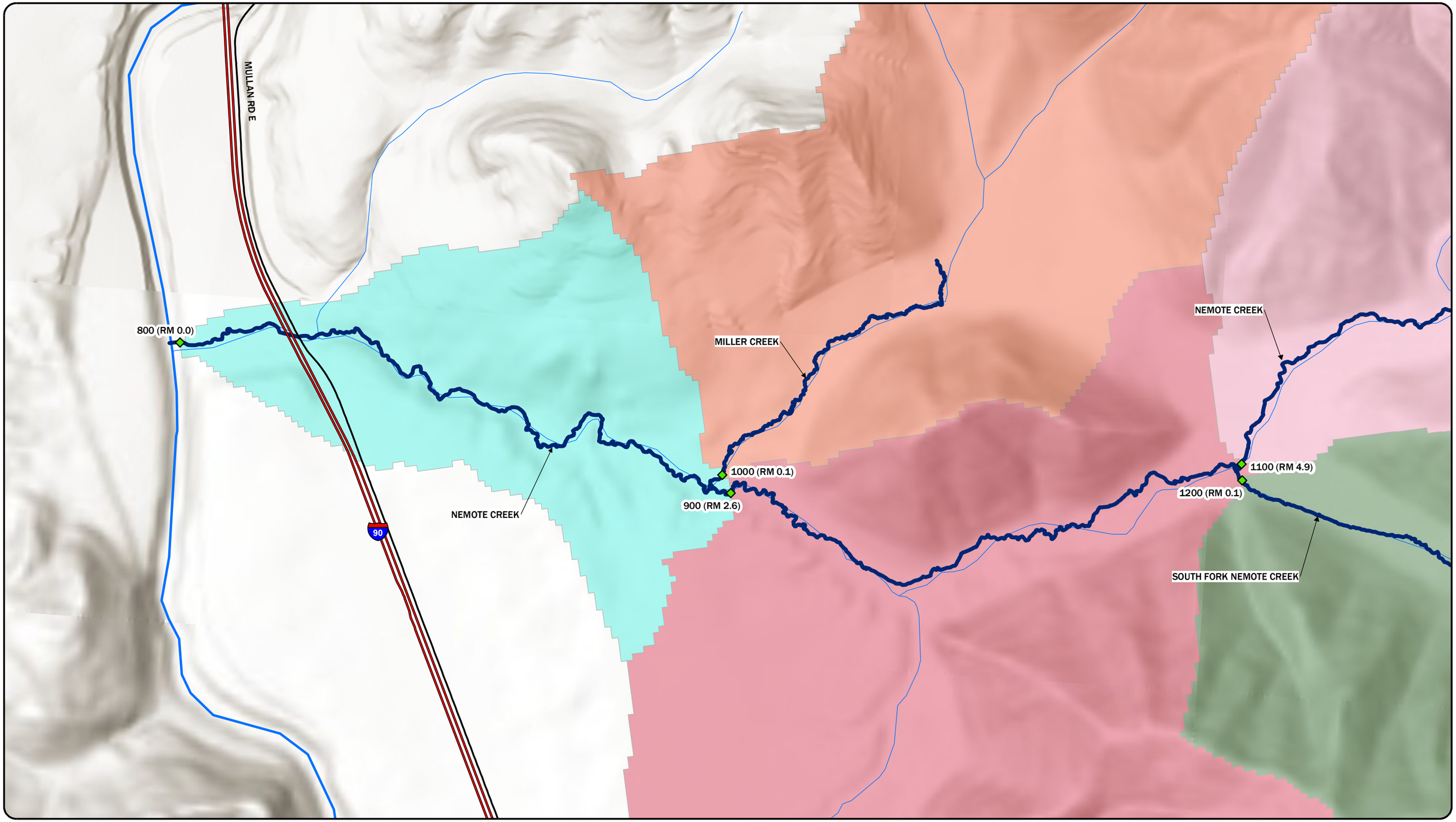
FIGURE 9

PIONEER TECHNICAL SERVICES, INC.

DATE: 2/27/2018

TRIBUTARY BASIN
MEADOW CREEK
FLOW NODE LOCATIONS

Path: G:\DNRC\Mineral -Beaverhead County\Mineral County Tributaries\CAD-GIS\GIS\CLKFK-GI-HYD-009-18.mxd



LEGEND

- FLOW NODES
- HUC 8 BOUNDARIES
- NHS INTERSTATE
- SECONDARY
- CLARK FORK TRIBUTARIES
- CLARK FORK RIVER STUDY REACH
- NHD HYDROGRAPHY

FLOW CHANGE NODE

- 800
- 900
- 1000
- 1100
- 1200

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD 1983
UNITS: INT'L FEET
SOURCE: PIONEER, MSL, USGS

0 750 1,500 3,000
Feet

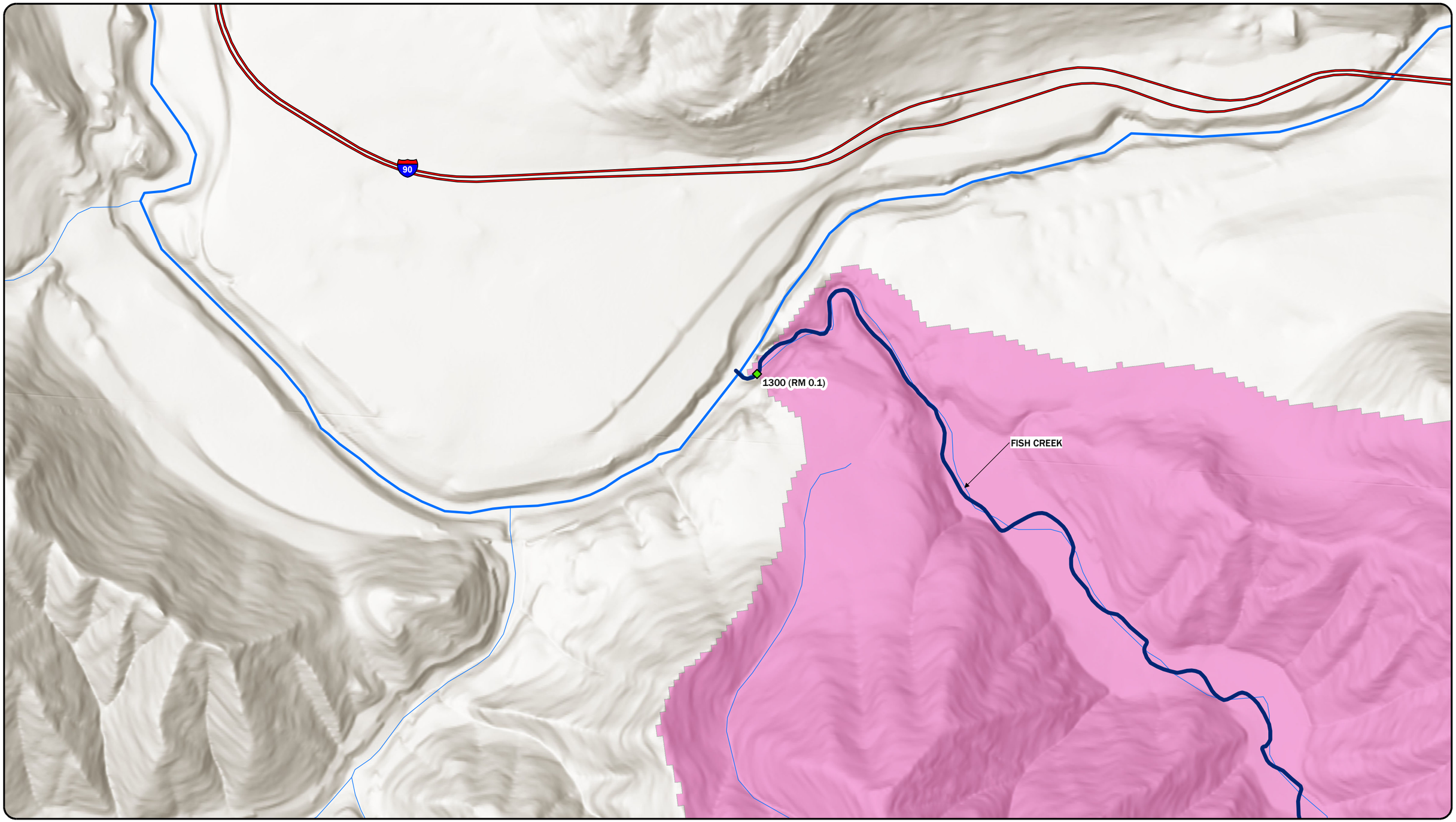
FIGURE 10

PIONEER TECHNICAL SERVICES, INC.

DATE: 2/27/2018

TRIBUTARY BASIN
NEMOTE CREEK
FLOW NODE LOCATIONS

Path: G:\DNRC\Mineral -Beaverhead County\Mineral County Tributaries\CAD-GIS\GIS\CLKFK-GI-HYD-010-18.mxd



LEGEND

- FLOW NODES
- HUC 8 BOUNDARIES
- NHS INTERSTATE
- CLARK FORK TRIBUTARIES
- CLARK FORK RIVER STUDY REACH
- NHD HYDROGRAPHY

FLOW CHANGE NODE
1300

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD 1983
UNITS: INT'L FEET
SOURCE: PIONEER, MSL, USGS

0 750 1,500 3,000
Feet

FIGURE 11

PIONEER TECHNICAL SERVICES, INC.

DATE: 2/27/2018

TRIBUTARY BASIN
FISH CREEK
FLOW NODE LOCATION

Path: G:\DNRC\Mineral -Beaverhead County\Mineral County Tributaries\CAD-GIS\GIS\CLKFK-GI-HYD-011-18.mxd

3.3 Ungaged Flow Node Analysis

To calculate peak flood discharge estimates at the ungaged flow nodes, methods described in USGS SIR 2015-5109-F (Sando et al., 2015a) were considered. These methods included estimating flood frequency using regional flood-frequency relations (regression analysis) and estimating flood frequency on gaged streams by translating gaged data to ungaged locations (drainage area gage transfer and logarithmic interpolation between two gaged sites).

The SIR 2015-5019-F report provides guidance on conditions where regional regression equations might not yield reliable results. These limiting guidelines include the following:

1. A site where the basin characteristics are outside the range of values used to develop the regression equations.
2. A site that is affected by regulation or urbanization.

The Clark Fork River Tributaries Study reach is within the West Hydrologic region as defined by SIR 2015-5019-F. For the study flow nodes identified in Table 6, basin characteristics (drainage area, % forested land cover, and mean annual precipitation) were compared with SIR 2015-5019-F, Table 3 (range of values of basin characteristics used to develop regional regression equations). The comparison indicated that all the study reach flow nodes were within the range of values used to develop the West Region regional regression equations.

None of the Clark Fork River tributary drainages are considered regulated. Therefore, the Clark Fork River Tributaries Study flow nodes meet the SIR 2015-5019-F guidelines and regional regression equations are applicable.

One study tributary, Dry Creek, has a USGS gage site: Dry Creek Gaging Station 12353820 is near the junction with Clark Fork River approximately 0.6 miles upstream of flow node 200 at the confluence with mainstem Clark Fork River. The watershed area difference between the Dry Creek gaging station and flow node 200 is less than 1 %. Therefore, no gage transfer calculations were conducted for flow node 200 and the Dry Creek gaging station peak flow estimates from Table 5 will be considered for flow node 200.

3.3.1 Regional Regression Equations Method

Ungaged flow nodes located on the Clark Fork River tributaries are not regulated and are within the drainage areas supported by the West Region regression equations. The regression equations, presented in SIR 2015-5019-F, use a drainage area (A), percentage of basin with forest land cover (F), and mean annual precipitation (P) as shown below in the following set of equations (Sando et al., 2015a):

$$Q_{50} = 0.131A^{0.920}P^{2.24}(F+1)^{-0.845}$$
$$Q_{10} = 2.44A^{0.853}P^{1.71}(F+1)^{-0.875}$$
$$Q_{4} = 6.61A^{0.831}P^{1.53}(F+1)^{-0.890}$$
$$Q_{2} = 12.2A^{0.818}P^{1.42}(F+1)^{-0.896}$$
$$Q_{1} = 21.5A^{0.806}P^{1.32}(F+1)^{-0.904}$$
$$Q_{0.2} = 63.5A^{0.783}P^{1.12}(F+1)^{-0.915}$$

where

Q_x	is the X AEP peak flow magnitude, in cfs.
A	is the contributing drainage area, in square miles.
F	is the percent of basin with forest land cover.
P	is the mean annual precipitation in inches.

The peak flow regional regression estimates for the 13 flow nodes were calculated using the USGS StreamStats software (USGS, 2012).

The 1%+ (plus) percent AEP event was calculated for all the flow nodes to provide a confidence range that the 1% flood frequency peak flow estimates were likely to fall within. Per FEMA guidance documents, for the regional regression estimates, the average standard error of prediction" or "average standard error of estimate" percentage (SEP, in percent) from SIR 2015-5019-F (Sando et al., 2015a) was used to define the equation's statistical (plus or minus one standard error), (Fema, 2016a). The resulting 1% AEP flows plus one SEP was used to determine the 1%+ (plus) flood frequency peak flow estimates.

Appendix B provides the 1%+ (plus) regional regression flood frequency calculations for the study flow nodes.

The West Region regression equation input variables are shown in Table 8 Table 11 Recommended Flood Discharge Estimates using Regional Regresssion EquationsRegional regression flood frequency peak flow estimates are presented in Table 9. For the two tributary basins that include more than one flow node (Meadow Creek and Nemote Creek), Figure 12 and Figure 13 plot the calculated peak discharges and correlating drainage areas for the two basins. Results indicate increasing flow magnitude with increasing drainage area. One exception was in the Nemote Creek basin where Miller Creek had slightly higher peak flows than the next largest,

but similar, flow node drainage area (South Fork Nemote Creek). This difference was due to the lower percent of forested cover in Miller Creek compared with South Fork Nemote Creek. Appendix B provides the flood frequency calculations at the ungaged flow nodes.

Table 8 Regional Regression Variables

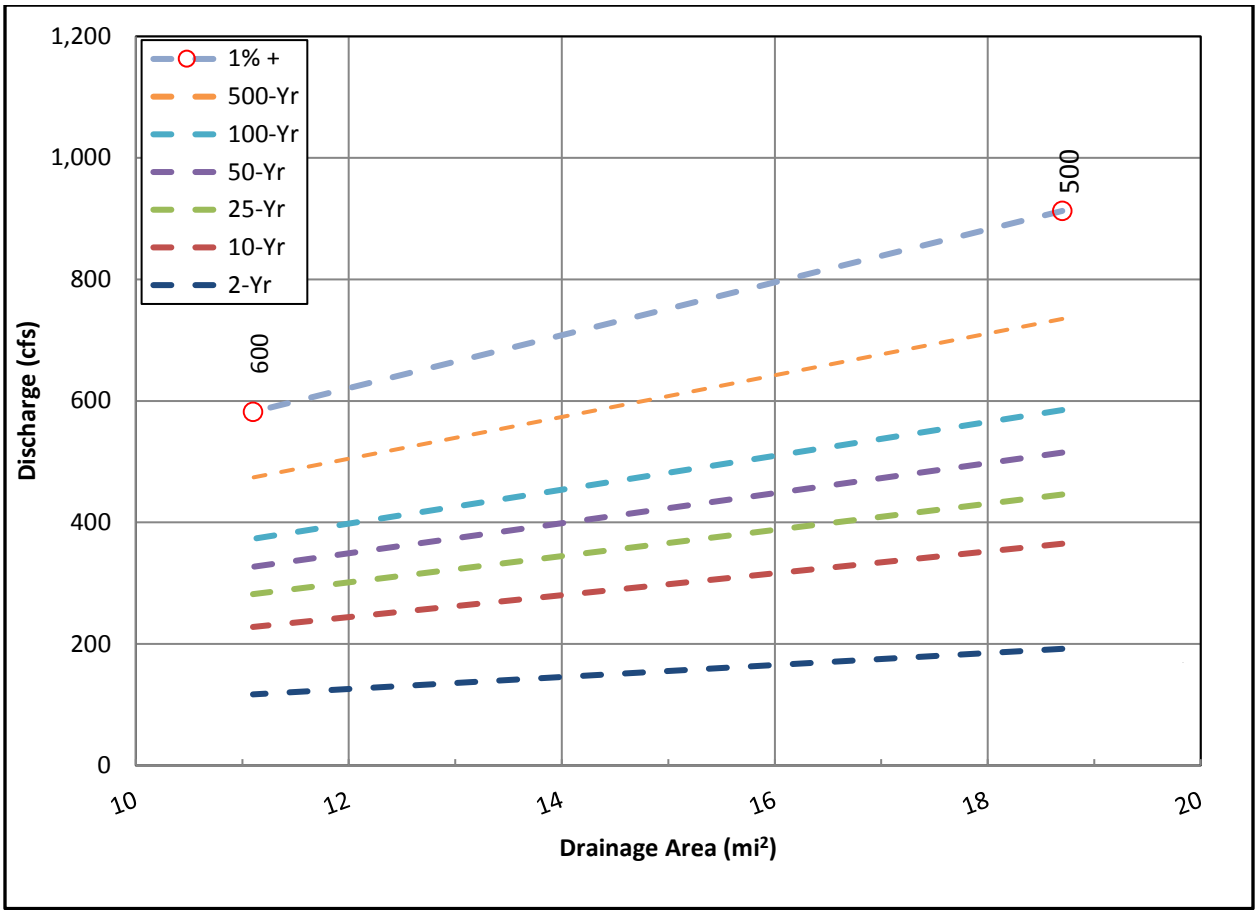
Node/USGS Station ID	Location Description	Basin Area (mi^2)	F (%)	P (in)
100	Tamarack Creek at junction with Clark Fork River	27.6	88.4	34.0
200	Dry Creek at junction with Clark Fork River	44.9	77.0	48.8
300	Cedar Creek at junction with Clark Fork River	71.0	79.2	52.7
400	Trout Creek at junction with Clark Fork River	71.4	73.3	56.6
500	Meadow Creek at junction with Clark Fork River	18.7	76.5	40.2
600	Meadow Creek upstream of Sunrise Creek Junction	11.1	80.1	40.5
700	Sunrise Creek at junction with Meadow Creek	6.5	78.2	43.1
800	Nemote Creek at junction with Clark Fork River	35.1	70.9	30.9
900	Nemote Creek upstream of Miller Creek junction	26.6	73.1	31.2
1000	Miller Creek at junction with Nemote Creek	7.5	67.4	31.6
1100	Nemote Creek upstream of South Fork Nemote Creek junction	15.1	76.9	34.9
1200	South Fork Nemote Creek at junction with Nemote Creek	7.7	80.3	29.6
1300	Fish Creek at junction with Clark Fork River	260.4	72.5	44.5

Table 9 Regional Regression Flood Frequency Peak Flow Estimates

Node/USGS Station ID	Location Description	West Region Regression Estimated Discharge (cfs)						
		50% Annual Chance 2-year	10% Annual Chance 10-year	4% Annual Chance 25-year	2% Annual Chance 50-year	1% Annual Chance 100-year	0.2% Annual Chance 500-year	1% + 100-year
100	Tamarack Creek at junction with Clark Fork River	167	337	420	491	564	725	880
200	Dry Creek at junction with Clark Fork River	663	1,070	1,240	1,380	1,530	1,810	2,387
300	Cedar Creek at junction with Clark Fork River	1,170	1,760	1,990	2,190	2,380	2,750	3,714
400	Trout Creek at junction with Clark Fork River	1,470	2,130	2,380	2,600	2,810	3,200	4,384
500	Meadow Creek at junction with Clark Fork River	192	365	446	515	585	735	913
600	Meadow Creek upstream of Sunrise Creek Junction	117	228	282	327	373	474	582
700	Sunrise Creek at junction with Meadow Creek	83	163	202	235	268	340	418
800	Nemote Creek at junction with Clark Fork River	203	425	539	635	735	961	1,147
900	Nemote Creek upstream of Miller Creek junction	157	333	423	500	580	761	905
1000	Miller Creek at junction with Nemote Creek	54	123	161	193	228	307	356
1100	Nemote Creek upstream of South Fork Nemote Creek junction	115	238	300	352	407	528	635
1200	South Fork Nemote Creek at junction with Nemote Creek	41	98	128	155	183	250	286
1300	Fish Creek at junction with Clark Fork River	2,850	4,300	4,890	5,380	5,870	6,810	9,159

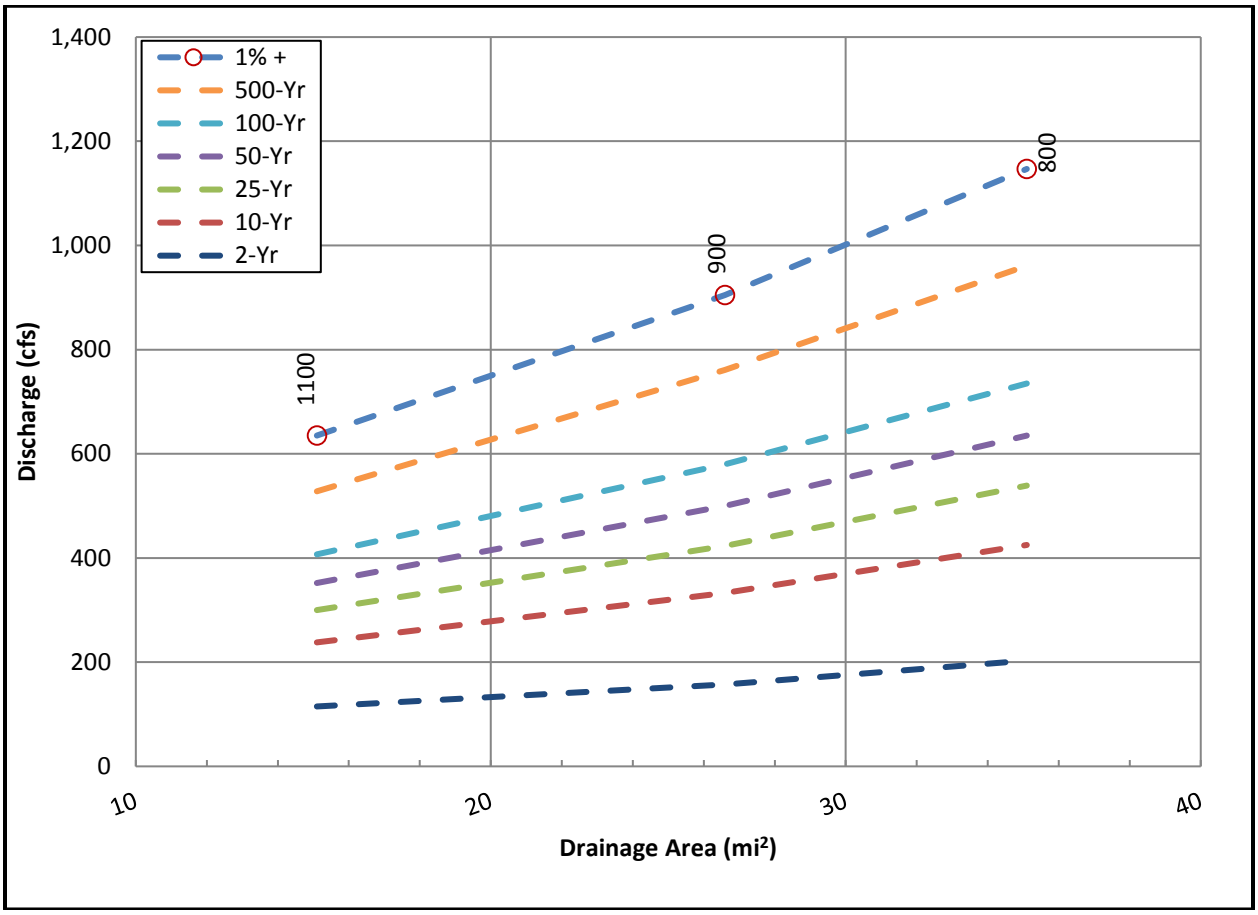
Source: StreamStats USGS 2012)

Figure 12 Meadow Creek Regional Regression Peak Flow Estimates



Data label numbers represent flow node numbers

Figure 13 Nemote Creek Regional Regression Peak Flow Estimates



Data label numbers represent flow node numbers

To determine if the regional regression equation peak flow estimates are reasonable the regional regression discharges were compared with gage analysis peak flow estimates for the USGS gages within the study area using SIR 2015-5019-D tables (Sando et al., 2015c). Table 10 summarizes the comparison.

Table 10 Study Reach Peak Flow Estimates Gage and Regional Regression Comparison

Station identification number	Station name	Drainage Area mi^2	Flow Records (year)	Period of record (water year)	Hydrologic region	Type of peak-flow frequency estimate[3]	Annual peak flow, in cubic feet per second, for indicated annual exceedance probability, in percent									
							66.7	50	42.9	20	10	4	2	1	0.5	0.2
12353400	Negro Gulch near Alberton, Montana	8.07	23	1959–73, 1984–91	W	at-site	20	28	32	55	81	124	165	215	276	375
						regression	32	43	48	74	102	135	163	193	224	264
						weighted	21	29	33	57	85	127	164	206	250	312
12353800	Thompson Creek near Superior, Montana	12.0	20	1961–79, 1982	W	at-site	50	67	76	117	154	204	244	284	326	383
						regression	94	116	127	178	231	287	335	383	433	490
						weighted	52	70	79	122	162	217	261	307	354	417
12353820	Dry Creek near Superior, Montana	44.8	10	1982–91	W	at-site	352	386	401	462	508	561	599	635	670	714
						regression	585	671	713	889	1,080	1,250	1,390	1,530	1,670	1,820
						weighted	356	390	405	469	519	580	626	672	718	777

Source: SIR 2015- 5019-D (Sando et al., 2015c).

The Thompson Creek gage (20-year period of record) and the Negro Gulch gage (23-year period of record) regional regression 1% AEP flow estimates are within 1 standard error (68% confidence interval). At the Dry Creek gage gage (10-year period of record), the 1% AEP regional regression estimate exceeds the 1% AEP gage estimate by approximately 6-standard errors. These results indicate that at the gages with periods of record longer than 10 years, the regional regression results provide reasonable estimates.

Based on these regression and gage peak flow estimate comparisons, Pioneer concluded that the regional regression method produced reasonable peak flow estimates at the study flow nodes. The Dry Creek gage analysis is interpreted to be underpredicting the 1% AEP do to the short period of record (10-years) and the regional regression estimate will provide a conservative value. Therefore, the regional regression estimate peak flow AEP estimates will be used at the Dry Creek flow node.

4 SUMMARY/DISCUSSION

Pioneer conducted a peak discharge frequency analysis for 7 tributaries to the mainstem Clark Fork. The Clark Fork River Tributaries Study reach extends 55 miles along the Clark Fork River mainstem upstream from the Mineral/Sanders County Boundary. The tributaries being evaluated contained 1 inactive USGS stream measurement gage (USGS gaging station 12353820 Dry Creek near Superior, Montana). Data from the Clark Fork River tributaries are considered to be a mixed population data set (peak flows created by different types of events). Information gathered from this analysis will be used to support the Mineral County hydraulic analyses and floodplain mapping studies.

Previous flood studies on the Clark Fork River tributaries are limited. Relevant earlier flood studies include the USGS SIR 2015-5019-C, SIR 2015-5019-D and USGS SIR 2015-5019-F peak flow data through 2011, published in 2015 (Sando et al., 2015a, Sando et al., 2015b and Sando et al., 2015c, respectively).

For this study, Pioneer conducted flood frequency estimates for both gaged and ungaged sites. Peak flow estimates were calculated at 13 flow nodes within the 7-study tributaries (1 gaged site and 12 ungaged sites). The flow nodes were located at major tributaries, population centers, and at the end of study reaches.

At the ungaged flow nodes, Pioneer used the regional regression method to calculate flood frequency peak flow estimates. Only a single stream gage exists on the Clark Fork River study tributaries (USGS stream gage 12353820); therefore, the two-station interpolation method or the gage transfer method was not used to estimate peak flows at ungaged flow nodes.

The basin parameters for the flow nodes evaluated in this study all fall within the range of basin and climatic characteristics used to develop the regional regression equations, and therefore are applicable to this study. In addition, the study regional regression 1% AEP estimates fall within 1-

standard error of stream gage analysis for stream gages in the study area that had periods of record exceeding 10-years (USGS gage station 12353400 Negro Gulch and 12353800 Thompson Creek), indicating the regional regression estimates are reasonable.

The Dry Creek gage regional regression 1% AEP estimate was approximately 6-standard errors greater than the 1% AEP gage Bulletin 17C estimate. This difference is interpreted to be attributable to Dry Creek's limited period of record (10-years).

Due to the flow node parameter's conformance with the study's basin and climatic characteristics, and the good agreement with gage peak flow estimates that exceed 10-years of record, the regional regression equations were determined to provide the most accurate peak flow estimates for the study.

Pioneer also developed peak flow 1%+ (plus) estimates for all flow nodes using standard FEMA methodologies (FEMA, 2016a).

Table 11 summarizes the recommended flood frequency discharge rates for the Clark Fork River tributaries. Figure 14 shows the recommended 1% annual discharge for each flow node location.

The hydrologic analysis results provided in Table 11 represent the recommended discharges at each flow node location throughout the study reach. Figure 14 shows the recommended 1%AEP for each flow node location. The methods used for hydrological analysis are industry accepted methods (Bulletin #17C [USGS, 2016]and SIR 2015-5019-F [Sando et al, 2015c]) based on the Clark Fork River tributaries basin characteristics. This hydrologic analysis conforms to FEMA standards for detailed/enhanced level studies (FEMA, 2017), and the recommended flows of this analysis are deemed reliable and suitable for future floodplain studies and hydraulic analyses.

Table 11 Recommended Flood Discharge Estimates using Regional Regresssion Equations

Node/USGS Station ID	Location Description	West Region Regression Estimated Discharge (cfs)						
		50% Annual Chance 2-year	10% Annual Chance 10-year	4% Annual Chance 25-year	2% Annual Chance 50-year	1% Annual Chance 100-year	0.2% Annual Chance 500-year	1% + 100-year
100	Tamarack Creek at junction with Clark Fork River	167	337	420	491	564	725	880
200	Dry Creek at junction with Clark Fork River	663	1,070	1,240	1,380	1,530	1,810	2,387
200	Cedar Creek at junction with Clark Fork River	1,170	1,760	1,990	2,190	2,380	2,750	3714
300	Trout Creek at junction with Clark Fork River	1,470	2,130	2,380	2,600	2,810	3,200	4384
400	Meadow Creek at junction with Clark Fork River	192	365	446	515	585	735	913
500	Meadow Creek upstream of Sunrise Creek Junction	117	228	282	327	373	474	582
600	Sunrise Creek at junction with Meadow Creek	83	163	202	235	268	340	418
700	Nemote Creek at junction with Clark Fork River	203	425	539	635	735	961	1147
800	Nemote Creek upstream of Miller Creek junction	157	333	423	500	580	761	905
900	Miller Creek at junction with Nemote Creek	54	123	161	193	228	307	356
1000	Nemote Creek upstream of South Fork Nemote Creek junction	115	238	300	352	407	528	635
1100	South Fork Nemote Creek at junction with Nemote Creek	41	98	128	155	183	250	286
1200	Fish Creek at junction with Clark Fork River	2,850	4,300	4,890	5,380	5,870	6,810	9159

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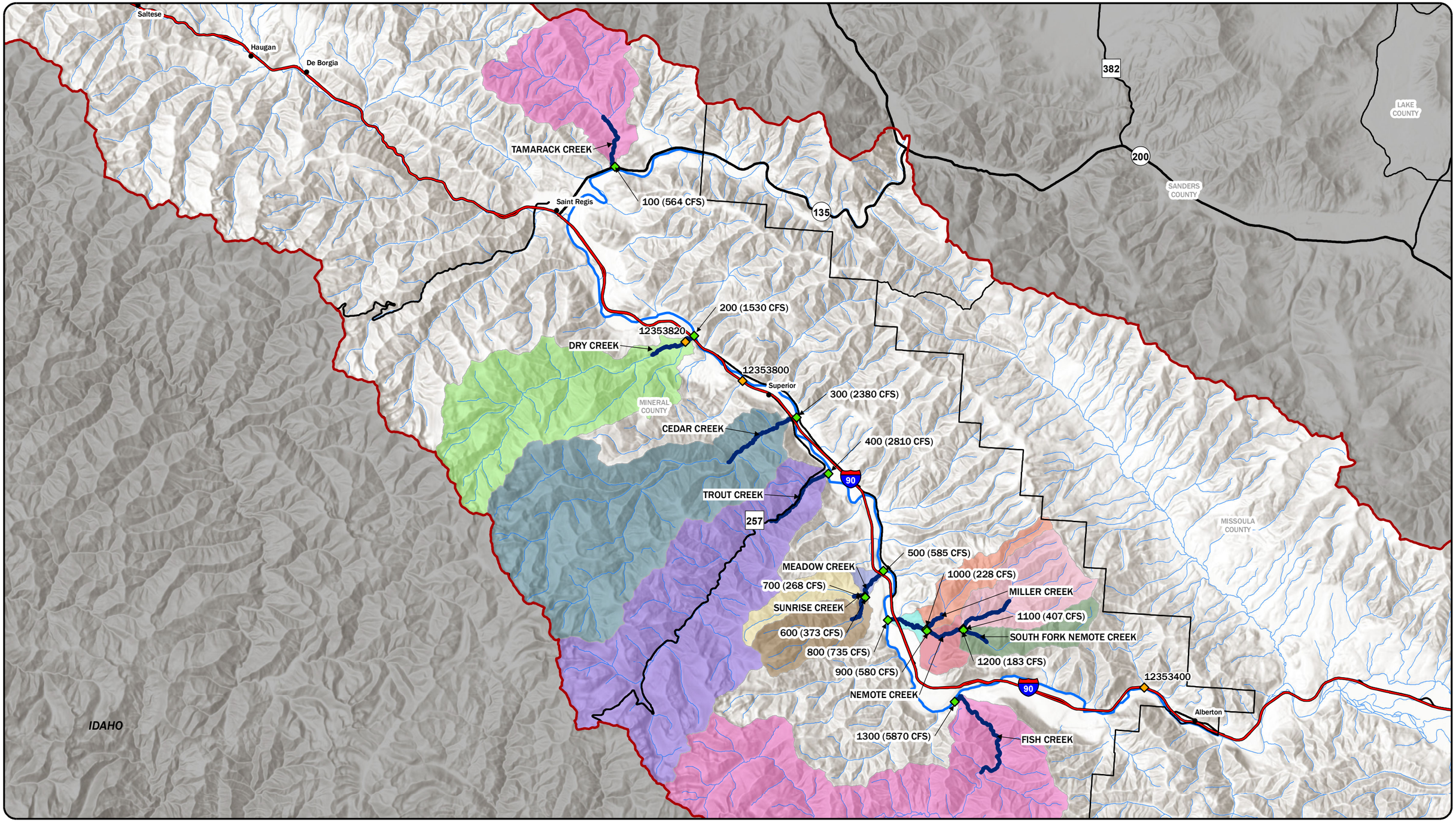

LEGEND

- FLOW NODES
- INACTIVE USGS GAGE
- TOWNS
- HUC 8 BOUNDARIES
- MONTANA COUNTY BOUNDARIES
- NHS INTERSTATE
- PRIMARY
- SECONDARY
- CLARK FORK TRIBUTARIES
- CLARK FORK RIVER STUDY REACH
- NHD HYDROGRAPHY

FLOW CHANGE NODE

100	400	900	
200	500	1000	
300	600	1100	
	700	1200	
	800	1300	

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD 1983
UNITS: INT'L FEET
SOURCE: PIONEER, MSL, USGS

0 2 4 8
Miles

FIGURE 14

PIONEER TECHNICAL SERVICES, INC.

DATE: 2/27/2018

CLARK FORK TRIBS
RECOMMENDED 1-PERCENT
ANNUAL DISCHARGE

Path: G:\DNRC\Mineral -Beaverhead County\Mineral County Tributaries\CAD-GIS\GIS\CLKFK-GI-HYD-014-18.mxd

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USGS, 2016. Draft – Guidelines for Determining Flood Flow Frequency, Bulletin 17C. U.S. Geological Survey, August 2016.

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USGS, 2014, U.S. Geological Survey Peak FQ version 7.1

https://water.usgs.gov/software/PeakFQ/.

Appendix A
Gage Flood Frequency Analysis

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.002.000
  Version 7.1         Annual peak flow frequency analysis      Run Date / Time
  3/14/2014                                                    12/15/2017 10:34

                         --- PROCESSING OPTIONS ---

                      Plot option         = None
                      Basin char output   = None
                      Print option        = Yes
                      Debug print         = No
                      Input peaks listing = Long
                      Input peaks format  = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  -
C:\Users\jjupka\Desktop\watstore\DRYCREEK.TXT
                         specifications -
C:\Users\jjupka\Desktop\watstore\PKFQWPSF.TMP
                      Output file(s):
                         main - C:\Users\jjupka\Desktop\watstore\DRYCREEK.PRT


1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Version 7.1         Annual peak flow frequency analysis      Run Date / Time
  3/14/2014                                                    12/15/2017 10:34

                Station - 12353820  Dry Creek near Superior MT


                     I N P U T   D A T A   S U M M A R Y

               Number of peaks in record            =       10
               Peaks not used in analysis           =        0
               Systematic peaks in analysis         =       10
               Historic peaks in analysis           =        0
               Beginning Year                       =     1982
               Ending Year                          =     1991
               Historical Period Length             =       10
               Generalized skew                     =   -0.273
                    Standard error                  =    0.550
                    Mean Square error               =    0.303
               Skew option                          =   WEIGHTED
               Gage base discharge                  =      0.0
               User supplied high outlier threshold =   --
               User supplied PILF (LO) criterion    =   --
               Plotting position parameter          =     0.00
               Type of analysis                       BULL.17B
               PILF (LO) Test Method                      GBT
               Perception Thresholds            =   Not Applicable
               Interval Data                    =   Not Applicable


  *********  NOTICE  --  Preliminary machine computations.        *********
  *********  User responsible for assessment and interpretation.  *********

    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                   0.0
    WCF198I-LOW OUTLIERS BELOW FLOOD BASE WERE DROPPED.       1       169.9
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.       590.8
```

```
**WCF164W-HISTORIC PERIOD IGNORED.    10.0
  WCF002J-CALCS COMPLETED.  RETURN CODE =  2
```

Kendall's Tau Parameters

	TAU	P-VALUE	MEDIAN SLOPE	No. of PEAKS
SYSTEMATIC RECORD	-0.067	0.858	-2.333	10

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.002
Version 7.1 Annual peak flow frequency analysis Run Date / Time
3/14/2014 12/15/2017 10:34

Station - 12353820 Dry Creek near Superior MT

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE		LOGARITHMIC		
	DISCHARGE	EXCEEDANCE PROBABILITY	MEAN	STANDARD DEVIATION	SKEW
SYSTEMATIC RECORD	0.0	1.0000	2.5564	0.1602	-1.682
BULL.17B ESTIMATE	169.9	0.9000	2.5870	0.0922	-0.035

BULL.17B ESTIMATE OF MSE OF AT-SITE SKEW 0.4995

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	<-- FOR BULLETIN 17B ESTIMATES --> VARIANCE OF EST.	68% CONFIDENCE INTERVALS LOWER	UPPER
0.9950		80.7	--	--	--
0.9900		101.4	--	--	--
0.9500		174.1	--	--	--
0.9000		220.9	--	--	--
0.8000	323.2	282.0	----	310.7	334.8
0.6667	352.9	339.9	----	341.1	364.4
0.5000	386.9	397.1	----	374.8	399.3
0.4292	401.8	418.9	----	389.4	415.0
0.2000	462.2	485.5	----	446.2	480.8
0.1000	506.8	515.8	----	486.8	531.3
0.0400	558.9	536.7	----	533.1	591.4
0.0200	595.3	545.3	----	564.9	633.9
0.0100	629.8	550.4	----	594.9	674.8
0.0050	663.1	553.5	----	623.6	714.4
0.0020	705.6	555.8	----	660.0	765.6

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Version 7.1 Annual peak flow frequency analysis Run Date / Time
3/14/2014 12/15/2017 10:34

Station - 12353820 Dry Creek near Superior MT

I N P U T D A T A L I S T I N G

WATER YEAR	PEAK VALUE	PEAKFQ CODES	REMARKS
1982	404.0		
1983	319.0		
1984	506.0		
1985	431.0		
1986	360.0		
1987	400.0		
1988	146.0		
1989	305.0		
1990	363.0		
1991	560.0		

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Version 7.1 Annual peak flow frequency analysis Run Date / Time
3/14/2014 12/15/2017 10:34

Station - 12353820 Dry Creek near Superior MT

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	B17B ESTIMATE
1991	560.0	0.0909	0.0909
1984	506.0	0.1818	0.1818
1985	431.0	0.2727	0.2727
1982	404.0	0.3636	0.3636
1987	400.0	0.4545	0.4545
1990	363.0	0.5455	0.5455
1986	360.0	0.6364	0.6364
1983	319.0	0.7273	0.7273
1989	305.0	0.8182	0.8182
1988	146.0	0.9091	0.9091

1

```
 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      10

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  12353820       USGS Dry Creek near Superior MT


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.002.000
  Version 7.1         Annual peak flow frequency analysis      Run Date / Time
  3/14/2014                                                    12/15/2017 10:30

                         --- PROCESSING OPTIONS ---

                      Plot option         = None
                      Basin char output   = None
                      Print option        = Yes
                      Debug print         = No
                      Input peaks listing = Long
                      Input peaks format  = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  -
C:\Users\jjupka\Desktop\watstore\DRYCREEK.TXT
                         specifications -
C:\Users\jjupka\Desktop\watstore\PKFQWPSF.TMP
                      Output file(s):
                         main - C:\Users\jjupka\Desktop\watstore\DRYCREEK.PRT


1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Version 7.1         Annual peak flow frequency analysis      Run Date / Time
  3/14/2014                                                    12/15/2017 10:30

                 Station - 12353820  Dry Creek near Superior MT


                     I N P U T   D A T A   S U M M A R Y

               Number of peaks in record            =       10
               Peaks not used in analysis           =        0
               Systematic peaks in analysis         =       10
               Historic peaks in analysis           =        0
               Beginning Year                       =     1982
               Ending Year                          =     1991
               Historical Period Length             =       10
               Generalized skew                     =   -0.273
                    Standard error                  =    0.550
                    Mean Square error               =    0.303
               Skew option                          =   WEIGHTED
               Gage base discharge                  =      0.0
               User supplied high outlier threshold =   --
               User supplied PILF (LO) criterion    =   --
               Plotting position parameter          =     0.00
               Type of analysis                            EMA
               PILF (LO) Test Method                      MGBT
               Perception Thresholds:
                    Begin     End       Low     High     Comment
                     1982    1991       0.0       INF     DEFAULT

               Interval Data                    =   None Specified


  *********  NOTICE  --  Preliminary machine computations.        *********
  *********  User responsible for assessment and interpretation.  *********
```

```
WCF002J-CALCS COMPLETED.  RETURN CODE =  2
EMA003I-PILFS (LOS) WERE DETECTED USING MULTIPLE GRUBBS-BECK TEST   1     305.0
  THE FOLLOWING PEAKS (WITH CORRESPONDING P-VALUES) WERE CENSORED:
        146.0    (0.0055)
EMA002W-CONFIDENCE INTERVALS ARE NOT EXACT IF HISTORIC PERIOD > 0
```

Kendall's Tau Parameters

	TAU	P-VALUE	MEDIAN SLOPE	No. of PEAKS
SYSTEMATIC RECORD	-0.067	0.858	-2.333	10

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.002
Version 7.1 Annual peak flow frequency analysis Run Date / Time
3/14/2014 12/15/2017 10:30

Station - 12353820 Dry Creek near Superior MT

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	LOGARITHMIC MEAN	LOGARITHMIC STANDARD DEVIATION	LOGARITHMIC SKEW
EMA W/O REG. INFO	2.5846	0.0950	0.428
EMA W/REG. INFO	2.5831	0.0978	-0.067

EMA ESTIMATE OF MSE OF SKEW W/O REG. INFO (AT-SITE) 0.5061
EMA ESTIMATE OF MSE OF SKEW W/SYSTEMATIC ONLY (AT-SITE) 0.5061

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	EMA W/ REG INFO ESTIMATE	EMA W/O REG INFO ESTIMATE	<------ FOR EMA ESTIMATES ------> VARIANCE OF EST.	68% CONFIDENCE INTERVALS LOWER	UPPER
0.9950	211.4	238.8	0.0085	146.5	245.4
0.9900	224.3	247.6	0.0068	160.8	256.1
0.9500	263.3	275.9	0.0036	205.0	290.1
0.9000	286.5	293.8	0.0025	232.4	311.6
0.8000	317.1	318.7	0.0017	269.8	341.6
0.6667	348.2	345.6	0.0013	308.9	374.2
0.5000	383.9	378.3	0.0010	351.2	413.6
0.4292	399.6	393.4	0.0010	368.4	431.4
0.2000	463.1	459.1	0.0012	429.5	508.5
0.1000	510.2	512.6	0.0016	469.7	572.6
0.0400	565.0	580.7	0.0024	513.7	655.8
0.0200	603.1	631.9	0.0031	542.6	718.9
0.0100	639.4	683.6	0.0039	568.8	782.7
0.0050	674.3	736.3	0.0049	592.8	847.6
0.0020	718.8	808.0	0.0063	621.8	935.8

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Version 7.1 Annual peak flow frequency analysis Run Date / Time
3/14/2014 12/15/2017 10:30

Station - 12353820 Dry Creek near Superior MT

I N P U T D A T A L I S T I N G

WATER YEAR	PEAK VALUE	PEAKFQ CODES	<--- Intervals ---> LOW	HIGH	REMARKS
1982	404.0				
1983	319.0				
1984	506.0				
1985	431.0				
1986	360.0				
1987	400.0				
1988	146.0				
1989	305.0				
1990	363.0				
1991	560.0				

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Version 7.1 Annual peak flow frequency analysis Run Date / Time
3/14/2014 12/15/2017 10:30

Station - 12353820 Dry Creek near Superior MT

EMPIRICAL FREQUENCY CURVES -- HIRSCH-STEDINGER PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	EMA ESTIMATE	INTERVALS LOW	HIGH
1991	560.0	0.0909		
1984	506.0	0.1818		
1985	431.0	0.2727		
1982	404.0	0.3636		
1987	400.0	0.4545		
1990	363.0	0.5455		

```
    1986      360.0     0.6364
    1983      319.0     0.7273
    1989      305.0     0.8182
  * 1988      146.0     0.9091

    * DENOTES PILF (LO)

1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.005
  Version 7.1         Annual peak flow frequency analysis      Run Date / Time
  3/14/2014                                                    12/15/2017 10:30

                Station - 12353820  Dry Creek near Superior MT


                         EMA REPRESENTATION OF DATA

  WATER <----- OBSERVED-----><-------- EMA -------><-PERCEPTION THRESHOLDS->
   YEAR    Q_LOWER    Q_UPPER    Q_LOWER    Q_UPPER        LOWER       UPPER
   1982      404.0      404.0      404.0      404.0        305.0        INF
   1983      319.0      319.0      319.0      319.0        305.0        INF
   1984      506.0      506.0      506.0      506.0        305.0        INF
   1985      431.0      431.0      431.0      431.0        305.0        INF
   1986      360.0      360.0      360.0      360.0        305.0        INF
   1987      400.0      400.0      400.0      400.0        305.0        INF
   1988      146.0      146.0        0.0      305.0        305.0        INF
   1989      305.0      305.0      305.0      305.0        305.0        INF
   1990      363.0      363.0      363.0      363.0        305.0        INF
   1991      560.0      560.0      560.0      560.0        305.0        INF
1


 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      10


Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  12353820       USGS Dry Creek near Superior MT


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

Appendix B
Regional Regression Calculations

Streamstats West Regression Calculations												
						West Region Regression						
						Estimated Discharge (cfs)						
Node/USGS Station ID	Location Description	Study Reach River Station (miles)	Basin Area (mi^2)	F (%)	P (in)	50% Annual Chance 2-year	10% Annual Chance 10-year	4% Annual Chance 25-year	2% Annual Chance 50-year	1% Annual Chance 100-year	0.2% Annual Chance 500-year	1% + 100-year
100	Tamarack Creek at junction with Clark Fork River	0.1	27.6	88.4	34.0	167	337	420	491	564	725	880
200	Dry Creek at junction with Clark Fork River	0.0	44.9	77.0	48.8	663	1,070	1,240	1,380	1,530	1,810	2,387
300	Cedar Creek at junction with Clark Fork River	0.1	71.0	79.2	52.7	1,170	1,760	1,990	2,190	2,380	2,750	3,714
400	Trout Creek at junction with Clark Fork River	0.1	71.4	73.3	56.6	1,470	2,130	2,380	2,600	2,810	3,200	4,384
500	Meadow Creek at junction with Clark Fork River	0.0	18.7	76.5	40.2	192	365	446	515	585	735	913
600	Meadow Creek upstream of Sunrise Creek Junction	2.0	11.1	80.1	40.5	117	228	282	327	373	474	582
700	Sunrise Creek at junction with Meadow Creek	0.0	6.5	78.2	43.1	83	163	202	235	268	340	418
800	Nemote Creek at junction with Clark Fork River	0.0	35.1	70.9	30.9	203	425	539	635	735	961	1,147
900	Nemote Creek upstream of Miller Creek junction	2.6	26.6	73.1	31.2	157	333	423	500	580	761	905
1000	Miller Creek at junction with Nemote Creek	0.1	7.5	67.4	31.6	54	123	161	193	228	307	356
1100	Nemote Creek upstream of South Fork Nemote Creek junction	4.9	15.1	76.9	34.9	115	238	300	352	407	528	635
1200	South Fork Nemote Creek at junction with Nemote Creek	0.1	7.7	80.3	29.6	41	98	128	155	183	250	286
1300	Fish Creek at junction with Clark Fork River	0.1	260.4	72.5	44.5	2,850	4,300	4,890	5,380	5,870	6,810	9,159

West hydrologic region (recommended by SIR 2015-5019-F)

$Q_{66.7} = 0.047\ A^{0.943}\ P^{2.44}\ (F+1)^{-0.840}$

$Q_{50} = 0.131\ A^{0.920}\ P^{2.24}\ (F+1)^{-0.845}$

$Q_{42.9} = 0.199\ A^{0.910}\ P^{2.16}\ (F+1)^{-0.847}$

$Q_{20} = 0.906\ A^{0.876}\ P^{1.88}\ (F+1)^{-0.864}$

$Q_{10} = 2.44\ A^{0.853}\ P^{1.71}\ (F+1)^{-0.875}$

$Q_{4} = 6.61\ A^{0.831}\ P^{1.53}\ (F+1)^{-0.890}$

$Q_{2} = 12.2\ A^{0.818}\ P^{1.42}\ (F+1)^{-0.896}$

$Q_{1} = 21.5\ A^{0.806}\ P^{1.32}\ (F+1)^{-0.904}$

$Q_{0.5} = 35.5\ A^{0.796}\ P^{1.23}\ (F+1)^{-0.910}$

$Q_{0.2} = 63.5\ A^{0.783}\ P^{1.12}\ (F+1)^{-0.915}$

[QAEP, peak-flow magnitude, in cubic feet per second, for annual exceedance probability (AEP) in percent; n, number of streamflow-gaging stations used in developing regression equations for indicated hydrologic region; σδ2, model error variance; MVP, mean variance of prediction; SEP, mean standard error of prediction; SEM, mean standard error of model; Pseudo R2, pseudo coefficient of determination; A, contributing drainage area, in square miles; P, mean annual precipitation, in inches; F, percentage of basin that is forest; E5000, percentage of basin above 5,000 feet elevation; SLP30, percentage of basin with slope greater than 30 percent; ETSPR, Mean spring (March–June) evapotranspiration, in inches per

Upper and Lower Confidence Limits of Regression Predicted Discharges

Flow Node	$Q_{AEP,0}$ 1% Annual Chance	Upper 84% Confidence Limit 1%+
100	564	880
200	1,530	2387
300	2,380	3714
400	2,810	4384
500	585	913
600	373	582
700	268	418
800	735	1147
900	580	905
1000	228	356
1100	407	635
1200	183	286
1300	5,870	9159

Regression equation for indicated Q_{AEP}	*SEP* , in percent
West hydrologic region	
$Q_{50} = 0.047A^{0.943} P^{2.44} (F + 1)^{-0.840}$	56.5
$Q_{10} = 2.44 A^{0.853} P^{1.71} (F + 1)^{-0.875}$	52.8
$Q_{4} = 6.61 A^{0.831} P^{1.53} (F + 1)^{-0.890}$	53.2
$Q_{2} = 12.2 A^{0.818} P^{1.42} (F + 1)^{-0.896}$	54.2
$Q_{1} = 21.5 A^{0.806} P^{1.32} (F + 1)^{-0.904}$	56.0
$Q_{0.2} = 63.5 A^{0.783} P^{1.12} (F + 1)^{-0.915}$	61.4

Appendix C
Digital Data and Calculation Files