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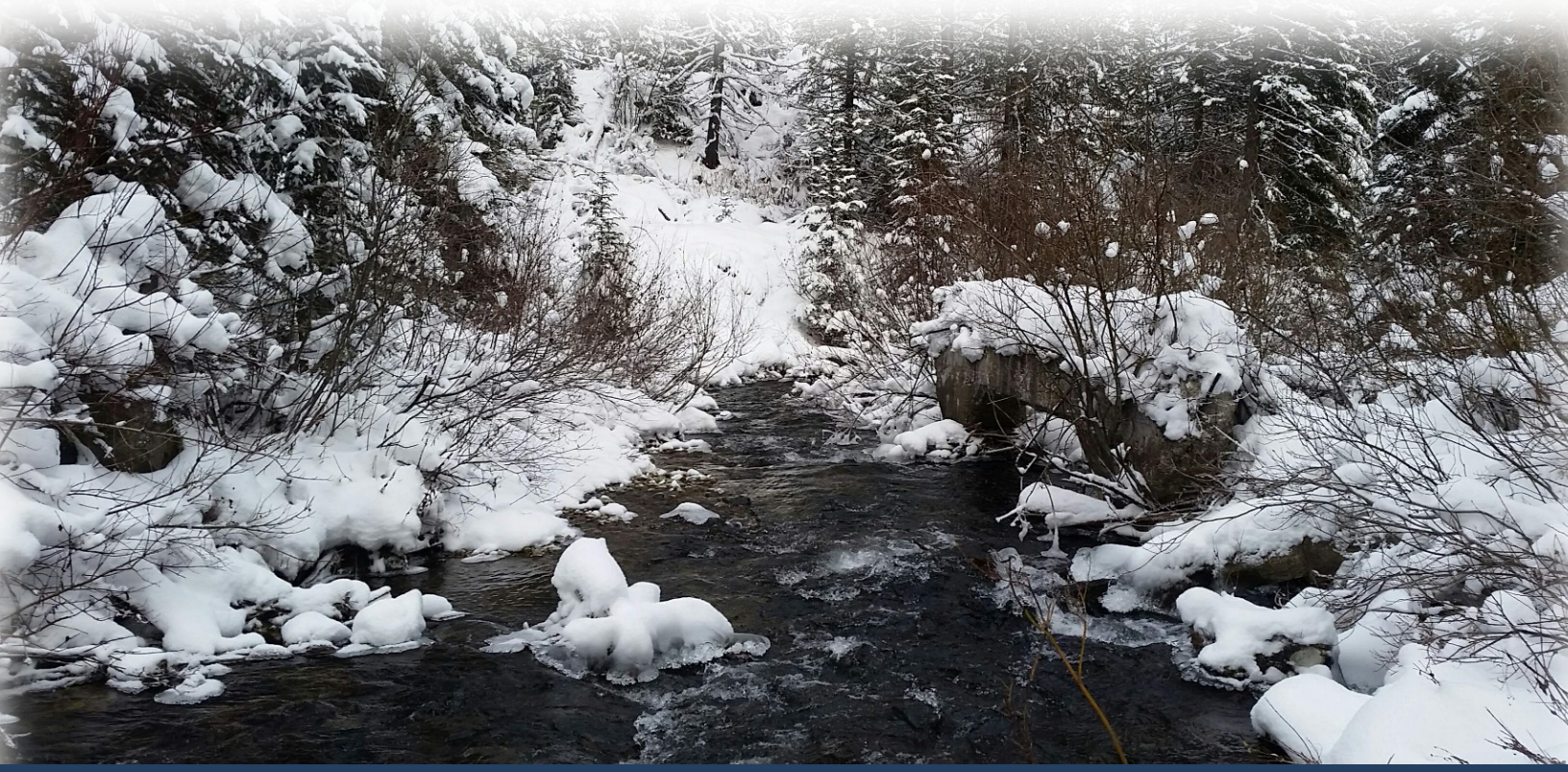

Mineral County Modernization Project, Phase II
St. Regis River Tributary Study Area
Hydrologic Analysis Report

Montana Department of Natural Resources and Conservation (DNRC)

March 1, 2018

Pioneer Technical Services, Inc. 106 Pronghorn Trail, Bozeman Montana 59718

www.pioneer-technical.com

Mineral County Modernization Project Phase II

St. Regis River Tributaries Study Area Hydrologic Analysis Report

Prepared for:

State of Montana, Department of Natural Resources and Conservation

1424 9th Avenue

Helena, Montana 59620

Prepared by:

Pioneer Technical Services, Inc.

106 Pronghorn Trail

Bozeman, Montana 59718

St. Regis 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.

George Austiguy P.E.

Date: 03-01-18 Montana Registration No. 9528

Pioneer Technical Services, Inc.
106 Pronghorn Trail, Suite A
Bozeman, MT 59718

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EXECUTIVE SUMMARY

Flood flow frequency calculations were conducted for tributaries along the mainstem St. Regis River. The St. Regis River tributary study reach covers the entire St. Regis River, which extends from the headwaters at Lookout Pass on the Montana-Idaho border to the confluence with the Clark Fork River in the city of St. Regis. Information gathered from this analysis will be used in conjunction with the previous mainstem analysis for both enhanced and base level hydraulic analyses and floodplain mapping.

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

The 13 tributaries analyzed in this report flow to the St. Regis River, a tributary to the Clark Fork River, located west of the continental divide in western Montana. The watershed is formed by the Bitterroot Mountains to the south and the Coeur d'Alene Mountains to the north. The study watershed basin area encompasses the entire St. Regis watershed area of approximately 363 square miles (HUC-12 area).

The primary cause of flooding on the St. Regis 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 1960 documenting basin flood history. Past flood studies for the St. Regis 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 St. Regis 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 27 locations (flow nodes) within the 13 St. Regis River tributaries (0 gaged sites and 27 ungaged sites). Peak flow estimates at the 27 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 East Fork of Timber Creek near Haugan, Montana (16-years of record), and North Fork Little Joe Creek near St. Regis, Montana (15-years of record), indicate reasonable agreement with the gage-based flood frequency analysis.

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

1 INTRODUCTION

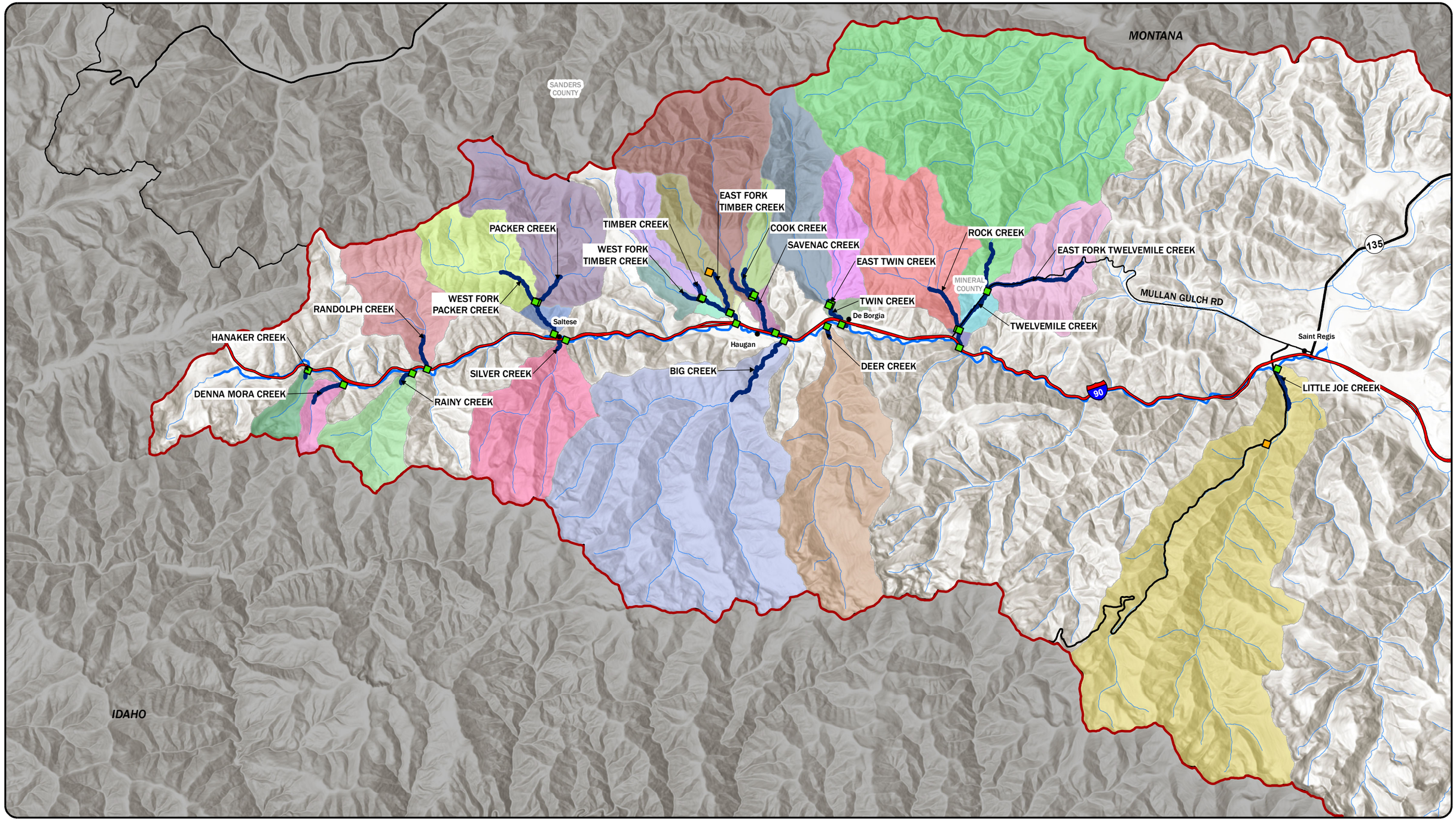
As part of the Mineral County Modernization Phase II St. Regis River Floodplain Study activities, the Montana Department of Natural Resources and Conservation (DNRC) contracted Pioneer Technical Services, Inc. (Pioneer) to complete a comprehensive peak flow hydrologic analysis for 13 St. Regis River tributaries in the study reach. Pioneer completed flood flow frequency calculations for 13 tributaries that report to the mainstem St. Regis River. The St. Regis River tributary study reach covers the entire St. Regis River, which extends from the headwaters at Lookout Pass on the Montana-Idaho border to the confluence with the Clark Fork River in the city of St. Regis. This study area encompasses approximately 363 square miles. The study area hydrologic analysis report for the St. Regis River (Pioneer, 2017) detailed the analysis that was previously completed on the mainstem. Information gathered from this analysis will be used in conjunction with the previous mainstem analysis for both enhanced and base level hydraulic analyses and floodplain mapping. Figure 1 shows the project study reach.

1.1 Background Information

The Federal Emergency Management Agency (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 St. Regis River tributaries in the Mineral County study area are sparsely populated with a predominantly rural environment. The existing floodplain mapping for the mainstem 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 enhanced 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 and base level analyses 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
- PRIMARY
- SECONDARY
- CITY/COUNTY
- ST. REGIS TRIBUTARIES PROFILE BASELINES
- ST. REGIS RIVER STUDY REACH
- NHD HYDROGRAPHY
- FLOW CHANGE NODE
  - 100
  - 200
  - 300
  - 400
  - 500
  - 600
  - 700
  - 800
  - 900
  - 1000
  - 1100
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  - 2100
  - 2200
  - 2300
  - 2400
  - 2500
  - 2600
  - 2700

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

0 1.25 2.5 5
Miles

FIGURE 1

ST. REGIS RIVER TRIBUTARIES STUDY AREA

PIONEER TECHNICAL SERVICES, INC.

DATE: 2/27/2018

Path: G:\DNRC\Mineral -Beaverhead County\Mineral County Tributaries\CAD-GIS\GIS\STRGS-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 St. Regis River tributaries. This St. Regis River Tributaries Hydrologic Analysis report will provide the groundwork for completing floodplain mapping projects along the St. Regis 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 analysis also included calculation of the 1% + (plus) annual chance discharge estimates and conforms to FEMA standards for detailed/enhanced level studies (FEMA, 2017).

1.2 Basin Description

The 13 tributaries analyzed in this report flow to the St. Regis River, a tributary to the Clark Fork River, located west of the continental divide in western Montana. The watershed is formed by the Bitterroot Mountains to the south and the Coeur d'Alene Mountains to the north. The study watershed basin area encompasses the entire St. Regis watershed area of approximately 363 square miles (HUC-12 area).

The St. Regis River basin elevations within the study area range from approximately 5,200 feet in in the headwaters near St. Regis Lake to approximately 2,600 feet in the city of St. Regis. The overall basin elevations range from 7,300 feet in the Bitterroot Mountains to 2,600 feet near the confluence with the Clark Fork River. The terrain varies from a high alpine environment in its headwaters to narrow inter-mountain valleys. The hydrology of the basin is primarily snowmelt driven, although significant flows can result from precipitation events. Land use in the St. Regis River basin is primarily agricultural with irrigated farming and ranching operations.

1.3 Flood History

There are historical records from U.S. Geological Survey (USGS) stream gages on two St. Regis River tributaries within the study area that document St. Regis River tributary flooding history. The gages are:

1. East Fork Timber Creek near Haugan, MT 12353850.
2. North Fork Little Joe Creek near St. Regis, MT 12354100.

The USGS stream gage East Fork Timber Creek near Haugan, MT (12353850) has a 16-year period of record (1961-1975, 1979). The annual peak flow record for the East Fork Timber Creek gage is shown in Figure 2. The Timber Creek drainage is one of the 13 tributary basins evaluated in this report.

The USGS stream gage North Fork Little Joe Creek near St. Regis, MT (12354100) has a 15-year period of record (1960–1974). The annual peak flow record for the North Fork Little Joe Creek gage is shown in Figure 3. The North Fork Little Joe Creek drainage is one of the 13 tributary basins evaluated in this report.

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

There are no records that document the flooding mechanisms on the St. Regis River tributaries. Because the primary cause of flooding on the St. Regis 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 the East Fork of Timber Creek occurred in water year 1979 with a flow of 112 cubic feet per second (cfs), matching the 1% (100-year) chance annual flow of 112 cfs. The second highest flood on record occurred in 1965 with a flow of 66 cfs. In the 16-year period of record at the East Fork Timber Creek gage, the 10-year flow has been exceeded 1 time, which was in 1979.

Figure 3 shows that the peak flood of record on the North Fork of Little Joe Creek occurred in water year 1972 with a flow of 295 cfs, exceeding the 10% (10-year) chance annual flow of 268 cfs. In the 15-year period of record at the North Fork Little Joe Creek gage, the 10-year flow has been exceeded 1 time, which was in 1972.

From 1961 -1975, the main stem St. Regis peak flood was in 1974 (no records from 1975-2002).

Figure 2 East Fork Timber Creek near Haugan (12353850)

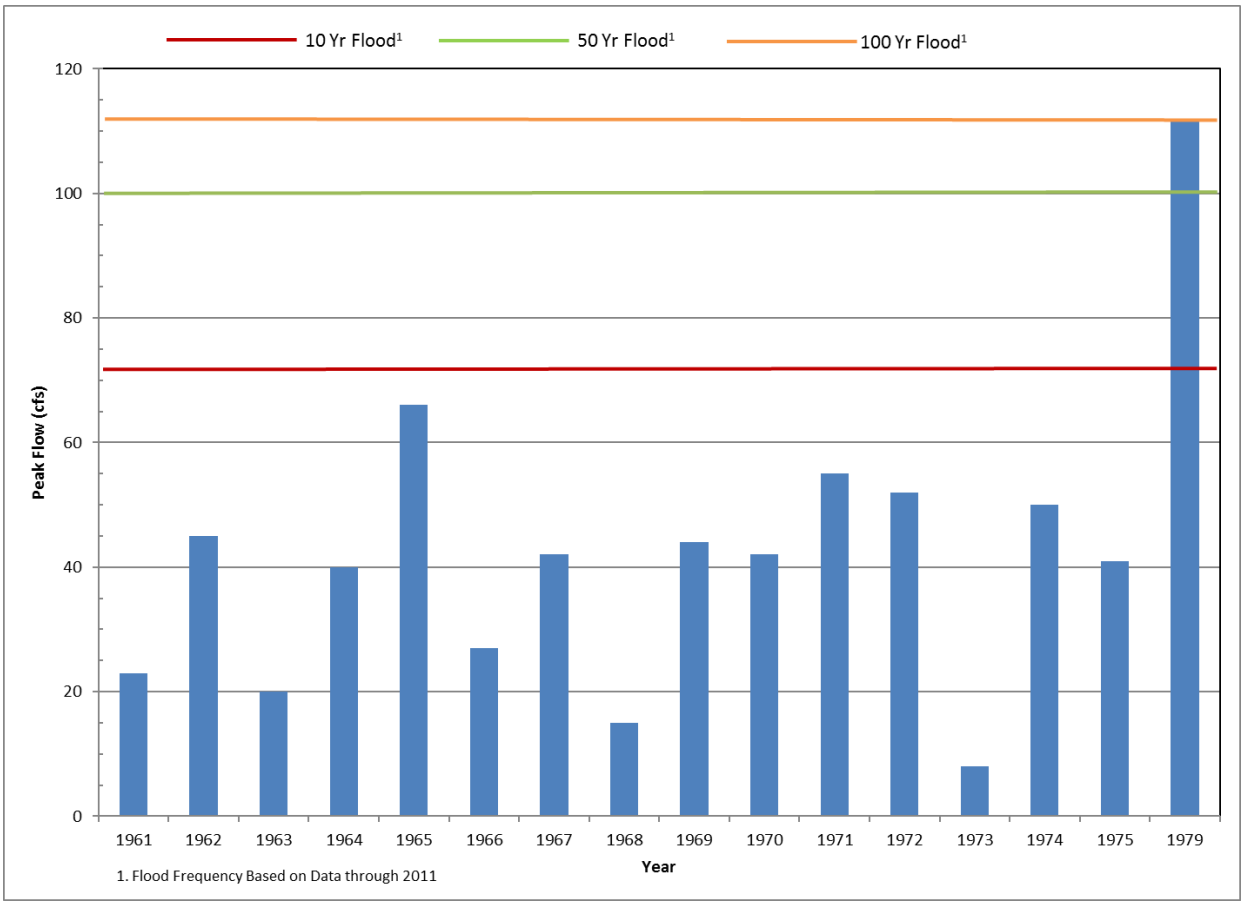
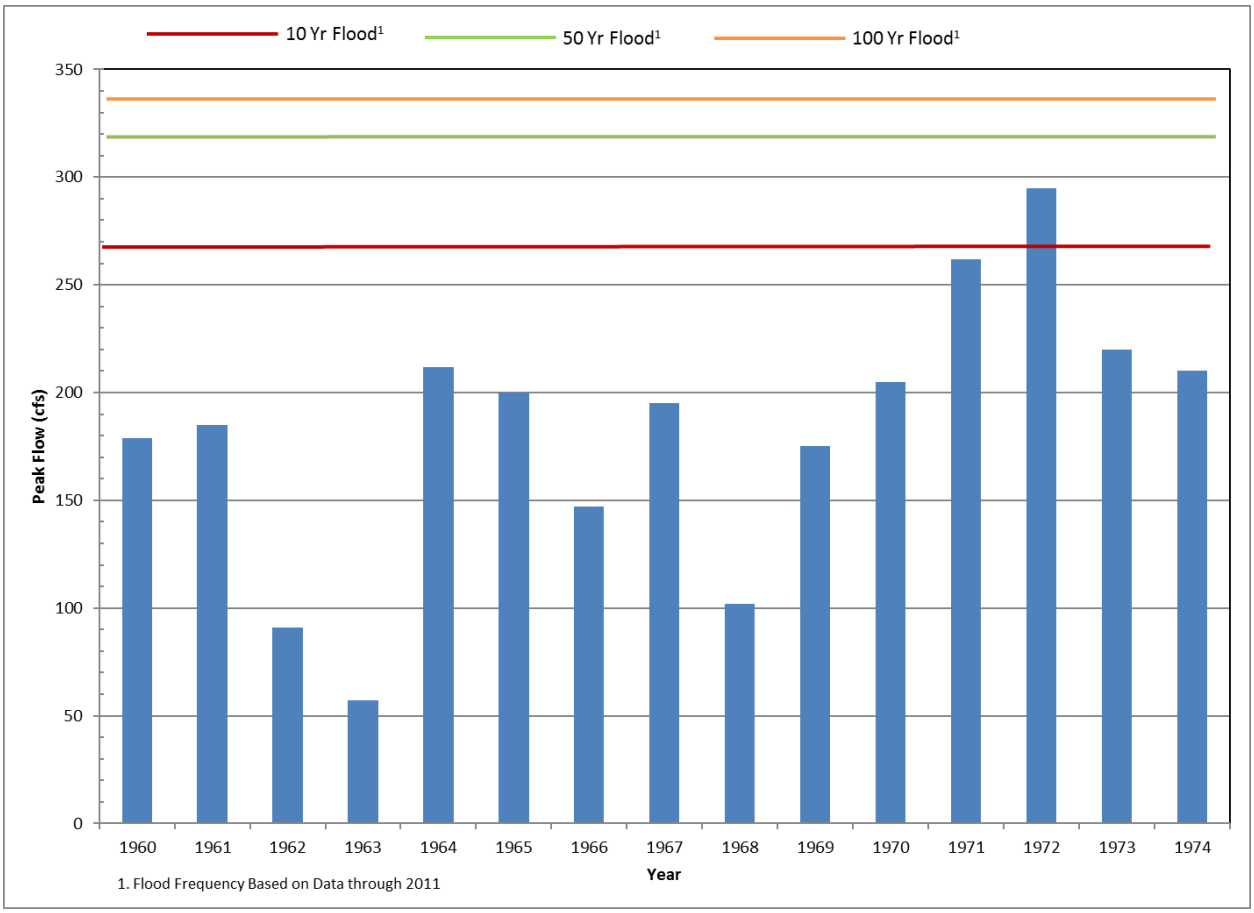


Figure 3 North Fork Little Joe Creek near St. Regis (12354100)



2 PAST STUDIES AND EXISTING FLOOD DATA

Past flood studies for the St. Regis River are limited. Studies relevant to this analysis were those that included peak flow frequency analyses. There are no FEMA Flood Insurance Studies within the mainstem St. Regis River basin in Mineral County. Table 1 shows a summary of the mainstem St. Regis River Tributaries Floodplain Mapping.

Table 1 St. Regis River Tributaries Floodplain Mapping Summary

County	Map Panel Summary					Study Details			
	Community	# of FIRM Panels	# of FBFM Panels	FIRM Panel Effective Date	FIS Date	Stream	Approx. (mi)	Detailed (mi)	Total (mi)
Mineral	Mineral Co.	4	0	11/1/1996	none	Hanaker Creek, Denna Mora Creek, Rainy Creek, Randolph Creek, Silver Creek, Packer Creek, Timber Creek, Savanac Creek, Big Creek, Deer Creek, Twin Creek, Twelvemile Creek, Little Joe Creek	30	NA	NA

Source: FEMA Map Service Center

FBFM: Flood Boundary and Floodway Map. FIRM: Flood Insurance Rate Map. FIS: Flood Insurance Studies

mi: Miles measured along channel alignment

The SIR 2015-5019-C document (Sando et al., 2015a) provides flood frequency analysis on the two St. Regis River tributary gages in the study area. The SIR is 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., 2015a). 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.

The USGS SIR 2015-5019-F (Sando et al., 2015b) selected 537 gaging stations from the SIR 2015-5019-C gage study (Sando et al., 2015a). 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. Table 2 provides the SIR 2015-5019-F (Sando et al., 2015b) discharge summary for the St. Regis River tributary gages.

Table 2 SIR-2015-5019-F St. Regis 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) (cfs)							
				2	5	10	25	50	100	200	500
12353850	East Fork Timber Creek near Haugan, MT	2.8	16	39	58	72	88	100	112	123	138
12354100	N. Fork Little Joe Creek near St. Regis, MT	14.6	15	184	238	268	300	319	337	352	370

Based on systematic data through 2011. USGS: U.S. Geological Survey. mi^2: square miles. cfs: cubic feet per second.

2.2 Additional Previous Studies

Additional related previous studies conducted on the St. Regis River tributaries are limited and related to total maximum daily load assessments such as the Montana Department of Environmental Quality (DEQ) *St. Regis Watershed Total Maximum Daily Loads and Framework Water Quality Restoration Assessment* report (DEQ, 2008).

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 was organized into three sections:

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

Within the study area, 27 locations (flow change nodes) on 13 St. Regis River tributaries were identified as having significant changes in streamflow or being at a critical location. Out of the 27 flow change nodes, 2 are in gaged tributaries and 11 are within ungaged basins. The study tributaries were based on the Mineral County Modernization Phase II St. Regis River study area map provided by the DNRC. Detailed profile baselines and river stationing for each tributary were developed as part of this analysis. The study area begins at the confluence of the St. Regis

River and the Clark Fork River. The upstream extent of the study reach ends at the border of Mineral County and the Idaho state line.

3.1 Stream Gage Analysis

There are 2 discontinued USGS stream gages located within the St. Regis River tributary study area:

1. East Fork Timber Creek near Haugan, MT 12353850.
2. North Fork Little Joe Creek near St. Regis, MT 12354100.

The USGS stream gage East Fork Timber Creek near Haugan, MT (12353850) has a 16-year period of record (1961-1975, 1979). The USGS stream gage North Fork Little Joe Creek near St. Regis, MT (12354100) has a 15-year period of record (1960–1974). While both gages are in tributary basins evaluated for this report, they are both located upstream from their respective basin's study area boundary (see Figure 1). Consequently, they could not be used as flow nodes; however, they were both candidates for use in gage-transfer calculations within their basin area.

The FEMA guidance documents (FEMA, 2017) indicate that gage station records equal or exceeding 10-years in length are applicable to all types of studies. Both the East Fork Timber Creek near Haugan, MT and the North Fork Little Joe Creek near St. Regis, MT meet 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., 2015a). 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. The USGS gaging stations East Fork Timber Creek near Haugan, MT (12353850) and the North Fork Little Joe Creek near St. Regis, MT (12354100) were included in the USGS analysis.

In 2016, the USGS began implementing Bulletin 17C guidelines to provide estimates for selected stream gages operated by the Wyoming-Montana 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 St. Regis River USGS gages using Bulletin 17C methods on gage data through 2016. Pioneer performed a flood frequency analysis for the East Fork Timber Creek and the North Fork Little Joe Creek gages using Bulletin 17C methods, to update the previous gage peak flow analysis to be consistent with the mainstem flood frequency analyses. The calculations were conducted using the USGS PEAK FQ flood frequency analysis software (USGS, 2014). Calculations are provided in Appendix A.

The 1% + (plus) AEP event was calculated using FEMA methodology (FEMA, 2016b) for the East Fork Timber Creek and the North Fork Little Joe Creek gages to provide a confidence range that the 1% flood frequency peak flow estimates were 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 East Fork Timber Creek and the North Fork Little Joe Creek gages.

Table 3 shows a summary of the East Fork Timber and North Fork Little Joe Creek gages. The flood frequency analysis results for the gages, using Bulletin 17C methods (USGS, 2016), are shown in Table 4. Table 5 compares flood frequency estimates between the SIR 2015-5019-C analysis (Sando et al., 2015a) using Bulletin 17B and this study's Bulletin 17C analysis.

Table 3 St. Regis River Tributary 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)
12353850	East Fork Timber Creek near Haugan, MT	2.8	1961–75, 1979	16	NA
12354100	North Fork Little Joe Creek near St. Regis, MT	14.6	1960–74	15	NA

1. Source: National Water Information System (NWIS).
2. Data from SIR 2015-5019-C, Table 1-1 (Sando et al., 2015a).
mi^2: square miles. NA: Not applicable.

Table 4 St. Regis 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)									
			1.5	2	5	10	25	50	100	200	500	100+
12353850	East Fork Timber Creek near Haugan, MT	1961–75, 1979	30	38	61	76	95	109	122	138	153	171
12354100	North Fork Little Joe Creek near St. Regis, MT	1960–74	177	193	229	250	275	293	309	325	346	366

cfs: cubic feet per second.

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
12353850	East Fork Timber Creek near Haugan, MT	39	38	58	61	72	76	88	95	100	109	112	122	123	136	138	153	132	171
12354100	North Fork Little Joe Creek near St. Regis, MT	184	193	238	229	268	250	300	275	319	293	337	309	352	325	370	346	370	366

cfs: cubic feet per second.

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 tributaries, the locations of major tributary confluences and other flow change locations must be identified. The results from 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 identified 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 significant 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), 13 flow nodes were located just upstream of each tributary confluence with the mainstem St. Regis River. Additional flow nodes were located where study reach sub-tributaries joined tributary mainstems. In total, 27 flow nodes were identified. Table 6 summarizes the 27-flow nodes used in the study. Figure 4 through Figure 9map the flow node locations within their corresponding watershed areas 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 St Regis River mainstem, FEMA guidance requirements assuming coincident peaks were referenced. For the assumption of coincident peaks to be appropriate, FEMA guidance documents (FEMA, 2016a) 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.
3. The likelihood of both watersheds being covered by the storm is high.

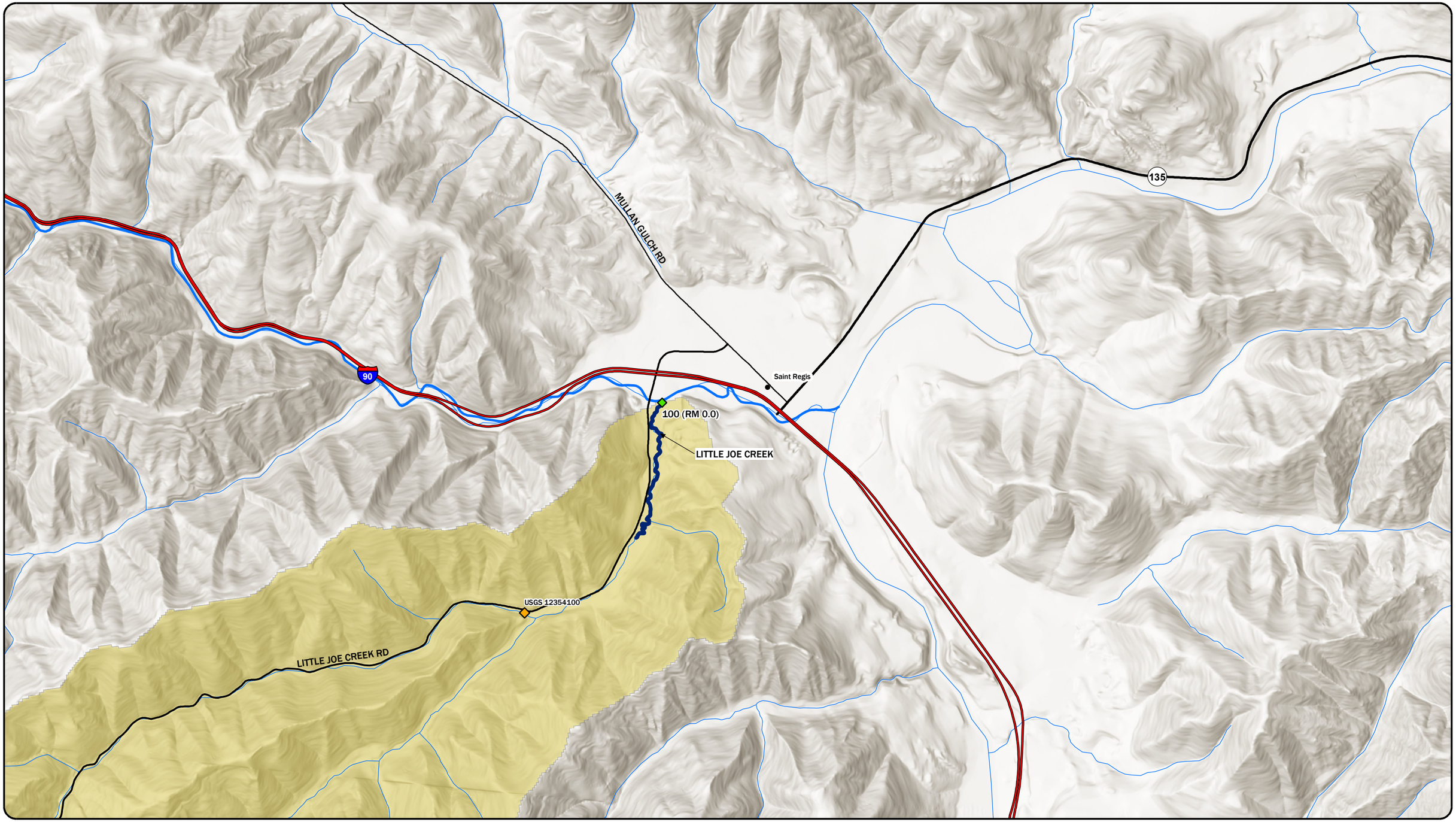
The study tributaries do not meet these drainage area ratio criteria. Study tributaries and the St. Regis river mainstem are not gaged at the tributary's/mainstem confluence. Therefore, data to determine criteria No. 2 is not available. The St. Regis river mainstem drainage area at the tributary confluences is one or more 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 determined that the tributaries do not meet the FEMA criteria for coincident peaks.

Table 6 Flow Node Information Used in Hydrologic Analyses

Node Number	Location Description	Tributary River Station (mi)	Calculated Basin Area (StreamStats) (mi^2)	Tributary
100	Little Joe Creek at junction with St. Regis River	0.0	43.51	Little Joe Creek
200	Twelvemile Creek at junction with St. Regis River	0.0	59.96	Twelvemile Creek
300	Twelvemile Creek upstream of Rock Creek junction	0.6	48.95	Twelvemile Creek
400	Rock Creek at junction with Twelvemile Creek	0.1	10.83	Twelvemile Creek
500	Twelvemile Creek upstream of East Fork Twelvemile Creek junction	2.2	40.58	Twelvemile Creek
600	East Fork Twelvemile Creek at junction with Twelvemile Creek	0.0	7.25	Twelvemile Creek
700	Twin Creek at junction with St. Regis River	0.2	11.82	Twin Creek
800	West Twin Creek at junction with Twin Creek	1.0	7.73	Twin Creek
900	East Twin Creek at junction with Twin Creek	0.1	3.52	Twin Creek
1000	Deer Creek at junction with St. Regis River	0.1	16.70	Deer Creek
1100	Savenac Creek at junction with St. Regis River	0.5	15.07	Savenac Creek
1200	Savenac Creek upstream of Cook Creek junction	2.3	12.57	Savenac Creek
1300	Cook Creek at junction with Savenac Creek	0.1	1.89	Savenac Creek
1400	Big Creek at junction with St. Regis River	0.0	37.99	Big Creek
1500	Timber Creek at junction with St. Regis River	0.0	8.35	Timber Creek
1600	Timber Creek upstream of East Fork Timber Creek junction	0.5	4.78	Timber Creek
1700	East Fork Timber Creek at junction with Timber Creek	0.0	3.42	Timber Creek
1800	Timber Creek upstream of West Fork Timber Creek junction	1.6	3.04	Timber Creek
1900	West Fork Timber Creek at junction with Timber Creek	0.1	1.29	Timber Creek
2000	Silver Creek at junction with St. Regis River	0.0	9.86	Silver Creek
2100	Packer Creek at junction with St. Regis River	0.1	18.21	Packer Creek
2200	Packer Creek upstream of West Fork Packer Creek junction	1.4	10.44	Packer Creek

Node Number	Location Description	River Station (mi)	StreamStats Calculated Basin Area (mi^2)	Tributary
2300	West Fork Packer Creek at junction with Packer Creek	0.0	7.03	Packer Creek
2400	Randolph Creek at junction with St. Regis River	0.1	6.96	Randolph Creek
2500	Rainy Creek at junction with St. Regis River	0.0	4.58	Rainy Creek
2600	Denna Mora Creek at junction with St. Regis River	0.1	1.41	Denna Mora Creek
2700	Hanaker Creek at junction with St. Regis River	0.0	1.62	Hanaker Creek

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



LEGEND

- INACTIVE USGS GAGE
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- HUC 8 BOUNDARIES
- NHS INTERSTATE
- PRIMARY
- SECONDARY
- CITY/COUNTY
- ST. REGIS TRIBUTARIES PROFILE BASELINES
- ST. REGIS 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 2,000 4,000 8,000
Feet

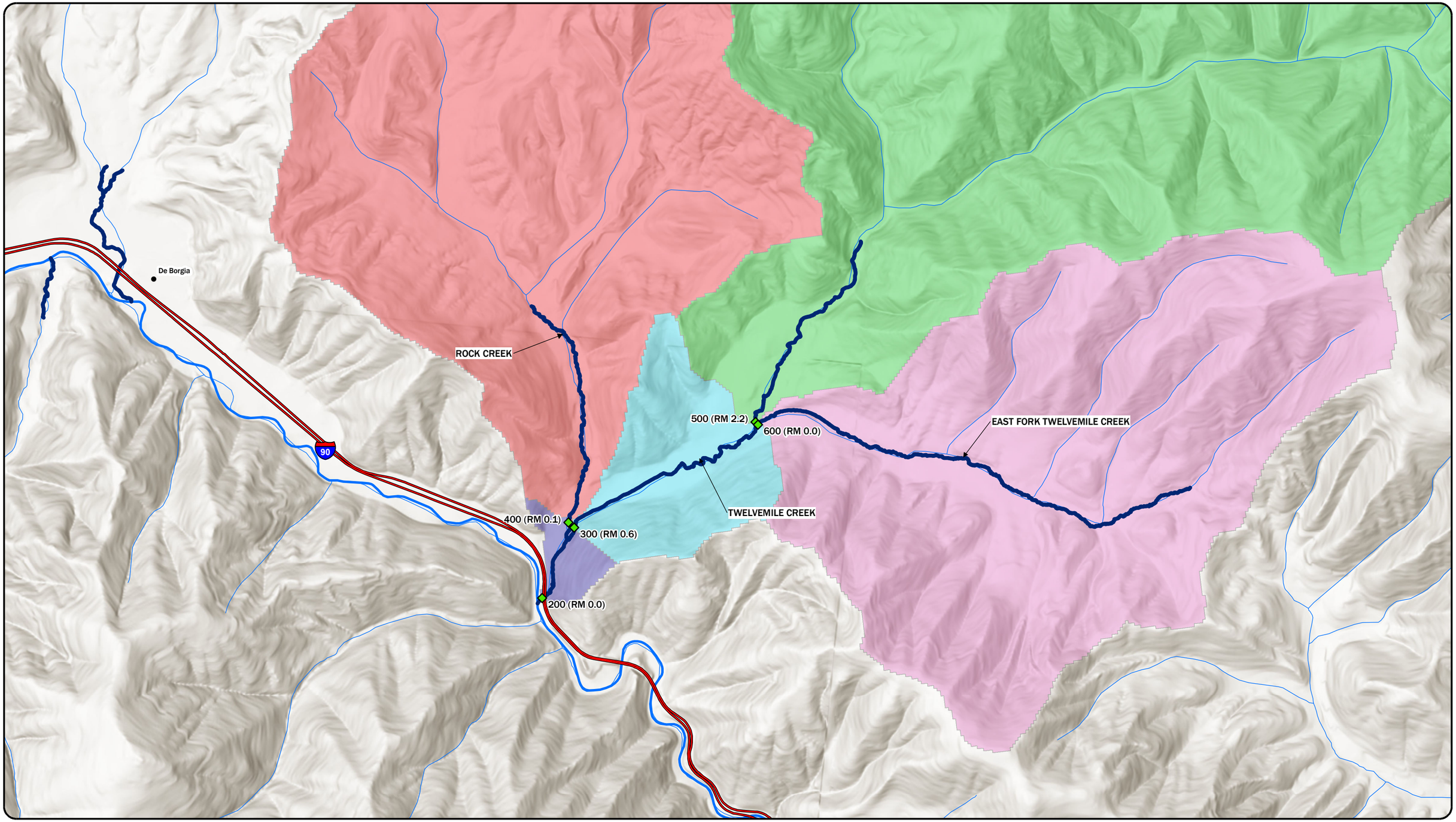
FIGURE 4

PIONEER TECHNICAL SERVICES, INC.

TRIBUTARY BASIN
LITTLE JOE CREEK
FLOW NODE LOCATION

DATE: 2/15/2018

Path: G:\DNRC\Mineral -Beaverhead County\Mineral County Tributaries\CAD-GIS\GIS\STRGS-GI-HYD-004-18.mxd



LEGEND

- FLOW NODES
- TOWNS
- HUC 8 BOUNDARIES
- NHS INTERSTATE
- ST. REGIS TRIBUTARIES PROFILE BASELINES
- ST. REGIS RIVER STUDY REACH
- NHD HYDROGRAPHY

FLOW CHANGE NODE

- 200
- 300
- 400
- 500
- 600

N

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

0 1,500 3,000 6,000
Feet

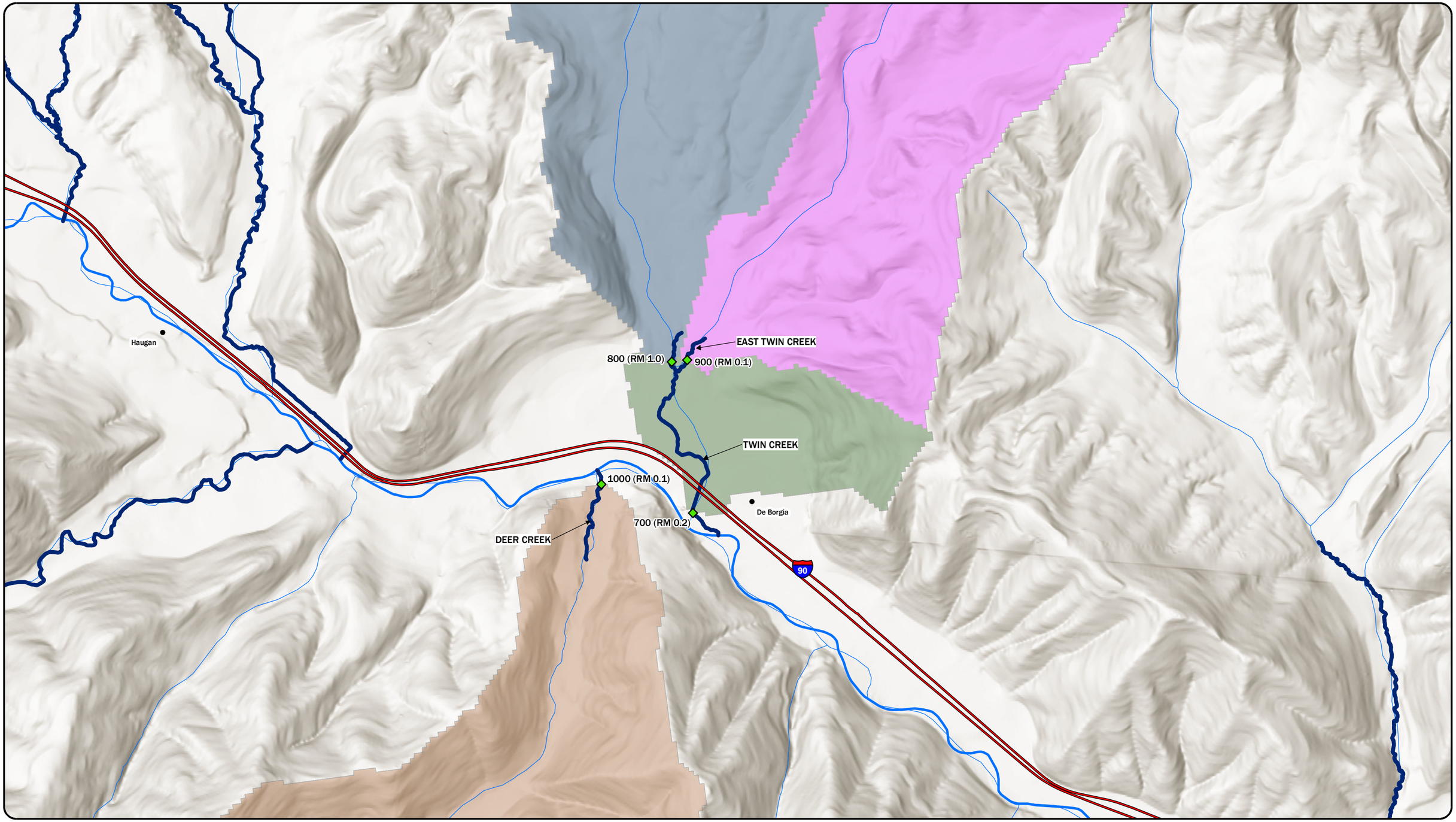
FIGURE 5

PIONEER TECHNICAL SERVICES, INC.

TRIBUTARY BASIN
TWELVEMILE CREEK
FLOW NODE LOCATIONS

DATE: 2/15/2018

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



LEGEND

- FLOW NODES
- TOWNS
- HUC 8 BOUNDARIES
- NHS INTERSTATE
- ST. REGIS TRIBUTARIES PROFILE BASELINES
- ST. REGIS RIVER STUDY REACH
- NHD HYDROGRAPHY

FLOW CHANGE NODE

- 700
- 800
- 900
- 1000

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

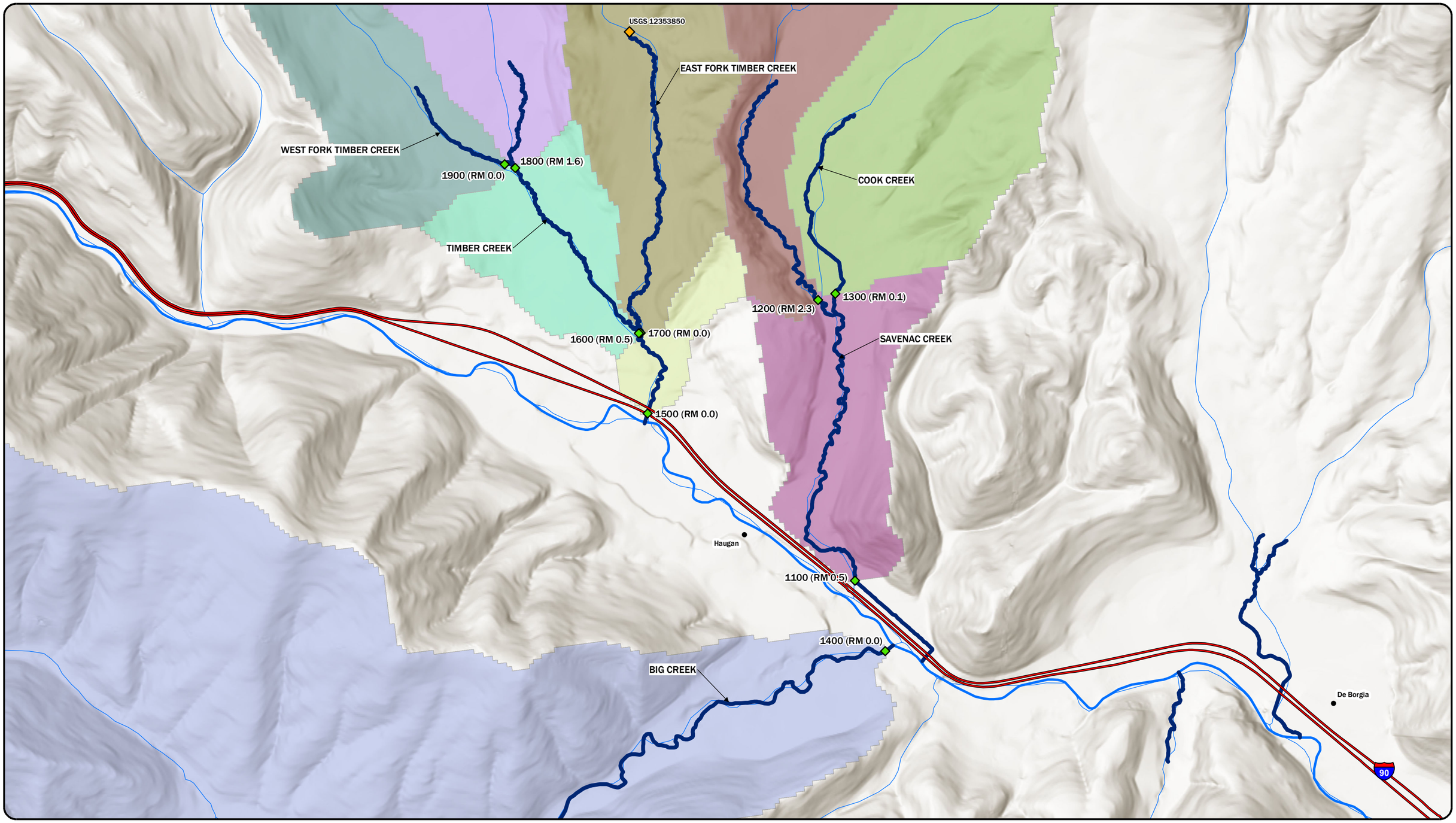
FIGURE 6

TRIBUTARY BASIN
TWIN & DEER CREEKS
FLOW NODE LOCATIONS

PIONEER TECHNICAL SERVICES, INC.

DATE: 2/15/2018

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



LEGEND

- INACTIVE USGS GAGE
- FLOW NODES
- TOWNS
- HUC 8 BOUNDARIES
- NHS INTERSTATE
- ST. REGIS TRIBUTARIES PROFILE BASELINES
- ST. REGIS RIVER STUDY REACH
- NHD HYDROGRAPHY
- FLOW CHANGE NODE
- 1100
- 1200
- 1300
- 1400
- 1500
- 1600
- 1700
- 1800
- 1900

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 7

PIONEER TECHNICAL SERVICES, INC.

TRIBUTARY BASIN
BIG, SAVENAC, & TIMBER CREEKS
FLOW NODE LOCATIONS

DATE: 2/15/2018

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

WEST FORK PACKER CREEK

PACKER CREEK

2300 (RM 0.0)

2200 (RM 1.4)

2100 (RM 0.1)

Saltese

SILVER CREEK

2000 (RM 0.0)

LEGEND

- FLOW NODES
- TOWNS
- HUC 8 BOUNDARIES
- NHS INTERSTATE
- ST. REGIS TRIBUTARIES PROFILE BASELINES
- ST. REGIS RIVER STUDY REACH
- NHD HYDROGRAPHY

FLOW CHANGE NODE

- 2000
- 2100
- 2200
- 2300

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

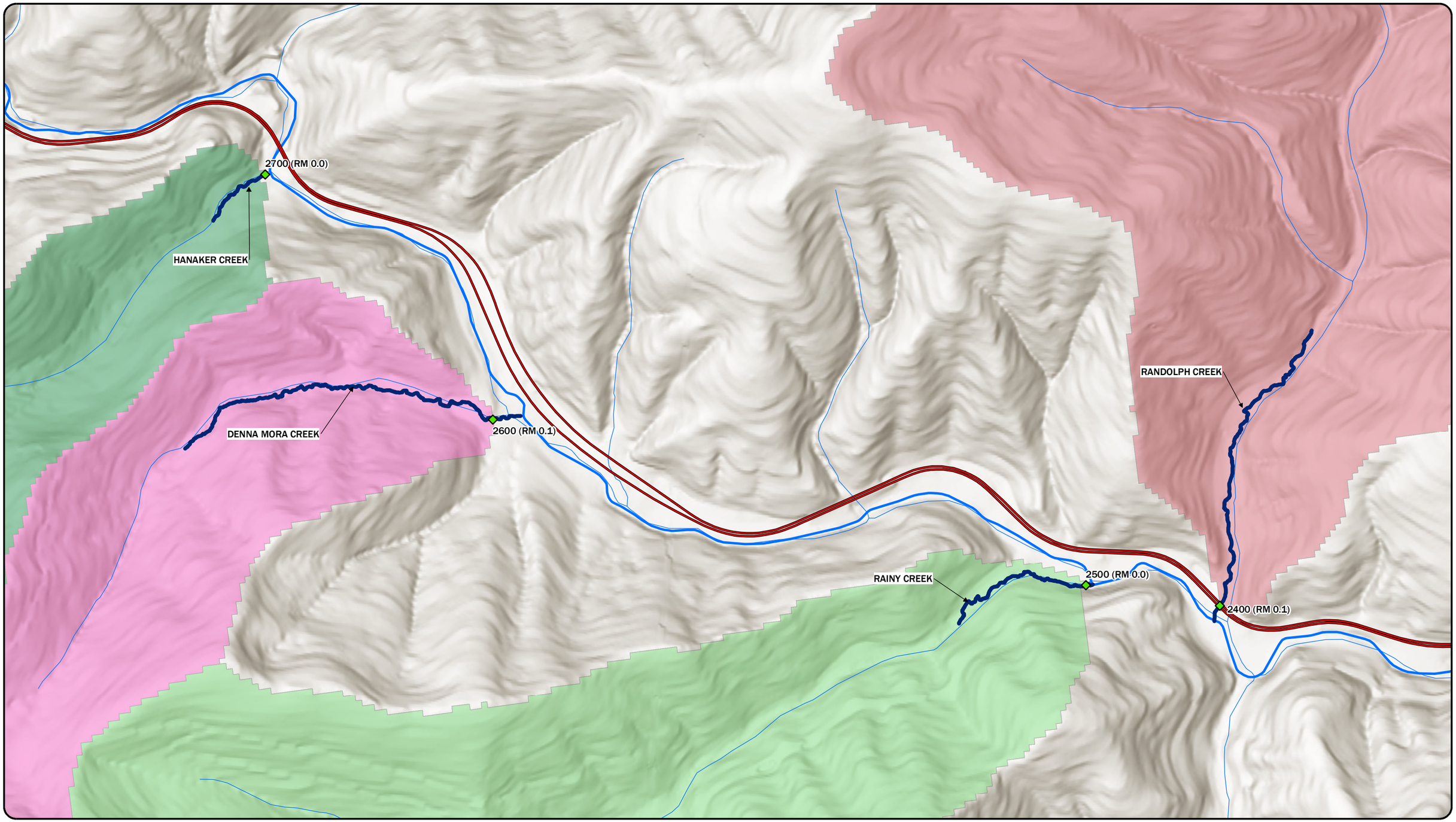
FIGURE 8

TRIBUTARY BASIN
PACKER & SILVER CREEKS
FLOW NODE LOCATIONS

PIONEER TECHNICAL SERVICES, INC.

DATE: 2/15/2018

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



LEGEND

- FLOW NODES
- HUC 8 BOUNDARIES
- NHS INTERSTATE
- ST. REGIS TRIBUTARIES PROFILE BASELINES
- ST. REGIS RIVER STUDY REACH
- NHD HYDROGRAPHY
- 2700

FLOW CHANGE NODE

- 2400
- 2500
- 2600

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.

TRIBUTARY BASIN
RANDOLPH, RAINY, DENNA
MORA, & HANAKER CREEKS
FLOW NODE LOCATIONS

DATE: 2/15/2018

Path: G:\DNRC\Mineral -Beaverhead County\Mineral County Tributaries\CAD-GIS\GIS\STRGS-GI-HYD-009-18.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., 2015b) 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 St. Regis River Tributary Study reach is within the West Hydrologic region as defined by SIR 2015-5019-F (Sando et al., 2015b). 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 St. Regis River tributary drainages are considered regulated. Therefore, the flow nodes meet the SIR 2015-5019-F guidelines and regional regression equations are applicable.

The study area USGS gages, one on the East Fork of Timber Creek near Haugan, MT (12353850) and the other on the North Fork Little Joe Creek near St. Regis, MT (12354100), are the only USGS gages within their respective tributary basin. Therefore, no two-station gage interpolation methods were possible for this analysis. Both the study-area gages are potential candidates for estimating peak flows on the same stream using the drainage-area adjustment method. The drainage-area adjustment method is considered unreliable if the drainage-area ratio of the ungaged site to the gaged site (D_U/D_G) is less than 0.5 or greater than 1.5 (Sando et al., 2015b). Within the Timber Creek basin there are 4-ungaged flow nodes (Figure 7). Of the 4-ungaged flow nodes, 3 are on Timber Creek upstream from the confluence with the East Fork of Timber Creek and not downstream from the USGS gage. The fourth flow node (1500) does not meet the drainage area ratio criteria. Therefore, the drainage area ration adjustment gage transfer is not applicable on Timber Creek.

Within the Little Joe Creek basin (Figure 4), there is 1-ungaged flow node (100). The drainage area ratio between the ungaged flow node and the USGS North Fork Little Joe Creek gage station does not meet the drainage area ratio criteria. Therefore, the drainage area ration adjustment gage transfer is not applicable on Little Joe Creek.

3.3.1 Regional Regression Equations Method

Ungaged flow nodes located on the St. Regis 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., 2015b):

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

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 27 flow nodes were calculated using the USGS StreamStats software (USGS, 2018).

The 1%+ (plus) AEP event was calculated using FEMA guidance methodologies (FEMA, 2016b) for all the flow nodes to provide a confidence limit of plus 1-standard error that the 1% flood frequency peak flow estimates were likely to fall below. 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., 2015b) was used to define the equation's statistical confidence upper limit of plus one standard error, (FEMA, 2016b). The resulting upper limit of plus one standard error 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 Hydrologic Region regression equation input variables are shown in Table 7. Regional regression flood frequency peak flow estimates are presented in Table 8. For the five tributary basins that include more than one flow node (Twelvemile Creek, Twin Creek, Savenac Creek, Timber Creek, and Packer Creek), Figure 10 through Figure 14 plot the calculated peak discharges and correlating drainage areas for the five basins. Results indicate increasing flow magnitude with increasing drainage area.

Table 7 Regional Regression Variables

Node/USGS Station ID	Location Description	Study Reach River Station (miles)	Basin Area (mi^2)	F (%)	P (in)
100	Little Joe Creek at junction with St. Regis River	0.0	43.5	86.8	45.00
200	Twelvemile Creek at junction with St. Regis River	0.0	60.0	94.4	35.27
300	Twelvemile Creek upstream of Rock Creek junction	0.6	48.9	94.9	36.28
400	Rock Creek at junction with Twelvemile Creek	0.1	10.8	92.9	30.85
500	Twelvemile Creek upstream of East Fork Twelvemile Creek junction	2.2	40.6	95.4	37.17
600	East Fork Twelvemile Creek at junction with Twelvemile Creek	0.0	7.3	94.9	32.81
700	Twin Creek at junction with St. Regis River	0.2	11.8	80.4	34.05
800	West Twin Creek at junction with Twin Creek	1.0	7.7	83.0	35.55
900	East Twin Creek at junction with Twin Creek	0.1	3.5	78.4	32.05
1000	Deer Creek at junction with St. Regis River	0.1	16.7	88.9	46.21
1100	Savenac Creek at junction with St. Regis River	0.5	15.1	93.0	35.67
1200	Savenac Creek upstream of Cook Creek junction	2.3	12.6	96.2	36.99
1300	Cook Creek at junction with Savenac Creek	0.1	1.9	79.4	29.79
1400	Big Creek at junction with St. Regis River	0.0	38.0	83.2	45.51
1500	Timber Creek at junction with St. Regis River	0.0	8.4	78.6	32.15
1600	Timber Creek upstream of East Fork Timber Creek junction	0.5	4.8	75.4	32.79
1700	East Fork Timber Creek at junction with Timber Creek	0.0	3.4	84.0	31.50
1800	Timber Creek upstream of West Fork Timber Creek junction	1.6	3.0	84.1	35.05
1900	West Fork Timber Creek at junction with Timber Creek	0.1	1.3	71.6	29.22
2000	Silver Creek at junction with St. Regis River	0.0	9.9	92.0	47.82
2100	Packer Creek at junction with St. Regis River	0.1	18.2	90.0	44.44
2200	Packer Creek upstream of West Fork Packer Creek junction	1.4	10.4	92.1	43.28
2300	West Fork Packer Creek at junction with Packer Creek	0.0	7.0	86.3	47.30
2400	Randolph Creek at junction with St. Regis River	0.1	7.0	82.3	51.52
2500	Rainy Creek at junction with St. Regis River	0.0	4.6	84.6	56.94

Node/USGS Station ID	Location Description	Study Reach River Station (miles)	Basin Area (mi^2)	F (%)	P (in)
2600	Denna Mora Creek at junction with St. Regis River	0.1	1.4	94.9	53.59
2700	Hanaker Creek at junction with St. Regis River	0.0	1.6	83.1	56.42

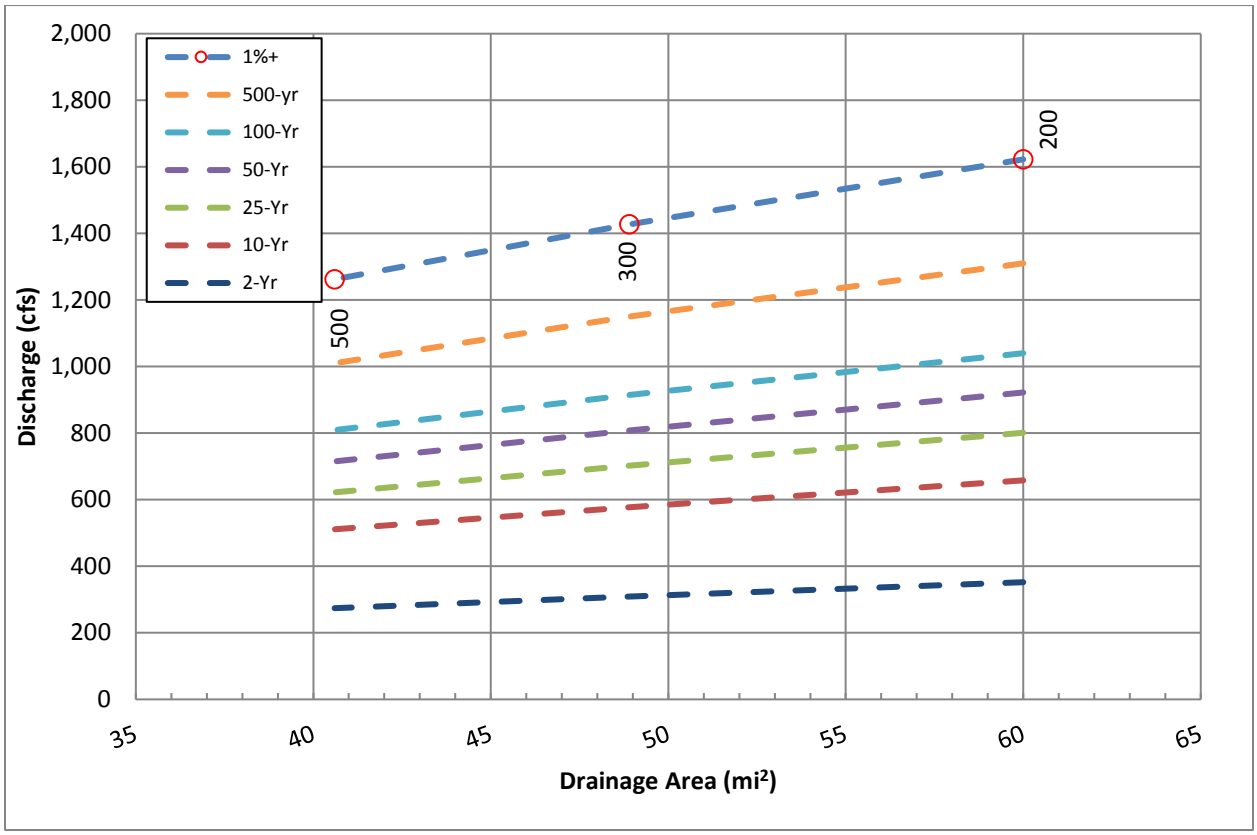
Table 8 Regional Regression Flood Frequency Peak Flow Estimates

Node/USGS Station ID	Location Description	West Region Regression						
		Estimated Discharge (cfs)						
		50% Annual Chance	10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance	1% +
		2-year	10-year	25-year	50-year	100-year	500-year	100-year
100	Little Joe Creek at junction with St. Regis River	485	816	958	1,080	1,200	1,440	1,872
200	Twelvemile Creek at junction with St. Regis River	352	658	801	922	1,040	1,310	1,622
300	Twelvemile Creek upstream of Rock Creek junction	309	577	702	808	915	1,150	1,427
400	Rock Creek at junction with Twelvemile Creek	55	123	159	190	223	298	348
500	Twelvemile Creek upstream of East Fork Twelvemile Creek junction	274	511	622	715	809	1,010	1,262
600	East Fork Twelvemile Creek at junction with Twelvemile Creek	43	96	124	148	173	231	270
700	Twin Creek at junction with St. Regis River	83	178	226	267	310	407	484
800	West Twin Creek at junction with Twin Creek	60	129	165	195	226	297	353
900	East Twin Creek at junction with Twin Creek	24	58	77	93	110	150	172
1000	Deer Creek at junction with St. Regis River	209	369	441	501	561	687	875
1100	Savenac Creek at junction with St. Regis River	103	209	262	307	353	456	551
1200	Savenac Creek upstream of Cook Creek junction	92	185	232	271	311	400	485

Node/USGS Station ID	Location Description	West Region Regression						
		Estimated Discharge (cfs)						
		50% Annual Chance	10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance	1% +
		2-year	10-year	25-year	50-year	100-year	500-year	100-year
1300	Cook Creek at junction with Savenac Creek	12	30	41	50	60	85	94
1400	Big Creek at junction with St. Regis River	455	769	904	1,020	1,130	1,370	1,763
1500	Timber Creek at junction with St. Regis River	55	123	159	190	223	299	348
1600	Timber Creek upstream of East Fork Timber Creek junction	35	82	107	128	151	205	236
1700	East Fork Timber Creek at junction with Timber Creek	22	52	69	83	99	135	154
1800	Timber Creek upstream of West Fork Timber Creek junction	24	56	73	87	103	138	161
1900	West Fork Timber Creek at junction with Timber Creek	9	23	32	39	48	68	74
2000	Silver Creek at junction with St. Regis River	136	243	292	333	374	460	583
2100	Packer Creek at junction with St. Regis River	205	368	441	503	565	696	881
2200	Packer Creek upstream of West Fork Packer Creek junction	113	214	261	300	341	427	532
2300	West Fork Packer Creek at junction with Packer Creek	101	188	228	261	295	367	460
2400	Randolph Creek at junction with St. Regis River	128	227	271	307	344	421	537
2500	Rainy Creek at junction with St. Regis River	106	183	217	245	273	331	426

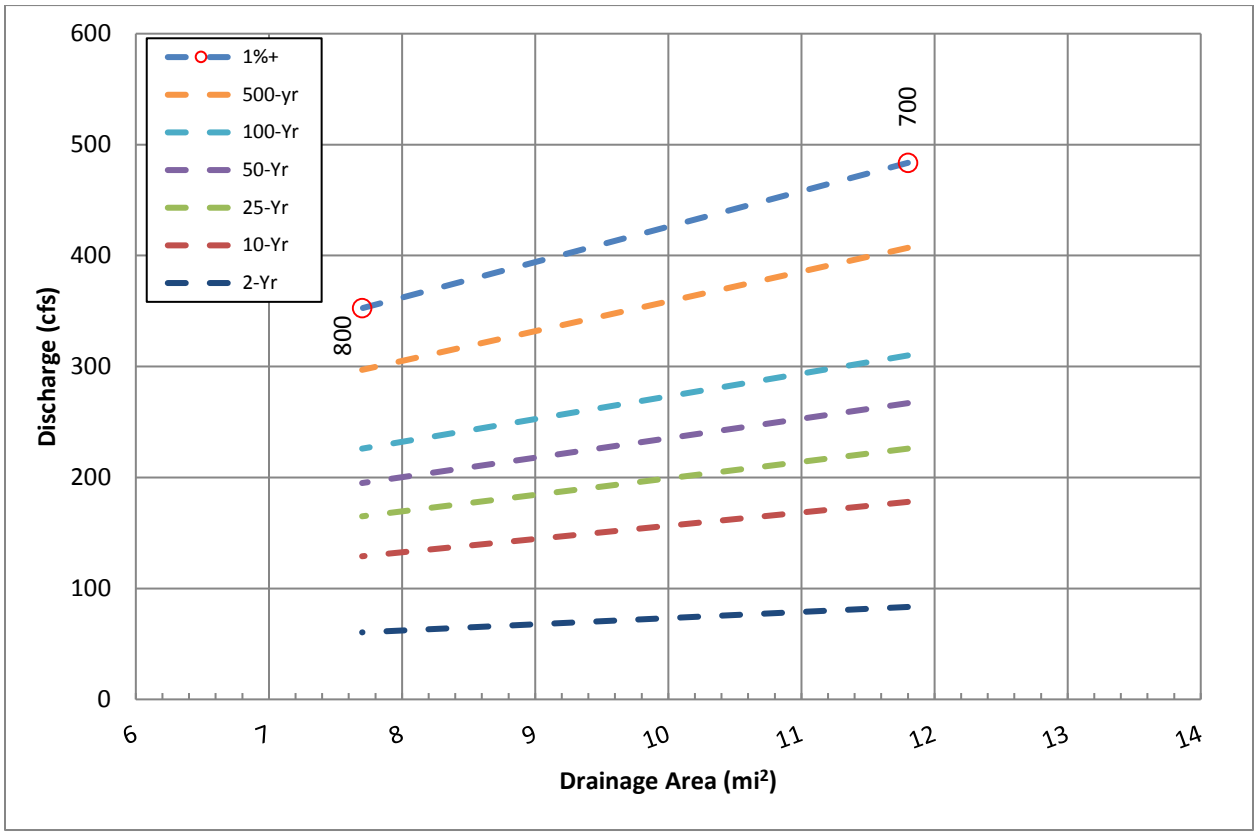
Node/USGS Station ID	Location Description	West Region Regression						
		Estimated Discharge (cfs)						
		50% Annual Chance	10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance	1% +
		2-year	10-year	25-year	50-year	100-year	500-year	100-year
2600	Denna Mora Creek at junction with St. Regis River	28	54	67	77	87	110	136
2700	Hanaker Creek at junction with St. Regis River	40	75	91	104	117	146	183

Figure 10 Twelvemile Creek Regional Regression **Flood Frequency** Estimates



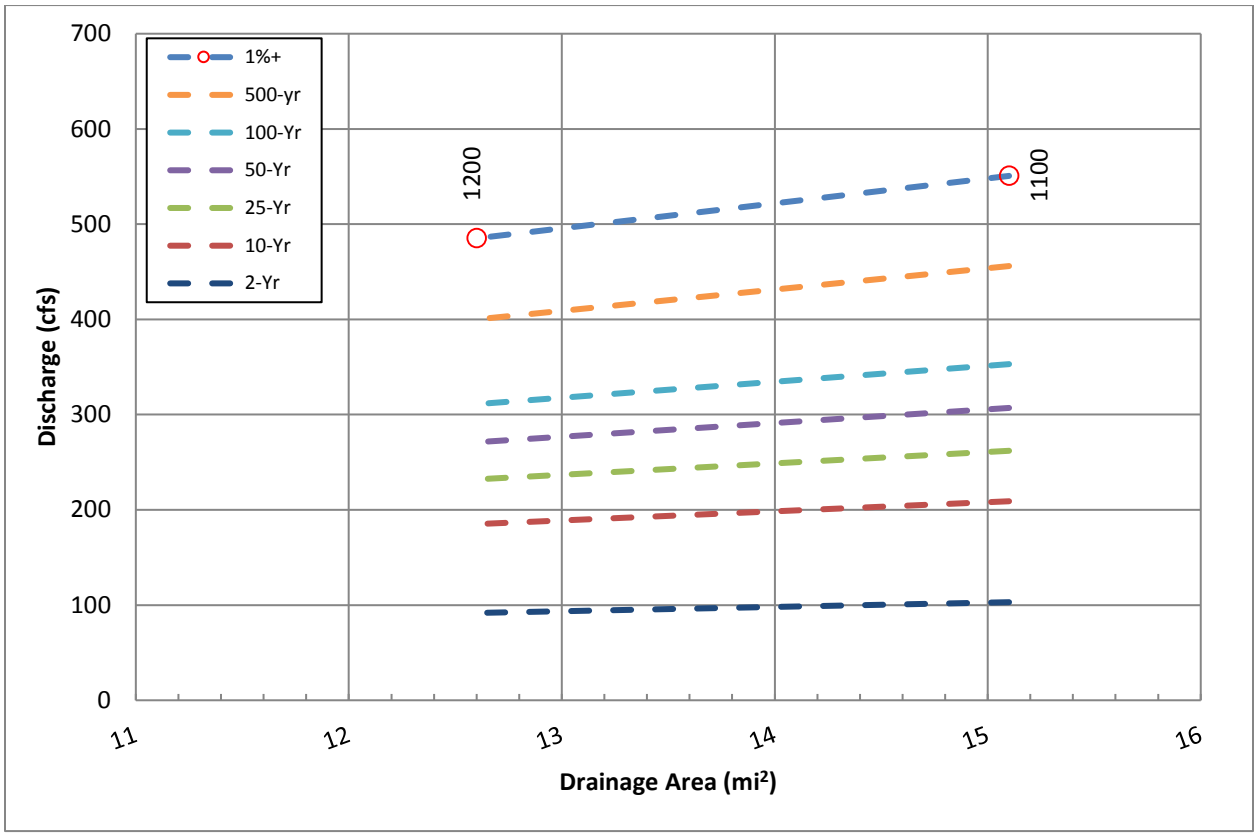
Data label numbers represent flow node numbers

Figure 11 Twin Creek Regional Regression **Flood Frequency** Estimates



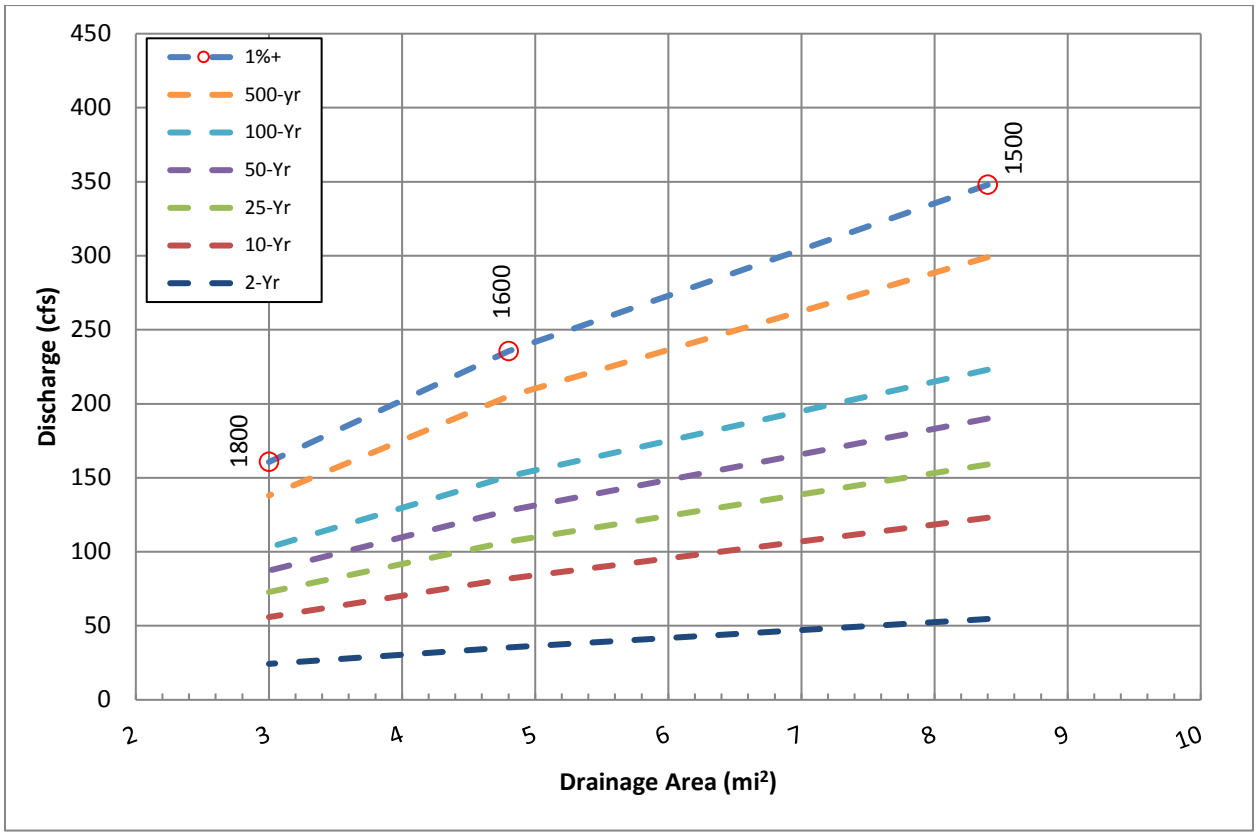
Data label numbers represent flow node numbers

Figure 12 Savenac Creek Regional Regression Flood Frequency Estimates



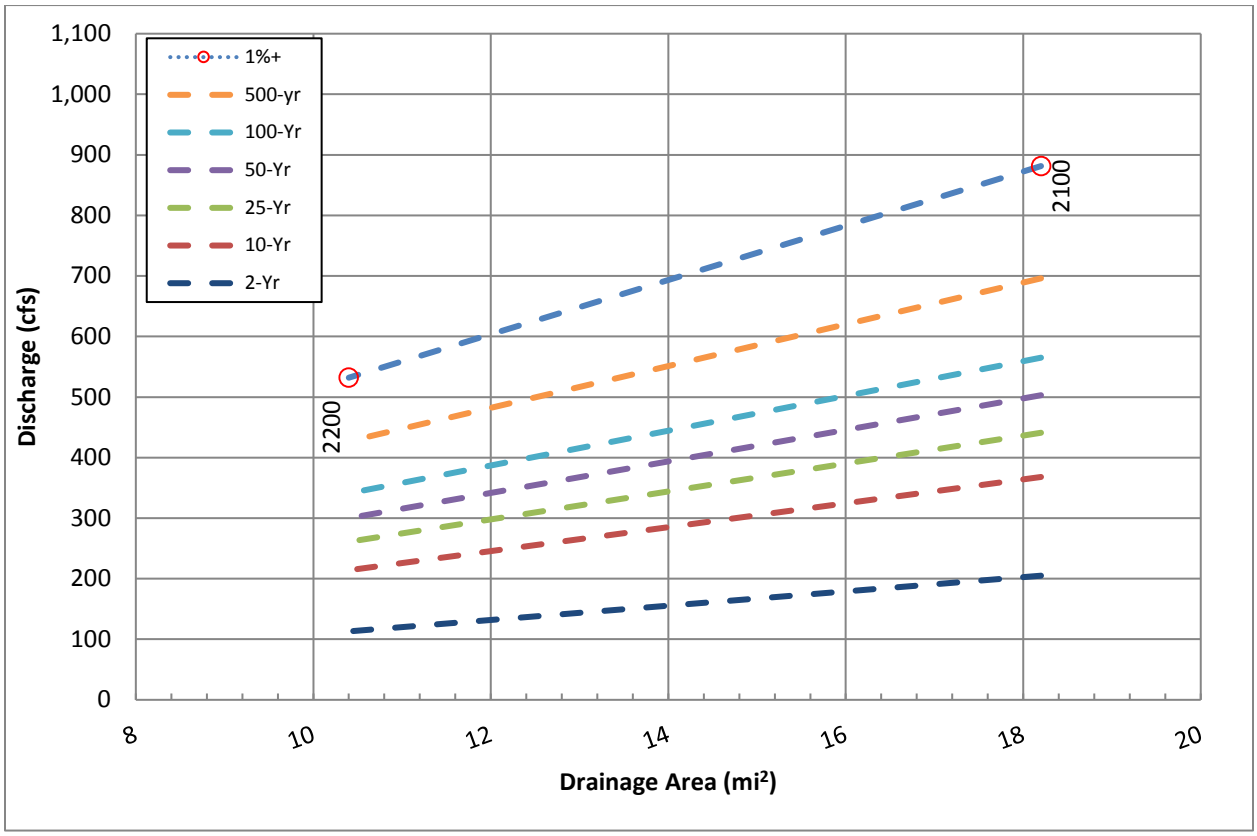
Data label numbers represent flow node numbers

Figure 13 Timber Creek Regional Regression Flood Frequency Estimates



Data label numbers represent flow node numbers

Figure 14 Packer Creek Regional Regression Flood Frequency Estimates



Data label numbers represent flow node numbers

To provide a measure of confidence for the peak flow estimates, the regional regression peak flow estimates are plotted with the gage analysis peak flow estimates for the USGS gages within the study area, using SIR 2015-5019-D tables (Sando et al., 2015c). Table 9 summarizes the comparison. The data from Table 9 are plotted in Figure 15 and Figure 16 along with a confidence interval equal to 1 standard error of the regression model. The average standard error of prediction or *average standard error of estimate* percentage (SEP, in percent) from SIR 2015-5019-F (Sando et al., 2015b) was used to define the regional regression statistical confidence interval of plus\minus one standard error, (FEMA, 2016b).

Table 9 and Figure 15 indicate that at the East Fork Timber Creek gage site, the 1% AEP gage Bulletin 17B estimate exceeds the regional regression estimate by approximately 36%. The gage Bulletin 17B estimate is within the west hydrologic region regional regression 1-standard error envelope.

Table 9 and Figure 16 indicate the regional regression 1% AEP estimate exceeds the gage Bulletin 17B estimate by approximately 43% at the North Fork Little Joe Creek gage site. The gage

Bulletin 17B estimate is within the west hydrologic region regional regression 1-standard error envelope.

It should be noted that the period of record for both the East Fork Timber Creek gage and the North Fork Little Joe Creek gage are relatively short (16 years and 15 years respectively) and therefore gage -based peak flow estimates can be expected to have greater uncertainty associated with increasing recurrence interval magnitudes.

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.

Figure 15 1% AEP Peak Flow Regional Regression Results for East Fork Timber Creek Near Haugan, Montana

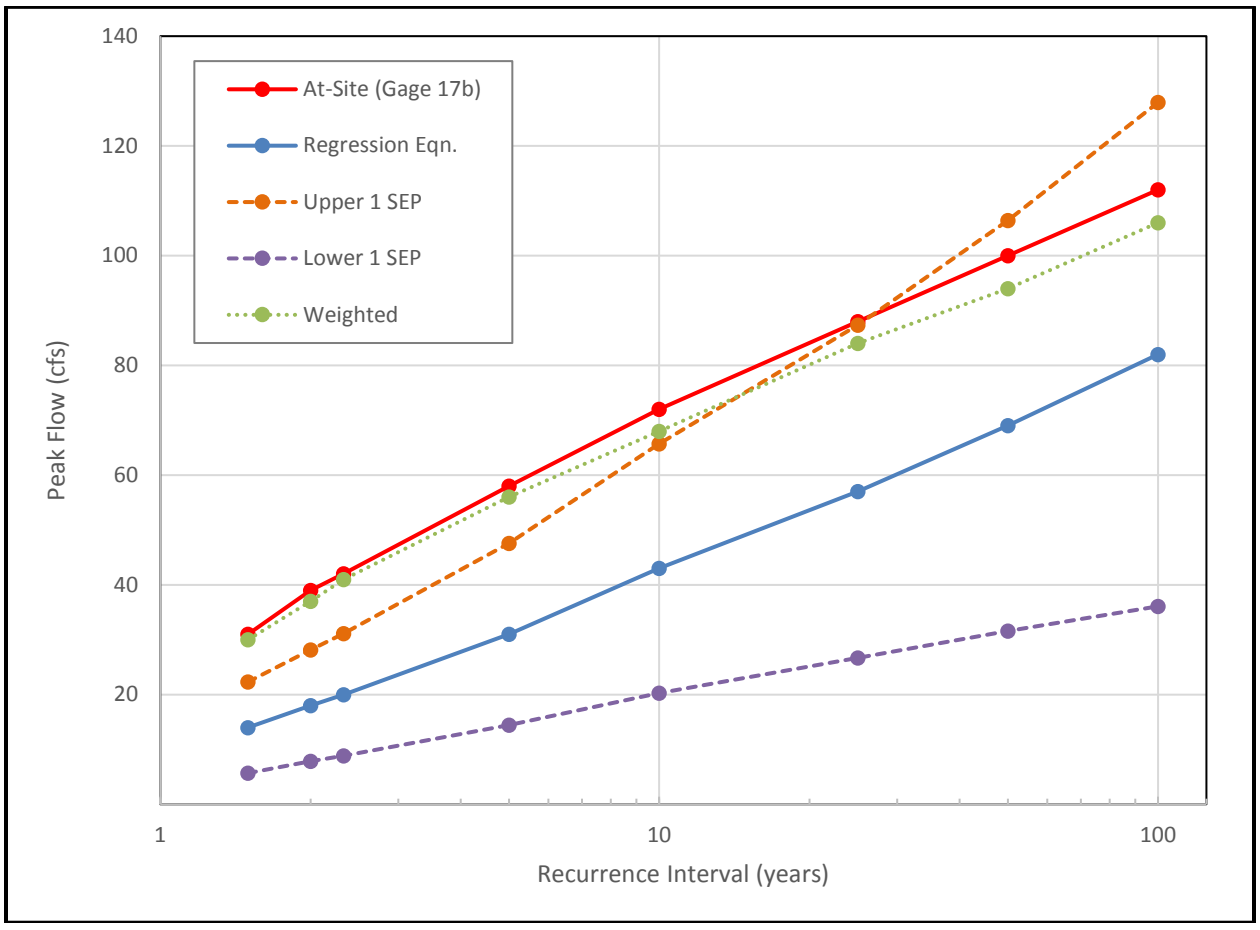


Figure 16 1% AEP Peak Flow Regional Regression Results for North Fork Little Joe Creek Near St. Regis, Montana

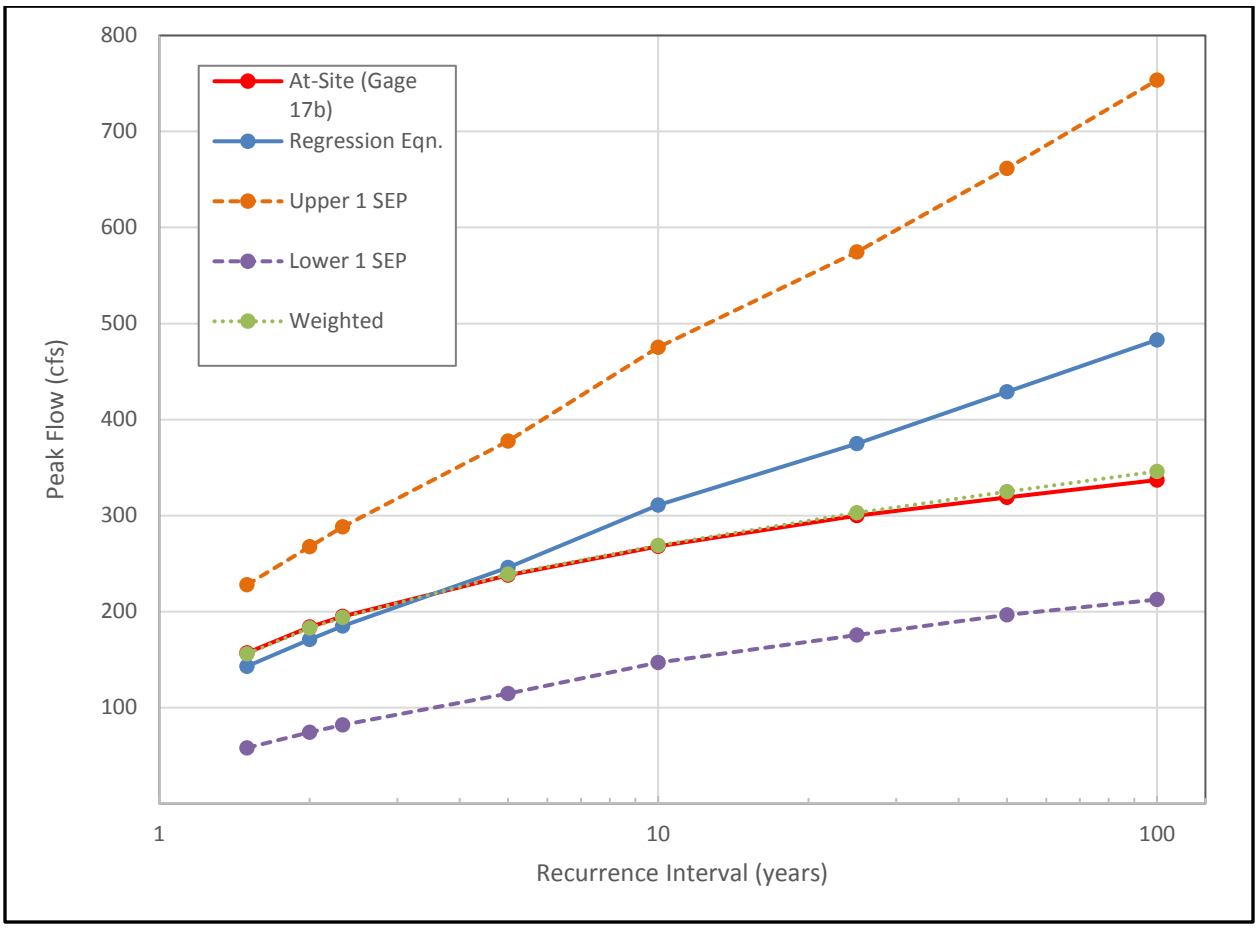


Table 9 Study Reach Peak Flow Estimates Gage and Regional Regression Comparison

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
12353850	East Fork Timber Creek near Haugan, MT	2.77	16	1961-71, 1979	W	at-site	31	39	42	58	72	88	100	112	123	138
						regression	14	18	20	31	43	57	69	82	95	112
						weighted	30	37	81	56	68	84	94	106	117	131
12354100	North Fork Little Joe Creek near St. Regis, MT	14.6	15	1960-74	W	at-site	157	184	195	238	268	300	319	337	352	370
						regression	143	171	185	246	311	375	429	483	537	597
						weighted	156	183	194	239	269	303	325	346	366	390

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

4 SUMMARY/DISCUSSION

Pioneer conducted a peak discharge frequency analysis for 13 tributaries to the mainstem St. Regis River. The St. Regis River Tributary Study reach extends 37 miles along the St. Regis River mainstem upstream from the confluence with the Clark Fork River. The tributaries being evaluated contained 2 inactive USGS stream measurement gage stations (USGS gaging station 12353850 East Fork Timber Creek near Haugan, MT and station 1235400 North Fork Little Joe Creek near St. Regis, MT). Data from the St. Regis River tributaries are considered to be a mixed population data set (peak flows created by different types of events). Information from this analysis will be used to support the Mineral County Phase II hydraulic analyses and floodplain mapping studies.

Previous flood studies on the St. Regis 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., 2015c, and Sando et al., 2015b, respectively).

For this study, Pioneer conducted flood frequency estimates for 27 flow nodes within the 13-study tributaries (27 ungaged sites). The flow nodes were located at major tributaries, developed areas, 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. Two stream gages exist on the St. Regis River study tributaries, in separate tributary basins. Neither of gages met the drainage area ratio criteria for the gage transfer method. Therefore, the gage transfer method and the two-station interpolation method were not used to estimate peak flows at ungaged flow nodes.

The tributary basins in this study are unregulated. 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. Therefore, regional regression method peak flow estimates are applicable to this study.

In addition, regional regression 1% AEP estimate comparison with the 2-study area gage 17B estimates (USGS gaging station 12353850 East Fork Timber Creek near Haugan, MT and station 1235400 North Fork Little Joe Creek near St. Regis, MT) indicate the 1% AEP gage-based estimates the fall within 1 standard error of regional regression model standard error of prediction.

Due to the flow node parameter's conformance with the study's basin and climatic characteristics and the lack of available stream flow gaging stations within the study area, the

regional regression equations were determined to provide the most applicable and accurate peak flow estimates for the study.

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

Table 10 summarizes the recommended flood frequency discharge rates for the St. Regis River tributaries. Figure 17, Figure 18, and Figure 19 show the recommended 1% annual discharge 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, 2015b]) based on the St. Regis River tributaries' basin characteristics. This hydrologic analysis conforms to FEMA standards for 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 10 Recommended Flood Discharge Estimates using Regional Regresssion Equations

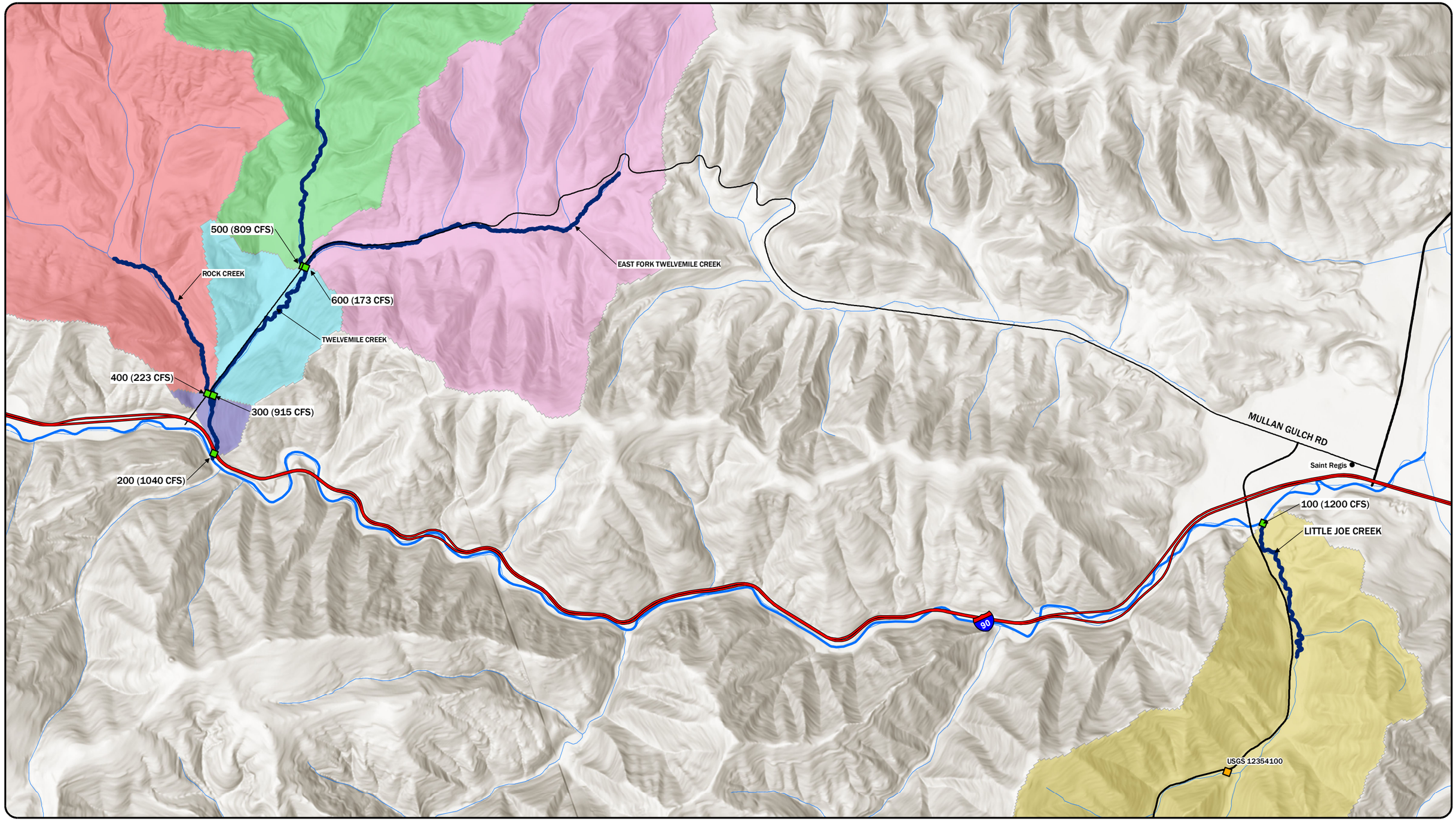
Node/USGS Station ID	Location Description	West Region Regression Estimated Discharge (cfs)						
		50% Annual Chance	10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance	1% +
		2-year	10-year	25-year	50-year	100-year	500-year	100-year
100	Little Joe Creek at junction with St. Regis River	485	816	958	1,080	1,200	1,440	1,872
200	Twelvemile Creek at junction with St. Regis River	352	658	801	922	1,040	1,310	1,622
300	Twelvemile Creek upstream of Rock Creek junction	309	577	702	808	915	1,150	1,427
400	Rock Creek at junction with Twelvemile Creek	55	123	159	190	223	298	348
500	Twelvemile Creek upstream of East Fork Twelvemile Creek junction	274	511	622	715	809	1,010	1,262
600	East Fork Twelvemile Creek at junction with Twelvemile Creek	43	96	124	148	173	231	270
700	Twin Creek at junction with St. Regis River	83	178	226	267	310	407	484
800	West Twin Creek at junction with Twin Creek	60	129	165	195	226	297	353
900	East Twin Creek at junction with Twin Creek	24	58	77	93	110	150	172
1000	Deer Creek at junction with St. Regis River	209	369	441	501	561	687	875
1100	Savenac Creek at junction with St. Regis River	103	209	262	307	353	456	551
1200	Savenac Creek upstream of Cook Creek junction	92	185	232	271	311	400	485
1300	Cook Creek at junction with Savenac Creek	12	30	41	50	60	85	94

Node/USGS Station ID	Location Description	West Region Regression Estimated Discharge (cfs)						
		50% Annual Chance	10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance	1% +
		2-year	10-year	25-year	50-year	100-year	500-year	100-year
1400	Big Creek at junction with St. Regis River	455	769	904	1,020	1,130	1,370	1,763
1500	Timber Creek at junction with St. Regis River	55	123	159	190	223	299	348
1600	Timber Creek upstream of East Fork Timber Creek junction	35	82	107	128	151	205	236
1700	East Fork Timber Creek at junction with Timber Creek	22	52	69	83	99	135	154
1800	Timber Creek upstream of West Fork Timber Creek junction	24	56	73	87	103	138	161
1900	West Fork Timber Creek at junction with Timber Creek	9	23	32	39	48	68	74
2000	Silver Creek at junction with St. Regis River	136	243	292	333	374	460	583
2100	Packer Creek at junction with St. Regis River	205	368	441	503	565	696	881
2200	Packer Creek upstream of West Fork Packer Creek junction	113	214	261	300	341	427	532
2300	West Fork Packer Creek at junction with Packer Creek	101	188	228	261	295	367	460
2400	Randolph Creek at junction with St. Regis River	128	227	271	307	344	421	537
2500	Rainy Creek at junction with St. Regis River	106	183	217	245	273	331	426
2600	Denna Mora Creek at junction with St. Regis River	28	54	67	77	87	110	136

Node/USGS Station ID	Location Description	West Region Regression Estimated Discharge (cfs)						
		50% Annual Chance	10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance	1% +
		2-year	10-year	25-year	50-year	100-year	500-year	100-year
2700	Hanaker Creek at junction with St. Regis River	40	75	91	104	117	146	183

cfs: cubic feet per second.

.



LEGEND

- INACTIVE USGS GAGE
- FLOW NODES
- TOWNS
- HUC 8 BOUNDARIES
- NHS INTERSTATE
- PRIMARY
- SECONDARY
- CITY/COUNTY
- ST. REGIS TRIBUTARIES PROFILE BASELINES
- ST. REGIS RIVER STUDY REACH
- NHD HYDROGRAPHY
- FLOW CHANGE NODE
  - 100
  - 200
  - 300
  - 400
  - 500
  - 600

N

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

0 2,000 4,000 8,000
Feet

FIGURE 17

ST. REGIS TRIBS
RECOMMENDED 1-PERCENT
ANNUAL DISCHARGE

PIONEER TECHNICAL SERVICES, INC.

DATE: 2/27/2018

Path: G:\DNRC\Mineral -Beaverhead County\Mineral County Tributaries\CAD-GIS\GIS\STRGS-GI-HYD-017-18.mxd

PACKER CREEK
WEST FORK PACKER CREEK
2300 (295 CFS)
2200 (341 CFS)
2100 (565 CFS)
Saltese
SILVER CREEK
2000 (374 CFS)
USGS 12353850
EAST FORK TIMBER CREEK
TIMBER CREEK
1800 (103 CFS)
WEST FORK TIMBER CREEK
1900 (48 CFS)
1700 (99 CFS)
1200 (311 CFS)
1600 (151 CFS)
1500 (223 CFS)
COOK CREEK
1300 (60 CFS)
SAVENAC CREEK
1100 (353 CFS)
Haugan
1400 (1130 CFS)
BIG CREEK
EAST TWIN CREEK
900 (110 CFS)
800 (226 CFS)
TWIN CREEK
De Borgia
700 (310 CFS)
DEER CREEK
1000 (561 CFS)

LEGEND

- INACTIVE USGS GAGE
- FLOW NODES
- TOWNS
- HUC 8 BOUNDARIES
- NHS INTERSTATE
- ST. REGIS TRIBUTARIES PROFILE BASELINES
- ST. REGIS RIVER STUDY REACH
- NHD HYDROGRAPHY
- FLOW CHANGE NODE
- 200
- 400
- 700
- 800
- 900
- 1000
- 1100
- 1200
- 1300
- 1400
- 1500
- 1600
- 1700
- 1800
- 1900
- 2000
- 2100
- 2200
- 2300
- 2400

N

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

0 2,000 4,000 8,000
Feet

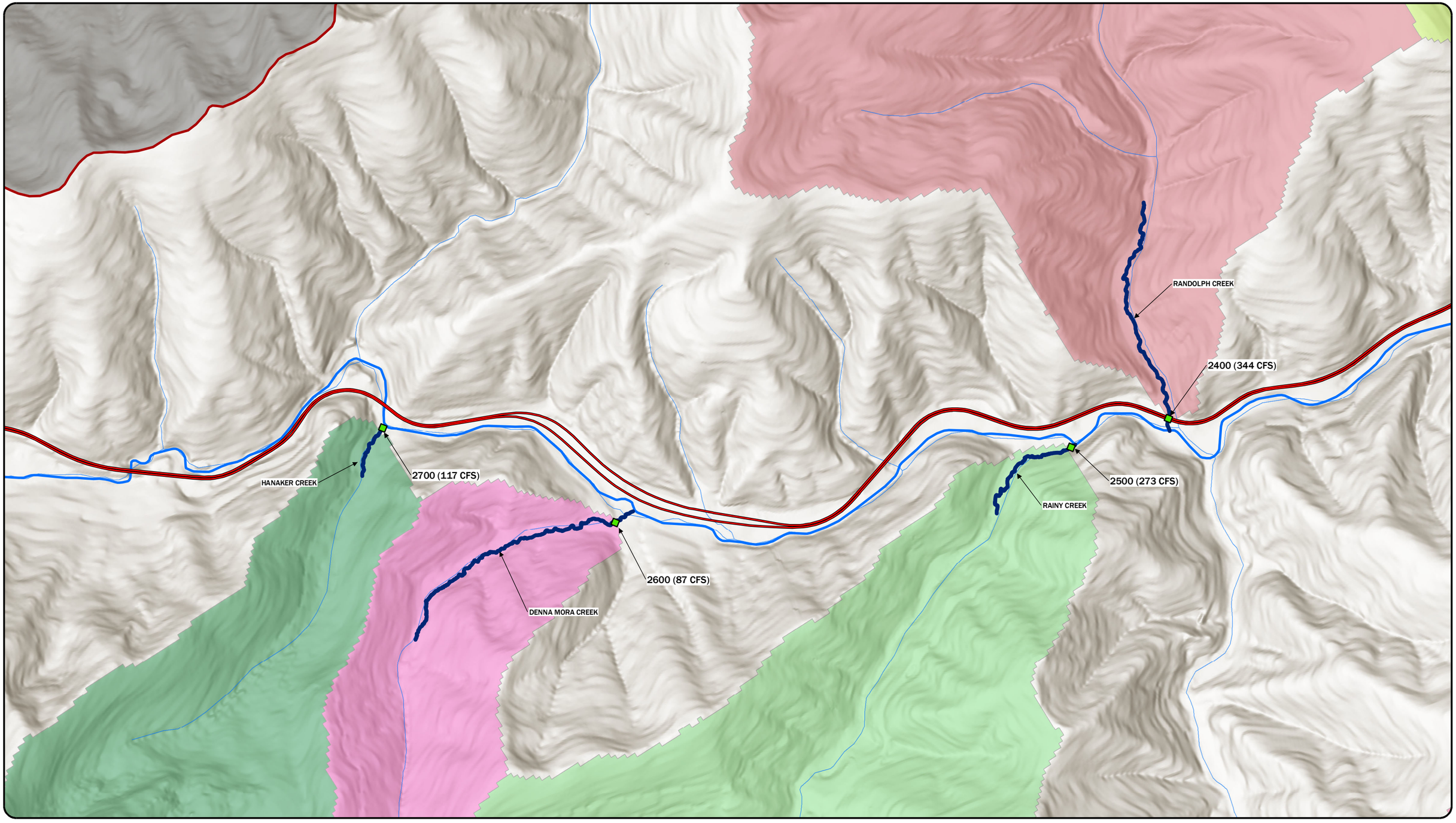
FIGURE 18

ST. REGIS TRIBS
RECOMMENDED 1-PERCENT
ANNUAL DISCHARGE

PIONEER TECHNICAL SERVICES, INC.

DATE: 2/27/2018

Path: G:\DNRC\Mineral -Beaverhead County\Mineral County Tributaries\CAD-GIS\GIS\STRGS-GI-HYD-018-18.mxd



LEGEND

- FLOW NODES
- HUC 8 BOUNDARIES
- NHS INTERSTATE
- ST. REGIS TRIBUTARIES PROFILE BASELINES
- ST. REGIS RIVER STUDY REACH
- NHD HYDROGRAPHY

FLOW CHANGE NODE

- 2000
- 2100
- 2300
- 2400
- 2500
- 2600
- 2700

N

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

0 1,000 2,000 4,000
Feet

FIGURE 19

ST. REGIS TRIBS
RECOMMENDED 1-PERCENT
ANNUAL DISCHARGE

PIONEER TECHNICAL SERVICES, INC.

DATE: 2/27/2018

Path: G:\DNRC\Mineral -Beaverhead County\Mineral County Tributaries\CAD-GIS\GIS\STRGS-GI-HYD-019-18.mxd

5 REFERENCES

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Appendix A
Gage Flood Frequency Analysis

EASTFORKTIMBERCREEK_PEAK_1%+17B

1

Program PeakFq — U. S. GEOLOGICAL SURVEY — Seq.002.000
Version 7.1 — Annual peak flow frequency analysis — Run Date / Time
3/14/2014 — 01/31/2018 15:07

--- 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\EASTFORKTIMBERCREEK_PEAK.TXT
specifications -
C:\Users\jjupka\Desktop\watstore\PKFQWPSF.TMP
Output file(s):
main -
C:\Users\jjupka\Desktop\watstore\EASTFORKTIMBERCREEK_PEAK.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 — 01/31/2018 15:07

Station - 12353850 East Fork Timber Creek near Haugan MT

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

Number of peaks in record	=	16
Peaks not used in analysis	=	0
Systematic peaks in analysis	=	16
Historic peaks in analysis	=	0
Beginning Year	=	1961
Ending Year	=	1979
Historical Period Length	=	19
Generalized skew	=	-0.276
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 8.7
WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE. 122.7

EASTFORKTIMBERCREEK_PEAK_1%+17B
**WCF164W-HISTORIC PERIOD IGNORED. 19.0
WCF002J-CALCS COMPLETED. RETURN CODE = 2

Kendall's Tau Parameters

	TAU	P-VALUE	MEDIAN SLOPE	No. of PEAKS
SYSTEMATIC RECORD	0.225	0.241	1.393	16

1

Program PeakFq — U. S. GEOLOGICAL SURVEY — Seq.001.002
Version 7.1 — Annual peak flow frequency analysis — Run Date / Time
3/14/2014 — 01/31/2018 15:07

Station - 12353850 East Fork Timber Creek near Haugan 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	1.5597	0.2724	-0.819
BULL.17B ESTIMATE	8.7	0.9375	1.5831	0.2268	-0.252

BULL.17B ESTIMATE OF MSE OF AT-SITE SKEW 0.3223

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		4.5	--	--	--
0.9900		5.9	--	--	--
0.9500		11.4	--	--	--
0.9000	19.4	15.7	----	17.7	21.0
0.8000	24.9	22.3	----	23.1	26.6
0.6667	31.1	29.9	----	29.2	33.1
0.5000	39.1	39.5	----	36.8	41.6
0.4292	42.9	43.9	----	40.4	45.7
0.2000	59.7	62.1	----	55.8	64.4
0.1000	73.6	75.2	----	68.1	80.4
0.0400	91.2	89.5	----	83.3	101.1
0.0200	104.2	98.7	----	94.4	116.6
0.0100	117.1	106.6	----	105.3	132.3
0.0050	129.9	113.6	----	116.1	148.1
0.0020	146.9	121.5	----	130.2	169.1

1

Program PeakFq — U. S. GEOLOGICAL SURVEY — Seq.001.003
Version 7.1 — Annual peak flow frequency analysis — Run Date / Time
3/14/2014 — 01/31/2018 15:07

EASTFORKTIMBERCREEK_PEAK_1%+17B

Station - 12353850 East Fork Timber Creek near Haugan MT

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

WATER YEAR	PEAK VALUE	PEAKFQ CODES	REMARKS
1961	23.0		
1962	45.0		
1963	20.0		
1964	40.0		
1965	66.0		
1966	27.0		
1967	42.0		
1968	15.0		
1969	44.0		
1970	42.0		
1971	55.0		
1972	52.0		
1973	8.0		
1974	50.0		
1975	41.0		
1979	112.0	H	

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 01/31/2018 15:07

Station - 12353850 East Fork Timber Creek near Haugan MT

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	B17B ESTIMATE
1979	112.0	0.0588	0.0588
1965	66.0	0.1176	0.1176
1971	55.0	0.1765	0.1765
1972	52.0	0.2353	0.2353

EASTFORKTIMBERCREEK_PEAK_1%+17B

1974	50.0	0.2941	0.2941
1962	45.0	0.3529	0.3529
1969	44.0	0.4118	0.4118
1967	42.0	0.4706	0.4706
1970	42.0	0.5294	0.5294
1975	41.0	0.5882	0.5882
1964	40.0	0.6471	0.6471
1966	27.0	0.7059	0.7059
1961	23.0	0.7647	0.7647
1963	20.0	0.8235	0.8235
1968	15.0	0.8824	0.8824
1973	8.0	0.9412	0.9412

1

End PeakFQ analysis.

Stations processed	:	1
Number of errors	:	0
Stations skipped	:	0
Station years	:	16

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: 12353850 USGS East Fork Timber Creek near H

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

EASTFORKTIMBERCREEK_PEAK_1%+EMA

1

Program PeakFq — U. S. GEOLOGICAL SURVEY — Seq.002.000
Version 7.1 — Annual peak flow frequency analysis — Run Date / Time
3/14/2014 — 01/31/2018 15:02

--- 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\EASTFORKTIMBERCREEK_PEAK.TXT
specifications -
C:\Users\jjupka\Desktop\watstore\PKFQWPSF.TMP
Output file(s):
main -
C:\Users\jjupka\Desktop\watstore\EASTFORKTIMBERCREEK_PEAK.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 — 01/31/2018 15:02

Station - 12353850 East Fork Timber Creek near Haugan MT

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

Number of peaks in record	=	16
Peaks not used in analysis	=	0
Systematic peaks in analysis	=	16
Historic peaks in analysis	=	0
Beginning Year	=	1961
Ending Year	=	1979
Historical Period Length	=	19
Generalized skew	=	-0.276
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
1961	1979	1.0	INF	DEFAULT
1979	1979	112.0	INF	HISTORIC
1976	1978	INF	INF	

Interval Data = None Specified

EASTFORKTIMBERCREEK_PEAK_1%+EMA

********* 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 15.0
THE FOLLOWING PEAKS (WITH CORRESPONDING P-VALUES) WERE CENSORED:
8.0 (0.0549)
EMA002W-CONFIDENCE INTERVALS ARE NOT EXACT IF HISTORIC PERIOD > 0

Kendall's Tau Parameters

	TAU	P-VALUE	MEDIAN SLOPE	No. of PEAKS
SYSTEMATIC RECORD	0.225	0.241	1.393	16

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.002
Version 7.1 Annual peak flow frequency analysis Run Date / Time
3/14/2014 01/31/2018 15:02

Station - 12353850 East Fork Timber Creek near Haugan MT

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	LOGARITHMIC		
	MEAN	STANDARD DEVIATION	SKEW
EMA W/O REG. INFO	1.5675	0.2537	-0.495
EMA W/REG. INFO	1.5683	0.2517	-0.355

EMA ESTIMATE OF MSE OF SKEW W/O REG. INFO (AT-SITE) 0.3044
EMA ESTIMATE OF MSE OF SKEW W/SYSTEMATIC ONLY (AT-SITE) 0.3499

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	6.9	6.3	0.0432	3.3	9.8
0.9900	8.3	7.7	0.0334	4.3	11.3
0.9500	13.5	13.1	0.0163	8.7	17.0
0.9000	17.3	17.1	0.0112	12.2	21.1
0.8000	23.0	23.0	0.0074	17.8	27.4
0.6667	29.7	30.0	0.0055	24.3	34.8
0.5000	38.3	38.8	0.0045	32.4	44.6
0.4292	42.4	42.9	0.0043	36.2	49.4
0.2000	60.7	60.9	0.0045	52.1	71.9
0.1000	75.8	75.2	0.0056	64.6	92.5
0.0400	94.8	92.4	0.0078	79.2	121.6
0.0200	108.7	104.5	0.0101	89.1	145.3
0.0100	122.3	116.0	0.0128	98.2	170.6

0.0050	135.8	127.0	0.0161	106.5	197.9
0.0020	153.3	140.7	0.0212	116.4	237.2

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Version 7.1 Annual peak flow frequency analysis Run Date / Time
3/14/2014 01/31/2018 15:02

Station - 12353850 East Fork Timber Creek near Haugan 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
1961	23.0				
1962	45.0				
1963	20.0				
1964	40.0				
1965	66.0				
1966	27.0				
1967	42.0				
1968	15.0				
1969	44.0				
1970	42.0				
1971	55.0				
1972	52.0				
1973	8.0				
1974	50.0				
1975	41.0				
1979	112.0	H			

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 01/31/2018 15:02

Station - 12353850 East Fork Timber Creek near Haugan MT

EASTFORKTIMBERCREEK_PEAK_1%+EMA

EMPIRICAL FREQUENCY CURVES -- HIRSCH-STEDINGER PLOTTING POSITIONS

	WATER YEAR	RANKED DISCHARGE	EMA ESTIMATE	INTERVALS LOW	HIGH
	1979	112.0	0.0313		
	1965	66.0	0.1211		
	1971	55.0	0.1797		
	1972	52.0	0.2383		
	1974	50.0	0.2969		
	1962	45.0	0.3555		
	1969	44.0	0.4141		
	1967	42.0	0.5312		
	1970	42.0	0.4727		
	1975	41.0	0.5898		
	1964	40.0	0.6484		
	1966	27.0	0.7070		
	1961	23.0	0.7656		
	1963	20.0	0.8242		
	1968	15.0	0.8828		
*	1973	8.0	0.9414		

* 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 01/31/2018 15:02

Station - 12353850 East Fork Timber Creek near Haugan MT

EMA REPRESENTATION OF DATA

WATER YEAR	<----- OBSERVED -----> Q_LOWER	Q_UPPER	<-------- EMA -------> Q_LOWER	Q_UPPER	<-PERCEPTION THRESHOLDS-> LOWER	UPPER
1961	23.0	23.0	23.0	23.0	15.0	INF
1962	45.0	45.0	45.0	45.0	15.0	INF
1963	20.0	20.0	20.0	20.0	15.0	INF
1964	40.0	40.0	40.0	40.0	15.0	INF
1965	66.0	66.0	66.0	66.0	15.0	INF
1966	27.0	27.0	27.0	27.0	15.0	INF
1967	42.0	42.0	42.0	42.0	15.0	INF
1968	15.0	15.0	15.0	15.0	15.0	INF
1969	44.0	44.0	44.0	44.0	15.0	INF
1970	42.0	42.0	42.0	42.0	15.0	INF
1971	55.0	55.0	55.0	55.0	15.0	INF
1972	52.0	52.0	52.0	52.0	15.0	INF
1973	8.0	8.0	0.0	15.0	15.0	INF
1974	50.0	50.0	50.0	50.0	15.0	INF
1975	41.0	41.0	41.0	41.0	15.0	INF
1976	0.0	INF	0.0	INF	INF	INF
1977	0.0	INF	0.0	INF	INF	INF
1978	0.0	INF	0.0	INF	INF	INF
1979	112.0	112.0	112.0	112.0	112.0	INF

1

End PeakFQ analysis.
Stations processed : 1
Number of errors : 0

EASTFORKTIMBERCREEK_PEAK_1%+EMA

Stations skipped : 0
Station years : 16

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: 12353850 USGS East Fork Timber Creek near H

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 12/18/2017 12:24

--- 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\NORTHFORKLITTLEJOECREEK_1%+INPUT.TXT
specifications -
C:\Users\jjupka\Desktop\watstore\PKFQWPSF.TMP
Output file(s):
main -
C:\Users\jjupka\Desktop\watstore\NORTHFORKLITTLEJOECREEK_1%+17B_INPUT.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 12/18/2017 12:24

Station - 12354100 North Fork Little Joe Cr nr ST. Regis MT

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

Number of peaks in record	=	15
Peaks not used in analysis	=	0
Systematic peaks in analysis	=	15
Historic peaks in analysis	=	0
Beginning Year	=	1960
Ending Year	=	1974
Historical Period Length	=	0
Generalized skew	=	-0.277
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 64.2
WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE. 372.4

Kendall's Tau Parameters

	TAU	P-VALUE	MEDIAN SLOPE	No. of PEAKS
SYSTEMATIC RECORD	0.429	0.029	7.143	15

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.002
Version 7.1 Annual peak flow frequency analysis Run Date / Time
3/14/2014 12/18/2017 12:24

Station - 12354100 North Fork Little Joe Cr nr ST. Regis 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	2.2291	0.1875	-1.394
BULL.17B ESTIMATE	64.2	0.9333	2.2475	0.1522	-0.589

BULL.17B ESTIMATE OF MSE OF AT-SITE SKEW 0.4948

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		32.5	--	--	--
0.9900		41.4	--	--	--
0.9500		73.4	--	--	--
0.9000	111.0	95.2	----	104.2	117.4
0.8000	133.5	124.9	----	126.8	140.0
0.6667	156.7	154.9	----	149.8	163.6
0.5000	182.9	186.7	----	175.4	190.9
0.4292	194.3	199.5	----	186.2	203.1
0.2000	238.7	242.7	----	227.6	251.6
0.1000	269.4	265.8	----	255.4	286.1
0.0400	302.5	284.6	----	285.0	323.8
0.0200	323.8	293.6	----	303.8	348.4
0.0100	342.7	299.8	----	320.4	370.4
0.0050	359.7	304.2	----	335.2	390.3
0.0020	379.8	308.0	----	352.6	413.9

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Version 7.1 Annual peak flow frequency analysis Run Date / Time
3/14/2014 12/18/2017 12:24

Station - 12354100 North Fork Little Joe Cr nr ST. Regis MT

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

WATER YEAR	PEAK VALUE	PEAKFQ CODES	REMARKS
1960	179.0		
1961	185.0		
1962	91.0		
1963	57.0		
1964	212.0		
1965	200.0		
1966	147.0		
1967	195.0		
1968	102.0		
1969	175.0		
1970	205.0		
1971	262.0		
1972	295.0		
1973	220.0		
1974	210.0		

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 12/18/2017 12:24

Station - 12354100 North Fork Little Joe Cr nr ST. Regis MT

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	B17B ESTIMATE
1972	295.0	0.0625	0.0625
1971	262.0	0.1250	0.1250
1973	220.0	0.1875	0.1875
1964	212.0	0.2500	0.2500
1974	210.0	0.3125	0.3125
1970	205.0	0.3750	0.3750
1965	200.0	0.4375	0.4375

1967	195.0	0.5000	0.5000
1961	185.0	0.5625	0.5625
1960	179.0	0.6250	0.6250
1969	175.0	0.6875	0.6875
1966	147.0	0.7500	0.7500
1968	102.0	0.8125	0.8125
1962	91.0	0.8750	0.8750
1963	57.0	0.9375	0.9375

1

End PeakFQ analysis.
Stations processed : 1
Number of errors : 0
Stations skipped : 0
Station years : 15

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: 12354100 USGS North Fork Little Joe Cr nr S

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 12/18/2017 12:12

--- 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\NORTHFORKLITTLEJOECREEK_1%+INPUT.TXT
specifications -
C:\Users\jjupka\Desktop\watstore\PKFQWPSF.TMP
Output file(s):
main -
C:\Users\jjupka\Desktop\watstore\NORTHFORKLITTLEJOECREEK_1%+INPUT.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 12/18/2017 12:12

Station - 12354100 North Fork Little Joe Cr nr ST. Regis MT

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

Number of peaks in record	15
Peaks not used in analysis	0
Systematic peaks in analysis	15
Historic peaks in analysis	0
Beginning Year	1960
Ending Year	1974
Historical Period Length	15
Generalized skew	-0.277
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
1960	1974	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   4   175.0
  THE FOLLOWING PEAKS (WITH CORRESPONDING P-VALUES) WERE CENSORED:
       57.0   (0.0259)
       91.0   (0.0306)
      102.0   (0.0012)
      147.0   (0.0755)
EMA002W-CONFIDENCE INTERVALS ARE NOT EXACT IF HISTORIC PERIOD > 0

Kendall's Tau Parameters

	TAU	P-VALUE	MEDIAN SLOPE	No. of PEAKS
SYSTEMATIC RECORD	0.429	0.029	7.143	15

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.002
Version 7.1 Annual peak flow frequency analysis Run Date / Time
3/14/2014 12/18/2017 12:12

Station - 12354100 North Fork Little Joe Cr nr ST. Regis MT

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	LOGARITHMIC		
	MEAN	STANDARD DEVIATION	SKEW
EMA W/O REG. INFO	2.2941	0.0761	1.157
EMA W/REG. INFO	2.2861	0.0878	0.000

EMA ESTIMATE OF MSE OF SKEW W/O REG. INFO (AT-SITE) 0.5184
EMA ESTIMATE OF MSE OF SKEW W/SYSTEMATIC ONLY (AT-SITE) 0.5184

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	114.8	150.4	0.0081	80.3	133.0
0.9900	120.7	151.9	0.0066	86.5	137.6
0.9500	138.5	157.9	0.0035	105.5	151.9
0.9000	149.1	162.5	0.0025	118.4	160.8
0.8000	163.0	169.7	0.0015	135.3	173.1
0.6667	177.1	178.5	0.0010	151.3	186.5
0.5000	193.2	190.4	0.0007	174.5	202.8
0.4292	200.3	196.3	0.0006	184.6	210.6
0.2000	229.1	224.0	0.0007	216.7	245.5
0.1000	250.4	248.9	0.0010	235.4	273.2
0.0400	275.3	283.3	0.0016	255.3	309.7
0.0200	292.7	310.8	0.0022	268.5	337.7
0.0100	309.3	340.1	0.0028	280.7	366.3
0.0050	325.3	371.4	0.0036	292.1	395.6

0.0020 345.8 416.0 0.0047 306.1 435.4

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Version 7.1 Annual peak flow frequency analysis Run Date / Time
3/14/2014 12/18/2017 12:12

Station - 12354100 North Fork Little Joe Cr nr ST. Regis 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
1960	179.0				
1961	185.0				
1962	91.0				
1963	57.0				
1964	212.0				
1965	200.0				
1966	147.0				
1967	195.0				
1968	102.0				
1969	175.0				
1970	205.0				
1971	262.0				
1972	295.0				
1973	220.0				
1974	210.0				

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 12/18/2017 12:12

Station - 12354100 North Fork Little Joe Cr nr ST. Regis MT

EMPIRICAL FREQUENCY CURVES -- HIRSCH-STEDINGER PLOTTING POSITIONS

NORTHFORKLITTLEJOECREEK_1%+INPUT.PRT

WATER YEAR	RANKED DISCHARGE	EMA ESTIMATE	INTERVALS LOW	HIGH
1972	295.0	0.0625		
1971	262.0	0.1250		
1973	220.0	0.1875		
1964	212.0	0.2500		
1974	210.0	0.3125		
1970	205.0	0.3750		
1965	200.0	0.4375		
1967	195.0	0.5000		
1961	185.0	0.5625		
1960	179.0	0.6250		
1969	175.0	0.6875		
* 1966	147.0	0.7500		
* 1968	102.0	0.8125		
* 1962	91.0	0.8750		
* 1963	57.0	0.9375		

* 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 12/18/2017 12:12

Station - 12354100 North Fork Little Joe Cr nr ST. Regis MT

EMA REPRESENTATION OF DATA

WATER YEAR	<----- OBSERVED-----> Q_LOWER	Q_UPPER	<-------- EMA -------> Q_LOWER	Q_UPPER	<-PERCEPTION THRESHOLDS-> LOWER	UPPER
1960	179.0	179.0	179.0	179.0	175.0	INF
1961	185.0	185.0	185.0	185.0	175.0	INF
1962	91.0	91.0	0.0	175.0	175.0	INF
1963	57.0	57.0	0.0	175.0	175.0	INF
1964	212.0	212.0	212.0	212.0	175.0	INF
1965	200.0	200.0	200.0	200.0	175.0	INF
1966	147.0	147.0	0.0	175.0	175.0	INF
1967	195.0	195.0	195.0	195.0	175.0	INF
1968	102.0	102.0	0.0	175.0	175.0	INF
1969	175.0	175.0	175.0	175.0	175.0	INF
1970	205.0	205.0	205.0	205.0	175.0	INF
1971	262.0	262.0	262.0	262.0	175.0	INF
1972	295.0	295.0	295.0	295.0	175.0	INF
1973	220.0	220.0	220.0	220.0	175.0	INF
1974	210.0	210.0	210.0	210.0	175.0	INF

1

End PeakFQ analysis.
Stations processed : 1
Number of errors : 0
Stations skipped : 0
Station years : 15

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: 12354100   USGS North Fork Little Joe Cr nr S

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	Little Joe Creek at junction with St. Regis River	0.0	43.5	86.8	45.00	485	816	958	1,080	1,200	1,440	1,872
200	Twelvemile Creek at junction with St. Regis River	0.0	60.0	94.4	35.27	352	658	801	922	1,040	1,310	1,622
300	Twelvemile Creek upstream of Rock Creek junction	0.6	48.9	94.9	36.28	309	577	702	808	915	1,150	1,427
400	Rock Creek at junction with Twelvemile Creek	0.1	10.8	92.9	30.85	55	123	159	190	223	298	348
500	Twelvemile Creek upstream of East Fork Twelvemile Creek junction	2.2	40.6	95.4	37.17	274	511	622	715	809	1,010	1,262
600	East Fork Twelvemile Creek at junction with Twelvemile Creek	0.0	7.3	94.9	32.81	43	96	124	148	173	231	270
700	Twin Creek at junction with St. Regis River	0.2	11.8	80.4	34.05	83	178	226	267	310	407	484
800	West Twin Creek at junction with Twin Creek	1.0	7.7	83.0	35.55	60	129	165	195	226	297	353
900	East Twin Creek at junction with Twin Creek	0.1	3.5	78.4	32.05	24	58	77	93	110	150	172
1000	Deer Creek at junction with St. Regis River	0.1	16.7	88.9	46.21	209	369	441	501	561	687	875
1100	Savenac Creek at junction with St. Regis River	0.5	15.1	93.0	35.67	103	209	262	307	353	456	551
1200	Savenac Creek upstream of Cook Creek junction	2.3	12.6	96.2	36.99	92	185	232	271	311	400	485
1300	Cook Creek at junction with Savenac Creek	0.1	1.9	79.4	29.79	12	30	41	50	60	85	94
1400	Big Creek at junction with St. Regis River	0.0	38.0	83.2	45.51	455	769	904	1,020	1,130	1,370	1,763
1500	Timber Creek at junction with St. Regis River	0.0	8.4	78.6	32.15	55	123	159	190	223	299	348
1600	Timber Creek upstream of East Fork Timber Creek junction	0.5	4.8	75.4	32.79	35	82	107	128	151	205	236
1700	East Fork Timber Creek at junction with Timber Creek	0.0	3.4	84.0	31.50	22	52	69	83	99	135	154
1800	Timber Creek upstream of West Fork Timber Creek junction	1.6	3.0	84.1	35.05	24	56	73	87	103	138	161
1900	West Fork Timber Creek at junction with Timber Creek	0.1	1.3	71.6	29.22	9	23	32	39	48	68	74
2000	Silver Creek at junction with St. Regis River	0.0	9.9	92.0	47.82	136	243	292	333	374	460	583
2100	Packer Creek at junction with St. Regis River	0.1	18.2	90.0	44.44	205	368	441	503	565	696	881
2200	Packer Creek upstream of West Fork Packer Creek junction	1.4	10.4	92.1	43.28	113	214	261	300	341	427	532
2300	West Fork Packer Creek at junction with Packer Creek	0.0	7.0	86.3	47.30	101	188	228	261	295	367	460
2400	Randolph Creek at junction with St. Regis River	0.1	7.0	82.3	51.52	128	227	271	307	344	421	537
2500	Rainy Creek at junction with St. Regis River	0.0	4.6	84.6	56.94	106	183	217	245	273	331	426
2600	Denna Mora Creek at junction with St. Regis River	0.1	1.4	94.9	53.59	28	54	67	77	87	110	136
2700	Hanaker Creek at junction with St. Regis River	0.0	1.6	83.1	56.42	40	75	91	104	117	146	183

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 month; E6000, percent of basin above 6,000 feet elevation]

Upper and Lower Confidence Limits of Regression Predicted Discharges

Flow Node	$Q_{AEP,0}$ 1% Annual Chance	Upper 84% Confidence Limit 1%+
100	1,200	1872
200	1,040	1623
300	915	1428
400	223	348
500	809	1262
600	173	270
700	310	484
800	226	353
900	110	172
1000	561	875
1100	353	551
1200	311	485
1300	60	94
1400	1,130	1763
1500	223	348
1600	151	236
1700	99	154
1800	103	161
1900	48	74
2000	374	584
2100	565	882
2200	341	532
2300	295	460
2400	344	537
2500	273	426
2600	87	136
2700	117	183

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