Flood Discharge-Frequency Hydrologic Analysis for the Big Hole River, Montana

Hydrologic Analysis Report

Future West

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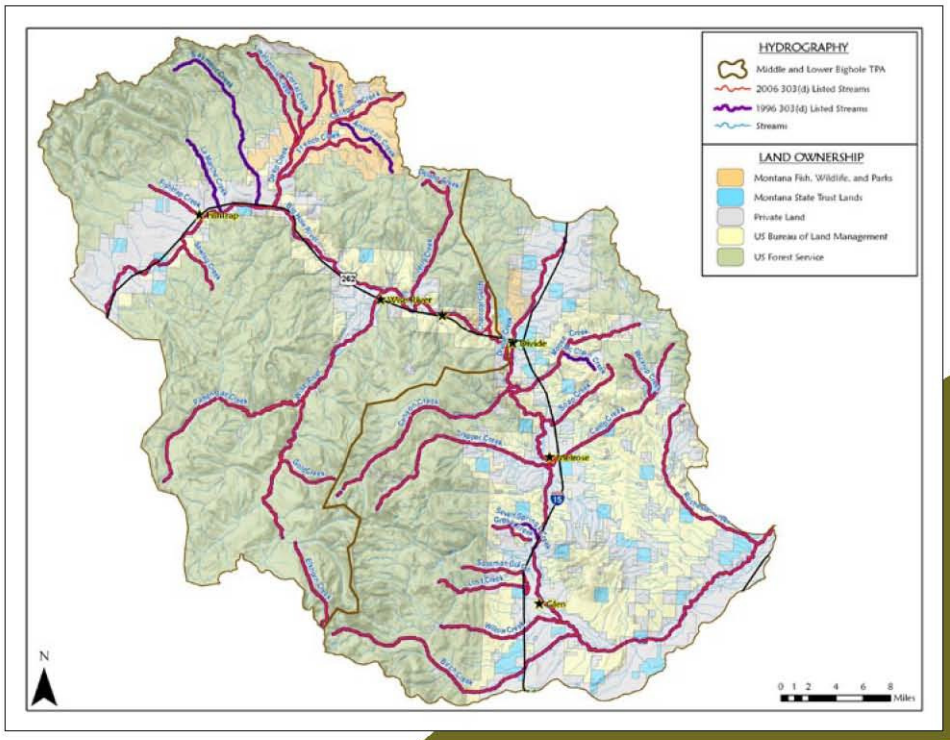

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Professional Engineer Certification and Approval

Professional Engineer Certification

I hereby certify this analysis and report meets technical engineering standards for hydrologic modeling.

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Table of Contents

1. Introduction **1**
- **1.1. Background Information** **1**
- **1.2. Basin Description** **2**
- **1.3. Flood History** **2**
- **1.4. Big Hole River Flood Study** **3**

2. Past Studies and Existing Flood Data **4**
- **2.1. SCS Flood Plain Management Study** **4**
- **2.2. FEMA Flood Insurance Study** **5**
- **2.3. Flood Inundation Potential Mapping and Channel Migration Zone Delineation** **6**
- **2.4. Irrigation Water Management** **7**
- **2.5. Total Maximum Daily Load** **7**

3. Hydrologic Analyses and Results **8**
- **3.1. Regional Regression Equation Analysis** **12**
  - 3.1.1. Basin Characteristics, Active Channel and Bankfull Width Regression Equations 12
  - 3.1.2. Weighted Combinations 16
- **3.2. USGS Stream Gage Analyses** **17**
  - 3.2.1. Single Station Statistical Gage Analysis 18
  - 3.2.2. Two Station Comparison Gage Analysis 20
  - 3.2.3. Regression Weighted Gage Analysis 29
  - 3.2.4. Gage Analysis Results Comparison 30
- **3.3. Ungaged Sites on Gaged Streams** **32**
  - 3.3.1. Log Interpolation of Gage Analyses 32
  - 3.3.2. Drainage Area Gage Transfer 34

4. Hydrologic Discussion **38**
- **4.1. Recommended Discharges** **40**
- **4.2. Comparison with Past Studies** **46**

5. Summary **48**

6. References **49**

Appendices
- **Appendix A. Calculations of Drainage Areas Above Elevation 6000’** **A**
- **Appendix B. Annual Peak Stream Flow Records** **B**
- **Appendix C. PKFQWin Input and Output Data** **C**
- **Appendix D. Two Station Comparison Method Calculations** **D**
- **Appendix E. Review and Correspondence** **E**

Tables

Table 1. Big Hole River Floodplain Study reach descriptions. 3
Table 2. Results and flow change locations of the 1986 SCS Flood Plain Management Study. 4
Table 3. Results and flow location of the 1977 Morrison-Maierle study described in the FEMA FIS. 5
Table 4. Results and flow change locations of the 2005 Flood Inundation Potential Mapping Study. 6
Table 5. Flow node and USGS stream gage information utilized in the hydrologic analysis. 9
Table 6. WRIR 03-4308 Average Standard Error Percentages for Southwest Region. 12
Table 7. Regression equation calculated variables. 13
Table 8. Resultant discharges for the Big Hole River based upon the basin characteristics regression method. 14
Table 9. Resultant discharges for the Big Hole River based upon the active channel width regression method. 15
Table 10. Resultant discharges for the Big Hole River based upon the bankfull width regression method. 16
Table 11. USGS Stream Gages along Big Hole River. 17
Table 12. Results of the baseline statistical gage analysis of USGS 06024450 (at Wisdom). 18
Table 13. Results of the baseline statistical gage analysis of USGS 06025500 (near Melrose). 19
Table 14. Results of the updated statistical gage analysis of USGS 06024450 (at Wisdom) and USGS 06025500 (near Melrose). 19
Table 15. Results of the statistical gage analysis of USGS 06023500 (near Jackson), USGS 06024540 (near Wisdom), USGS 06025250 (near Divide), and USGS 06026210 (near Glen). 20
Table 16. Two Station Comparison method initial assessments with USGS 06025500 (near Melrose). 21
Table 17. Two Station Comparison method results for USGS 06023500 (near Jackson). 22
Table 18. Two Station Comparison method results for USGS 06024450 (at Wisdom). 22
Table 19. Two Station Comparison method results for USGS 06024540 (near Wisdom). 22
Table 20. Two Station Comparison method results for USGS 06025250 (near Divide). 23
Table 21. Two Station Comparison method results for USGS 06026210 (near Glen). 23
Table 22. Equivalent years of record attributed to the various regression methods 29
Table 23. Results from regression weighted Two Station Comparison gage analyses. 30
Table 24. Comparison of flood frequency results by method for gaged sites. 31
Table 25. Log linear interpolation of Two Station Comparison gage results to ungaged flow nodes. 33
Table 26. Drainage area transfer method results for all flow node locations. 35
Table 27. Drainage area transfer method results for flow nodes downstream of USGS 06025500 (near Melrose). 37
Table 28. Results for all flow change locations generated by differing methodologies. 39
Table 29. Recommended Discharges and Hydrologic Methods for the Big Hole River 43
Table 30. Summary of Discharges for Big Hole River at Melrose. 46
Table 31. Detailed comparison of flow estimates between the 1986 SCS Study and the present study. 47

Figures

Figure 1. Big Hole River Flood Study reach limits. 10
Figure 2. Delineated subbasin areas, flow node locations, and elevation above 6000'. 11
Figure 3. Frequency curves for Two Station Comparison of USGS 06023500 (near Jackson) to USGS 06025500 (near Melrose). 24
Figure 4. Frequency curves for Two Station Comparison of USGS 06024450 (at Wisdom) to USGS 06025500 (near Melrose). 25
Figure 5. Frequency curves for Two Station Comparison of USGS 06024540 (near Wisdom) to USGS 06025500 (near Melrose). 26
Figure 6. Frequency curves for Two Station Comparison of USGS 06025250 (near Divide) to USGS 06025500 (near Melrose). 27
Figure 7. Frequency curves for Two Station Comparison of USGS 06026210 (near Glen) to USGS 06025500 (near Melrose). 28
Figure 8. Two Station Comparison Gage Analyses transferred to ungaged sites by a combination of log interpolation and drainage area methods. 36
Figure 9. Comparison of transferring Two Station Comparison with- and without USGS 06026210 (near Glen) analysis. 41
Figure 10. Recommended 1-percent annual discharge for each location. 44

1. Introduction

In cooperation with Future West, the Montana Department of Natural Resources and Conservation (DNRC), the Montana Department of Environmental Quality (DEQ), the Big Hole River Watershed Committee (BHWC), Anaconda-Deer Lodge County, Madison County, Beaverhead County, and Butte-Silver Bow County, Atkins has been contracted to develop a detailed study level flood discharge-frequency hydrologic analysis for 150 miles of the Big Hole River. This flood discharge-frequency hydrologic analysis is the first of a two phase effort to better understand the flood hazard and refine the flood hazard boundary along the river. The second phase of the project consists of an approximate level hydraulic analysis.

1.1. Background Information

The Big Hole River for much of its entire length has either never been mapped for flood hazard or has been mapped as an Approximate A Zone under the National Flood Insurance Program (NFIP) managed by the Federal Emergency Management Agency (FEMA). Flood hazard designations of this type commonly originated in the 1970s from Flood Hazard Boundary Maps which often lack technical basis for their flood hazard delineations. Montana is presently experiencing increasing developmental pressures in rural settings. Local governments that participate in the NFIP are tasked to provide regulatory framework for areas designated with a flood hazard in compliance with minimum standards set forth by the NFIP. The most difficult hazard areas to regulate development are the Approximate A Zones where little or no technical information is available to support those activities. The basis for regulation then comes in the form of “best available data”. Generally, communities then place the burden of developing technical information on the individual. This leads to inconsistencies of data throughout a reach of questionable integrity due to a lack of standards.

Present day technology has expedited hydrologic and hydraulic modeling and the associated mapping processes to develop detailed flood study information. The majority of cost often exists in the large scale collection of high resolution topographic data that adequately captures the topographic features that influence the flow regime and allows for hydraulic modeling and flood hazard mapping. For rural areas, the large costs associated with collecting high resolution topographic information can’t be justified and alternative topographic datasets are often used. For most of the intercontinental United States, the United States Geologic Survey (USGS) has produced the National Elevation Dataset (NED). Common products include 30- and 10-meter Digital Elevation Models (DEM). These datasets are in grid format with each 30- and 10-meter cell representing one elevation point. Typically, these datasets allow for coarse hydraulic modeling and mapping that require substantial manipulation to incorporate subtle topographic features and channel geometry. Past studies have shown that hydraulic modeling and hazard mapping with these NED products generally leads to a high level of error when compared to efforts utilizing high resolution topographic datasets such as LiDAR. For example, a study conducted by Anderson Consulting Engineers in 2010 (**Reference 1**) compared detailed level study water surface elevations and top widths produced with LiDAR topography to the same reach modeled by approximate methods with 10-meter DEM topography. Their results indicated a high level of geometric variability in both longitudinal profile and cross section shape which led to large discrepancies in base flood elevations and cross section top widths. Some reaches showed discrepancy in water surface elevation over 10 feet or differences in top width of greater than 80%. They recommended limiting the use of these NED products and approximate modeling methodologies to rural areas. For Montana, there are currently no established State guidelines for performing approximate level floodplain studies however FEMA has established approximate level study standards that apply.

Montana DNRC in cooperation with FEMA provide oversight and support to the Montana communities participating in the NFIP. One of DNRC Water Resource Division’s goals is to establish guidelines and standards to be used by communities and technical specialists for the development of flood studies of approximate nature. Montana DNRC has identified this pilot project to evaluate methodologies and develop State Standards for hydrologic and hydraulic analyses and flood hazard mapping.

1.2. Basin Description

The Big Hole River originates high in the Beaverhead Mountains of the Bitterroot Range in Southwest Montana. It flows northwest and north through the town of Wisdom and between the Anaconda Range to the northwest and the Pioneer Mountains to the east. It then flows eastward along the northern boundary of the Pioneer Mountains and begins a south east trajectory past the town of Wise River where the Wise River enters. Just south of Glen, Montana, the river turns back northward to join the Beaverhead River and Ruby River to form the Jefferson River, near Twin Bridges, Montana. The upper watershed is characterized by a very broad, low sloping valley until just downstream of the North Fork Big Hole River where the river enters a steeper canyon where the river remains confined until the confluence with Wise River where it opens to a larger floodplain area. Just downstream of Wise River, the Big Hole River enters another steep canyon remaining fairly confined until north of Melrose where the valley becomes more broad with floodplain areas prevalent for the remaining reach to the confluence with the Beaverhead River.

The Big Hole River's flood risk is typical of most Montana rivers in that flooding primarily results from rapid snowmelt in the high elevation mountains of the upper watershed. The Big Hole River typically shows two spring melt peaks in the hydrograph. The first peak comes in early spring when the Upper Big Hole Valley begins to melt off the season's snowpack. This peak is followed by a larger peak occurring when the high elevation mountainous areas melt in late spring.

The Big Hole River can generally be broken into three distinct reaches related to the river character and its geologic controls. As mentioned, the upper watershed is a high elevation, broad, low sloping valley. The soils and channel substrate in this area are generally fine grained. The river is sinuous and braided with several historic channels filled with spring water. This multi-thread channel system and abundant wetland areas have many implications for the hydraulic component of this flood study. The possibility exists for several divided flow scenarios that may require special attention to be modeled appropriately. Furthermore, since the valley is so broad and low sloping, shallow overbank flooding is expected and backwater effects from road embankments and undersized culverts will likely play a large role on water surface elevations. The second distinct reach begins down valley from Wisdom where the river enters a confined steep canyon. The geologic controls imposed on the river have created a primarily bedrock channel with large boulders that produce much energy loss in the form of roughness and turbulence. The river is confined with steep canyon walls and high banks which will likely produce a floodplain confined to the banks with high velocity and depth through this reach. The third reach begins upstream of Melrose where the canyon gives way to broad floodplains and split channels. Similar to the Upper Valley, unless the split channels are submerged, special care should be taken during hydraulic modeling of this reach.

1.3. Flood History

Flooding on the Big Hole River is not well documented throughout history. Where the Big Hole River is incised though the canyon sections, flooding rarely leaves the banks. Where the river is located in broad valleys, it's likely that the overbank areas attenuate flood flows. The largest flood documented happened in 1927 when a dam failed on Pattengail Creek. Pattengail Creek is a tributary to the Wise River located about 11 miles south of the confluence with the Big Hole River. This dam break produced the largest flow on record of 23,000 cfs at the USGS gaging station near Melrose. Although, majority of this flow was determined to have originated from the dam break, the Big Hole River was also experiencing high flows at that time. This dam break produced catastrophic flooding in which four lives were lost.

In 1972, the highest natural runoff produced flow was recorded at the Melrose gaging station of 14,300 cfs. The Daily Tribune-Examiner noted flooding and damages below Melrose. A photograph of Brown's Bridge, 6 miles downstream of Melrose, showed water reaching the bottom of the bridge deck. In 1975, that newspaper reported flood problems in Wisdom and Twin Bridges. A flow rate of 12,700 cfs was recorded at the Melrose gaging station for that event. In 1997, the fifth highest natural flow of 13,000 cfs was recorded at the Melrose gage. Aerial photographs were taken of the flooding between Twin Bridges and Sportsmans Park Campground. The Madisonian newspaper mentioned the 1997 and 1975 floods as a forewarning since the pre-melt snowpack in 2011 was comparable to those years. They continued to mention that flooding on the lower Big Hole is a common problem but flood damage is not common.

The Big Hole River Watershed is capable of producing large scale flooding and continued development pressures in this rural area warrant the need for a comprehensive understanding of flood risk to provide land managers a planning tool for smart development.

1.4. Big Hole River Flood Study

The Big Hole River floodplain study has been divided into three reaches with the previously analyzed SCS reach not being included in the Phase 2 investigation. The reach limits and lengths are shown in **Table 1.**

Table 1. Big Hole River Floodplain Study reach descriptions.

Reach	Length (mi)	Downstream Study Limit	Upstream Study Limit
Lower	39	River Mouth (Jefferson River Confluence)	Madison/Butte-Silver Bow County Boundary
SCS	34	Madison/Butte-Silver Bow County Boundary	Anaconda-Deer Lodge/Butte-Silver Bow County Boundary
Middle	22	Anaconda-Deer Lodge/Butte-Silver Bow County Boundary	Anaconda-Deer Lodge/Beaverhead County Boundary
Upper	55	Anaconda-Deer Lodge/Beaverhead County Boundary	Pioneer Creek Confluence

As illustrated in Table 1, the reaches of the study are divided by the county boundaries. The Lower Reach extends from the mouth of the Big Hole River to the Madison/Butte-Silver Bow County boundary at Melrose. The Middle Reach of the study begins at the Anaconda-Deer Lodge/Butte-Silver Bow County Boundary about 8.5 miles upstream of Wise River and terminates at the confluence with Pintler Creek which divides Anaconda-Deer Lodge and Beaverhead Counties. From here the Upper Reach of the study initiates with the upstream limit of the study being the confluence with Pioneer Creek. These reach limits are visually represented on **Figure 1**. The goal for this phase of the flood study is to develop flow change locations and flood discharge-frequency estimates to be used for each reach. This report summarizes the hydrologic findings for the 50-, 10-, 4-, 2-, 1- and 0.2-percent annual chance flood events along with a brief synopsis of past efforts on the Big Hole River.

2. Past Studies and Existing Flood Data

The Big Hole River is an iconic Montana valley that is cherished by many groups of people from the ranchers that reside along the river and make their living from working the land to recreationalists that frequent the river for its world renowned blue ribbon fly fishing. Many agencies and other groups have conducted studies throughout the past related to water resource management to fisheries. The variety of socioeconomic issues continues to evolve as expanding populations place an increasing demand on natural resources. A brief non-inclusive list of relevant past studies on the Big Hole River and existing flood hazard data is presented here for reference.

2.1. SCS Flood Plain Management Study

The most relevant studies toward this flood discharge-frequency analysis are past flood studies conducted on the Big Hole River. The most recent is the Soil Conservation Service (SCS), presently known as the Natural Resource Conservation Service (NRCS), study, "Flood Plain Management Study, Big Hole River, Silver Bow County, Montana" (**Reference 2**). This study's spans approximately 34 miles with an upstream limit at the Silver Bow County boundary about 8.5 miles upstream of Wise River, Montana and the downstream limit located just downstream of Melrose, Montana. This study reach is shown visually on **Figure 1**, occurring between the Middle and Lower study reaches. The SCS study was completed December, 1986.

The study utilized the USGS gage at Melrose as the primary source for flood flow frequency information. At the time of study, 63 years of annual peak flow information was recorded, including the 1927 Pattengail Dam failure that produced a peak flow of 23,000 cfs. SCS estimated the natural peak discharge that occurred simultaneously with the dam break instead of the full dam break peak flow. The resulting annual peak flow records from the gage at Melrose were analyzed according to the methods set forth in Bulletin 17B (**Reference 3**). Several flow change locations were desired for development of the hydraulic model. To apply the flood discharge-frequency results of the gage analysis to sites upstream, a drainage area relationship regression was performed with 28 other USGS gaging stations surrounding the study reach. The flow change locations established by SCS and their corresponding calculated flow rates are presented in **Table 2**.

Table 2. Results and flow change locations of the 1986 SCS Flood Plain Management Study.

		Discharge (cfs)			
Study Reach Description	Drainage Area (mi^2)	10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Downstream Study Limit, below Trapper and Camp Creeks	2,365	11,950	15,130	16,280	18,590
Just above Trapper and Camp Creeks	2,282	11,670	14,800	15,930	18,210
Just below Moose Creek	2,250	11,560	14,670	15,800	18,060
Just below Divide Creek	2,146	11,200	14,250	15,350	17,580
Just above Divide Creek	2,054	10,880	13,860	14,950	17,140
Just below Jerry Creek	1,999	10,690	13,640	14,710	16,880
Just below Wise River	1,942	10,490	13,390	14,450	16,600
Just above Wise River	1,682	9,530	12,250	13,250	15,280
Upstream Study Limit	1,609	9,260	11,920	12,900	14,900

As stated in Appendix F of the SCS study, "Peaks from this study's equations were also compared to peaks in a 1980 Corps of Engineers Hydrology report. The comparison showed almost no difference in this case." Unfortunately, the lack of widespread availability for the United States Army Corps of Engineers (USACE) report titled, "Hydrology – Beaverhead River, Big Hole River, and Jefferson River – Twin Bridges, Montana" (**Reference 4**) prevented a more detailed synopsis for the present study.

The SCS report also compared their peak estimate results to the "Big Hole River near Melrose, Flood Insurance Study (FIS), Butte-Silver Bow" (**Reference 5**). As stated in Appendix F of the SCS report, "The FIS study indicates peaks from 3 to 10 percent higher than those in this (1986 SCS) study. This difference is due to the FIS study using a smaller negative regional skew, using a different period of record, and not adjusting the peaks for drainage area." Additional information as to which flow rates and locations were compared was not available in that discussion.

It is important to note the latest FIS revision for Silver Bow County (**Reference 5**) adopted the 1986 SCS Flood Plain Study with an approximate level designation since it did not meet FEMA standards for a detailed flood study.

2.2. FEMA Flood Insurance Study

The FEMA Flood Insurance Study (FIS) for Silver Bow County (**Reference 5**) describes several flood studies completed by Morrison-Maierle, Inc. in June 1977. In that FIS, the Big Hole River was studied by both detailed and approximate methods. Priority for detailed studies was given to areas being developed or that had proposed construction through 1982. The FIS detailed study on the Big Hole River near Melrose prepared a hydrologic investigation for flood discharge-frequency estimates similar to the SCS study described in Section 2.1. The USGS gage at Melrose was the principal source of data; however the peak event of 1927 caused by dam failure was omitted from the analysis. The FIS describes that the period of record used for the analysis was 1923 – 1977 and that a log-Pearson type III distribution of annual peak flow data was used under the methodologies set forth in Bulletin 17, not to be confused with Bulletin 17B that was published at a later date and used by the SCS during their study. The results of the hydrologic analysis are shown in **Table 3**.

Table 3. Results and flow location of the 1977 Morrison-Maierle study described in the FEMA FIS.

		Discharge (cfs)			
Study Reach Description	Drainage Area (mi^2)	10-Percent-Annual-Chance	2- Percent-Annual-Chance	1- Percent-Annual-Chance	0.2- Percent-Annual-Chance
Big Hole River near Melrose	2,362	12,300	16,542	18,261	22,072

The FIS detailed study on the Big Hole River was studied through Melrose for about one half mile and consists of only the east split channel since the west channel is in Beaverhead County. The standard step backwater program HEC-2 was used to calculate water surface elevations through this reach.

As previously mentioned, the latest FIS revision for Silver Bow County adopted the 1986 SCS Flood Plain Study with an approximate level designation since it did not meet FEMA standards for a detailed flood study.

2.3. Flood Inundation Potential Mapping and Channel Migration Zone Delineation

DTM consulting, Inc. and Applied Geomorphology, Inc. teamed to study the Big Hole River under two related, but separate components (**Reference 6**). The primary goal for both components was to provide a planning tool to stakeholders for use in smart development along the Big Hole River. The first component is the Flood Inundation Potential section where a multi-county initiative to coordinate land use planning lead to the desire for mapping of the 100-year floodplain for the main stem of the Big Hole River. The techniques used were in part both a qualitative assessment of geologic and geomorphic controls in addition to a series of "at a station" quantitative analyses to predict flood depths. The second component of this study was to delineate channel migration and channel avulsion hazard areas along the Big Hole River based primarily on a collection of current and historic aerial images.

The Flood Inundation Potential Mapping component of this study was performed using 30-meter DEMs for mapping and an approximation method for determining flood depths at a single cross sections throughout the reach. Those depths were then interpolated between sections and projected onto the DEM. This methodology mimics that of detailed flood study hydraulics and mapping workflow processes, however the results are rather coarse.

Flood discharge-frequency estimates for this study were calculated from regional regression equations described in the USGS Water Resource Investigation Report 03-4308, "Methods for Estimating Flood Frequency in Montana Based on Data through Water Year 1998" (**Reference 7**). The estimates calculated in their study are shown in **Table 4** below.

Table 4. Results and flow change locations of the 2005 Flood Inundation Potential Mapping Study.

Location	Drainage Area (mi2)	1-Percent-Annual-Chance Discharge (cfs)
Miner Creek Bridge	116	6,462
Little Lake Road Bridge	380	14,528
Wisdom Bridge	591	19,607
Mudd Creek Bridge	1,274	33,283
Dickie Bridge	1,603	38,971

Based on proximity and similar drainage area, the flow results of this study at Dickie Bridge are suitable for comparison with the upstream study limit calculated flows of the SCS study. Although the SCS study based their estimates on a gage analysis and this study utilized regional regression equations, the results are substantially different with regression estimates being three times higher. Generally, basin characteristic regression equations produce conservative (higher) flow estimates, however preliminary calculations for the present study suggest regression estimates are lower than the gage analyses for this system. The results presented in their report and shown on **Table 4** suggest an incorrect flow rate was calculated from regression equations which inevitably propagated through their analysis to the final floodplain mapping product. Regardless, the coarse nature of the approach coupled with erring on the side of conservatism still provides a useful tool for land use management and planning at a large scale.

The migration zone component of the study is similar to the broad goal of a flood study in that its intent is mapping of high hazard areas throughout a riverine corridor, however it considers different factors than those of a flood study. Historic aerial imagery is analyzed and former river channels are identified for creation of the channel avulsion zone. For migration zones, the same historic imagery is reviewed and areas that show either excessive bank or future potential erosion are identified as a migration zone. These areas are shown on maps and provide regulators and planners an additional tool for illustrating risk and regulating development.

2.4. Irrigation Water Management

Much attention has been given to water users in the Big Hole River watershed. Agriculture, recreation, and fisheries all have interest in how much water flows down the river. The cornerstone of concern is the last remaining self sustained fluvial arctic grayling population in the lower 48 states that resides in the Big Hole River. Much controversy has existed during the 2000's as to whether this species should be listed on the Endangered Species List and to many local people, that listing may jeopardize their way of life by potentially limiting their water consumption from the Big Hole River. The opposition is concerned that during the two most crucial months of the year: May when the grayling are spawning; and August when hot temperatures threaten survival, water users are not leaving enough water in the river to provide a healthy environment for the grayling. Montana DNRC has investigated the water rights and irrigation water management. Furthermore, the NRCS has worked with users to develop an Environmental Quality Incentive Program (EQIP) plan. The goals of the plan are to reduce water consumption during critical months by providing water consumers compensation for deferring their use on specific parcels of land. Recent work by DNRC investigated the effectiveness of that plan on flows measured throughout the irrigation season of 2004 (**Reference 8**). Although abnormal precipitation may have influenced the effectiveness of that plan, their findings suggest that the plan provided more flow in the Big Hole River during the 2004 irrigation season.

2.5. Total Maximum Daily Load

The Department of Environmental Quality (DEQ) has performed an intensive Total Maximum Daily Load (TMDL) analysis of the entire Big Hole River Watershed (**References 9 and 10**). The primary goal for developing TMDLs is to identify solutions to pollution problems for streams and rivers that do not meet State standards. Eventually, TMDLs will improve water quality to a level that supports all state designated beneficial water users. Their extensive data collection consisted of environmental sampling, measurements, and observations for the development of sediment, metals, and nutrient TMDLs. Sediment TMDLs were developed by identifying and quantifying sediment pollutant loading from abandoned mines, silviculture, unpaved roads, and livestock grazing. Metals and nutrient TMDLs were established by sampling during spring runoff and base flow conditions. Measurements and sources are used to develop achievable goals for reduction of pollutants in the system.

3. Hydrologic Analyses and Results

Several flow change locations were identified throughout the entire 150 mile length of the Big Hole River. These flow change locations are required to adequately represent the peak flow distribution for inclusion into the hydraulic model during Phase 2 of this flood study. The identification of flow change locations (flow nodes) was an iterative process that began by first analyzing Hydrologic Unit Code (HUC) 12 digit watersheds. These are the smallest delineated watershed groups widely available. For example, as shown on **Figure 1**, the HUC 8 digit watershed for the project area is the entire Big Hole River watershed. The HUC 12 digit watersheds were inspected as an initial inspection of drainage area contribution along the entire reach length.

For hydraulic model development, calculated peak flow rates are often simulated in a steady-state model. For conservatism, the peak flow calculated at one point is projected upstream until the next flow node is reached. This procedure was followed for the Big Hole River during flow node location placement. Flow nodes were assigned just upstream of major tributaries so that the flow node downstream will have accounted for that drainage area's contribution.

After several iterations, 26 flow nodes were identified which are shown on **Figure 2** and **Table 5**. Also shown on **Table 5** is the location description for each flow node location and USGS gage along with profile baseline stationing, proposed hydraulic model stationing, and contributing watershed area. FEMA's Guidelines and Specifications, Appendix C (**Reference 11**) outlines the methodologies to follow for development of a hydrologic analysis for a FEMA flood study. These guidelines, in addition to USGS's WRIR 03-4308, "Methods for Estimating Flood Frequency in Montana Based on Data through Water Year 1998", (**Reference 7**) were followed for the development of flood discharge-frequency estimates on the Big Hole River.

Table 5. Flow node and USGS stream gage information utilized in the hydrologic analysis.

Node/Gage ID	Location Description	River Station (miles)[1]	Profile/Model Station (feet)[2,3,4]	Cumulative Basin Area (mi^2)	Subbasin Area (mi^2)
06023500	BIG HOLE RIVER NEAR JACKSON, MT	149.1	401,150	43.9	
50	BIG HOLE RIVER BELOW BERRY CREEK	144.0	374,530	75.2	75.2
75	BIG HOLE RIVER ABOVE GOVERNOR CREEK	137.0	330,300	113	37.8
85	BIG HOLE RIVER ABOVE MINER CREEK	131.4	308,000	352	239
100	BIG HOLE RIVER ABOVE BIG SWAMP CREEK	128.3	291,500	432	80
200	BIG HOLE RIVER ABOVE BIG LAKE CREEK	118.5	231,750	499	67
300/06024450	BIG HOLE RIVER BELOW BIG LAKE CREEK AT WISDSOM, MT	110.7	198,475	591	92
350	BIG HOLE RIVER ABOVE SWAMP CREEK	105.9	173,150	676	85
400	BIG HOLE RIVER ABOVE NORTH FORK BIG HOLE RIVER	102.0	152,700	774	98
500	BIG HOLE RIVER BELOW PINTLER CREEK	94.5	113,150	1,206	432
550/06024540	BIG HOLE RIVER BELOW MUDD CREEK NEAR WISDOM	89.0	83,850	1,274	68
600	BIG HOLE RIVER ABOVE FISHTRAP CREEK	82.1	47,700	1,313	39
700	BIG HOLE RIVER ABOVE DEEP CREEK	75.8	14,300	1,464	151
800*	BIG HOLE RIVER BELOW BRYANT CREEK	73.1	0	1,601	137
900*	BIG HOLE RIVER ABOVE WISE RIVER	63.9		1,672	71
1000	BIG HOLE RIVER ABOVE JERRY CREEK	61.7		1,946	274
1100*	BIG HOLE RIVER ABOVE DIVIDE CREEK	50.7		2,043	97
1200	BIG HOLE RIVER ABOVE CANYON AND MOOSE CREEKS	48.1		2,146	103
06025250	BIG HOLE RIVER AT MAIDEN ROCK NEAR DIVIDE, MT	47.3		2,196	50
1300*	BIG HOLE RIVER ABOVE TRAPPER AND CAMP CREEKS	39.4		2,274	78
1350	BIG HOLE RIVER ABOVE CHERRY CREEK	36.6	193,489	2,367	93
1400	BIG HOLE RIVER ABOVE ROCK CREEK	31.1	164,100	2,433	66
06025500	BIG HOLE RIVER NEAR MELROSE, MT	30.9	163,235	2,469	36
1500	BIG HOLE RIVER ABOVE WILLOW CREEK	25.4	134,110	2,502	33
1600	BIG HOLE RIVER ABOVE BIRCH CREEK	23.9	126,420	2,569	67
1625/06026210	BIG HOLE RIVER NEAR GLEN, MT	16.9	89,480	2,665	96
1650	BIG HOLE RIVER UPSTREAM OF OWSLEY SLOUGH	11.1	58,550	2,693	28
1675	BIG HOLE RIVER UPSTREAM OF NEZ PERCE CREEK	5.4	28,620	2,722	29
1700	BIG HOLE RIVER AT MOUTH	0.0	0	2,792	70

*[1] Miles above mouth of Big Hole River. [2] Locations between USGS 06023500 and Node ID 800 are in feet above Beaverhead County/Anaconda County boundary. [3] Locations between Node ID 1350 and Node ID 1700 are in feet above mouth. [4] Locations between Node ID 900 and 1300 are within the previously studied SCS reach (**Reference 2**). *Denotes flow change location that are coincident with previously studied SCS reach.*

Figure 1. Big Hole River Flood Study reach limits.

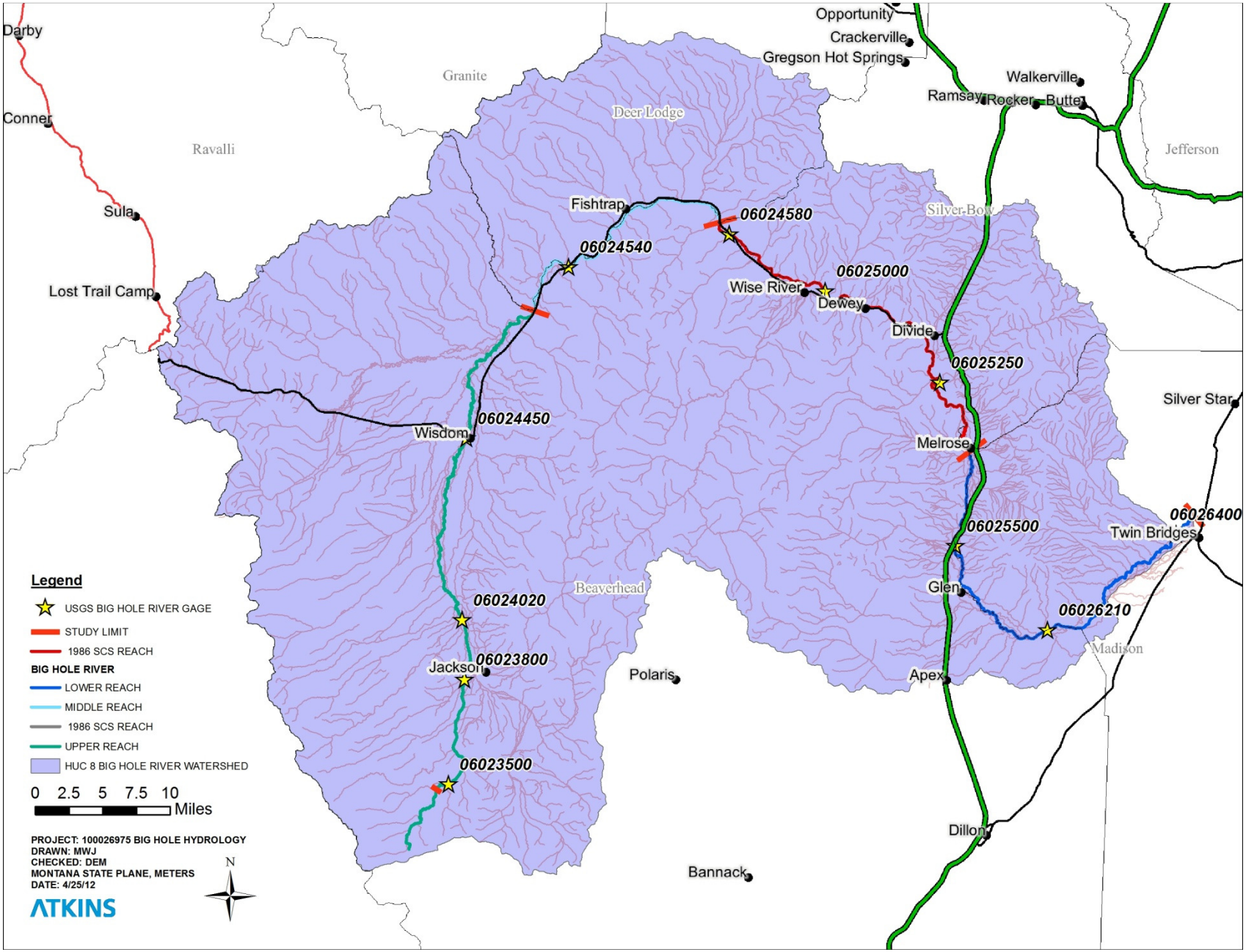
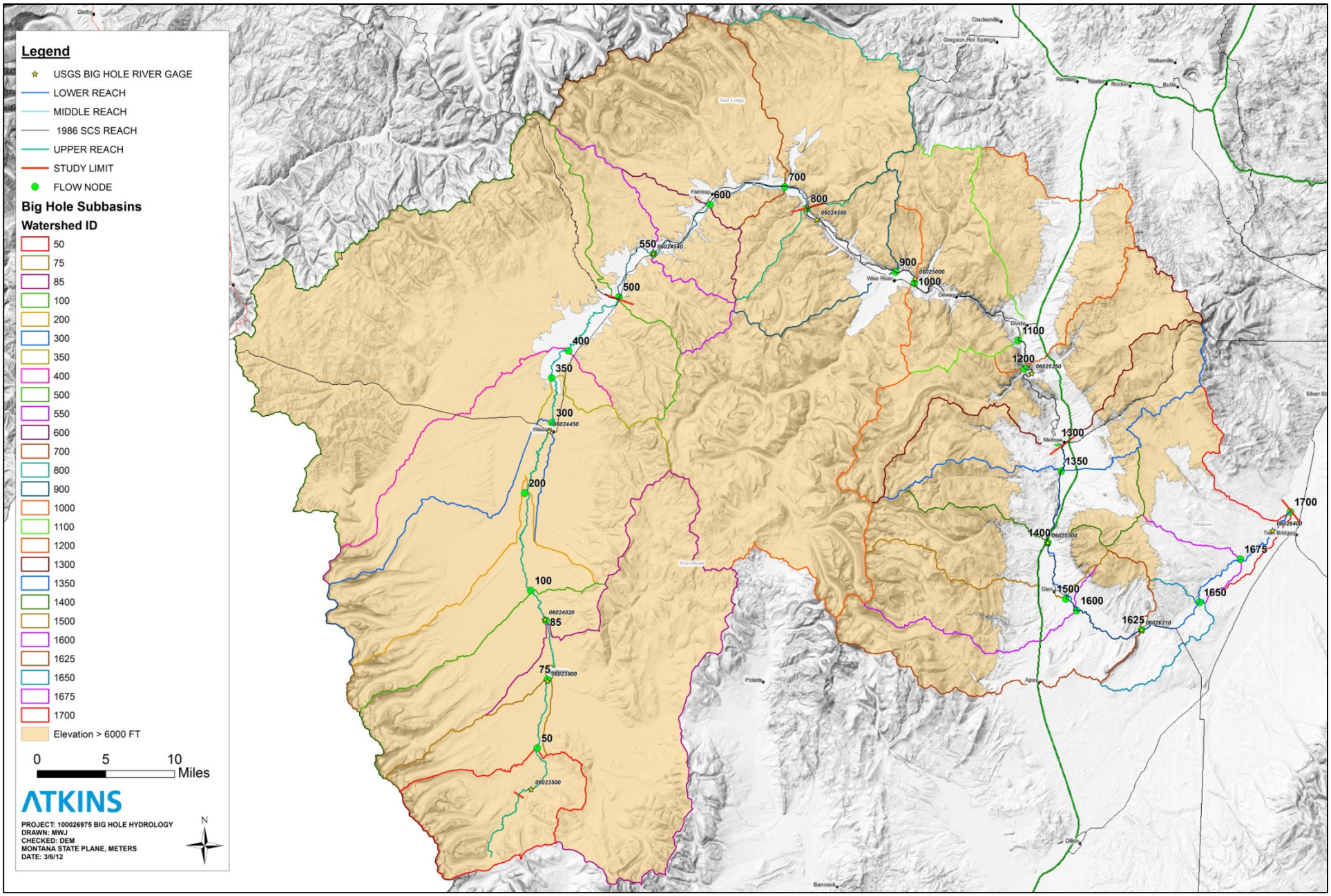


Figure 2. Delineated subbasin areas, flow node locations, and elevation above 6000'.



3.1. Regional Regression Equation Analysis

Regional regression equations were used to compute the annual peak discharge values for all delineated basins within the Big Hole River watershed. These equations are presented in USGS WRIR 03-4308 and are based on gage data through water year 1998. USGS WRIR 03-4308 separates Montana into eight different regions based on topography and climatic conditions. The entire Big Hole River watershed is located in the Southwest Region.

3.1.1. Basin Characteristics, Active Channel and Bankfull Width Regression Equations

USGS WRIR 03-4308 provides regression equations based on basin characteristics, active-channel width, bankfull width and various weighted combinations of the methods. It also provides the average Standard Error of Prediction (SEP) for all the methods. Shown below in **Table 6** are the average SEP values listed in WRIR 03-4308 for the Southwest Region.

Table 6. WRIR 03-4308 Average Standard Error Percentages for Southwest Region.

Method	2-year	10-year	25-year	50-year	100-year	500-year
Basin Characteristics (BC)	94.4	75.9	75.6	77.4	80.3	89.9
Active Channel Width (ACW)	60.5	62.8	73.2	82.1	91.3	114.9
Bankfull Width (BW)	68.8	67.4	76.7	85.1	94.1	117.5

Based on **Table 6**, higher reliability can be expected from discharge estimates calculated with basin characteristic regression equations for the 1% annual chance event when compared to either channel width regression estimates.

Prior to using the equations, the variables for all delineated basins were estimated. The calculated parameters, along with the range of values used to develop the regression equations are presented below in **Table 7**.

ArcGIS 10.0 was used to estimate all variables for the basin characteristics equations in a manner consistent with the methods used by the USGS to formulate the regression equations. The drainage areas (A) were delineated using 10 m Digital Elevation Models (DEM). Drainage area delineations are shown in **Figure 2** with the subbasin areas and cumulative drainage areas shown in **Table 7**.

The percentage of each drainage area above elevation 6000’ was estimated reclassifying the 10M DEM raster for values greater than or equal to 6000’. The resultant raster contained cells with either no data or elevation data greater than 6000’. The raster was converted to a polygon and clipped to each subbasin area. The areas of each basin above 6000’ are shown on **Figure 2**. The resulting percentage of each drainage area above elevation 6000’ is summarized in **Table 7** with the calculations included in **Appendix A**.

Active channel and bankfull widths regression equations were reviewed for utilization in development of flood discharge frequency estimates for Big Hole River. The active-channel widths and bankfull widths were measured during field reconnaissance. Throughout the entire reach, the Big Hole River fluctuates between single thread channel and multiple channels. Careful examination was required to select a representative single thread location where multiple thread characteristics dominated the vicinity of the proposed flow change location. The presence of secondary channel compromises the applicability of the regression method based on channel characteristics if a single measurement describing the reach cannot be attained. Once a channel splits, each split contains a different channel forming flow where simply measuring both channels and adding the resulting peak flow estimates is not appropriate. Hence, conducting a regression analysis based on channel characteristics at locations where a representative single thread was not found could not be justified. There were also locations where the channel was wider than the guidelines set forth in WRIR 03-4308. WRIR 03-4308 states that streams in the southwest region should have an active channel width from 1.8’ to 223’ and a bankfull width of 3.5’ to 260’.

Table 7. Regression equation calculated variables.

Description/Basin ID	Drainage Area (mi^2)	Subbasin Area (mi^2)	Drainage Area Above 6000' (%)	Active Channel Width (ft)	Bankfull Width (ft)
Southwest Region Range of Values Used to Develop Regression Equations	**0.39 to 2,476**	**-**	**0 to 100**	**1.8 to 223***	**3.5 to 260***
50	75.2		100	36	56
75	113	37.8	100	32	39
85	352	239	100	83	98
100	432	80	100	74	83
200	499	67	100	-	-
300	591	92	100	101	134
350	676	85	99.9	117	140
400	774	98	99.5	164	179
500	1,206	432	98.5	131	150
550	1,274	68	97.9	211	220
600	1,313	39	97.6	300	338
700	1,464	151	97.3	149	191
800	1,601	137	97.2	173	206
900	1,672	71	96.8	-	-
1000	1,946	274	96.7	174	211
1100	2,043	97	96.3	203	261
1200	2,146	103	94.8	135	184
1300	2,274	128	94.1	173	191
1350	2,367	93	93.5	+	+
1400	2,433	66	92.2	223	260
1500	2,502	69	91.5	*N/A*	*N/A*
1600	2,569	67	90.9	*N/A*	*N/A*
1625	2,665	96	89.4	*N/A*	*N/A*
1650	2,693	28	88.4	*N/A*	*N/A*
1675	2,722	29	87.8	*N/A*	*N/A*
1700	2,792	70	86.7	*N/A*	*N/A*

*N/A denotes locations where the regression parameters were not collected because the locations were outside the limits set forth by USGS personnel. + indicates a location where the river was comprised of multiple channels. – indicates locations with access difficulties *USGS personnel suggested a revised suggested maximum of active channel and bankfull widths as discussed in this section.*

However, during the analysis it was discovered that regression analysis based on channel characteristics actually produced a higher discharge for the more frequent events before the measured widths reached the maximum set forth by WRIR 03-4308. For example, erroneous results are obtained when the active channel width of 200' is input to the active channel width equation. The 2-year peak flow estimate exceeds the 10-year peak flow estimate. When the maximum suggested bankfull width of 260' is input to the bankfull width equation, the 2-year peak flow event exceeds the 500-year peak flow estimate. This phenomenon invokes skepticism in the maximum suggested widths presented in WRIR 03-4308. After discussion of the issue with

local USGS personnel, a revised limit for the active channel width of 100' was proposed. The revised limit is based on observation that the largest gage used during development of the Southwest Region regression equations was Big Hole River near Melrose (USGS 06025500), and without the addition of comparable sized gages to the sample population, results become skewed near the upper limit of input data. Regardless, each flow node location was visited with the exception of a few locations due to access difficulties, lack of a single thread channel, or the channel exceeding the published range of applicability. All measured values for active channel and bankfull widths are presented in **Table 7**.

Regression equations for basin characteristics, active-channel width and bankfull width were calculated for each basin independently. All calculations were performed utilizing the equations presented in WRIR 03-4308. Results of the regression analyses are included below in **Tables 8 - 10**.

Table 8. Resultant discharges for the Big Hole River based upon the basin characteristics regression method.

Location	Drainage Area (mi^2)	Drainage Area Above 6000' (%)	Discharge (cfs)					
			2-year	10-year	25-year	50-year	100-year	500-year
50	75.2	100	214	425	547	640	743	986
75	113	100	306	582	737	854	982	1,280
85	352	100	832	1,380	1,680	1,900	2,130	2,630
100	432	100	997	1,620	1,950	2,190	2,450	3,000
200	499	100	1,130	1,810	2,170	2,430	2,700	3,290
300	591	100	1,310	2,060	2,450	2,730	3,030	3,660
350	676	99.9	1,480	2,280	2,710	3,010	3,320	3,990
400	774	99.5	1,660	2,530	2,990	3,310	3,650	4,360
500	1,206	98.5	2,460	3,560	4,150	4,540	4,970	5,820
550	1,274	97.9	2,580	3,720	4,320	4,730	5,170	6,040
600	1,313	97.6	2,650	3,810	4,420	4,840	5,290	6,170
700	1,464	97.3	2,910	4,140	4,790	5,230	5,700	6,620
800	1,601	97.2	3,150	4,440	5,110	5,570	6,060	7,010
900	1,672	96.8	3,270	4,590	5,290	5,760	6,250	7,230
1000	1,946	96.7	3,740	5,160	5,910	6,410	6,940	7,970
1100	2,043	96.3	3,900	5,360	6,130	6,640	7,190	8,240
1200	2,146	94.8	4,070	5,580	6,380	6,920	7,490	8,580
1300	2,274	94.1	4,280	5,850	6,670	7,230	7,820	8,940
1350	2,367	93.5	4,430	6,040	6,890	7,460	8,060	9,210
1400	2,433	92.2	4,530	6,180	7,060	7,650	8,270	9,450
1500	2,502	91.5	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
1600	2,569	90.9	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
1625	2,665	89.4	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
1650	2,693	88.4	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
1675	2,722	87.8	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
1700	2,792	86.7	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*

N/A denotes locations where the regression parameters were not collected because the locations were outside the limits set forth by USGS personnel.

Table 9. Resultant discharges for the Big Hole River based upon the active channel width regression method.

Location	Active Channel Width (ft)	Discharge (cfs)					
		2-year	10-year	25-year	50-year	100-year	500-year
50	36.0	481	910	1,190	1,390	1,620	2,140
75	31.5	385	766	1,010	1,200	1,410	1,910
85	82.5	1,920	2,650	3,130	3,420	3,770	4,430
100	73.5	1,580	2,280	2,730	3,020	3,350	4,000
200	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
300	101	2,670	3,420	3,940	4,250	4,610	5,260
350	117	3,440	4,160	4,710	5,010	5,380	6,010
400	164	6,020	6,410	6,960	7,220	7,570	8,060
500	131	4,170	4,830	5,380	5,680	6,050	6,650
550	211	9,180	8,880	9,360	9,510	9,800	10,100
600	300	16,600	14,000	14,200	14,000	14,100	13,700
700	149	5,160	5,690	6,250	6,530	6,890	7,430
800	173	6,640	6,910	7,460	7,690	8,040	8,480
900	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
1000	174	6,660	6,930	7,470	7,710	8,050	8,500
1100	203	8,650	8,490	8,980	9,150	9,450	9,750
1200	135	4,390	5,030	5,590	5,880	6,250	6,830
1300	173	4,390	6,910	7,460	7,690	8,040	8,480
1350	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
1400	223	10,100	9,560	10,000	10,100	10,400	10,600
1500	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
1600	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
1625	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
1650	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
1675	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
1700	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*

N/A denotes locations where the regression parameters were not collected because the locations were either outside the limits set forth by USGS personnel, the river was comprised of multiple channels, or access difficulties prevented collection of channel width information.

Table 10. Resultant discharges for the Big Hole River based upon the bankfull width regression method.

Location	Bankfull Width (ft)	Discharge (cfs)					
		2-year	10-year	25-year	50-year	100-year	500-year
50	55.5	679	1,180	1,480	1,710	1,960	2,540
75	39.0	349	707	931	1,110	1,300	1,800
85	97.5	1,970	2,690	3,120	3,410	3,740	4,440
100	82.5	1,440	2,110	2,500	2,780	3,090	3,760
200	*N/A*	*N/A*	N/A	N/A	N/A	N/A	N/A
300	134	3,570	4,260	4,720	5,020	5,370	6,060
350	140	3,880	4,540	5,010	5,300	5,650	6,320
400	179	6,180	6,510	6,930	7,180	7,500	8,070
500	150	4,440	5,040	5,500	5,790	6,130	6,790
550	220	9,160	8,830	9,130	9,270	9,530	9,910
600	338	20,600	16,500	16,100	15,700	15,600	15,200
700	191	7,040	7,200	7,590	7,810	8,120	8,640
800	206	8,120	8,040	8,390	8,570	8,850	9,310
900	*N/A*	*N/A*	N/A	N/A	N/A	N/A	N/A
1000	211	8,450	8,290	8,620	8,790	9,070	9,500
1100	261	12,700	11,300	11,400	11,500	11,600	11,700
1200	184	6,550	6,810	7,220	7,450	7,770	8,320
1300	191	6,550	7,190	7,580	7,800	8,110	8,630
1350	*N/A*	*N/A*	N/A	N/A	N/A	N/A	N/A
1400	260	12,600	11,300	11,400	11,400	11,600	11,700
1500	*N/A*	*N/A*	N/A	N/A	N/A	N/A	N/A
1600	*N/A*	*N/A*	N/A	N/A	N/A	N/A	N/A
1625	*N/A*	*N/A*	N/A	N/A	N/A	N/A	N/A
1650	*N/A*	*N/A*	N/A	N/A	N/A	N/A	N/A
1675	*N/A*	*N/A*	N/A	N/A	N/A	N/A	N/A
1700	*N/A*	*N/A*	N/A	N/A	N/A	N/A	N/A

N/A denotes locations where the regression parameters were not collected because the locations were either outside the limits set forth by USGS personnel or the river was comprised of multiple channels.

Since drainage area and percentage of each subbasin above 6000' are the only variables in the basin characteristic regression equation, the computed flow estimates follow a logical trend of flow increasing with drainage area. Both active and bankfull width measurements showed high variability and the results are sporadic and suspect. This may be explained in part by the variable stream type along the entire reach of the Big Hole River. Beginning in the Upper Valley as broad and low sloping, transitioning to a steep confined canyon in the Middle Reach, and the Lower Reach transitioning back to wide and low sloping with abundant floodplain area. Although flood frequency peak discharge results generated by channel width regression equations were not inspiring, the use of weight combinations of each equation type deserves discussion.

3.1.2. Weighted Combinations

The USGS has also included within WRIR 03-4308 procedures for various weighted combinations of the three types of regression equations. The three types can be weighted inversely proportional to their individual error variances and averaged to produce weighted estimates, with overall lower SEPs, that can potentially be more reliable than the individual equations. However, for the development of flood discharge

frequency estimates on the Big Hole River, weighted combinations was viewed inappropriate due to the questionable applicability of the channel width regression equations for a river system of varied character along its entire reach. Furthermore, the revised channel width maximum limit suggested by USGS prevented use of those equations for most the entire study. In addition to these limitations, it was also observed during investigation of weighted combinations that combinations including both active channel and bankfull width are not supported. The weighted combinations of basin characteristics, active channel width, and bankfull width and combinations of just active channel and bankfull widths contain a zero weighting factor for bankfull width. Although for these combinations bankfull width is not considered, the USGS provided new SEPs for that do not match the SEPs for the combinations that exclude bankfull width. In addition to the illogical results for frequent floods near the upper published limit of applicability as discussed in Section 3.1.1, publication of these SEP factors invokes further skepticism in the credibility of the channel width regression equations for the Southwest Region since WRIR 03-4308 does not provide discussion on the reasoning for omission.

3.2. USGS Stream Gage Analyses

The United States Geological Survey (USGS) has historically operated 12 stream gages along the Big Hole River. The number of annual peaks recorded at each gage ranges from zero to 87 years. The most notable gage is USGS 06025500 located near Melrose, MT which has been in operation since 1924 and contains 87 years of record. USGS gage information was obtained for the present study through water year 2011. Subsequent review and revision of the present study required addition of peak flow record through water year 2012 for USGS 06025250 (near Divide). A summary of the gages historically operated along the Big Hole River is displayed in **Table 11** with the location of each gage illustrated in **Figure 2**. Annual peak stream flow records for each gage are included in **Appendix B**.

Table 11. USGS Stream Gages along Big Hole River.

Station No.	Station Name	Abbreviated Description	Period of Record	Number of Annual Peaks	Drainage Area (mi^2)
06023500	Big Hole River near Jackson, MT	Near Jackson	1948 – Present*	8	44
06023800	Big Hole River above Spring Creek near Jackson, MT		2010 – Present	2	*N/A*
06024020	Big Hole River at Miner Creek near Jackson, MT		2010 – Present	2	352
06024450	Big Hole River below Big Lake Creek at Wisdom, MT.	At Wisdom	1988 – Present	24	593
06024540	Big Hole River below Mudd Creek near Wisdom, MT	Near Wisdom	1998 – Present	14	1,274
06024580	Big Hole River near Wise River, MT		1980 – Present*	5	1,611
06025000	Big Hole River near Dewey, MT		1910 – 1913	0	1,946
06025250	Big Hole River at Maiden Rock near Divide, MT	Near Divide	1998 – Present*	10^+	2,146
06025500	Big Hole River near Melrose, MT.	Near Melrose	1924 – Present	87	2,433
06026210	Big Hole River near Glen, MT	Near Glen	1998 – Present	14	2,665
06026400	Big Hole River near mouth		1980 – 1981	2	2,762
06026420	Big Hole River below Hamilton Ditch near Twin Bridges, MT		2007 – Present	4	2,790

N/A denotes that this drainage area was not provided by USGS.
** denotes discontinuous record, $^+$ indicates gage was updated through water year 2012*

All gage analyses were performed utilizing the assumptions and procedures outlined in *Guidelines for Determining Flood Flow Frequency, Bulletin 17B of the Hydrologic Subcommittee* (**Reference 3**). The software package PKFQWin (Version 5.2.0) (**Reference 12**) developed by the USGS was utilized for the analysis. The annual peak flow data for all applicable gages was downloaded from the USGS website in WATSTORE text format (**References 13 – 24**) to allow the data to be directly input into the PKFQWin program. As recommended by local USGS personnel, a Generalized Skew Standard Error (GSSE) of 0.64 was utilized for all gage analyses.

3.2.1. Single Station Statistical Gage Analysis

As previously mentioned, the USGS has historically operated numerous stream gages along the Big Hole River. The number of annual peaks recorded at each gage ranges from zero to 87 years. According to Bulletin 17B, in order to perform a reliable statistical gage analysis, the period of record should be at least ten years. This would limit the list of applicable gages to USGS 06024450 (at Wisdom), USGS 06024540 (near Wisdom), USGS 06025500 (near Melrose), and USGS 06026210 (near Glen). However, according to Dalrymple and Benson (**Reference 25**), in order to accurately estimate the 1-percent annual chance discharge, it is recommended that the analyzed gage have a minimum record of 20 years. Therefore, the results of the statistical gage analysis for USGS 06024540 and USGS 06026210 should be taken with caution as they both have a limited period of record equal to 14 years. This period of record can be improved through the Two Station Comparison method as discussed in Section 3.2.2.

Prior to the establishment of the updated flood flow frequency estimates proposed for the present study, the State of MT requires that a baseline analysis be performed to ensure consistency with the gage analyses performed by the USGS within WRIR 03-4308. This step is done to ensure that parameters used for the present study's analysis of each gage agree with what was used by USGS to maintain consistency between analyses. In preparation of the WRIR 03-4308, the USGS performed an analysis of USGS 06024450 (at Wisdom) and USGS 06025500 (near Melrose).

For the baseline analysis of USGS 06024450, the annual peak flow data records collected after water year 1998 were removed from the file. This resulted in a baseline period of record equal to 11 years. As seen in **Table 12** below, utilizing a GSSE of 0.64 produces baseline results that mirror those listed in WRIR 03-4308 for USGS 06024450. PKFQWin input and output for the baseline analysis are included in **Appendix C.**

Table 12. Results of the baseline statistical gage analysis of USGS 06024450 (at Wisdom).

Frequency	WRIR 03-4308 Estimated Discharge (cfs)	Baseline Estimated Discharge (cfs)
2-year	1,680	1,680
5-year	3,120	3,120
10-year	4,290	4,290
25-year	6,010	6,010
50-year	7,450	7,450
100-year	9,020	9,020
500-year	13,300	13,300

In order to perform the baseline analysis for USGS 06025500, the period of record was truncated by removing the data collected after water year 1998 in order to match the period of record of the WRIR 03-4308 analysis performed in 1998. It was also noted that the recorded peak flow captured by USGS 06025500 of 1927 was due in large part to a dam failure on a tributary upstream of the gage near Wise River. The peak produced by the 1927 dam break on Pattengail Creek was significantly higher than the next highest discharge of 14,300 cfs (1972). Therefore the peak flow record for 1927 was removed from the analysis, resulting in a period of record equal to 73 years. This event was removed from past studies as well. As previously mentioned, a GSSE of 0.64 was applied. As seen in **Table 13**, the resultant discharges for the baseline analysis of USGS 06025500 match those of WRIR 03-4308. PKFQWin input and output for the baseline analysis of USGS 06025500 are included in **Appendix C.**

Table 13. Results of the baseline statistical gage analysis of USGS 06025500 (near Melrose).

Frequency	WRIR 03-4308 Estimated Discharge (cfs)	Baseline Estimated Discharge (cfs)
2-year	7,160	7,160
5-year	10,400	10400
10-year	12,300	12,300
25-year	14,500	14,500
50-year	15,900	15,900
100-year	17,200	17,200
500-year	19,900	19,900

Using the parameters obtained during the baseline analysis, an updated statistical gage analysis was performed with additional peak flow data recorded since completion of WRIR 03-4308. The recorded annual peaks of 1999-2011 (13 years) for USGS 06024450 (at Wisdom) and recorded annual peaks of 1999-2012 (14 years) for USGS 06025500 near Melrose were added to their respective baseline input and an updated statistical gage analysis was performed following the procedures outlined in Bulletin 17B. As described above, based on conversations with USGS personnel, a weighted skew was calculated using a GSSE of 0.64. The results of the updated PKFQWin analysis for USGS 06024450 and USGS 06025500 are displayed in **Table 14**. The input and output files are included in **Appendix C**.

Table 14. Results of the updated statistical gage analysis of USGS 06024450 (at Wisdom) and USGS 06025500 (near Melrose).

Frequency	USGS 06024450 Estimated Discharge (cfs)	USGS 06025500 Estimated Discharge (cfs)
2-year	1,630	6,900
10-year	3,750	12,200
25-year	5,010	14,400
50-year	6,010	15,900
100-year	7,060	17,300
500-year	9,680	20,200

The methods and parameters utilized within the updated statistical gage analyses of USGS 06024450 and 06025500 were also utilized to perform a gage analysis for USGS 06024540 (near Wisdom) and USGS 06026210 (near Glen) as they both presently have a period of record equal to 14 years. The analysis of these gages could not be baselined and compared to the results listed in WRIR 03-4308 as they each only had one year of record when WRIR 03-4308 was published. Similarly, gages USGS 06023500 (near Jackson) and USGS 06025250 (near Divide) were analyzed. However, given that gages USGS 06023500 and USGS 06025250 only have a period of record equal to eight and ten years, respectively, the single station analysis was performed for comparison purposes and for consideration within the Two Station Comparison method, described in Section 3.2.2, which may provide an increased equivalent years of record. The results of the PKFQWin analysis for USGS 06024540 (near Wisdom), USGS 06026210 (near Glen), USGS 06023500 (near Jackson), and USGS 06025250 (near Divide) are displayed in **Table 15**. The input and output are included in **Appendix C.**

Table 15. Results of the statistical gage analysis of USGS 06023500 (near Jackson), USGS 06024540 (near Wisdom), USGS 06025250 (near Divide), and USGS 06026210 (near Glen).

Frequency	06023500 Estimated Discharge (cfs)	06024540 Estimated Discharge (cfs)	06025250 Estimated Discharge (cfs)	06026210 Estimated Discharge (cfs)
2-year	471	3,420	6,060	6,110
10-year	714	6,430	10,900	11,300
25-year	841	7,850	13,000	14,300
50-year	938	8,850	14,400	16,400
100-year	1,040	9,810	15,800	18,600
500-year	1,280	11,900	18,700	23,600

These results follow a logical trend of increasing discharge with increasing drainage area. These results were done in part to evaluate each gage regardless of whether the gage had a suitable period of record, as well as to be used in the Two Station Comparison Method where obtaining a lengthier equivalent period of record may be possible.

3.2.2. Two Station Comparison Gage Analysis

As mentioned, USGS has operated and is currently operating several gages on the Big Hole River. Of these 12 gages, 7 have a limited period of record (less than 10 years) considered unsuitable for a statistical gage analysis. Described in Appendix 7 of Bulletin 17B is a procedure to improve flood discharge-frequency estimates of short record gage by comparing the records to those of a long term gage on the same stream with overlapping record. This method performs regression on the concurrent peak flows measured at both gages and uses that correlation to improve estimates of the mean and standard deviation of the short term gage record. This procedure essentially improves the confidence of the short term gage record for use in a statistical gage analysis and is being used more frequently. One example is the recent analysis performed by DNRC titled, “Hydrology Design Report – Clark Fork River and Flathead River near Paradise, Sanders County, MT” (**Reference 26**). In the study, DNRC utilized this methodology to improve estimates of the mean and standard deviation for the USGS gage at Perma (USGS 12388700) for use in a FEMA detailed flood study. Additionally, the USGS has utilized this method in their recent report titled, “Two-Station Comparison of Peak Flows to Improve Flood-Frequency Estimates for Seven Streamflow Gaging Stations in the Salmon and Clearwater River Basins, Central Idaho” (**Reference 27**). This report utilized the Two Station Comparison method to improve estimates of the mean and standard deviation for seven short term gaging stations in Idaho.

This method builds on the single station gage analysis performed for this study and described above. The USGS gage at Melrose (USGS 06025500) contains the most reliable gage record available on the Big Hole River with 87 years of recorded annual peak flow information. As done during single gage analysis, the 1927 dam break event was removed from this analysis. All other gages on the Big Hole River have concurrent record with this gage so application of the Two Station Comparison method is reasonable. USGS 06025500 (at Melrose) was used as the basis for improving estimates of the mean and standard deviation for gages USGS 06023500 (near Jackson), USGS 06024450 (at Wisdom), USGS 06024540 (near Wisdom), USGS 06025250 (near Divide), and USGS 06026210 (near Glen). **Table 16** shows the gages where Two Station Comparison method was considered.

Table 16. Two Station Comparison method initial assessments with USGS 06025500 (near Melrose).

Station No.	Number of Annual Peaks	Equivalent Years of Record, EYR	Correlation Coefficient, r	Weighted Skew Coefficient (GSSE = 0.64)
06025500	87	Base Gage	Base Gage	-0.579
06023500	8	20	.845	0.251
06024450	24	66	.943	-0.185
06024540	14	72	.982	-0.452
06025250	10	78	.995	-0.467
06026210	14	85	.999	-0.303

When the computed correlation coefficient is compared to certain criteria, improvements to the mean and standard deviation are possible. Bulletin 17B recommends a minimum of 10 years of overlapping record be available before applying this method; however these procedures were done for gages with less than 10 years of record for evaluation and consideration for the development of flood frequency estimates. Since the correlation coefficient values were high and above the defined threshold, improvements to the mean and standard deviation were possible for the gages listed in **Table 16**.

Once the procedure is deemed worthwhile, improvements to the mean and standard deviation are calculated as described in Bulletin 17B. Weighted skew values were calculated for each stream gage station based on the regional skew, obtained from the single gage PeakFQ analysis, and the station skew. A generalized skew standard error of 0.64 was used in the calculation of the weighted skew, as done in WRIR 03-4308 and confirmed during baseline analysis. Once the weighted skew value was known, Appendix 3 of Bulletin 17B was used to obtain the standardized variate (K) for each exceedance probability desired for computation. The values listed in Appendix 3 are provided for skew values of two significant figures. For a more accurate prediction, these K values were interpolated from the table of values using several significant figures of the weighted skew coefficient. Once the K values were determined, the adjusted flood discharge-frequency estimates for the short term gage can be calculated and plotted. Results from each Two Station Comparison are shown below in **Tables 17 - 21** and plotted with the long term gage results, concurrent long term results, short term original frequency, and all data points on **Figures 3 - 7**. It is important to note that for the updated analysis of USGS 06025250 (near Divide) through water year 2012, the base long term gage, USGS 06025500 (near Melrose), was required to be updated though water year 2012 for the Two Station Comparison calculations. The updated results for the base gage are not presented throughout this analysis to avoid confusion with the remaining gage analyses that utilized USGS 06025500 (near Melrose) base gage through water year 2011. Calculations are included in **Appendix D**.

Table 17. Two Station Comparison method results for USGS 06023500 (near Jackson).

Year Flood	Annual Exceedance Probability	Original Discharge Estimate (cfs)	Adjusted Discharge Estimate (cfs)
2	**.5**	471	308
10	**0.1**	714	668
25	**0.04**	841	906
50	**0.02**	938	1,110
100	**0.01**	1,040	1,340
500	**0.002**	1,280	1,970

Table 18. Two Station Comparison method results for USGS 06024450 (at Wisdom).

Year Flood	Annual Exceedance Probability	Original Discharge Estimate (cfs)	Adjusted Discharge Estimate (cfs)
2	**.5**	1,630	1,980
10	**0.1**	3,750	4,060
25	**0.04**	5,010	5,200
50	**0.02**	6,010	6,080
100	**0.01**	7,060	6,980
500	**0.002**	9,680	9,160

Table 19. Two Station Comparison method results for USGS 06024540 (near Wisdom).

Year Flood	Annual Exceedance Probability	Original Discharge Estimate (cfs)	Adjusted Discharge Estimate (cfs)
2	**.5**	3,420	4,140
10	**0.1**	6,430	7,450
25	**0.04**	7,850	8,970
50	**0.02**	8,850	10,000
100	**0.01**	9,810	11,000
500	**0.002**	11,900	13,200

Table 20. Two Station Comparison method results for USGS 06025250 (near Divide).

Year Flood	Annual Exceedance Probability	Original Discharge Estimate (cfs)	Adjusted Discharge Estimate (cfs)
2	**.5**	6,110	6,740
10	**0.1**	10,900	11,800
25	**0.04**	13,000	14,000
50	**0.02**	14,440	15,500
100	**0.01**	15,800	16,900
500	**0.002**	18,700	19,900

Table 21. Two Station Comparison method results for USGS 06026210 (near Glen).

Year Flood	Annual Exceedance Probability	Original Discharge Estimate (cfs)	Adjusted Discharge Estimate (cfs)
2	**.5**	5,660	6,960
10	**0.1**	11,300	13,200
25	**0.04**	14,300	16,400
50	**0.02**	16,400	18,700
100	**0.01**	18,600	21,000
500	**0.002**	23,600	26,200

Figure 3. Frequency curves for Two Station Comparison of USGS 06023500 (near Jackson) to USGS 06025500 (near Melrose).

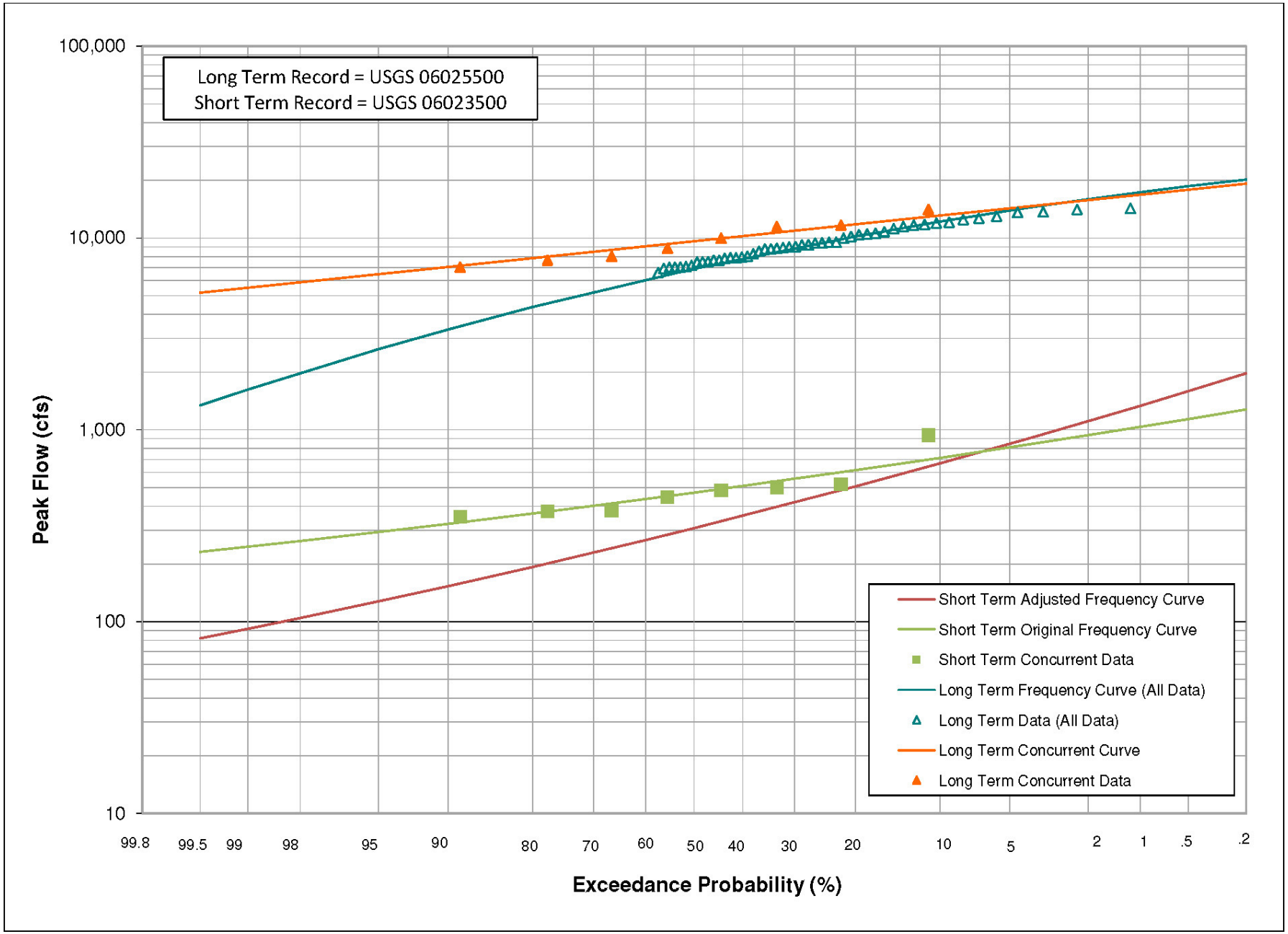


Figure 4. Frequency curves for Two Station Comparison of USGS 06024450 (at Wisdom) to USGS 06025500 (near Melrose).

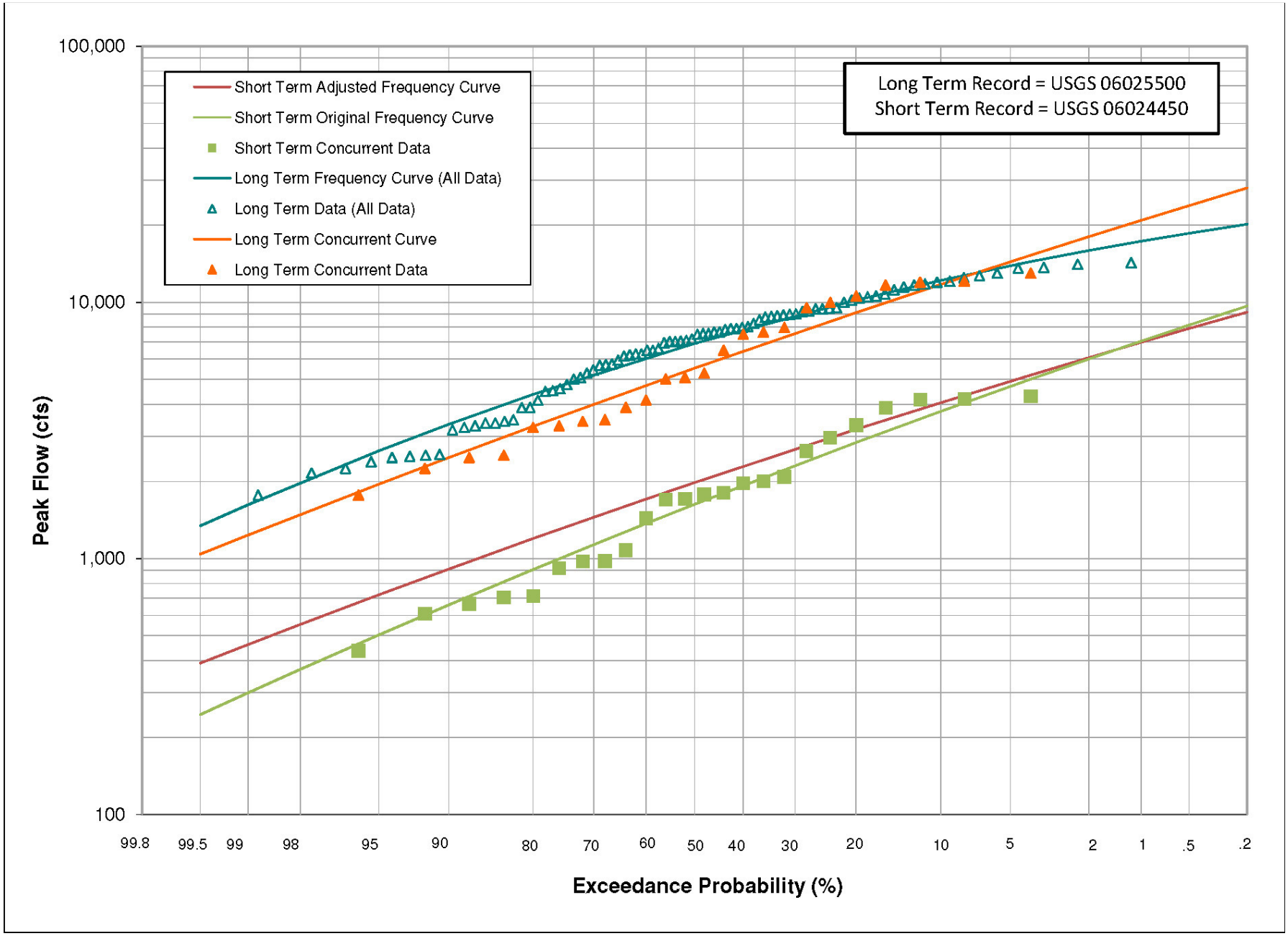


Figure 5. Frequency curves for Two Station Comparison of USGS 06024540 (near Wisdom) to USGS 06025500 (near Melrose).

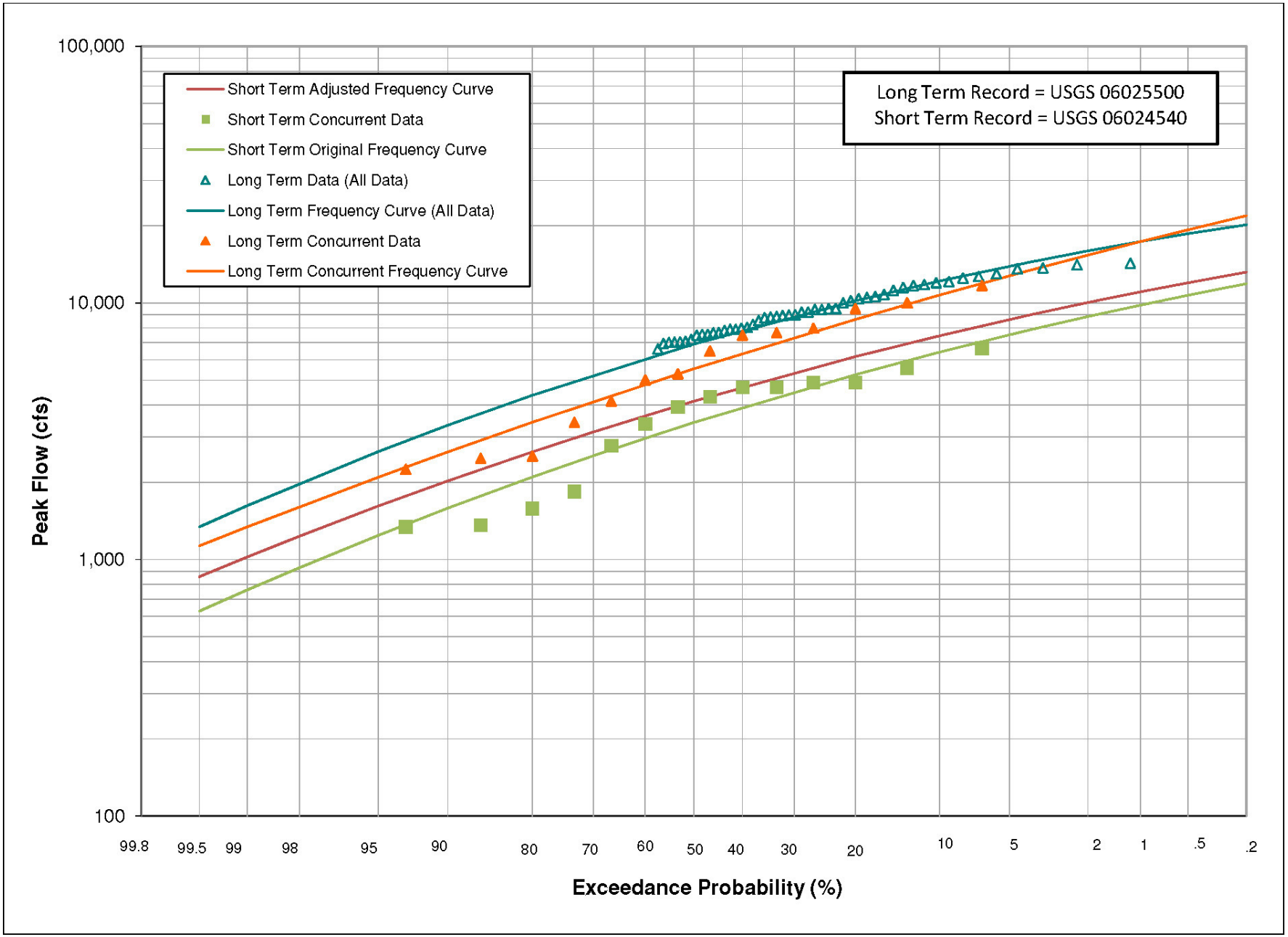


Figure 6. Frequency curves for Two Station Comparison of USGS 06025250 (near Divide) to USGS 06025500 (near Melrose).

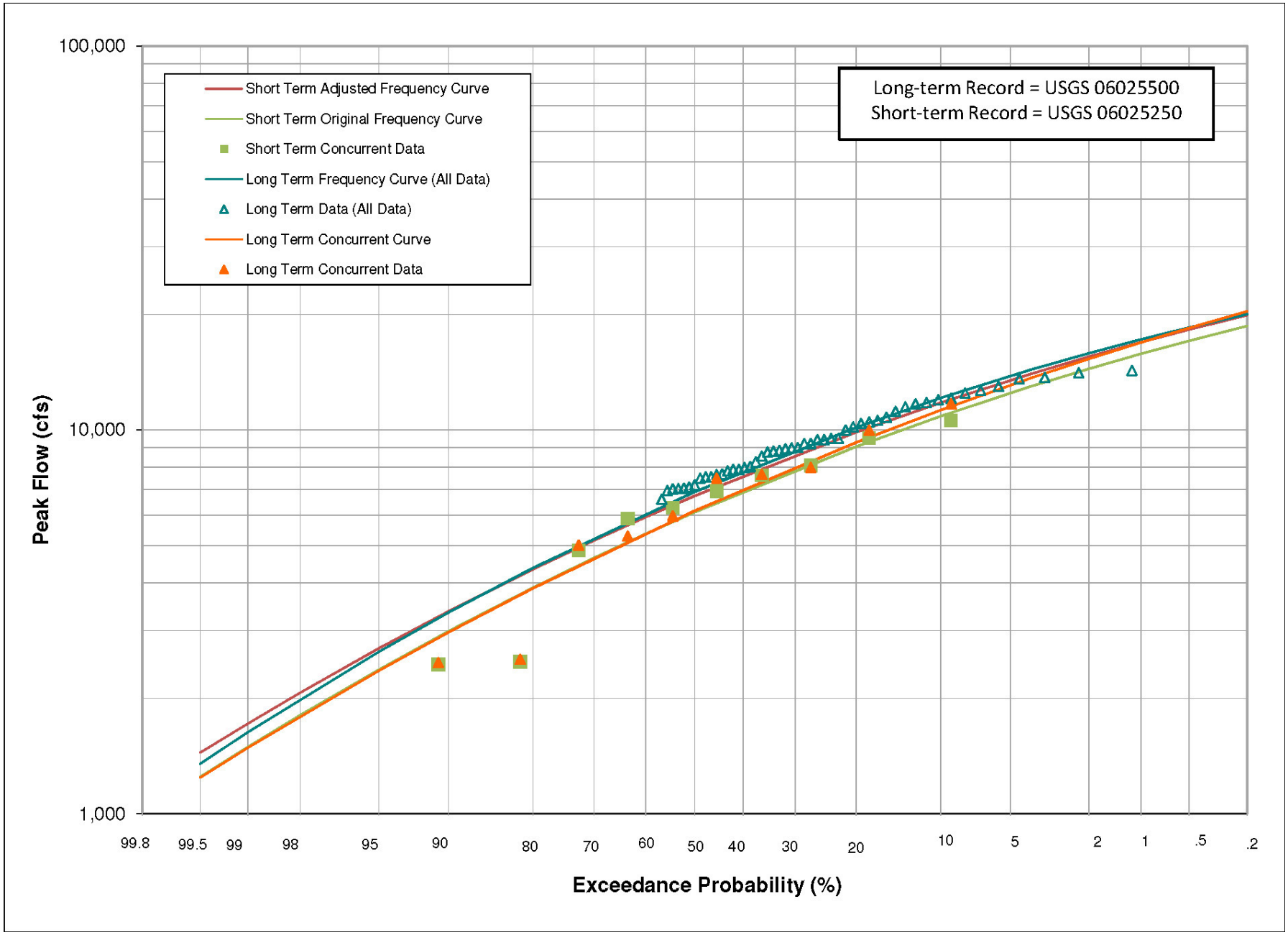
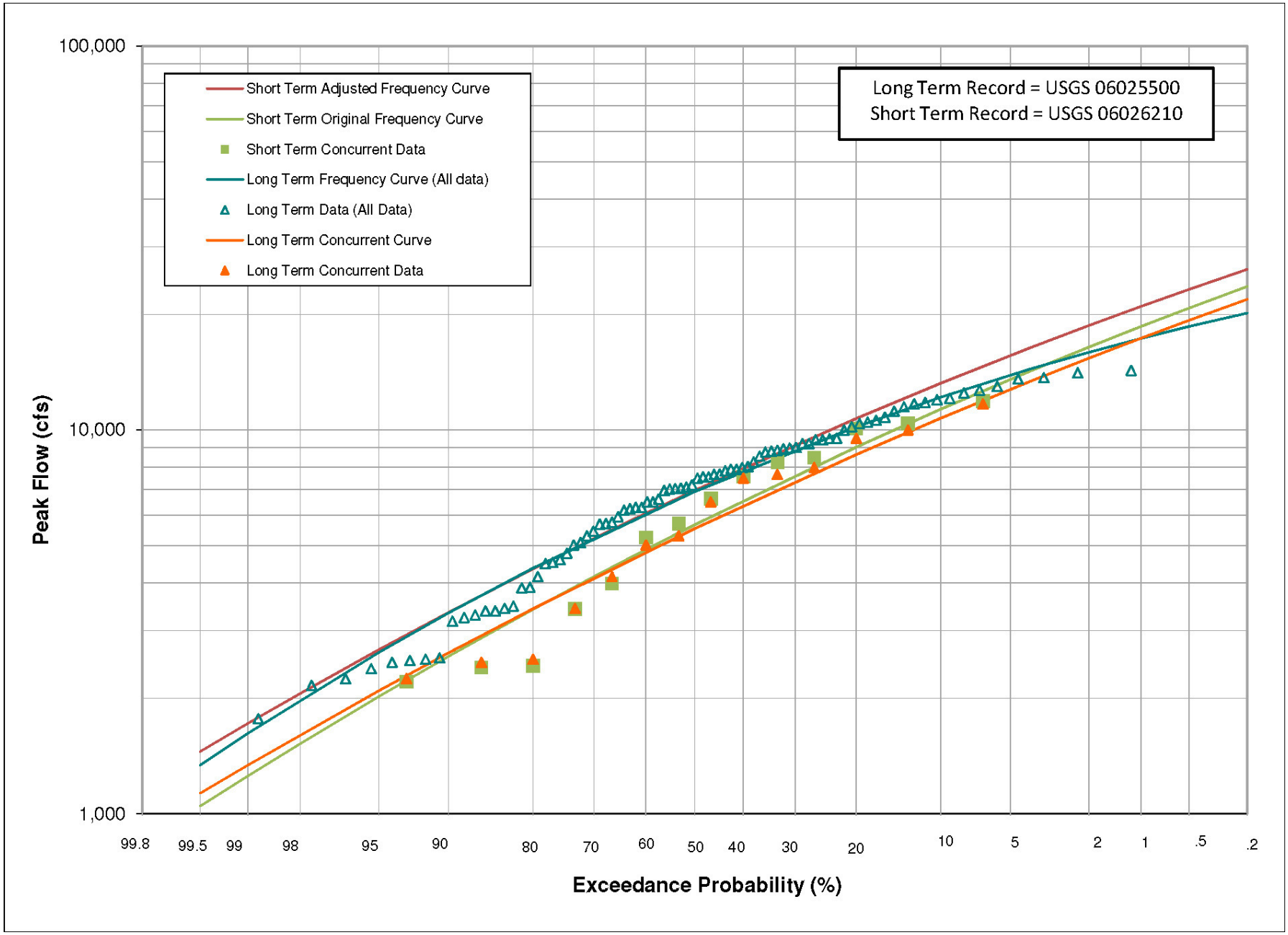


Figure 7. Frequency curves for Two Station Comparison of USGS 06026210 (near Glen) to USGS 06025500 (near Melrose).



One observation of this method is how the weighted skew is calculated and applied for calculation of the adjusted discharge estimate. The methodology performs regression of the concurrent flow records of the long term and short term gage records to improve the estimate of the mean and standard variation. Inspection of **Figures 3 – 7** illustrate that although the mean and standard deviation is statistically improved during these analyses and the method, in general, should provide more confidence in the results, the method does not provide for any skew influence of the long term records applied to the short term record. The station skew is an important parameter obtained from a lengthy gage record. Typically, the station skew is weighted with a regional skew to potentially remove uncertainty associated with limited records. This method simply applies the same weighted skew value of the single gage analysis for the short term gage. Shown on **Figure 7** towards the lower exceedance probability events (right side of plot), rather than mimic the skew trend of the long term gage record, the weighted skew used for the improved estimate considers only the short term record. Inspection of the 1%- and 0.2% annual chance flood events plotted on **Figure 7** show a substantial spike in calculated flows at USGS 06026210 when compared to the trend. The spike may be considered erroneous for this system since only 200 mi^2 of drainage area is added between USGS 06026210 and the base gage USGS 06025500. If a skew factor generated from the base gage was applied to the Two Station Comparison method for USGS 06026210, the results may better fit the patterns observed for the other gages downstream.

3.2.3. Regression Weighted Gage Analysis

In order to potentially improve the results of the gage analysis, WRIR 03-4308 provides a method for weighting the results of a statistical gage analysis with a regression analysis based upon the basin characteristics, active channel widths, or bankfull widths. Typically, this method is useful when peak stream flow data has large variability or if a gage contains a relatively short period of record. Since the time sampling error (variability of annual peak discharges) is largely dependent upon the period of record, the length of record at the gaged site and the equivalent years of record of the regional regression equations are utilized as weighting factors. This weighting allows for a gage with a longer period of record to rely heavily on the gage analysis, which is more site specific, rather than the regional regression analysis which are based upon a wide region of sites. While the greater the value of equivalent years of record relates to the more reliable the method. The equivalent years of record for the regression analysis presented in WRIR 03-4308 are tabulated in **Table 22**.

Table 22. Equivalent years of record attributed to the various regression methods

	Equivalent Years of Record (yr)		
Frequency	**Basin Characteristics**	**Active Channel Widths**	**Bankfull Widths**
50-Percent Annual Chance	0.9	2.5	2.5
10-Percent Annual Chance	2.4	3.6	3.7
4-Percent Annual Chance	3.4	3.6	3.7
2-Percent Annual Chance	4.0	3.6	3.6
1-Percent Annual Chance	4.5	3.6	3.6
0.2-Percent Annual Chance	5.3	3.5	3.5

As mentioned, active channel and bankfull width regression estimates may also be used to weight a gage estimate. These two methods were explored but are not presented here for two reasons. First, width measurements for both active channel and bankfull widths were highly variable throughout the entire project reach due to changes in stream type associated with geologic controls. Secondly, conversations with USGS personnel revealed that the reported range of applicability listed in WRIR 03-4308 was incorrect and that rather than 223’ for active channel width maxima, a target of around 100’ should be used. This range was revised based on the limited distribution of stations used for regression in the Southwest Region and that USGS 06025500 (near Melrose) provided the maximum values in that dataset. **Table 7** shows the revised range of applicability prevents use of the channel width regression equations for most of the study reach.

Since the single gage analysis for most of the Big Hole River gages may be considered invalid due to their limited period of record, weighting gage analyses with regression estimates was only considered for gages analyzed under the Two Station Comparison method. Those results are shown below in **Table 23**.

Table 23. Results from regression weighted Two Station Comparison gage analyses.

		Peak Discharge (cfs)					
USGS Gage ID	**Location**	**2-year**	**10-year**	**25-year**	**50-year**	**100-year**	**500-year**
06023500	Near Jackson	297	609	795	950	1,120	1,580
06024450	At Wisdom	1,970	3,960	5,010	5,810	6,620	8,560
06024540	Near Wisdom	4,120	7,290	8,680	9,610	10,500	12,500
06025250	Near Divide	6,700	11,500	13,600	14,900	16,200	18,900
06025500	Near Melrose	6,880	12,000	14,000	15,400	16,700	19,300
06026210	Near Glen	6,930	13,000	15,900	18,000	20,100	24,800

By weighting the Two Station Comparison gage analyses results with basin characteristics regression equation, there is a decrease in the flow estimate since the basin characteristic regression estimates are much lower than results from gage analyses. Caution should be used in the Southwest Region when applying these regression equations to large systems since USGS 06025500 (near Melrose) was the maximum station used for development of the regression relationships. Furthermore, the appropriateness of weighting a gage analyses with regression and applying those results to ungaged sites is not documented in WRIR 03-4308.

3.2.4. Gage Analysis Results Comparison

Results from the Single Gage (SG), Two Station Comparison (2G), basin characteristics regression (RG), and basin characteristics regression weighted Two Station Comparison (2GRW) analyses described above are presented in **Table 24** for comparison purposes. As mentioned, the single station gage analysis was done to evaluate each gage regardless of whether the gage had a suitable period of record, as well as to be used in the Two Station Comparison Method where obtaining a lengthier equivalent period on gages with limited period of record was possible. The Two Station Comparison method was performed to apply the long period of record of USGS 06025500 (near Melrose) to other gages with much less record and improve the estimate of the mean and increase their equivalent years of record. From that analysis, it was possible to evaluate the affect of weighting with results obtained through the basin characteristics regression equations.

Results obtained from the single station gage analysis are reasonable as they follow a logical increasing flow rate with increasing drainage area. However, only four gages have a suitable period of record for a statistical analysis which was reduces their range of use throughout the entire reach. The results obtained solely from basin characteristic regression equations are much lower than results generated by both types of gage analyses. This reduces confidence in that methodology and when coupled with the observation that the largest gage utilized in development of the regression equation was USGS 06025500 (near Melrose), further skepticism is invoked. Additionally, applying a regression weighted gage analysis to an ungaged site is not documented in WRIR 03-4308.

After careful evaluation of the results and comparison to alternative flood discharge development methodologies, the Two Station Comparison was considered the most reliable and representative of the true flood peak discharges. By utilizing the long period of record of USGS 06025500 (near Melrose), each gage, regardless of its inherent period of record, showed high correlation of its concurrent record with USGS 06025500. This allowed significant improvement to the mean discharge and its standard deviation. From the high correlation, each gage showed a significant improvement to its equivalent period of record, which supports the use of this methodology over the single gage analyses. For these reasons, it was considered that the Two Station Comparison gage analysis was superior to the single gage analyses and was the preferred approach for applying those results to ungaged sites throughout the study reach.

Table 24. Comparison of flood frequency results by method for gaged sites.

			Peak Discharge (cfs)			
USGS Gage ID	**Location**	**Event (RI)**	**SG[1]**	**2G[2]**	**RG[3]**	**2GRW[4]**
06023500	Near Jackson	2-year	471	308	133	297
06024450	At Wisdom	2-year	1,630	1,980	1,310	1,970
06024540	Near Wisdom	2-year	3,420	4,140	2,580	4,120
06025250	Near Divide	2-year	6,110	6,740	4,150	6,700
06025500	Near Melrose	2-year	6,910		4,590	6,880*
06026210	Near Glen	2-year	5,660	6,960	4,900[+]	6,930[+]
06023500	Near Jackson	10-year	714	668	282	609
06024450	At Wisdom	10-year	3,750	4,060	2,060	3,960
06024540	Near Wisdom	10-year	6,430	7,450	3,720	7,290
06025250	Near Divide	10-year	10,900	11,800	5,680	11,500
06025500	Near Melrose	10-year	12,200		6,250	12,000*
06026210	Near Glen	10-year	11,300	13,200	6,670[+]	13,000[+]
06023500	Near Jackson	25-year	841	906	370	795
06024450	At Wisdom	25-year	5,010	5,200	2,450	5,010
06024540	Near Wisdom	25-year	7,850	8,970	4,320	8,680
06025250	Near Divide	25-year	13,600	14,000	6,490	13,600
06025500	Near Melrose	25-year	13,000		7,140	14,000*
06026210	Near Glen	25-year	14,300	16,400	7,620[+]	15,900[+]
06023500	Near Jackson	50-year	938	1,110	439	950
06024450	At Wisdom	50-year	6,010	6,080	2,730	5,810
06024540	Near Wisdom	50-year	8,850	10,000	4,730	9,610
06025250	Near Divide	50-year	14,400	15,500	7,040	14,900
06025500	Near Melrose	50-year	15,900		7,730	15,400*
06026210	Near Glen	50-year	16,400	18,700	8,260[+]	18,000[+]
06023500	Near Jackson	100-year	1,040	1,340	515	1,120
06024450	At Wisdom	100-year	7,060	6,980	3,030	6,620
06024540	Near Wisdom	100-year	9,810	11,000	5,170	10,500
06025250	Near Divide	100-year	15,800	16,900	7,610	16,200
06025500	Near Melrose	100-year	17,300		8,350	16,700*
06026210	Near Glen	100-year	18,600	21,000	8,920[+]	20,100[+]
06023500	Near Jackson	500-year	1,280	1,970	701	1,580
06024450	At Wisdom	500-year	9,680	9,160	3,660	8,560
06024540	Near Wisdom	500-year	11,900	13,200	6,040	12,500
06025250	Near Divide	500-year	18,700	19,900	8,710	18,900
06025500	Near Melrose	500-year	20,200		9,550	19,300*
06026210	Near Glen	500-year	23,600	26,200	10,200[+]	24,800[+]

*[1]Single Gage (Section 3.2.1), [2]Two Station Comparison (Section 3.2.2), [3]Basin Characteristics Regression (Section 3.1.1), [4]Two Station Comparison Weighted by Basin Characteristics Regression (Section 3.2.3); *Values are basin characteristic regression weighted single station gage results. [+]Results presented exceed the upper limit of applicability for basin characteristics regression as presented in WRIR 03-4308.*

3.3. Ungaged Sites on Gaged Streams

As shown in **Table 5**, most flow change locations do not coincide with the USGS gage locations so application of gage results to ungaged sites on the same stream is required. This allows compensation for differences in drainage area between the gaged and ungaged site. WRIR 03-4308 provides two methodologies considered for this analysis for transferring results obtained at a gage to an ungaged site. In the event only one gage is present along the studied stream, estimates at the ungaged site are obtained through a gage transfer. When the ungaged site is located between two gages, WRIR 03-4308 recommends log interpolation of the gaged sites results to the ungaged sites between.

3.3.1. Log Interpolation of Gage Analyses

For locations that are ungaged and located between two gaged locations with a reliable period of record, the log interpolation method presented in WRIR 03-4308 was utilized. For these bounded locations, the log interpolation method utilizes the logarithms of flood-frequency characteristics at the ungaged site to linearly interpolate between the logarithms of the flood-frequency characteristics of the bounding gaged locations. The log interpolation method effectively uses a comparison of drainage areas to interpolate between the discharges calculated at two gaged locations.

WRIR 03-4308 recommends the following formula for log interpolation of the gaged sites results to ungaged sites between:

$$\log Q_{T,U} = \log Q_{T,G1} + \frac{\log Q_{T,G2} - \log Q_{T,G1}}{\log DA_{G2} - \log DA_{G1}}(\log DA_U - \log DA_{G1}),$$

where

$\log$	is the base 10 logarithm,
$Q_{T,U}$	is the *T*-year flood at the ungaged site, in cubic feet per second,
$Q_{T,G1}$	is the *T*-year flood at the upstream gaged site, in cubic feet per second,
$Q_{T,G2}$	is the *T*-year flood at the downstream gaged site, in cubic feet per second,
DA_{G2}	is the drainage area at the downstream gaged site, in square miles,
DA_{G1}	is the drainage area at the upstream gaged site, in square miles,
DA_U	is the drainage area at the ungaged site, in square miles,

Since the period of record is limited (less than 10 years) for all but two gages, the single gage analysis for each gage was not interpolated for the entire length of the Big Hole River study reach, with the exception of the base long term record gage USGS 06025500 (near Melrose). The single station gage analysis at this gage served to improve the estimates at the gages with less record using the Two Station Comparison methodology. Those improved results obtained under Two Station Comparison methodology allowed use of those gage analyses for interpolation throughout the majority of the Big Hole River study reach. After performing Two Station Comparison, the equivalent years of record for gages with limited record increased to a minimum of 20 years. Log interpolation of the Two Station Comparison gage analyses was applied for all flow nodes between suitable gages and is shown in **Table 25**.

Table 25. Log linear interpolation of Two Station Comparison gage results to ungaged flow nodes.

Location ID/ USGS Gage ID	Location Description	Peak Discharge (cfs)					
		2-year	10-year	25-year	50-year	100-year	500-year
6023500	**Near Jackson**	**308**	**668**	**906**	**1,110**	**1,340**	**1,970**
50	Below Berry Creek	495	1,060	1,410	1,710	2,040	2,910
75	Above Governor Creek	682	1,450	1,910	2,300	2,710	3,800
85	Above Minor Creek	1,460	3,030	3,920	4,620	5,340	7,140
100	Above Big Swamp	1,660	3,410	4,400	5,160	5,960	7,900
200	Above Big Lake Creek	1,800	3,700	4,750	5,570	6,410	8,460
300/06024450	**At Wisdom**	**1,980**	**4,060**	**5,200**	**6,080**	**6,980**	**9,160**
350	Above Steel Creek	2,270	4,540	5,750	6,660	7,590	9,790
400	Above N. Fork Big Hole River	2,590	5,060	6,340	7,290	8,230	10,500
500	Below Pintler Creek	3,940	7,150	8,650	9,670	10,700	12,900
550/06024540	**Near Wisdom**	**4,140**	**7,450**	**8,970**	**10,000**	**11,000**	**13,200**
600	Above Fishtrap Creek	4,260	7,650	9,200	10,300	11,300	13,500
700	Above Deep Creek	4,700	8,410	10,100	11,200	12,300	14,700
800	Below Bryant Creek	5,100	9,070	10,900	12,100	13,200	15,700
900	Above Wise River	5,300	9,410	11,200	12,500	13,700	16,300
1000	Above Jerry Creek	6,070	10,700	12,700	14,100	15,400	18,200
1100	Above Divide Creek	6,330	11,100	13,200	14,600	16,000	18,900
1200	Above Canyon and Moose Creeks	6,610	11,600	13,700	15,200	16,600	19,600
6025250	**Near Divide**	**6,740**	**11,800**	**14,000**	**15,500**	**16,900**	**19,900**
1300	Above Trapper and Camp Creeks	6,790	11,900	14,100	15,600	17,000	20,000
1350	Above Cherry Creek	6,850	12,100	14,300	15,800	17,200	20,100
1400	Above Rock Creek	6,890	12,100	14,300	15,800	17,200	20,200
06025500*	**Near Melrose**	**6,910**	**12,200**	**14,400**	**15,900**	**17,300**	**20,200**
1500	Above Willow Creek	6,920	12,400	14,700	16,400	17,900	21,100
1600	Above Birch Creek	6,940	12,700	15,400	17,300	19,100	23,100
1625/06026210	**Near Glen**	**6,960**	**13,200**	**16,400**	**18,700**	**21,000**	**26,200**

*Bold values indicate results of the Two Station Comparison gage analyses used for interpolation. *Denotes USGS 06025500 Big Hole River near Melrose was analyzed under the Single Station methodology and served as the base long term gage for the Two Station Comparison methodology utilized at all other gages in the analysis.*

Flow change location IDs downstream of USGS gage 06026210 (near Glen) cannot be included in the log interpolation analysis since no suitable gage downstream was available for use. Consequently, to develop flood discharge frequency for these ungaged sites downstream of USGS gage 06026210 (near Glen), the drainage area gage transfer method was required.

3.3.2. Drainage Area Gage Transfer

In instances where the ungaged location is not located between two gaged locations or if interpolation between gages is not desired, WRIR 03-4308 presents a method in which the flood-frequency data of the ungaged location is compared with the flood-frequency data of a nearby gaged location present on the same stream. WRIR 03-4308 provides this equation for drainage area gage transfer:

$$Q_{T,U} = Q_{T,G}\left(\frac{DA_U}{DA_G}\right)^{\exp_T}$$

where

$Q_{T,U}$ is the *T*-year flood at the ungaged site, in cubic feet per second,

$Q_{T,G}$ is the *T*-year flood at gaged site, in cubic feet per second,

DA_G is the drainage area at the gaged site, in square miles,

DA_U is the drainage area at the ungaged site, in square miles,

$\exp_T$ is the regression coefficient for a simple OLS regression relating the log of the *T*-year flood to log of drainage area within each region.

This particular method of transfer assists in transferring the results of a statistical gage analysis to locations that fall outside the applicable range of regression variables. However, it is recommended that the ratio of drainage areas (ungaged drainage area location versus the gaged drainage area location) be within the range of 0.5 to 1.5. Estimates at ungaged sites can also be calculated using the gage transfer method based on either the active channel width or bankfull widths. Again, due to the chaotic nature of the field measurements, results from width transfer methods are not further considered. Having numerous gages along the study reach, log interpolation of gaged sites to the ungaged sites between is the preferred method for applying gage results. However, drainage area gage transfer method was evaluated throughout the study reach in the event the results proved more reliable. Where the potential for transfer from two gages was possible at an ungaged site, the gage that provided the most favorable drainage area ratio was selected.

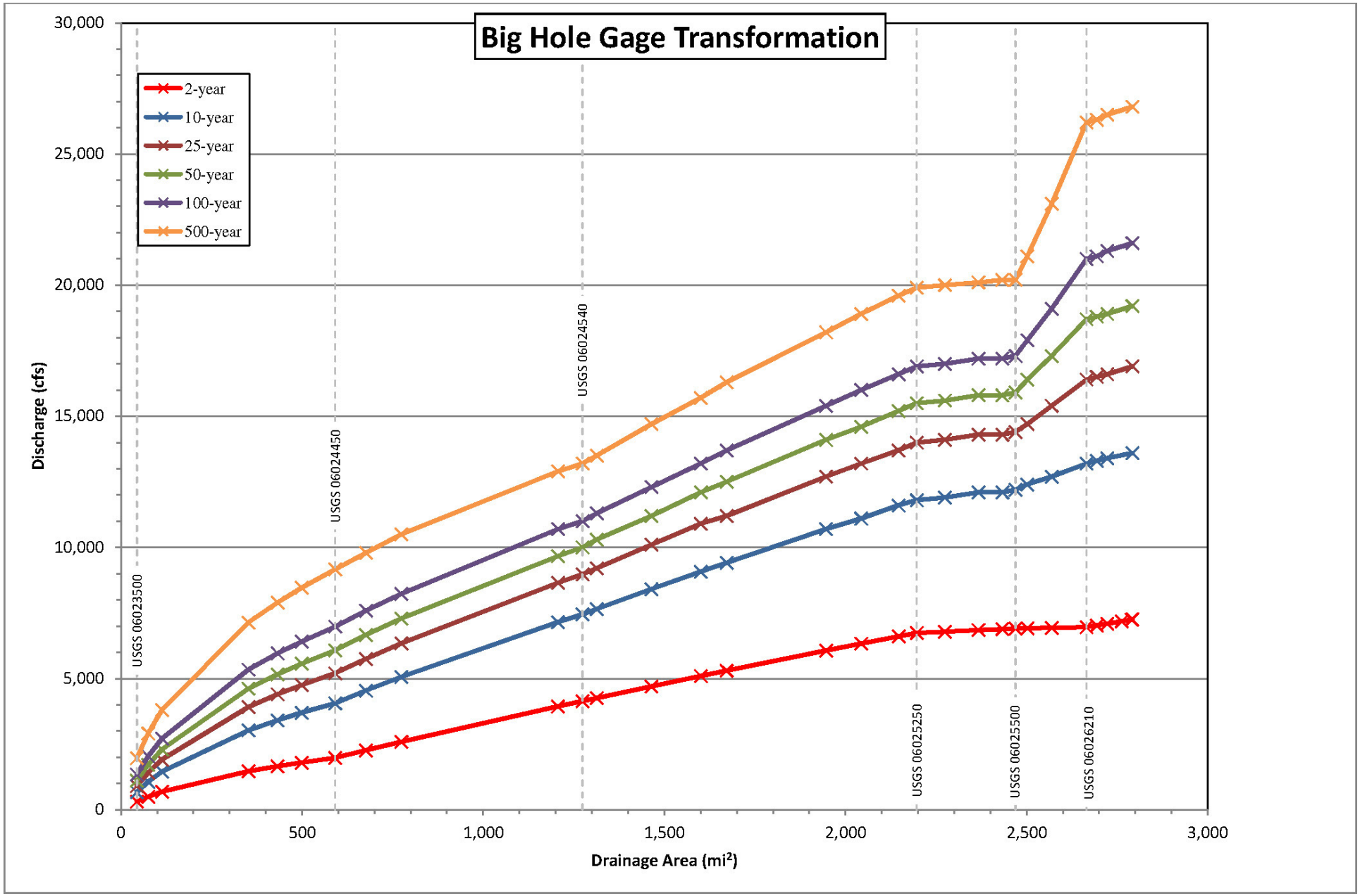
Table 26. Drainage area transfer method results for all flow node locations.

Location ID/ USGS Gage ID	Drainage Area (mi2)	DA_U/ DA_G	Peak Discharge (cfs)					
			2-year	10-year	25-year	50-year	100-year	500-year
6023500	**44**	**-**	**308**	**668**	**906**	**1,110**	**1,340**	**1,970**
50	75	1.71	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
75	113	0.19	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
85	352	0.60	1,240	2,790	3,690	4,400	5,150	7,030
100	432	0.73	1,500	3,240	4,230	5,000	5,810	7,810
200	499	0.84	1,700	3,590	4,650	5,470	6,320	8,400
300/06024450	**591**	**-**	**1,980**	**4,060**	**5,200**	**6,080**	**6,980**	**9,160**
350	676	1.14	2,230	4,470	5,680	6,610	7,550	9,810
400	774	1.31	2,520	4,930	6,210	7,190	8,170	10,500
500	1206	0.95	3,940	7,160	8,650	9,670	10,700	12,800
550/06024540	**1274**	**-**	**4,140**	**7,450**	**8,970**	**10,000**	**11,000**	**13,200**
600	1313	1.03	4,250	7,610	9,150	10,200	11,200	13,400
700	1464	1.15	4,690	8,230	9,830	10,900	11,900	14,200
800	1601	1.26	5,080	8,780	10,400	11,500	12,600	14,800
900	1672	0.76	5,280	9,690	11,700	13,100	14,400	17,300
1000	1946	0.89	6,050	10,800	12,900	14,400	15,700	18,700
1100	2043	0.93	6,320	11,200	13,300	14,800	16,200	19,200
1200	2146	0.98	6,600	11,600	13,800	15,300	16,700	19,700
6025250	**2196**	**-**	**6,740**	**11,800**	**14,000**	**15,500**	**16,900**	**19,900**
1300	2274	1.04	6,950	12,100	14,300	15,800	17,200	20,300
1350	2367	0.96	6,650	11,800	14,000	15,500	16,900	19,800
1400	2433	0.99	6,820	12,100	14,300	15,800	17,100	20,000
06025500*	**2469**	**-**	**6,910**	**12,200**	**14,400**	**15,900**	**17,300**	**20,200**
1500	2502	1.01	6,990	12,300	14,500	16,000	17,400	20,300
1600	2569	0.96	6,740	12,900	16,000	18,300	20,600	25,700
1625/06026210	**2665**	**-**	**6,960**	**13,200**	**16,400**	**18,700**	**21,000**	**26,200**
1650	2693	1.01	7,030	13,300	16,500	18,800	21,100	26,300
1675	2722	1.02	7,090	13,400	16,600	18,900	21,300	26,500
1700	2792	1.05	7,260	13,600	16,900	19,200	21,600	26,800

*Bold values indicate results of the Two Station Comparison gage analyses used for drainage area gage transfer. Bold boxed areas illustrate range of transferred gaged site to ungaged sites. *Denotes USGS 06025500 Big Hole River near Melrose was analyzed under the Single Station methodology and served as the base long term gage for the Two Station Comparison methodology utilized at all other gages in the analysis. N/A denotes ungaged sites exceeded the recommended range for drainage area gage transfer.*

The values shown in **Table 26** illustrate the benefit of interpolation between gages. At the ungaged site boundaries between where different gages are applied, there is a drastic jump in flow value and in some cases like the transition between Nodes 1300 and 1350, a decrease. The sharp increases may be possible if the flow change locations were located just downstream of tributaries but flow change locations were placed just upstream of tributaries for hydraulic modeling purposes. Also, if attenuation features were present, a downstream decrease in peak flow may be possible. However, lack of such features suggests the method is less reliable than others performed. The preferred method for transferring gage results to ungaged sites between multiple gages is log interpolation. Although log interpolation is preferred, USGS 06026210 (near Glen) is the most downstream gage available for use in log interpolation, flow nodes 1650, 1675, and 1700 flow estimates require use of the drainage area transfer method with those results shown on **Table 26**. These results, combined with the log interpolation results from **Table 25** are plotted with respect to drainage area on **Figure 8**.

Figure 8. Two Station Comparison Gage Analyses transferred to ungaged sites by a combination of log interpolation and drainage area methods.



As discussed in the Two Station Comparison section, USGS 06026210 (near Glen) shows a substantial spike in flow estimate by only adding a small percentage of drainage area. These results are considered suspect since downstream of USGS 06025500 (near Melrose) the contributing area is not large enough to explain the drastic increase of flow of the 100-year and 500-year events between USGS 06025500 and USGS 06026210. For that reason, the Two Station Comparison results obtained at USGS 06026210 (near Glen) were discarded from the analysis and the Single Station Gage analysis results from USGS 06025500 (near Melrose) were transferred by drainage area ratio to the remaining downstream sites, shown in **Table 27** to provide a more reasonable progression of increasing peak flow with drainage area.

Table 27. Drainage area transfer method results for flow nodes downstream of USGS 06025500 (near Melrose).

Location ID	Location Description	Peak Discharge (cfs)					
		2-year	10-year	25-year	50-year	100-year	500-year
06025500*	NEAR MELROSE	6,910	12,200	14,400	15,900	17,300	20,200
1500	ABOVE WILLOW CREEK	6,990	12,300	14,500	16,000	17,400	20,300
1600	ABOVE BIRCH CREEK	7,160	12,600	14,800	16,300	17,700	20,600
1625/ 06026210	NEAR GLEN	7,400	12,900	15,100	16,700	18,100	21,000
1650	UPSTREAM OF OWSLEY SLOUGH	7,470	13,000	15,300	16,800	18,200	21,100
1675	UPSTREAM OF NEZ PERCE CREEK	7,540	13,100	15,400	16,900	18,300	21,200
1700	AT MOUTH	7,710	13,300	15,600	17,200	18,600	21,500

**Base gage used for transfer to downstream flow change locations.*

4. Hydrologic Discussion

Several methods were evaluated for their suitability in representation of peak flood discharge-frequency estimates for use in the Big Hole River Flood Study. Some methods provided peculiar results, were thought to be suspect, and were discarded while other methods provided a logical and smooth progression of peak flow estimates along the entire reach. Shown on **Table 28** are the results of the various methods evaluated: basin characteristics regression for gaged and ungaged locations (RG), Two Station Comparison Gage results with those results transferred to ungaged sites by log interpolation between two gages (2G-INTR) and by drainage area ratio transfer of a single gage (2G-DAT), as well as the drainage area transfer of USGS 06025500 to the mouth. Based on the findings summarized in **Table 28** and other observations noticed throughout the analysis, additional discussion and discharge recommendations are provided.

Table 28. Results for all flow change locations generated by differing methodologies.

Location ID/ USGS Gage ID	Location Description	Peak Discharge (cfs)																							
		2-year				10-year				25-year				50-year				100-year				500-year			
		RG	2G-INTR	2G-DAT	DAT	RG	2G-INTR	2G-DAT	DAT	RG	2G-INTR	2G-DAT	DAT	RG	2G-INTR	2G-DAT	DAT	RG	2G-INTR	2G-DAT	DAT	RG	2G-INTR	2G-DAT	DAT
06023500	**Near Jackson**	**133**	**308**	**308**		**282**	**668**	**668**		**370**	**906**	**906**		**439**	**1,110**	**1,110**		**515**	**1,340**	**1,340**		**701**	**1,970**	**1,970**	
50	Below Berry Creek	214	495	*N/A*		425	1,060	*N/A*		547	1,410	*N/A*		640	1,710	*N/A*		743	2,040	*N/A*		986	2,910	*N/A*	
75	Above Governor Creek	306	682	*N/A*		582	1,450	*N/A*		737	1,910	*N/A*		854	2,300	*N/A*		982	2,710	*N/A*		1,280	3,800	*N/A*	
85	Above Minor Creek	832	1,460	1,240		1,380	3,030	2,790		1,680	3,920	3,690		1,900	4,620	4,400		2,130	5,340	5,150		2,630	7,140	7,030	
100	Above Big Swamp	997	1,660	1,500		1,620	3,410	3,240		1,950	4,400	4,230		2,190	5,160	5,000		2,450	5,960	5,810		3,000	7,900	7,810	
200	Above Big Lake Creek	1,130	1,800	1,700		1,810	3,700	3,590		2,170	4,750	4,650		2,430	5,570	5,470		2,700	6,410	6,320		3,290	8,460	8,400	
300/06024450	**At Wisdom**	**1,310**	**1,980**	**1,980**		**2,060**	**4,060**	**4,060**		**2,450**	**5,200**	**5,200**		**2,730**	**6,080**	**6,080**		**3,030**	**6,980**	**6,980**		**3,660**	**9,160**	**9,160**	
350	Above Steel Creek	1,480	2,270	2,230		2,280	4,540	4,470		2,710	5,750	5,680		3,010	6,660	6,610		3,320	7,590	7,550		3,990	9,790	9,810	
400	Above N. Fork Big Hole River	1,660	2,590	2,520		2,530	5,060	4,930		2,990	6,340	6,210		3,310	7,290	7,190		3,650	8,230	8,170		4,360	10,500	10,500	
500	Below Pintler Creek	2,460	3,940	3,940		3,560	7,150	7,160		4,150	8,650	8,650		4,540	9,670	9,670		4,970	10,700	10,700		5,820	12,900	12,800	
550/06024540	**Near Wisdom**	**2,580**	**4,140**	**4,140**		**3,720**	**7,450**	**7,450**		**4,320**	**8,970**	**8,970**		**4,730**	**10,000**	**10,000**		**5,170**	**11,000**	**11,000**		**6,040**	**13,200**	**13,200**	
600	Above Fishtrap Creek	2,650	4,260	4,250		3,810	7,650	7,610		4,420	9,200	9,150		4,840	10,300	10,200		5,290	11,300	11,200		6,170	13,500	13,400	
700	Above Deep Creek	2,910	4,700	4,690		4,140	8,410	8,230		4,790	10,100	9,830		5,230	11,200	10,900		5,700	12,300	11,900		6,620	14,700	14,200	
800	Below Bryant Creek	3,150	5,100	5,080		4,440	9,070	8,780		5,110	10,900	10,400		5,570	12,100	11,500		6,060	13,200	12,600		7,010	15,700	14,800	
900	Above Wise River	3,270	5,300	5,280		4,590	9,410	9,690		5,290	11,200	11,700		5,760	12,500	13,100		6,250	13,700	14,400		7,230	16,300	17,300	
1000	Above Jerry Creek	3,740	6,070	6,050		5,160	10,700	10,800		5,910	12,700	12,900		6,410	14,100	14,400		6,940	15,400	15,700		7,970	18,200	18,700	
1100	Above Divide Creek	3,900	6,330	6,320		5,360	11,100	11,200		6,130	13,200	13,300		6,640	14,600	14,800		7,190	16,000	16,200		8,240	18,900	19,200	
1200	Above Canyon and Moose Creeks	4,070	6,610	6,600		5,580	11,600	11,600		6,380	13,700	13,800		6,920	15,200	15,300		7,490	16,600	16,700		8,580	19,600	19,700	
06025250	**Near Divide**	**4,150**	**6,740**	**6,740**		**5,680**	**11,800**	**11,800**		**6,490**	**14,000**	**14,000**		**7,040**	**15,500**	**15,500**		**7,610**	**16,900**	**16,900**		**8,710**	**19,900**	**19,900**	
1300	Above Trapper and Camp Creeks	4,280	6,790	6,950		5,850	11,900	12,100		6,670	14,100	14,300		7,230	15,600	15,800		7,820	17,000	17,200		8,940	20,000	20,300	
1350	Above Cherry Creek	4,430	6,850	6,650		6,040	12,100	11,800		6,890	14,300	14,000		7,460	15,800	15,500		8,060	17,200	16,900		9,210	20,100	19,800	
1400	Above Rock Creek	4,530	6,890	6,820		6,180	12,100	12,100		7,060	14,300	14,300		7,650	15,800	15,800		8,270	17,200	17,100		9,450	20,200	20,000	
06025500*	**Near Melrose**	**4,590**	**6,910**	**6,910**	**6,910**	**6,250**	**12,200**	**12,200**	**12,200**	**7,140**	**14,400**	**14,400**	**14,400**	**7,730**	**15,900**	**15,900**	**15,900**	**8,350**	**17,300**	**17,300**	**17,300**	**9,550**	**20,200**	**20,200**	**20,200**
1500	Above Willow Creek	*N/A*	6,920	6,990	6,990	*N/A*	12,400	12,300	12,300	*N/A*	14,700	14,500	14,500	*N/A*	16,400	16,000	16,000	*N/A*	17,900	17,400	17,400	*N/A*	21,100	20,300	20,300
1600	Above Birch Creek	*N/A*	6,940	6,740	7,160	*N/A*	12,700	12,900	12,600	*N/A*	15,400	16,000	14,800	*N/A*	17,300	18,300	16,300	*N/A*	19,100	20,600	17,700	*N/A*	23,100	25,700	20,600
1625/ 06026210	**Near Glen**	***N/A***	**6,960**	**6,960**	7,400	***N/A***	**13,200**	**13,200**	12,900	***N/A***	**16,400**	**16,400**	15,100	***N/A***	**18,700**	**18,700**	16,700	***N/A***	**21,000**	**21,000**	18,100	***N/A***	**26,200**	**26,200**	21,000
1650	Upstream of Owsley Slough	*N/A*	*N/A*	7,030	7,470	*N/A*	*N/A*	13,300	13,000	*N/A*	*N/A*	16,500	15,300	*N/A*	*N/A*	18,800	16,800	*N/A*	*N/A*	21,100	18,200	*N/A*	*N/A*	26,300	21,100
1675	Upstream of Nez Pearce Creek	*N/A*	*N/A*	7,090	7,540	*N/A*	*N/A*	13,400	13,100	*N/A*	*N/A*	16,600	15,400	*N/A*	*N/A*	18,900	16,900	*N/A*	*N/A*	21,300	18,300	*N/A*	*N/A*	26,500	21,200
1700	At Mouth	*N/A*	*N/A*	7,260	7,710	*N/A*	*N/A*	13,600	13,300	*N/A*	*N/A*	16,900	15,600	*N/A*	*N/A*	19,200	17,200	*N/A*	*N/A*	21,600	18,600	*N/A*	*N/A*	26,800	21,500

Basin Characteristics Regression (RG), Two Station Comparison Gage transferred to ungaged sites by log interpolation between two gages (2G-INTR), Two Station Comparison Gage result transferred to ungaged sites by drainage area ratio transfer of a single gage (2G-DAT), and Drainage Area Transfer of USGS 06025500 (DAT), N/A denotes locations where the regression parameters were outside the limits set forth by USGS or not located between two gages, ***bold*** *values signify gage locations. *Denotes USGS 06025500 Big Hole River near Melrose was analyzed under the Single Station methodology and served as the base long term gage for the Two Station Comparison methodology utilized at all other gages in the analysis.*

4.1. Recommended Discharges

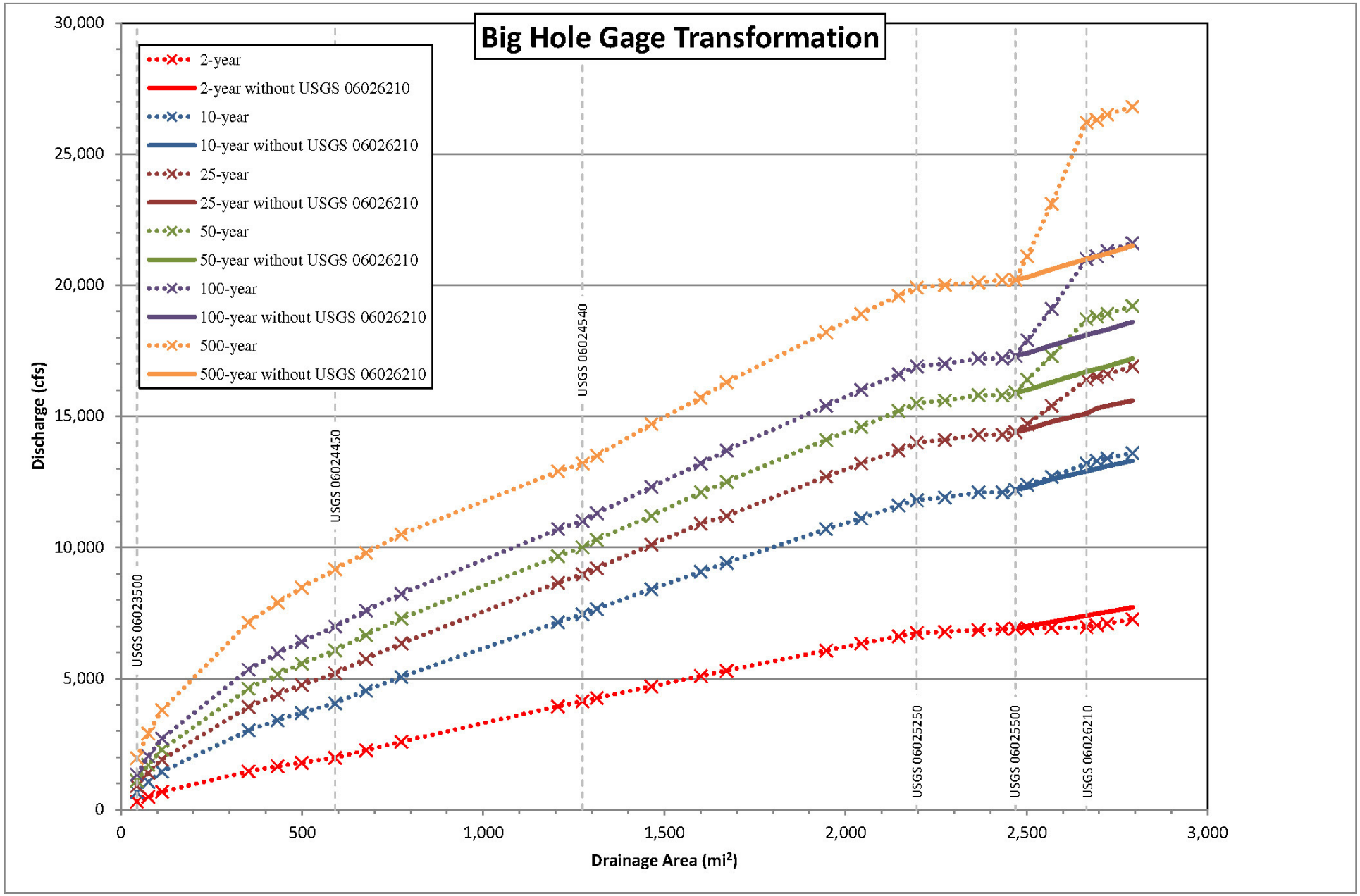
Based upon the hydrologic analysis described in the previous sections, it is recommended that the discharges calculated using the Two Station Comparison Method be adopted at all analyzed gage locations except USGS 06026210 (near Glen). As noted in the gage analysis section, the results of the analysis for USGS 06026210 created a drastic increase in discharges that cannot be reasonably explained since there are no major tributaries located between it and USGS 06025500 (near Melrose). Given the geography of the land between USGS 06026210 and USGS 06025500 being best described as a low sloping valley stream with wide floodplains, one would expect the flood flows to attenuate. Therefore the gage analysis of USGS 06026210 (near Glen) was discarded as the results did not provide a logical comparison with the more reliable gage near Melrose (USGS 06025500). The Two Station Comparison method was preferred over the single station gage analysis as it was considered more reliable, given the high correlation values and resulting equivalent years of record for each gage. For the single gage analysis, USGS 06023500 (near Jackson) has only eight years of record. After performing the Two Station Comparison method, the equivalent period of record for USGS 06023500 becomes 20 years. This indicates an increased reliability produced by the Two Station Comparison method.

It is noted that the SCS study of 1986 estimated a natural peak discharge that occurred concurrently with the dam break of 1927. In review of the SCS study it was decided that the assumptions made in the estimation of the natural discharge were considered to play too large a role as they had a great effect upon the resultant discharge. It is also common practice and recommended to neglect such flow anomalies. Therefore, it was decided to not utilize this estimated peak discharge within the present study.

For the ungaged locations upstream of USGS 06025500 (near Melrose), it is recommended that the log interpolated values calculated from the Two Station Comparison method results while using the logarithms of drainage areas be utilized. This method provides a realistic relationship of discharge versus contributing drainage area throughout the reach. The log interpolated values using the active channel and bankfull widths were not utilized due to the inconsistent measurements collected throughout the studied reaches. Given that the channel characteristics do not increase in a consistent manner, the results of the interpolations were also considered inconsistent and unrealistic.

For the ungaged locations downstream of USGS 06025500 (near Melrose), it is recommended that the gage transfer method based upon the drainage area ratio be utilized to transfer the gage analysis results of USGS 06025500. As previously mentioned, the gage analysis of USGS 06026210 (near Glen) creates unrealistic results for the less frequent events and should therefore be discarded. Since USGS 06025500 (near Melrose) is the most downstream gage that has a period of record long enough to produce reliable results, it was recommended for the gage transfer. The drainage areas of the downstream locations are well within the limits of the drainage area ratio (0.5 – 1.5) defined by WRIR 03-4308 and predominately mirror the same drainage area characteristics of the gage location. The effect of removing USGS 06026210 (near Glen) from the analysis and using drainage area transfer method to the downstream sites is shown on **Figure 9** below. The gage transfer method based on active channel and bankfull widths were not utilized because the Big Hole River is typically comprised of multiple channels which creates defining the river with a single width impractical.

Figure 9. Comparison of transferring Two Station Comparison with- and without USGS 06026210 (near Glen) analysis.



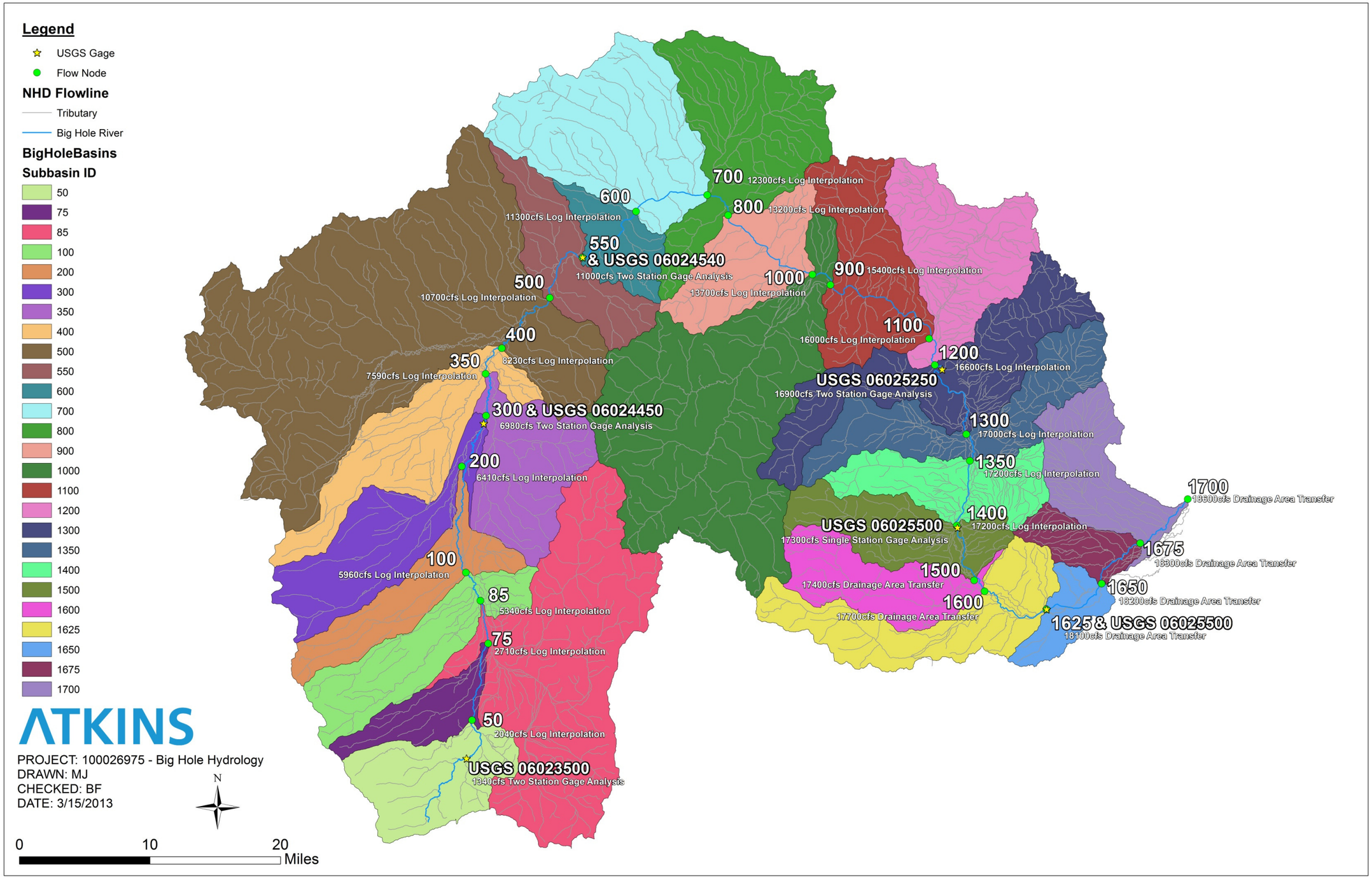
Recommended 50-, 10-, 4-, 2-, 1- and 0.2-percent annual chance discharges for all delineated locations of the Big Hole River, along with the recommended methods, are presented in **Table 29**. **Figure 10** displays the recommended 1-percent annual chance discharges for each site along with the hydrologic method utilized. These discharges are proposed for further use in the analysis of the Big Hole River.

Table 29. Recommended Discharges and Hydrologic Methods for the Big Hole River

Location ID/ USGS Gage ID	Location Description	Hydrologic Method	Discharge (cfs)					
			2-year	10-year	25-year	50-year	100-year	500-year
06023500	Near Jackson	Two Station Comparison	**308**	**668**	**906**	**1,110**	**1,340**	**1,970**
50	Below Berry Creek	Log Interpolation	495	1,060	1,410	1,710	2,040	2,910
75	Above Governor Creek	Log Interpolation	682	1,450	1,910	2,300	2,710	3,800
85	Above Minor Creek	Log Interpolation	1,460	3,030	3,920	4,620	5,340	7,140
100	Above Big Swamp	Log Interpolation	1,660	3,410	4,400	5,160	5,960	7,900
200	Above Big Lake Creek	Log Interpolation	1,800	3,700	4,750	5,570	6,410	8,460
300/06024450	At Wisdom	Two Station Comparison	**1,980**	**4,060**	**5,200**	**6,080**	**6,980**	**9,160**
350	Above Steel Creek	Log Interpolation	2,270	4,540	5,750	6,660	7,590	9,790
400	Above N. Fork Big Hole River	Log Interpolation	2,590	5,060	6,340	7,290	8,230	10,500
500	Below Pintler Creek	Log Interpolation	3,940	7,150	8,650	9,670	10,700	12,900
550/06024540	Near Wisdom	Two Station Comparison	**4,140**	**7,450**	**8,970**	**10,000**	**11,000**	**13,200**
600	Above Fishtrap Creek	Log Interpolation	4,260	7,650	9,200	10,300	11,300	13,500
700	Above Deep Creek	Log Interpolation	4,700	8,410	10,100	11,200	12,300	14,700
800	Below Bryant Creek	Log Interpolation	5,100	9,070	10,900	12,100	13,200	15,700
900	Above Wise River	Log Interpolation	5,300	9,410	11,200	12,500	13,700	16,300
1000	Above Jerry Creek	Log Interpolation	6,070	10,700	12,700	14,100	15,400	18,200
1100	Above Divide Creek	Log Interpolation	6,330	11,100	13,200	14,600	16,000	18,900
1200	Above Canyon & Moose Creeks	Log Interpolation	6,610	11,600	13,700	15,200	16,600	19,600
06025250	Near Divide	Two Station Comparison	**6,740**	**11,800**	**14,000**	**15,500**	**16,900**	**19,900**
1300	Above Trapper & Camp Creeks	Log Interpolation	6,790	11,900	14,100	15,600	17,000	20,000
1350	Above Cherry Creek	Log Interpolation	6,850	12,100	14,300	15,800	17,200	20,100
1400	Above Rock Creek	Log Interpolation	6,890	12,100	14,300	15,800	17,200	20,200
06025500*	Near Melrose	Single Station Analysis	**6,910**	**12,200**	**14,400**	**15,900**	**17,300**	**20,200**
1500	Above Willow Creek	Drainage Area Gage Transfer	6,990	12,300	14,500	16,000	17,400	20,300
1600	Above Birch Creek	Drainage Area Gage Transfer	7,160	12,600	14,800	16,300	17,700	20,600
1625/06026210	Near Glen	Drainage Area Gage Transfer	7,400	12,900	15,100	16,700	18,100	21,000
1650	Above Owsley Slough	Drainage Area Gage Transfer	7,470	13,000	15,300	16,800	18,200	21,100
1675	Above Nez Pearce Creek	Drainage Area Gage Transfer	7,540	13,100	15,400	16,900	18,300	21,200
1700	At Mouth	Drainage Area Gage Transfer	7,710	13,300	15,600	17,200	18,600	21,500

**Denotes USGS 06025500 Big Hole River near Melrose was analyzed under the Single Station methodology and served as the base long term gage for the Two Station Comparison methodology utilized at all other gages in the analysis.*

Figure 10. Recommended 1-percent annual discharge for each location.



As previously mentioned, methods involving channel characteristics were not used since there was a series of reaches with an inconsistent progression of values. Typically, a stream will display a consistent increase in measured widths in the downstream direction. However, the Big Hole River displays reaches where a reach is much wider or narrower than the upstream and downstream locations. A large reason for the inconsistent progression and broad range of values is due to the type of stream realized within the study reaches. In the upper reach of the Big Hole River, the stream can be described as a low sloping shallow meandering stream comprised of finer sediments with wide floodplains that exhibits relatively low velocities. As the stream reaches Fishtrap, velocity increase and the stream becomes more channelized as it travels through a steep mountain canyon that is bounded by rocky banks. Once the stream reaches the valley floor downstream of Divide, it becomes a wide stream accompanied by wide floodplains with a channel geometry composed of large cobbles and boulders. Given the broad range of stream types realized within the Big Hole River along with the inconsistent widths, utilization of the flood-frequency methods based upon the channel characteristics listed in WRIR 03-4308 provides inconsistent and unrealistic results. Therefore, the methods utilizing the active channel and bankfull widths were discarded.

The regression methods based on basin characteristics were not utilized largely due to the availability of gage data with relatively lengthy periods of record located at multiple locations throughout the watershed. Given that gage data is specific to the gage site and specific drainage area, it is safe to assume that it would be more accurate than the regression methods as they are generalized over a large region using a wide range of values. The reliability of the regression method based upon basin characteristics is also brought into question when comparing the regression results with the results for the statistical gage analyses. For example, at USGS 06025500 (near Melrose) the regression method based upon the drainage characteristics results in a 1-percent annual chance discharge of 8,350 cfs while the statistical gage analysis of USGS 06025500 results in a 1-percent annual discharge of 17,300 cfs. Given that USGS 06025500 has such a lengthy period of record (87 years), it can be assumed that the results of the gage analysis are reliable and site specific. Hence, given the large discrepancy in discharges the regression methods based upon drainage area characteristics were neglected.

The regression methods based on channel characteristics (active channel and bankfull widths) were also reviewed. However, as previously mentioned the Big Hole River is comprised of multiple channel types and experiences a wide range of inconsistent widths throughout the studied reach. The maximum limits of active channel and bankfull widths utilized in WRIR 03-4308 were taken from USGS 06025500 along the Big Hole River and are equal to 223’ and 260’, respectively. However, upon performing the regression analyses based upon the channel characteristics, it was apparent that the method produced erroneous results once the widths reached approximately 150’. In discussions with USGS personnel, it was discovered that besides the measurements taken at USGS 06025500, the next two largest widths utilized for the creation of the active channel regression methods were equal to 105’ and 85’. USGS personnel then directed that the maximum limit utilized in the regression methods should therefore be decreased to about 100’. In review of the active channel and bankfull measurements collected for this study, it is apparent that the vast majority of the river exhibits widths greater than the recommended limit imposed by USGS personnel. Hence, the results of the regression methods based upon channel characteristics were abandoned.

The weighting of the gage analysis by regression was also performed. As mentioned above, the reliability of the regression equations is questionable. When weighting of the gage analysis by regression is performed, the method produces a significant decrease in the discharges. This decrease is produced by the large differential in calculated discharges of the original regression calculations and those of the statistical gage analysis. As discussed in Section 3.2.3, the weighted method utilizes the length of record at the gaged site and the equivalent years of record of the regional regression equations as weighting factors. This weighting allows for a gage with a longer period of record to rely heavily on the gage analysis, which is more site specific, rather than the regional regression analysis which are based upon a wide region of sites. The relatively low reliability of the regression methods is shown in the small equivalent years of record displayed in **Table 22**. Given the low reliability of the regression methods as well as the drastic difference in the results of the regression methods when compared with the more reliable gage analysis, the weighting method was considered to decrease the reliability of the results and is therefore not recommended for further use.

4.2. Comparison with Past Studies

Since at least two past efforts to compute flood discharge-frequency have occurred based on a gage analysis of USGS 06025550 (near Melrose) those results are presented again for comparison to the results of the recommended discharges at the Melrose gage.

Table 30. Summary of Discharges for Big Hole River at Melrose.

Description	Drainage Area (mi^2)	1%-Annual-Chance Discharge (cfs)
1986 SCS Flood Study	2,365	16,280
1977 FEMA FIS	2,362	18,261
2013 Two Station Gage Interpolation, ID 1350	2,367	17,200

When the present results of log interpolation of the Two Station Comparison method to flow node ID 1350 are compared to the results of the previous SCS flood study, there is a discrepancy. This is likely attributed to an increased length of record and the application of a different skew. No values compare well with the 1977 FEMA FIS study, likely due to the shorter period of record and application of a different skew, as mentioned when comparing those two past studies. Further comparison with the 1986 SCS Flood Study is shown in **Table 31**. Some flow nodes used for comparison slightly differ in location so inspection of both study's drainage areas are recommended during comparison. Generally, the results obtained in this study are higher than those of the previous study. Again, this is likely due to the differences in skew used and the increased period of record. This may present future issues for tying-in to past hydraulic models, however at the time of the present study, the 1986 SCS Flood Study hydraulic model has not been incorporated by FEMA as a detailed study, so matching existing Base Flood Elevations (BFEs) at the upstream extent of a new hydraulic model are not expected unless requested by the stakeholders.

Table 31. Detailed comparison of flow estimates between the 1986 SCS Study and the present study.

1986 SCS Study						2013 Big Hole River Study					
Location Description	Drainage Area (mi^2)	10-year (cfs)	50-year (cfs)	100-year (cfs)	500-year (cfs)	ID	Drainage Area (mi^2)	10-year (cfs)	50-year (cfs)	100-year (cfs)	500-year (cfs)
LOWER END OF STUDY BELOW TRAPPER AND CAMP CREEKS (SECTION A)	2,365	11,950	15,130	16,280	18,590	**1350**	2,359	12,100	15,800	17,200	20,100
JUST ABOVE TRAPPER AND CAMP CREEKS (SECTION E)	2,282	11,670	14,800	15,930	18,210	**1300**	2,271	11,900	15,600	17,000	20,000
JUST BELOW MOOSE CREEK (SECTION W)	2,250	11,560	14,670	15,800	18,060	**1200**	2,146	11,600	15,200	16,600	19,600
JUST BELOW DIVIDE CREEK (SECTION AG)	2,146	11,200	14,250	15,350	17,580	**-**		-	-	-	-
JUST ABOVE DIVIDE CREEK (SECTION AH)	2,054	10,880	13,860	14,950	17,140	**1100**	2,042	11,100	14,600	16,000	18,900
JUST BELOW JERRY CREEK (SECTION BQ)	1,999	10,690	13,640	14,710	16,880	**1000**	1,946	10,700	14,100	15,400	18,200
JUST BELOW WISE RIVER (SECTION BW)	1,942	10,490	13,390	14,450	16,600	**-**		-	-	-	-
JUST ABOVE WISE RIVER (SECTION BX)	1,682	9,530	12,250	13,250	15,280	**900**	1,672	9,410	12,500	13,700	16,300
UPPER END OF STUDY	1,609	9,260	11,920	12,900	14,900	**800**	1,601	9,070	12,100	13,200	15,700

5. Summary

A flood discharge-frequency analysis was performed for 150 miles of the Big Hole River by Atkins under contract with Future West in conjunction with the Montana Department of Natural Resources and Conservation, the Montana Department of Environmental Quality, the Big Hole River Watershed Committee, Anaconda-Deer Lodge County, Madison County, Beaverhead County, and Butte-Silver Bow County. The first phase of the project was to complete a hydrologic analysis that meets FEMA's current standard for a detailed study.

The second hydraulics analysis phase will be conducted at the approximate level for 116 miles of the Big Hole River, with the remaining 34 miles been previously studied. Most of the river is unmapped for flood hazard and local regulators and planners have struggled to provide a technical basis for regulating land development.

Some studies have commenced in the past but the most relevant is the SCS Flood Plain Management Study of 1986. This study was an in depth flood analysis and was used as a comparison to the results of this study. This study has been incorporated to the Butte-Silver Bow FIS as an Approximate Zone A hazard area. Other studies in the past have identified the 1% annual chance flood potential in addition to channel migration and avulsion hazard zones. Additionally, irrigation water usage and TMDL planning has been performed for the Big Hole River watershed.

This report summarizes the flood discharge-frequency estimates calculated by following several different methodologies and presents an Atkins recommended discharge section to be used in the hydraulic analysis phase of this project. It was found that the USGS gage at Melrose provided 87 years of annual peak flow measurements and was the best source of flow data to be evaluated. Several other USGS gages with a period of record ranging from zero (0) to 24 years were considered. In addition to gage analyses, regression estimates were generated for the entire project area. Typically, these results were about half of what was observed during gage analyses. As described in Appendix C of FEMA's "Guidelines and Specifications for Flood Hazard Mapping", flood discharge-frequency estimates should be generated with actual stream flow measurements. Since the confidence in the gage results far outweigh results generated by other means, it is recommended that those results be adopted for inclusion in the hydraulic model for phase 2 of the Big Hole River Flood Study.

6. References

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Appendices

Appendix A. Calculations of Drainage Areas Above Elevation 6000’

Basin ID	Drainage Area (mi^2)	Drainage Area Above 6000' (mi^2)	Drainage Area Above 6000' (%)
USGS 06023500	43.9	43.9	100
50	75.2	75.2	100
75	113	113	100
85	352	352	100
100	432	432	100
200	499	499	100
300	591	591	100
350	676	675	99.9
400	774	770	99.5
500	1,206	1,188	98.5
550	1,274	1,248	97.9
600	1,313	1,281	97.6
700	1,464	1,425	97.3
800	1,601	1,556	97.2
900	1,672	1,618	96.8
1000	1,946	1,882	96.7
1100	2,043	1,968	96.3
1200	2,146	2,035	94.8
USGS 06025250	2,196	2,083	94.8
1300	2,274	2,140	94.1
1350	2,367	2,213	93.5
1400	2,433	2,242	92.2
USGS 06025500	2,469	2,274	92.1
1500	2,502	2,289	91.5
1600	2,569	2,336	90.9
1625	2,665	2,382	89.4
1650	2,693	2,382	88.4
1675	2,722	2,390	87.8
1700	2,792	2,420	86.7

Appendix B. Annual Peak Stream Flow Records

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Peak Streamflow for Montana
USGS 06023500 Big Hole River near Jackson MT

Available data for this site: Surface-water: Peak streamflow GO

Beaverhead County, Montana
Hydrologic Unit Code 10020004
Latitude 45°14'44.85",
Longitude 113°27'25.74" NAD83
Drainage area 44 square miles
Gage datum 6,950 feet above NGVD29

Output formats

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- Graph
- Tab-separated file
- peakfq (watstore) format
- Reselect output format

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)	Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1948	May 29, 1948		938	1952	Jun. 07, 1952	3.79	381
1949	May 16, 1949	3.64	352	1953	Jun. 19, 1953	4.33	484
1950	Jun. 22, 1950	4.41	520	2010	Jun. 16, 2010	3.71	446
1951	May 24, 1951	3.70	377	2011	Jun. 24, 2011	3.78	502

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Data Category: Surface Water
Geographic Area: United States
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News updated April, 2012

Peak Streamflow for the Nation
USGS 06023800 Big Hole River ab Spring Creek nr Jackson MT

Available data for this site Surface-water: Peak streamflow GO

Beaverhead County, Montana
Hydrologic Unit Code 10020004
Latitude 45°21'40", Longitude 113°26'28" NAD27
Gage datum 6,470 feet above NGVD29

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
2010	Jun. 17, 2010	4.31	279
2011	Jun. 24, 2011	4.13	305

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Peak Streamflow for the Nation
USGS 06023800 Big Hole River ab Spring Creek nr Jackson MT

Available data for this site Surface-water: Peak streamflow GO

Beaverhead County, Montana
Hydrologic Unit Code 10020004
Latitude 45°21'40", Longitude 113°26'28" NAD27
Gage datum 6,470 feet above NGVD29

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
2010	Jun. 17, 2010	4.31	279
2011	Jun. 24, 2011	4.13	305

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Peak Streamflow for the Nation

USGS 06024020 Big Hole River at Miner Creek nr Jackson MT

Available data for this site Surface-water: Peak streamflow GO

Beaverhead County, Montana
Hydrologic Unit Code 10020004
Latitude 45°25'22", Longitude 113°26'58" NAD27
Gage datum 6,320 feet above NGVD29

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
2010	Jun. 17, 2010	4.95	2,150
2011	Jun. 09, 2011	4.60	2,300

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Peak Streamflow for the Nation

USGS 06024450 Big Hole River bl Big Lake Cr at Wisdom MT

Beaverhead County, Montana
Hydrologic Unit Code 10020004
Latitude 45°37'07", Longitude 113° 27'25" NAD27
Drainage area 575 square miles
Gage datum 6,040 feet above NGVD29

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1988	Jun. 01, 1988	4.58	1,080
1989	Jun. 17, 1989	4.50	978
1990	Apr. 24, 1990	4.20	667
1991	Jun. 07, 1991	6.09	4,300
1992	Jun. 17, 1992	4.24	610
1993	Jun. 17, 1993	5.08	1,700
1994	Apr. 23, 1994	4.62	977
1995	Jun. 06, 1995	6.37	4,200
1996	May 19, 1996	5.87	2,960
1997	Jun. 09, 1997	6.17	4,170
1998	May 24, 1998	5.27	1,710
1999	May 31, 1999	5.44	1,970
2000	Apr. 14, 2000	4.22	707
2001	Jun. 14, 2001	4.23[2]	714
2002	Jun. 03, 2002	5.02	1,440
2003	Jun. 01, 2003	5.30	1,780
2004	Jun. 30, 2004	3.77	437
2005	Jun. 13, 2005	4.51	918
2006	Jun. 10, 2006	5.59	2,090
2007	Jun. 07, 2007	5.23	2,010
2008	Apr. 30, 2008	5.44	1,810
2009	Apr. 23, 2009	5.76	2,630
2010	Jun. 17, 2010	6.66	3,870
2011	Jun. 10, 2011	6.20	3,320

? Peak Gage-Height Qualification Codes.

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Peak Streamflow for the Nation

USGS 06024540 Big Hole River bl Mudd Cr nr Wisdom MT

Available data for this site Surface-water: Peak streamflow GO

Beaverhead County, Montana
Hydrologic Unit Code 10020004
Latitude 45°48'27", Longitude 113° 18'45" NAD27
Drainage area 1,267 square miles
Gage datum 5,880 feet above NGVD29

Output formats

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- Graph
- Tab-separated file
- peakfq (watstore) format
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Water Year	Date	Gage Height (feet)	Stream-flow (cfs)	Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1998	May 24, 1998	5.05	3,380	2005	Jun. 14, 2005	4.22	1,840
1999	May 31, 1999	5.59	4,690	2006	Jun. 11, 2006	5.56	4,310
2000	Apr. 13, 2000	3.89[2]	1,360	2007	Jun. 08, 2007	4.76	2,780
2001	Jun. 07, 2001	4.08	1,580	2008	May 22, 2008	5.83	4,900
2002	Jun. 04, 2002	5.29	3,930	2009	May 26, 2009	5.95	4,690
2003	Jun. 01, 2003	5.97	4,900	2010	Jun. 18, 2010	6.47	5,580
2004	May 23, 2004	3.86	1,340	2011	Jun. 10, 2011	6.68	6,660

Peak Gage-Height Qualification Codes.

- 2 -- Gage height not the maximum for the year

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Peak Streamflow for the Nation

USGS 06024580 Big Hole River near Wise River MT

Silver Bow County, Montana
Hydrologic Unit Code 10020004
Latitude 45°51'04", Longitude 113°04'06" NAD27
Drainage area 1,611 square miles
Gage datum 5,700 feet above NGVD29

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1980	May 10, 1980	5.91[2]	5,100
1981	Jun. 10, 1981	6.44	6,420
2009	Aug. 08, 2009	3.42	801
2010	Jun. 18, 2010	6.85	8,100
2011	Jun. 11, 2011	7.14	9,130

Peak Gage-Height Qualification Codes.

- 2 -- Gage height not the maximum for the year

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Peak Streamflow for the Nation

USGS 06025250 Big Hole River at Maiden Rock nr Divide MT

Available data for this site: Surface-water: Peak streamflow GO

Beaverhead County, Montana
Hydrologic Unit Code 10020004
Latitude 45°42'04.57",
Longitude 112°44'09.49" NAD83
Drainage area 2,199 square miles
Gage datum 5,300 feet above NGVD29

Output formats

- Table
- Graph
- Tab-separated file
- peakfq (watstore) format
- Reselect output format

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)	Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1998	May 25, 1998	6.24	4,860	2008	May 21, 2008	7.18	7,630
1999	May 30, 1999	7.05	6,930	2009	May 25, 2009	7.26	8,090
2000	May 31, 2000	5.00	2,450	2010	Jun. 18, 2010	7.68	9,540
2001	Jun. 06, 2001	5.02	2,490	2011	Jun. 10, 2011	7.95	10,600
2002	Jun. 03, 2002	6.53	5,880	2012	Apr. 01, 2012	6.64	6,270

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Explanation of terms
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Data Category: Surface Water
Geographic Area: United States
GO

News updated March, 2012

Peak Streamflow for the Nation

USGS 06025500 Big Hole River near Melrose MT

Available data for this site Surface-water: Peak streamflow GO

Madison County, Montana
Hydrologic Unit Code 10020004
Latitude 45°31'36", Longitude 112° 42'03" NAD27
Drainage area 2,476 square miles
Gage datum 5,032.87 feet above NGVD29

Output formats

- Table
- Graph
- Tab-separated file
- peakfq (watstore) format
- Reselect output format

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)	Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1924	May 19, 1924		4,600	1968	Jun. 12, 1968	5.55	7,040
1925	Jun. 05, 1925		6,960	1969	May 21, 1969	6.30	9,010
1926	Apr. 12, 1926		3,880	1970	Jun. 08, 1970	6.20	8,980
1927	Jun. 14, 1927		23,000[3]	1971	Jun. 01, 1971	6.35	9,430
1928	May 26, 1928		9,230	1972	Jun. 10, 1972	8.04	14,300
1929	Jun. 19, 1929		7,100	1973	May 21, 1973	3.44	2,510
1930	Apr. 09, 1930		5,690	1974	Jun. 17, 1974	7.07	10,200
1931	Jun. 05, 1931		2,160	1975	Jun. 21, 1975	7.54	12,700
1932	Jun. 17, 1932	4.88	6,290	1976	May 20, 1976	6.65[2]	10,800
1933	Jun. 05, 1933	5.95	8,550	1977	Jun. 12, 1977	4.66	4,780
1934	Apr. 25, 1934	3.95	3,380	1978	Jun. 10, 1978	5.86	7,550
1935	Jun. 13, 1935	4.47	4,520	1979	May 27, 1979	5.76	7,550
1936	Jun. 04, 1936	5.50	7,030	1980	May 10, 1980	5.37	6,610
1937	May 20, 1937	3.43	2,390	1981	Jun. 11, 1981	6.40	9,220

1938	Jul. 03, 1938	6.39	8,760	1982	May 28, 1982	6.48	9,440
1939	May 06, 1939	5.00	6,290	1983	May 30, 1983	5.90	7,900
1940	May 28, 1940	3.96	3,380	1984	Jun. 22, 1984	6.85	10,500
1942	May 27, 1942	7.72	12,500	1985	Apr. 13, 1985	5.32	6,500
1943	May 31, 1943	6.47	9,500	1986	Jun. 01, 1986	6.25	8,810
1944	Jun. 11, 1944	5.99	7,830	1987	May 01, 1987	3.40	2,550
1945	Jun. 08, 1945	4.61	4,490	1988	Jun. 02, 1988	3.93	3,480
1946	May 30, 1946	5.16	5,750	1989	Jun. 16, 1989	4.25	3,890
1947	May 10, 1947	7.45	13,600	1990	Jun. 11, 1990	3.82	3,300
1948	Jun. 03, 1948	7.76	14,100	1991	Jun. 07, 1991	6.88	10,600
1949	Jun. 02, 1949	5.88	8,040	1992	Jun. 18, 1992	2.83	1,770
1950	Jun. 22, 1950	6.16	8,860	1993	May 21, 1993	4.72	5,090
1951	May 25, 1951	5.80	7,060	1994	May 21, 1994	3.79	3,250
1952	Apr. 20, 1952	5.75	7,680	1995	Jun. 07, 1995	7.35	12,000
1953	Jun. 04, 1953	7.02	11,500	1996	Jun. 10, 1996	7.36	12,100
1954	May 21, 1954	5.11	5,710	1997	Jun. 09, 1997	8.09	13,000
1955	Jun. 16, 1955	5.37	6,240	1998	Jun. 27, 1998	4.69	5,020
1956	May 27, 1956	7.19	11,800	1999	May 30, 1999	5.74	7,500
1957	May 21, 1957	6.13	8,940	2000	May 29, 2000	3.33	2,480
1958	May 25, 1958	6.05	8,270	2001	Jun. 06, 2001	3.46	2,530
1959	Jun. 09, 1959	5.83	7,900	2002	Jun. 03, 2002	4.97	5,300
1960	Mar. 28, 1960	5.17	6,180	2003	May 31, 2003	6.74	9,520
1961	Jun. 13, 1961	4.92	5,450	2004	Jun. 12, 2004	3.18	2,250
1962	Jun. 15, 1962	5.17	5,950	2005	May 21, 2005	3.93	3,430
1963	Jun. 05, 1963	5.57	7,200	2006	May 21, 2006	5.49	6,500
1964	Jun. 09, 1964	7.88	13,700	2007	Jun. 08, 2007	4.42	4,150
1965	Jun. 13, 1965	6.92	11,200	2008	May 21, 2008	6.16	7,660
1966	May 11, 1966	3.71	3,180	2009	Jun. 01, 2009	6.21	7,980
1967	Jun. 08, 1967	6.66	10,400	2010	Jun. 18, 2010	6.94	10,000
				2011	Jun. 10, 2011	7.46	11,700

Peak Gage-Height Qualification Codes.

- 2 -- Gage height not the maximum for the year

Peak Streamflow Qualification Codes.

- 3 -- Discharge affected by Dam Failure

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News - updated January 2013

Network Maintenance: Notification: Friday March 15, 2013. There is planned Network Maintenance scheduled for this weekend, so there could be minor connection issues. Recent real -time data will be available at http://waterdata.usgs.gov/nwis

Peak Streamflow for the Nation

USGS 06025500 Big Hole River near Melrose MT

Available data for this site Surface-water: Peak streamflow GO

Madison County, Montana
Hydrologic Unit Code 10020004
Latitude 45°31'35.69",
Longitude 112°42'06.21" NAD83
Drainage area 2,476 square miles
Gage datum 5,032.87 feet above NGVD29

Output formats

- Table
- Graph
- Tab-separated file
- peakfq (watstore) format
- Reselect output format

Water Year	Date	Gage Height (feet)	Stream - flow (cfs)
1924	May 19, 1924		4,600
1925	Jun. 05, 1925		6,960
1926	Apr. 12, 1926		3,880
1927	Jun. 14, 1927		23,000[3]
1928	May 26, 1928		9,230
1929	Jun. 19, 1929		7,100
1930	Apr. 09, 1930		5,690
1931	Jun. 05, 1931		2,160
1932	Jun. 17, 1932	4.88	6,290
1933	Jun. 05, 1933	5.95	8,550
1934	Apr. 25, 1934	3.95	3,380
1969	May 21, 1969	6.30	9,010
1970	Jun. 08, 1970	6.20	8,980
1971	Jun. 01, 1971	6.35	9,430
1972	Jun. 10, 1972	8.04	14,300
1973	May 21, 1973	3.44	2,510
1974	Jun. 17, 1974	7.07	10,200
1975	Jun. 21, 1975	7.54	12,700
1976	May 20, 1976	6.65[2]	10,800
1977	Jun. 12, 1977	4.66	4,780
1978	Jun. 10, 1978	5.86	7,550
1979	May 27, 1979	5.76	7,550

1935	Jun. 13, 1935	4.47	4,520	1980	May 10, 1980	5.37	6,610
1936	Jun. 04, 1936	5.50	7,030	1981	Jun. 11, 1981	6.40	9,220
1937	May 20, 1937	3.43	2,390	1982	May 28, 1982	6.48	9,440
1938	Jul. 03, 1938	6.39	8,760	1983	May 30, 1983	5.90	7,900
1939	May 06, 1939	5.00	6,290	1984	Jun. 22, 1984	6.85	10,500
1940	May 28, 1940	3.96	3,380	1985	Apr. 13, 1985	5.32	6,500
1942	May 27, 1942	7.72	12,500	1986	Jun. 01, 1986	6.25	8,810
1943	May 31, 1943	6.47	9,500	1987	May 01, 1987	3.40	2,550
1944	Jun. 11, 1944	5.99	7,830	1988	Jun. 02, 1988	3.93	3,480
1945	Jun. 08, 1945	4.61	4,490	1989	Jun. 16, 1989	4.25	3,890
1946	May 30, 1946	5.16	5,750	1990	Jun. 11, 1990	3.82	3,300
1947	May 10, 1947	7.45	13,600	1991	Jun. 07, 1991	6.88	10,600
1948	Jun. 03, 1948	7.76	14,100	1992	Jun. 18, 1992	2.83	1,770
1949	Jun. 02, 1949	5.88	8,040	1993	May 21, 1993	4.72	5,090
1950	Jun. 22, 1950	6.16	8,860	1994	May 21, 1994	3.79	3,250
1951	May 25, 1951	5.80	7,060	1995	Jun. 07, 1995	7.35	12,000
1952	Apr. 20, 1952	5.75	7,680	1996	Jun. 10, 1996	7.36	12,100
1953	Jun. 04, 1953	7.02	11,500	1997	Jun. 09, 1997	8.09	13,000
1954	May 21, 1954	5.11	5,710	1998	Jun. 27, 1998	4.69	5,020
1955	Jun. 16, 1955	5.37	6,240	1999	May 30, 1999	5.74	7,500
1956	May 27, 1956	7.19	11,800	2000	May 29, 2000	3.33	2,480
1957	May 21, 1957	6.13	8,940	2001	Jun. 06, 2001	3.46	2,530
1958	May 25, 1958	6.05	8,270	2002	Jun. 03, 2002	4.97	5,300
1959	Jun. 09, 1959	5.83	7,900	2003	May 31, 2003	6.74	9,520
1960	Mar. 28, 1960	5.17	6,180	2004	Jun. 12, 2004	3.18	2,250
1961	Jun. 13, 1961	4.92	5,450	2005	May 21, 2005	3.93	3,430
1962	Jun. 15, 1962	5.17	5,950	2006	May 21, 2006	5.49	6,500
1963	Jun. 05, 1963	5.57	7,200	2007	Jun. 08, 2007	4.42	4,150
1964	Jun. 09, 1964	7.88	13,700	2008	May 21, 2008	6.16	7,660
1965	Jun. 13, 1965	6.92	11,200	2009	Jun. 01, 2009	6.21	7,980
1966	May 11, 1966	3.71	3,180	2010	Jun. 18, 2010	6.94	10,000
1967	Jun. 08, 1967	6.66	10,400	2011	Jun. 10, 2011	7.46	11,700
1968	Jun. 12, 1968	5.55	7,040	2012	Apr. 27, 2012	5.25	5,970

Peak Gage-Height Qualification Codes.

- 2 -- Gage height not the maximum for the year

Peak Streamflow Qualification Codes.

- 3 -- Discharge affected by Dam Failure

National Water Information System: Web Interface

News updated March, 2012

Peak Streamflow for the Nation
USGS 06026210 Big Hole River near Glen MT

Available data for this site Surface-water: Peak streamflow GO

Madison County, Montana
Hydrologic Unit Code 10020004
Latitude 45°26'26", Longitude 112° 33'20" NAD27
Drainage area 2,655 square miles
Gage datum 4,850 feet above NGVD29

Output formats

- Table
- Graph
- Tab-separated file
- peakfq (watstore) format
- Reselect output format

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)	Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1998	Jun. 27, 1998	5.18	5,250	2005	May 21, 2005	4.48	3,420
1999	May 30, 1999	6.15	7,570	2006	May 21, 2006	5.80	6,630
2000	May 29, 2000	3.99	2,430	2007	Jun. 09, 2007	4.73	3,980
2001	Jun. 06, 2001	3.90	2,410	2008	May 22, 2008	6.36	8,260
2002	Jun. 03, 2002	5.46	5,710	2009	Jun. 01, 2009	6.43	8,470
2003	May 31, 2003	7.05	10,100	2010	Jun. 18, 2010	7.16	10,400
2004	Jun. 12, 2004	3.84	2,210	2011	Jun. 10, 2011	7.63	11,900

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Data Category: Surface Water
Geographic Area: United States
GO

News updated April, 2012

Peak Streamflow for the Nation
USGS 06026400 Big Hole River near Twin Bridges MT

Available data for this site Surface-water: Peak streamflow GO

Madison County, Montana
Hydrologic Unit Code 10020004
Latitude 45°32'53.89", Longitude 112°21'55.13" NAD83
Drainage area 2,762 square miles
Gage datum 4,680 feet above NGVD29

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1980	May 11, 1980	6.59	7,460
1981	Jun. 11, 1981	7.54	8,940

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Explanation of terms
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URL: http://nwis.waterdata.usgs.gov/nwis/peak?

Page Contact Information: USGS Water Data Support Team
Page Last Modified: 2012-04-25 16:50:18 EDT
0.25 0.25 nadww01

National Water Information System: Web Interface

Peak Streamflow for the Nation

USGS 06026420 Big Hole R bl Hamilton Ditch nr Twin Bridges, MT

Available data for this site Surface-water: Peak streamflow GO

Madison County, Montana
Hydrologic Unit Code 10020005
Latitude 45°32'59", Longitude 112°21'32" NAD27
Drainage area 2,790 square miles
Gage datum 4,630 feet above NGVD29

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
2007	Jul. 01, 2007		420[1,2]
2009	Jun. 02, 2009	5.68	7,950
2010	Jun. 19, 2010	5.97	9,500
2011	Jun. 13, 2011	6.00	11,200

Peak Streamflow Qualification Codes.

- 1 -- Discharge is a Maximum Daily Average
- 2 -- Discharge is an Estimate

Appendix C. PKFQWin Input and Output Data

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/20/2012 16:48

                         --- PROCESSING OPTIONS ---

                      Plot option         = Graphics device
                      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)  - U:\BIGHOLE\PEAKFQ\4450_1998.TXT

                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main - U:\BIGHOLE\PEAKFQ\4450_1998.PRT


1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/20/2012 16:48

         Station - 06024450  Big Hole River bl Big Lake Cr at Wisdom MT


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

               Number of peaks in record           =       11
               Peaks not used in analysis          =        0
               Systematic peaks in analysis        =       11
               Historic peaks in analysis          =        0
               Years of historic record            =        0
               Generalized skew                    =   -0.266
                    Standard error                 =    0.640
                    Mean Square error              =    0.410
               Skew option                         =   WEIGHTED
               Gage base discharge                 =      0.0
               User supplied high outlier threshold =   --
               User supplied low outlier criterion  =   --
               Plotting position parameter         =     0.00


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

    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                   0.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.            352.3
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.      7865.8
1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/20/2012 16:48

         Station - 06024450  Big Hole River bl Big Lake Cr at Wisdom 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	3.2213	0.3230	0.134
BULL.17B ESTIMATE	0.0	1.0000	3.2213	0.3230	-0.073

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	232.9	269.2	129.6	67.8	432.2
0.9900	283.5	317.7	181.9	91.8	503.5
0.9500	482.4	504.3	397.8	205.5	768.6
0.9000	638.2	649.1	567.9	310.9	970.3
0.8000	892.7	886.3	842.4	502.5	1305.0
0.6667	1217.0	1192.0	1188.0	762.8	1762.0
0.5000	1680.0	1637.0	1680.0	1131.0	2502.0
0.4292	1918.0	1870.0	1935.0	1313.0	2929.0
0.2000	3121.0	3096.0	3299.0	2134.0	5556.0
0.1000	4292.0	4362.0	4787.0	2828.0	8762.0
0.0400	6006.0	6331.0	7350.0	3739.0	14420.0
0.0200	7446.0	8086.0	9942.0	4444.0	19940.0
0.0100	9022.0	10100.0	13340.0	5171.0	26720.0
0.0050	10740.0	12420.0	17850.0	5925.0	34920.0
0.0020	13250.0	15990.0	26310.0	6967.0	48270.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 03/20/2012 16:48

Station - 06024450 Big Hole River bl Big Lake Cr at Wisdom MT

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1988	1080.0		1994	977.0	
1989	978.0		1995	4200.0	
1990	667.0		1996	2960.0	
1991	4300.0		1997	4170.0	
1992	610.0		1998	1710.0	
1993	1700.0				

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
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/20/2012 16:48

         Station - 06024450  Big Hole River bl Big Lake Cr at Wisdom MT
```

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1991	4300.0	0.0833	0.0833
1995	4200.0	0.1667	0.1667
1997	4170.0	0.2500	0.2500
1996	2960.0	0.3333	0.3333
1998	1710.0	0.4167	0.4167
1993	1700.0	0.5000	0.5000
1988	1080.0	0.5833	0.5833
1989	978.0	0.6667	0.6667
1994	977.0	0.7500	0.7500
1990	667.0	0.8333	0.8333
1992	610.0	0.9167	0.9167

1

```
 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      11

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:  06024450       USGS Big Hole River bl Big Lake Cr

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/20/2012 16:24

                         --- PROCESSING OPTIONS ---

                      Plot option         = Graphics device
                      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)  - U:\BIGHOLE\PEAKFQ\5500_1998.TXT

                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main - U:\BIGHOLE\PEAKFQ\5500_1998-ALL.PRT


1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/20/2012 16:24

              Station - 06025500  Big Hole River near Melrose MT


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

               Number of peaks in record           =       74
               Peaks not used in analysis          =        1
               Systematic peaks in analysis        =       73
               Historic peaks in analysis          =        0
               Years of historic record            =        0
               Generalized skew                    =   -0.201
                    Standard error                 =    0.640
                    Mean Square error              =    0.410
               Skew option                         =   WEIGHTED
               Gage base discharge                 =      0.0
               User supplied high outlier threshold =   --
               User supplied low outlier criterion  =   --
               Plotting position parameter         =     0.00


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

  **WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.       1
  **WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =   73
    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                   0.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.           1610.1
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.     28773.8
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2
1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/20/2012 16:24

              Station - 06025500  Big Hole River near Melrose 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	3.8329	0.2153	-0.726
BULL.17B ESTIMATE	0.0	1.0000	3.8329	0.2153	-0.607

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	1436.0	1361.0	1341.0	1099.0	1768.0
0.9900	1733.0	1664.0	1645.0	1363.0	2091.0
0.9500	2791.0	2756.0	2730.0	2344.0	3211.0
0.9000	3522.0	3514.0	3477.0	3044.0	3974.0
0.8000	4581.0	4607.0	4553.0	4068.0	5081.0
0.6667	5747.0	5801.0	5734.0	5187.0	6326.0
0.5000	7155.0	7224.0	7155.0	6502.0	7888.0
0.4292	7792.0	7859.0	7797.0	7081.0	8618.0
0.2000	10410.0	10410.0	10460.0	9373.0	11750.0
0.1000	12330.0	12210.0	12430.0	10980.0	14170.0
0.0400	14500.0	14160.0	14680.0	12750.0	16970.0
0.0200	15940.0	15410.0	16190.0	13900.0	18880.0
0.0100	17240.0	16500.0	17580.0	14930.0	20630.0
0.0050	18440.0	17480.0	18860.0	15860.0	22260.0
0.0020	19870.0	18600.0	20410.0	16970.0	24230.0

1

Program PeakFq
Ver. 5.2
11/01/2007

U. S. GEOLOGICAL SURVEY
Annual peak flow frequency analysis
following Bulletin 17-B Guidelines

Seq.001.003
Run Date / Time
03/20/2012 16:24

Station - 06025500 Big Hole River near Melrose MT

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1924	4600.0		1962	5950.0	
1925	6960.0		1963	7200.0	
1926	3880.0		1964	13700.0	
1927	-23000.0	D	1965	11200.0	
1928	9230.0		1966	3180.0	
1929	7100.0		1967	10400.0	
1930	5690.0		1968	7040.0	
1931	2160.0		1969	9010.0	
1932	6290.0		1970	8980.0	
1933	8550.0		1971	9430.0	
1934	3380.0		1972	14300.0	
1935	4520.0		1973	2510.0	
1936	7030.0		1974	10200.0	
1937	2390.0		1975	12700.0	
1938	8760.0		1976	10800.0	
1939	6290.0		1977	4780.0	
1940	3380.0		1978	7550.0	
1942	12500.0		1979	7550.0	
1943	9500.0		1980	6610.0	
1944	7830.0		1981	9220.0	
1945	4490.0		1982	9440.0	
1946	5750.0		1983	7900.0	

1947	13600.0	1984	10500.0
1948	14100.0	1985	6500.0
1949	8040.0	1986	8810.0
1950	8860.0	1987	2550.0
1951	7060.0	1988	3480.0
1952	7680.0	1989	3890.0
1953	11500.0	1990	3300.0
1954	5710.0	1991	10600.0
1955	6240.0	1992	1770.0
1956	11800.0	1993	5090.0
1957	8940.0	1994	3250.0
1958	8270.0	1995	12000.0
1959	7900.0	1996	12100.0
1960	6180.0	1997	13000.0
1961	5450.0	1998	5020.0

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
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 03/20/2012 16:24

Station - 06025500 Big Hole River near Melrose MT

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1972	14300.0	0.0135	0.0135
1948	14100.0	0.0270	0.0270
1964	13700.0	0.0405	0.0405
1947	13600.0	0.0541	0.0541
1997	13000.0	0.0676	0.0676
1975	12700.0	0.0811	0.0811
1942	12500.0	0.0946	0.0946
1996	12100.0	0.1081	0.1081
1995	12000.0	0.1216	0.1216
1956	11800.0	0.1351	0.1351
1953	11500.0	0.1486	0.1486
1965	11200.0	0.1622	0.1622
1976	10800.0	0.1757	0.1757
1991	10600.0	0.1892	0.1892
1984	10500.0	0.2027	0.2027
1967	10400.0	0.2162	0.2162
1974	10200.0	0.2297	0.2297
1943	9500.0	0.2432	0.2432
1982	9440.0	0.2568	0.2568
1971	9430.0	0.2703	0.2703

1928	9230.0	0.2838	0.2838
1981	9220.0	0.2973	0.2973
1969	9010.0	0.3108	0.3108
1970	8980.0	0.3243	0.3243
1957	8940.0	0.3378	0.3378
1950	8860.0	0.3514	0.3514
1986	8810.0	0.3649	0.3649
1938	8760.0	0.3784	0.3784
1933	8550.0	0.3919	0.3919
1958	8270.0	0.4054	0.4054
1949	8040.0	0.4189	0.4189
1959	7900.0	0.4324	0.4324
1983	7900.0	0.4459	0.4459
1944	7830.0	0.4595	0.4595
1952	7680.0	0.4730	0.4730
1978	7550.0	0.4865	0.4865
1979	7550.0	0.5000	0.5000
1963	7200.0	0.5135	0.5135
1929	7100.0	0.5270	0.5270
1951	7060.0	0.5405	0.5405
1968	7040.0	0.5541	0.5541
1936	7030.0	0.5676	0.5676
1925	6960.0	0.5811	0.5811
1980	6610.0	0.5946	0.5946
1985	6500.0	0.6081	0.6081
1932	6290.0	0.6216	0.6216
1939	6290.0	0.6351	0.6351
1955	6240.0	0.6486	0.6486
1960	6180.0	0.6622	0.6622
1962	5950.0	0.6757	0.6757
1946	5750.0	0.6892	0.6892
1954	5710.0	0.7027	0.7027
1930	5690.0	0.7162	0.7162
1961	5450.0	0.7297	0.7297
1993	5090.0	0.7432	0.7432
1998	5020.0	0.7568	0.7568
1977	4780.0	0.7703	0.7703
1924	4600.0	0.7838	0.7838
1935	4520.0	0.7973	0.7973
1945	4490.0	0.8108	0.8108
1989	3890.0	0.8243	0.8243
1926	3880.0	0.8378	0.8378
1988	3480.0	0.8514	0.8514
1934	3380.0	0.8649	0.8649
1940	3380.0	0.8784	0.8784
1990	3300.0	0.8919	0.8919
1994	3250.0	0.9054	0.9054
1966	3180.0	0.9189	0.9189
1987	2550.0	0.9324	0.9324
1973	2510.0	0.9459	0.9459
1937	2390.0	0.9595	0.9595
1931	2160.0	0.9730	0.9730
1992	1770.0	0.9865	0.9865
1927	-23000.0	--	--

1

```
 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      74


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: 06025500 USGS Big Hole River near Melrose M

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/20/2012 16:50

                         --- PROCESSING OPTIONS ---

                      Plot option         = Graphics device
                      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)  - U:\BIGHOLE\PEAKFQ\4450_2011.TXT

                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main - U:\BIGHOLE\PEAKFQ\4450_2011.PRT


1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/20/2012 16:50

         Station - 06024450  Big Hole River bl Big Lake Cr at Wisdom MT


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

               Number of peaks in record           =       24
               Peaks not used in analysis          =        0
               Systematic peaks in analysis        =       24
               Historic peaks in analysis          =        0
               Years of historic record            =        0
               Generalized skew                    =   -0.266
                    Standard error                 =    0.640
                    Mean Square error              =    0.410
               Skew option                         =   WEIGHTED
               Gage base discharge                 =      0.0
               User supplied high outlier threshold =   --
               User supplied low outlier criterion  =   --
               Plotting position parameter         =     0.00


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

    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                   0.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.            297.9
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.      8519.4
1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/20/2012 16:50

         Station - 06024450  Big Hole River bl Big Lake Cr at Wisdom 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	3.2023	0.2952	-0.142
BULL.17B ESTIMATE	0.0	1.0000	3.2023	0.2952	-0.185

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	245.9	252.8	195.3	128.0	374.0
0.9900	299.1	305.5	250.6	164.8	440.2
0.9500	503.2	507.2	465.1	320.6	683.9
0.9000	658.6	660.4	627.8	449.2	864.6
0.8000	905.5	903.9	884.1	662.8	1153.0
0.6667	1210.0	1205.0	1198.0	930.1	1520.0
0.5000	1627.0	1619.0	1627.0	1287.0	2061.0
0.4292	1835.0	1827.0	1842.0	1459.0	2349.0
0.2000	2838.0	2835.0	2899.0	2227.0	3886.0
0.1000	3751.0	3765.0	3908.0	2866.0	5465.0
0.0400	5009.0	5062.0	5383.0	3689.0	7848.0
0.0200	6009.0	6106.0	6639.0	4310.0	9889.0
0.0100	7056.0	7211.0	8041.0	4938.0	12140.0
0.0050	8152.0	8380.0	9612.0	5575.0	14620.0
0.0020	9679.0	10030.0	11990.0	6434.0	18250.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 03/20/2012 16:50

Station - 06024450 Big Hole River bl Big Lake Cr at Wisdom MT

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1988	1080.0		2000	707.0	
1989	978.0		2001	714.0	
1990	667.0		2002	1440.0	
1991	4300.0		2003	1780.0	
1992	610.0		2004	437.0	
1993	1700.0		2005	918.0	
1994	977.0		2006	2090.0	
1995	4200.0		2007	2010.0	
1996	2960.0		2008	1810.0	
1997	4170.0		2009	2630.0	
1998	1710.0		2010	3870.0	
1999	1970.0		2011	3320.0	

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
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/20/2012 16:50

         Station - 06024450  Big Hole River bl Big Lake Cr at Wisdom MT


   EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

      WATER         RANKED       SYSTEMATIC      BULL.17B
       YEAR       DISCHARGE        RECORD        ESTIMATE

       1991         4300.0         0.0400         0.0400
       1995         4200.0         0.0800         0.0800
       1997         4170.0         0.1200         0.1200
       2010         3870.0         0.1600         0.1600
       2011         3320.0         0.2000         0.2000
       1996         2960.0         0.2400         0.2400
       2009         2630.0         0.2800         0.2800
       2006         2090.0         0.3200         0.3200
       2007         2010.0         0.3600         0.3600
       1999         1970.0         0.4000         0.4000
       2008         1810.0         0.4400         0.4400
       2003         1780.0         0.4800         0.4800
       1998         1710.0         0.5200         0.5200
       1993         1700.0         0.5600         0.5600
       2002         1440.0         0.6000         0.6000
       1988         1080.0         0.6400         0.6400
       1989          978.0         0.6800         0.6800
       1994          977.0         0.7200         0.7200
       2005          918.0         0.7600         0.7600
       2001          714.0         0.8000         0.8000
       2000          707.0         0.8400         0.8400
       1990          667.0         0.8800         0.8800
       1992          610.0         0.9200         0.9200
       2004          437.0         0.9600         0.9600
1


 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      24


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:  06024450       USGS Big Hole River bl Big Lake Cr


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/22/2012 15:59

                         --- 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)  - U:\BIGHOLE\PEAKFQ\5500_2011.TXT

                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main - U:\BIGHOLE\PEAKFQ\5500_2011.PRT


1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/22/2012 15:59

              Station - 06025500  Big Hole River near Melrose MT


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

               Number of peaks in record           =       87
               Peaks not used in analysis          =        1
               Systematic peaks in analysis        =       86
               Historic peaks in analysis          =        0
               Years of historic record            =        0
               Generalized skew                    =   -0.201
                    Standard error                 =    0.640
                    Mean Square error              =    0.410
               Skew option                         =   WEIGHTED
               Gage base discharge                 =      0.0
               User supplied high outlier threshold =   --
               User supplied low outlier criterion  =   --
               Plotting position parameter         =     0.00


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

  **WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.       1
  **WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =   86
    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                   0.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.           1444.7
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.     29945.3
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2
1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/22/2012 15:59

              Station - 06025500  Big Hole River near Melrose 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	3.8180	0.2219	-0.674
BULL.17B ESTIMATE	0.0	1.0000	3.8180	0.2219	-0.579

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	1340.0	1283.0	1264.0	1044.0	1633.0
0.9900	1621.0	1568.0	1551.0	1295.0	1938.0
0.9500	2632.0	2604.0	2582.0	2235.0	3009.0
0.9000	3338.0	3330.0	3300.0	2910.0	3745.0
0.8000	4367.0	4387.0	4344.0	3904.0	4820.0
0.6667	5512.0	5554.0	5501.0	5002.0	6039.0
0.5000	6908.0	6963.0	6908.0	6309.0	7577.0
0.4292	7545.0	7598.0	7549.0	6889.0	8299.0
0.2000	10190.0	10190.0	10230.0	9221.0	11430.0
0.1000	12170.0	12070.0	12250.0	10890.0	13870.0
0.0400	14420.0	14150.0	14580.0	12750.0	16730.0
0.0200	15940.0	15510.0	16170.0	13980.0	18710.0
0.0100	17330.0	16720.0	17630.0	15090.0	20540.0
0.0050	18610.0	17810.0	19000.0	16100.0	22250.0
0.0020	20170.0	19100.0	20670.0	17320.0	24350.0

1

Program PeakFq
Ver. 5.2
11/01/2007

U. S. GEOLOGICAL SURVEY
Annual peak flow frequency analysis
following Bulletin 17-B Guidelines

Seq.001.003
Run Date / Time
03/22/2012 15:59

Station - 06025500 Big Hole River near Melrose MT

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1924	4600.0		1969	9010.0	
1925	6960.0		1970	8980.0	
1926	3880.0		1971	9430.0	
1927	-23000.0	D	1972	14300.0	
1928	9230.0		1973	2510.0	
1929	7100.0		1974	10200.0	
1930	5690.0		1975	12700.0	
1931	2160.0		1976	10800.0	
1932	6290.0		1977	4780.0	
1933	8550.0		1978	7550.0	
1934	3380.0		1979	7550.0	
1935	4520.0		1980	6610.0	
1936	7030.0		1981	9220.0	
1937	2390.0		1982	9440.0	
1938	8760.0		1983	7900.0	
1939	6290.0		1984	10500.0	
1940	3380.0		1985	6500.0	
1942	12500.0		1986	8810.0	
1943	9500.0		1987	2550.0	
1944	7830.0		1988	3480.0	
1945	4490.0		1989	3890.0	
1946	5750.0		1990	3300.0	

1947	13600.0	1991	10600.0
1948	14100.0	1992	1770.0
1949	8040.0	1993	5090.0
1950	8860.0	1994	3250.0
1951	7060.0	1995	12000.0
1952	7680.0	1996	12100.0
1953	11500.0	1997	13000.0
1954	5710.0	1998	5020.0
1955	6240.0	1999	7500.0
1956	11800.0	2000	2480.0
1957	8940.0	2001	2530.0
1958	8270.0	2002	5300.0
1959	7900.0	2003	9520.0
1960	6180.0	2004	2250.0
1961	5450.0	2005	3430.0
1962	5950.0	2006	6500.0
1963	7200.0	2007	4150.0
1964	13700.0	2008	7660.0
1965	11200.0	2009	7980.0
1966	3180.0	2010	10000.0
1967	10400.0	2011	11700.0
1968	7040.0		

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
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 03/22/2012 15:59

Station - 06025500 Big Hole River near Melrose MT

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1972	14300.0	0.0115	0.0115
1948	14100.0	0.0230	0.0230
1964	13700.0	0.0345	0.0345
1947	13600.0	0.0460	0.0460
1997	13000.0	0.0575	0.0575
1975	12700.0	0.0690	0.0690
1942	12500.0	0.0805	0.0805
1996	12100.0	0.0920	0.0920
1995	12000.0	0.1034	0.1034
1956	11800.0	0.1149	0.1149
2011	11700.0	0.1264	0.1264
1953	11500.0	0.1379	0.1379
1965	11200.0	0.1494	0.1494

1976	10800.0	0.1609	0.1609
1991	10600.0	0.1724	0.1724
1984	10500.0	0.1839	0.1839
1967	10400.0	0.1954	0.1954
1974	10200.0	0.2069	0.2069
2010	10000.0	0.2184	0.2184
2003	9520.0	0.2299	0.2299
1943	9500.0	0.2414	0.2414
1982	9440.0	0.2529	0.2529
1971	9430.0	0.2644	0.2644
1928	9230.0	0.2759	0.2759
1981	9220.0	0.2874	0.2874
1969	9010.0	0.2989	0.2989
1970	8980.0	0.3103	0.3103
1957	8940.0	0.3218	0.3218
1950	8860.0	0.3333	0.3333
1986	8810.0	0.3448	0.3448
1938	8760.0	0.3563	0.3563
1933	8550.0	0.3678	0.3678
1958	8270.0	0.3793	0.3793
1949	8040.0	0.3908	0.3908
2009	7980.0	0.4023	0.4023
1959	7900.0	0.4138	0.4138
1983	7900.0	0.4253	0.4253
1944	7830.0	0.4368	0.4368
1952	7680.0	0.4483	0.4483
2008	7660.0	0.4598	0.4598
1978	7550.0	0.4713	0.4713
1979	7550.0	0.4828	0.4828
1999	7500.0	0.4943	0.4943
1963	7200.0	0.5057	0.5057
1929	7100.0	0.5172	0.5172
1951	7060.0	0.5287	0.5287
1968	7040.0	0.5402	0.5402
1936	7030.0	0.5517	0.5517
1925	6960.0	0.5632	0.5632
1980	6610.0	0.5747	0.5747
1985	6500.0	0.5862	0.5862
2006	6500.0	0.5977	0.5977
1932	6290.0	0.6092	0.6092
1939	6290.0	0.6207	0.6207
1955	6240.0	0.6322	0.6322
1960	6180.0	0.6437	0.6437
1962	5950.0	0.6552	0.6552
1946	5750.0	0.6667	0.6667
1954	5710.0	0.6782	0.6782
1930	5690.0	0.6897	0.6897
1961	5450.0	0.7011	0.7011
2002	5300.0	0.7126	0.7126
1993	5090.0	0.7241	0.7241
1998	5020.0	0.7356	0.7356
1977	4780.0	0.7471	0.7471
1924	4600.0	0.7586	0.7586
1935	4520.0	0.7701	0.7701
1945	4490.0	0.7816	0.7816
2007	4150.0	0.7931	0.7931
1989	3890.0	0.8046	0.8046
1926	3880.0	0.8161	0.8161
1988	3480.0	0.8276	0.8276
2005	3430.0	0.8391	0.8391
1934	3380.0	0.8506	0.8506
1940	3380.0	0.8621	0.8621
1990	3300.0	0.8736	0.8736
1994	3250.0	0.8851	0.8851
1966	3180.0	0.8966	0.8966
1987	2550.0	0.9080	0.9080
2001	2530.0	0.9195	0.9195
1973	2510.0	0.9310	0.9310
2000	2480.0	0.9425	0.9425
1937	2390.0	0.9540	0.9540

```
       2004         2250.0         0.9655         0.9655
       1931         2160.0         0.9770         0.9770
       1992         1770.0         0.9885         0.9885
       1927       -23000.0           --             --
1


 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      87


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:  06025500       USGS Big Hole River near Melrose M


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/20/2012 17:35

                         --- 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\23991\DESKTOP\4540_2011.TXT

                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main - C:\USERS\23991\DESKTOP\4540_2011.PRT


1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/20/2012 17:35

          Station - 06024540  Big Hole River bl Mudd Cr nr Wisdom MT


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

               Number of peaks in record           =       14
               Peaks not used in analysis          =        0
               Systematic peaks in analysis        =       14
               Historic peaks in analysis          =        0
               Years of historic record            =        0
               Generalized skew                    =   -0.244
                    Standard error                 =    0.640
                    Mean Square error              =    0.410
               Skew option                         =   WEIGHTED
               Gage base discharge                 =      0.0
               User supplied high outlier threshold =   --
               User supplied low outlier criterion  =   --
               Plotting position parameter         =     0.00


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

    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                  0.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.           969.2
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.    11087.6
1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/20/2012 17:35
```

Station - 06024540 Big Hole River bl Mudd Cr nr Wisdom 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	3.5156	0.2391	-0.660
BULL.17B ESTIMATE	0.0	1.0000	3.5156	0.2391	-0.453

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	629.2	567.0	407.9	271.9	992.1
0.9900	760.9	702.9	551.8	357.7	1152.0
0.9500	1242.0	1210.0	1089.0	719.2	1711.0
0.9000	1585.0	1575.0	1468.0	1010.0	2100.0
0.8000	2096.0	2117.0	2021.0	1471.0	2692.0
0.6667	2681.0	2729.0	2642.0	2007.0	3416.0
0.5000	3417.0	3481.0	3417.0	2657.0	4436.0
0.4292	3761.0	3826.0	3780.0	2945.0	4959.0
0.2000	5252.0	5256.0	5401.0	4081.0	7541.0
0.1000	6430.0	6314.0	6766.0	4887.0	9892.0
0.0400	7849.0	7506.0	8555.0	5792.0	13030.0
0.0200	8851.0	8295.0	9936.0	6400.0	15420.0
0.0100	9806.0	9008.0	11360.0	6959.0	17830.0
0.0050	10720.0	9655.0	12830.0	7481.0	20240.0
0.0020	11880.0	10430.0	14850.0	8123.0	23420.0

1

Program PeakFq
Ver. 5.2
11/01/2007

U. S. GEOLOGICAL SURVEY
Annual peak flow frequency analysis
following Bulletin 17-B Guidelines

Seq.001.003
Run Date / Time
03/20/2012 17:35

Station - 06024540 Big Hole River bl Mudd Cr nr Wisdom MT

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1998	3380.0		2005	1840.0	
1999	4690.0		2006	4310.0	
2000	1360.0		2007	2780.0	
2001	1580.0		2008	4900.0	
2002	3930.0		2009	4690.0	
2003	4900.0		2010	5580.0	
2004	1340.0		2011	6660.0	

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
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 03/20/2012 17:35

Station - 06024540 Big Hole River bl Mudd Cr nr Wisdom MT

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
2011	6660.0	0.0667	0.0667
2010	5580.0	0.1333	0.1333
2003	4900.0	0.2000	0.2000
2008	4900.0	0.2667	0.2667
1999	4690.0	0.3333	0.3333
2009	4690.0	0.4000	0.4000
2006	4310.0	0.4667	0.4667
2002	3930.0	0.5333	0.5333
1998	3380.0	0.6000	0.6000
2007	2780.0	0.6667	0.6667
2005	1840.0	0.7333	0.7333
2001	1580.0	0.8000	0.8000
2000	1360.0	0.8667	0.8667
2004	1340.0	0.9333	0.9333

1

End PeakFQ analysis.
Stations processed : 1
Number of errors : 0
Stations skipped : 0
Station years : 14

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: 06024540 USGS Big Hole River bl Mudd Cr nr

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/22/2012 15:34

                         --- 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)  - U:\BIGHOLE\PEAKFQ\6210_2011.TXT

                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main - U:\BIGHOLE\PEAKFQ\6210_2011.PRT


1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/22/2012 15:34

               Station - 06026210  Big Hole River near Glen MT


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

               Number of peaks in record           =       14
               Peaks not used in analysis          =        0
               Systematic peaks in analysis        =       14
               Historic peaks in analysis          =        0
               Years of historic record            =        0
               Generalized skew                    =   -0.195
                    Standard error                 =    0.640
                    Mean Square error              =    0.410
               Skew option                         =   WEIGHTED
               Gage base discharge                 =      0.0
               User supplied high outlier threshold =   --
               User supplied low outlier criterion  =   --
               Plotting position parameter         =     0.00


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

    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                   0.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.           1523.9
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.     19851.1
1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/22/2012 15:34

               Station - 06026210  Big Hole River near Glen 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	3.7404	0.2519	-0.403
BULL.17B ESTIMATE	0.0	1.0000	3.7404	0.2519	-0.303

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	1048.0	992.8	696.5	448.8	1664.0
0.9900	1256.0	1205.0	925.1	582.9	1921.0
0.9500	2021.0	1992.0	1777.0	1147.0	2822.0
0.9000	2573.0	2562.0	2384.0	1605.0	3459.0
0.8000	3411.0	3426.0	3287.0	2344.0	4443.0
0.6667	4392.0	4430.0	4326.0	3229.0	5669.0
0.5000	5663.0	5718.0	5663.0	4339.0	7441.0
0.4292	6272.0	6328.0	6306.0	4844.0	8372.0
0.2000	9020.0	9032.0	9304.0	6917.0	13200.0
0.1000	11320.0	11230.0	12000.0	8467.0	17900.0
0.0400	14260.0	13950.0	15790.0	10300.0	24630.0
0.0200	16440.0	15910.0	18910.0	11580.0	30110.0
0.0100	18610.0	17820.0	22340.0	12810.0	35900.0
0.0050	20780.0	19680.0	26110.0	14000.0	42000.0
0.0020	23640.0	22070.0	31710.0	15520.0	50540.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 03/22/2012 15:34

Station - 06026210 Big Hole River near Glen MT

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1998	5250.0		2005	3420.0	
1999	7570.0		2006	6630.0	
2000	2430.0		2007	3980.0	
2001	2410.0		2008	8260.0	
2002	5710.0		2009	8470.0	
2003	10100.0		2010	10400.0	
2004	2210.0		2011	11900.0	

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
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/22/2012 15:34

                Station - 06026210  Big Hole River near Glen MT
```

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
2011	11900.0	0.0667	0.0667
2010	10400.0	0.1333	0.1333
2003	10100.0	0.2000	0.2000
2009	8470.0	0.2667	0.2667
2008	8260.0	0.3333	0.3333
1999	7570.0	0.4000	0.4000
2006	6630.0	0.4667	0.4667
2002	5710.0	0.5333	0.5333
1998	5250.0	0.6000	0.6000
2007	3980.0	0.6667	0.6667
2005	3420.0	0.7333	0.7333
2000	2430.0	0.8000	0.8000
2001	2410.0	0.8667	0.8667
2004	2210.0	0.9333	0.9333

1

```
 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      14

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:  06026210       USGS Big Hole River near Glen MT


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/27/2012 16:58

                         --- PROCESSING OPTIONS ---

                      Plot option         = Graphics device
                      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\23991\DOCUMENTS\SCRAP\BIGHOLE\PEAK06023500.TXT
                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main -
C:\USERS\23991\DOCUMENTS\SCRAP\BIGHOLE\PEAK06023500.PRT

1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/27/2012 16:58

               Station - 06023500  Big Hole River near Jackson MT


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

                Number of peaks in record            =        8
                Peaks not used in analysis           =        0
                Systematic peaks in analysis         =        8
                Historic peaks in analysis           =        0
                Years of historic record             =        0
                Generalized skew                     =   -0.287
                     Standard error                  =    0.640
                     Mean Square error               =    0.410
                Skew option                          =   WEIGHTED
                Gage base discharge                  =      0.0
                User supplied high outlier threshold =   --
                User supplied low outlier criterion  =   --
                Plotting position parameter          =     0.00


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

  **WCF118W-SYSTEMATIC RECORD SHORTER THAN 17B SPEC.     8
    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                  0.0
    WCF162I-SYSTEMATIC PEAKS EXCEEDED HIGH-OUTLIER CRITERION.   1     860.8
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.            264.1
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2
1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
```

Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 03/27/2012 16:58

Station - 06023500 Big Hole River near Jackson 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	2.6784	0.1344	1.659
BULL.17B ESTIMATE	0.0	1.0000	2.6784	0.1344	0.251

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	231.1	331.0	177.6	124.8	302.5
0.9900	245.8	332.7	200.2	138.8	317.0
0.9500	293.3	342.3	266.5	187.3	363.9
0.9000	323.7	352.1	304.9	220.5	394.7
0.8000	366.4	370.9	355.2	268.8	440.1
0.6667	413.1	397.8	407.6	321.9	495.0
0.5000	470.7	439.6	470.7	384.0	573.5
0.4292	497.6	462.3	500.3	410.8	615.0
0.2000	615.9	586.0	638.5	513.0	836.0
0.1000	714.1	718.7	770.3	584.2	1060.0
0.0400	841.0	933.9	978.6	666.5	1393.0
0.0200	937.7	1134.0	1179.0	724.8	1678.0
0.0100	1036.0	1375.0	1437.0	781.6	1994.0
0.0050	1138.0	1663.0	1780.0	837.6	2345.0
0.0020	1277.0	2135.0	2439.0	911.6	2868.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 03/27/2012 16:58

Station - 06023500 Big Hole River near Jackson MT

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1948	938.0		1952	381.0	
1949	352.0		1953	484.0	
1950	520.0		2010	446.0	
1951	377.0		2011	502.0	

Explanation of peak discharge qualification codes

PeakFQ NWIS

CODE	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
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 03/27/2012 16:58

Station - 06023500 Big Hole River near Jackson MT

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1948	938.0	0.1111	0.1111
1950	520.0	0.2222	0.2222
2011	502.0	0.3333	0.3333
1953	484.0	0.4444	0.4444
2010	446.0	0.5556	0.5556
1952	381.0	0.6667	0.6667
1951	377.0	0.7778	0.7778
1949	352.0	0.8889	0.8889

1

End PeakFQ analysis.
Stations processed : 1
Number of errors : 0
Stations skipped : 0
Station years : 8

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: 06023500 USGS Big Hole River near Jackson M

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/15/2013 16:59

                         --- 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\23991\DOCUMENTS\SCRAP\BIGHOLE\PEAK06025250WITH2012.TXT
                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main -
C:\USERS\23991\DOCUMENTS\SCRAP\BIGHOLE\PEAK06025250WITH2012.PRT

1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/15/2013 16:59

         Station - 06025250  Big Hole River at Maiden Rock nr Divide 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
               Years of historic record            =        0
               Generalized skew                    =   -0.180
                    Standard error                 =    0.640
                    Mean Square error              =    0.410
               Skew option                         =   WEIGHTED
               Gage base discharge                 =      0.0
               User supplied high outlier threshold =   --
               User supplied low outlier criterion  =   --
               Plotting position parameter         =     0.00


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

    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                  0.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.          2080.8
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.    16470.8
1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/15/2013 16:59
```

Station - 06025250 Big Hole River at Maiden Rock nr Divide 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	3.7675	0.2206	-0.963
BULL.17B ESTIMATE	0.0	1.0000	3.7675	0.2206	-0.501

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	1248.0	1011.0	653.2	443.3	2033.0
0.9900	1495.0	1276.0	933.9	591.4	2331.0
0.9500	2376.0	2264.0	1977.0	1227.0	3345.0
0.9000	2989.0	2964.0	2690.0	1744.0	4039.0
0.8000	3883.0	3975.0	3697.0	2563.0	5086.0
0.6667	4881.0	5070.0	4787.0	3506.0	6371.0
0.5000	6107.0	6344.0	6107.0	4616.0	8202.0
0.4292	6670.0	6899.0	6715.0	5093.0	9149.0
0.2000	9046.0	9029.0	9381.0	6893.0	13850.0
0.1000	10860.0	10420.0	11600.0	8102.0	18110.0
0.0400	12980.0	11810.0	14510.0	9405.0	23740.0
0.0200	14440.0	12630.0	16770.0	10250.0	27980.0
0.0100	15800.0	13300.0	19090.0	11020.0	32190.0
0.0050	17080.0	13850.0	21490.0	11710.0	36370.0
0.0020	18660.0	14450.0	24760.0	12550.0	41820.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 03/15/2013 16:59

Station - 06025250 Big Hole River at Maiden Rock nr Divide MT

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1998	4860.0		2008	7630.0	
1999	6930.0		2009	8090.0	
2000	2450.0		2010	9540.0	
2001	2490.0		2011	10600.0	
2002	5880.0		2012	6270.0	

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
Ver. 5.2            Annual peak flow frequency analysis    Run Date / Time
11/01/2007          following Bulletin 17-B Guidelines     03/15/2013 16:59

       Station - 06025250  Big Hole River at Maiden Rock nr Divide MT
```

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
2011	10600.0	0.0909	0.0909
2010	9540.0	0.1818	0.1818
2009	8090.0	0.2727	0.2727
2008	7630.0	0.3636	0.3636
1999	6930.0	0.4545	0.4545
2012	6270.0	0.5455	0.5455
2002	5880.0	0.6364	0.6364
1998	4860.0	0.7273	0.7273
2001	2490.0	0.8182	0.8182
2000	2450.0	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:  06025250       USGS Big Hole River at Maiden Rock


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/05/2013 15:17

                         --- 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\23991\DOCUMENTS\SCRAP\BIGHOLE\PEAK06025500_WITH2012.TXT
                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main -
C:\USERS\23991\DOCUMENTS\SCRAP\BIGHOLE\PEAK06025500_WITH2012.PRT

1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       03/05/2013 15:17

               Station - 06025500  Big Hole River near Melrose MT


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

                Number of peaks in record           =       88
                Peaks not used in analysis          =        1
                Systematic peaks in analysis        =       87
                Historic peaks in analysis          =        0
                Years of historic record            =        0
                Generalized skew                    =   -0.201
                     Standard error                 =    0.640
                     Mean Square error              =    0.410
                Skew option                         =   WEIGHTED
                Gage base discharge                 =      0.0
                User supplied high outlier threshold =   --
                User supplied low outlier criterion  =   --
                Plotting position parameter         =     0.00


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

  **WCF109W-PEAKS WITH MINUS-FLAGGED DISCHARGES WERE BYPASSED.       1
  **WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS =   87
    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                 0.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.          1452.5
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.     29718.4
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2
1
```

Program PeakFq — U. S. GEOLOGICAL SURVEY — Seq.001.002
Ver. 5.2 — Annual peak flow frequency analysis — Run Date / Time
11/01/2007 — following Bulletin 17-B Guidelines — 03/05/2013 15:17

Station - 06025500 Big Hole River near Melrose 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	3.8176	0.2207	-0.670
BULL.17B ESTIMATE	0.0	1.0000	3.8176	0.2207	-0.578

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	1351.0	1295.0	1276.0	1057.0	1643.0
0.9900	1633.0	1581.0	1563.0	1309.0	1949.0
0.9500	2643.0	2616.0	2594.0	2248.0	3017.0
0.9000	3347.0	3339.0	3310.0	2923.0	3751.0
0.8000	4372.0	4391.0	4349.0	3914.0	4821.0
0.6667	5511.0	5552.0	5500.0	5007.0	6031.0
0.5000	6898.0	6951.0	6898.0	6305.0	7557.0
0.4292	7529.0	7582.0	7534.0	6883.0	8273.0
0.2000	10160.0	10160.0	10190.0	9198.0	11370.0
0.1000	12110.0	12020.0	12190.0	10860.0	13780.0
0.0400	14350.0	14080.0	14500.0	12700.0	16620.0
0.0200	15850.0	15430.0	16070.0	13920.0	18570.0
0.0100	17230.0	16630.0	17520.0	15020.0	20380.0
0.0050	18500.0	17720.0	18870.0	16030.0	22070.0
0.0020	20040.0	19000.0	20530.0	17240.0	24140.0

1

Program PeakFq — U. S. GEOLOGICAL SURVEY — Seq.001.003
Ver. 5.2 — Annual peak flow frequency analysis — Run Date / Time
11/01/2007 — following Bulletin 17-B Guidelines — 03/05/2013 15:17

Station - 06025500 Big Hole River near Melrose MT

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

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1924	4600.0		1969	9010.0	
1925	6960.0		1970	8980.0	
1926	3880.0		1971	9430.0	
1927	-23000.0	D	1972	14300.0	
1928	9230.0		1973	2510.0	
1929	7100.0		1974	10200.0	
1930	5690.0		1975	12700.0	
1931	2160.0		1976	10800.0	

1932	6290.0	1977	4780.0
1933	8550.0	1978	7550.0
1934	3380.0	1979	7550.0
1935	4520.0	1980	6610.0
1936	7030.0	1981	9220.0
1937	2390.0	1982	9440.0
1938	8760.0	1983	7900.0
1939	6290.0	1984	10500.0
1940	3380.0	1985	6500.0
1942	12500.0	1986	8810.0
1943	9500.0	1987	2550.0
1944	7830.0	1988	3480.0
1945	4490.0	1989	3890.0
1946	5750.0	1990	3300.0
1947	13600.0	1991	10600.0
1948	14100.0	1992	1770.0
1949	8040.0	1993	5090.0
1950	8860.0	1994	3250.0
1951	7060.0	1995	12000.0
1952	7680.0	1996	12100.0
1953	11500.0	1997	13000.0
1954	5710.0	1998	5020.0
1955	6240.0	1999	7500.0
1956	11800.0	2000	2480.0
1957	8940.0	2001	2530.0
1958	8270.0	2002	5300.0
1959	7900.0	2003	9520.0
1960	6180.0	2004	2250.0
1961	5450.0	2005	3430.0
1962	5950.0	2006	6500.0
1963	7200.0	2007	4150.0
1964	13700.0	2008	7660.0
1965	11200.0	2009	7980.0
1966	3180.0	2010	10000.0
1967	10400.0	2011	11700.0
1968	7040.0	2012	5970.0

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

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1972	14300.0	0.0114	0.0114
1948	14100.0	0.0227	0.0227
1964	13700.0	0.0341	0.0341
1947	13600.0	0.0455	0.0455
1997	13000.0	0.0568	0.0568
1975	12700.0	0.0682	0.0682
1942	12500.0	0.0795	0.0795
1996	12100.0	0.0909	0.0909
1995	12000.0	0.1023	0.1023
1956	11800.0	0.1136	0.1136
2011	11700.0	0.1250	0.1250
1953	11500.0	0.1364	0.1364
1965	11200.0	0.1477	0.1477
1976	10800.0	0.1591	0.1591
1991	10600.0	0.1705	0.1705
1984	10500.0	0.1818	0.1818
1967	10400.0	0.1932	0.1932
1974	10200.0	0.2045	0.2045
2010	10000.0	0.2159	0.2159
2003	9520.0	0.2273	0.2273
1943	9500.0	0.2386	0.2386
1982	9440.0	0.2500	0.2500
1971	9430.0	0.2614	0.2614
1928	9230.0	0.2727	0.2727
1981	9220.0	0.2841	0.2841
1969	9010.0	0.2955	0.2955
1970	8980.0	0.3068	0.3068
1957	8940.0	0.3182	0.3182
1950	8860.0	0.3295	0.3295
1986	8810.0	0.3409	0.3409
1938	8760.0	0.3523	0.3523
1933	8550.0	0.3636	0.3636
1958	8270.0	0.3750	0.3750
1949	8040.0	0.3864	0.3864
2009	7980.0	0.3977	0.3977
1959	7900.0	0.4091	0.4091
1983	7900.0	0.4205	0.4205
1944	7830.0	0.4318	0.4318
1952	7680.0	0.4432	0.4432
2008	7660.0	0.4545	0.4545
1978	7550.0	0.4659	0.4659
1979	7550.0	0.4773	0.4773
1999	7500.0	0.4886	0.4886
1963	7200.0	0.5000	0.5000
1929	7100.0	0.5114	0.5114
1951	7060.0	0.5227	0.5227
1968	7040.0	0.5341	0.5341
1936	7030.0	0.5455	0.5455
1925	6960.0	0.5568	0.5568
1980	6610.0	0.5682	0.5682
1985	6500.0	0.5795	0.5795
2006	6500.0	0.5909	0.5909
1932	6290.0	0.6023	0.6023
1939	6290.0	0.6136	0.6136
1955	6240.0	0.6250	0.6250

1960	6180.0	0.6364	0.6364
2012	5970.0	0.6477	0.6477
1962	5950.0	0.6591	0.6591
1946	5750.0	0.6705	0.6705
1954	5710.0	0.6818	0.6818
1930	5690.0	0.6932	0.6932
1961	5450.0	0.7045	0.7045
2002	5300.0	0.7159	0.7159
1993	5090.0	0.7273	0.7273
1998	5020.0	0.7386	0.7386
1977	4780.0	0.7500	0.7500
1924	4600.0	0.7614	0.7614
1935	4520.0	0.7727	0.7727
1945	4490.0	0.7841	0.7841
2007	4150.0	0.7955	0.7955
1989	3890.0	0.8068	0.8068
1926	3880.0	0.8182	0.8182
1988	3480.0	0.8295	0.8295
2005	3430.0	0.8409	0.8409
1934	3380.0	0.8523	0.8523
1940	3380.0	0.8636	0.8636
1990	3300.0	0.8750	0.8750
1994	3250.0	0.8864	0.8864
1966	3180.0	0.8977	0.8977
1987	2550.0	0.9091	0.9091
2001	2530.0	0.9205	0.9205
1973	2510.0	0.9318	0.9318
2000	2480.0	0.9432	0.9432
1937	2390.0	0.9545	0.9545
2004	2250.0	0.9659	0.9659
1931	2160.0	0.9773	0.9773
1992	1770.0	0.9886	0.9886
1927	-23000.0	--	--

1

```
 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      88

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:  06025500       USGS Big Hole River near Melrose M


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

Appendix D. Two Station Comparison Method Calculations

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Long-Term Record

Big Hole River near Melrose (06025500)

All Years: (1924-2011)

$N =$ 86

$\Sigma X_i =$ 328.35208

$\overline{X}_3 =$ 3.81805

$\sigma_X =$ 0.22194

Concurrent Years: (1948-1953, 2010-2011)

$N_1 =$ 8

$\Sigma X_i =$ 31.86496

$\Sigma X^2_i =$ 126.99801

$\overline{X}_1 =$ 3.98312

$\sigma_X =$ 0.10424 (S_{x1})

Non-Concurrent Years: (1924-1947, 1954-2009)

$N_2 =$ 78

$\Sigma X_i =$ 296.48712

$\overline{X}_2 =$ 3.82338

$\sigma_X =$ 0.22420 (S_{x2})

No.	Water Year	Q (cfs)	$X=\log_{10}Q$	X^2
1	1924	4,600	3.66276	13.41579
2	1925	6,960	3.84261	14.76565
3	1926	3,880	3.58883	12.87971
4	1928	9,230	3.96520	15.72282
5	1929	7,100	3.85126	14.83219
6	1930	5,690	3.75511	14.10087
7	1931	2,160	3.33445	11.11858
8	1932	6,290	3.79865	14.42975
9	1933	8,550	3.93197	15.46036
10	1934	3,380	3.52892	12.45325
11	1935	4,520	3.65514	13.36004
12	1936	7,030	3.84696	14.79907
13	1937	2,390	3.37840	11.41357
14	1938	8,760	3.94250	15.54334
15	1939	6,290	3.79865	14.42975
16	1940	3,380	3.52892	12.45325
17	1942	12,500	4.09691	16.78467
18	1943	9,500	3.97772	15.82229
19	1944	7,830	3.89376	15.16138
20	1945	4,490	3.65225	13.33890
21	1946	5,750	3.75967	14.13510
22	1947	13,600	4.13354	17.08614
23	1948	14,100	4.14922	17.21602
24	1949	8,040	3.90526	15.25102
25	1950	8,860	3.94743	15.58223
26	1951	7,060	3.84880	14.81330
27	1952	7,680	3.88536	15.09603
28	1953	11,500	4.06070	16.48927
29	1954	5,710	3.75664	14.11231
30	1955	6,240	3.79518	14.40343
31	1956	11,800	4.07188	16.58022
32	1957	8,940	3.95134	15.61307
33	1958	8,270	3.91751	15.34685
34	1959	7,900	3.89763	15.19150
35	1960	6,180	3.79099	14.37159
36	1961	5,450	3.73640	13.96066
37	1962	5,950	3.77452	14.24698
38	1963	7,200	3.85733	14.87901

Short-Term Record

Big Hole River near Jackson MT (06023500)

All Years: (1948-1953, 2010-2011)

$N =$ 8

$\overline{X} =$ 2.67836

$\sigma_X =$ 0.13439

Concurrent Years: (1948-1953, 2010-2011)

$N_3 =$ 8

$\Sigma(XY) =$ 85.42878 ($\Sigma X_1 Y_1$)

$\Sigma Y_i =$ 21.42690

$\Sigma Y^2_i =$ 57.51542

$\overline{Y}_3 =$ 2.67836

$\sigma_Y =$ 0.13439 (S_{y3})

b= 1.08949

$S_{Y1} =$ 0.13439

$S_{X1} =$ 0.10424

r = 0.84508

$^*r_{Mean} =$ 0.408248

Since $r>r_{Mean}$, improvement to the mean is possible.

$^*r_{StandardDeviation} =$ 0.720042

Since $r>r_{StandardDeviation}$, improvement to the standard deviation is possible.

Q	$Y=\log_{10}(Q)$	Y^2	X*Y
938	2.97220	8.83399	12.33232
352	2.54654	6.48488	9.94490
520	2.71600	7.37667	10.72124
377	2.57634	6.63753	9.91583
381	2.58092	6.66117	10.02783
484	2.68485	7.20839	10.90235

39	1964	13,700	4.13672	17.11246				
40	1965	11,200	4.04922	16.39617				
41	1966	3,180	3.50243	12.26700				
42	1967	10,400	4.01703	16.13656				
43	1968	7,040	3.84757	14.80382				
44	1969	9,010	3.95472	15.63985				
45	1970	8,980	3.95328	15.62839				
46	1971	9,430	3.97451	15.79674				
47	1972	14,300	4.15534	17.26682				
48	1973	2,510	3.39967	11.55778				
49	1974	10,200	4.00860	16.06888				
50	1975	12,700	4.10380	16.84120				
51	1976	10,800	4.03342	16.26851				
52	1977	4,780	3.67943	13.53819				
53	1978	7,550	3.87795	15.03847				
54	1979	7,550	3.87795	15.03847				
55	1980	6,610	3.82020	14.59394				
56	1981	9,220	3.96473	15.71909				
57	1982	9,440	3.97497	15.80040				
58	1983	7,900	3.89763	15.19150				
59	1984	10,500	4.02119	16.16996				
60	1985	6,500	3.81291	14.53831				
61	1986	8,810	3.94498	15.56283				
62	1987	2,550	3.40654	11.60452				
63	1988	3,480	3.54158	12.54278				
64	1989	3,890	3.58995	12.88774				
65	1990	3,300	3.51851	12.37994				
66	1991	10,600	4.02531	16.20309				
67	1992	1,770	3.24797	10.54933				
68	1993	5,090	3.70672	13.73976				
69	1994	3,250	3.51188	12.33332				
70	1995	12,000	4.07918	16.63972				
71	1996	12,100	4.08279	16.66914				
72	1997	13,000	4.11394	16.92453				
73	1998	5,020	3.70070	13.69521				
74	1999	7,500	3.87506	15.01610				
75	2000	2,480	3.39445	11.52230				
76	2001	2,530	3.40312	11.58123				
77	2002	5,300	3.72428	13.87023				
78	2003	9,520	3.97864	15.82955				
79	2004	2,250	3.35218	11.23713				
80	2005	3,430	3.53529	12.49830				
81	2006	6,500	3.81291	14.53831				
82	2007	4,150	3.61805	13.09027				
83	2008	7,660	3.88423	15.08723				
84	2009	7,980	3.90200	15.22563				
85	2010	10,000	4.00000	16.00000	446	2.64933	7.01898	10.59734
86	2011	11,700	4.06819	16.55014	502	2.70070	7.29380	10.98696

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Criterion and adjustment procedure for the mean

eqn 7-4 $r =$ 0.84508 > 0.40825 $= r_{Mean}$ Since $r > r_{Mean}$, adjustment to the mean is worthwhile.

Calculate $\bar{Y}$, $Var(\bar{Y})$, $\bar{Y}_3$, $Var(\bar{Y}_3)$

eqn 7-3 $Var(\bar{Y}) =$ 0.00091232

eqn 7-5b $\bar{Y} =$ 2.49852

eqn 7-6 $Var(\bar{Y}_3) =$ 0.0022575

If $Var(\bar{Y}_3) < Var(\bar{Y})$, then use $\bar{Y}_3$. Otherwise, use $\bar{Y}$.

Final estimate of mean = 2.49852 $= \bar{Y}$

Equivalent years of record for the mean

eqn 7-7 $N_e =$ 19.8

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Criterion and adjustment procedure for the standard deviation

eqn 7-9 $|r| =$ 0.84508 > 0.72004 $= r_{StandardDeviation}$ Since $r > r_{StandardDeviation}$, improvement to the standard deviation is possible.

where,

A = -36.48000

B = 4.96000

C = 7.23429

eqn 7-8 $Var(S_y^2) =$ 6.5623E-05

eqn 7-10 $S_y^2 =$ 0.062545

$S_y =$ 0.25009

eqn 7-11 $Var(S_{y3}^2) =$ 0.00009319

If $Var(S_{y3}^2) < Var(S_y^2)$, use S_{y3}. Otherwise, use S_y.

Final estimate of standard deviation = 0.25009 = S_y

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Calculation of weighted skew for short term record, all years

G_b =	-0.286665	Generalized skew coefficient (from PeakFQ)
G =	1.659	Station skew (matches PeakFQ? = yes)
N =	8	Number of years of record
MSE_{Gb} =	0.4096	(from PeakFQ)
A =	-0.022433	
B =	0.55	
MSE_G =	1.073661	
G_W =	0.2505043	Weighted skew (matches PeakFQ? = yes)

orig M=	2.6784	adj M =	2.498517
orig S=	0.1344	adj S =	0.250091

Short Term Frequency Curves

Original					Adjusted		
T	P	K	X	Q	K - B17B	X	Q
1.005025126	0.995	-2.34058	2.363811	231	-2.34062	1.913151	82
1.01010101	0.99	-2.14082	2.390665	246	-2.14079	1.963125	92
1.020408163	0.98	-1.91708	2.420739	263	-1.91701	2.019091	104
1.052631579	0.95	-1.57063	2.467304	293	-1.57051	2.105746	128
1.111111111	0.9	-1.25175	2.510157	324	-1.25163	2.185495	153
1.25	0.8	-0.85147	2.563948	366	-0.85137	2.285597	193
1.428571429	0.7	-0.5531	2.604041	402	-0.55303	2.360208	229
1.666666667	0.6	-0.29161	2.639178	436	-0.29158	2.425597	266
2	0.5	-0.04171	2.672762	471	-0.04167	2.488095	308
5	0.2	0.827158	2.789511	616	0.827071	2.70536	507
10	0.1	1.30537	2.853772	714	1.305247	2.824947	668
25	0.04	1.833818	2.924788	841	1.833686	2.957105	906
50	0.02	2.185455	2.972047	938	2.18534	3.04505	1,109
100	0.01	2.508688	3.015489	1,036	2.508598	3.125894	1,336
200	0.005	2.810312	3.056028	1,138	2.810255	3.201335	1,590
500	0.002	3.183315	3.106163	1,277	3.183315	3.294634	1,971

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Long-Term Record

Big Hole River near Melrose (06025500)

All Years: (1924-2011)

$N =$ 86
$\Sigma X_i =$ 328.35208
$\overline{X}_3 =$ 3.81805
$\sigma_X =$ 0.22194

Concurrent Years: (1988-2011)

$N_1 =$ 24
$\Sigma X_i =$ 89.66694
$\Sigma X^2_i =$ 336.61098
$\overline{X}_1 =$ 3.73612
$\sigma_X =$ 0.26411 (S_{x1})

Non-Concurrent Years: (1924-1987)

$N_2 =$ 62
$\Sigma X_i =$ 238.68514
$\overline{X}_2 =$ 3.84976
$\sigma_X =$ 0.19666 (S_{x2})

No.	Water Year	Q (cfs)	$X=\log_{10}Q$	X^2
1	1924	4,600	3.66276	13.41579
2	1925	6,960	3.84261	14.76565
3	1926	3,880	3.58883	12.87971
4	1928	9,230	3.96520	15.72282
5	1929	7,100	3.85126	14.83219
6	1930	5,690	3.75511	14.10087
7	1931	2,160	3.33445	11.11858
8	1932	6,290	3.79865	14.42975
9	1933	8,550	3.93197	15.46036
10	1934	3,380	3.52892	12.45325
11	1935	4,520	3.65514	13.36004
12	1936	7,030	3.84696	14.79907
13	1937	2,390	3.37840	11.41357
14	1938	8,760	3.94250	15.54334
15	1939	6,290	3.79865	14.42975
16	1940	3,380	3.52892	12.45325
17	1942	12,500	4.09691	16.78467
18	1943	9,500	3.97772	15.82229
19	1944	7,830	3.89376	15.16138
20	1945	4,490	3.65225	13.33890
21	1946	5,750	3.75967	14.13510
22	1947	13,600	4.13354	17.08614
23	1948	14,100	4.14922	17.21602
24	1949	8,040	3.90526	15.25102
25	1950	8,860	3.94743	15.58223
26	1951	7,060	3.84880	14.81330
27	1952	7,680	3.88536	15.09603
28	1953	11,500	4.06070	16.48927
29	1954	5,710	3.75664	14.11231
30	1955	6,240	3.79518	14.40343
31	1956	11,800	4.07188	16.58022
32	1957	8,940	3.95134	15.61307
33	1958	8,270	3.91751	15.34685
34	1959	7,900	3.89763	15.19150
35	1960	6,180	3.79099	14.37159
36	1961	5,450	3.73640	13.96066
37	1962	5,950	3.77452	14.24698
38	1963	7,200	3.85733	14.87901
39	1964	13,700	4.13672	17.11246

Short-Term Record

Big Hole River d/s of Big Lake Crk at Wisdom, MT (06024450)

All Years: (1988-2011)

$N =$ 24

$\overline{X} =$ 3.20226
$\sigma_X =$ 0.29516

Concurrent Years: (1988-2011)

$N_3 =$ 24
$\Sigma Y_i =$ 76.85422
$\Sigma Y^2_i =$ 248.11083
$\overline{Y}_3 =$ 3.20226
$\sigma_Y =$ 0.29516 (S_{y3})

$\Sigma(XY) =$ 288.82684 ($\Sigma X_1 Y_1$)

b= 1.05345
$S_{Y1} =$ 0.29516
$S_{X1} =$ 0.26411
r = 0.94263

$r_{Mean} =$ 0.213201

Since $r > r_{Mean}$, improvement to the mean is possible.

$r_{StandardDeviation} =$ 0.43027

Since $r > r_{StandardDeviation}$, improvement to the standard deviation is possible.

40	1965	11,200	4.04922	16.39617
41	1966	3,180	3.50243	12.26700
42	1967	10,400	4.01703	16.13656
43	1968	7,040	3.84757	14.80382
44	1969	9,010	3.95472	15.63985
45	1970	8,980	3.95328	15.62839
46	1971	9,430	3.97451	15.79674
47	1972	14,300	4.15534	17.26682
48	1973	2,510	3.39967	11.55778
49	1974	10,200	4.00860	16.06888
50	1975	12,700	4.10380	16.84120
51	1976	10,800	4.03342	16.26851
52	1977	4,780	3.67943	13.53819
53	1978	7,550	3.87795	15.03847
54	1979	7,550	3.87795	15.03847
55	1980	6,610	3.82020	14.59394
56	1981	9,220	3.96473	15.71909
57	1982	9,440	3.97497	15.80040
58	1983	7,900	3.89763	15.19150
59	1984	10,500	4.02119	16.16996
60	1985	6,500	3.81291	14.53831
61	1986	8,810	3.94498	15.56283
62	1987	2,550	3.40654	11.60452
63	1988	3,480	3.54158	12.54278
64	1989	3,890	3.58995	12.88774
65	1990	3,300	3.51851	12.37994
66	1991	10,600	4.02531	16.20309
67	1992	1,770	3.24797	10.54933
68	1993	5,090	3.70672	13.73976
69	1994	3,250	3.51188	12.33332
70	1995	12,000	4.07918	16.63972
71	1996	12,100	4.08279	16.66914
72	1997	13,000	4.11394	16.92453
73	1998	5,020	3.70070	13.69521
74	1999	7,500	3.87506	15.01610
75	2000	2,480	3.39445	11.52230
76	2001	2,530	3.40312	11.58123
77	2002	5,300	3.72428	13.87023
78	2003	9,520	3.97864	15.82955
79	2004	2,250	3.35218	11.23713
80	2005	3,430	3.53529	12.49830
81	2006	6,500	3.81291	14.53831
82	2007	4,150	3.61805	13.09027
83	2008	7,660	3.88423	15.08723
84	2009	7,980	3.90200	15.22563
85	2010	10,000	4.00000	16.00000
86	2011	11,700	4.06819	16.55014

Q	$Y=\log_{10}(Q)$	Y^2	X*Y
1,080	3.03342	9.20166	10.74311
978	2.99034	8.94213	10.73517
667	2.82413	7.97569	9.93673
4,300	3.63347	13.20209	14.62582
610	2.78533	7.75806	9.04668
1,700	3.23045	10.43580	11.97436
977	2.98989	8.93947	10.50016
4,200	3.62325	13.12794	14.77989
2,960	3.47129	12.04987	14.17254
4,170	3.62014	13.10539	14.89303
1,710	3.23300	10.45226	11.96436
1,970	3.29447	10.85351	12.76626
707	2.84942	8.11919	9.67222
714	2.85370	8.14359	9.71148
1,440	3.15836	9.97525	11.76261
1,780	3.25042	10.56523	12.93224
437	2.64048	6.97214	8.85138
918	2.96284	8.77844	10.47452
2,090	3.32015	11.02337	12.65943
2,010	3.30320	10.91110	11.95112
1,810	3.25768	10.61247	12.65357
2,630	3.41996	11.69610	13.34468
3,870	3.58771	12.87167	14.35084
3,320	3.52114	12.39841	14.32464

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Criterion and adjustment procedure for the mean

eqn 7-4 $r =$ 0.94263 > 0.21320 $= r_{Mean}$ Since $r > r_{Mean}$, adjustment to the mean is worthwhile.

Calculate $\bar{Y}$, $Var(\bar{Y})$, $\bar{Y}_3$, $Var(\bar{Y}_3)$

eqn 7-3 $Var(\bar{Y}) =$ 0.00131852

eqn 7-5b $\bar{Y} =$ 3.28856

eqn 7-6 $Var(\bar{Y}_3) =$ 0.0036299

If $Var(\bar{Y}_3) < Var(\bar{Y})$, then use $\bar{Y}_3$. Otherwise, use $\bar{Y}$.

Final estimate of mean = 3.28856 $= \bar{Y}$

Equivalent years of record for the mean

eqn 7-7 $N_e =$ 66.1

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Criterion and adjustment procedure for the standard deviation

eqn 7-9 $|r| =$ 0.94263 > 0.43027 $= r_{StandardDeviation}$ Since $r > r_{StandardDeviation}$, improvement to the standard deviation is possible.

where,

A = -8.73751

B = 1.28455

C = 0.06166

eqn 7-8 $Var(S_y^2) =$ 2.8902E-04

eqn 7-10 $S_y^2 =$ 0.064343

$S_y =$ 0.25366

eqn 7-11 $Var(S_{y3}^2) =$ 0.00065995

If $Var(S_{y3}^2) < Var(S_y^2)$, use S_{y3}. Otherwise, use S_y.

Final estimate of standard deviation = 0.25366 = S_y

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Calculation of weighted skew for short term record, all years

G_b =	-0.266	Generalized skew coefficient (from PeakFQ)
G =	-0.142	Station skew (matches PeakFQ? = yes)
N =	24	Number of years of record
MSE_{Gb} =	0.4096	(from PeakFQ)

A =	-0.318667
B =	0.9031679
MSE_G =	0.2177401

G_W =	-0.184818	Weighted skew (matches PeakFQ? = yes)

orig M=	3.2023	adj M =	3.288563
orig S=	0.2952	adj S =	0.253659

Short Term Frequency Curves

Original					Adjusted		
T	P	K	X	Q	K - B17B	X	Q
1.005025126	0.995	-2.4022	2.390872	246	-2.74901	2.591253	390
1.01010101	0.99	-2.18968	2.475811	299	-2.46123	2.66425	462
1.020408163	0.98	-1.95334	2.56726	369	-2.1514	2.742841	553
1.052631579	0.95	-1.59067	2.701785	503	-1.69562	2.858453	722
1.111111111	0.9	-1.26014	2.818661	659	-1.29964	2.958897	910
1.25	0.8	-0.84934	2.956883	905	-0.83134	3.077685	1,196
1.428571429	0.7	-0.54588	3.054323	1,133	-0.50121	3.161426	1,450
1.666666667	0.6	-0.28174	3.136114	1,368	-0.2241	3.231718	1,705
2	0.5	-0.03079	3.211328	1,627	0.030725	3.296357	1,979
5	0.2	0.83139	3.452933	2,837	0.849291	3.503993	3,191
10	0.1	1.299706	3.574181	3,751	1.260082	3.608194	4,057
25	0.04	1.812626	3.699724	5,009	1.685427	3.716087	5,201
50	0.02	2.151452	3.778789	6,009	1.953301	3.784036	6,082
100	0.01	2.461269	3.848553	7,056	2.189662	3.843991	6,982
200	0.005	2.749027	3.911287	8,152	2.402209	3.897905	7,905
500	0.002	3.103172	3.985897	9,680	2.65499	3.962026	9,163

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Long-Term Record

Big Hole River near Melrose (06025500)

All Years: (1924-2011)

$N =$ 86
$\Sigma X_i =$ 328.35208
$\overline{X}_3 =$ 3.81805
$\sigma_X =$ 0.22194

Concurrent Years: (1998-2011)

$N_1 =$ 14
$\Sigma X_i =$ 52.24911
$\Sigma X^2_i =$ 195.74163
$\overline{X}_1 =$ 3.73208
$\sigma_X =$ 0.23920 (S_{x1})

Non-Concurrent Years: (1924-1997)

$N_2 =$ 72
$\Sigma X_i =$ 276.10298
$\overline{X}_2 =$ 3.83476
$\sigma_X =$ 0.21623 (S_{x2})

No.	Water Year	Q (cfs)	$X=\log_{10}Q$	X^2
1	1924	4,600	3.66276	13.41579
2	1925	6,960	3.84261	14.76565
3	1926	3,880	3.58883	12.87971
4	1928	9,230	3.96520	15.72282
5	1929	7,100	3.85126	14.83219
6	1930	5,690	3.75511	14.10087
7	1931	2,160	3.33445	11.11858
8	1932	6,290	3.79865	14.42975
9	1933	8,550	3.93197	15.46036
10	1934	3,380	3.52892	12.45325
11	1935	4,520	3.65514	13.36004
12	1936	7,030	3.84696	14.79907
13	1937	2,390	3.37840	11.41357
14	1938	8,760	3.94250	15.54334
15	1939	6,290	3.79865	14.42975
16	1940	3,380	3.52892	12.45325
17	1942	12,500	4.09691	16.78467
18	1943	9,500	3.97772	15.82229
19	1944	7,830	3.89376	15.16138
20	1945	4,490	3.65225	13.33890
21	1946	5,750	3.75967	14.13510
22	1947	13,600	4.13354	17.08614
23	1948	14,100	4.14922	17.21602
24	1949	8,040	3.90526	15.25102
25	1950	8,860	3.94743	15.58223
26	1951	7,060	3.84880	14.81330
27	1952	7,680	3.88536	15.09603
28	1953	11,500	4.06070	16.48927
29	1954	5,710	3.75664	14.11231
30	1955	6,240	3.79518	14.40343
31	1956	11,800	4.07188	16.58022
32	1957	8,940	3.95134	15.61307
33	1958	8,270	3.91751	15.34685
34	1959	7,900	3.89763	15.19150
35	1960	6,180	3.79099	14.37159
36	1961	5,450	3.73640	13.96066
37	1962	5,950	3.77452	14.24698
38	1963	7,200	3.85733	14.87901
39	1964	13,700	4.13672	17.11246

Short-Term Record

Big Hole River below Mudd Crk near Wisdom, MT (06024540)

All Years: (1998-2011)

$N =$ 14

$\overline{X} =$ 3.51563
$\sigma_X =$ 0.23914

Concurrent Years: (1998-2011)

$N_3 =$ 14
$\Sigma Y_i =$ 49.21880
$\Sigma Y^2_i =$ 173.77841
$\overline{Y}_3 =$ 3.51563
$\sigma_Y =$ 0.23914 (S_{y3})

$\Sigma(XY) =$ 184.41903 ($\Sigma X_1 Y_1$)

b= 0.98220
$S_{Y1} =$ 0.23914
$S_{X1} =$ 0.23920
r = 0.98248

$r_{Mean} =$ 0.288675

Since $r > r_{Mean}$, improvement to the mean is possible.

$r_{StandardDeviation} =$ 0.555834

Since $r > r_{StandardDeviation}$, improvement to the standard deviation is possible.

40	1965	11,200	4.04922	16.39617
41	1966	3,180	3.50243	12.26700
42	1967	10,400	4.01703	16.13656
43	1968	7,040	3.84757	14.80382
44	1969	9,010	3.95472	15.63985
45	1970	8,980	3.95328	15.62839
46	1971	9,430	3.97451	15.79674
47	1972	14,300	4.15534	17.26682
48	1973	2,510	3.39967	11.55778
49	1974	10,200	4.00860	16.06888
50	1975	12,700	4.10380	16.84120
51	1976	10,800	4.03342	16.26851
52	1977	4,780	3.67943	13.53819
53	1978	7,550	3.87795	15.03847
54	1979	7,550	3.87795	15.03847
55	1980	6,610	3.82020	14.59394
56	1981	9,220	3.96473	15.71909
57	1982	9,440	3.97497	15.80040
58	1983	7,900	3.89763	15.19150
59	1984	10,500	4.02119	16.16996
60	1985	6,500	3.81291	14.53831
61	1986	8,810	3.94498	15.56283
62	1987	2,550	3.40654	11.60452
63	1988	3,480	3.54158	12.54278
64	1989	3,890	3.58995	12.88774
65	1990	3,300	3.51851	12.37994
66	1991	10,600	4.02531	16.20309
67	1992	1,770	3.24797	10.54933
68	1993	5,090	3.70672	13.73976
69	1994	3,250	3.51188	12.33332
70	1995	12,000	4.07918	16.63972
71	1996	12,100	4.08279	16.66914
72	1997	13,000	4.11394	16.92453
73	1998	5,020	3.70070	13.69521
74	1999	7,500	3.87506	15.01610
75	2000	2,480	3.39445	11.52230
76	2001	2,530	3.40312	11.58123
77	2002	5,300	3.72428	13.87023
78	2003	9,520	3.97864	15.82955
79	2004	2,250	3.35218	11.23713
80	2005	3,430	3.53529	12.49830
81	2006	6,500	3.81291	14.53831
82	2007	4,150	3.61805	13.09027
83	2008	7,660	3.88423	15.08723
84	2009	7,980	3.90200	15.22563
85	2010	10,000	4.00000	16.00000
86	2011	11,700	4.06819	16.55014

Q	$Y=\log_{10}(Q)$	Y^2	X*Y
3,380	3.52892	12.45325	13.05948
4,690	3.67117	13.47751	14.22602
1,360	3.13354	9.81907	10.63665
1,580	3.19866	10.23141	10.88542
3,930	3.59439	12.91966	13.38651
4,900	3.69020	13.61755	14.68195
1,340	3.12710	9.77878	10.48263
1,840	3.26482	10.65904	11.54209
4,310	3.63448	13.20943	13.85795
2,780	3.44404	11.86144	12.46072
4,900	3.69020	13.61755	14.33357
4,690	3.67117	13.47751	14.32493
5,580	3.74663	14.03727	14.98654
6,660	3.82347	14.61896	15.55460

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Criterion and adjustment procedure for the mean

eqn 7-4 $r =$ 0.98248 > 0.28868 $= r_{Mean}$ Since $r > r_{Mean}$, adjustment to the mean is worthwhile.

Calculate $\bar{Y}$, $Var(\bar{Y})$, $\bar{Y}_3$, $Var(\bar{Y}_3)$

eqn 7-3 $Var(\bar{Y}) =$ 0.00079455

eqn 7-5b $\bar{Y} =$ 3.60007

eqn 7-6 $Var(\bar{Y}_3) =$ 0.0040847

If $Var(\bar{Y}_3) < Var(\bar{Y})$, then use $\bar{Y}_3$. Otherwise, use $\bar{Y}$.

Final estimate of mean = 3.60007 $= \bar{Y}$

Equivalent years of record for the mean

eqn 7-7 $N_e =$ 72.0

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Criterion and adjustment procedure for the standard deviation

eqn 7-9 $|r| =$ 0.98248 > 0.55583 $= r_{StandardDeviation}$ Since $r > r_{StandardDeviation}$, improvement to the standard deviation is possible.

where,

A = -17.34435

B = 3.77961

C = 0.48782

eqn 7-8 $Var(S_y^2) =$ 1.1126E-04

eqn 7-10 $S_y^2 =$ 0.049481

$S_y =$ 0.22244

eqn 7-11 $Var(S_{y3}^2) =$ 0.00050311

If $Var(S_{y3}^2) < Var(S_y^2)$, use S_{y3}. Otherwise, use S_y.

Final estimate of standard deviation = 0.22244 $= S_y$

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Calculation of weighted skew for short term record, all years

G_b =	-0.244	Generalized skew coefficient (from PeakFQ)
G =	-0.660	Station skew (matches PeakFQ? = yes)
N =	14	Number of years of record
MSE_{Gb} =	0.4096	(from PeakFQ)

A =	-0.277194
B =	0.7683802
MSE_G =	0.4078723

G_W =	-0.452478	Weighted skew (matches PeakFQ? = yes)

orig M=	3.5156	adj M =	3.600066
orig S=	0.2391	adj S =	0.222444

Short Term Frequency Curves

Original					Adjusted		
T	P	K	X	Q	K - B17B	X	Q
1.005025126	0.995	-2.1522	2.798846	629	-2.99738	2.933317	858
1.01010101	0.99	-1.99017	2.881352	761	-2.65237	3.010064	1,023
1.020408163	0.98	-1.80404	2.968638	930	-2.28736	3.091257	1,234
1.052631579	0.95	-1.50659	3.094033	1,242	-1.76299	3.2079	1,614
1.111111111	0.9	-1.2234	3.199953	1,585	-1.32006	3.306426	2,025
1.25	0.8	-0.85594	3.32142	2,096	-0.81213	3.419414	2,627
1.428571429	0.7	-0.57385	3.40447	2,538	-0.46483	3.496667	3,138
1.666666667	0.6	-0.32119	3.472474	2,968	-0.18046	3.559925	3,630
2	0.5	-0.07518	3.533609	3,417	0.075191	3.616792	4,138
5	0.2	0.812221	3.720291	5,252	0.855842	3.790443	6,172
10	0.1	1.320182	3.808157	6,429	1.223274	3.872176	7,450
25	0.04	1.896174	3.894798	7,849	1.585581	3.952769	8,970
50	0.02	2.287436	3.947013	8,851	1.803929	4.001339	10,031
100	0.01	2.652408	3.991533	9,807	1.990101	4.042752	11,034
200	0.005	2.99737	4.030295	10,722	2.152195	4.078808	11,990
500	0.002	3.429568	4.074792	11,879	2.338265	4.120199	13,189

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Long-Term Record

Big Hole River near Melrose (06025500)

All Years: (1924-2012)

$N =$ 87

$\Sigma X_i =$ 332.12806

$\overline{X}_3 =$ 3.81756

$\sigma_X =$ 0.22069

Concurrent Years:(1998-2002, 2008-2012)

$N_1 =$ 10

$\Sigma X_i =$ 37.72800

$\Sigma X^2_i =$ 142.80605

$\overline{X}_1 =$ 3.77280

$\sigma_X =$ 0.22750 (S_{x1})

Non-Concurrent Years: (1924-1997, 2003-2007)

$N_2 =$ 77

$\Sigma X_i =$ 294.40005

$\overline{X}_2 =$ 3.82338

$\sigma_X =$ 0.22065 (S_{x2})

No.	Water Year	Q (cfs)	$X=\log_{10}Q$	X^2
1	1924	4,600	3.66276	13.41579
2	1925	6,960	3.84261	14.76565
3	1926	3,880	3.58883	12.87971
4	1928	9,230	3.96520	15.72282
5	1929	7,100	3.85126	14.83219
6	1930	5,690	3.75511	14.10087
7	1931	2,160	3.33445	11.11858
8	1932	6,290	3.79865	14.42975
9	1933	8,550	3.93197	15.46036
10	1934	3,380	3.52892	12.45325
11	1935	4,520	3.65514	13.36004
12	1936	7,030	3.84696	14.79907
13	1937	2,390	3.37840	11.41357
14	1938	8,760	3.94250	15.54334
15	1939	6,290	3.79865	14.42975
16	1940	3,380	3.52892	12.45325
17	1942	12,500	4.09691	16.78467
18	1943	9,500	3.97772	15.82229

Short-Term Record

Big Hole River at Maiden Rock nr Divide MT (06025250)

All Years: (1998-2002, 2008-2012)

$N =$ 10

$\overline{X} =$ 3.76747

$\sigma_X =$ 0.22065

Concurrent Years:(1998-2002, 2008-2012)

$N_3 =$ 10

$\Sigma(XY) =$ 142.58817 ($\Sigma X_1 Y_1$)

$\Sigma Y_i =$ 37.67471

$\Sigma Y^2_i =$ 142.37653

$\overline{Y}_3 =$ 3.76747

$\sigma_Y =$ 0.22065 (S_{y3})

b= 0.96395

$S_{Y1} =$ 0.22065

$S_{X1} =$ 0.22750

r = 0.99388

From Table 7-1

$^*r_{Mean} =$ 0.353553 Since $r>r_{Mean}$, improvement to the mean is possible.

$^*r_{StandardDeviation} =$ 0.649883 Since $r>r_{StandardDeviation}$, improvement to the standard deviation is possible.

19	1944	7,830	3.89376	15.16138
20	1945	4,490	3.65225	13.33890
21	1946	5,750	3.75967	14.13510
22	1947	13,600	4.13354	17.08614
23	1948	14,100	4.14922	17.21602
24	1949	8,040	3.90526	15.25102
25	1950	8,860	3.94743	15.58223
26	1951	7,060	3.84880	14.81330
27	1952	7,680	3.88536	15.09603
28	1953	11,500	4.06070	16.48927
29	1954	5,710	3.75664	14.11231
30	1955	6,240	3.79518	14.40343
31	1956	11,800	4.07188	16.58022
32	1957	8,940	3.95134	15.61307
33	1958	8,270	3.91751	15.34685
34	1959	7,900	3.89763	15.19150
35	1960	6,180	3.79099	14.37159
36	1961	5,450	3.73640	13.96066
37	1962	5,950	3.77452	14.24698
38	1963	7,200	3.85733	14.87901
39	1964	13,700	4.13672	17.11246
40	1965	11,200	4.04922	16.39617
41	1966	3,180	3.50243	12.26700
42	1967	10,400	4.01703	16.13656
43	1968	7,040	3.84757	14.80382
44	1969	9,010	3.95472	15.63985
45	1970	8,980	3.95328	15.62839
46	1971	9,430	3.97451	15.79674
47	1972	14,300	4.15534	17.26682
48	1973	2,510	3.39967	11.55778
49	1974	10,200	4.00860	16.06888
50	1975	12,700	4.10380	16.84120
51	1976	10,800	4.03342	16.26851
52	1977	4,780	3.67943	13.53819
53	1978	7,550	3.87795	15.03847
54	1979	7,550	3.87795	15.03847
55	1980	6,610	3.82020	14.59394
56	1981	9,220	3.96473	15.71909
57	1982	9,440	3.97497	15.80040
58	1983	7,900	3.89763	15.19150
59	1984	10,500	4.02119	16.16996
60	1985	6,500	3.81291	14.53831
61	1986	8,810	3.94498	15.56283
62	1987	2,550	3.40654	11.60452
63	1988	3,480	3.54158	12.54278
64	1989	3,890	3.58995	12.88774
65	1990	3,300	3.51851	12.37994

66	1991	10,600	4.02531	16.20309					
67	1992	1,770	3.24797	10.54933					
68	1993	5,090	3.70672	13.73976					
69	1994	3,250	3.51188	12.33332					
70	1995	12,000	4.07918	16.63972					
71	1996	12,100	4.08279	16.66914					
72	1997	13,000	4.11394	16.92453		Q	$Y=\log_{10}(Q)$	Y^2	X*Y
73	1998	5,020	3.70070	13.69521		4860	3.68664	13.59129	13.64315
74	1999	7,500	3.87506	15.01610		6930	3.84073	14.75123	14.88308
75	2000	2,480	3.39445	11.52230		2450	3.38917	11.48645	11.50436
76	2001	2,530	3.40312	11.58123		2490	3.39620	11.53417	11.55768
77	2002	5,300	3.72428	13.87023		5880	3.76938	14.20821	14.03820
78	2003	9,520	3.97864	15.82955					
79	2004	2,250	3.35218	11.23713					
80	2005	3,430	3.53529	12.49830					
81	2006	6,500	3.81291	14.53831					
82	2007	4,150	3.61805	13.09027					
83	2008	7,660	3.88423	15.08723		7630	3.88252	15.07400	15.08061
84	2009	7,980	3.90200	15.22563		8090	3.90795	15.27206	15.24883
85	2010	10,000	4.00000	16.00000		9540	3.97955	15.83681	15.91819
86	2011	11,700	4.06819	16.55014		10600	4.02531	16.20309	16.37569
87	2012	5,970	3.77597	14.25798		6270	3.79727	14.41924	14.33838

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Criterion and adjustment procedure for the mean

eqn 7-4 $r =$ 0.99388 > 0.35355 $= r_{Mean}$ Since $r > r_{Mean}$, adjustment to the mean is worthwhile.

Calculate $\bar{Y}$, $Var(\bar{Y})$, $\bar{Y}_3$, $Var(\bar{Y}_3)$

eqn 7-3 $Var(\bar{Y}) =$ 0.00061969

eqn 7-5b $\bar{Y} =$ 3.81062

eqn 7-6 $Var(\bar{Y}_3) =$ 0.0048686

If $Var(\bar{Y}_3) < Var(\bar{Y})$, then use $\bar{Y}_3$. Otherwise, use $\bar{Y}$.

Final estimate of mean = 3.81062 $= \bar{Y}$

Equivalent years of record for the mean

eqn 7-7 $N_e =$ 78.6

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Criterion and adjustment procedure for the standard deviation

eqn 7-9 $|r| =$ 0.99388 > 0.64988 $= r_{StandardDeviation}$ Since $r > r_{StandardDeviation}$, improvement to the standard deviation is possible.

where,

A = -27.80000

B = 6.45714

C = 2.23175

eqn 7-8 $Var(S_y^2) =$ 6.9817E-05

eqn 7-10 $S_y^2 =$ 0.045832

$S_y =$ 0.21409

eqn 7-11 $Var(S_{y3}^2) =$ 0.00052675

If $Var(S_{y3}^2) < Var(S_y^2)$, use S_{y3}. Otherwise, use S_y.

Final estimate of standard deviation = 0.21409 = S_y

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Calculation of weighted skew for short term record, all years

G_b =	-0.179332	Generalized skew coefficient (from PeakFQ)
G =	-0.963	Station skew (matches PeakFQ? = yes)
N =	10	Number of years of record
MSE_{Gb} =	0.4096	(from PeakFQ)

A =	-0.231229
B =	0.6897319
MSE_G =	0.5871795

G_W =	-0.501183	Weighted skew (matches PeakFQ? = yes)

orig M=	3.7675	adj M =	3.81062
orig S=	0.2206	adj S =	0.214085

Short Term Frequency Curves

		Original				Adjusted	
T	P	K	X	Q	K - B17B	X	Q
1.005025126	0.995	-2.10715	3.096232	1,248	-3.0421	3.159352	1,443
1.01010101	0.99	-1.95384	3.174686	1,495	-2.68654	3.235472	1,720
1.020408163	0.98	-1.77649	3.257458	1,809	-2.31141	3.315781	2,069
1.052631579	0.95	-1.49062	3.375917	2,376	-1.77455	3.430716	2,696
1.111111111	0.9	-1.21599	3.475517	2,989	-1.32315	3.527353	3,368
1.25	0.8	-0.85654	3.589145	3,883	-0.80819	3.6376	4,341
1.428571429	0.7	-0.57851	3.666425	4,639	-0.45795	3.712581	5,159
1.666666667	0.6	-0.32813	3.729428	5,363	-0.17241	3.773709	5,939
2	0.5	-0.08321	3.785832	6,107	0.083214	3.828435	6,737
5	0.2	0.808189	3.956466	9,046	0.856538	3.993992	9,863
10	0.1	1.323163	4.035779	10,859	1.215992	4.070946	11,775
25	0.04	1.910562	4.113215	12,978	1.566938	4.146078	13,998
50	0.02	2.311417	4.159453	14,436	1.776488	4.19094	15,522
100	0.01	2.686548	4.198585	15,797	1.95384	4.228908	16,940
200	0.005	3.042098	4.232416	17,077	2.107164	4.261733	18,270
500	0.002	3.488811	4.27094	18,661	2.281759	4.299111	19,912

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Long-Term Record

Big Hole River near Melrose (06025500)

All Years: (1924-2011)

$N =$ 86

$\Sigma X_i =$ 328.35208

$\overline{X}_3 =$ 3.81805

$\sigma_X =$ 0.22194

Concurrent Years: (1998-2011)

$N_1 =$ 14

$\Sigma X_i =$ 52.24911

$\Sigma X^2_i =$ 195.74163

$\overline{X}_1 =$ 3.73208

$\sigma_X =$ 0.23920 (S_{x1})

Non-Concurrent Years: (1924-1997)

$N_2 =$ 72

$\Sigma X_i =$ 276.10298

$\overline{X}_2 =$ 3.83476

$\sigma_X =$ 0.21623 (S_{x2})

No.	Water Year	Q (cfs)	$X=\log_{10}Q$	X^2
1	1924	4,600	3.66276	13.41579
2	1925	6,960	3.84261	14.76565
3	1926	3,880	3.58883	12.87971
4	1928	9,230	3.96520	15.72282
5	1929	7,100	3.85126	14.83219
6	1930	5,690	3.75511	14.10087
7	1931	2,160	3.33445	11.11858
8	1932	6,290	3.79865	14.42975
9	1933	8,550	3.93197	15.46036
10	1934	3,380	3.52892	12.45325
11	1935	4,520	3.65514	13.36004
12	1936	7,030	3.84696	14.79907
13	1937	2,390	3.37840	11.41357
14	1938	8,760	3.94250	15.54334
15	1939	6,290	3.79865	14.42975
16	1940	3,380	3.52892	12.45325
17	1942	12,500	4.09691	16.78467
18	1943	9,500	3.97772	15.82229
19	1944	7,830	3.89376	15.16138
20	1945	4,490	3.65225	13.33890
21	1946	5,750	3.75967	14.13510
22	1947	13,600	4.13354	17.08614
23	1948	14,100	4.14922	17.21602
24	1949	8,040	3.90526	15.25102
25	1950	8,860	3.94743	15.58223
26	1951	7,060	3.84880	14.81330
27	1952	7,680	3.88536	15.09603
28	1953	11,500	4.06070	16.48927
29	1954	5,710	3.75664	14.11231
30	1955	6,240	3.79518	14.40343
31	1956	11,800	4.07188	16.58022
32	1957	8,940	3.95134	15.61307
33	1958	8,270	3.91751	15.34685
34	1959	7,900	3.89763	15.19150
35	1960	6,180	3.79099	14.37159
36	1961	5,450	3.73640	13.96066
37	1962	5,950	3.77452	14.24698
38	1963	7,200	3.85733	14.87901

Short-Term Record

Big Hole River near Glen, MT (06026210)

All Years: (1998-2011)

$N =$ 14

$\overline{X} =$ 3.74036

$\sigma_X =$ 0.25188

Concurrent Years: (1998-2011)

$N_3 =$ 14

$\Sigma Y_i =$ 52.36509

$\Sigma Y^2_i =$ 196.68931

$\overline{Y}_3 =$ 3.74036

$\sigma_Y =$ 0.25188 (S_{y3})

$\Sigma(XY) =$ 196.21288 ($\Sigma X_1 Y_1$)

b= 1.05158

$S_{Y1} =$ 0.25188

$S_{X1} =$ 0.23920

r = 0.99864

$r_{Mean} =$ 0.288675

Since $r > r_{Mean}$, improvement to the mean is possible.

$r_{StandardDeviation} =$ 0.555834

Since $r > r_{StandardDeviation}$, improvement to the standard deviation is possible.

39	1964	13,700	4.13672	17.11246
40	1965	11,200	4.04922	16.39617
41	1966	3,180	3.50243	12.26700
42	1967	10,400	4.01703	16.13656
43	1968	7,040	3.84757	14.80382
44	1969	9,010	3.95472	15.63985
45	1970	8,980	3.95328	15.62839
46	1971	9,430	3.97451	15.79674
47	1972	14,300	4.15534	17.26682
48	1973	2,510	3.39967	11.55778
49	1974	10,200	4.00860	16.06888
50	1975	12,700	4.10380	16.84120
51	1976	10,800	4.03342	16.26851
52	1977	4,780	3.67943	13.53819
53	1978	7,550	3.87795	15.03847
54	1979	7,550	3.87795	15.03847
55	1980	6,610	3.82020	14.59394
56	1981	9,220	3.96473	15.71909
57	1982	9,440	3.97497	15.80040
58	1983	7,900	3.89763	15.19150
59	1984	10,500	4.02119	16.16996
60	1985	6,500	3.81291	14.53831
61	1986	8,810	3.94498	15.56283
62	1987	2,550	3.40654	11.60452
63	1988	3,480	3.54158	12.54278
64	1989	3,890	3.58995	12.88774
65	1990	3,300	3.51851	12.37994
66	1991	10,600	4.02531	16.20309
67	1992	1,770	3.24797	10.54933
68	1993	5,090	3.70672	13.73976
69	1994	3,250	3.51188	12.33332
70	1995	12,000	4.07918	16.63972
71	1996	12,100	4.08279	16.66914
72	1997	13,000	4.11394	16.92453
73	1998	5,020	3.70070	13.69521
74	1999	7,500	3.87506	15.01610
75	2000	2,480	3.39445	11.52230
76	2001	2,530	3.40312	11.58123
77	2002	5,300	3.72428	13.87023
78	2003	9,520	3.97864	15.82955
79	2004	2,250	3.35218	11.23713
80	2005	3,430	3.53529	12.49830
81	2006	6,500	3.81291	14.53831
82	2007	4,150	3.61805	13.09027
83	2008	7,660	3.88423	15.08723
84	2009	7,980	3.90200	15.22563
85	2010	10,000	4.00000	16.00000
86	2011	11,700	4.06819	16.55014

Q	$Y=\log_{10}(Q)$	Y^2	X*Y
5250	3.72016	13.83959	13.76721
7570	3.87910	15.04738	15.03173
2430	3.38561	11.46233	11.49228
2410	3.38202	11.43804	11.50941
5710	3.75664	14.11231	13.99075
10100	4.00432	16.03459	15.93174
2210	3.34439	11.18496	11.21101
3420	3.53403	12.48934	12.49382
6630	3.82151	14.60397	14.57110
3980	3.59988	12.95916	13.02455
8260	3.91698	15.34273	15.21445
8470	3.92788	15.42827	15.32661
10400	4.01703	16.13656	16.06813
11900	4.07555	16.61008	16.58008

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Criterion and adjustment procedure for the mean

eqn 7-4 $r =$ 0.99864 > 0.28868 $= r_{Mean}$ Since $r > r_{Mean}$, adjustment to the mean is worthwhile.

Calculate $\bar{Y}$, $Var(\bar{Y})$, $\bar{Y}_3$, $Var(\bar{Y}_3)$

eqn 7-3 $Var(\bar{Y}) =$ 0.00074898

eqn 7-5b $\bar{Y} =$ 3.83077

eqn 7-6 $Var(\bar{Y}_3) =$ 0.0045319

If $Var(\bar{Y}_3) < Var(\bar{Y})$, then use $\bar{Y}_3$. Otherwise, use $\bar{Y}$.

Final estimate of mean = 3.83077 $= \bar{Y}$

Equivalent years of record for the mean

eqn 7-7 $N_e =$ 84.7

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Criterion and adjustment procedure for the standard deviation

eqn 7-9 $|r| =$ 0.99864 > 0.55583 $= r_{StandardDeviation}$ Since $r > r_{StandardDeviation}$, improvement to the standard deviation is possible.

where,

A = -17.34435

B = 3.77961

C = 0.48782

eqn 7-8 $Var(S_y^2) =$ 9.8075E-05

eqn 7-10 $S_y^2 =$ 0.054641

$S_y =$ 0.23375

eqn 7-11 $Var(S_{y3}^2) =$ 0.00061929

If $Var(S_{y3}^2) < Var(S_y^2)$, use S_{y3}. Otherwise, use S_y.

Final estimate of standard deviation = 0.23375 = S_y

Big Hole Hydrology Analysis

Two Station Comparison per Bulletin 17B-Appendix 7 Guidelines

Calculation of weighted skew for short term record, all years

G_b =	-0.195	Generalized skew coefficient (from PeakFQ)
G =	-0.403	Station skew (matches PeakFQ? = yes)
N =	14	Number of years of record
MSE_{Gb} =	0.4096	(from PeakFQ)

A =	-0.297754
B =	0.8352012
MSE_G =	0.3803641

G_W =	-0.302886	Weighted skew (matches PeakFQ? = yes)

orig M=	3.7404	adj M =	3.830767
orig S=	0.2519	adj S =	0.233755

Short Term Frequency Curves

Original					Adjusted		
T	P	K	X	Q	K - B17B	X	Q
1.005025126	0.995	-2.29153	3.020216	1,048	-2.85903	3.162455	1,454
1.01010101	0.99	-2.10179	3.098998	1,256	-2.54626	3.235566	1,720
1.020408163	0.98	-1.88798	3.183127	1,524	-2.21227	3.313639	2,059
1.052631579	0.95	-1.55437	3.305526	2,021	-1.72634	3.427228	2,674
1.111111111	0.9	-1.24477	3.410502	2,573	-1.30957	3.524648	3,347
1.25	0.8	-0.85293	3.532922	3,411	-0.82356	3.638257	4,348
1.428571429	0.7	-0.55869	3.618048	4,150	-0.4856	3.717255	5,215
1.666666667	0.6	-0.2994	3.688715	4,883	-0.20505	3.782836	6,065
2	0.5	-0.05041	3.753061	5,663	0.050409	3.84255	6,959
5	0.2	0.823562	3.9552	9,020	0.852914	4.030139	10,719
10	0.1	1.30959	4.053899	11,321	1.244755	4.121734	13,235
25	0.04	1.850401	4.154011	14,256	1.642206	4.21464	16,392
50	0.02	2.212284	4.215916	16,441	1.887974	4.272089	18,711
100	0.01	2.546276	4.269772	18,611	2.101786	4.322069	20,993
200	0.005	2.859042	4.317567	20,776	2.291537	4.366424	23,250
500	0.002	3.247231	4.373604	23,638	2.514004	4.418427	26,208

Appendix E. Review and Correspondence

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March 15, 2013

Mr. Steve Story, PE, CFM
Montana DNRC
State Floodplain Engineer
PO Box 201601
Helena, MT 59620

RE: Response to Comments on Draft Flood Discharge-Frequency Hydrologic Analysis for the Big Hole River, Montana

Dear Mr. Story,

This letter serves as a response to the review comments sent by Montana DNRC to Atkins in regard to the hydrologic analysis of Big Hole River, MT dated December 21, 2012. The review comments and responses are summarized below.

DNRC's Comment 1. The Hydrologic Analysis Report and associated products shall be sealed by the Engineer of Record.

Response: A page was added to the report before the Table of Contents to certify the analysis meets engineering hydrologic standards and sealed by the Engineer of Record, Ben Fennelly.

DNRC's Comment 2. Provide a brief, stand alone Executive Summary.

Response: A stand alone document summarizing the study has been prepared and included with this revised submittal.

DNRC's Comment 3. The RFQ required the Hydrologic Analysis be performed to FEMA's detailed/enhanced level for riverine studies. The study level should be confirmed in report Sections 1 and 3.

Response: The wording of "approximate" has been removed from the report where it occurs in the context of the hydrologic analysis.

DNRC's Comment 4. Pages 1 and 42: Beaverhead County has been omitted from the listed project stakeholders. Please revise to include Beaverhead County.

Response: Beaverhead County has been added to the list of project stakeholders in the Introduction and Summary sections of the report.

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DNRC's Comment 5. Sections 1 and 1.3.: The hydrologic analysis extended through the 1986 SCS Study reach, and therefore covers the entire 150 mile length of the Big Hole River. Please revise the narrative throughout the report to clarify the study extents.

Response: Sections 1, 3, and 5 have been updated with the correct mileage to which the detailed level hydrologic analysis applies.

DNRC's Comment 6. Section 1.1, second paragraph: Please expand on the "high level of error" description of the NED products. Additionally, please revise the last sentence to state that there are no established "State" guidelines for Approximate studies. FEMA has established some Approximate study guidelines that are applicable in Montana.

Response: Section 1.1 was expanded to included a discussion of Anderson Consulting Engineers study performed in 2010 comparing NED products and approximate modeling methodologies to LiDAR based detailed studies. Additionally, "State" was added to the last sentence of that section to clarify the difference between State and Federal standards.

DNRC's Comment 7. Section 1.3: As stated in the RFQ, the 50-percent annual chance flood event should be included. The report and tables should be updated to include the 2-year (50-percent annual chance) recurrence interval.

Response: The 2-year (50-percent annual chance) recurrence interval analysis has been added to the revised report.

DNRC's Comment 8. Section 2.1, second paragraph:

a. The last two sentences of this paragraph are confusing and infer that flow change locations correspond with the regression gaging stations. Please review and revise for clarity.
b. Reference 3: If the 1980 USACE report wasn't acquired for review by Atkins, as inferred by the text, how were the flows compared? Please explain.

Response:

a. The last two sentences were reviewed and revised for clarity.
b. The 1986 SCS study compared their peak flow results to the 1980 USACE study in Appendix F of that report. The third paragraph was revised for clarity. The citation for the 1980 USACE report was kept for documentation purposes but relocated for clarity.

DNRC's Comment 9. Sections 2.1 and 2.2: The last paragraph of Section 2.1, on page 4, is confusing and should possibly be moved into Section 2.2. Some additional discussion and clarification would be beneficial to describe the Melrose detailed study, and 1986 NRCS Study (which has been adopted as an Approximate Study in the Effective Butte-Silver Bow FIS, dated Jan. 6, 2012).

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Please clearly specify and list the flow comparisons, along with the locations where the comparisons are being made. For instance, the narrative states that there is a "discrepancy in computed flow rates from 3 to 10 percent". Which flow rates are being compared? The 1986 FIS, referred to in the Table 3 title, should be listed as a Reference.

Response: Similar to DNRC's Comment 8, the comparison presented was made by SCS and documented in Appendix F of the 1986 SCS Flood Plain Study, Big Hole River report. The discussion for that comparison in Section 2.1 was revised for clarity and further discussion was added in Section 2.2 to acknowledge incorporation of the SCS study to the FEMA FIS. Citations for the FEMA FIS was changed to reference the original FIS cited by the SCS study in Section 2.1 and in Section 2.2, the title of Table 3 was changed to reflect the current Effective FIS.

DNRC's Comment 10. Section 2.3:

a. States that "the primary goal for both components was to provide a regulatory tool that provides hazard mapping along the Big Hole River". Please confirm the accuracy of this statement. DNRC's understanding is that the purpose of the study was to provide planning tools to the stakeholders for smart development.
b. Second & Fourth Paragraphs: the study results are described as "approximate in nature". We suggest another descriptor be considered to avoid association with "Approximate Study" terminology.

Note: The 2005 Flood Inundation/CMZ study was submitted to DNRC for State adoption/designation by the project stakeholders in 2011. DNRC reviewed the study and determined that the methods did not satisfy State standards, as documented in the DNRC Technical Memorandum, dated Sept. 20, 2011. The outcome of that review was the impetus for this project.

Response: Section 2.3 was revised to clarify misconstrued information.

DNRC's Comment 11. As requested in the RFQ, the report should include an overview and assessment of flood history and existing flood data.

Response: Section 1.3 was added to the revised report that consolidates available flood history information along the Big Hole River. The title of Section 2 was changed to include "Existing Flood Data" since this section summarizes this information.

DNRC's Comment 12. Section 3:

a. DNRC requests an additional table be provided that summarizes the selected flow node and stream gage locations. Please include: node/stream gage identification; node/stream gage location/landmark description (such as "directly above Divide Creek confluence" etc.); node/stream gage stations in both River Miles above stream mouth and River Stations (feet) corresponding to those used for the Phase II Floodplain Data Tables; sub-basin area; and cumulative basin area. Additionally, locations that correspond with those established in the 1986 USGS study should be identified.

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b. DNRC also requests that stream gage listings be accompanied by a brief descriptor so that the gages are more easily tracked and identified. For example, the heading for Table 24 ends with the station number, 06026210. For anyone who is unfamiliar with this basin, the addition of "(near Glen)" gives a quick location reference. Please incorporate the gage descriptions to the report narrative, tables, and figures as appropriate.

Response:

a. **Table 5** was added to the report narrative and includes Node/Gage ID, Location Description, Profile Station (in miles above mouth), Model Station (in feet), and Basin Area (square miles), and the contributing Sub-basin Area (square miles).
b. Gage location descriptions were added, as appropriate, to the report narrative, tables, and figures for clarity.

DNRC's Comment 13. Section 3.1 – Regional Regression Equation Analysis:

a. Table 6 does not include sub-basin areas as stated. Additionally, the range of values used to develop the regression equations, listed in Table 6, do not correspond with the values listed in WRIR 03-4308 (Table 6) or the revised channel widths, please resolve. Lastly, please identify the node locations where there were multiple channels.
b. For the Southwest Region, weighted combinations of methods have SEP values as low as 64.3 for the 100-year peak discharge (WRIR 03-4308, Table 12, p. 95). Please explain the reasoning for not evaluating the weighted combination methods, and incorporate the explanation into the report narrative.
c. The explanation of why the maximum active channel and bankfull channel widths were revised to 100-feet is unclear. Please provide further detail and explanation.

Response:

a. Table 7 (formerly Table 6) of the revised report has been updated with the correct published range of values used to develop regression equations. The revised channel widths were omitted from this table since the intent of the table is to present published values. A footnote was added for clarity and to remind the reader of the expanded revised channel width discussion provided in the same section (Section 3.1.1). Table 7 (formerly Table 6) of the revised report has been modified to include a footnote showing node locations where multiple channels prevented use of channel width regression equations.
b. The revised report includes Section 3.1.2 that describes weighted combinations and reasoning for their omission from the analysis.
c. Further discussion and explanation of the revised channel width regression target was added to Section 3.1.1.

DNRC's Comment 14. Section 3.2 – USGS Stream Gage Analyses:

a. Table 10 – Confirm the discontinuous records indicated for Gages 06024540 and 06026210. Add a column for the abbreviated gage description (discussed in Comment 11.b, above).

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b. Following Section 3.2.3, DNRC requests a comprehensive table summarizing the various gage analyses methods performed and results, i.e. the Single Station, Two Station Comparison, and the Regression Weighted Gage Analysis. Discussion regarding the selected method at each gage, along with reasoning, should accompany the new summary table.
c. USGS gages 06023500 and 06025250 have 8 and 9 years of record, respectively. The report narrative states that the Single Station analysis of these gages was performed for "comparison purposes", and that the Two Station Comparison method analysis was performed for "evaluation". Bulletin 17B recommends an overlapping period of 10 years for reliable correlation coefficient estimates using the Two Station Comparison method. Application of the Two Station Comparison method for these gages, with record less than 10 years, is not supported by Bulletin 17B or DNRC.

   The analysis should be revised to exclude the two gages, or further justification provided. Additionally, FEMA G&S, Appendix C, Section 2.1, states that gaging station data are applicable when the record length is 10 years or longer. Table 23 also indicates an anomaly at Gage 06025250, where the 500-year flows recede downstream. Although this may be possible, the results also raise concerns regarding the method's reliability for this gage. Prior to re-submittal, we suggest Atkins consult with DNRC regarding their approach to resolve this issue.

Response:

a. Table 11 (formerly Table 10) of the revised report has been corrected to reflect the continuous record of USGS gages 06024540 and 06026210. A column was added to include the abbreviated location description.
b. Table 24 was added to the revised report in the newly added Section 3.2.4 Gage Analysis Results and Comparison that summarizes the Single Station, Two Station Comparison, and the Regression Weighted Gage Analyses. Section 3.2.4 contains added discussion for each methodology and their suitability for use in development of flood discharge frequency estimates. The discussion remained general since the reasoning for methodology selection for each gage was universal.
c. Based on discussion with DNRC, USGS 06025250 was updated with 2012 peak flow information bringing the total period of record to 10 years. USGS gage 06023500 analysis under Two Station Comparison methodology was unchanged and considered superior to the underestimated peak flow results generated by regression equations. The technical memo submitted to DNRC, along with this Response to Comments letter have been included as Appendix E of the revised report.

DNRC's Comment 15. Section 3.2.4 – Log Interpolation of Gage Analyses:

a. The method is used to develop flood discharge estimates at ungaged Sites (corresponding with the node locations), whereas the methods in Sections 3.2.1 – 3.2.3 apply to methods at gaged sites. For organizational clarity, DNRC recommends separating Sections 3.2.4 and 3.2.5 from Section 3.2, as the methods both apply to developing estimates for ungaged locations.
b. The specific equation in WRIR 03-4308 that is being applied should be cited. Please confirm that WRIR 03-4308 supports the use of channel widths for this method, as

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stated, and discuss the gage period of record overlap (which would also be beneficial to include in Table 23).

c. Please identify that Gage 06025500 data is based on the single gage analysis, not the Two Station Comparison. This information is not apparent in the narrative or in Table 23.

Response:

a. Sections 3.2.4 and 3.2.5 were moved from the gage analysis discussion to a new Section 3.3 Ungaged Sites on Gage Streams for organizational clarity.
b. Equation 21 (p. 35) from WRIR 03-4308 and its description of variables was added to the added Section 3.3.1 Log Interpolation of Gage Analyses.
c. Discussion was added to the revised report under the new Section 3.3.1 to clarify USGS 06025500 (near Melrose) results were not obtained by the Two Station Comparison methodology. A footnote was also added to Table 25 (formerly Table 23).

DNRC's Comment 16. Section 3.2.5 – Gage Transfer: The Section excludes the Gage Transfer that was performed at gage 06025500 and applied downstream to the river mouth; as described in Section 4.1. Atkins may consider at least mentioning the additional analysis within Section 3.2.5 for reference. Documentation, including electronic files of all calculation spreadsheets should also be provided.

Response: The report was revised to contain discussion about the drainage area ratio gage transfer of USGS 06025500 (near Melrose) through and including 06026210 (near Glen) to each flow change location downstream in the newly added Section 3.3.2 (formerly 3.2.5).

DNRC's Comment 17. Evaluation of method results: A table should be generated that summarizes all of the various methods and results evaluated for the ungaged site locations (i.e. regional regression equation methods, log interpolation of gage analyses method, and gage transfer methods).

Response: Table 28 was added to the revised report to present results obtained through various methodologies for each flow change location.

DNRC's Comment 18. Table 25: The hydrologic method for USGS 06025500 is listed as Two Station Comparison when it should be the Single Station Analysis.

Response: Table 29 (formerly Table 25) of the revised report has been updated to show the correct analysis type for USGS 06025500 (near Melrose).

DNRC's Comment 19. Provide QA/QC documentation following the process outlined in Atkins SOQ submitted for this project. This includes documentation of senior engineer reviews and peer reviews.

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Response: Atkins QA/QC documentation has been included with this submittal and peer review and correspondence has been included in Appendix E of the revised report.

DNRC's Comment 20. Provide digital files of all model files, calculation spreadsheets, etc. Files should be organized and labeled for easy identification and/or supplemented by a list describing the files.

Response: All electronic files have been included with the submittal package.

If any of the response discussion items are unclear, please call me direct at 406-624-3096 or email matthew.w.johnson@atkinsglobal.com to discuss further. I appreciate your review and look forward to future correspondence.

Sincerely,

Matthew Johnson, EI, CFM
Atkins

cc: Jen Boyer, Future-West
Lynda Saul, DEQ
Laurence Siroky/DNRC
John Connors/DNRC
Dan March, Atkins
Ben Fennelly, Atkins

Steve,

We've been addressing the State's review comments for Big Hole River Hydrology and had an internal meeting to discuss, in particular Comment 14.c. Within Comment 14.c, you suggest that we consult with DNRC regarding our approach. It is recognized that USGS gages 06023500 and 06025250 did not have the Bulletin 17B recommended period of record equal to at least 10 years at the time of the original analysis. However, USGS WRIR 03-4001 *"Two Station Comparison of Peak Flows to Improve Flood Frequency Estimates for Seven Streamflow Gaging Station in the Salmon and Clearwater River Basin, Central Idaho"* defines a short term record being that of 10 or fewer years and presents options for lengthening the period of record. During the Two Station gage analysis, it was recognized that gages 06023500 and 06025250 correlated very well with the long term gage (06025500) as illustrated by correlation values of 0.85 and 0.99. These correlation values resulted in equivalent years of record, which can also be interpreted as a measure of reliability, equal to 20 and 78 years for gages 06023500 and 06025250, respectively. We note these periods of record are considerably greater than the Bulletin 17B recommended minimum of 10 years.

During the analysis, Atkins also investigated alternative methods for using the two gages of limited record. The reviewed methods included log interpolation of neighboring gages as well as the various regression methods of USGS WRIR 03-4308 *"Methods for Estimating Flood Frequency in Montana Based on Data through Water Year 1998."* USGS 06023500 was limited to the regression methods as the closest reliable gage was outside the drainage area limits required to perform a gage transfer. Regression analyses for the 06023500 location yielded the results listed in Table 1, below. Table 1 also displays a comparison of the regression results with the results of the Two Station Gage Analysis. Table 2 displays the standard error of prediction for each calculated event.

Table 1. Comparison of regression analyses with the Two Station Method

	Discharge (cfs)						
Regression Method	**2-year**	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**	**500-year**
Basin Characteristics	133	218	282	369	438	514	700
Active Channel	481	723	910	1,190	1,390	1,620	2,140
Bankfull Channel	611	893	1,090	1,380	1,590	1,840	2,410
Weighted Basin & Active Channel	317	477	565	658	723	790	965
Weighted Basin & Bankfull Channel	357	519	602	686	746	808	977
Weighted Active & Bankfull Channel	478	732	920	1,180	1,380	1,600	2,150
Weighted Basin, Active Channel & Bankfull Channel	317	477	565	658	723	790	965
Two Station Gage Analysis	308	507	668	906	1,110	1,340	1,970

Table 2. SEP for all regression analyses at USGS 06023500.

	Standard Error of Prediction (%)						
Regression Method	**2-year**	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**	**500-year**
Basin Characteristics	91.1	76.0	72.7	72.1	73.6	76.0	84.7
Active Channel	59.9	56.5	61.9	72.2	80.9	89.9	113.0
Bankfull Channel	68.4	62.5	66.7	76.0	84.2	93.1	116.2
Weighted Basin & Active Channel	49.6	46.9	50.8	57.3	62.4	67.3	79.5
Weighted Basin & Bankfull Channel	57.5	52.1	54.4	59.5	63.9	68.5	80.1
Weighted Active & Bankfull Channel	59.9	56.5	61.9	72.2	80.9	89.9	113.0
Weighted Basin, Active Channel & Bankfull Channel	49.6	46.9	50.8	57.3	62.4	67.3	79.5

Review of the regression results displays a wide variability in discharges. It is noted that the regression results based solely on the basin characteristics produces results that are drastically lower than all other results. Comparison with the annual peak discharges shows that the gage has experienced peaks greater than 320 cfs every year while exceeding 500 cfs three out of eight recorded years. This relationship alone declared the basin characteristic regression unreliable. Review of the regression analyses based on the channel characteristics of bankfull and active channel widths displays unreasonably high standard error of prediction (SEP) values. Casting further doubt on the use of the channel characteristic parameters is the seemingly constant presence of secondary channels, influence of ice, hydraulic structures, and grazing practices which discount the reliability of the measurements of the natural stream characteristics.

During the analysis, Atkins felt it was imperative to utilize a consistent method for extended reaches of the study, rather than a mosaic of methodologies between sites. Review of the channel characteristics listed in Table 3 for the locations downstream of 06023500 show variability that inevitably results in unrealistic changes in discharge.

Table 3. Channel characteristics of flow nodes downstream of USGS 06023500.

ID Number	Active Channel Width (ft)	Bankfull Channel Width (ft)
USGS 06023500	36	53
50	36	56
75	32	39
85	83	98
100	74	83

Given the lack of reliability that the regression equations hold for this immediate reach, the Two Station gage analysis was thought to provide the most reliable solutions in comparison with the alternatives. Hence, Atkins is recommending that we continue with the originally submitted values.

In regards to the utilization of USGS 06025250, the location of the gage does fall between gages 06025500 (86 reliable annual peaks) and 06024540 (14 reliable annual peaks). Hence a gage interpolation is possible and preferable to the aforementioned regression methods. Results of the log-

interpolation for the location of USGS 06025250 are displayed below in Table 4. Upon review, it is evident that the log-interpolation results in a decrease of the discharge for all events, when compared to the submitted results utilizing the Two Station methodology. However, it should be noted that the gages utilized by the log-interpolation have a drainage area difference of approximately 1,400 mi^2 with 06024540 having a drainage area about 57% that of USGS 06025250 (1,267 mi^2 vs 2,196 mi^2). The vast difference in drainage area between the gages decreases the reliability in the log-interpolation results.

Table 4. Source data and results of the log-interpolation for 06025250.

Gage ID	Drainage Area (mi^2)	Period of Record	Annual Peaks	Peak Discharge (cfs)						
				2-year	5-year	10-year	25-year	50-year	100-year	500-year
06024540	1,274	1998 - 2011	14	4,140	6,170	7,450	8,970	10,000	11,000	13,200
06025250	*2,196*	*1998 - 2011*	*9*	*6,330*	*9,360*	*11,200*	*13,300*	*14,700*	*16,000*	*18,800*
06025500	2,469	1924 - 2011	87	6,910	10,200	12,200	14,400	15,900	17,300	20,200

To further investigate the reliability of utilizing gage 06025250 within the Two Station gage analysis, Atkins performed a sensitivity analysis by adding an additional annual peak to the gage analyses. Atkins updated the period of record for gages 06025250 and 06025500 with the annual peak discharge of 2012. This resulted in gages 06025250 and 06025500 respectively having a total of 10 and 87 reliable annual peaks, which satisfies the DNRC's criteria for a gage analysis as listed in Review Comment 14.c. The results of the updated Two Station gage analyses using the original and updated data are presented below in Table 5.

Table 5. Comparison of the original and updated Two Station analyses.

Analysis	Period of Record	Number of Annual Peaks	Computed Curve (cfs)						
			2-year	5-year	10-year	25-year	50-year	100-year	500-year
Original	**1998 - 2011**	**9**	6,680	9,820	11,800	14,100	15,700	17,100	20,300
Updated	**1998 - 2012**	**10**	6,740	9,860	11,800	14,000	15,500	16,900	19,900

As illustrated by Table 5, the addition of the respective annual peaks for 2012 resulted in a slight decrease in discharges for events greater than the 10-year. Comparing the results of the updated Two Station gage analysis with those of Table 4 shows that the originally submitted discharges utilizing the Two Station gage analysis method are closer to the updated Two Station results than those of the log-interpolation method. Since the short term record of the updated Two Station method is greater than 10 years and can be considered 'reliable', one can make the assumption that the originally submitted Two Station results are more reliable than those of the alternative log-interpolation method. Therefore, Atkins recommends keeping the originally submitted results.

Johnson, Matthew W

From: Story, Steve [sestory@mt.gov]
Sent: Wednesday, March 13, 2013 12:52 PM
To: Fennelly, Benjamin T
Cc: March, Dan; Johnson, Matthew W; Connors, John
Subject: RE: Project Status Request

Follow Up Flag: Follow up
Flag Status: Flagged

Ben,

We have thoroughly reviewed the technical memorandum you submitted in response to DNRC's Comment 14.c.

Regarding selection of the Two Station Comparison method results for gage 06023500 (Big Hole R nr Jackson), we find your assessment and justification to be reasonable, and support your conclusions. We do feel that it would be beneficial for Table 1 to include the Single Station analysis results, along with appropriate discussion. There was some original concern that the peaks were being overestimated, however review of the 1948 flows (at this gage and the Melrose gage) support the selected results. At the Melrose Gage, the 1948 flow of 14,100 cfs is the second largest on record, and is slightly less than a 25-year event. Using the two station results for the Jackson gage, the 1948 peak of 938 cfs is slightly greater than the 25-year event. The correlation provides added confidence to the selected flows at the Jackson gage.

Considering the additional assessment of gage 06025250 (Big Hole at Maiden Rock), we also support selection of the Two Station Comparison Method for this gage, but feel the 'updated' analysis (which includes the additional peak for WY 2012) should replace the 'original' submitted analysis. It is observed that the updated flows resolve the 500-year reduction that previously occurred and was inconsistent with the other recurrence intervals, and are closer to the discharges from the 1986 USGS study. Please incorporate the revisions into the revised report.

Thank you,
Steve

Stephen E. Story, PE, CFM
MT DNRC, Water Resources Division
406.444.6664

From: Fennelly, Benjamin T [mailto:ben.fennelly@atkinsglobal.com]
Sent: Friday, March 08, 2013 4:38 PM
To: Story, Steve
Cc: March, Dan; Johnson, Matthew W
Subject: RE: Project Status Request

Steve,

Per your request within Review Comment 14.c of the Big Hole Hydrologic study, Atkins is submitting a memo (see attached) outlining Atkins' response and reasoning. Please let us know if you have any questions or would like to discuss the issue on Monday.

Thanks,

Ben

Benjamin T. Fennelly, PE, CFM
Senior Engineer, Integrated Water Resources

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From: Story, Steve [mailto:sestory@mt.gov]
Sent: Tuesday, March 05, 2013 2:20 PM
To: Fennelly, Benjamin T
Cc: March, Dan
Subject: RE: Project Status Request

Ben,
Regarding Big Hole Hydrology comment 14.c., as I mentioned, I would like to hear how you plan to address/resolve the comment prior to re-submittal to ensure that I support the approach. Thanks,
Steve

Stephen E. Story, PE, CFM
MT DNRC, Water Resources Division
406.444.6664

From: Fennelly, Benjamin T [mailto:ben.fennelly@atkinsglobal.com]
Sent: Monday, March 04, 2013 12:10 PM
To: Story, Steve
Cc: March, Dan
Subject: FW: Project Status Request

Steve,

As requested, here is an update on the following projects:

- **West Spring Creek and Tributaries Analysis** – The external review led to some significant changes in the model that needed to be answered and reviewed internally before the other comments could be addressed. The analysis is being reviewed internally with some sensitivity analyses being performed as well. We expect to have responses to the State's and FEMA's comments addressed and sent back out to the State and FEMA by the 18th.
- **Big Hole River Hydrologic Analysis** – all comments have been addressed and are being finalized. We are performing a sensitivity analysis in regards to the State's review comment 14.c. We plan on having the comments addressed and an updated submittal sent out to the State by the end of next week.
- **Big Hole River Study** – The Big Hole hydraulic model has been updated with the additional survey data for the Wisdom area and has been through the first round of internal review. We are updating the report, profiles, maps, and FPDTs to include the changes in the profiles. We have attached a draft map displaying the latest results of the Wisdom area.
- **Whitefish River near Kalispell Hydraulics** – This is a fairly typical process and Atkins does have checks/reviews in place as part of the Merge Revised and Non-Revised Areas task to ensure that such data gets incorporated. For all submitted areas, the updated mapping, profiles, and FWDTs are reviewed, particularly in areas of confluences. Our production team is aware of this particular issue and once the studies (Whitefish River and Stillwater River) are approved by FEMA, the Whitefish River profiles and FWDT will be updated as necessary to ensure that the correct data is included in subsequent submittals.
- **Yellowstone County - State Data Request for Detailed Study Documentation** – This data will be compiled and submitted to the State by the middle of next week. The structure of the submittal will be based upon similar submittals made previously (e.g. Lake and Cascade Counties).

Thanks,

Ben

Benjamin T. Fennelly, PE, CFM
Senior Engineer, Integrated Water Resources

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From: Story, Steve [mailto:sestory@mt.gov]
Sent: Monday, March 04, 2013 8:27 AM
To: March, Dan; Fennelly, Benjamin T
Cc: Gibson, Mary
Subject: Project Status Request

Dan and Ben,

Please let me know the status of the following study re-submittals:

- West Spring Creek & Tributaries Hydraulics
- Big Hole River Hydrologic Analysis

Additionally, I have a few questions:

- Whitefish River near Kalispell Hydraulics – I reviewed and approved this study, but would like to know **what measures you have in place** to ensure that all of the issues stated to be addressed during the *Merge and Revise* phase, are not forgotten or overlooked? For instance, Profile 01P needs to be updated with the correct backwater data, and therefore will replace/supersede the profile submitted with the Hydraulics task package. There are several items that should be tracked to ensure they are incorporated. Note that for Flathead County, all of the studies should be provided with the Preliminary Submittal package.

- Big Hole River Study – Have you updated the model with the new survey data for the Wisdom area yet? If so, please update me on the outcome, and if not, please let me know when you anticipate having this work completed?

Thanks,
Steve

Stephen E. Story, PE, CFM
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