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Streamflow Statistics for Development of Water Rights Claims for the Jarbidge Wild and Scenic River, Owyhee Canyonlands Wilderness, Idaho, 2013–14—A Supplement to Scientific Investigations Report 2013–5212

Scientific Investigations Report 2014–5143

U.S. Department of the Interior
U.S. Geological Survey

Cover: Photograph of the mouth of the Jarbidge River near its confluence with the Bruneau River. Photograph taken looking upstream by John Wirt, U.S. Geological Survey, July 31, 2012.

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U.S. Department of the Interior
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SALLY JEWELL, Secretary

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
acre	0.004047	square kilometer (km^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

°C=(°F-32)/1.8

Datums

Vertical coordinate information is referenced to North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to North American Datum of 1983 (NAD 83).

Elevation, as used in this report, refers to distance above the vertical datum.

Abbreviations and Acronyms

AEP	Annual exceedance probability
BLM	Bureau of Land Management
ORV	Outstanding remarkable value
USGS	U.S. Geological Survey
WSR	Wild and Scenic River

Streamflow Statistics for Development of Water Rights Claims for the Jarbidge Wild and Scenic River, Owyhee Canyonlands Wilderness, Idaho, 2013–14—A Supplement to Scientific Investigations Report 2013–5212

By Molly S. Wood

Abstract

The U.S. Geological Survey (USGS), in cooperation with the Bureau of Land Management (BLM), estimated streamflow statistics for stream segments designated "Wild," "Scenic," or "Recreational" under the National Wild and Scenic Rivers System in the Owyhee Canyonlands Wilderness in southwestern Idaho. The streamflow statistics were used by the BLM to develop and file a draft, federal reserved water right claim to protect federally designated "outstanding remarkable values" in the Jarbidge River. The BLM determined that the daily mean streamflow equaled or exceeded 20, 50, and 80 percent of the time during bimonthly periods (two periods per month) and the bankfull (66.7-percent annual exceedance probability) streamflow are important thresholds for maintaining outstanding remarkable values. Although streamflow statistics for the Jarbidge River below Jarbidge, Nevada (USGS 13162225) were published previously in 2013 and used for the draft water right claim, the BLM and USGS have since recognized the need to refine streamflow statistics given the approximate 40 river mile distance and intervening tributaries between the original point of estimation (USGS 13162225) and at the mouth of the Jarbidge River, which is the downstream end of the Wild and Scenic River segment. A drainage-area-ratio method was used in 2013 to estimate bimonthly exceedance probability streamflow statistics at the mouth of the Jarbidge River based on available streamgage data on the Jarbidge and East Fork Jarbidge Rivers. The resulting bimonthly streamflow statistics were further adjusted using a scaling factor calculated from a water balance on streamflow statistics calculated for the Bruneau and East Fork Bruneau Rivers and Sheep Creek. The final, adjusted bimonthly exceedance probability and bankfull streamflow statistics compared well with available verification datasets (including discrete streamflow measurements made at the mouth of the Jarbidge River) and are considered the best available estimates for streamflow statistics in the Jarbidge Wild and Scenic River segment.

Introduction

The U.S. Geological Survey (USGS), in cooperation with the Bureau of Land Management (BLM), collected streamflow data in 2012 and estimated streamflow statistics for stream segments designated "Wild," "Scenic," or "Recreational" under the National Wild and Scenic Rivers System in the Owyhee Canyonlands Wilderness in southwestern Idaho. The streamflow statistics were published in Wood and Fosness (2013) and were used by the BLM to develop and file a draft, federal reserved water right claim to protect federally designated "outstanding remarkable values" (ORVs) in the stream segments. ORVs are characteristics that make a river or stream worthy of protection under the Wild and Scenic Rivers Act of 1968 (Public Law 90-542; 16 U.S.C. 1271 et seq.). The BLM determined that the daily mean streamflow equaled or exceeded 20 and 80 percent of the time during bimonthly periods (two periods per month) and the bankfull streamflow are important thresholds for maintaining outstanding remarkable values. The 50-percent exceedance, or median, bimonthly streamflow is important to the BLM, not as a basis for a water right claim, but for determining whether future measured conditions are greater than, equal to, or less than median conditions. Prior to the Wood and Fosness (2013) study, streamflow statistics estimated using available datasets and tools for the Owyhee Canyonlands Wilderness were inaccurate for use in the water rights claim.

Wood and Fosness (2013) included estimates of streamflow statistics for the Jarbidge River in the Bruneau-Jarbidge Rivers Wilderness of the Owyhee Canyonlands Wilderness based only on streamflow data collected at a USGS streamgage on the Jarbidge River below Jarbidge, Nevada (USGS 13162225) (fig. 1). After the publication of Wood and Fosness (2013), the BLM and USGS recognized the need to refine streamflow statistics developed for the Jarbidge River given the approximate 40 river mile distance and intervening tributaries between the point of estimation (USGS 13162225 in Nevada) and end of the Wild and Scenic River (WSR) segment at the mouth of the Jarbidge River at its confluence with the Bruneau River. Estimates of streamflow statistics were available at ungaged locations in the Jarbidge River through the USGS StreamStats program for Idaho (Ries and others, 2004; U.S. Geological Survey, 2013) but generally were unsuitable for use as the bimonthly exceedance probability streamflow statistics (hereafter referred to as bimonthly streamflow statistics) needed for the water rights determination for reasons described in Wood and Fosness (2013). Instead, an adjustment of the drainage-area-ratio method described in Wood and Fosness (2013) was used to estimate bimonthly streamflow statistics at the mouth of the Jarbidge River based on available streamgage data on the Jarbidge, East Fork Jarbidge, Bruneau, and East Fork Bruneau Rivers and streamflow statistics estimated and published for Sheep Creek in Wood and Fosness (2013).

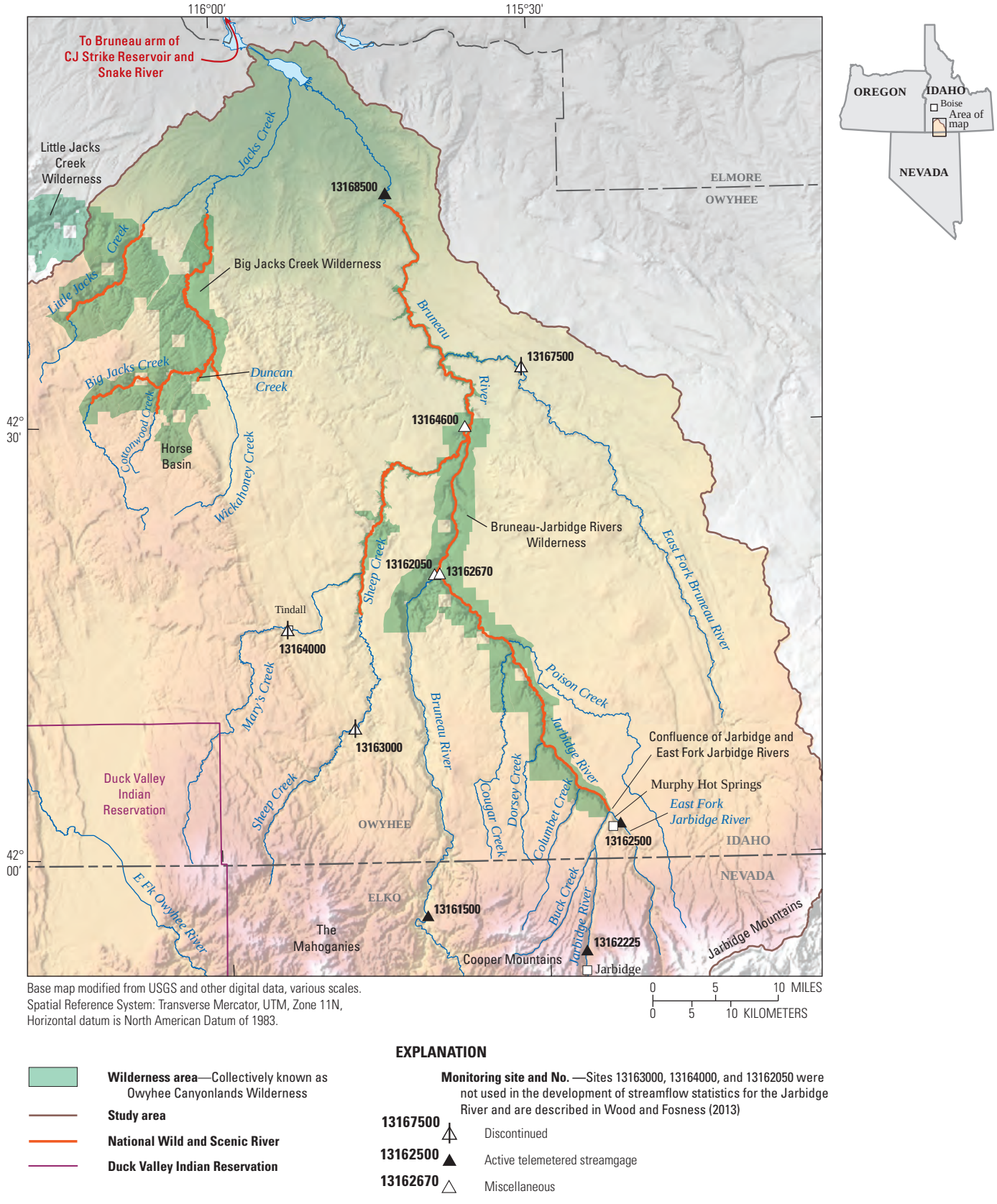
Both high and low (minimum) streamflows can be important for ensuring long-term protection of the ecological health and recreational value of the Jarbidge River. High streamflows support recreational uses, particularly boating, and viable habitat for fish and riparian vegetation. Low or minimum streamflows support healthy aquatic macroinvertebrate communities and sustain hiding pools and passage for fish, particularly bull trout (Bureau of Land Management, 2013). The BLM has identified the 20-, 50-, and 80-percent bimonthly exceedance probability and the bankfull (66.7-percent annual exceedance probability [AEP] or 1.5 year recurrence interval) streamflows as important metrics for sustaining ORVs in the Bruneau-Jarbidge Rivers Wilderness and Owyhee Canyonlands Wilderness. Additional rationale for selected streamflow statistics is provided in Wood and Fosness (2013).

Purpose and Scope

This report provides streamflow data and statistics in support of the BLM's efforts to determine streamflows required to sustain ORVs for the Jarbidge WSR in southwestern Idaho. The report provides streamflow statistics that were not included in Wood and Fosness (2013) and that are considered a more accurate estimate of streamflow statistics for the WSR segment of the Jarbidge River than those estimated in Wood and Fosness (2013) using only the USGS streamgage on the Jarbidge River below Jarbidge, Nevada (USGS 13162225). The study was conducted in water years (WYs) 2013–14 in cooperation with the BLM.

Description of Study Area

The Jarbidge River originates in the Jarbidge Mountains to the south in Nevada and flows through the Bruneau-Jarbidge Rivers Wilderness (fig. 1), part of the Owyhee Canyonlands Wilderness. The Jarbidge River joins the East Fork Jarbidge River about 5 mi north of the Idaho-Nevada state line, near Murphy Hot Springs, Idaho. From that point, the Jarbidge River canyon becomes narrow and ranges from 200 to 1,200 ft deep (Bureau of Land Management, 1987). The 29.6-mi long WSR segment of the Jarbidge River begins at the confluence with the East Fork Jarbidge River and ends at the mouth at the confluence with the Bruneau River. The area is remote, and no road access to the river exists within the WSR segment. With the exception of some small tributaries that flow into the Jarbidge River within the WSR segment (such as Columbet, Cougar, Dorsey, and Poison Creeks; fig. 1), streamflow is not expected to substantially change during passage through the WSR segment because of limited overland runoff.



Base map modified from USGS and other digital data, various scales.
Spatial Reference System: Transverse Mercator, UTM, Zone 11N,
Horizontal datum is North American Datum of 1983.

EXPLANATION

Wilderness area—Collectively known as Owyhee Canyonlands Wilderness

Study area

National Wild and Scenic River

Duck Valley Indian Reservation

Monitoring site and No. —Sites 13163000, 13164000, and 13162050 were not used in the development of streamflow statistics for the Jarbidge River and are described in Wood and Fosness (2013)

13167500 Discontinued

13162500 Active telemetered streamgage

13162670 Miscellaneous

Figure 1. Study area extent and locations of monitoring sites in the Bruneau River and Jarbidge River Basins, Idaho, 2013. Information for monitoring sites used to estimate and verify streamflow statistics for the Jarbidge River is shown in table 1.

The Jarbidge River has unique scenic beauty and offers unsurpassed solitude, challenging recreational opportunities, and excellent habitat for wildlife and native plants. The southernmost population of bull trout (*Salvelinus confluentus*) in North America exists in the Jarbidge River (U.S. Fish and Wildlife Service, 2012). These bull trout are genetically distinct and are isolated from other bull trout populations by more than 150 mi. The Bruneau and Jarbidge River basins contain the largest concentration of sheer-walled rhyolite and basalt canyons in the Western United States (Bureau of Land Management, 2013). The Jarbidge River also is nationally renowned for challenging whitewater boating opportunities.

Climate generally is semiarid and cool (Bailey, 1995), but summertime temperatures in some areas can exceed 100 °F. Mean annual precipitation in the Jarbidge River drainage basin is 15.8 in. (U.S. Geological Survey, 2013). High streamflows usually are the result of snowmelt and rain-on-snow events and typically peak in May–June, a little later than other rivers in the Owyhee Canyonlands Wilderness as described in Wood and Fosness (2013), because of the streamflow contribution from high elevation areas.

Methods

The drainage-area-ratio method was used to estimate streamflow statistics at the mouth of the Jarbidge River, just upstream of the confluence of the Jarbidge and Bruneau Rivers. Prior to the analysis in 2013, streamflow had been measured by the USGS only three times within a limited range of hydrologic conditions at the mouth of the Jarbidge River (at USGS streamgage 13162670). As a result, the partial-record method described in Wood and Fosness (2013) to estimate streamflow statistics for other monitoring sites in the Owyhee Canyonlands Wilderness could not be used to estimate streamflow statistics for the Jarbidge River. The drainage-area-ratio method allows the estimation of streamflow at a point of interest by adjusting available streamflow data from streamgages elsewhere in the drainage basin using a ratio between the drainage area at the point of interest and at the streamgage. The drainage-area-ratio method is most often used when the drainage-area-ratio is between 0.5 and 1.5 (Berenbrock, 2002; Risley and others, 2008). The drainage-area-ratio method was applied to larger drainage area ratios for this analysis, as high as 3.16. Although uncertainty could be high in computed streamflow statistics because of the use of higher-than-normal drainage-area ratios, the drainage–area-ratio method was considered the best option for computing bimonthly streamflow statistics, given the paucity of streamflow data available in the WSR segment of the Jarbidge River.

Streamflow records from two streamgages in the Jarbidge River drainage basin were available for use in the analysis: Jarbidge River below Jarbidge, Nevada (USGS 13162225) and East Fork Jarbidge River near Three Creek, Idaho (USGS 13162500) (fig. 1, table 1). Streamgage 13162500 on the East Fork Jarbidge River was operated by the USGS in 1928–33 and 1953–71 and by Idaho Power Company (IPCo) in 2006–present (as of 2014). Both USGS and IPCo streamflow records were used in the analysis. All active (as of 2014) streamgages on the Jarbidge River with continuously recorded streamflow are upstream of the confluence of the Jarbidge and East Fork Jarbidge Rivers and the WSR segment.

Calculation of Bimonthly Streamflow Statistics at Available Streamgages

Records of daily mean streamflow from streamgages on the Jarbidge (USGS 13162225) and East Fork Jarbidge Rivers (USGS 13162500) were divided into bimonthly periods to calculate bimonthly exceedance probability streamflows. The first bimonthly period was defined as the 1st through the 14th, and the second bimonthly period was defined as the 15th through the end of the month. Data from each of the 24 bimonthly periods were combined for all years in the period of record and were used to develop an exceedance probability curve for each period on the basis of the Weibull plotting position formula described in Helsel and Hirsch (2002) and Wanielista and others (1997). The Weibull formula is commonly used for the development of streamflow exceedance probability and flood frequency curves and is a standard procedure in Bulletin 17B, a well-recognized guidance manual for calculating flood frequency statistics in the United States (Interagency Advisory Committee on Water Data, 1982). Daily mean streamflow data were ranked in descending order, and exceedance probabilities were calculated for each value according to equation 1:

$$Exceedance\ probability_i\left(percent\right) = \left[RankQ_{dmi} / \left(n+1\right)\right] \times 100 \quad (1)$$

where

i is the plotting position or rank,

$RankQ_{dmi}$ is the *ith* rank of the daily mean streamflow (ft^3/s), and

n is the total number of daily mean streamflow values.

Table 1. Monitoring sites used to estimate and verify streamflow statistics for the Jarbidge River above mouth, near Grasmere, Owyhee Canyonlands Wilderness, Idaho (USGS 13162670), 2013–14.

[See figure 1 for site locations. **USGS StreamStats:** Source is U.S. Geological Survey (2013). Note that USGS StreamStats is not fully implemented in Nevada. Basin characteristics shown for sites 13162225 and 13161500 are approximate. **Latitude and longitude:** In degrees, minutes, and seconds. **Abbreviations:** in., inch; mi^2, square miles; ft^3/s, cubic feet per second; IPCo, Idaho Power Company; USGS, U.S. Geological Survey. NA, not applicable]

USGS site No.	Site name	Latitude	Longitude	USGS StreamStats				Site type	Period of record used in analysis	Range of daily mean streamflows used in analysis (ft^3/s)
				Mean basin elevation (ft)	Maximum basin elevation (ft)	Mean annual precipitation in basin (in.)	Drainage area (mi^2)			
Jarbidge River Basin										
13162225	Jarbidge River below Jarbidge, Nevada	41°53'26"	115°25'43"	8,120	10,800	32.9	30.6	Telemetered streamgage	April 1998 to October 2011; January 2012 to September 2013	1.00–633
13162500	East Fork Jarbidge River near Three Creek, Idaho	42°01'55"	115°22'06"	7,630	10,800	24.7	84.6	Telemetered streamgage	October 1928 to March 1933 and September 1953 to September 1971 (USGS); March 2006 to September 2013 (IPCo)	2.28–1,120
13162670	Jarbidge River above mouth, near Grasmere, Idaho	42°19'43"	115°39'05"	6,300	10,800	15.8	470	Miscellaneous	Measurements made on August 7, 1986; September 21, 1988; August 14, 1989; Febuary 16, 2014; May 19, 2014; May 28, 2014	NA
Bruneau River Basin										
13161500	Bruneau River at Rowland, Nevada	41°56'00"	115°40'28"	6,710	9,910	18.4	382	Telemetered streamgage	June 1913 to September 1918; October 1966 to September 2013	1.70–2,070
13164600	Sheep Creek above mouth, near Grasmere, Idaho	42°29'48"	115°36'16"	5,690	8,530	10.6	600	Miscellaneous	Bimonthly streamflow statistics published in Wood and Fosness (2013)	NA
13167500	East Fork Bruneau River near Hot Spring, Idaho	42°33'25"	115°30'38"	5,530	8,800	10.5	502	Telemetered streamgage, discontinued	August 1910 to November 1914, February to April 1915, December 1948 to September 1971	0.0–586
13168500	Bruneau River near Hot Spring, Idaho	42°46'16"	115°43'13"	5,630	10,800	11.8	2,686	Telemetered streamgage	July 1909 to March 1915; October 1943 to September 2013	21.0–6,470

Daily mean streamflows corresponding to the 20 (Q_{20}), 50 (Q_{50}), and 80 (Q_{80}) percent exceedance probabilities then were extracted from the streamflow exceedance probability curves for each bimonthly period. The exceedance probability corresponds to the streamflow that is equaled or exceeded over a given period of time. For example, the daily mean streamflow corresponding to the Q_{20} for the bimonthly period May 1–14 is equaled or exceeded during 20 percent of the days during that time period over the period of record. Q_{20} represents a high streamflow condition; Q_{50} represents a median streamflow condition; and Q_{80} represents a low streamflow condition. Annual values for Q_{20}, Q_{50}, and Q_{80} also were compiled because they were easily calculated and could be used by the BLM for comparison with the bimonthly statistics.

Drainage-Area-Ratio Method

The point of interest for streamflow statistics on the Jarbidge River is at the mouth, just upstream of the confluence with the Bruneau River and several miles downstream of the confluence of the Jarbidge and East Fork Jarbidge Rivers. Streamflow statistics calculated at the available streamgages were first adjusted to the confluence of the Jarbidge and East Fork Jarbidge Rivers using a drainage-area ratio according to equation 2 (fig. 2):

$$Q_{SBC} = \left(Q_{13162225} \times \left(DA_{JAC} / DA_{13162225}\right)^{a}\right) + \left(Q_{13162500} \times \left(DA_{EFJAC} / DA_{13162500}\right)^{a}\right) \quad (2)$$

where

Q_{SBC} is the streamflow statistic (Q_{20}, Q_{50}, or Q_{80}) estimated in the Jarbidge River just downstream of the confluence of the Jarbidge and East Fork Jarbidge Rivers (ft^3/s);

$Q_{13162225}$ is the streamflow statistic (Q_{20}, Q_{50}, or Q_{80}) estimated based on the period of record at USGS streamgage 13162225, Jarbidge River below Jarbidge, Nevada (ft^3/s);

DA_{JAC} is the area of the drainage basin of the Jarbidge River upstream of the confluence with the East Fork Jarbidge River (96.6 mi^2);

$DA_{13162225}$ is the area of the drainage basin of the Jarbidge River at USGS streamgage 13162225 (30.6 mi^2);

a is an exponent representing a non-linear relation between streamflow statistics and drainage area, as determined by Berenbrock (2002) (0.77);

$Q_{13162500}$ is the streamflow statistic (Q_{20}, Q_{50}, or Q_{80}) estimated based on the period of record at USGS and Idaho Power Company streamgage 13162500, East Fork Jarbidge River near Three Creek, Idaho (ft^3/s);

DA_{EFJAC} is the area of the drainage basin of the East Fork Jarbidge River upstream of the confluence with the Jarbidge River (85.2 mi^2); and

$DA_{13162500}$ is the area of the drainage basin of the East Fork Jarbidge River at USGS and Idaho Power Company streamgage 13162500 (84.6 mi^2).

The streamflow statistics computed for the confluence of the Jarbidge and East Fork Jarbidge Rivers then were further adjusted to the mouth of the Jarbidge River according to equation 3 (fig. 2):

$$Q_{13162670\_DA\_Ratio} = Q_{SBC} \times \left(DA_{13162670} / DA_{SBC}\right)^{a} \quad (3)$$

where

$Q_{13162670\_DA\_Ratio}$ is the streamflow statistic (Q_{20}, Q_{50}, or Q_{80}) estimated at the mouth of the Jarbidge River at USGS streamgage 13162670 using a drainage-area-ratio method (ft^3/s);

Q_{SBC} is the streamflow statistic (Q_{20}, Q_{50}, or Q_{80}) estimated in the Jarbidge River just downstream of the confluence of the Jarbidge and East Fork Jarbidge Rivers (ft^3/s);

$DA_{13162670}$ is the area of the drainage basin at the mouth of the Jarbidge River at USGS streamgage 13162670, just upstream of its confluence with the Bruneau River (470 mi^2);

DA_{SBC} is the area of the drainage basin of the Jarbidge River just downstream of the confluence of the Jarbidge and East Fork Jarbidge Rivers (182 mi^2); and

a is an exponent representing the non-linear relation between streamflow statistics and drainage area, as determined by Berenbrock (2002) (0.77).

Drainage areas were obtained from streamgage records and by delineating basins using the USGS StreamStats program (U.S. Geological Survey, 2013).

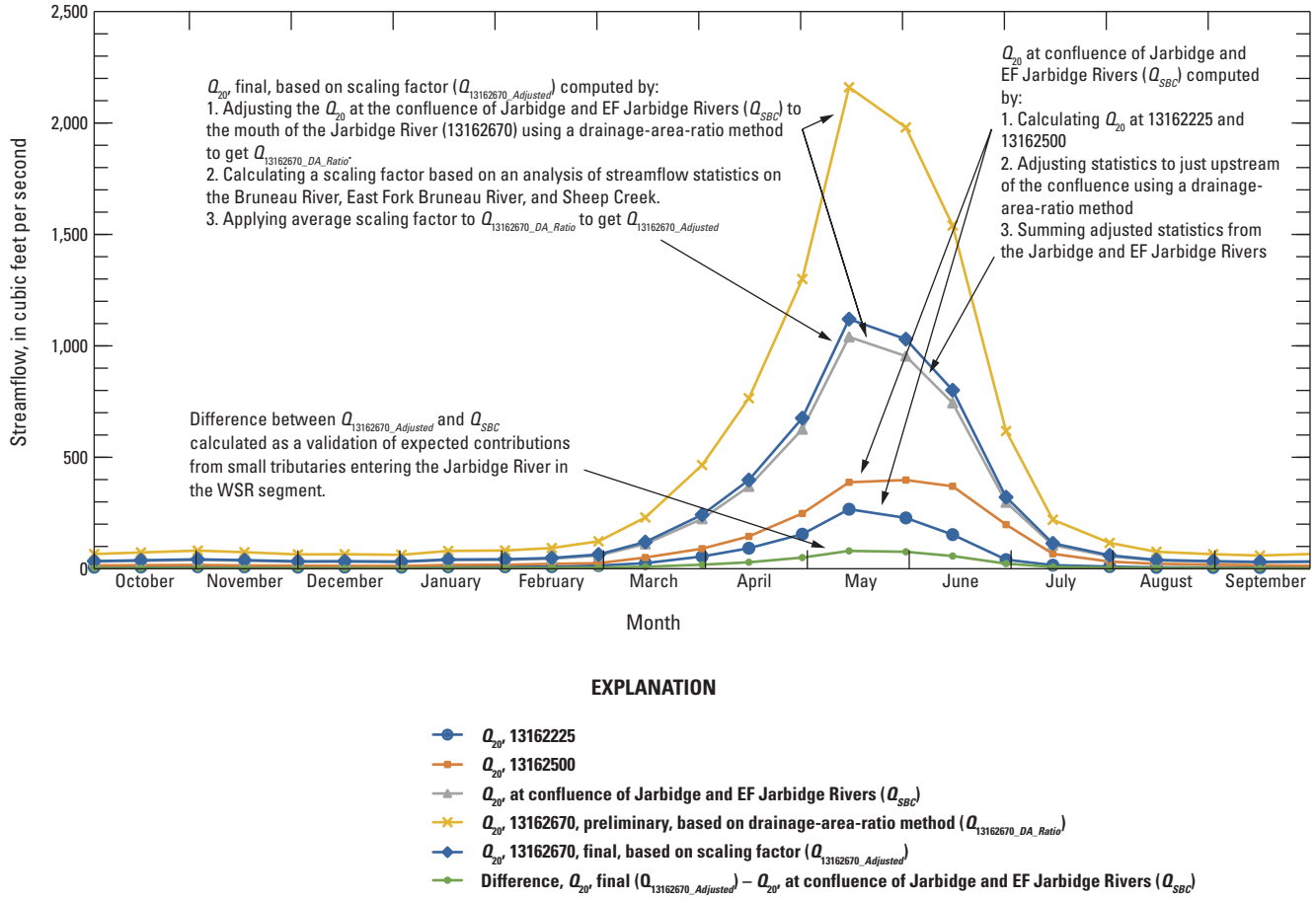


Figure 2. Twenty-percent bimonthly exceedance probability streamflow statistics calculated at various locations on the Jarbidge River using available streamflow records and the adjustment procedure to calculate final bimonthly exceedance probability streamflow statistics at the Jarbidge River above mouth, near Grasmere, Idaho (USGS 13162670).

The drainage–area-ratio method used for the Jarbidge River does not account for travel time of streamflow from the streamgages to the confluence of the main stem and East Fork Jarbidge Rivers and ultimately to the mouth of the Jarbidge River at the Bruneau River. An inherent assumption in the analysis is that the travel time is less than 1 day. Berenbrock (2002) assumed that the drainage-area ratio between gaged and ungaged sites was nonlinear in a regional frequency analysis of peak streamflows at ungaged sites in Idaho. An exponent was applied in that study to a ratio that was computed on the basis of a regression between the logarithms of drainage area and the magnitude of floods with AEPs from 50 to 0.2 percent. The average exponent was 0.77 for the region that encompasses the study area. The exponent calculated by Berenbrock (2002) was assumed to be valid also for streamflow statistics described in this report and was applied in the Jarbidge River analysis.

Further Adjustments to Bimonthly Streamflow Statistics Using a Scaling Factor

The bimonthly streamflow statistics calculated for the mouth of the Jarbidge River (USGS 13162670) using the drainage-area-ratio method, $Q_{13162670\_DA\_Ratio}$, appeared unrealistically high on the basis of a discussion with BLM River Rangers who have first-hand experience with streamflow conditions and recreational uses on the Jarbidge River. As stated previously in the section, "Description of Study Area", the river channel in the WSR segment of the Jarbidge River flows through a deep canyon. Streamflow contributions along the WSR segment from overland runoff and small tributaries, such as Columbet, Cougar, Dorsey, and Poison Creeks, were expected to be small based on visual observations (Evan Worthington and Casey Steenhoven, Bureau of Land Management, oral commun., 2013) and were over-estimated using the drainage-area-ratio method alone. A scaling factor was then investigated as a means of adjusting the bimonthly streamflow statistics at the mouth of the Jarbidge River (USGS 13162670) using streamflow statistics for the Bruneau River upstream and downstream of the confluence with the Jarbidge River and for Sheep Creek.

Bimonthly streamflow statistics were calculated using long-term streamflow records for the Bruneau River at Rowland, Nevada (USGS 13161500), upstream of the confluence with the Jarbidge River, and for the Bruneau River near Hot Spring, Idaho (USGS 13168500), downstream of the confluence with the Jarbidge River (fig. 1, table 1). Bimonthly streamflow statistics also were calculated for the tributaries Sheep Creek above mouth, near Grasmere, Idaho (USGS 13164600) using a drainage-area-ratio method (described in Wood and Fosness, 2013) and the East Fork Bruneau River near Hot Spring, Idaho (USGS 13167500) (fig. 1) using available streamflow records (table 1). Streamflow statistics for the Bruneau River above Jarbidge River, near Grasmere, Idaho (USGS 13162050; fig. 1) were calculated using a partial-record method and published in Wood and Fosness (2013), but were not used for this analysis because uncertainty was lower for available streamflow records and resulting streamflow statistics for the upstream streamgage on the Bruneau River (USGS 13161500). A water balance was calculated for the Bruneau River using equation 4 to determine the inflows that were not explained by Sheep Creek and the East Fork Bruneau River and that were at least partially attributable to the Jarbidge River (table 2):

$$Q_{Diff} = (Q_{13168500} - (Q_{13161500} + Q_{13164600} + Q_{13167500}) \quad (4)$$

where

Q_{Diff} is the remainder in streamflow statistic (Q_{20}, Q_{50}, or Q_{80}) estimated in the Bruneau River not explained by the Bruneau River (USGS streamgage 13161500), Sheep Creek (USGS streamgage 13164600) and East Fork Bruneau River (USGS streamgage 13167500) (ft^3/s);

$Q_{13168500}$ is the streamflow statistic (Q_{20}, Q_{50}, or Q_{80}) estimated based on the period of record at USGS streamgage 13168500, Bruneau River near Hot Spring, Idaho (ft^3/s);

$Q_{13161500}$ is the streamflow statistic (Q_{20}, Q_{50}, or Q_{80}) estimated based on the period of record at USGS streamgage 13161500, Bruneau River at Rowland, Nevada (ft^3/s);

$Q_{13164600}$ is the streamflow statistic (Q_{20}, Q_{50}, or Q_{80}) estimated using a drainage–area-ratio method at USGS streamgage 13164600, Sheep Creek above mouth, near Grasmere, Idaho (ft^3/s) (estimation procedures described in Wood and Fosness, 2013); and

$Q_{13167500}$ is the streamflow statistic (Q_{20}, Q_{50}, or Q_{80}) estimated based on the period of record at USGS streamgage 13167500, East Fork Bruneau River near Hot Spring, Idaho (ft^3/s).

A scaling factor was calculated by comparing Q_{Diff} calculated using equation 4 to the bimonthly streamflow statistics calculated for the mouth of the Jarbidge River (USGS 13162670) using the drainage-area-ratio method, during a period when streamflows from the Jarbidge River were expected to dominate any unexplained contributions from other minor tributaries on the Bruneau River (June through mid-July based on an examination of available streamflow records and a discussion with BLM River Rangers). The scaling factor was calculated for each streamflow statistic for three bimonthly periods: June 1–14, June 15–30, and July 1–14, using equation 5 (table 2):

$$SF = \left(\frac{Q_{Diff}}{Q_{13162670\_DA\_Ratio}}\right) \quad (5)$$

where

SF is the scaling factor calculated to determine how should be adjusted to provide more reasonable estimates of streamflows at the mouth of the Jarbidge River at USGS streamgage 13162670.

Table 2. Bimonthly exceedance probability streamflow statistics calculated for the Bruneau, East Fork Bruneau, and Jarbidge Rivers and Sheep Creek, June 1–July 14, and scaling factor used to calculate final bimonthly exceedance probability streamflow statistics for the Jarbidge River above mouth, near Grasmere, Idaho (USGS 13162670).

[**Streamflow statistic:** Q_{20}, 20-percent exceedance probability streamflow; Q_{50}, 50-percent exceedance probability streamflow; Q_{80}, 80-percent exceedance probability streamflow. Q_{Diff}, the remainder in streamflow statistic (Q_{20}, Q_{50}, or Q_{80}) estimated in the Bruneau River not explained by the Bruneau River (13161500), Sheep Creek (13164600), and East Fork Bruneau River (13167500); $Q_{13162670\_DA\_Ratio}$, the bimonthly streamflow statistic (Q_{20}, Q_{50}, or Q_{80}) estimated at the mouth of the Jarbidge River at streamgage 13162670 using a drainage-area-ratio approach; SF, the scaling factor calculated to determine how $Q_{13162670\_DA\_Ratio}$ should be adjusted to provide more reasonable estimates of streamflow statistics at the mouth of the Jarbidge River at streamgage 13162670, calculated as $Q_{Diff}/Q_{13162670\_DA\_Ratio}$; SF_{Avg}, the average of all SF values calculated for $Q_{13162670\_DA\_Ratio}$ (Q_{20}, Q_{50}, and Q_{80} values) for three bimonthly periods (June 1–14, June 15–30, and July 1–14); $Q_{13162670\_Adjusted}$ is the final adjusted bimonthly streamflow statistic (Q_{20}, Q_{50}, or Q_{80}) at the mouth of the Jarbidge River at streamgage 13162670, calculated as $Q_{13162670\_DA\_Ratio} \times SF_{Avg}$. **Abbreviations:** USGS, U.S. Geological Survey; ft^3/s, cubic feet per second]

USGS site No.	Site name	Streamflow statistic	Streamflow (ft^3/s)		
			June		July
			Days 1–14	Days 15–30	Days 1–14
13161500	Bruneau River at Rowland, Nevada	Q_{20}	392	232	99.0
		Q_{50}	211	111	45.0
		Q_{80}	110	43.8	17.0
13164600	Sheep Creek above mouth, near Grasmere, Idaho	Q_{20}	814	225	66.3
		Q_{50}	228	118	31.6
		Q_{80}	149	70	15.8
13167500	East Fork Bruneau River near Hot Spring, Idaho	Q_{20}	152	96.0	38.0
		Q_{50}	86.0	45.0	19.0
		Q_{80}	37.2	19.0	6.0
13168500	Bruneau River near Hot Spring, Idaho	Q_{20}	1,640	1,130	566
		Q_{50}	1,010	632	288
		Q_{80}	605	309	136
		Q_{Diff}			
		Q_{20}	282	577	363
		Q_{50}	485	358	192
		Q_{80}	309	176	97.2
		$Q_{13162670\_DA\_Ratio}$			
13162670	Jarbidge River above mouth, near Grasmere, Idaho	Q_{20}	1,980	1,540	618
		Q_{50}	1,180	687	259
		Q_{80}	552	282	126
		SF			
		Q_{20}	0.14	0.37	0.59
		Q_{50}	0.41	0.52	0.74
		Q_{80}	0.56	0.62	0.77
		SF_{Avg}	0.52		
		$Q_{13162670\_Adjusted}$[1]			
13162670	Jarbidge River above mouth, near Grasmere, Idaho	Q_{20}	1,030	801	321
		Q_{50}	614	357	135
		Q_{80}	287	147	65.5

[1] $Q_{13162670\_Adjusted}$ streamflow statistics are shown for June 1–July 14 only as a demonstration of the calculation, but SF_{Avg} was used to calculate $Q_{13162670\_Adjusted}$ for all bimonthly periods (see table 3).

The average scaling factor for three bimonthly periods (June 1–14, June 15–30, and July 1–14) was 0.52 (table 2). The average scaling factor was applied to calculate the final adjusted bimonthly streamflow statistics at the mouth of the Jarbidge River according to equation 6 (fig. 2):

$$Q_{13162670\_Adjusted} = Q_{13162670\_DA\_Ratio} \times SF_{Avg} \quad (6)$$

where

SF_{Avg} is the average of all SF values (eq. 5) calculated for Q_{20}, Q_{50}, and Q_{80} values) for three bimonthly periods (June 1–14, June 15–30, and July 1–14) (0.52), and

$Q_{13162670\_Adjusted}$ is the final adjusted bimonthly streamflow statistic (Q_{20}, Q_{50}, or Q_{80}) at the mouth of the Jarbidge River at USGS streamgage 13162670.

Calculation of Bankfull Streamflow Statistic

The drainage-area-ratio method was not used to estimate the bankfull streamflow statistic at the mouth of the Jarbidge River because of concerns about estimating and adjusting annual peak streamflow statistics based on streamgages with varying periods of record and using a relatively short period of record (14 complete water years) for the only active, continuously-recording USGS streamgage on the Jarbidge River (USGS 13162225). As a result, the USGS StreamStats program was considered the best available tool to estimate the bankfull streamflow statistic at the mouth of the Jarbidge River (USGS 13162670).

Jarbidge River Streamflow Statistics

The final adjusted bimonthly streamflow statistics ($Q_{13162670\_Adjusted}$) and bankfull streamflow statistic (fig. 3, table 3) represent the best estimates for streamflow statistics at the mouth of the Jarbidge River (USGS 13162670) and in the WSR segment based on available streamflow records and on discussions with BLM River Rangers. The estimated bimonthly streamflow statistics for the Jarbidge River (USGS 13162670) peak in mid- to late-May and June, which matches patterns observed in streamflow statistics for the upstream streamgages on the Jarbidge River (USGS 13162225) and East Fork Jarbidge River (USGS 13162500), is expected because of streamflow contribution and runoff timing from high elevation areas of the drainage basin. The highest bimonthly streamflow statistics at the mouth (USGS 13162670) occurred in the second half of May and were about four times higher than the corresponding bimonthly streamflow statistics at the upstream streamgage below Jarbidge, Nevada (USGS 13162225). The lowest bimonthly streamflow statistics at USGS 13162670 occurred in the second half of September and were about five times higher than the corresponding bimonthly streamflow statistics at USGS 13162225. Overall, the bimonthly streamflow statistics at USGS 13162670 ranged from 3.7 to 7.4 times higher than the corresponding streamflow statistics at USGS 13162225, depending on bimonthly period (not shown in tables 2–3).

Validation of Streamflow Statistics

To validate the final adjusted bimonthly streamflow statistics at the mouth (USGS 13162670), the difference in streamflow statistics was calculated for the WSR segment between the mouth (USGS 13162670) and the confluence of the Jarbidge and East Fork Jarbidge Rivers, where only small streamflow contributions from tributaries (fig. 1) were expected. Differences in Q_{20} ranged from 1.30 to 80.0 ft^3/s (fig. 2), and seem reasonable based on the size of the contributing tributaries and discussions with BLM River Rangers. The largest differences were during peak streamflows in mid-April through mid-June, which also seems reasonable based on the expected timing of runoff in the contributing tributaries.

After completion of the streamflow statistics described in this report, three additional streamflow measurements were made in the Jarbidge River at the mouth (USGS 13162670). All available measurements are within the range of streamflow statistics computed for the corresponding bimonthly period which further supports the validity of the estimated statistics (fig. 3). Additionally, streamflows in the Jarbidge River in 2014 generally were near to below long-term mean streamflows. Monthly mean streamflows at USGS 13162225 in April, May, and June 2014, for example, were 71, 69, and 38 percent of the respective long-term monthly mean streamflows for the streamgage's period of record (1998–2013). The magnitudes of streamflow measurements made at USGS 13162670 in spring 2014 generally were near or below the computed bimonthly Q_{50} statistics (fig. 3) and further support the validity of the estimated statistics.

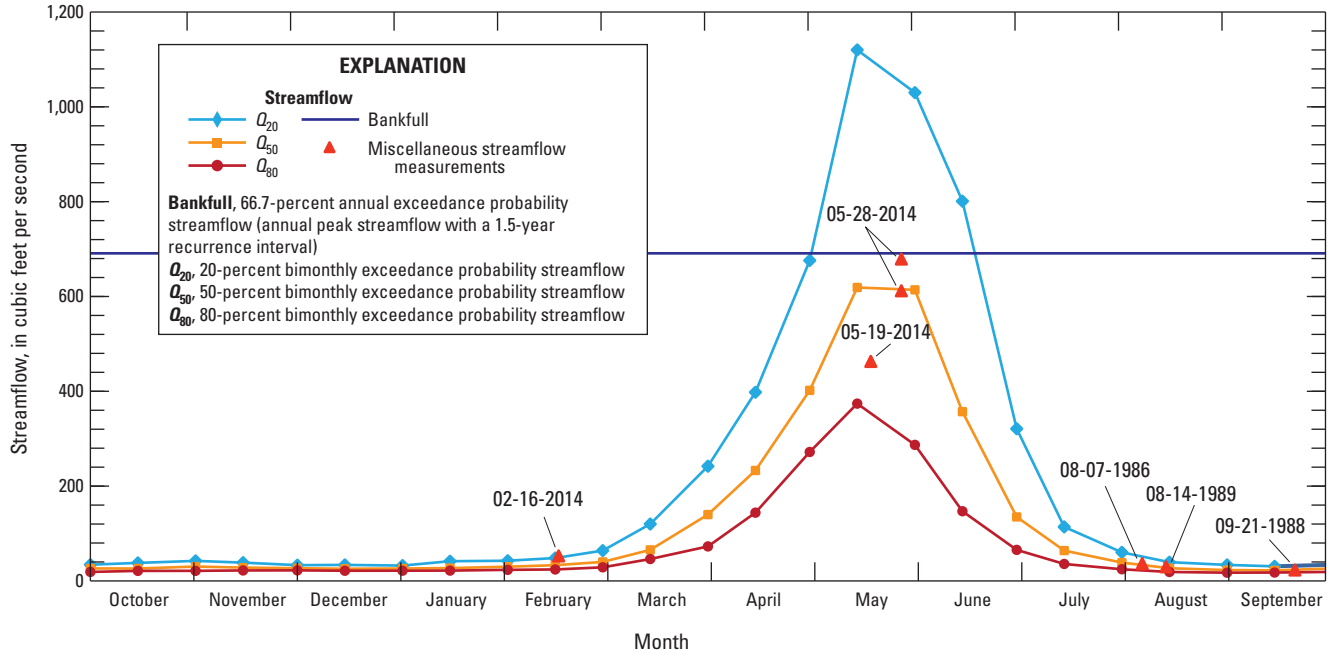


Figure 3. Final bimonthly exceedance probability and bankfull streamflow statistics, and miscellaneous streamflow measurements at Jarbidge River above mouth, near Grasmere, Idaho (USGS 13162670).

As a test of the estimated ratio between bimonthly streamflow statistics estimated at USGS 13162670 and 13162225, the measurements at USGS 13162670 on May 19 and 28, 2014, were compared to the corresponding daily mean streamflows at USGS 13162225. The ratios between the discrete streamflow measurements at USGS 13162670 and daily mean streamflows at USGS 13162225 ranged from 3.27 to 3.63, which is slightly lower than the range of ratios for the May 15–31 bimonthly period (4.19–4.49) (not shown in tables). Streamflows were unsteady on May 19 and 28, 2014, and the bimonthly streamflow statistics were based on daily mean streamflows, not individual streamflow measurements, so the difference in the ratio between the measurement at USGS 13162670 and daily mean streamflow at USGS 13162225 and the ratio between bimonthly streamflow statistics is reasonable and explainable. A hydrologic technician on site during the May 19 and 28, 2014, streamflow measurements noted that there was no recent (within the past year) evidence of higher streamflows than those measured on May 28 (612 and 679 ft^3/s), but he observed high water marks on the right streambank about 2–2.5 ft above the water level on May 28, which indicated higher streamflows estimated around 1,000 ft^3/s are possible and have occurred in the past (Gregory Pachman, U.S. Geological Survey, written commun., 2014). If this rough estimate of historical streamflow is correct, it aligns well with the highest Q_{20} estimate, which was 1,120 ft^3/s during the May 15–31 bimonthly period (fig. 3, table 3). Additionally, the bankfull streamflow statistic (691 ft^3/s) is reasonable relative to the magnitudes of bimonthly streamflow statistics and based on observations of high water marks at the streamgage.

Table 3. Annual and bimonthly exceedance probability and bankfull streamflow statistics calculated for the Jarbidge River above mouth, near Grasmere, Idaho (USGS 13162670).

[**Streamflow statistic**: Q_{20}, 20-percent exceedance probability streamflow; Q_{50}, 50-percent exceedance probability streamflow; Q_{80}, 80-percent exceedance probability streamflow. The bankfull statistic is defined as the streamflow with a 66.7-percent annual exceedance probability, or the streamflow that has a 66.7-percent chance of occurring at any time in a given year (1.5-year recurrence interval). **Abbreviations:** USGS, U.S. Geological Survey; ft^3/s, cubic feet per second]

Streamflow statistic	Annual	Streamflow (ft^3/s)											
		January		February		March		April		May		June	
		Days 1–14	Days 15–31	Days 1–14	Days 15–29	Days 1–14	Days 15–31	Days 1–14	Days 15–30	Days 1–14	Days 15–31	Days 1–14	Days 15–30
Q_{20}	213	32.4	41.6	42.6	48.3	64.0	120	242	398	676	1,120	1,030	801
Q_{50}	39.9	26.2	27.1	30.0	33.2	40.1	65.5	140	233	402	619	614	357
Q_{80}	23.3	21.6	21.8	23.4	24.2	28.7	46.2	72.8	144	272	374	287	147
Bankfull	[1]691												

Streamflow statistic	Annual	Streamflow (ft^3/s)											
		July		August		September		October		November		December	
		Days 1–14	Days 15–31	Days 1–14	Days 15–31	Days 1–14	Days 15–30	Days 1–14	Days 15–31	Days 1–14	Days 15–30	Days 1–14	Days 15–31
Q_{20}	213	321	114	60.3	39.6	33.8	30.8	34.3	38.0	42.3	38.6	33.3	33.8
Q_{50}	39.9	135	64.0	38.7	26.8	22.9	22.3	26.3	26.2	30.3	28.1	26.8	25.7
Q_{80}	23.3	65.5	35.8	24.6	18.9	17.4	17.7	19.0	21.2	21.3	22.1	22.3	21.5

[1]Source: USGS StreamStats (U.S. Geological Survey, 2013). Bankfull streamflow statistic 90-percent prediction intervals are 215–2,220 ft^3/s.

Limitations and Uncertainty

The methods selected for this study and their resulting streamflow statistics have inherent uncertainties because of the limited availability of long-term streamflow records and measurements in the study area. Although the results presented in this report are considered the best available for the study area and have been supported by limited streamflow measurements, the techniques used were non-standard and may result in large and not fully quantifiable uncertainty in the estimated streamflow statistics. As previously stated in the section, "Methods," the drainage-area-ratio method was applied to locations with a range of drainage-area ratios outside the commonly used range specified in Risley and others (2008) and Berenbrock (2002). However, the scaling factor calculated using available streamflow records on the Bruneau River upstream and downstream of the Jarbidge River is intended to reduce the uncertainty owing to extrapolation of the drainage-area-ratio method outside its typical use. Some uncertainty exists in the scaling factor calculation because it does not include contributions from small, unmeasured tributaries and overland runoff along the Bruneau River, and because uncertainty in the streamflow statistics estimated for Sheep Creek is high for reasons presented in Wood and Fosness (2013). The streamflow statistics calculated for the WSR segment of the Jarbidge River should be revised over time, perhaps using another method such as the partial-record method presented in Wood and Fosness (2013), after more streamflow measurements are made at the mouth of the Jarbidge River (USGS 13162670). The USGS monitoring program described in Wood and Fosness (2013) was re-initiated and re-scoped in February 2014 in an effort to collect additional streamflow information to support and eventually revise development of streamflow statistics at monitoring sites in the Owyhee Canyonlands Wilderness. As part of that monitoring program, additional streamflow measurements will be collected on the Jarbidge River at the mouth (USGS 13162670) in 2014–19 to verify and, if needed, refine the streamflow statistics presented in this supplement to Wood and Fosness (2013).

Summary

Streamflow statistics needed for development of water rights claims to protect federally designated outstanding remarkable values for the Jarbidge River were published in Wood and Fosness (2013) at USGS streamgage 13162225, about 40 mi upstream of the downstream end of the designated Wild and Scenic River (WSR) segment. The U.S. Geological Survey (USGS) and Bureau of Land Management (BLM) have since recognized the need to calculate streamflow statistics at the downstream end of the WSR segment, at the mouth of the Jarbidge River near its confluence with the Bruneau River. To address this need, the USGS estimated bimonthly exceedance probability streamflow statistics for the Jarbidge River in the Owyhee Canyonlands Wilderness in Idaho using a drainage-area-ratio method applied to available streamflow data at upstream streamgages on the Jarbidge River (USGS 13162225) and East Fork Jarbidge River (USGS 13162500). In the drainage-area-ratio method, streamflow statistics calculated from available streamflow data from streamgages in the drainage basin are adjusted to a downstream site using a ratio between drainage areas of the two locations. The available streamflow records and drainage-area ratios were used to estimate the daily mean streamflow exceeded 80, 50, and 20 percent of the time for bimonthly (80, 50, and 20 percent bimonthly streamflow exceedances) and annual periods. The streamflow statistics were further adjusted using a scaling factor calculated using a water balance on available streamflow statistics on the Bruneau River, which is the receiving water body for the Jarbidge River, East Fork Bruneau River, and Sheep Creek. A bankfull streamflow statistic (66.7-percent annual exceedance probability or 1.5 year recurrence interval) was calculated for the Jarbidge River using the USGS StreamStats program.

The final adjusted bimonthly and bankfull streamflow statistics represent the best estimates for streamflow statistics at the mouth of the Jarbidge River (USGS 13162670) and in the WSR segment based on available streamflow records, on-site observations of historical and possible streamflows, and on discussions with BLM River Rangers. The magnitudes of streamflow measurements made at the mouth of the Jarbidge River (USGS 13162670) in 1986, 1988, 1989, and 2014 are within the range of estimated streamflow statistics. The estimated bimonthly streamflow statistics for the Jarbidge River at the mouth (USGS 13162670) peak in mid- to late May and June, which matches patterns observed in streamflow statistics for the upstream streamgages on the Jarbidge River (13162225) and East Fork Jarbidge River (13162500) and is expected because of streamflow contribution and runoff timing from high elevation areas of the drainage basin.

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