# TECHNICAL MEMORANDUM

SUBJECT: **Snake-Salt River Basin Plan**
**Task 3A – Surface Water Data Collection and Study Period Selection**

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DATE: March 31, 2003

## Introduction

The feasibility study determined that three 12-month spreadsheet models (one each representing average-year, dry-year, and wet-year streamflows) constitute an appropriate level of detail for a modeling tool to verify existing uses and evaluate future surface water uses. Gage flows used in the three spreadsheets are to be typical of three different conditions, and are to be developed by averaging observed or estimated streamflows that occurred during historical average, wet, or dry years. Accordingly, the objectives of this task were to:

- collect historical records of streamflow from available sources
- determine the study period to be used to develop average, wet, and dry year flow estimates for the Snake and Salt River basin spreadsheet models
- select indicator gages and use them to identify the historical average, wet, and dry years out of the study period
- assemble surface water information required for the spreadsheet

The methodology used to extend or fill streamflow data where records are unavailable and the means to estimate streamflow at ungaged model nodes are also discussed in this memorandum.

## Historical Streamflow Records

Analysis of available historical streamflow data began by reviewing the USGS Water-Data Report, Volume 1. Surface Water for 2000. This report lists discontinued and active surface water discharge, water quality, sediment and biological stations in Wyoming. Historical records for those stations having greater than 5 years of reported flow data were requested from the Wyoming Water Resources Data System (WRDS). Based on this review, Table 1 was prepared to show the period of record for selected gages within the Snake and Salt River basins. Some gage data may exist for periods prior to the period of record shown. These periods have not been listed because they are of short duration (less than 5 years continuous data).

**Table 1**
**Streamflow Station in the Snake and Salt River Basins**

| USGS Number | Station Name | Latitude | Longitude | Elevation (ft) | Drainage Area ($mi^2$) | Period of Record | | Notes |
|---|---|---|---|---|---|---|---|---|
| | | | | | | From | To | |
| **Snake River Basin** | | | | | | | | |
| 13010065 | Snake River above Jackson Lake at Flagg Ranch, WY | 44:05:21 | 110:41:38 | 6802 | 486.0 | Oct-1983 | Sep-2001 | Prior to 1988 water year, published as station 13010200. Estimated daily discharge records are fair. |
| 13011000 | Snake River near Moran, WY | 43:51:30 | 110:35:09 | 6728 | 807.0 | Sep-1903 | Sep-2001 | Published as "South Fork Snake River at Moran" prior to October 1910 and as "Snake River at Moran" October 1910-September 1968. Monthly discharge only for some periods. |
| 13011500 | Pacific Creek at Moran, WY | 43:51:01 | 110:31:04 | 6720 | 169.0 | Sep-1944<br>Jul-1978 | Sep-1975<br>Sep-2001 | Published as "near Moran" prior to October 1968. No diversion or regulation upstream from station. |
| 13011900 | Buffalo Fork above Lava Creek near Moran, WY | 43:50:17 | 110:26:28 | 6773 | 323.0 | Sept-1965 | Sep-2001 | 410 acres irrigated upstream of gage. Records good except for estimated daily discharges which are poor |
| 13012000 | Buffalo Fork near Moran, WY | 43:50:10 | 110:30:30 | 6720 | 378.0 | Oct-1944 | Sep-1960 | |
| 13013650 | Snake River at Moose, WY | 43:39:14 | 110:42:52 | 6431 | 1677.0 | Apr-1995 | Sep-2001 | |
| 13014500 | Gros Ventre River at Kelley, WY | 43:37:20 | 110:42:52 | 6750 | 622.0 | Oct-1944 | Sep-1958 | |
| 13015000 | Gros Ventre River at Zenith, WY | 43:33:26 | 110:45:46 | 6260 | 683.0 | Oct-1987 | Sep-2001 | No winter records |
| 13016100 | Snake River near Wilson, WY | 43:29:57 | 110:50:16 | 6160 | 2342.0 | Oct-1972 | Oct-1975 | |
| 13016305 | Granite Creek above Granite Creek Supplement, near Moose, WY | 43:36:14 | 110:48:17 | 6400 | 14.9 | Jun-1995 | Sep-2001 | No diversions upstream from station. |
| 13016450 | Fish Creek at Wilson, WY | 43:30:03 | 110:52:15 | 6150 | 71.1 | Mar-1994 | Sep-2001 | Natural flow of stream affected by transbasin diversion from Snake River through Granite Creek Supplemental for irrigation in Fish Creek Basin and by additional diversions upstream from station within Fish Creek Basin. Records good except for estimated daily discharges which are poor |
| 13018000 | Flat Creek near Jackson, WY | 43:33:24 | 110:37:15 | 6780 | 40.1 | Jun-1933<br>Apr-1989 | Nov-1941<br>Sep-1993 | No winter records. |
| 13018300 | Cache Creek near Jackson, WY | 43:27:08 | 110:42:12 | 6750 | 10.6 | Jul-1962 | Sep-2001 | Records fair, except for estimated daily discharges which are poor |
| 13018350 | Flat Creek below Cache Creek near Jackson, WY | 43:27:30 | 110:47:46 | 6130 | 129.0 | Apr-1989<br>Oct-1999 | Sep-1996<br>Sep-2001 | No winter records April 1989 to September 1996. Records good except for estimated daily discharges which are poor |
| 13018500 | Flat Creek near Cheney, WY | 43:24:04 | 110:46:24 | 5940 | 142.0 | Apr-1989 | Sep-1993 | No winter records. |
| 13018750 | Snake River below Flat Creek near Jackson, WY | 43:22:20 | 110:44:19 | 5950 | 2627.0 | Nov-1975 | Sep-2001 | Records good except for estimated daily discharges which are fair |
| 13019438 | Little Granite Creek at Mouth near Bondurant, WY | 43:17:56 | 110:31:33 | 6390 | 21.1 | Jan-1982 | Oct-1992 | |
| 13019500 | Hoback River near Jackson, WY | 43:17:55 | 110:40:10 | 6040 | 564.0 | Oct-1944 | Sep-1958 | |

| USGS Number | Station Name | Latitude | Longitude | Elevation (ft) | Drainage Area ($mi^2$) | Period of Record | | Notes |
|---|---|---|---|---|---|---|---|---|
| | | | | | | From | To | |
| **Snake River Basin** | | | | | | | | |
| 13022500 | Snake River above Reservoir near Alpine, WY | 43:11:46 | 110:53:22 | 5684 | 3465.0 | Jul-1953 | Sep-2001 | Published as "above Greys River" prior to April 1939. Records good except for estimated daily discharges which are fair |
| 13023500 | Snake River below Greys River at Alpine, WY | 43:10:20 | 111:02:30 | 5544 | 3940.0 | Oct-1944 | Jun-1954 | |
| **Greys River Basin** | | | | | | | | |
| 13023000 | Greys River above Reservoir near Alpine, WY | 43:08:34 | 110:58:36 | 5729 | 448.0 | Oct-1953 | Sep-2001 | Published as "Greys River near Alpine, ID" 1937-1939. Less than 500 acres irrigated by diversions from Greys River and tributaries upstream from station. |
| **Salt River Basin** | | | | | | | | |
| 13024000 | Salt River near Smoot, WY | 42:36:20 | 110:55:10 | 6600 | 47.8 | Jun-1932 | Sep-1957 | |
| 13024500 | Cottonwood Creek near Smoot, WY | 42:36:40 | 110:53:30 | 6750 | 26.3 | Oct-1932 | Sep-1957 | |
| 13025000 | Swift Creek near Afton, WY | 42:43:30 | 110:54:00 | 6420 | 27.4 | Oct-1942 | Sep-1980 | No winter records November 1971 to April 1980. |
| 13025500 | Crow Creek near Fairview, WY | 42:40:30 | 111:00:25 | 6240 | 115.0 | Apr-1946<br>Oct-1961 | Oct-1949<br>Sep-1967 | |
| 13026500 | Salt River near Thayne, WY | 42:52:10 | 110:58:50 | 5980 | 570.0 | Oct-1961 | Sep-1967 | |
| 13027000 | Strawberry Creek near Bedford, WY | 42:54:10 | 110:54:00 | 6520 | 21.3 | Jun-1932 | Sep-1943 | |
| 13027500 | Salt River above Reservoir, near Etna, WY | 43:04:47 | 111:02:14 | 5676 | 829.0 | Oct-1953 | Sep-2001 | Diversions above station for power development, industry, municipal supply, and irrigation of about 60,500 acres. |

## Study Period Selection

It is important in any water availability evaluation to select a study period that is long enough to include a variety of hydrologic conditions, including an extended period of dry years as well as wet years and average years. At the same time, it is important to avoid selecting a study period so long that many streamflows must be synthesized to fill-in missing data. Additionally, a single annual cycle will be used to model each hydrologic condition; therefore, the average data developed for input to the model should be derived from an operationally consistent time period. Construction of reservoir storage, changes in irrigation practices or change in water use (agricultural to suburban ranchette) are all significant in the study period selection.

### Salt River

It is desirable in evaluating long-term hydrologic conditions to utilize streamflow records that have a long period of continuous record and reflect natural (virgin) flow, unaffected by upstream depletions or storage regulation. Unfortunately, no such streamflow gaging station exists in the Salt River Basin. However, the Greys River above Reservoir, near Alpine gage has less than 500 acres of irrigated lands upstream of this gage (per USGS Water Resources Data) and has been in continuous operation since the 1954 water year. Since the irrigated acreage is small relative to the overall drainage basin (less than one percent), diversions were assumed to be small compared to the total natural flow. Therefore this gage was considered a natural flow gage and was used for the study period selection for the Salt River. The long term hydrograph is shown in Figure 1. Figure 2 is a plot of Cumulative Deviation from the Mean Annual Flow for the Greys River and represents a running total of the annual deviations from the long-term mean annual streamflow. Downward sloping lines (left to right) represent periods of time during which annual streamflow is less than the long-term mean. Conversely, upward sloping lines represent years which are wetter than average. As shown on Figure 2, the periods from 1969 through 1976, from 1981 through 1986, and from 1995 through 1999 can be generally characterized as wet periods, whereas the periods from 1957 through 1961, from 1977 through 1981, and from 1986 through 1994 can be generally characterized as dry periods. The period from 1961 through 1969 can generally be characterized as near average. Exceptions to each of these generalities exist within each period. For example, 1973 is a dry year within a generally wet period and 1978 is a wet year within a generally dry period.

Numerous irrigation systems were converted from flood to sprinkler systems during the late 1960's – early 1970's. Improvements in irrigation efficiencies ultimately impacted the overall watershed. Venn (2002)[1] presented a double mass balance analysis of Salt River flows versus Greys River flows, showing a break in the trend line beginning in approximately 1971. He attributed the shift to changes in irrigation practice, from flood to sprinkler. This would suggest that the study period for the Salt River should begin no sooner than 1971. On the other hand, as no other major water developments have occurred in the Salt River basin since 1971, there's no reason to begin the study period any later in time.

Based on an evaluation of the long-term hydrologic conditions on the Greys River, together with an understanding of the availability of historical streamflow records and irrigation

[1] Venn, Brian J., "Hydrologic Impacts Due to Conversion from Flood to Sprinkler Irrigation Practices," M.S. Thesis, University of Wyoming, Department of Civil and Architectural Engineering, May 2002.

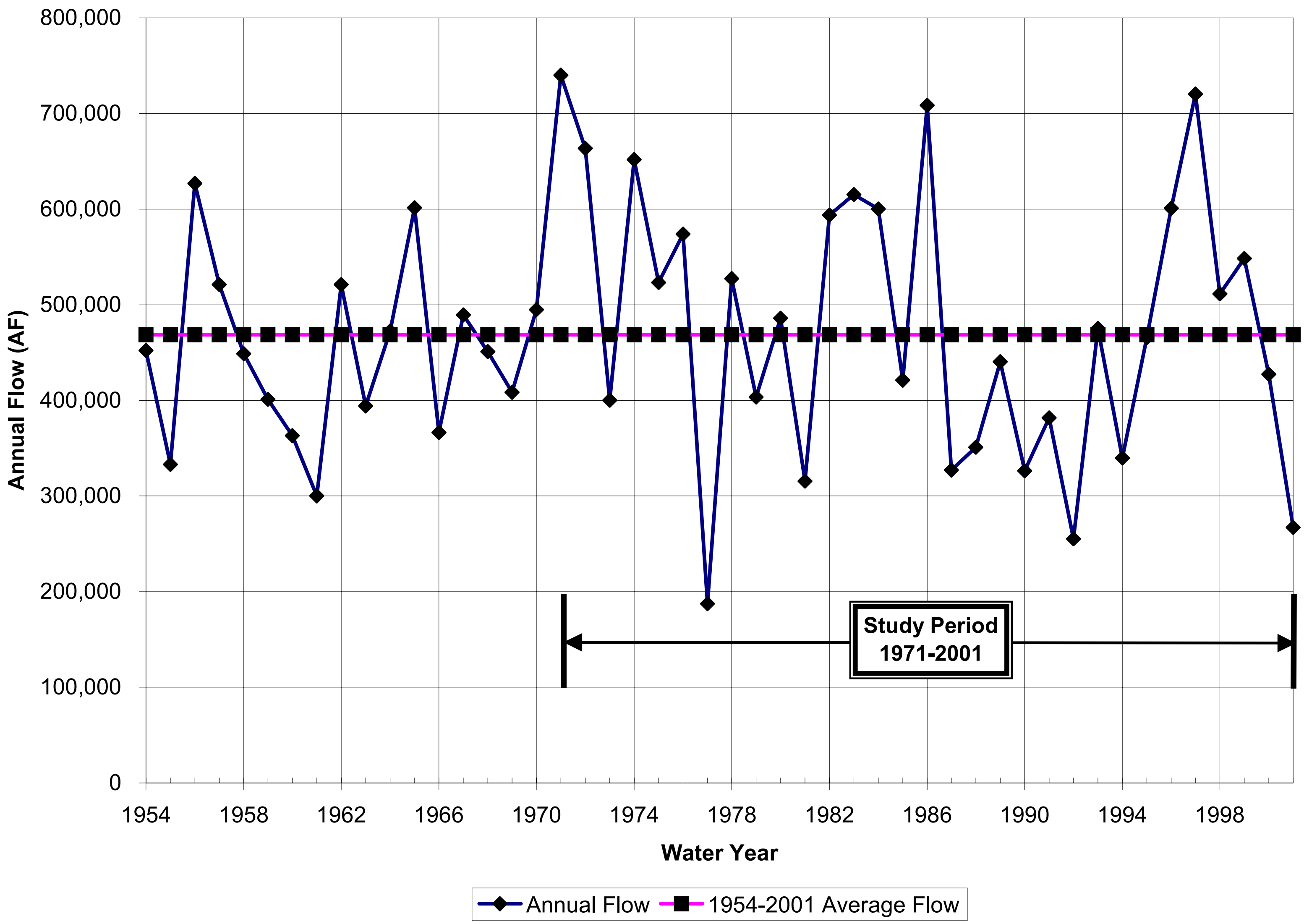


**Figure 1 Annual Flows for USGS 13023000 – Greys River above Reservoir near Alpine, WY**

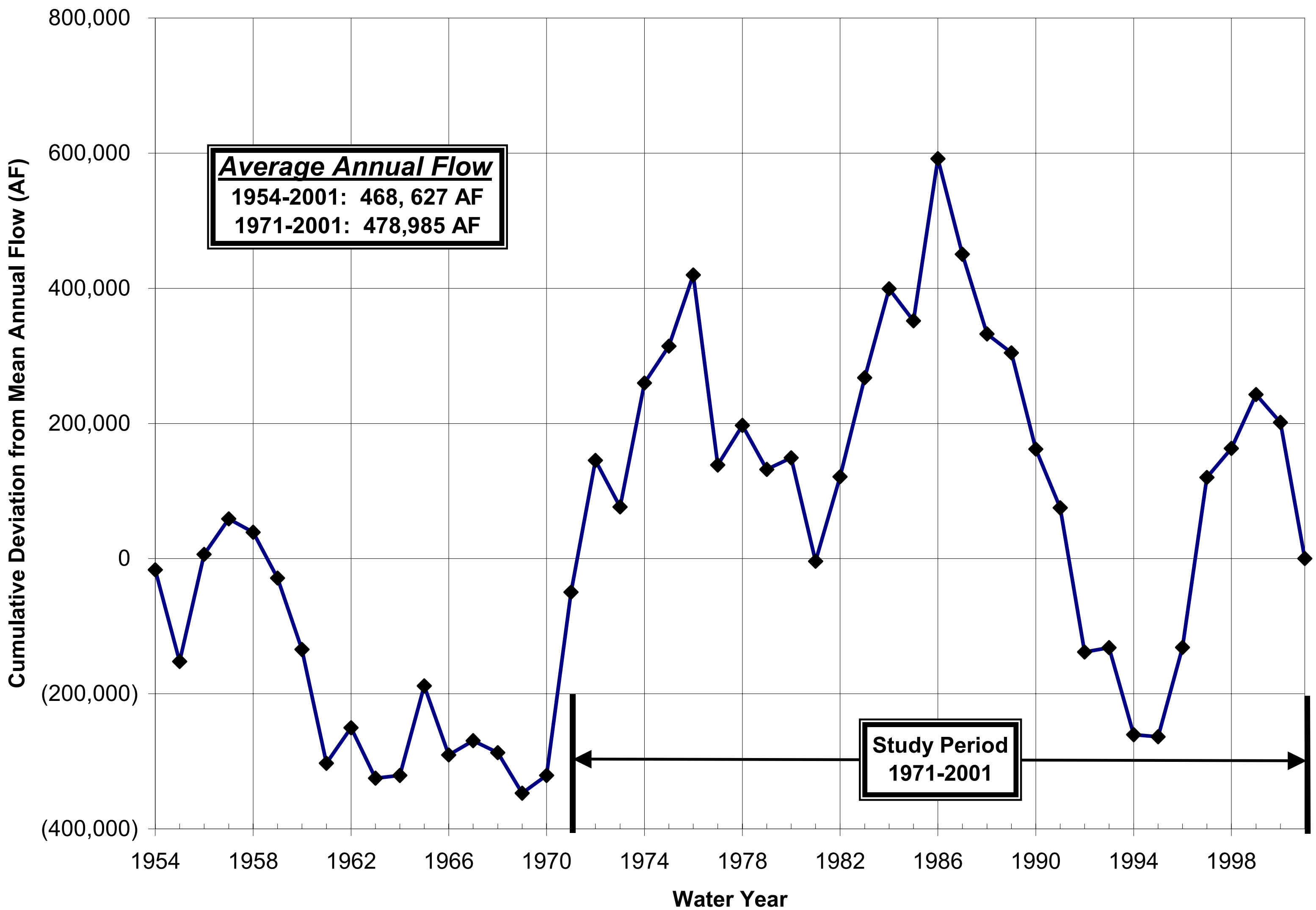


**Figure 2 Cumulative Deviation from the Mean Annual Flow for USGS 13023000 – Greys River above Reservoir near Alpine, WY**

practices within the Salt River Basin, a 31-year study period of 1971 through 2001 was selected as the candidate study period.

This selection was further supported by an analysis of the characteristics of the long term (1954-2001) record and the proposed study period (1971-2001). This information is tabulated below:

**Table 2**
**Characteristics of Annual Flow Series for**
**USGS 13023000 – Greys River above Reservoir, near Alpine, WY**

| | 1954-2001 | | | 1971-2001 | | |
|---|---|---|---|---|---|---|
| Mean (AF) | 468,627 | | | 478,985 | | |
| Standard Deviation | 128,603 | | | 143,253 | | |
| Three highest years | 1971 | 1997 | 1986 | 1971 | 1997 | 1986 |
| Three highest values (AF) | 740,050 | 720,160 | 708,630 | 740,050 | 720,160 | 708,630 |
| Three lowest years | 1977 | 1992 | 2001 | 1977 | 1992 | 2001 |
| Three lowest values (AF) | 187,390 | 255,120 | 267,035 | 187,390 | 255,120 | 267,035 |

Table 2 shows that means of the two periods are very similar. Standard deviation for the shorter period is higher, which is to be expected for a smaller sample size. Most notably, the shorter study period includes both the three highest annual flows of record, as well as the three lowest.

## Snake River

The Snake River near Moran gage has the longest period of record (1904-2001) of all the gages within the Snake River basin. However, this gage is located immediately downstream of Jackson Lake Dam, and measured flows are directly influenced by reservoir releases which makes it unsuitable for evaluating long-term hydrologic conditions within the Snake River basin. The Cache Creek near Jackson gage has no diversions upstream of the station and has been in continuous operation since 1963. However, it has a small drainage area (approximately 10.6 square miles) and as such, may not be representative of the overall basin. The Buffalo Fork above Lava Creek, near Moran gage has approximately 410 acres of land irrigated upstream of the gage and has been in operation since 1966. Because the irrigated acreage is small relative to the gage's drainage basin (less than one percent), this gage can be considered a natural flow gage. The long term hydrograph of the Buffalo Fork gage is presented in Figure 3. Figure 4 is a plot of Cumulative Deviation from the Mean Annual Flow for Buffalo Fork. As shown on Figure 4, the periods from 1966 through 1976, and from 1995 through 1999 can be generally characterized as wet periods, whereas the periods from 1976 through 1981, and from 1986 through 1994 can be generally characterized as dry periods. The period from 1981 through 1986 can generally be characterized as near average. Exceptions to each of these generalities exist within each period. For example, 1973 is a dry year within a generally wet period and 1978 is a wet year within a generally dry period. There is no distinct time frame in which reservoir operations, irrigation, or other water use practices changed significantly within the Snake River Basin. Jackson Lake was constructed at the mouth of a natural lake during 1910-11, and enlarged in 1916. The dam was modified in 1991 to correct dam safety deficiencies. This appears to have been accomplished without significantly impacting the reservoir's operations. Therefore, it

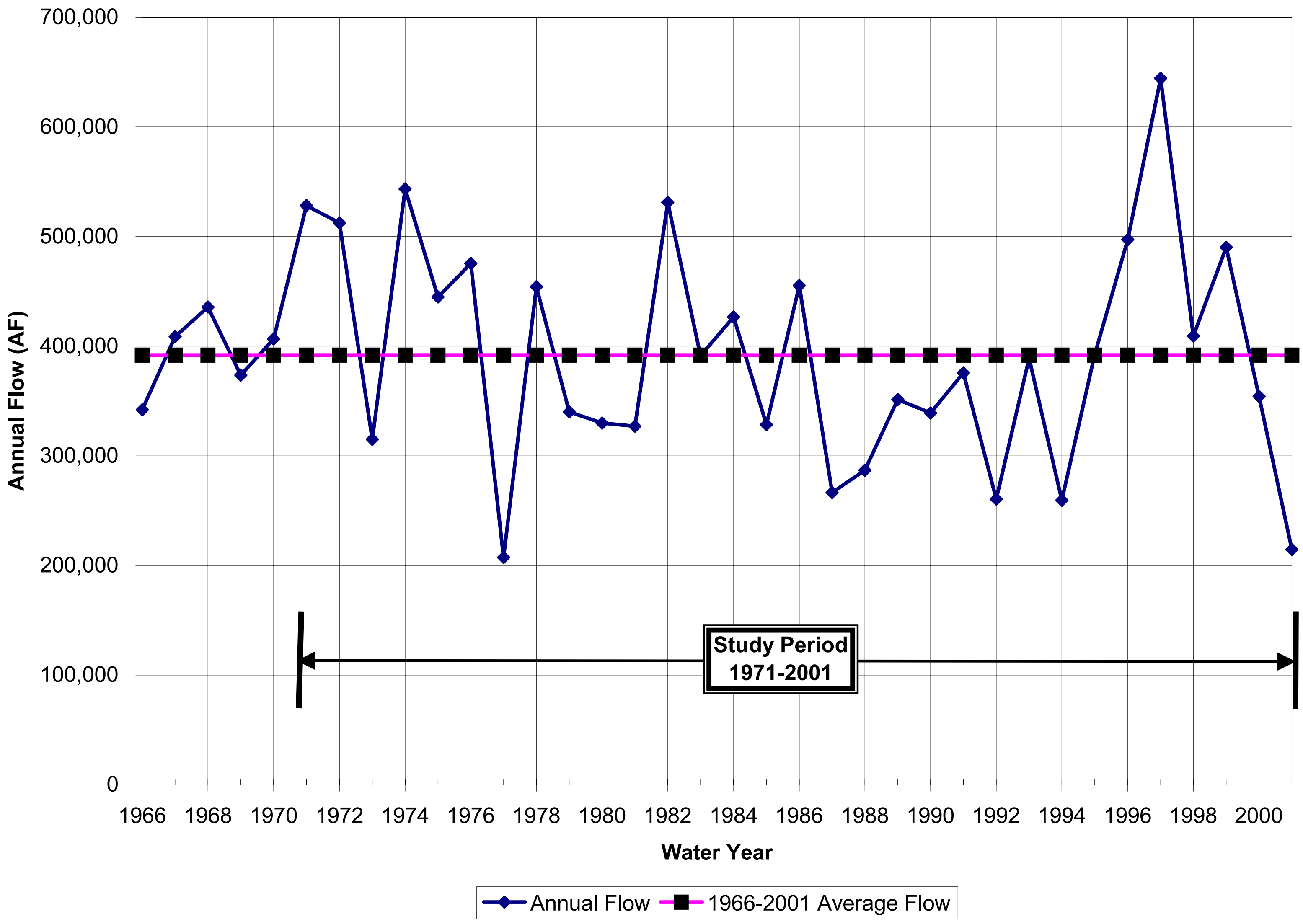


**Figure 3 Annual Flows for USGS 13011900 – Buffalo Fork above Lava Creek near Moran, WY**

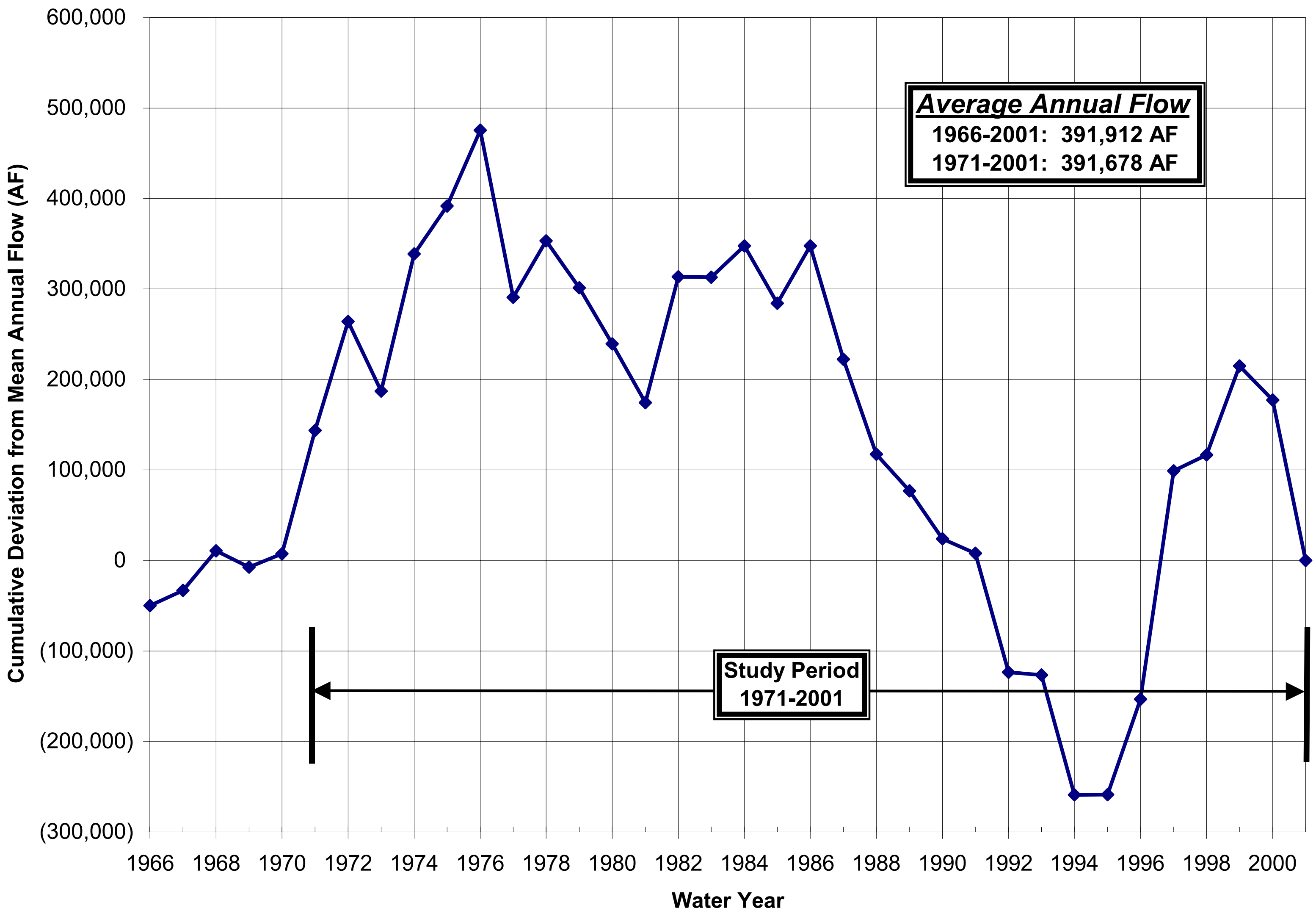


**Figure 4 Cumulative Deviation from the Mean Annual Flow for USGS 13011900 – Buffalo Fork above Lava Creek near Moran, WY**

would have been possible to use a longer study period in the Snake River basin than in the Salt, but in the interest of consistency, 1971-2001 was used for the Snake River as well.

This selection is further supported by an analysis of the characteristics of the long term (1966-2001) record and the proposed study period (1971-2001). This information is tabulated below:

**Table 3**
**Characteristics of Annual Flow Series for**
**USGS 13011900 – Buffalo Fork above Lava Creek near Moran, WY**

| | 1966-2001 | | | 1971-2001 | | |
|---|---|---|---|---|---|---|
| Mean (AF) | 391,912 | | | 391,678 | | |
| Standard Deviation | 98,314 | | | 105,363 | | |
| Three highest years | 1997 | 1974 | 1982 | 1997 | 1974 | 1982 |
| Three highest values (AF) | 644,360 | 543,410 | 531,160 | 644,360 | 543,410 | 531,160 |
| Three lowest years | 1977 | 2001 | 1994 | 1977 | 2001 | 1994 |
| Three lowest values (AF) | 207,270 | 214,628 | 259,370 | 207,270 | 214,628 | 259,370 |

Table 3 shows that means of the two periods are very similar. Standard deviation for the shorter period is higher, which is to be expected for a smaller sample size. Most notably, the shorter study period includes both the three highest annual flows of record, as well as the three driest.

## Indicator Gage Selection

### Approach

The periods of record for gaging stations listed in Table 1 were reviewed. Gages that operated throughout the study period were selected for evaluation as indicator gages. These gages were to provide annual flow characterization (average, wet, or dry) that could be applied to portions of the basin where long-term information did not exist. Table 4 lists the gages that met this initial screening criterion.

**Table 4**
**Potential Indicator Gages for the Snake and Salt River Basins**

| USGS Number | Station Name | Drainage Area ($mi^2$) | Period of Record From | Period of Record To |
|---|---|---|---|---|
| 13011000 | Snake River near Moran, WY | 807.0 | Sep-1903 | Sep-2001 |
| 13011900 | Buffalo Fork above Lava Creek near Moran, WY | 323.0 | Sep-1965 | Sep-2001 |
| 13018300 | Cache Creek near Jackson, WY | 10.6 | Jul-1962 | Sep-2001 |
| 13022500 | Snake River above Reservoir near Alpine, WY | 3465.0 | Jul-1953 | Sep-2001 |
| 13023000 | Greys River above Reservoir near Alpine, WY | 448.0 | Oct-1953 | Sep-2001 |
| 13027500 | Salt River above Reservoir, near Etna, WY | 829.0 | Oct-1953 | Sep-2001 |

The wettest and driest 20 percent of the study period years, on an annual basis, were identified for the gages listed above and are shown in Table 5. To the extent possible, virgin flow gages, free from transbasin diversion, irrigation depletions, or storage regulation were desirable. Each potential indicator gage is discussed below:

Snake River near Moran, WY – As stated above, gages that are impacted by reservoir operations are not typically selected as an indicator gage. Located immediately below Jackson Lake, this gage reflects reservoir operations and would have required adjustment for change in reservoir storage and reservoir evaporation.

Buffalo Fork above Lava Creek near Moran, WY – This gage is one of the few long term gages that is minimally impacted by man’s activities. Located very near the Snake River Moran gage, this gage was expected to reflect the same hydrologic conditions as the Snake River gage, without requiring adjustment. Therefore, average, wet, and dry year determinations from this gage record were applied to gages and headwater inflow nodes for the entire Snake River basin.

Cache Creek near Jackson, WY – Although this gage is also unaffected by man’s activities, it was eliminated as an indicator gage because its small drainage area may not be hydrologically representative of larger sub-basins. For example, all other potential index gages have 1987 as a dry year. All except the Greys River have 1988 as a dry year as well. Cache Creek shows neither year as being dry. This gage was not selected as an indicator gage.

Snake River above Reservoir near Alpine, WY – This gage is significantly impacted by man’s activities. It reflects reservoir deliveries from Jackson Lake to Palisades Reservoir, as well as all consumptive uses in the Snake River basin. Since it is not a virgin flow gage, it was not selected as an indicator gage.

Greys River above Reservoir, near Alpine, WY – This gage is minimally impacted by man’s activities and can be assumed to be a virgin flow gage. Therefore, it was selected as an indicator gage. Average, wet and dry years determined from this gage were used to determine average, wet and dry year flows for the Salt River.

Salt River above Reservoir near Etna, WY – This gage is significantly impacted by man’s activities. Since it is not a virgin flow gage, it was not selected as an indicator gage. The Greys River gage will serve as the indicator gage for the Salt River.

## Results

In summary, the same two gages that served in determining study period of record became designated indicator gages for the study: Buffalo Fork above Lava Creek near Moran, WY, and Greys River above Reservoir, near Alpine, WY. If there had been additional suitable gages, more indicator gages could have been selected and applied to different sub-areas of the basin, but this was not the case.

## Table 5
## Potential Indicator Gages for the Snake and Salt River Basins

| | | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13011000 | Snake River near Moran, WY | Wet | | | Wet | | | Dry | Dry | | | | | | Wet | | Wet | Dry | Dry | Dry | Dry | | | Dry | | | Wet | Wet | | | | |
| 13011900 | Buffalo Fork above Lava Creek near Moran, WY | Wet | Wet | Dry | Wet | | | Dry | | | | | Wet | | | | | Dry | Dry | | | | Dry | | Dry | | Wet | Wet | | | | Dry |
| 13018300 | Cache Creek near Jackson, WY | Wet | Wet | | | | | Dry | | | | | | | | Dry | Wet | | | | Dry | Dry | Dry | | Dry | | Wet | Wet | Wet | | | Dry |
| 13022500 | Snake River above Reservoir near Alpine, WY | Wet | Wet | | Wet | | | Dry | | | | Dry | | | | | Wet | Dry | Dry | | | | Dry | | Dry | | Wet | Wet | | | | Dry |
| 13023000 | Greys River above Reservoir near Alpine, WY | Wet | Wet | | Wet | | | Dry | | | | Dry | | Wet | | | Wet | Dry | | | Dry | | Dry | | Dry | | | Wet | | | | Dry |
| 13027500 | Salt River above Reservoir near Etna, WY | Wet | Wet | | | | | Dry | | | | Dry | | Wet | Wet | | Wet | Dry | Dry | | Dry | | Dry | | | | | Wet | | | | Dry |

LEGEND

Dry Year

Wet Year

## Gage Filling and Data Extension

Six gages in the Snake/Salt Basin, including the Greys River gage selected as an indicator gage, have complete records over the study period The remaining gages required data filling or extension for all or part of the study period.

The mixed-station method described by Alley and Burns (1981) was used to fill the gage records for the Snake/Salt River Basin Models. Ayres Associates developed a Graphical User Interface for the Colorado Decision Support System as a front end to the USGS Mixed Station Model (Colorado River Decision Support System, 2000). This GUI and model were used to perform the data filling and extension.

The mixed station method allows the use of different independent gages to estimate gage flows for different missing members of a monthly time series. The Simple Linear Regression calculation option was used in this study. Accordingly, a simple linear regression model is developed for each independent gage with which a dependent gage has a common period of record. The regression that produces the smallest standard error of prediction (SEP) for a given month is then used to fill the missing data. The mixed station model also allows for either a cyclic or non-cyclic regression. The non-cyclic regression is developed from pairs of data for all months in the common record, and can be applied to any month. The cyclic approach, on the other hand, uses only same-month data pairs to develop a regression model for a given month. A minimum of five concurrent values was the threshold for use of the cyclic option. The smallest standard error is again the criterion to determine whether the cyclic or non-cyclic value is used.

To fill gages in the Snake Basin, the set of independent gages was limited to those within the basin and the gage on the Greys River above the Reservoir at Alpine. Due to the fewer potential independent gages in the Salt Basin, all Snake and Salt basin gages were available in the filling of the Salt River basin gages.

## Ungaged Tributary Inflow Estimation

Several tributaries to the Snake and Salt Rivers, while included in the model network, do not have maintained gaging stations/records. It was therefore necessary to estimate average, wet, and dry year flows for these catchments as inflows to the models. Inflow was estimated for tributaries with sizable diversion rights. Flow contributions from tributaries that do not have modeled diversions were included in the basin gain calculation.

An average annual runoff for these catchments was estimated using regression equations derived for mountainous regions of Wyoming published in USGS WRIR 88-4045 (Lowham, 1988). Derived from several long-term gage records, these regression equations estimate annual average runoff from physical parameters of catchment area and average elevation, or area and average annual precipitation. For this study, the average basin elevation method was used because it is the more basin-specific method. Catchment areas and mean basin elevations were derived from USGS 1:100000 scale topographic maps. The average elevation regression equation is:

$$Q_a = 0.0015A^{1.01}\left(\frac{Elev}{1000}\right)^{2.88}$$

*where,*

$Q_a$ = *annual runoff (cfs)*

$A$ = *contributing area (mi²)*

$Elev$ = *average basin elevation (feet)*

Once average annual discharge values were calculated, it was necessary to derive monthly runoff values for the entire model period. This was done by correlation to a nearby gaging station with similar catchment characteristics. The derived monthly values are the product of the respective gaged monthly flow multiplied by the ratio of the annual ungaged and gaged discharges. Once the time series of estimated flows was created, average, wet, and dry years flows were calculated based on the respective indicator gage. Table 6 presents the average annual runoff estimate using the above regression and the corresponding gage used in the distribution of flows for the Salt and Snake River Basins.

In some cases the annual flow estimations appeared low in comparison to nearby gaged catchments. In the event that this resulted in shortages to diversions in the spreadsheet models, a second estimation method was used. In this case, a simple area weighting of the monthly flows of a similar watershed in close proximity was used. This was the case in Cedar Creek, Lee Creek, Birch Creek, and Stewart Creek in the Salt River Basin. These tributary flows were estimated based on gaged flow in Strawberry Creek.

## Summary and Conclusions

- The model study period for both the Snake and Salt River Basins is 1971-2001.
- The following indicator gage and applicable hydrological areas have been selected:
    - Buffalo Fork above Lava Creek near Moran, WY – Snake River Basin
    - Greys River above Reservoir near Alpine, WY – Salt River Basin
- Gage records were filled using simple linear regression models selected by the USGS Mixed Station Model.
- Ungaged headwater flows were developed using elevation-based regression models; in a few cases this approach appeared inadequate and instead, nearby gage flow was scaled by drainage area.

## Table 6 Ungaged Tributary Streamflow Estimates, Methods of WRIR 88-4045

| Basin | Catchment and Downstream Extent | Drainage Area (sq. mi.) | Mean Basin Elevation (ft amsl) | Estimated Annual Runoff (Mean Basin Elevation Method) | | 1971-2001 Average Annual Flow at Nearest Recording Gage | | Notes |
|---|---|---|---|---|---|---|---|---|
| | | | | Annual Runoff AF | Annual Runoff AF/sq. mi. | Gage # | Annual Gaged Runoff AF/sq. mi. | |
| Salt | Spring Creek, S16 T31N R119W | 42.7 | 7532 | 16127 | **378** | 13025500 | **430** | MBE Method used. |
| Salt | Stewart Creek, S22 T36N R119W [1] | 7.9 | 7201 | 2595 | **330** | 13027000 | **2610** | MBE Method was not used. Estimate based on Strawberry Creek Flows. |
| Salt | Birch Creek, S36 T36N R119W | 2.8 | 8143 | 1270 | **460** | 13027000 | **2610** | MBE Method was not used. Estimate based on Strawberry Creek Flows. |
| Salt | Lee Creek, S12 T35N R119W [2] | 6.6 | 8094 | 2976 | **452** | 13027000 | **2610** | MBE Method was not used. Estimate based on Strawberry Creek Flows. |
| Salt | Cedar Creek, S5 T34N R118W | 5.9 | 8216 | 2823 | **476** | 13027000 | **2610** | MBE Method was not used. Estimate based on Strawberry Creek Flows. |
| Salt | Willow Creek near Turnerville, S14 T33N R118W | 14.2 | 8333 | 7126 | **500** | 13027000 | **2610** | MBE Method used. |
| Salt | Dry Creek, S8 T31N R118W | 20.5 | 8326 | 10250 | **501** | 13024500 | **1253** | MBE Method used. |
| Salt | Toms Creek, S6 T32N R119W | 18.8 | 6651 | 4932 | **262** | 13025500 | **430** | MBE Method used. |
| Salt | Stump Creek, S6 T32N R119W [1] | 102.7 | 7226 | 34542 | **336** | 13025500 | **430** | MBE Method used. |
| Snake | Lava Creek, confluence with Buffalo Fork | 27.1 | 7995 | 12096 | **447** | 13011900 | **1213** | MBE Method used. |
| Snake | Ditch Creek, confluence with Snake River | 63.2 | 7543 | 24078 | **381** | 13014500 | **634** | MBE Method used. |
| Snake | Spring Creek, S13 T40N R117W | 13.1 | 6440 | 3121 | **238** | 13016450 | **1600** | MBE Method used. |
| Snake | Fish Creek, S11 T41N R117W | 14.5 | 7680 | 5731 | **396** | 13016450 | **1600** | MBE Method used. |
| Snake | Nowlin, Twin and Sheep Creeks, S11 T41N R116W | 32.9 | 7826 | 13846 | **421** | 13018000 | **848** | MBE Method used. |
| Snake | Granite Creek (Hoback), confluence with Little Granite Creek | 61.5 | 8758 | 36003 | **586** | 13019500 | **925** | MBE Method used. |
| Snake | Upper Hoback, confluence of Granite Creek | 367.9 | 7828 | 158831 | **432** | 13019438 | **1146** | MBE Method used. |

Notes:
1. Calculations based on multiple sub-basins.
2. Includes Green and Prater Canyons.

## References

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