Chapter 3 HYDROLOGIC CONDITIONS

This chapter provides modeled hydrologic information for the upper Snake River basin. This information updates hydrologic information provided in the 2004 Upper Snake BA and is presented in three parts. Section 3.1 provides additional information regarding past and current hydrologic conditions in the Snake and Columbia River basins. Section 3.2 replaces the modeled analysis of the hydrologic effects from Reclamation's proposed actions provided in the 2004 Upper Snake BA; specifically assessing upper Snake flow augmentation volumes and timing, and the resulting flow conditions in the lower Snake and Columbia Rivers. Section 3.3 describes anticipated future hydrologic conditions in the Snake River at Brownlee Reservoir and downstream attributed to cumulative effects of non-Federal actions.

Most of the modeled analyses described here were conducted using the Upper Snake River MODSIM model, a general-purpose river and reservoir operations computer simulation model. The surface water distribution model, MODSIM Version 7, was used to analyze the flow effects of water development activities occurring upstream of Brownlee Reservoir, including Reclamation's proposed actions as described in this document. The Upper Snake River MODSIM model is an updated version of the model version used to conduct analyses described in the 2004 Upper Snake BA. See Appendix B for further discussion about these recent updates to the Upper Snake River MODSIM model.

3.1 Historical and Current Hydrologic Conditions

The 2004 Upper Snake BA describes historical hydrologic environmental baseline conditions and changes that occurred as a result of Reclamation's past operations as well as private upstream water development activities. The following text provides additional information on environmental baseline hydrologic conditions for the upper Snake River basin and the Columbia River basin, placing the hydrologic contributions of the upper Snake River in the context of flows in the larger mainstem Columbia River system.

3.1.1 Depletions in the Upper Snake River Basin

Reclamation conducted modeled analyses using MODISM to describe current flow conditions and the depletive effects attributed to its proposed actions as well as from private water development activities upstream. This information replaces information presented in the 2004 Upper Snake BA and is the most current information regarding depletive effects from water development activities located above Brownlee Reservoir in the upper Snake River basin. This analysis entailed comparisons of modeled inflows to Brownlee Reservoir for the 2007 Proposed Action scenario and for two other simulations that remove specific facets of water system development and land use practices. These two simulations include a “Without Reclamation” scenario and a “Naturalized Flow” scenario.

The modeled “Without Reclamation” scenario isolates the effects of Reclamation’s actions on Brownlee Reservoir inflows and the resulting downstream flow conditions to determine associated effects to listed salmon and steelhead below the Hells Canyon Complex. Through a rather complex analysis, this simulation removed Reclamation project operations from the model. A Brownlee Reservoir inflow hydrograph was calculated under the assumption that Reclamation’s storage projects no longer operated while private diversions and storage projects continued to operate. The development of the “Without Reclamation” scenario made no other assumptions as to how water users would react if Reclamation operations are not occurring. The “without Reclamation” hydrograph was then compared to Reclamation’s Proposed Action scenario in order to quantify the amount of water depletion occurring as a result of Reclamation’s upper Snake projects (see Table 3-1).

The modeled “Naturalized Flow” scenario represents inflows to Brownlee Reservoir that would be observed without the cumulative influence of all reservoir operations, irrigation diversions and groundwater pumping, both Federal and private, above Brownlee Reservoir. This “naturalized” hydrograph was compared to Reclamation’s Proposed Action scenario in order to quantify the amount of water depletion occurring as a result of all (Federal and private) irrigation practices (see Table 3-2). Very limited data exist on very early (pre- and early 1900s) diversions, and no data are available on pre-development flows of the Snake River. Accordingly, this “Naturalized Flow” scenario is only able to generally characterize the magnitude of the proposed action and cumulative effects attributed to the historical irrigation practices within the Snake River Basin on flows into Brownlee Reservoir.

Table 3-1. Modeled changes in flow into Brownlee Reservoir comparing Reclamation's Proposed Action and Without Reclamation scenarios for dry, average, and wet water year types. [1]

Month	Wet				Average				Dry			
	Proposed Action [2] (cfs)	Without Reclamation [3] (cfs)	Hydrologic Change		Proposed Action [2] (cfs)	Without Reclamation [3] (cfs)	Hydrologic Change		Proposed Action [2] (cfs)	Without Reclamation [3] (cfs)	Hydrologic Change	
			cfs	percent			Cfs	percent			cfs	percent
October	17,726	17,331	396	2	13,905	14,166	-262	-2	12,247	12,661	-414	-3
November	19,903	24,161	-4,258	-18	15,735	20,629	-4,894	-24	14,053	18,045	-3,992	-22
December	19,259	24,354	-5,095	-21	15,431	20,678	-5,247	-25	12,700	17,247	-4,547	-26
January	34,405	28,772	5,634	20	17,472	20,153	-2,681	-13	12,174	17,152	-4,977	-29
February	34,295	28,548	5,747	20	18,586	22,328	-3,742	-17	12,091	17,588	-5,497	-31
March	46,161	44,065	2,097	5	20,712	26,218	-5,506	-21	11,957	18,538	-6,581	-35
April	54,281	56,760	-2,479	-4	28,842	35,502	-6,661	-19	11,652	14,767	-3,115	-21
May	55,860	75,034	-19,173	-26	31,306	43,349	-12,043	-28	12,122	15,076	-2,954	-20
June	44,760	66,988	-22,227	-33	26,899	36,088	-9,189	-25	9,358	9,464	-106	-1
July	17,607	17,248	359	2	11,798	9,740	2,058	21	6,981	4,915	2,065	42
August	12,386	7,412	4,974	67	9,840	5,996	3,844	64	6,736	4,261	2,475	58
September	14,433	10,331	4,102	40	11,888	8,477	3,411	40	8,446	6,419	2,028	32

1 Period of Record: 1929 - 1998 – Water year types based on annual Brownlee Reservoir inflows calculated using MODSIM Proposed Action scenario.

2 The Proposed Action scenario simulates future hydrologic conditions with implementation of the proposed actions (storing, releasing, and diverting project water).

3 The Without Reclamation scenario simulates hydrologic conditions if Reclamation's reservoirs and diversions were not operating.

Wet Years: Average of years at or below 10 percent exceedance
Average Years: Average of years between 10 percent and 90 percent exceedance
Dry Years: Average of years at or above 90 percent exceedance

Source: Upper Snake River MODSIM, May 2007 run.

Table 3-2. Modeled changes in flow into Brownlee Reservoir comparing Reclamation's Proposed Action and Naturalized Flow scenarios for dry, average, and wet water year types. [1]

Month	Wet				Average				Dry			
	Proposed Action [2] (cfs)	Naturalized Flow [3] (cfs)	Hydrologic Change cfs	Hydrologic Change percent	Proposed Action [2] (cfs)	Naturalized Flow [3] (cfs)	Hydrologic Change Cfs	Hydrologic Change percent	Proposed Action [2] (cfs)	Naturalized Flow [3] (cfs)	Hydrologic Change cfs	Hydrologic Change percent
October	17,726	20,968	-3,242	-15	13,905	16,901	-2,996	-18	12,247	15,546	-3,299	-21
November	19,903	19,603	300	2	15,735	15,770	-35	0	14,053	13,026	1,027	8
December	19,259	20,373	-1,113	-5	15,431	16,601	-1,170	-7	12,700	13,000	-301	-2
January	34,405	25,758	8,648	34	17,472	16,618	854	5	12,174	13,501	-1,327	-10
February	34,295	25,692	8,603	33	18,586	18,888	-302	-2	12,091	13,864	-1,773	-13
March	46,161	43,451	2,710	6	20,712	24,435	-3,723	-15	11,957	16,041	-4,084	-25
April	54,281	64,277	-9,996	-16	28,842	41,542	-12,700	-31	11,652	22,120	-10,467	-47
May	55,860	94,161	-38,300	-41	31,306	60,186	-28,879	-48	12,122	30,605	-18,483	-60
June	44,760	90,330	-45,570	-50	26,899	57,851	-30,952	-54	9,358	22,844	-13,485	-59
July	17,607	40,817	-23,210	-57	11,798	25,632	-13,834	-54	6,981	10,174	-3,193	-31
August	12,386	21,612	-9,226	-43	9,840	14,359	-4,519	-31	6,736	8,056	-1,320	-16
September	14,433	20,495	-6,061	-30	11,888	14,913	-3,025	-20	8,446	9,683	-1,237	-13

1 Period of Record: 1929 - 1998 – Water year types based on annual Brownlee Reservoir inflows calculated using MODSIM Proposed Action scenario.

2 The Proposed Action scenario simulates future hydrologic conditions with implementation of the proposed actions (storing, releasing, and diverting project water).

3 The Naturalized Flow scenario simulates hydrologic conditions removing the cumulative influence of Federal and private reservoir operations, irrigation diversions, and groundwater pumping above Brownlee Reservoir.

Wet Years: Average of years at or below 10 percent exceedance
Average Years: Average of years between 10 percent and 90 percent exceedance
Dry Years: Average of years at or above 90 percent exceedance

Source: Upper Snake River MODSIM, June 2007 run.

These model configurations were based on the most current available information, and the data availability dictated the techniques or assumptions made in its development. These scenarios are designed to make relative comparisons of modeled simulations. While every attempt was made to quantify and identify all land use influences, other minor effects exist that were difficult to quantify or even identify. The analyses that follow provide additional information about hydrologic effects associated with actions in the upper Snake, focusing on the combined flow effects attributed to Reclamation's proposed actions as well as the effects attributed to private water development activities that occur upstream of Brownlee Reservoir.

Tables 3-1 and 3-2 provide the modeled monthly inflows to Brownlee Reservoir comparing Reclamation's Proposed Action to the "Without Reclamation" scenario (see Table 3-1) and the "Naturalized Flow" scenario (see Table 3-2) for wet, average, and dry water year types. The amount of water depleted varies depending on hydrologic conditions each year. Model output data for the 1929 to 1998 period of record were sorted and categorized into wet, average, and dry water year types based on the modeled total annual volume into Brownlee Reservoir for the MODSIM Proposed Action scenario. The wet and dry water year types each constitute 10 percent of the years, whereas the average group of water year types comprises the remaining 80 percent. For each of these categories, the data were averaged and are provided in Tables 3-1 and 3-2.

Table 3-1 indicates that the greatest volume of monthly depletions resulting from Reclamation's proposed actions occurs in May and June in wet and average years, and February and March of dry water year types. In dry years, monthly depletions are more evenly distributed from November through May, with the greatest depletions occurring in February and March. In all water year types, Reclamation's proposed actions improve inflows to Brownlee Reservoir for the summer months (July and August) and September by as much as 67 percent. Reclamation's proposed actions reduce the total inflow into Brownlee Reservoir for the months of April through June combined by 22 percent during wet water year types. Total inflow into Brownlee Reservoir for the same period is reduced by 24 percent during average years whereas flow reductions in dry years comprise about 16 percent of total Brownlee Reservoir inflow for these same months. Conversely, Reclamation's proposed actions result in increased flow into Brownlee Reservoir by 27 percent for July through September during wet water years. During average and dry water years, modeled Brownlee Reservoir inflow for this period increased by 38 percent and 42 percent, respectively. Reduced flows during the spring months are an artifact of Reclamation's projects storing a portion of the reservoir inflows for subsequent delivery during the summer irrigation months or flood control operations.

Table 3-2 indicates that the greatest volume of modeled monthly depletions from Reclamation's proposed actions and private diversions combined occurs in May and June in wet and average years. In dry years, the greatest volume of monthly depletions occurs in April through June. Increased flows occur in January and March in wet years because of project operations for flood control. Reclamation's proposed actions and private diversions combined reduce the total flow into Brownlee Reservoir for the months of April through June by 38 percent during wet water year types, reduce flow by 45 percent during average years, and reduce flow in dry years by 56 percent. During the summer months of July and August, depletions into Brownlee, comparing the Proposed Action to the Naturalized Flow scenario, comprise 52 percent of total flow under wet water year conditions, 46 percent of total flow in average water years, and about 25 percent in dry water years.

Table 3-3 presents the modeled average monthly and average annual depletion volumes for the Without Reclamation and the Naturalized Flow modeled scenarios. Average depletions into Brownlee Reservoir attributed to Reclamation's proposed actions total 2.3 million acre-feet annually for the 1928 to 2000 period of record. Modeled data for the Snake River basin for the 1928 to 2000 period indicate that all irrigation development, including Reclamation's actions and private diversions, have depleted average inflows into Brownlee Reservoir by approximately 6.0 million acre-feet annually.

3.1.2 Flow Conditions in the Snake and Columbia Rivers

Figure 3-1 shows the historical observed average monthly flows for the Snake and Columbia River systems from 1996 through 2006. Snake River flows are represented by plot lines showing observed inflows into Brownlee Reservoir and discharges at Lower Granite Dam. Columbia River flows are depicted for discharges below McNary and Bonneville Dams and below the Willamette River. The plot of the Columbia River below the Willamette River is the sum of the discharge from Bonneville Dam and the flow below Salem, Oregon, on the Willamette River. This calculation is an estimate of flows in the Columbia River near its mouth.

As shown in Figure 3-1, flows in the Snake and Columbia systems peak in May and June and are lowest in September and October. Higher flows in December and January at the Columbia River mouth result from higher flows on the Willamette River during these winter months (flows in the Willamette River are largely influenced by rainfall compared to the Columbia River which is largely influenced by snowmelt). Figure 3-1 shows the relative amount of water coming from the Snake River above Brownlee Dam and below Lower Granite Dam as compared to the total

Table 3-3. Modeled changes in average monthly volumes into Brownlee Reservoir comparing Reclamation's Proposed Action to the Naturalized Flow and Without Reclamation scenarios. [1]

Month	Comparing Proposed Action to Naturalized Flow				Comparing Proposed Action to Without Reclamation			
	Proposed Action [2] (acre-feet)	Naturalized Flow [3] (acre-feet)	Hydrologic Change		Proposed Action [2] (acre-feet)	Without Reclamation [4] (acre-feet)	Hydrologic Change	
			acre-feet	percent			acre-feet	percent
October	868,174	1,061,763	-193,589	-18	868,174	888,397	-20,223	-2
November	954,126	951,814	2,312	0	954,126	1,240,072	-285,946	-23
December	959,011	1,026,000	-66,989	-7	959,011	1,277,173	-318,162	-25
January	1,155,117	1,065,473	89,644	8	1,155,117	1,280,110	-124,994	-10
February	1,098,231	1,070,999	27,232	3	1,098,231	1,261,276	-163,045	-13
March	1,399,893	1,590,271	-190,378	-12	1,399,893	1,694,586	-294,693	-17
April	1,776,880	2,499,800	-722,920	-29	1,776,880	2,121,672	-344,792	-16
May	1,973,229	3,753,075	-1,779,846	-47	1,973,229	2,709,379	-736,149	-27
June	1,605,554	3,430,023	-1,824,470	-53	1,605,554	2,172,237	-566,684	-26
July	730,273	1,576,301	-846,028	-54	730,273	612,063	118,209	19
August	602,690	891,676	-288,987	-32	602,690	367,692	234,998	64
September	703,980	892,365	-188,385	-21	703,980	504,526	199,455	40
Average Annual	**13,827,157**	**19,809,559**	**-5,982,402**	**-30**	**13,827,157**	**16,129,185**	**-2,302,028**	**-14**

1 Period of Record: 1928 – 2000.

2 The Proposed Action scenario simulates future hydrologic conditions with implementation of the proposed actions (storing, releasing, and diverting project water).

3 The Naturalized Flow scenario simulates hydrologic conditions removing the cumulative influence of Federal and private reservoir operations, irrigation diversions, and groundwater pumping above Brownlee Reservoir.

4 The Without Reclamation scenario simulates hydrologic conditions if Reclamation's reservoirs and diversions were not operating.

Source: Upper Snake MODSIM, May and June 2007 runs flow in the lower Columbia River. When monthly flows are compared, Snake River flows at Brownlee Reservoir contribute between 6 percent (July) and 14 percent (March) to the total flow of the Columbia River at McNary Dam and slightly less to the total Columbia River flow downstream.

The scale of Figure 3-1 does not allow one to discern the shape of the Snake River inflow into Brownlee Reservoir hydrograph because the graph must include Columbia River flows that exceed 325,000 cfs, and Snake River flows into Brownlee Reservoir are much smaller (flows up to about 30,000 cfs). Figure 3-2 shows the same historical observed average monthly inflow data for Brownlee Reservoir for the same 1996 through 2006 period at a different scale that better illustrates the shape of the hydrograph. Inflows peak at approximately 30,000 cfs during April and May when snowmelt occurs and are less, around 11,000 cfs, during the irrigation season in July, August, and September. Because the scale of Figure 3-2 is much smaller (only showing flows to 35,000 cfs), the Snake River curve is more clearly defined than is shown in Figure 3-1.

The historical average annual flow from 1996 through 2006 was approximately 14 million acre-feet into Brownlee Reservoir and about 36 million acre-feet below Lower Granite Dam. Model runs that were updated in 2007 for the Snake River upstream of Brownlee Reservoir using data for water years 1928 through 2000 indicated that the annual average difference in flows with and without the effect of Reclamation's operations was 2.3 million acre-feet (see Table 3-3). This difference in annual flow represents approximately 14 percent of the annual inflow to Brownlee Reservoir, and approximately 2 percent of the average annual flow of about 128 million acre-feet in the Columbia River at McNary Dam. These calculations indicate that the modeled differences in Reclamation operations on the Snake River have a small relative impact on the lower Columbia River flows.

Approximately 6.0 million acre-feet of average annual depletions at Brownlee Reservoir from all upstream diversions represents a 30 percent decrease annually on average to Brownlee Reservoir inflows, but comprises less than 5 percent of the total Columbia River flow at McNary Dam. This modeled analysis indicates that reductions in Snake River flows resulting from Federal and non-Federal irrigation in the upper Snake River basin most directly affect the Snake River below Hells Canyon Dam and to a lesser extent to Lower Granite Dam. However, depletions associated with actions in the upper Snake have a small effect compared to the magnitude of flows in the lower Columbia River flows.

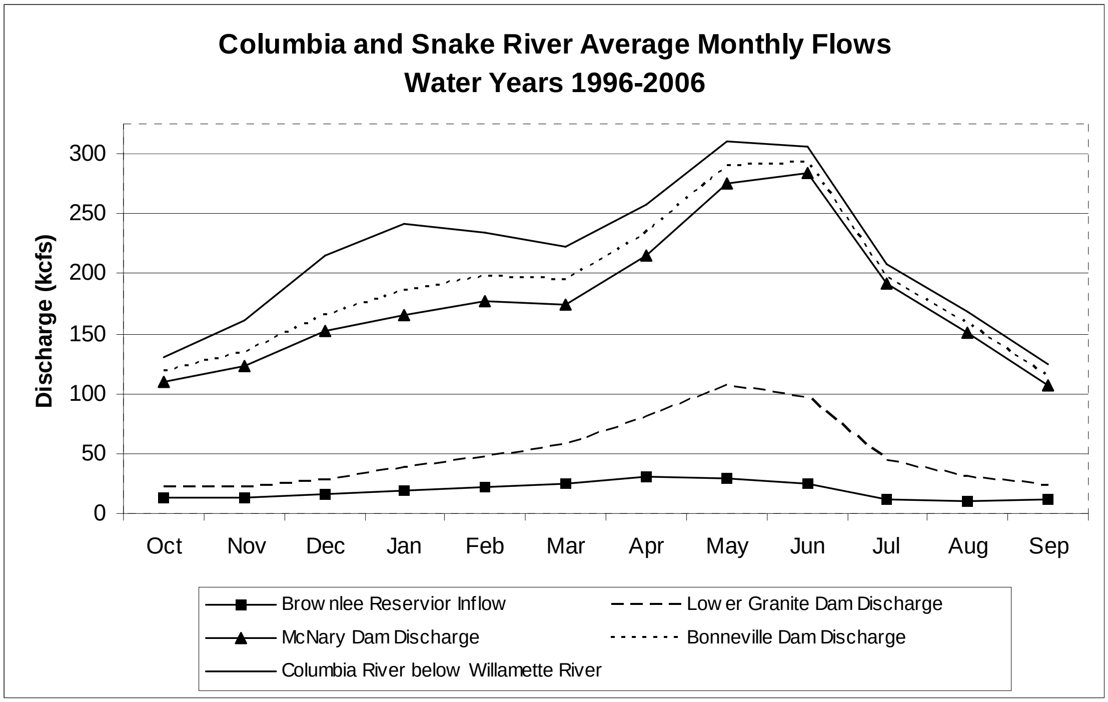

Figure 3-1. Average monthly flows for select locations on the Snake and Columbia Rivers.

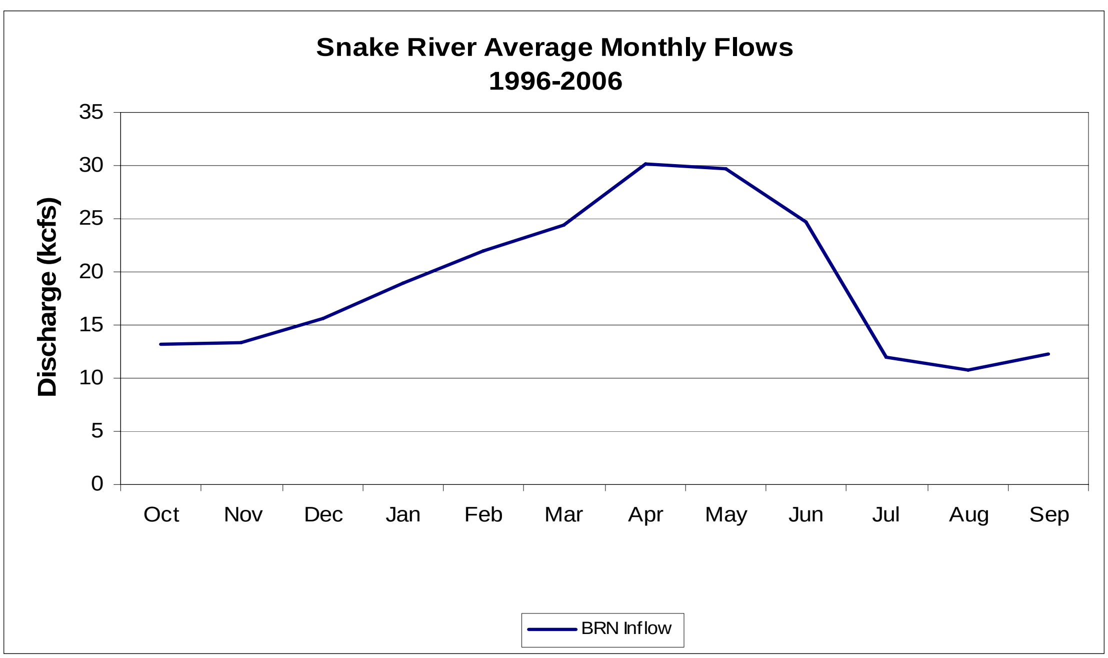

Figure 3-2. Average monthly flows for Snake River at Brownlee Reservoir.

With the exception of 2006, dry weather in southern Idaho has contributed to lower flows in the Snake River beginning in 2000. Figure 3-3 shows the annual average flows as measured by the U.S. Geological Survey (USGS) gage in the Snake River at Weiser. The lower flows in recent years are the result of a combination of low precipitation and the delayed influences of both groundwater pumping and water conservation practices.

Flow from springs along the Snake River has also decreased. The largest concentration of natural springs exists in the Snake River reach from Milner to King Hill, which includes the Thousand Springs. Figure 3-4 depicts spring discharge trends from 1902 to 2003, showing a general increase from 1902 to 1951 and a general downward trend to 2003. The flows peaked in 1951 at 6,820 cfs and had dropped to 5,200 cfs by 2003 (Ondrechen 2004; Kjelstrom 1995). Section 3.3 discusses the potential future hydrologic conditions in the upper Snake River basin given the current trends.

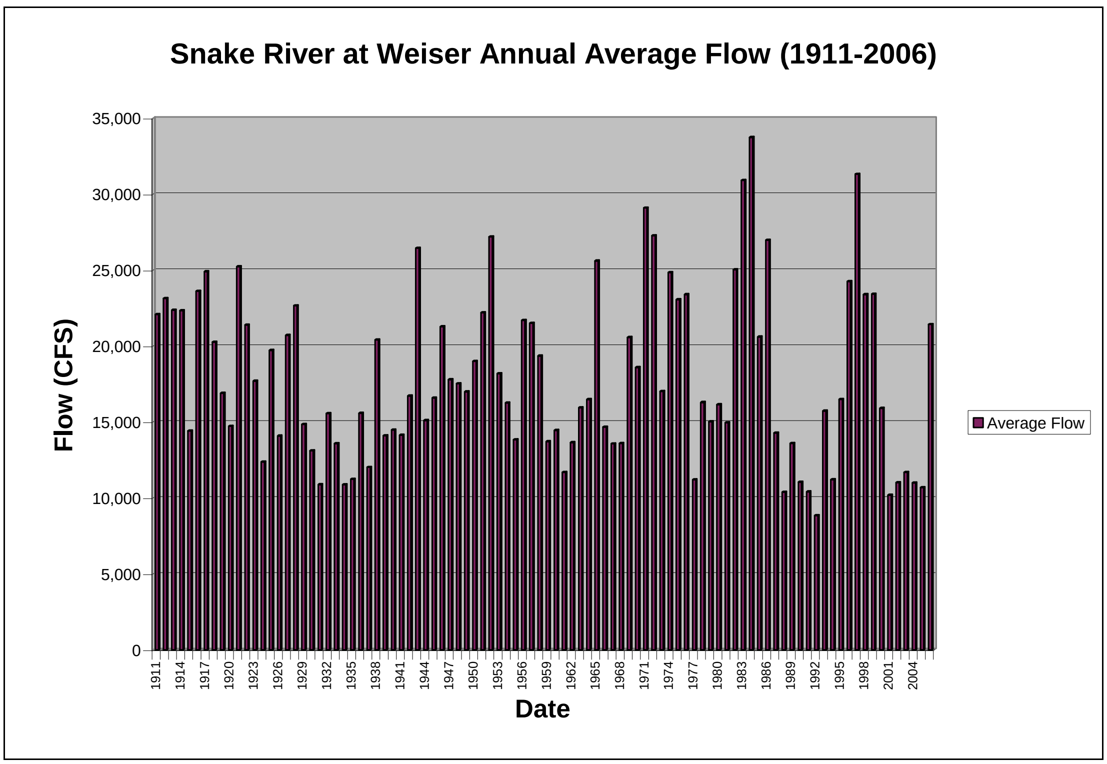

Figure 3-3. Average annual flow for the Snake River at Weiser for the 1911 to 2006 period.

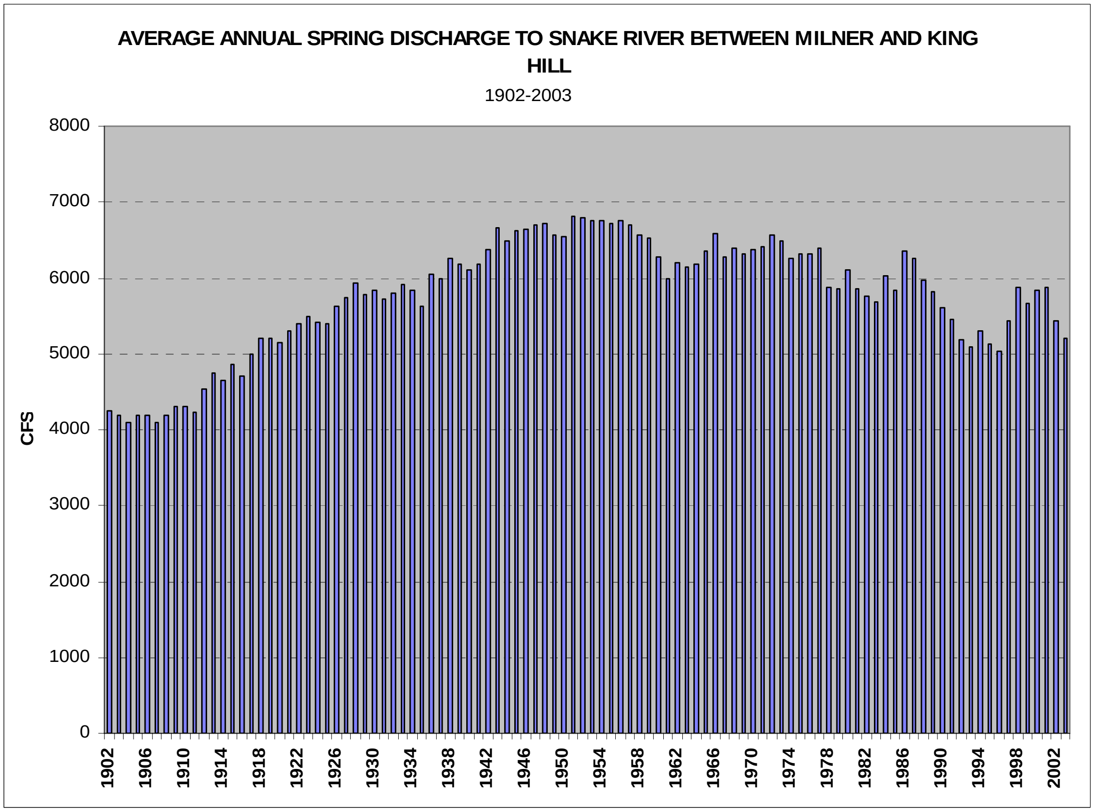

Figure 3-4. Average annual spring discharge to Snake River, Milner to King Hill reach, for 1902 to 2003 period (Source: Ondrechen 2004; Kjelstrom 1995).

3.2 Modeled Hydrologic Analysis of Proposed Actions

Chapter 2 described proposed refinements to Reclamation's proposed actions involving adjustments to the timing of upper Snake River flow augmentation delivery. The following text discusses the modeled hydrologic analyses of flow conditions anticipated to occur as a result of Reclamation's proposed actions, including the cumulative effects of private storage and diversions in the upper Snake on downstream flows. Information is provided on salmon flow augmentation quantities and frequencies during wet, average, and dry water years; the effect on river flows of shifting the timing of flow augmentation releases to earlier in the year; and the resulting flow conditions in the lower Snake River and Columbia River.

3.2.1 Modeled Analysis of Salmon Flow Augmentation

Reclamation has conducted modeled analyses to investigate the proposed refinements to flow augmentation management for this remand. The Upper Snake River MODSIM model used is an updated version of the model used in the 2004 Upper

Snake BA. The data summarized in the tables, graphs, and text were developed using the 2007 updated MODSIM model. Refer to Appendix B for background information on the MODSIM.

3.2.1.1 Upper Snake Flow Augmentation Volume Delivered

One of the challenges in providing flow augmentation is predicting the amount of available water. Reclamation is committed to improving the certainty of acquiring annual flow augmentation volumes. Flow augmentation largely relies on willing sellers offering water to Reclamation for lease. The availability of water for lease from Idaho's rental pools for flow augmentation varies with runoff volume, carryover storage, general rental pool conditions, and legal and institutional constraints. Many of these factors are outside of Reclamation's control. The best currently available estimate of Reclamation's ability to acquire water for this purpose under the proposed actions is that the future rental water availability will closely mimic recent conditions. Reclamation conducted a modeled analysis using the experience it has gained from past flow augmentation activities to identify flow augmentation volume goals by water year type to allow improved regional planning and management of river flows for the benefit of ESA-listed salmon and steelhead.

Table 3-4 is a matrix that represents the modeled range of potential augmentation water delivery to Brownlee Reservoir under various water year forecast and reservoir storage carryover conditions. The modeled data in Table 3-4 demonstrate that the April through September runoff forecast is the driving component for determining the potential volume available for flow augmentation each year. In general, the greater the runoff forecast volume, the greater the amount of augmentation water delivered. Similarly, the greater the volume of water in storage at the end of the previous irrigation season (carryover), the greater the amount of flow augmentation potential for the succeeding year. At this time, values in Table 3-4 represent a reasonable estimate of targeted flow augmentation volumes for delivery under recently experienced operating conditions and assumptions.

The relationship among forecast, carryover, and subsequent flow augmentation volume is not exact. Other factors, especially actual runoff versus forecast runoff (that is, effects of nature), can influence these relationships and, in turn, produce different results under actual operating conditions than those produced in the model. The flow of the Snake River above Hells Canyon Dam is highly variable. Total annual historical flows range from a minimum of 6,428,000 acre-feet in 1992 to a maximum of 24,504,000 acre-feet in 1984. Maximum annual storage volume in Reclamation's seven storage reservoirs above Milner Dam has ranged from 2,254,000 acre-feet in 2004 to 4,045,695 acre-feet, the maximum storage capacity. The system is rarely completely full, but fills to within 100,000 to 200,000 acre-feet of maximum in roughly 40 percent of the years.

Table 3-4. Matrix of modeled flow augmentation volume by water year type and reservoir carryover. [1]

Total November 1 Carryover Volume [3]	**Total April 1 Forecast** [2] **Less than 5,400,000 acre-feet** *(represents dry years)*	**5,400,000 to 8,699,999 acre-feet** *(represents average years)*	**8,700,000 acre-feet or greater** *(represents wet years)*
Less than 2,400,000 acre-feet ***(represents dry years)***	average: 198,000 minimum: 146,000 maximum: 254,000	average: 391,000 minimum: 277,000 maximum: 428,000	average: 452,000 minimum: 427,000 maximum: 477,000
2,400,000 – 3,599,999 acre-feet ***(represents average years)***	average: 360,000 minimum: 191,000 maximum: 487,000	average: 475,000 minimum: 396,000 maximum: 487,000	487,000
3,600,000 acre-feet or greater ***(represents wet years)***	average: 370,000 minimum: 204,000 maximum: 464,000	487,000	487,000

1 Assumptions: (1) The modeled period of record is from water years 1928 through 2000; (2) The calculated unregulated runoff volumes were sorted and divided into fourths, based on modeled output, to represent dry (bottom fourth), average (two middle fourths), and wet (top fourth) water years; and (3) The carryover volumes were similarly divided, based on modeled output, to represent dry, average, and wet water years.

2 Combined April 1 through September 30 total unregulated runoff forecast for Snake River at Heise, Payette River at Horseshoe Bend, and Boise River at Lucky Peak.

3 Combined November 1 contents (active storage) at Grassy Lake, Jackson, Palisades, Ririe, American Falls, Walcott, Island Park, Anderson Ranch, Arrowrock, Lucky Peak, Deadwood, and Cascade Reservoirs.

Source: Snake River MODSIM, May 2007

Table 3-4 illustrates a simplified version of a very complex system of water accounting and delivery on the Snake River. Actual operations are based on real-time, imperfect forecasts that ultimately influence the amount of water available for augmentation. In addition, actual augmentation volumes assume that a willing seller of reservoir storage water exists. Historically, rental water can be a substantial portion of the total augmentation water in the system comprising as much as 67 percent and as little as 10 percent of the total volume delivered. Rental water has averaged 42 percent of the total volume of flow augmentation delivered in a year.

Reclamation's modeled analyses predict that Reclamation will be able to provide a significant volume of water for flow augmentation in every year (see Table 3-4). Although the full 487,000 acre-feet cannot be guaranteed in all years, at least 400,000 acre-feet would be available in 7 of 10 years. In dry years, such as the 1-in-10 year occurrence, it is expected that 279,000 acre-feet would be available for flow augmentation. In dry years such as 1994, the modeled augmentation volume of 251,245 acre-feet would be 9.6 percent of the April through August inflows into Brownlee Reservoir. In wet years such as 1999, the modeled 487,000 acre-feet would equal 5.4 percent of the April through August Brownlee Reservoir inflows.

3.2.1.2 Timing of Salmon Flow Augmentation Water Delivery

As discussed above, Reclamation is proposing to refine its flow augmentation activities to deliver water at times most beneficial to ESA-listed salmon and steelhead. *Chapter 2, Description of the Proposed Actions* describes how Reclamation would operate to provide flow augmentation water earlier in the season.

Figure 3-5 illustrates current delivery of flow augmentation and how it can be adapted to shift the timing of some flow augmentation releases to earlier timeframes. These estimated volumes are an example of how Reclamation could release water for flow augmentation. Year-to-year water conditions and reservoir carryover storage will dictate specific operations.

Table 3-5 provides the modeled inflows to Brownlee Reservoir resulting from the proposed actions and other upstream water development activity under dry, average, and wet water year types. The table also identifies the proportion of inflows that are comprised of flow augmentation water. In wet water years, flow augmentation would be delivered predominantly in the summer months as system capacity and flood control operations would constrain the ability to deliver it in the spring, comprising 13 to 14 percent of Brownlee Reservoir inflow in the summer (see Table 3-5). In dry or average water years, Reclamation would have the operational flexibility to shift delivery of some flow augmentation water to earlier in the spring season to more closely mimic the spring freshet. In these years, modeled flow augmentation comprised 6 to 7 percent of May and June inflow to Brownlee Reservoir in average years and almost 12 percent of Brownlee Reservoir inflow in dry years.

Operational constraints at some Reclamation projects (described in *Section 2.3.2, Proposed Flow Augmentation Operational Refinements*) provide challenges to shifting the timing of flow augmentation water delivery to Brownlee Reservoir. The augmentation contribution in the month of April is consistent for all water year types. The dry water year types have low Brownlee Reservoir inflows when compared to the other years. However, Table 3-5 illustrates that in dry type water years, the flow augmentation contribution is almost 12 percent in May and June. The flow augmentation component in wet and average type water years ranges between 11.5 and 15.0 percent, but is instead delivered during the months of July and August.

In very wet years with high spring through early summer flows in the lower Snake and Columbia Rivers, dam operators are challenged to meet established standards for total dissolved gas. Reclamation would delay the start of augmentation releases in those situations, but would still attempt to provide augmentation releases before the end of July, where possible. The constraints associated with some project operations require that some flow augmentation water will still be provided during August.

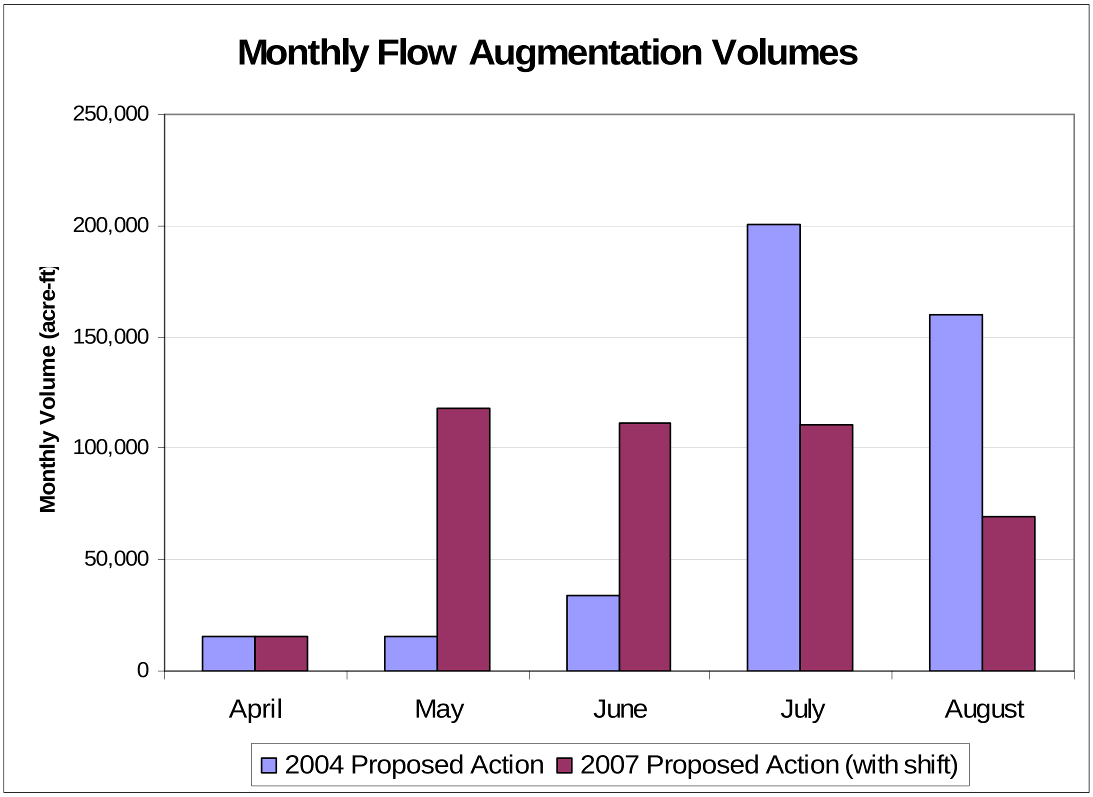

Figure 3-5. Comparison of average monthly flow augmentation volumes for the 2004 Proposed Action and the 2007 Proposed Action (water years 1928 to 2000).

Table 3-5. Modeled total Brownlee Reservoir inflows and flow augmentation component for the Proposed Actions using a 1928 to 2000 period of record.

Month	Average of Wet Years (at or below 10 percent exceedance)			Average of Average Years (between 10 percent and 90 percent exceedance)			Average of Dry Years (at or above 90 percent exceedance)		
	Total Inflows (cfs)	Flow Augmentation Component		Total Inflows (cfs)	Flow Augmentation Component		Total Inflows (cfs)	Flow Augmentation Component	
		cfs	percent		cfs	percent		cfs	percent
April	58,139	261	0.45	28,667	261	0.91	11,652	261	2.24
May	57,995	1,505	2.59	32,663	2,016	6.17	12,526	1,498	11.96
June	42,746	1,555	3.64	27,203	2,005	7.37	9,358	1,098	11.73
July	20,704	2,977	14.38	11,873	1,826	15.38	7,213	350	4.85
August	12,935	1,682	13.00	10,171	1,171	11.52	6,961	350	5.03

Source: Upper Snake MODSIM – May 2007

3.2.2 Modeled Lower Snake and Columbia River Flows

The Upper Snake River MODSIM database and output do not extend to control points below Brownlee Dam. In order to quantify potential flow effects at Lower Granite and McNary Dams from Reclamation's proposed actions (including the storage, release, and diversion of project water), it was necessary to integrate flows above Brownlee Dam with those of reservoirs in the FCRPS. This was accomplished by using BPA's HYDSIM model output for water years 1929 through 1998. See the *Comprehensive Analysis*, Appendix B (USACE et al. 2007b) for more information on the HYDSIM model.

The analysis assumed that inflows to Brownlee Reservoir were passed through the Hells Canyon Complex. To calculate the resulting flow conditions in the lower Snake and Columbia River, output from the HYDSIM model run FRIII_BIOP2007Prosp_CRWMP, representing modeled flows in the lower Snake and Columbia Rivers from the proposed upper Snake and FCRPS actions, were adjusted using output from MODSIM. Hydrologic changes at Brownlee Reservoir, calculated by comparing modeled inflows for the Proposed Action and Without Reclamation MODSIM scenarios (see Table 3-1), were used to adjust modeled HYDSIM discharge at Lower Granite and McNary Dams. Tables 3-6 and 3-7 display the adjusted HYDSIM data for discharge at Lower Granite and McNary Dams for the proposed actions and without Reclamation operating for dry, average, and wet water year types as measured by total annual inflow at Brownlee Reservoir for the 1929 to 1998 period. The tables indicate the resulting modeled flow conditions on the lower Snake and Columbia River from Reclamation's upper Snake operations as well as the FCRPS operations and all private non-Federal operations combined. The tables also show the modeled flow conditions that would occur without Reclamation's upper Snake proposed actions (Without Reclamation) and the hydrologic change attributed to the upper Snake actions in the lower Snake and Columbia Rivers.

Water year type conditions for the upper Snake basin do not always coincide with similar water year conditions in other watersheds within the Columbia River basin. For example, a dry year in the upper Snake may occur in the same year that the Clearwater or Salmon River basins experience average or wet year conditions.

Reclamation's upper Snake actions deplete monthly flows at Lower Granite Dam during the April to June spring period by 2 to 13 percent, with the greatest depletions occurring in wet and average water year types (see Table 3-6). The proposed actions increased flows at Lower Granite Dam during the summer months of July and August and in September for all water year types. Flows increased as much as 15 percent during this period in wet years and as high as 12 percent in dry years. As described in Section 3.1.2 and demonstrated in Table 3-7, Reclamation's depletive effects are

Table 3-6. Modeled Lower Granite Dam discharge comparing Reclamation's Proposed Action and Without Reclamation scenarios for dry, average, and wet water year types. [1]

Month	Wet				Average				Dry			
	Proposed Action [2] (cfs)	Without Reclamation [3] (cfs)	Hydrologic Change		Proposed Action [2] (cfs)	Without Reclamation [3] (cfs)	Hydrologic Change		Proposed Action [2] (cfs)	Without Reclamation [3] (cfs)	Hydrologic Change	
			cfs	percent			cfs	percent			cfs	percent
October	23,518	23,122	396	2	20,108	20,369	-262	-1	18,135	18,549	-414	-2
November	30,658	34,916	-4,258	-12	23,604	28,497	-4,894	-17	19,759	23,751	-3,992	-17
December	33,602	38,697	-5,095	-13	31,241	36,488	-5,247	-14	25,672	30,220	-4,547	-15
January	56,646	51,013	5,634	11	34,923	37,603	-2,681	-7	26,689	31,666	-4,977	-16
February	71,001	65,255	5,747	9	42,883	46,624	-3,742	-8	28,709	34,205	-5,497	-16
March	96,397	94,300	2,097	2	49,065	54,571	-5,506	-10	30,051	36,632	-6,581	-18
April	116,680	119,158	-2,479	-2	82,852	89,513	-6,661	-7	52,094	55,208	-3,115	-6
May	151,043	170,217	-19,173	-11	107,231	119,274	-12,043	-10	62,200	65,154	-2,954	-5
June	149,023	171,251	-22,227	-13	103,085	112,274	-9,189	-8	42,420	42,526	-106	-0
July	63,818	63,460	359	1	48,864	46,806	2,058	4	28,465	26,400	2,065	8
August	37,457	32,483	4,974	15	32,240	28,396	3,844	14	23,794	21,320	2,475	12
September	30,921	26,819	4,102	15	26,627	23,216	3,411	15	20,480	18,452	2,028	11

1 Period of Record: 1929 - 1998 – Water year types based on annual Brownlee Reservoir inflows calculated using MODSIM Proposed Action scenario.

2 The Proposed Action scenario simulates future hydrologic conditions with implementation of the proposed actions (storing, releasing, and diverting project water).

3 The Without Reclamation scenario simulates hydrologic conditions if Reclamation's reservoirs and diversions were not operating.

Wet years: Average of years at or below 10 percent exceedance
Average years: Average of years between 10 percent and 90 percent exceedance
Dry years: Average of years at or above 90 percent exceedance

Source: HYDSIM – FRIII_BIOP2007Prosp_CRWMP run

Table 3-7. Modeled McNary Dam discharge comparing Reclamation's Proposed Action and Without Reclamation scenarios for dry, average, and wet water year types. [1]

Month	Wet				Average				Dry			
	Proposed Action [2] (cfs)	Without Reclamation [3] (cfs)	Hydrologic Change		Proposed Action [2] (cfs)	Without Reclamation [3] (cfs)	Hydrologic Change		Proposed Action [2] (cfs)	Without Reclamation [3] (cfs)	Hydrologic Change	
			cfs	percent			cfs	percent			cfs	percent
October	113,969	113,573	396	0	109,961	110,223	-262	-0	105,341	105,755	-414	-0
November	121,881	126,139	-4,258	-3	119,542	124,436	-4,894	-4	126,376	130,368	-3,992	-3
December	131,555	136,650	-5,095	-4	134,494	139,741	-5,247	-4	140,949	145,497	-4,547	-3
January	221,659	216,025	5,634	3	172,270	174,951	-2,681	-2	148,664	153,641	-4,977	-3
February	202,129	196,382	5,747	3	156,580	160,321	-3,742	-2	139,786	145,283	-5,497	-4
March	244,257	242,160	2,097	1	150,712	156,218	-5,506	-4	119,933	126,514	-6,581	-5
April	270,498	272,976	-2,479	-1	202,221	208,882	-6,661	-3	162,709	165,824	-3,115	-2
May	352,652	371,825	-19,173	-5	277,896	289,940	-12,043	-4	186,050	189,003	-2,954	-2
June	373,074	395,301	-22,227	-6	301,663	310,852	-9,189	-3	199,657	199,763	-106	-0
July	247,655	247,296	359	0	199,514	197,456	2,058	1	171,141	169,075	2,065	1
August	167,569	162,595	4,974	3	147,783	143,939	3,844	3	135,412	132,937	2,475	2
September	103,334	99,232	4,102	4	100,224	96,813	3,411	4	90,526	88,498	2,028	2

1 Period of Record: 1929 - 1998 – Water year types based on annual Brownlee Reservoir inflows calculated using MODSIM Proposed Action scenario.

2 The Proposed Action scenario simulates future hydrologic conditions with implementation of the proposed actions (storing, releasing, and diverting project water).

3 The Without Reclamation scenario simulates hydrologic conditions if Reclamation's reservoirs and diversions were not operating.

Wet years: Average of years at or below 10 percent exceedance
Average years: Average of years between 10 percent and 90 percent exceedance
Dry years: Average of years at or above 90 percent exceedance

Source: HYDSIM – FRIII_BIOP2007Prosp_CRWMP run small relative to total flows in the Columbia River. Additional information about the combined flow effects from the hydro operations of the Upper Snake and FCRPS actions are provided in the *Comprehensive Analysis,* Appendix B (USACE et al. 2007b).

3.3 Future Hydrologic Conditions

In the hydrologic analysis for this 2007 Upper Snake BA, Reclamation modelers adjusted the (1928 to 2000) historical gains data set to reflect the current level of surface and groundwater development. This was necessary because historical gains reflected groundwater irrigation practices that were different than those occurring today. Little groundwater pumping occurred before 1945, which resulted in little impact to Snake River flows. This changed with the introduction of the centrifugal pump after Word War II. Today, it is estimated that groundwater pumpers consume 2 million acre-feet of water per year upstream of King Hill, Idaho (Contor et al. 2004). Furthermore, surface water irrigators are currently using less water because of increased farm efficiency and the cessation of winter water deliveries through private canals for stockwater. Since the 1970s, water diversions from the Snake River decreased approximately 20 percent. The lagged effects of recent groundwater development and decreased surface water recharge, combined with possible climate change, may result in future flows in the Snake River at Brownlee Reservoir being different than those historically experienced.

3.3.1 The Lagged Effects of Past Groundwater Development

The Snake River is hydraulically connected to the Eastern Snake Plain Aquifer (ESPA). Approximately 2 million acre-feet of ground water is consumptively used each year above King Hill, Idaho. Additional groundwater irrigation occurs in the Boise and Payette basins. The impact of groundwater depletions to surface flow in the Snake River varies depending on the proximity of wells to the river, well pumping rates, and the hydrogeologic characteristics of the aquifer and the riverbed. Ultimately, all of the ground water pumped and consumptively used from the ESPA will be reflected as losses from the Snake River or its tributaries. The modeled hydrological response of the Snake River to groundwater pumping from the ESPA can span over 100 years, although in most cases the bulk of the impacts are expected to occur within the first 1 to 20 years. Groundwater pumping has two potential impacts that are of importance in this consultation; it reduces base river flows and potentially reduces the volume of water stored in Reclamation reservoirs, which indirectly could reduce the reliability or volume of flow augmentation water that Reclamation is able to provide.

The State of Idaho ordered a moratorium on new well permits in the Snake River basin upstream of Weiser in May 1992 (IDWR 1992). Because of the time delay for the effects to be seen to the river, the full impact of groundwater withdrawals has not yet been manifested (IWRRI 2004). It is estimated that approximately 10 percent of the depletive effects of groundwater pumping above King Hill have yet to occur. Consequently, of the approximately 2 million acre-feet of groundwater depletion above King Hill, it is estimated that about 200,000 acre-feet of annual depletions from groundwater pumping have yet to be experienced (USBR 2005).

The 200,000 acre-feet effect will be spread along the Snake River from King Hill to the eastern end of the ESPA and occur gradually over many decades. About 68 percent of the impacts are expected to occur above Milner Dam, where Reclamation's storage dams are located and Reclamation diversions from the Snake River occur. The remaining impacts are expected to occur between Milner Dam and King Hill, and affect the discharge at Thousand Springs. If not mitigated, much of the decrease in base streamflow above Milner Dam will result in decreased irrigation supply to surface water users and increased demand on the reservoir system. If not mitigated, some (the remaining) reductions above Milner Dam and essentially all of the decreases between Milner and King Hill will be experienced as reduced streamflows into Brownlee Reservoir.

Water users with senior priority water rights that are being affected by decreased spring and river flows have "called" for the State to regulate against the junior groundwater diversions. These calls ask the State to curtail groundwater pumping in order to meet the senior water rights. In addition, Idaho Power Company has filed suit in Idaho District Court asserting that Idaho must regulate groundwater pumping in order to meet their senior downstream water rights for power generation. Reclamation is required under the Reclamation Act of 1902 to comply with State law when appropriating water. Consistent with that mandate, projects in the upper Snake were developed and are operated with Idaho water rights. In addition to the project water rights, State protection of water provided for flow augmentation was extended to Reclamation consistent with terms of the Nez Perce Water Rights Settlement. To protect those rights, Reclamation joined in the call by surface water users above Milner Dam. Reclamation's interest in these proceedings is to protect the refill capability of project reservoirs in order to provide water to contracting entities and for flow augmentation.

The Idaho Department of Water Resources (IDWR) is responding to the calls in accordance with their Rules for Conjunctive Management of Surface and Ground Water Resources. In its Orders the IDWR required groundwater users to provide mitigation water to senior surface and spring rights or face curtailment. Hearings are set to begin later this year to address the IDWR Director's determinations and set the stage for court actions that will finally establish the legal and technical principles that will apply to conjunctive management.

In addition to its regulatory response, the State is considering means to stabilize the ESPA and thereby offset some of the impacts of groundwater pumping. Measures under consideration include managed aquifer recharge from river flows surplus to existing water rights and retirement of irrigated lands through the U.S. Department of Agriculture's Conservation Reserve Enhancement Program (CREP). The CREP program was established for a maximum of 100,000 acres, with expectations that the ultimate impact to the river would be about 200,000 acre-feet per year. As of May, 2007, owners of 45,644 acres have applied for the program (Patton 2007). About 2,000 acres have been rejected, and 18,445 acres have proceeded through the multi-step approval process. The IDWR estimated that about 50,000 acres will ultimately be approved, but it has taken steps to streamline the approval process and encourage additional participation (IDWR 2007).

The Idaho Supreme Court issued a ruling on the constitutionality of the State's Rules for Conjunctive Management of Surface and Ground Water Resources on March 5, 2007 (*American Falls Reservoir District No. 2 et al. v. The Idaho Department of Water Resources et al*., 154 P.3d 433 (Idaho 2007)). The case was brought by surface water right holders above Milner Dam. One provision of the Rules specifies that in determining injury from groundwater pumping to a surface water users' rights, the Director of the IDWR may take into account "reasonable carryover" of storage water. The surface water users asserted that this provision of the Rules is contrary to Idaho law. The Supreme Court held:

> While the prior appropriation doctrine certainly gives pre-eminent rights to those who put water to beneficial use first in time, this is not an absolute rule without exception. As previously discussed, the Idaho Constitution and statutes do not permit waste and require water to be put to beneficial use or be lost. Somewhere between the absolute right to use a decreed water right and an obligation not to waste it and to protect the public's interest in this valuable commodity, lies an area for the exercise of discretion by the Director. This is certainly not unfettered discretion, nor is it discretion to be exercised without any oversight. That oversight is provided by the courts, and upon a properly developed record, this Court can determine whether that exercise of discretion is being properly carried out. For the purposes of this appeal, however, the CM Rules are not facially defective in providing some discretion in the Director to carry out this difficult and contentious task. This Court upholds the reasonable carryover provisions in the CM Rules. (Opinion, page 24)

The 2007 Replacement Plan filed by groundwater user defendants (Ground Water Districts' Joint Replacement Water Plan for 2007 filed with the IDWR on May 8, 2007) asserts that the Department should account for:

> Any water released past Milner Dam during the 2007 water year for hydropower generation or related to ESA requirements…

The plan would also require that the mitigation required be reduced by the volume of water leased to Reclamation for flow augmentation. If approved, this provision would cause surface water user entities suffering injury from groundwater pumping to be more cautious in renting water for flow augmentation.

The manner in which the Director of IDWR exercises his/her discretion to comply with the Supreme Court's statement will determine whether the volume of water available for rental stays consistent with or is reduced below that anticipated by Reclamation when the Nez Perce Water Rights Settlement was adopted. Future curtailment is possible to meet the growing mitigation obligation for the Thousand Springs calls, any of the other calls, or for the Idaho Power Company lawsuit in the event efforts to enhance the aquifer through voluntary means fail. Therefore, the potential exists that yet to be realized impacts of groundwater pumping will be fully mitigated and base flows will not continue to decline as a result of groundwater depletions.

If the ultimate administration of groundwater pumping reduces the volume or reliability of Reclamation's flow augmentation expectations, it will be necessary to consider reinitiation of consultation under the provisions of 50 CFR 406.16.

3.3.2 Possible Effects of Future Climate Change

The Climate Impacts Group (CIG) at the University of Washington has analyzed the effects of global climate change on the Pacific Northwest (CIG 2006). In general, climate models project a future rate of warming in the Pacific Northwest of approximately 0.5°F (0.3°C) per decade through at least 2050 relative to 1970 to 1999 average temperatures. Much of the temperature increase is projected to take place in the summer months, June through August. Models also indicate that small changes in regional precipitation would occur. The model projects that rising temperatures could diminish mountain snow packs, decrease summer flows, increase winter flows, and peak spring flows might occur earlier. Winter hydropower production could increase, but less water could be available during the summer for agriculture, recreation, hydropower, and fish (CIG 2006).

According to a study by the CIG, southern Idaho's Snake River basin is thought to be at greater risk of impacts from climate change than the rest of the Columbia River basin because the Snake River is proportionally more developed when depletions are compared to streamflows (VanRheenen et al. 2006). At this time no comprehensive climate change studies have been completed for the Snake River basin. Reclamation is pursuing various activities and building partnerships with others to better understand and incorporate climate change information into future water resources management and project operations. On the local scale, Reclamation participates on the Climate Impacts Subcommittee of the Idaho Water Supply Committee to investigate the implications of climate change for southern Idaho. Reclamation is also currently conducting a climate change study in association with a water storage assessment for the Boise River system to determine its effects on water supply. The Pacific Northwest Region is developing "climate changed" water supply data sets in partnership with other entities for various watersheds in the Columbia River basin to improve modeled operational analyses. At a larger scale, encompassing the western United States, the Secretary of Interior has convened a Climate Change Task Force that will evaluate information needs and identify strategies for managing lands and waters, protecting fish and wildlife, and minimizing the Department's environmental footprint. Results and techniques learned from these efforts will allow a better understanding of potential climate impacts above Brownlee Reservoir and provide the tools to respond to any changing climate trends.

3.3.3 Summary

Future hydrologic conditions in the Snake River above Brownlee Reservoir will be affected by many factors including hydrologic variability, climate change, continued water storage and diversion activities by Reclamation and private irrigation projects, hydropower generation, and the State's administration of water rights. Some of these future effects and conditions have been described throughout this chapter. Reclamation's reservoirs are operated with a high level of flexibility in order to respond to a wide variety of hydrological and meteorological conditions. Reservoir operators can respond to changing conditions, whether natural or anthropogenic. This will continue to occur as new hydrologic information becomes available. Reclamation will continue to monitor Idaho's administration of groundwater pumping and investigate climate conditions to ensure proposed actions occur as described in this BA. If conditions do change from those described here, re-initiation of consultation may be necessary as triggered by 50 CFR 406.16.