3.6 RIVERFLOW ISSUES

3.6.1 INTRODUCTION

This section considers the potential effects of interim surplus criteria on three types of releases from Glen Canyon Dam and Hoover Dam. The Glen Canyon Dam releases analyzed are those needed for restoration of beaches and habitat along the Colorado River between the Glen Canyon Dam and Lake Mead, and for low steady summer flows to be provided for the study and recovery of endangered Colorado River fish, in years when releases from the dam are near the minimum. The Hoover Dam releases analyzed are the frequency of flood releases from the dam and the effect of flood flows along the river downstream of Hoover Dam.

3.6.2 BEACH/HABITAT-BUILDING FLOWS

The construction and operation of Glen Canyon Dam has caused two major changes related to sediment resources downstream in Glen Canyon and Grand Canyon. The first is reduced sediment supply. Because the dam traps virtually all of the incoming sediment from the Upper Basin in Lake Powell, the Colorado River is now released from the dam as clear water. The second major change was the reduction in the high water zone from the level of predam annual floods to the level of powerplant releases. Thus the height of annual sediment deposition and erosion has been reduced.

During the investigations leading to the preparation of *the Operation of Glen Canyon Dam Final EIS* (Reclamation, 1995), the relationships between releases from the dam and downstream sedimentation processes were brought sharply into focus, and flow patterns designed to conserve sediment for building beaches and habitat (i.e., BHBF releases) were identified. The BHBF releases are scheduled high releases of short duration that exceed the hydraulic capacity of the powerplant. Such releases were presented as a commitment in the ROD (Reclamation, 1996) for the FEIS, at a then-assumed frequency of 1 in 5 years.

In addition to the BHBF releases described above that exceed the hydraulic capacity of the Glen Canyon Powerplant, the *Operation of Glen Canyon Dam FEIS* identified the need for Beach/Habitat Maintenance Flow releases which do not exceed the hydraulic capacity of the powerplant. These flows were designed to prevent backwater habitat from filling with sediment and reduce vegetation on camping beaches in years between BHBFs. BHBF releases and Beach/Habitat Maintenance Flows serve as a tool for maintaining a mass balance of sediment in Glen Canyon and Grand Canyon.

3.6.2.1 METHODOLOGY

The frequencies at which BHBF releases from Glen Canyon Dam would occur under baseline conditions and under operation of the interim surplus criteria alternatives were estimated through the use of modeling as described above in Section 3.3.

The model was configured to simulate BHBF releases by incorporating the BHBF triggering criteria (contained in Section 3.6.2.2) into the Glen Canyon Dam operating rules. The model was also configured to make no more than one BHBF release in any given year.

3.6.2.2 AFFECTED ENVIRONMENT

Sediment along the Colorado River below Glen Canyon Dam is an important and dynamic resource, which affects fish and wildlife habitat along the river, creates camping beaches for recreation, and serves to protect cultural resources. Except for remnants of high river terraces deposited prior to the closure of Glen Canyon Dam, the now limited sediment supply that exists along the river channel is affected by dam operations.

Since construction of Glen Canyon Dam, the measured suspended sediment load (sand, silt, and clay) at Phantom Ranch averages 11 million tons per year. Most of this load comes from the Paria River and the Little Colorado River. Flash floods from other side canyons also contribute to the sediment supply (Reclamation, 1995). The suspended sediment load is sporadic in occurrence, depending on Glen Canyon Dam releases and tributary inputs.

Beneficial sediment mobilization and deposition below Glen Canyon Dam depends on the interaction of two occurrences for full effectiveness; the addition of sediment to the river corridor and BHBF releases. The higher energy of BHBF releases mobilizes suspended and riverbed-stored sand and deposits it as beaches in beach and shoreline areas. Once a BHBF release has been made, additional sediment supply from tributary inflows is needed before subsequent BHBF releases are fully effective in promoting further beach and sandbar deposition along the river.

Subsequent to the ROD cited above, the representatives of the AMP further refined specific criteria under which BHBFs would be made. The criteria provide that under the following two triggering conditions, BHBF releases may be made from Glen Canyon Dam:

1. If the January forecast for the January-July unregulated spring runoff into Lake Powell exceeds 13 maf (about 140 percent of normal) when January 1 content is greater than 21.5 maf; or

2. Any time a Lake Powell inflow forecast would require a monthly powerplant release greater than 1.5 maf.

Research concerning the relationships among dam operations, downstream sediment inflow, river channel and sandbar characteristics, and particle-size distribution along the river is ongoing.

3.6.2.3 ENVIRONMENTAL CONSEQUENCES

The effects of the interim surplus criteria alternatives on BHBF releases from Glen Canyon Dam were analyzed in terms of the yearly frequency at which BHBF releases could be made. Specifically, the frequency was indicated by the occurrence of one or both of the triggering criteria cited above, during a calendar year. The following discussion presents probability of occurrence under baseline conditions, and then compares the probability of BHBF releases under each interim surplus criteria alternative with the baseline conditions.

3.6.2.3.1 Baseline Conditions

Baseline hydrologic conditions at Lake Powell are described in Section 3.3. Under baseline conditions, the frequency of one or both BHBF flow release triggers occurring would be as follows: during the period through 2015 for which interim surplus criteria are being considered, the probability that BHBF releases could be made in a given year would be approximately 20.3 percent, which is equivalent to about 1 year in 5. This yearly probability is an average over that period. During the subsequent period ending in 2050, the average probability that BHBF releases could be made in any year would be approximately 13.6 percent, which is equivalent to about 1 year in 8.

The reduction in probability after 2015 under baseline conditions results from the fact that with time, the Lake Powell water level will probably decline because of increased Upper Basin depletions, as illustrated in Section 3.3. This water level decline would gradually reduce the probability that the BHBF triggering criteria would occur.

3.6.2.3.2 Flood Control Alternative

Hydrologic conditions at Lake Powell under the Flood Control Alternative are described in Section 3.3. The effect of those conditions on the frequency of one or both BHBF flow release triggers occurring would be as follows; during the period through 2015 in which interim surplus criteria would be applied, the probability that BHBF releases could be made in any single year would be approximately 20.4 percent, which equates to approximately 1 year in 5; and during the subsequent period ending 2050, the average probability that BHBF releases could be made in any year would be approximately 13.8 percent, which is equivalent to about 1 year in 8. Table 3.6-1 presents a comparison of the probabilities under this alternative with those under baseline conditions, as well as with the other three alternatives.

Table 3.6-1
BHBF Release Probabilities from Glen Canyon Dam

Period	Percent of Time That Conditions Needed for BHBF Releases Would Occur at Lake Powell				
	Baseline Condition	Flood Control Alternative	Six States Alternative	California Alternative	Shortage Protection Alternative
Through 2015	20.3%	20.4%	18.7%	18.3%	18.2%
2016-2050	13.6%	13.8%	13.4%	13.3%	13.3%

3.6.2.3.3 Six States Alternative

Hydrologic conditions at Lake Powell under the Six States Alternative are described in Section 3.3. The effect of those conditions on the frequency of one or both BHBF flow release triggers occurring would be as follows: during the period ending 2015 in which interim surplus criteria would be in force, the probability that BHBF releases could be made in any single year would be approximately 18.7 percent, which equates to approximately 1 year in 5; and during the subsequent period ending in 2050, the average probability that BHBF releases could be made in any year would be approximately 13.4 percent, which is equivalent to about 1 year in 8.

3.6.2.3.4 California Alternative

Hydrologic conditions at Lake Powell under the California Alternative are described in Section 3.3. The effect of those conditions on the frequency of one or both BHBF flow release triggers occurring would be as follows: during the period ending 2015 in which interim surplus criteria would be in force, the probability that BHBF releases could be made in any single year would be approximately 18.3 percent, which equates to approximately 1 year in 5; and during the subsequent period ending in 2050, the average probability that BHBF releases could be made in any year would be approximately 13.3 percent, which is equivalent to about 1 year in 8.

3.6.2.3.5 Shortage Protection Alternative

Hydrologic conditions at Lake Powell under the Shortage Protection Alternative are described in Section 3.3. The effect of those conditions on the frequency of one or both BHBF flow release triggers occurring would be as follows: during the period ending 2015 in which interim surplus criteria would be in force, the probability that BHBF releases could be made in any single year would be approximately 18.2 percent, which equates to approximately 1 year in 5; and during the subsequent period ending in 2050, the average probability that BHBF releases could be made in any year would be approximately 13.3 percent, which is equivalent to about 1 year in 8.

3.6.3 LOW STEADY SUMMER FLOW

3.6.3.1 AFFECTED ENVIRONMENT

During preparation of the *Operation of Glen Canyon Dam FEIS*, it was hypothesized that steady flows with a seasonal pattern may have a beneficial effect on the potential recovery of special status fish species down stream of Glen Canyon Dam. Accordingly, development of an experimental water release strategy was recommended by the Service to achieve steady flows when compatible with water supply conditions and the requirements of other resources. The strategy included developing and verifying a program of experimental flows which would include providing high steady flows in the spring and low steady flows in summer and fall during water years of approximately 8.23 maf. This strategy, commonly referred to as the low steady summer flow program, was contained in the Final Biological Opinion on the Operation of Glen Canyon Dam (Service, December 1994), and recognized in the ROD for the Glen Canyon Dam Operation FEIS (USDI, 1996).

3.6.3.2 ENVIRONMENTAL CONSEQUENCES

The ability to test the low steady summer flow release strategy at Glen Canyon Dam according to the ROD could be affected by the implementation of interim surplus criteria. This matter was investigated by analyzing the model releases from Glen Canyon Dam to determine the probabilities at which minimum releases of 8.23 maf per year would occur. The results of the model analysis indicates that under baseline conditions, the probability of 8.23 maf annual releases from the dam would be approximately 25.6 percent of the years during the interim period to 2015 and 51.2 percent during the subsequent period ending in 2050. The probabilities under the Flood Control Alternative would be approximately the same as for baseline conditions, as shown on Table 3.6-2. The effects of the remaining three interim surplus criteria alternatives during the interim period to 2015 would be one or two percentage points less than under baseline conditions, as shown on Table 3.6-2. During the subsequent period to 2050, the probabilities resulting from the remaining three surplus criteria would be one to two percentage points higher than under baseline conditions.

Table 3.6-2
Probability of Minimum Glen Canyon Dam Releases
(Annual Releases of 8.23 maf)

Period (Water Years)	Baseline Condition	Flood Control Alternative	Six States Alternative	California Alternative	Shortage Protection Alternative
Through 2015	25.6%	26.0%	24.3%	23.5%	23.3%
2016-2050	51.2%	50.9%	52.1%	52.8%	53.0%

Note: The "water year," on which this accounting is based, extends from October 1 to September 30.

3.6.4 FLOODING DOWNSTREAM OF HOOVER DAM

This analysis addresses the flooding that occurs along the Colorado River below Hoover Dam. The evaluation focuses on the change in the probability that various "threshold" flows would be released from Hoover, Davis and Parker dams. A threshold flow rate is one at which flood damages have been found to begin to occur along the river. The analysis is not limited to dam releases made expressly in connection with flood control operation, but also includes releases made for water supply and power generation purposes. For example, power generation requirements can cause releases from Hoover Dam to exceed 19,000 cfs, with such releases being regulated in Lake Mohave downstream.

3.6.4.1 AFFECTED ENVIRONMENT

Historical flows downstream of Hoover Dam have caused flood damages at various points along the lower Colorado River. A key threshold level was established as a result of flooding that occurred in 1983 when uncontrolled releases occurred over the Hoover Dam Spillways. The high Colorado River flows caused damages primarily to encroachments in the Colorado River floodplain. In addition, several lower thresholds that are significant along various reaches are evaluated in the following subsections.

The Colorado River Floodway Protection Act (Floodway Act) originated from congressional hearings held in 1983 following the flood. The Floodway Act called for the establishment of a federally declared floodway from Davis Dam to the SIB. The floodway is to accommodate either a 1-in-100 year river flow consisting of controlled releases and tributary inflow, or a flow of 40,000 cfs, whichever is greater. As discussed in Section 3.3.1, certain flood release rates from Hoover Dam are required depending on flood flow into Lake Mead and the amount of flood storage available.

3.6.4.1.1 Hoover Dam to Davis Dam

Critical flood flows for the reach between Hoover Dam and Davis Dam are 19,000 cfs, 28,000 cfs, 35,000 cfs, 43,000 cfs, and 73,000 cfs.

3.6.4.1.2 Davis Dam to Parker Dam

From Davis Dam to Parker Dam, the river is within levees for most of the reach. Historical flood flows have caused damage to some of the bank protection**.** Minor damage begins to occur at flows of 26,000 cfs.

3.6.4.1.3 Parker Dam to Laguna Dam

Below Parker Dam, significant damage to permanent homes has occurred during releases within the flood operation criteria. This area has been further developed since the flood operations in 1983. Minor damage begins at 19,000 cfs along the Parker Strip (the reach of river between Parker Dam and the town of Parker, Arizona). Backwater regions, which function as wildlife refuges and recreational areas, accumulated sediment, and in some cases became isolated from the Colorado River. Historical flood flows have also resulted in damage to infrastructure of agencies, including Wellton-Mohawk District.

During the scoping process for this DEIS, a letter from the Yuma County Water User's Association states that "[o]ur landowners are harmed by such releases, particularly should the flood control releases be required to go beyond the 19,000 cubic feet per second Hoover release level" (Pope, 1999). The letter indicates that a flood control releases of 28,000 cfs or greater could result in upwards of $200 million in damages to the Yuma area. Other injured parties could include the City of Yuma, the County of Yuma, Cocopah Indian Tribe, the Gila Valley, Bard Irrigation District, and the Quechan Indian Tribe. Conditions today are similar to those that occurred during historic floods

3.6.4.1.4 Laguna Dam to SIB

Below Laguna Dam, the banks of the Colorado River are not protected. Historical flood flows resulted in significant damage to the banks. The increased groundwater level in the Yuma result in some lands becoming water logged and caused drains to cease functioning. The following are the flows of concern:

- Laguna Dam south to Pilot Knob: 9,000 cfs is the threshold value. Flows of 10,000 cfs to 11,000 cfs impact leach fields of trailer parks located within levees.

- Pilot Knob to SIB: 15,000 cfs is a threshold value. Above that level, high groundwater, localized crop damage and damage to the United States Bypass Drain occurs.

3.6.4.2 ENVIRONMENTAL CONSEQUENCES

The effects of the interim surplus criteria on flood flows were analyzed by determining the probabilities that releases from Davis and Parker Dams would reach or exceed certain flow rates that have been found to be thresholds for damages. In addition, the analysis addressed the probabilities that releases of various magnitudes would be made from Hoover Dam corresponding to the required flood control releases discussed in Section 3.3.1.2, Operation of Hoover Dam. The release probabilities were determined from operation model results based on the historic Basin runoff conditions described in Section 3.3. The results of the analysis are shown in Table 3.6-3.

Table 3.6-3
Discharge Probabilities from Hoover, Davis and Parker Dams

Release Point	Discharge (cfs) [1]	Percent of Years With Flows Greater Than or Equal to Discharge				
		Baseline Conditions	Flood Control Alternative	California Alternative	Six States Alternative	Shortage Protection Alternative
Years 2001 to 2015						
Parker Dam	19,500	13.9	14.2	13.0	13.4	12.8
Davis Dam	26,000	12.5	12.9	11.5	11.6	11.4
Hoover Dam	19,000	34.8	35.3	36.4	32.9	36.4
Hoover Dam	28,000	11.1	11.5	10.1	10.4	10.1
Hoover Dam	35,000	2.1	2.1	2.0	2.0	2.0
Hoover Dam	40,000	0.2	0.2	0.2	0.2	0.2
Hoover Dam	73,000	0.0	0.0	0.0	0.0	0.0
Years 2016 to 2050						
Parker Dam	19,500	19.7	20.8	17.9	18.3	17.6
Davis Dam	26,000	15.2	16.5	14.4	14.8	14.4
Hoover Dam	19,000	58.7	56.5	56.5	57.6	56.5
Hoover Dam	28,000	12.5	13.4	11.5	12.0	11.5
Hoover Dam	35,000	2.4	2.4	2.4	2.4	2.4
Hoover Dam	40,000	0.3	0.3	0.3	0.3	0.3
Hoover Dam	73,000	0.0	0.0	0.0	0.0	0.0

(1) Average monthly discharge