RECLAMATION

*Managing Water in the West*

# Final Environmental Assessment Experimental Releases from Glen Canyon Dam, Arizona, 2008 through 2012

U.S. Department of the Interior
Bureau of Reclamation
Upper Colorado Region
Salt Lake City, Utah

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## Mission Statements

The US Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

The mission of the Bureau of Reclamation is to management, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

# Final Environmental Assessment for Experimental Releases from Glen Canyon Dam, Arizona, 2008 through 2012

| | |
|---|---|
| Proposed agency action: | Experimental releases from Glen Canyon Dam, Coconino County, Arizona, 2008 through 2012 |
| Type of statement: | Environmental assessment |
| Lead agency: | Bureau of Reclamation, Upper Colorado Region |
| Cooperating agencies: | None |
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# 1.0 Introduction

The Department of the Interior, acting through the Bureau of Reclamation (Reclamation), is proposing a series of experimental releases of water from Glen Canyon Dam to help native fish, particularly the endangered humpback chub, and conserve fine sediment in the Colorado River corridor in Grand Canyon National Park.

Glen Canyon Dam, authorized by the Colorado River Storage Project Act (CRSPA) of 1956 and completed by Reclamation in 1963, impounds the Colorado River some 15 miles upstream from Lees Ferry, Arizona. Below Glen Canyon Dam, the Colorado River flows for 15 miles through Glen Canyon. This area is managed by the National Park Service (NPS) as part of Glen Canyon National Recreation Area. Fifteen miles below Glen Canyon Dam, Lees Ferry, Arizona marks the beginning of Marble Canyon and the northern boundary of Grand Canyon National Park.

A major function of the dam is water conservation and storage. The dam is specifically managed to regulate releases of water from the upper Colorado River basin to the lower basin to satisfy provisions of the Colorado River Compact and subsequent water delivery commitments and thereby allow states within the upper basin (Arizona, Colorado, New Mexico, Utah, Wyoming) to deplete water from the watershed upstream of Glen Canyon Dam and utilize their apportionments of Colorado River water.

In addition, another function of the dam is to generate hydroelectric power. Water released from Lake Powell through Glen Canyon Dam's eight hydroelectric turbines generates power marketed by the Western Area Power Administration (Western). Between the dam's completion in 1963 and 1990, the dam's daily operations were primarily undertaken to maximize generation of hydroelectric power in accordance with Section 7 of the CRSPA, which requires production of the greatest practicable amount of power.

In 1970, Criteria for Coordinated Long-range Operation of Colorado River Reservoirs were established to govern operation of the mainstem reservoirs along the Colorado River. Annual operating plans prepared under the criteria include the requirement to:

> …reflect appropriate consideration of the uses of the reservoirs for all purposes, including flood control, river regulations, beneficial consumptive uses, power production, water quality control, recreation, enhancement of fish and wildlife, and other environmental factors. (Article 1(2))

Over time, additional considerations have arisen with respect to the operation of Glen Canyon Dam, including concerns regarding effects of dam operations on species listed pursuant to the Endangered Species Act of 1973, as amended (ESA). Later, by 1992, recognizing that how the dam is operated might affect Glen Canyon National Recreation Area and Grand Canyon National Park, President George H.W. Bush signed the Grand Canyon Protection Act (GCPA) into law.

The GCPA required the Secretary of the Interior to complete an environmental impact statement (EIS) evaluating alternative operating criteria, consistent with existing law, that would determine how the dam would be operated to both meet the purposes for which the dam was authorized and to meet the goals for protection of Glen Canyon National Recreation Area and Grand Canyon National Park (GCPA § 1804(a); S. Rep. No. 102-267, at 136 (1992)). The final EIS was completed in March 1995. The preferred alternative, the Modified Low Fluctuating Flow Alternative, was selected as the best means to operate Glen Canyon Dam in a record of decision issued on October 9, 1996.

Later in 1997, the Secretary adopted operating criteria for Glen Canyon Dam as required by Section 1804(c) of GCPA. The GCPA also requires the Secretary of the Interior to exercise:

> . . .other authorities under existing law in such a manner as to pro[t]ect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established, including, but not limited to natural and cultural resources and visitor use. (GCPA §1802(a))

Additionally, the GCPA requires the Secretary of the Interior to undertake research and monitoring to determine if revised dam operations were actually achieving the resource protection objectives of the final EIS and record of decision, i.e., mitigating adverse impacts, protecting, and improving the natural, cultural, and recreational values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established. These provisions of the GCPA were incorporated into the 1996 record of decision and led to the establishment of the Glen Canyon Dam Adaptive Management Program (GCDAMP) under Reclamation and the Grand Canyon Monitoring and Research Center (GCMRC) under the US Geological Survey (USGS).

Monitoring and research conducted by these organizations since 1996 have shown that some of the expected benefits of dam operations under the record of decision have not occurred, or have occurred to a lesser degree than anticipated, e.g., for the endangered humpback chub (*Gila cypha*) and conservation of fine sediment. In proposing these experiments, it is important to recognize that all operations including those proposed here, must be implemented in compliance with other specific provisions of existing federal law applicable to the operation of Glen Canyon Dam. These pre-1992 requirements are specifically mandated in the GCPA.

> The Secretary shall implement this section in a manner fully consistent with and subject to the Colorado River Compact, the Upper Colorado River Basin Compact, the Water Treaty of 1944 with Mexico, the decree of the Supreme Court in Arizona v. California, and the provisions of the Colorado River Storage Project Act of 1956 and the Colorado River Basin Project Act of 1968 that govern allocation, appropriation, development, and exportation of the waters of the Colorado River Basin. (GCPA § 1802(b))

This document is an environmental assessment and documents current conditions in Glen, Marble, and Grand canyons below Glen Canyon Dam (Figure 1). It describes how the proposed action, i.e., experimental high and steady flows from 2008 through 2012, is designed to help and assess the long-term benefits to the conservation of endangered humpback chub and fine sediment along the Colorado River downstream of Glen Canyon Dam.

This environmental assessment was prepared by the US Bureau of Reclamation (Reclamation) in compliance with the National Environmental Policy Act (NEPA) and the Council on Environmental Quality's regulations for implementing NEPA (40 CFR 1500-1508). This environmental assessment is not a decision document. The following outcomes could result:

1. a finding of no significant impact could be issued and the experiment could go forward as proposed;
2. a decision could be made to prepare an environmental impact statement; or
3. a decision could be made to withdraw the proposal on the basis of environmental impacts disclosed in this document.

## 1.1 Background and Related Actions

Reclamation, an agency within the US Department of the Interior, operates Glen Canyon Dam as part of the Colorado River Storage Project, which was authorized by Congress in 1956 (43 USC § 620). In 1995 Reclamation finalized an EIS on Glen Canyon Dam operations and in 1996 the Secretary of the Interior decided the dam would be operated using the Modified Low Fluctuating Flow Alternative in the EIS. In 2007 Reclamation completed an EIS that defines interim guidelines for lower basin shortages and the coordinated operations for Lake Powell and Lake Mead (Reclamation 2007a). Releases from Lake Powell are based largely on the contents of these two reservoirs. Coordinated operations under the 2007 record of decision govern the annual release from Lake Powell, while the 1996 record of decision governs releases from Lake Powell at shorter time increments, primarily daily and hourly releases. These two records of decision form the basis for no action here. This environmental assessment is tiered (40 CFR 1502.20 and 1508.28) from the 1995 EIS (Reclamation 1995) and the shortage and coordinated operations EIS described above (Reclamation 2007a).

Reclamation's (1995) EIS and Interior's (1996) decision called for an adaptive management approach, wherein the relationship between dam operations and downstream resources was recognized as uncertain and an active experimental approach was adopted. As a result, the GCDAMP was instituted and Reclamation collaborated with stakeholders in the GCDAMP and conducted numerous experimental releases from Glen Canyon Dam, including previous high-flow and steady-flow experiments, which helped inform the design of the proposed experimental releases described in this analysis. Experimentation was designed to assess relationships between dam operations and resources in and along the

Colorado River in Glen Canyon National Recreation Area and Grand Canyon National Park (Figure 1).

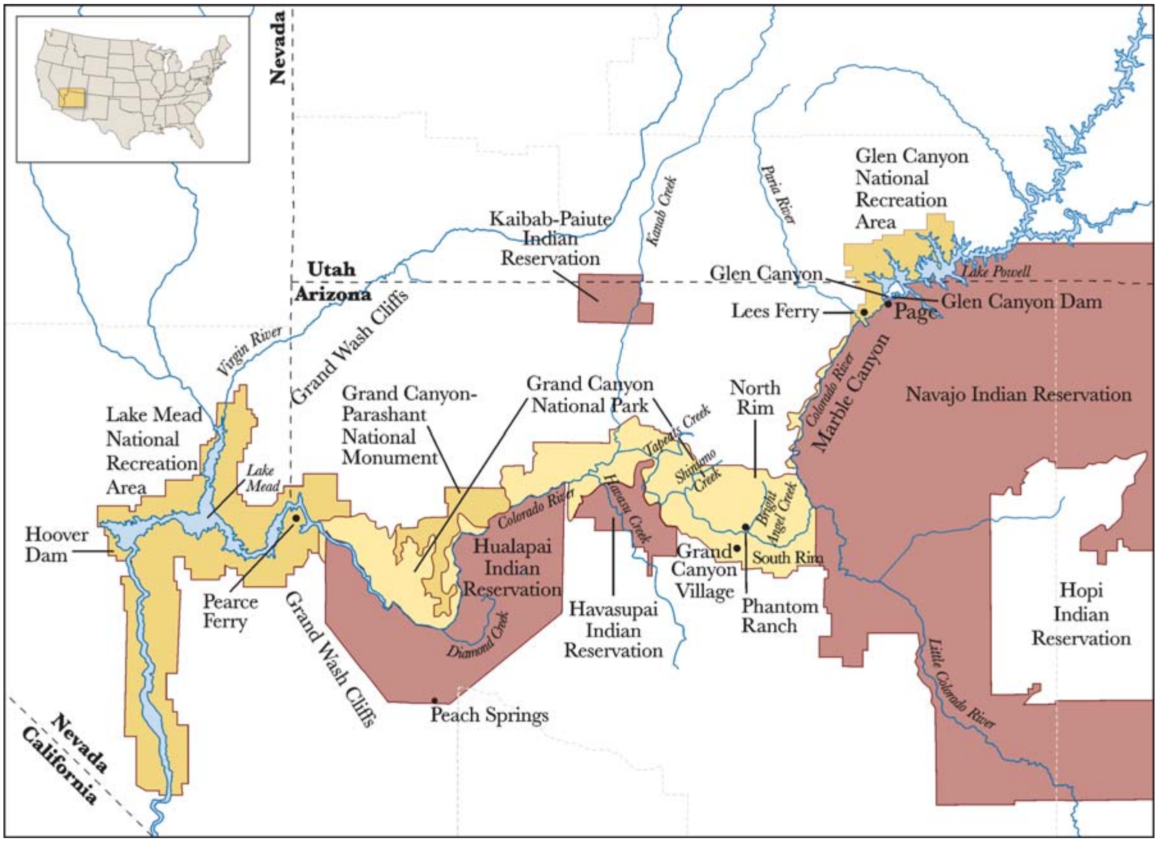

FIGURE 1 Geographic scope of the proposal, showing places referenced in the text. Map courtesy of USGS.

These experiments included a release of 45,000 cubic feet per second (cfs) beginning March 26, 1996, a powerplant capacity release of 31,000 cfs for 48 hours in 1997, and a combination of powerplant capacity releases and steady flows in March through September 2000. From 2003 through 2005, a series of test flows with higher winter fluctuations was conducted. From 2003 to 2006, mechanical removal of nonnative fish was undertaken to study whether populations of native fish, particularly the endangered humpback chub (*Gila cypha*), could be conserved by reducing numbers of nonnative fish, primarily trout.

Experimentation with dam releases also included high flows in November 2004 and alternating fluctuating and stable flows in the fall of 2005. The 2004 high flow test was timed to take advantage of enriched sediment in the Colorado River below the dam (Wiele et al. 2005). Suspended sediment concentrations during the 2004 experiment were 160 to 240 percent greater than during the 1996 experiment, although there was less sand in suspension below River Mile (RM) 42 (Topping et al. 2006). (River miles or RM are measured downstream from Lees Ferry, Arizona.)

## 1.2 Purpose of and Need for Action

The purpose of the proposed experimental releases from Glen Canyon Dam is to determine if prescribed releases can benefit resources located downstream of the dam in Glen, Marble, and Grand canyons, Glen Canyon National Recreation Area and Grand Canyon National Park, respectively, in accordance with applicable federal law, including the GCPA, while meeting the project purposes of the dam. Specifically, the purpose of the high flow test portion of the proposed action is to rebuild sandbars and beaches and rejuvenate backwaters – which may be important rearing habitat for native fish – during a period of enriched sediment storage conditions and to monitor changes over time. The purpose of the steady flow portion of the experiment is to potentially enhance the continuance of recent positive trends in the population of humpback chub and test the impact of fall steady flows on the endangered humpback chub and other aspects of the aquatic environment, particularly backwater environments.

This proposed action is needed because (1) much of the positive initial results of previous high flow tests have eroded, impacting recreational use and aquatic habitat; (2) previous tests were conducted under depleted and moderately enriched sediment conditions and there is a strong need to assess effects under current enriched sediment conditions; (3) the scientific information from the proposed high flow test will help inform the evaluation of long-term sustainability of the sediment resource; (4) there is a desire to enhance the current positive trends in the humpback chub population; and (5) there is a need to test whether recruitment of humpback chub can increase under fall steady flows. While recent population estimates show an improving humpback chub population, the experiment will help scientists better understand the cause of this improvement and methods by which further improvement could occur.

Both aspects of the proposed action have been designed to assist in and enhance the conservation of humpback chub. This document assesses whether these objectives could be accomplished during 2008 through 2012 without significant adverse impacts to natural, cultural, or socioeconomic resources.

## 1.3 Science Plan

While Reclamation has conducted two prior high flow tests in 1996 and 2004 with initial positive results, sandbars and backwaters declined thereafter. (Discussion of this point in contained in section 3.1.4.) In addition, recent tributary inputs to the Colorado River below Lees Ferry are the greatest in approximately a decade. Conducting a high flow test under these conditions is hypothesized to create more substantial sandbars and beaches rather than let this sediment be transported downstream to Lake Mead, and increase the overall conservation of fine sediment. Prior experimental high releases from the dam have had similar stated objectives (Schmidt et al. 1999:30)

1. remove or reduce predation of nonnative fish on endangered native fish;
2. rejuvenate backwater habitats for native fish, especially the endangered humpback chub (*Gila cypha*);
3. redeposit sand at higher elevations;
4. preserve and restore camping beaches; and
5. reduce near-shore vegetation.

The GCMRC was charged in 2007 by the Department of the Interior to create a science plan for a proposed high-flow release. The plan thus developed had as its major elements studies to assess impacts to sediment, archeological sites, and backwaters; riparian vegetation; aquatic food base; rainbow trout; and water quality. It also proposes a knowledge synthesis at the conclusion of the experiment and mitigation measures to reduce incidental take of Kanab ambersnail (USGS 2007a).

As this plan was finalized in anticipation of a potential high flow test in 2008, additional scientific efforts were included in the plan to identify impacts to the endangered humpback chub and its habitat. Greater emphasis was placed on understanding the potential benefits of backwaters created by the high-flow release for native fish, with substantially increased native fish and habitat monitoring and research. The resulting plan is included as an Appendix A.

With respect to the fall steady flow portion of the proposal, a September 2008 river trip is scheduled with significant efforts directed toward both fish and habitat sampling. Ongoing monitoring within the GCDAMP will also contribute to determining the effect of these flows. To improve the scientific understanding from this portion of the proposal, if the proposed action is approved, in April 2008 Reclamation will initiate discussions with the GCMRC and within the GCDAMP on potential additional scientific activities associated with the fall steady flows that may be proposed and undertaken during the period 2008 through 2012.

The total cost of the science plan is approximately $4.1 million, including the cost of the knowledge synthesis (USGS 2007a). Funding of the science plan would come from power revenues within the GCDAMP, Reclamation appropriated funds, and NPS funds.

## 1.4 Relevant Resources

Reclamation utilized the scoping results from the prior NEPA analyses, as well as knowledge gained from prior experimental releases from the dam (e.g. Valdez and Hoffnagle 1999), to determine relevant issues or resources for this environmental assessment. In 2000, a longer period of steady flows was conducted within existing NEPA compliance, and in 2002 and 2004 Reclamation, NPS, and GCMRC prepared an environmental assessment on a proposed high flow test. Consistent with these earlier experiments Reclamation has now prepared a biological assessment and an environmental assessment on the proposed action. Issues related to high magnitude releases from the dam are relatively well-known. In fact, one of the major purposes of this proposal is to replicate selected elements of the 1996, 1997, and 2004 experimental high flow tests, but under enriched sediment conditions. Also, this new proposal follows the high flow with steady fall flows; building on knowledge learned during previous steady-flow experiments in 2000. Based on prior scoping and experimental results, Table 1 lists (in alphabetical order) the issues or resources considered for this environmental assessment under the broad categories of natural, cultural and socioeconomic resources. The effects to resources are presented following a description of the alternatives under consideration.

TABLE 1 Summary of resources evaluated

| Environmental Issue |
|---|
| Air Quality |
| Birds |
| Cultural Resources |
| Environmental Justice |
| Fish, Sport Fish, Endangered Fish |
| Floodplains and Wetlands |
| Hydropower |
| Indian Trust Assets |
| Invertebrates, Herptofauna |
| Population Growth |
| Public Health and Hazards |
| Recreation |
| Sediment, Soils, and Geomorphology |
| Transportation and Traffic |
| Vegetation |
| Water Resources or Dam Operations |
| Wilderness |

## 1.5 Authorizing Actions, Permits or Licenses

Implementation of this proposal would require a number of authorizations or permits from various federal and state agencies and Indian tribal governments. Any field work within the boundaries of Glen Canyon National Recreation Area or Grand Canyon National Park would necessitate permits from the NPS. Tribal permits from the Hualapai Indian Tribe or Navajo Nation would be needed should any field work be proposed within reservation boundaries; permits might also be required by the Bureau of Indian Affairs (BIA). Researchers working with threatened or endangered species would have to obtain a permit from the US Fish and Wildlife Service (FWS). Researchers working with resident fish or wildlife species may need an Arizona Game and Fish Department (AGFD) permit. No other permits are known to be required at this time.

# 2.0 Alternatives

In light of recent population increases and new information about humpback chub, Reclamation re-initiated consultation under the ESA with the FWS on November 13, 2007. The proposed action included in Reclamation's biological assessment was developed during informal consultation with the FWS in November 2007. The proposed action in this environmental assessment prepared under NEPA is identical to that contained in Reclamation's biological assessment dated December 21, 2007. Reclamation's proposed action consists of continued implementation of Modified Low Fluctuating Flows selected in the 1996 record of decision (Interior 1996) with the added elements of identified experimental dam operations for the five-year experimental period (the remainder of water year 2008 through 2012). Accordingly, the FWS issued a biological opinion on the proposed action on February 27, 2008 which "…replaces the 1995 final biological opinion on the operation of Glen Canyon Dam (FWS 1995; Consultation No. 2-21-93-F-167)." The FWS further noted in its final biological opinion (FWS 2008) that "[a]t the end of the five year period of the proposed action, it is expected that Reclamation will reconsult with FWS" under the ESA.

Following the conclusion of this environmental assessment Reclamation will reassess work on the long-term experimental plan as described in a February 12, 2007 *Federal Register* notice (Reclamation 2008a). This environmental assessment considers two alternatives:  no action and the proposal, synonymous with proposed action.

## 2.1 No Action Alternative

Reclamation would continue to operate the dam as described in prior NEPA analyses (Reclamation 1995, 2007a). For the purpose of this NEPA analysis, no experimental flows or actions would be assumed to occur from 2008-2012. Projected monthly dam releases for various annual releases are summarized in Table 2, with the data from Reclamation (2007a). Annual and monthly release volumes would continue to be projected for different hydrologic conditions prior to the beginning of the water year and described in annual operating plans and in new operating guidelines (Reclamation 2007a). Scheduled monthly release volumes would continue to be updated at least monthly. Daily operations would conform to the limits imposed by the 1997 operating criteria for Glen Canyon Dam.

TABLE 2 No Action Glen Canyon Dam releases under dry (7.48 million acre-feet or maf), median (8.23 maf), and wet (12.3 maf) conditions, 2009-2012

| | Annual Releases | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 7.48 maf | | | 8.23 maf | | | 12.3 maf | | |
| Month | Mean (cfs) | Min (cfs) | Max (cfs) | Mean (cfs) | Min (cfs) | Max (cfs) | Mean (cfs) | Min (cfs) | Max (cfs) |
| Oct | 7,502 | 5,300 | 10,300 | 9,758 | 6,800 | 12,800 | 9,378 | 6,800 | 12,800 |
| Nov | 7,563 | 5,900 | 10,900 | 10,083 | 7,100 | 13,100 | 9,075 | 7,100 | 13,100 |
| Dec | 9,378 | 6,800 | 12,800 | 13,011 | 9,000 | 17,000 | 12,503 | 9,000 | 17,000 |
| Jan | 12,503 | 9,000 | 17,000 | 13,011 | 9,000 | 17,000 | 17,510 | 14,200 | 22,200 |
| Feb | 8,470 | 7,800 | 13,800 | 10,804 | 7,800 | 13,800 | 13,903 | 13,700 | 21,700 |
| Mar | 9,378 | 6,800 | 14,800 | 9,758 | 6,800 | 12,800 | 14,776 | 11,400 | 19,400 |
| Apr | 7,563 | 5,900 | 10,900 | 10,083 | 7,100 | 13,100 | 14,551 | 12,200 | 20,200 |
| May | 9,378 | 6,800 | 12,800 | 9,758 | 6,800 | 12,800 | 14,880 | 11,500 | 19,500 |
| Jun | 9,075 | 7,100 | 13,100 | 10,924 | 7,900 | 13,900 | 17,009 | 14,900 | 22,900 |
| Jul | 12,503 | 9,000 | 17,000 | 13,824 | 9,800 | 17,800 | 19,776 | 16,600 | 24,600 |
| Aug | 12,503 | 9,000 | 17,000 | 14,637 | 10,600 | 18,600 | 23,883 | 20,900 | 25,000 |
| Sep | 9,075 | 7,100 | 13,100 | 10,588 | 7,600 | 13,600 | 21,056 | 19,400 | 25,000 |

## 2.2 Proposed Action

The proposal consists of two types of experimental flows to be implemented beginning in 2008 and concluding in 2012: (1) an experimental high flow test of approximately 41,500 cfs for a maximum duration of 60 hours beginning March 4, 2008; and (2) steady flows in September and October of each year, 2008 through 2012. The overall concept of the experiment is to determine the effectiveness of sandbar building and backwater formation using a high flow test during enriched sediment conditions, and the subsequent impact on humpback chub in those backwaters during fluctuating flows in the spring and summer and steady flows in the fall. This experimental design is reflected in the science plan developed by GCMRC (Appendix A), but may be expanded as discussed in section 1.3.[1]

To gain a better understanding of the relationships between high releases and downstream resources, the March 2008 high flow test hydrograph (Figure 2) is proposed to partially replicate the November 2004 high flow test hydrograph with the following elements:

- on March 4, 2008 at 2200 hours the modified low-fluctuating flows described in Reclamation (1995) would increase at a rate of 1,500 cfs/hour until powerplant capacity is reached;
- on March 5 once powerplant capacity is reached, each of the four bypass tubes would be opened, where once every three hours bypass releases would be increased by 1,875 cfs until all bypass tubes are operating at full capacity for a total bypass release of 15,000 cfs;

[1] This proposed action was developed and builds on previous adaptive management experiments analyzed in environmental assessments prepared by Reclamation and other Interior agencies.

- an essentially constant flow of 41,500[2] cfs would be maintained for 60 hours;
- discharge would then be decreased at a down-ramp rate of 1,500 cfs/hour until the normal powerplant releases scheduled for March have been reached (Figure 2).[3]

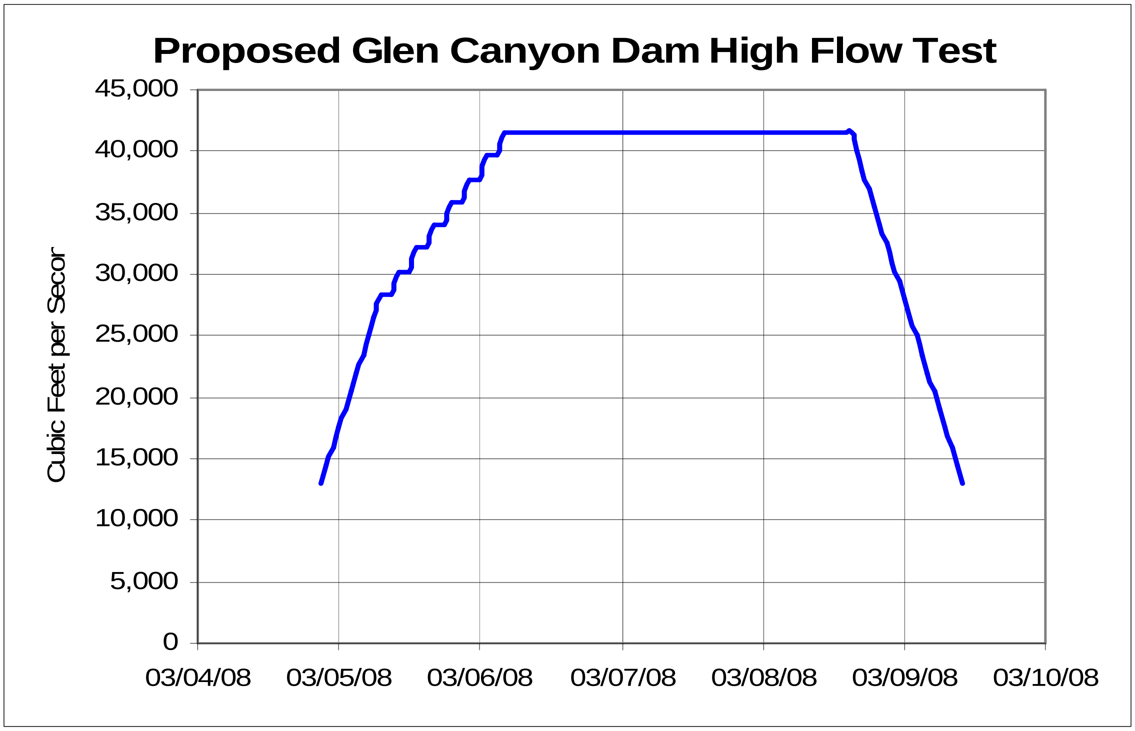


FIGURE 2 Hourly hydrograph of Glen Canyon Dam releases during the March 2008 high flow test.

As described in section 3.1.4, conservation of fine sediment is a key objective in the GCDAMP and determining the long-term sustainability of the sediment resource is a critical objective of the proposed action. Significant progress has been made in understanding sediment transport processes over the last decade, particularly as a result of high flow tests, but the long-term sustainability question cannot yet be answered. The proposed action is an essential step in that effort. This portion of the proposal is unique in proposing a high flow test during enriched sediment conditions, to be followed by modified low fluctuating flow operations during a low annual release year.

This proposed experiment neither mandates nor precludes future experimentation. Rather, this proposed experiment was developed consistent with the principles of adaptive

[2] The sum of powerplant capacity (approximately 26,500 cfs) plus the capacity of the four bypass tubes (15,000 cfs). Maximum powerplant capacity value calculated from the November 24-Month Study projected March 2008 Lake Powell reservoir elevation of 3,586 feet and interpolated from the maximum full gate turbine capacity for seven units. One of the powerplant units will be off-line for repairs and unavailable for use in the experiment.

[3] If this element of the proposal is undertaken, implementation of the high flow experiment would not affect the annual volume of water released from Glen Canyon Dam during water year 2008.

management to require full scientific and public analysis of the effects of the experiment and integration of such results into future decision making, as described at page 7 of the biological assessment (Reclamation 2007b).

The proposal also includes steady flows in the fall. The period and characteristics of these flows were developed during informal consultation with the FWS in November 2007. As described in the February 27, 2008 biological opinion, the FWS believes the following.

> Although the status of the Grand Canyon population of humpback chub has been improving, there is no clear indication for the cause of this improvement. Thus the proposed action takes a conservative approach to changes in dam release in an attempt to capitalize on this trend in status without unduly risking these gains with more drastic changes in dam operation. However, there exists the possibility that the population could decline, despite the current trend and potential for beneficial effects from Reclamation's proposed action. Reclamation has agreed to reinitiate consultation if the trend in humpback chub status should reverse and the population decline…" (FWS 2008:10)

The proposed action and the 2007 biological assessment rely on the best and most recent scientific information regarding the status and population trend of the humpback chub. This includes recognition that improvement in the humpback chub population began between 1994 and 1999 - before any of the recent suite of specific actions to benefit the species were undertaken (Coggins 2007) - and that significantly greater numbers of young humpback chub have been found in the mainstem Colorado River during 2002 through 2006, including above the Little Colorado River (Ackerman 2007). These improvements were seen during implementation of modified low fluctuating flow as adopted in the 1996 ROD. Subsequent to the improvement in humpback chub status, but before the improvement was detected by scientists, a 2004 high flow test, 2003 – 2005 high winter fluctuations, and 2003-2006 non-native fish removal efforts were proposed by Reclamation, NPS, and GCMRC and conducted.

The positive response of the humpback chub and the risks associated with warming of fish habitats were primary factors in the FWS conclusion that a conservative approach was warranted. The risks cited in the FWS's biological opinion refer primarily to the threat of warm water nonnative fish predation and competition (FWS 2008:49). Through the GCDAMP, GCRMC is developing a fish control program to address this threat but that plan has not been finalized. To date, efforts to control warm water nonnative fish predators has not been shown to be effective.

The timing of fall steady flows follows or is timed with young-of-year emergence of humpback chub from the Little Colorado River into the mainstem, depending on the timing of Little Colorado River monsoon floods. Releasing steady flows earlier in the year would warm backwaters more, but would enhance the potential for increases in small-bodied cyprinids that utilize the same habitats. The FWS concludes that steady flows during the September - October time period should also increase the productivity of backwaters. Intense monitoring and research conducted throughout this period will be undertaken to identify resultant beneficial or adverse effects of this element of the proposed action on these geomorphic features and aquatic species.

The steady flow portion of the proposal also utilizes the discussions held during the April 2007 science workshop sponsored by GCMRC. The basic conclusion of that workshop was that if humpback chub goals were being met, then continuation of the Modified Low Fluctuating Flow Alternative was the appropriate action, while if the goals were not being met, then steady flows during July through October should be tested (USGS in prep.). Recovery goals for the humpback chub are currently being developed by the FWS, but the "non-jeopardy" assessment of the 2008 biological opinion is an important consideration in determining if goals for the humpback chub are being met. Desired future conditions for the humpback chub and sediment resources are currently being developed by the NPS, FWS, and within the GCDAMP. A recommendation from the GCDAMP to the Secretary of the Interior is expected in the near future. When the Secretary of the Interior responds to this recommendation and determines specific target levels for various resources, the objectives for humpback chub and sediment will become clearer. However, Reclamation concurs with the FWS conclusion that the proposed action is a logical next step in the implementation of adaptive management and for the conservation of the humpback chub.

In addition, the 2008 biological opinion uses an adaptive management approach to the implementation of steady flows and describes triggers which would lead to reinitiation of formal consultation under ESA, including either a significant decline in the Grand Canyon population of humpback chub or a single year population estimate of 3,500 fish or less (FWS 2008:10). The purpose of the consultation would be to evaluate and determine the cause of the decline and propose actions to reverse the decline. Potential actions could include expanding the months when steady flows would be released from the dam, as well as other responses to scientific assessment of the causative factors.

Steady flow releases during September and October of 2008 through 2012 would include the following constraints:

- typical monthly dam release volumes would be maintained in all water years except 2008, where reallocation of water would occur due to the high flow test in March;
- dam releases for September and October would be steady[4] with a release rate determined to yield the appropriate monthly release volumes;
- if possible, dam operations would be managed so September and October releases would be similar (Table 3), but September releases may be structured to provide a transition between August and October monthly volumes.

[4] Regulation release capacity of ± 1,200 cfs within each hour will be available if needed for hydropower system regulation during the fall steady flow periods. Each hourly average release is expected to be very close to the steady flow target for the day. Also, spinning reserves will be available if needed for emergency response purposes.

### 2.2.1 Annual, Monthly, and Hourly Releases

Annual water volumes are established pursuant to the recently adopted Interim Guidelines for Coordinated Operations of Lake Powell and Lake Mead (approved December 13, 2007) and would not be affected by any aspect of this proposal, but monthly release volumes during 2008 would be adjusted due to the 41,500 cfs peak in March (Table 2). Tables 3 and 4 project monthly release volumes and mean, minimum, and maximum daily releases for 10$^{th}$, 50$^{th}$, and 90$^{th}$ percentiles. Statistically, the 7.48 maf release pattern corresponds to the 10$^{th}$ percentile category (dry hydrology), the 50$^{th}$ percentile corresponds to the 8.23 maf pattern, and the 12.3 maf monthly release pattern (wet hydrology) corresponds to the 90th percentile volume. All monthly volumes are modeled values and subject to change based on actual hydrology and operations. Descriptions of the model, its limitations and assumptions, are in prior documents (Reclamation 1988, 1995, 2007a).

The interim guidelines for coordinated operations of Lake Powell and Lake Mead define four operation tiers: (1) the Equalization Tier, (2) the Upper Level Balancing Tier, (3) the Mid-elevation Tier, and (4) the Lower Elevation Balancing Tier. Releases greater than 9.5 maf would occur during the Equalization Tier. Annual releases of 7.48 maf occur in the Mid-elevation Tier. Annual releases between 7.48 and 9.5 maf generally occur in the two balancing tiers. Implementation of equalization and balancing will follow descriptions in the Shortage EIS (Reclamation 2007a). Of note is that when operating in the Equalization Tier, the Upper Elevation Balancing Tier, or the Lower Elevation Balancing Tier, scheduled water year releases from Lake Powell would be adjusted each month based on forecast inflow and projected September 30 active storage at Lakes Powell and Mead.

TABLE 3 Comparison of alternative releases, water year 2008

| | No Action | | | | Proposed Action | | | |
|---|---|---|---|---|---|---|---|---|
| Month | Monthly volume (maf) | Mean (cfs) | Min (cfs) | Max (cfs) | Monthly Volume (maf) | Mean (cfs) | Min (cfs) | Max (cfs) |
| Oct | 600 | 9,758 | 6,800 | 12,800 | 601 | 9,774 | 6,800 | 12,800 |
| Nov | 600 | 10,083 | 7,100 | 13,100 | 604 | 10,134 | 7,200 | 13,200 |
| Dec | 800 | 13,011 | 9,000 | 17,000 | 800 | 13,011 | 9,000 | 17,000 |
| Jan | 800 | 13,011 | 9,000 | 17,000 | 800 | 13,011 | 9,000 | 17,000 |
| Feb | 600 | 10,804 | 7,800 | 13,800 | 600 | 10,804 | 7,400 | 13,400 |
| Mar | 600 | 9,758 | 6,800 | 12,800 | 830 | 13,499 | 7,200 | 13,200[1] |
| Apr | 600 | 10,083 | 7,100 | 13,100 | 550 | 9,243 | 6,200 | 12,200 |
| May | 600 | 9,758 | 6,800 | 12,800 | 555 | 9,042 | 6,000 | 12,000 |
| Jun | 650 | 10,924 | 7,900 | 13,900 | 650 | 10,924 | 7,900 | 13,900 |
| Jul | 850 | 13,824 | 9,800 | 17,800 | 820 | 13,336 | 9,300 | 17,300 |
| Aug | 900 | 14,637 | 10,600 | 18,600 | 820 | 13,336 | 9,300 | 17,300 |
| Sep | 630 | 10,588 | 7,600 | 13,600 | 600 | 10,083 | 10,083 | 10,083 |

[1] Maximum releases during normal modified low fluctuating flow operations in March 2008. During the high flow test the maximum release would be 41,500 cfs.

TABLE 4 Proposed Glen Canyon Dam releases under dry (7.48 maf), median (8.23 maf), and wet (12.3 maf) conditions, 2009-2012

| | Annual Releases | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 7.48 maf | | | 8.23 maf | | | 12.3 maf | | |
| Month | Mean (cfs) | Min (cfs) | Max (cfs) | Mean (cfs) | Min (cfs) | Max (cfs) | Mean (cfs) | Min (cfs) | Max (cfs) |
| Oct | 7,502 | 7,002 | 8,002 | 9,758 | 9,258 | 10,258 | 9,378 | 8,878 | 9,878 |
| Nov | 7,563 | 5,900 | 10,900 | 10,083 | 7,100 | 13,100 | 9,075 | 7,100 | 13,100 |
| Dec | 9,378 | 6,800 | 12,800 | 13,011 | 9,000 | 17,000 | 12,503 | 9,000 | 17,000 |
| Jan | 12,503 | 9,000 | 17,000 | 13,011 | 9,000 | 17,000 | 17,510 | 14,200 | 22,200 |
| Feb | 8,470 | 7,800 | 13,800 | 10,804 | 7,800 | 13,800 | 13,903 | 13,700 | 21,700 |
| Mar | 9,378 | 6,800 | 14,800 | 9,758 | 6,800 | 12,800 | 14,776 | 11,400 | 19,400 |
| Apr | 7,563 | 5,900 | 10,900 | 10,083 | 7,100 | 13,100 | 14,551 | 12,200 | 20,200 |
| May | 9,378 | 6,800 | 12,800 | 9,758 | 6,800 | 12,800 | 14,880 | 11,500 | 19,500 |
| Jun | 9,075 | 7,100 | 13,100 | 10,924 | 7,900 | 13,900 | 17,009 | 14,900 | 22,900 |
| Jul | 12,503 | 9,000 | 17,000 | 13,824 | 9,800 | 17,800 | 19,776 | 16,600 | 24,600 |
| Aug | 12,503 | 9,000 | 17,000 | 14,637 | 10,600 | 18,600 | 23,883 | 20,900 | 25,000 |
| Sep | 9,075 | 8,575 | 9,575 | 10,588 | 10,088 | 11,088 | 21,056 | 20,556 | 21,556 |

### 2.2.2 Mitigation Measures in the Proposal

Under NEPA, mitigation means reducing, eliminating, or compensating for the impact of an alternative (40 CFR 1508.20). Mitigation measures incorporated into the proposal are designed to accomplish these objectives. More complete descriptions of potential impacts of the proposal are contained in the various resource areas in section 3.0. As discussed under Socioeconomics in section 3.3, increased hydropower costs was a factor in proposing a steady flow test during the fall rather than the summer when much higher economic impacts would occur. In addition, the timing of the high flow test was designed to minimize impacts to recreation, tamarisk seedling dispersal, the aquatic foodbase, and the Kanab ambersnail.

With respect to the high-flow experiment conducted in November 2004, conservation measures were designed to mitigate any adverse impacts on endangered Kanab ambersnail (*Oxyloma haydeni kanabensis*) at Vaseys Paradise in Grand Canyon National Park as a result of temporary high-flow inundation of ambersnail habitat. These efforts included moving 4 percent of the total habitat of plants and animals. The current proposal repeats the 2004 mitigation measures for the Kanab ambersnail. Reclamation proposes to temporarily relocate snails that would be inundated by a 41,500 cfs flow to higher elevations at Vaseys Paradise. Further mitigation commitments could develop as a result of the completion of formal consultation with the FWS under the Endangered Species Act of 1973, as amended (ESA).

As part of information gathering during the formulation of the proposed action, the FWS, NPS, Western, and AGFD conducted a meeting with fishing guides and business owners in the Marble Canyon area. Their concerns were primarily socioeconomic and associated with public perception of impacts to fishing success in the Lees Ferry reach. To minimize potential adverse economic impact, Reclamation agreed to shift the timing of the proposed high flow test as early in 2008 as possible and to work with the FWS, NPS, and

AGFD to propose measures within the GCDAMP dedicated to improving communication between management agencies and the angling guides, dependent local businesses, and the public. These proposed measures include:

- creation of an ad hoc group within the GCDAMP to facilitate discussion among trout fishing guides and anglers, Marble Canyon business owners, recreational rafting companies, and other interested parties regarding proposed experimental actions affecting these resources, and
- consideration of updating the Lees Ferry Management Plan. The NPS and AGFD have primary authority and responsibility for this action, with the FWS and Reclamation participating in an advisory role. If this proposal were accepted by these agencies, workshops could be used to help develop the specific aspects of the management plan.

# 3.0 Environmental Impacts of the Proposal

This chapter describes environmental impacts of the proposal compared with taking no further experimental flow actions over the next five years. The action area or geographic scope is from the tail water below Glen Canyon Dam downstream along the Colorado River to Lake Mead, as shown in Figure 1. The lateral extent of the action area is the ground surface that would be inundated by the proposed high release of 41,500 cfs or the area indirectly or cumulatively affected.

Reclamation convened an interdisciplinary team of resource specialists to review alternatives and consider potential effects to natural, cultural, and socioeconomic resources listed in Table 1. They concluded that should the proposal be implemented, most resources would be temporarily and beneficially affected; however, implementing the proposal would result in adverse impacts to hydropower customers, trout guides, small businesses in the Marble Canyon area, and the Hualapai Tribe. By definition, this economic or social effect would not require preparation of an EIS (40 CFR 1508.14). Detailed information on resources affected by the proposal is provided below. The chapter is organized by resources, with natural resources described first, followed by cultural, then socioeconomic resources.

## 3.1 Natural Resources

Natural resources reviewed to determine effects of the proposed action include air quality, floodplains and wetlands, geology and soils (including prime farmlands), threatened and endangered species, vegetation, water resources (hydrology, water delivery systems, water quality), and wildlife. Based on this review of all natural resources in the action area, only those natural resources likely to be directly, indirectly, or cumulatively affected by the proposal are described here.

Of particular importance in evaluating effects of the proposal is humpback chub habitat, especially nursery backwaters, and the possible downstream transport of young humpback chub. Evaluation of the steady fall flow is important to better understand the contrast between fluctuating and steady flows with respect to the extent of longitudinal warming, warming of shoreline habitats and nursery backwaters, stability of shoreline habitats, and the effects to humpback chub survival, growth, and bioenergetic expenditure. Full evaluation of this aspect of the proposed action is important to better understand how discretionary releases from the dam might affect humpback chub and long-term species conservation. In the sections below, the relevant natural resources are presented by trophic levels.

### 3.1.1 Climate Change

The hydrologic model, Colorado River Simulation System (Reclamation 1988, 2007a), used to present future dam releases under both alternatives does not project future flows or take into consideration climatic projections, but rather relies on historic records of the Colorado River to depict a range of possible future storage levels in Lakes Powell and Mead and dam releases. Using the Colorado River Simulation System, projections of future Lake Powell reservoir elevations are probabilistic, based on the 100-year historic record. This record includes years of under and over average flow. Studies of proxy records, in particular analyses of tree-rings throughout the upper Colorado River basin, indicate droughts of greater severity and duration than those in the 100-year historic record. Such findings, when coupled with today’s understanding of decadal cycles brought on by the el Niño-Southern Oscillation, Pacific Decadal Oscillation, upstream consumptive use, and improved understanding of millennial-scale climate cycles (Bond et al. 1997), suggest the current drought could continue over the action period or there could be a shift to wetter conditions (Webb et al. 2005). Thus, the action period for this environmental assessment may include wetter or drier conditions than today or wetter or drier conditions than modeled in the Colorado River Simulation System. A continued drought like those documented in proxy records could result in decreased mean annual inflow to Lake Powell and decreased average storage in Lake Powell. This could affect downstream water resources and the effects on water resources under no action or the proposal.

### 3.1.2 Water Resources or Glen Canyon Dam Operations under No Action

As mentioned above, this environmental assessment is tiered off prior NEPA analyses. Full descriptions of the methods used for water resources modeling and other resources are described in these prior documents. The details of annual and monthly projected water resources and dam operations through the experimental period are in Reclamation (2007a). Only a summary is provided here. Annual releases from the dam would be the same under either alternative as noted in section 2.2, only monthly and hourly release volumes would differ. Tables 2 and 3 present the most probable future values if no action is taken.

### 3.1.3 Water Resources under the Proposal

One of the differences examined by Reclamation hydrologists was the level of Lake Powell and Lake Mead should the proposal be implemented. Projected differences in Lake Powell elevation with the proposal would be less than projected seasonal change within a given water year. The greatest differences in the elevation of Lake Powell would occur in March 2008 when the reservoir would decrease a projected 2.6 feet as a result of the proposed high-flow release. The effect on Lake Mead would be an increase by 2.5 feet in March. However because the 2008 water year release from Lake Powell is unchanged under the proposal, elevations of both Lakes Powell and Mead would be the same elevation under either alternative by September 30, 2008.

In terms of dam releases, Table 3 contrasts monthly volumes under the two alternatives. Tables 2 and 4 show proposed releases if the water year is dry (7.48 maf), median conditions (8.23 maf), or wet (12.3 maf). Predicted changes in levels of Lakes Powell and Mead or Glen Canyon Dam releases are minor, temporary effects. (Hydropower effects are covered under Socioeconomic Resources.)

#### *3.1.3.1 Water Quality*

Effects of the 2008 high flow are projected based on prior experiments and knowledge of water quality processes. Prior experimental high flows weakened the persistent chemical and thermal stratification below the depth of the penstock-withdrawal zone. The volume of water below this zone is normally relatively isolated from the convective and advective mixing processes of the upper portions of the reservoir. The water below the penstock withdrawal zone is typically cooler than the upper level of the reservoir and more saline with a marked reduction of dissolved oxygen concentrations. Releases from the powerplant following the 1996 high flow test had reduced water density and higher dissolved oxygen concentrations, the result of lowering the depth of chemical stratification in the reservoir. Similar positive water quality effects are projected under the proposal.

Water quality effects during a high flow test in 2008 would likely include a slight reduction in downstream temperature and a slight increase in salinity. During the year following the high flow test, salinity levels would probably decrease slightly, downstream temperatures would return to the no-action condition, and dissolved oxygen concentrations could increase slightly. The increase in the dissolved oxygen concentration from fluctuating flows is the result of down-ramping.

Based on model results, the release temperatures of the proposed September and October steady flows would not be significantly different from normal fluctuating releases. Determining the effect of subsequent downstream warming in near shore and backwater areas is one of the important purposes of this portion of the experiment. The proposed steady flows could increase the effect of low dissolved oxygen levels. However, analysis of past data shows than on average steady flow reduced dissolved oxygen level by about 0.25 mg/L. Both steady and fluctuating flows should come to saturation level below the dam at approximately the same distances.

### 3.1.4 Sediment and Geomorphology

The proposal is designed to test the hypothesis that sediment may be entrained from the channel bed and debris fans and deposited at higher elevations along river channel margins during a high flow, preserving or enhancing camping beaches and sediment conservation.

Significant sediment research in the Grand Canyon has occurred during the past 25 years. While this proposal builds on that monitoring, research and experimentation, this assessment does not intend to fully summarize all that information. During that period of time, there has never been a high flow test conducted during highly enriched sediment conditions nor has a high flow test ever been followed by Modified Low Fluctuating Flow releases during a low annual release year. Reclamation believes such an experiment is critical in determining the potential for long-term sustainability of the sediment resource. Topping et al. (2006) found that in the 1996 high flow test under depletion sediment concentrations, volumes of high elevation bars were increased at the expense of lower elevation portions of upstream sandbars. In 2004, moderately enriched sediment concentrations in upper Marble Canyon produced sandbars in many cases larger than the 1996 deposits, but downstream of RM 42 only 18 percent of sandbars were larger than was produced in the 1996 high flow test (Topping et al. 2006). Their final conclusion was that "…in future controlled floods, more sand is required to achieve increases in the total area and volume of eddy sandbars throughout all of Marble and Grand Canyons." Such condition currently exists as a result of significant sediment inputs during 2006 and 2007. In addition, if no action is taken, recent tributary sediment inputs eventually will be transported downstream to Lake Mead with no high elevation sandbar rebuilding.

With respect to the retention of sandbars thus created, Figure 3 shows the total sandbar volume at 12 sandbar sites in Marble Canyon from 1990 through 2006. Several conclusions are evident with respect to sandbar volume at these sites.

1. there is currently more sediment in these sandbars above 25,000 cfs than prior to the first high flow test in 1996. Mid-elevation and total storage volumes are similar to 1996 levels.
2. in contrast to the declining trend in total sediment storage prior to 1996, the high flow tests of 1996, 1997, 2000, and 2004 have each increased the amount of sand storage, for both mid-elevation and high elevation deposits
3. initial increases in sand storage decline rapidly, with half of the initial increases in total sediment storage eroded within 6 months in 1996 and within 15 months in 2004.

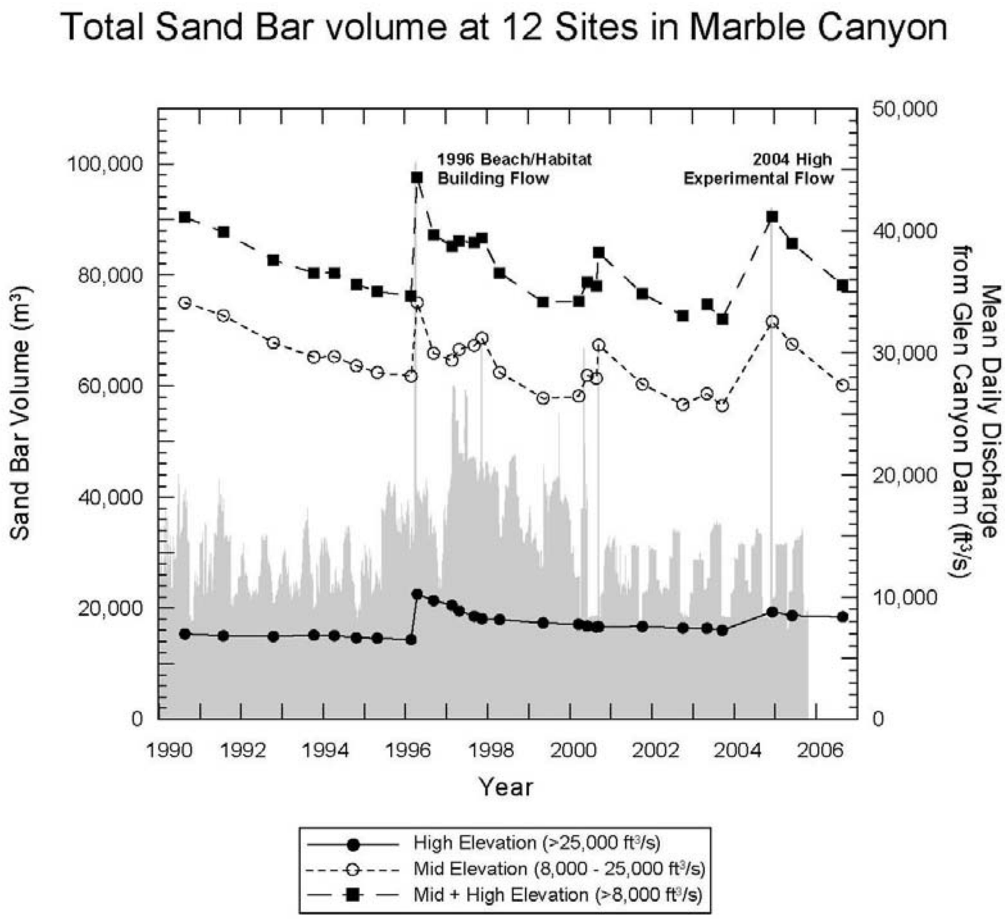


FIGURE 3 Total sandbar volume at 12 sites in Marble Canyon. *Source*: J. Hazel, preliminary data courtesy of Northern Arizona University.

Dam releases following historic high flow tests have had a significant effect on newly created sandbar deposits and the high flows which followed the 1996 and 2004 tests have been implicated in the rapid erosion of these sandbars (Schmidt et al. 2004). Following the 1996 high flow test, maximum daily releases usually reached 20,000 cfs during water year 1996 and exceeded 20,000 cfs for much of water year 1997, and following the 2004 high flow test, high fluctuating winter releases designed to disadvantage nonnative trout spawning reached daily maximums of 20,000 cfs for the January through March 2005 period (Reclamation 2008b). In contrast, Glen Canyon Dam releases during 2006 and 2007 had low annual volumes and Modified Low Fluctuating Flow constraints and have resulted in suppressed sediment transport, allowing sediment accumulation in the Colorado River mainstem above the Little Colorado River confluence and RM 30 (USGS 2007b); sediment transport conditions are expected to be similar in 2008.

While it is generally expected that significant positive sandbar building will occur during the high flow test, it is uncertain where that sandbar building will occur, how long those effects will persist, what benefits will accrue, and whether high flows will enable long-term sediment conservation. It is expected that monitoring and research activities will be followed by analysis and modeling to answer these questions.

#### *3.1.4.1 Sandbars under No Action*

Some geomorphologists believe that Grand Canyon sandbars will continue to degrade due to the existence of the dam; others hypothesize that dam operations, particularly high flows, may be used to rebuild, conserve, or enhance sandbars, particularly when combined with significant tributary sediment inputs (Topping et al. 2006). As stated above, an underlying purpose of this and prior experimental dam releases is to test such hypotheses, measure rates of sand deposition and erosion, as well as to observe changes in sandbar topography over time in relation to dam operations. Under the No Action Alternative, no specific experimental flow tests would occur, beach-habitat building flows triggered by a risk of spills would occur as specified in the 1997 Glen Canyon Dam operating criteria, and sandbars and beaches would likely decline in area and volume as in the period 1990 - 1996.

#### *3.1.4.2 Sandbars under the Proposal*

Based on prior experimental flows, sediment would likely be entrained quickly and efficiently by the proposed 41,500 cfs release. Suspended sediment concentrations within the river and eddies would be expected to decrease after the river stage reaches its peak. This response is expected to vary from that measured in 1996 due to current abundant sediment supply in the river. Together with sand supplied from the Little Colorado River, sand storage on average throughout Marble and Grand canyons is currently substantially greater than that preceding the 2004 high flow test (D. Topping, pers. comm..). As of August 2007, about 1.75 million metric tons (mmt) of fine sediment relative to October 2006 was still situated above the confluence of the Little Colorado River, with about 1.5 mmt above RM 30 (USGS 2007b). These conditions present an opportunity to evaluate effects of a high flow test under more sediment-rich conditions than observed during previous experiments.

Based on the results of high releases conducted in 1996, 1997, and 2004, a high flow test would likely increase the number and size of sandbars and campsites immediately after the event. For example, the 1996 flood created 84 new campsites, while destroying three others (Kearsley et al. 1999). A key question is whether a high flow under sediment enriched conditions might result in larger or more lasting effects.

#### *3.1.4.3 Backwaters under No Action*

Backwaters may be important rearing habitat for native fish due to low water velocity, warm water, and high levels of biological productivity. The importance of backwaters in Grand Canyon with respect to native fish is uncertain, and this is one of the key questions associated with the proposal. Backwaters are created as water velocity in eddy return channels declines to near zero with falling river discharge, leaving an area of stagnant water surrounded on three sides by sand deposits and open to the main channel environment on the fourth side. Reattachment sandbars are the primary geomorphic feature that functions to isolate near shore habitats from the cold, high velocity main channel environment.

Backwater numbers vary spatially among geomorphic reaches in Grand Canyon and tend to occur in greatest number in river reaches with the greatest active channel width, including the reach immediately downstream from the Little Colorado River (RM 61.5-77; McGuinn-Robbins 1995). Numbers and size of backwaters also vary temporally as a function of sediment availability and hydrology, and their size can vary within a year at a given site. Under no action, backwaters would continue to fluctuate with ongoing geomorphic and hydrologic processes.

#### *3.1.4.4 Backwaters under the Proposal*

Persistence of backwaters created during 1996 appeared to be strongly governed by post-high flow dam operations. Whereas the 1996 high flow test resulted in creation of 26 percent more backwaters potentially available as rearing areas for Grand Canyon fishes, most of these newly created habitats disappeared within two weeks due to reattachment bar erosion (Brouder et al. 1999; Hazel et al. 1999; Parnell et al. 1997; Schmidt et al. 2004). Nearly half of the total sediment aggradation in recirculation zones eroded away during the 10 months following the experiment and was associated in part with relatively high fluctuating flows of 15,000-20,000 cfs (Hazel et al. 1999). One of the key tests of this proposal is how summer Modified Low Fluctuating Flows and fall steady flows might affect backwaters (USGS 2007a).

Goeking et al. (2003) found no relationship between backwater number and flood frequency, although backwater size tends to be greatest following high flows and less in the absence of high flows due to infilling. Considering both area and number, however, no net positive or negative trend in backwater availability was noted during 1935 through 2000. At the decadal scale, several factors confound interpretation of high flow effects on backwaters bathymetry, including site-specific relationships between flow and backwater size, temporal variation within individual sites, and high spatial variation in reattachment bar topography (Goeking et al. 2003). Efficacy of high flow tests at creating or enlarging backwaters also depends on antecedent sediment load and distribution, hydrology of previous years (Rakowski and Schmidt 1999) and post-high flow river hydrology, which can shorten the duration of backwaters to a few weeks depending on return channel deposition rates or erosion of reattachment bars (Brouder et al. 1999).

Biologically, the 1996 high flow caused an immediate reduction in benthic invertebrate numbers and fine particulate organic matter (FPOM) through scouring (Brouder et al. 1999; Parnell and Bennet 1999). Invertebrates rebounded to pre-test levels by September 1996, but researchers thought that the rate of recolonization was hindered by a lack of FPOM. Still, recovery of key benthic taxa such as chironomids and other Diptera was relatively rapid (3 months), certainly rapid enough for use as food by the following summer's cohort of young-of-year (YOY) native fish (Brouder et al. 1999). Also during the 1996 high flow test, Parnell and Bennet (1999) documented burial of autochthonous vegetation during reattachment bar aggradation, which resulted in increased levels of dissolved organic carbon, nitrogen and phosphorus in sandbar ground water and in adjacent backwaters. These nutrients are thus available for uptake by aquatic or emergent vegetation in the backwater. The proposal is expected to have the same effects on backwaters: an immediate reduction in benthic invertebrate numbers and fine particulate organic matter, but over time, a potential beneficial change in backwaters. Another key purpose of the proposal is to determine the effect that flow stability has on backwater temperature, and consequential impacts to productivity and native and nonnative fish.

### 3.1.5 Vegetation

Vegetation along the river is distributed along a gradient with the first 60 miles classified as Upper Sonoran or cold desert plants, gradually shifting to warm desert species typical of Lower Sonoran vegetation. At any one location where cross-sections are taken, the more xerically adapted species such as four-wing saltbush (*Atriplex canescens*), brittle bush (*Encelia farinosa*), and rubber rabbitbrush (*Chrysothamnus nauseosus*), are found on the terraces away from the river. These upland plants would be largely unaffected by the proposal and are therefore not considered here.

Within the area that would be inundated by a flow of 41,500 cfs, vegetation has changed over time in response to changes in the water-levels of the Colorado River, increased soil salinity, climatic changes, and other factors (Carothers and Aitchison 1976, Kearsley et al. 2006). Prior to 1963, riparian vegetation was common in Glen Canyon and along the lower Colorado River, but relatively rare in Grand Canyon due to the combination of high flows, sediment deposition, and entrained debris scouring the floodplain (Clover and Jotter 1944; Kearsley and Ayers 1999:310; Stevens and Waring 1988; Stevens et al. 1995). By 1973 after 10 years of regulated flows, species that were ephemeral pre-dam occupants (Clover and Jotter 1944; Turner and Karpriscak 1980) expanded into the newly stable habitat. From 1983 to 1985, summer flows were maintained at or above 40,000 cfs, altering the composition, density, and location of riparian plants (Stevens and Waring 1988). Since then, the total size of the riparian zone or new high water zone has increased to 10 square miles (2,500 hectares) (Kearsley and Ayers 1999; Schmidt and Graf 1990) with salt cedar or tamarisk (*Tamarix ramosissima*) being the most dominant species, and arrowweed (*Pluchea sericea* (Nutt.) Cov.), black willow (*Salix gooddingii*), coyote willow (*Salix exigua* Nutt.), and Emory seepwillow (*Baccharis emoryi* Gray), found in lesser abundance (taxomony is after Welsh et al. 1987).

Stands of emergent marsh vegetation in the riparian zone tend to be dominated by a few species, depending on soil texture and drainage. A cattail (*Typha domingensis*) and common reed (*Phragmities australis*) association grows on fine-grained silty loams while a horseweed (*Conyza canadensis*), knotweed (*Polygonum aviculare*), and Bermuda grass (*Cynodon dactylon*) association grows on loamy sands. The riparian vegetation located at stage elevations above daily inundation fall out along moisture gradients and species tolerance to water stress (Kearsley et al. 2006; Stevens et al, 1995). Kearsley et al. (2006) demonstrated through four years of monitoring that annual operations affects plant species diversity and cover up to 35,000 cfs. Operational effects include duration of mean discharge and maximum discharge for at least three months or more. Vegetation above this surface elevation tends to be affected more by local precipitation than by annual operations. The effects of hydrologic gradients on species abundance and diversity in riparian areas has been observed in other semi-arid rivers (Shafroth et al. 1998; Stromberg et al. 1996).

#### *3.1.5.1 Vegetation under No Action*

If no action were taken by Reclamation through 2012, riparian vegetation would continue to change due to processes of expansion and colonization by invasive species such as tamarisk, camelthorn, Russian-thistle (*Salsola iberica*), red brome or foxtail brome (*Bromus rubens*), cheatgrass (*Bromus tectorum*), yellow sweet-clover (*Melilotus officinalis*), spiny sow-thistle (*Sonchus asper*), and Bermuda grass (*Cynodon dactylon*). Other natural processes would continue to result in alteration of the riparian zone. Kearsley et al. (2006) developed predictive models for vegetation dominance based on stage changes in river flows and cycles of inundation. Essentially, frequent changes in inundation resulting from dam operations led to an increase in total volume of tamarisk and other woody riparian species and is accompanied by a reduction in herbaceous species (Kearsley and Ayers 1999; Kearsley et al. 2006): a reduction in species is predicted in the absence of disturbance. Many of the changes in riparian vegetation can be accounted for with a reduction in fine sediments due to frequent water-level fluctuations and the lack of flooding which is integral to riparian system function (Nilsson et al. 1989; NRC 2002). Within Grand Canyon, Bowers et al. (1997) and Webb (1996) have demonstrated that short-lived plants such as *Brickellia longifola, Stephanomeria pauciflora, Gutierrezia sarothrae, Encelia frutescens*, and *Baccharis emoryi*, are actively colonizing the youngest and more disturbed surfaces. Longer-lived species are not as quick to colonize disturbed areas. For example, *Ephedra* spp., *Opuntia* spp., and *Acacia gregii* are found on surfaces older than seven years and as young as 28 years. Without the disturbances caused by the proposal or on-going formation of debris fans at tributary mouths, the longer-lived species will continue to expand towards the river edge.

Of course, some changes to riparian vegetation are occurring due to management actions. Executive Order 13112 defines invasive species as alien species whose introduction is likely to cause economic or environmental harm or harm to human health. This executive order calls on federal agencies to work to prevent and control the introduction and spread of invasive species. Both Glen Canyon National Recreation Area and Grand Canyon National Park support programs of noxious and invasive plant control and these programs are projected to continue.

#### *3.1.5.2 Vegetation under the Proposal*

Effects of prior experimental flows of similar magnitude on riparian vegetation were minimal (Valdez 1999:346), but subsequent flows do affect plant response to a disturbance. A study conducted in 2000 (Porter 2002) for flows of slightly lower magnitude (31,000 cfs) documented an increased germination of nonnative species in exposed areas (e.g. tamarisk). Studies during the 1996 flood did not specifically focus on seedling establishment (Kearsley and Ayers 1999), but expansion of Bermuda grass following the 1996 experimental release was noted by Phillips and Jackson (1996). As noted above, it is the long-term operations following a disturbance that affects riparian vegetation response to a disturbance event (Kearsley et al. 2006; Kearsley and Ayers 1999; Porter 2002). Long-term effects of the high flow in March and steady flows in September and October are predicted to be minor. Prior high flow experiments showed that sedimentation along channel margins and in eddy deposition zones buried low-growing plants; however, this effect was of insufficient magnitude, duration, or both, to restructure most vegetation patches in the long term (Kearsley and Ayers 1996; Valdez 1999:345).

In terms of effects to individual species, an increase in the density of cattails was noted in lower reaches of Grand Canyon following the 1996 high flow test as well as increased abundance of woody species in Kwagunt Marsh (Kearsley and Ayers 1996), but this may have been a result of high sustained releases that followed the high flow. Also, total foliar cover was diminished as a result of the 1996 flood, but no localities showed a significant change in area covered by wetland plants (Kearsley and Ayers 1996). The proposed 2008 flood would likely result in similar minor effects:  short term burial of seeds and plants on existing sandbars, some scouring of riparian vegetation, and a short-term increase in groundwater and soil nutrient concentrations. Newly exposed sediment may be subject to exotic colonization, particularly low velocity, low elevation sandbars (Porter 2002), but subsequent establishment in these sites is dependent on long-term operation during the summer growing season. Over time, later successional, woody species may occupy these areas.

The proposed high flow would increase the rate at which sediment is deposited at the delta of Lake Mead, as predicted in the Sediment section.  However, because of the short duration of the flow, the extensive area available for sediment deposition in Lake Mead, and the highly fluctuating water levels of Lake Mead, effects on riparian vegetation would be minor.

Established tamarisk and camelthorn located on sand bars and along channel margins are expected to survive a flood, growing up through newly deposited sand and vigorously resprouting and recolonizing sandbars, though the extent of the expansion is dependent on subsequent discharge. This expansion is likely to continue whether there is an experimental flood or not (Valdez 1999:346). One effect of prior floods on riparian vegetation was the burial of the seed bank by new sediment deposits (Kearsley and Ayers 1999; Valdez 1999), although, it is unclear whether the newly buried seeds remain viable, leading to further expansion of undesired plants onto sandbars. The creation of new habitat through the deposition of sediment during flooding can lead to increases in exotic species, especially fast-colonizing annuals and tamarisk (Kearsley et al. 2006; Porter 2002).

In conclusion, there might be changes in individual plants or patches of plants, but over time these changes would be minor against the larger changes wrought by processes of succession and adaptation along a hydrological gradient and those caused by daily fluctuations.  Compared to no action, the action alternative would likely lead to deposition of new sediment that could lead to some increase in nonnative plants, especially tamarisk and *Bromus* spp. Kearsley et al. (2006) demonstrated that these changes can be predictable over large spatial and temporal scales.

### 3.1.6 Terrestrial Invertebrates and Herptofauna

In this section, effects of the proposal are analyzed for specific terrestrial invertebrates or herptofauna of interest, particularly those listed as endangered, threatened, or of concern to states or tribal managers. A separate biological assessment of these effects was submitted to the FWS (Appendix B) and is reflected in a new biological opinion issued under Section 7 of the ESA (Appendix C). (The effects of the proposal on aquatic invertebrates are included under the discussions of fish and birds.)

The Kanab ambersnail (*Oxyloma haydeni kanabensis*) was listed as endangered in 1992. Populations of Kanab ambersnail presently occur at three springs, one at Three Lakes near Kanab, Utah; one at Vaseys Paradise, a small spring-fed riparian area adjacent to the Colorado River in Grand Canyon; and a translocated population at Upper Elves Chasm. Kanab ambersnails located at Elves Chasm would not be affected by this action.

Over 27 species of herpetofauna have been documented in the riparian zone of the Grand Canyon (Kearsley et al. 2006). Within this area, herpetofauna densities are highest where riparian vegetation has developed since construction of Glen Canyon Dam, i.e., between the more xeric terraces and the river shoreline. Toads and tree lizards use the shoreline proportionally more than other species (Carpenter 2006). Water level fluctuations can also help maintain areas with reduced vegetation cover and could likely lead to increase in use by basking reptiles. This zone would also provide an area with elevated humidity and increased food production such as insects (Kearsley et al. 2006)

Common lizards in the riparian zone are the side-blotched lizard (*Uta stansburiana*), Western whiptail (*Cnemidophorus tigris*), desert spiny lizard (*Sceloporus magister*), and the tree lizard (*Urosaurus ornatus*). The collared lizard (*Crotaphylus insularis)* and chuckwalla (*Sauromalus obesus)* are less common in the riparian zone than in the more xeric terraces. Warren and Schwalbe (1985) reported lizard densities during June averaged 858/hectare in the riparian zone versus 300/hectare in the old high water zone. Kearsley et al. (2006) suggested that the high density of lizards in the riparian zone may be attributed to increased abundance of food resources (insects) and to some degree to organic debris left on popular camping beaches.

Snakes are common in the higher and drier elevations of the riparian zone and in the more xeric terraces and hillsides. Eight snake species have been documented within the riparian zone; the most common of these are the Grand Canyon rattlesnake (*Crotalus viridis abyssus*), the southwestern speckled rattlesnake (*C. mitchellii pyrrhus)* and the desert striped whipsnake (*Masticophis taeniatus)*.

Amphibians include frogs, spadefoots, and true toads. Recent surveys have found abundant populations of Woodhouse’s toad (*Bufo woodhousii*), red-spotted toad, (*B. punctatus*), canyon treefrog, and tiger salamander (*Ambystoma tigrinum*) (Kearsley et al. 2003, 2006). Northern leopard frog (*Rana pipiens*) populations, on the other hand, have declined (Drost 2004, 2005). Listed as a candidate species in Arizona, the northern leopard frog is declining throughout its range. Leopard frogs have disappeared from 70 percent of the known sites above and below Glen Canyon Dam and there appear to be declines among some of the remaining populations (Drost 2004). The only known population below the dam is located in Glen Canyon in a series of off-channel pools. Inundation at this site occurs at approximately 21,000 cfs. This population has experienced wide year-to-year fluctuations in numbers, but a recent survey indicates a sharp decline in population with only two adult individuals found in 2004 (Drost 2004).

The canyon treefrog is confined to relatively steep side canyons, while the two toad species are found in the active riparian zone in spring and fall and along the shoreline in summer (Kearsley et al. 2003). For amphibians, egg deposition and larval development generally occurs in the backwaters or along the shallow water at the boundary of the aquatic and riparian habitats.

#### *3.1.6.1 Terrestrial Invertebrates and Herptofauna under No Action*

Kanab ambersnails are found in the riparian vegetation associated with the spring at Vaseys Paradise. Through analysis of historic photographs, an increase in the vegetative cover along the river in Grand Canyon has occurred since the completion of Glen Canyon Dam in 1963 (Turner and Karpiscak 1980). The increase in cover, reduction in beach-scouring flows, and introduction of nonnative water-cress, *Nasturtium officinale,* has led to a greater than 40 percent increase in suitable Kanab ambersnail habitat area at Vaseys Paradise from pre-dam conditions (Stevens et al 1997a). Under the no action alternative Kanab ambersnails are expected to maintain their population at Vaseys Paradise.

Herpetofauna densities are generally highest where riparian vegetation has developed since construction of Glen Canyon Dam. However, Carpenter (2006) found that, other than the resident frogs, herpetofuana utilize habitats from the river up to the xeric terraces. Toads and tree lizards use the shoreline proportionally more than any of the other species (Carpenter 2006). Amphibians and reptiles are not expected to change under the no action.

#### *3.1.6.2 Terrestrial Invertebrates and Herptofauna under the Proposal*

The proposed 2008 high flow test would result in a minor loss of the Vaseys Paradise habitat of Kanab ambersnail. But pre-dam, the Kanab ambersnail population in the Grand Canyon survived and recovered from innumerable flows equal to or higher than the proposal. The population of Kanab ambersnail at Vaseys Paradise and the effects of the proposal on them are currently under consultation with the FWS. Reclamation's finding is that the proposal "may affect, is likely to adversely affect" a percentage of snails and their habitat during the high flow test. No effect on snails or habitat would result from fall steady flows. At flows of 45,000 cfs, approximately 17 percent of Kanab ambersnail habitat would be inundated. This habitat varies from high to low suitability for Kanab ambersnail. If the proposed high flow is implemented, Reclamation would move approximately 25 percent of affected habitat, including higher quality vegetation and snails within the flood zone, as was done in 2004. Additionally, all vegetation in the potentially flooded zone will be searched for snails and all snails that are found will be temporarily moved with the vegetation.  The vegetation and snails would be replaced after the flood waters have receded. Moving snails and their habitat, as mentioned under the section on mitigation measures, could result in an adverse effect or "take" of the species. This potential for take is the reason for the "may affect" finding in Reclamation's biological assessment.

Populations of northern leopard frog in the Glen Canyon reach were monitored before and after the 1996 flood and the populations were little affected in the short-run and recovered quickly over time (Spence 1996). However, since 1996 northern leopard frogs have declined dramatically in Glen and Grand canyons and in 2004 only two adults were found in an off-channel pool in Glen Canyon. Clearly other factors besides high flows have played a role in this decline. Using the conclusions of the 1997 report and the 2004 status of this population, effects are uncertain to populations of these species from the proposal.

### 3.1.7 Fish under No Action

The river from the dam to the Paria River presently supports a self-sustaining fishery of rainbow trout (*Oncorhynchus mykiss)* and occasional brown trout (*Salmo trutta)*. Prior to implementation of the 1996 record of decision and flow changes made therein, stocking was necessary to maintain the fishery. Management of trout in this reach, as agreed to by the management agencies is for rainbow trout and not for brown trout; the latter is a particularly piscivorous predator on native fish. This reach of river also supports small numbers of bluehead sucker (*Catostomus discobolus*), flannelmouth sucker (*Catostomus latipinnis*), and speckled dace (*Rhinichthys osculus*). The flannelmouth sucker spawns in this reach and up the Paria River (McIvor and Thieme 2000; McKinney et al. 1999; Thieme 1998), although the water is too cold in the mainstem for survival of eggs and larvae.

From the Paria River to the Little Colorado River, rainbow trout is the dominant nonnative species (Ackerman 2007; Johnstone and Lauretta 2007), but this 61 miles of the Colorado River supports low to moderate numbers of native bluehead sucker flannelmouth sucker, humpback chub, and speckled dace (*Rhinichthys osculus*) (Hoffnagle et al. 1999). Most native fish in the mainstem from the dam to the Little Colorado River are large juveniles and adults. Earlier life stages rely extensively on more protected nearshore habitats, primarily backwaters (Lauretta and Serrato 2006; Trammell et al. 2002). Native fish spawning may occur in warm springs at RM 30-32 (Valdez and Masslich 1999). Other nonnative species sporadically found in that reach include brown trout, common carp (*Cyprinus carpio*), red shiner (*Cyprinella lutrensis*), plains killifish (*Fundulus zebrinus*), fathead minnow (*Pimephales promelas*), and channel catfish (*Ictalurus punctatus*).

The 174 miles from the Little Colorado River to Bridge Canyon has six major tributaries and supports a diverse fish fauna of cool- to warm-water species to about Havasu Creek, including the three non-listed native species and seven known aggregations of humpback chub. Non-listed native fish are also well represented in the tributaries: Bright Angel, Shinumo, Tapeats, Kanab, and Havasu creeks (Leibfried et al. 2006), especially during spawning periods.

Below the Little Colorado River, warm water nonnative species such as common carp, channel catfish, and fathead minnow increase in numbers and are most abundant between Shinumo and Diamond creeks (Ackerman 2007). Red shiner and plains killifish are common in backwaters immediately below the Little Colorado River and occur sporadically downstream from that point (Johnstone and Lauretta 2007; Lauretta and Serrato 2006).

The 45-mile reach of the Colorado River from Bridge Canyon to Pearce Ferry is flat and muddy due to high lake elevation sediment deposition on the old river channel.

Abundances of flannelmouth suckers, speckled dace, and bluehead suckers are limited due to lack of spawning habitat and large numbers of predators (Valdez 1994; Valdez et al. 1995).

Razorback suckers in Grand Canyon, if any exist, are likely old and no reproduction has been documented. Razorback suckers evolved under a water regime featuring high spring flows, and adult suckers would be able to locate refuge areas during the proposed flow and would suffer no adverse effects. There is no indication that young razorback suckers occur in Grand Canyon today. The status of this species in Grand Canyon was included in the FWS's biological opinion (2008:86), with a concurrence that the proposal "may affect, but is not likely to adversely affect" the species.

All fish above the Paria River rely heavily on algal and invertebrate benthic production in the Lees Ferry reach as a food source; food resources for fish in lower reaches, in which there are larger and more frequent fine sediment inputs, are presently being investigated by GCMRC and cooperators. Year-to-year variance in algae, macrophytes, and macroinvertebrates (amphipods, chironomids, oligochaetes, and snails) is primarily due to differences in hydrology and sediment discharges from tributaries (Blinn et al. 1994; Shaver et al. 1997). Invertebrate production and abundance has typically decreased during the fall and winter seasons (McKinney et al. 1999; Rogers et al. 2002). Under the No Action Alternative, the food base should continue to demonstrate seasonal patterns of varying abundance. Organic matter drift magnitudes would continue as at present under record of decision flow constraints.

### 3.1.8 Fish under the Proposal

Effects of the proposal are expected to be comparable to those from other experimental flow tests (Hoffnagle et al. 1999; Makinster et al. 2007; McKinney et al. 1999; Valdez and Hoffnagle 1999). Catch-per-unit effort (CPUE) of humpback chub and flannelmouth sucker did not differ in 1996 pre- versus post-flood periods. Valdez and Hoffnalge (1999) concluded there were no significant adverse effects on movement, habitat use, or diet of humpback chub. The CPUE of plains killifish, bluehead sucker, and fathead minnow decreased following the high flow while the CPUE of speckled dace and rainbow trout increased. There were some shifts in the distribution of fish within the river from prior high flow tests, changes indicative of downstream displacement, but most changes were short-term. Hoffnagle et al. (1999) concluded that catch rates of all species before and after the high flow test were similar to those recorded in previous years. In other words, high flows did not significantly affect fish distributions or abundances through Glen or Grand canyons.

A March high flow test would probably temporarily disrupt native flannelmouth suckers and native bluehead suckers in the area from the dam to the Paria River, but these species were largely unaffected by the 1996 and 2004 floods. Speckled dace is the most common native fish species in the mainstream and in most tributaries. Little is known about population size, distribution, reproductive success, movement, or survival for this species in Grand Canyon, although there were shifts observed in habitat use by speckled dace during the 1996 flood (Valdez and Cowdell 1996).

High flow tests are not expected to significantly impact standing biomass of benthic invertebrates over the long term. During the March 1996 high flow test, benthic algal and invertebrate standing stocks on cobble bars and in backwaters were reduced immediately following the test but had rebounded to pre-test levels within a few months afterwards (Blinn et al. 1999; Brouder et al. 1999; McKinney et al. 1999).

Stabilization of flows during September and October has the potential for improving food base production because of the absence of negative effects brought about from desiccation and dewatering that occurs in the zone of fluctuation. Drift during steady flows may be reduced compared to fluctuating flows (Blinn et al. 1992; Rogers et al. 2002; Shannon et al. 1996). Most of the fish species in the project area, as is true of stream fish in general (Gerking 1994:375), are not food specialists and are capable of foraging from the benthos or feeding on organic matter drift. The catastomid suckers likely are the most specialized feeders, and they feed primarily by scraping algae and invertebrates from the surface of benthic substrates. Rainbow trout are rather catholic feeders on a wide variety of invertebrates and, although they feed primarily on organic drift, they also forage directly from the benthos and on terrestrial invertebrates (Elliott 1973, Gerking 1994:236; Tippets and Moyle 1978,). Diminished drift rates will be short-lived and should not affect higher trophic levels, however, and steady flows should allow for greater standing biomass of algal and invertebrate prey overall. Small native fish in low velocity nearshore habitats intended to be positively affected by the steady flows will not be dependent on drift for their food resources.

In terms of species listed under the ESA and consultation with the FWS, Reclamation's conclusion in its biological assessment (Reclamation 2007b) is that the proposed action is not likely to result in the destruction or adverse modification of designated critical habitat for the humpback chub or razorback sucker. Reclamation's finding is that the proposal may affect, and is likely to adversely affect the humpback chub due to the "take" that is likely to result from downstream transport of young humpback chub during the high flow. The long-term effects on humpback chub from creation and improvement of rearing habitats are expected to be positive.

Creation and improvement of backwater rearing habitats expected from the high flow test could expand spatial extent of backwater habitat. Steady flows could result in more hydraulically stable nearshore rearing habitats, slightly warmer temperatures and increased abundance of invertebrate prey items (Reclamation 2007b). Collectively, these effects should result in improved growth and survival of young-of-year humpback chub and other native fish prior to the onset of winter. However, the same benefits could be accrued to predatory or competitive nonnative fish, primarily small-bodied cyprinids which utilize the same backwater habitats as young native fish. Thus, in order for the proposal to be most beneficial to humpback chub and other native fish, it is essential that a nonnative fish control plan (coldwater and warmwater) be developed and implemented. This effort was referenced in the Shortage EIS biological opinion as a conservation measure. Progress to this end is being made at this time by USGS, and active management of warm and cold water nonnative fish should begin as soon as possible.

Effects of high flows on rainbow trout in the Lees Ferry reach suggest at most a temporary reduction in abundance of smaller sizes classes, but no lasting impacts to the fish population size, size structure, body condition or diet. McKinney et al. (1999) noted a decline in proportion of <152 mm (age 1) fish following the 1996 high flow test suggesting some downstream displacement, but overall found no lasting impacts to either trout abundance or condition. Speas et al. (2004) noted no change in age 1 fish abundance following powerplant capacity flows in 1997 and 2000. Similar results were observed during the 2004 high flow test (AGFD, unpublished data).

Lasting effects of fall stable flows on the rainbow trout population are likely to be minimal. Korman et al. (2005) noted increased growth of young-of-year rainbow trout during periods of relatively stable daily flows, suggesting similar results may be seen due to the proposed action. However, Speas et al. (2004) noted no clearly defined response by the rainbow trout population (including fish growth rates) to low steady summer flows conducted in 2000.

### 3.1.9 Birds under No Action

More than 30 species of birds have been recorded breeding in the riparian zone along the Colorado River in Grand Canyon (Brown 1988). Most birds in this area nest and forage for insects within the riparian zone and the adjacent upland area. Of the 15 most common riparian breeding bird species, 10 are neotropical migrants that breed in the study area but winter primarily south of the United States-Mexico border. The rest of the breeding birds that use the canyon are year-round residents or short-distance migrants that primarily winter in the region or in nearby southern Arizona (Brown 1989; Brown et al. 1987).

Eleven of the breeding birds in Glen and Grand canyons are considered obligate riparian birds due to their complete dependence on the riparian zone. Obligate riparian birds nesting within the riparian zone include the neotropical migrants Lucy's warbler (*Vermivora luciae*) and Bell's vireo (*Vireo bellii*), two species identified as "high priority" under regional Partners-in-Flight bird plans and area state bird plans. The remaining riparian obligates include common yellowthroat (*Geothlypis trichas*), yellow warbler (*Dendroica petechia*), yellow-breasted chat (*Icteria virens*), black-chinned hummingbird (*Archilochus alexandri*), the endangered Southwestern willow flycatcher (*Empidonax trailii extimus*), and Bewick's wren (*Thryomanes bewickii*), a sometimes permanent resident of Grand Canyon (Spence 2004). Black Phoebe (*Sayornis nigricans*) is a common permanent resident of the canyon with a close association to water (Spence 2004).

Winter songbirds include ruby-crowned kinglet (*Regulus calendula*), white-crowned sparrow (*Zonotrichia leucophrys*), dark-eyed junco (*Junco hyemalis*), and song sparrow (Spence 2004). Spence (2004) found that winter species diversity increased below RM 205. Breeding and wintering songbirds are not expected to be impacted by no action.

The aquatic bird community is almost exclusively made up of winter residents (Spence 2004, Yard and Blake 2004). Thirty-four species of wintering waterfowl along with loons, cormorants, grebes, herons, rails, and sandpipers use the river corridor. Increases in abundance and species richness have been attributed to the increased river clarity and productivity associated with the presence of Glen Canyon Dam (Spence 2004; Stevens et al. 1997b). The majority of waterfowl tend to concentrate above the LCR due to the greater primary productivity that benefits dabbling ducks and greater clarity for diving, piscivorous ducks. Common waterfowl species include American coot (*Fulica americana*), American widgeon (*Anas americana*), bufflehead (*Bucephala albeola*), common goldeneye (*B. clangula*), common merganser (*Mergus merganser*), gadwall (*A. strepera*), green-winged teal (*A. crecca*), lesser scaup (*Aythya affinis*), mallard (*A. platyrhynchos*), and ring-necked duck (*A. collaris*). Other than great blue heron (*Ardea herodias*) and spotted sandpiper (*Actitis macularia*), which are fairly common winter and summer residents along the river, other shorebirds are rare in this area (Spence 2004, Yard and Blake 2004). Aquatic birds would be unaffected by no action.

The southwestern willow flycatcher (SWFL; *Empidonax traillii extimus)* was designated by the FWS as endangered in 1995. Critical habitat for SWFL was redesignated in October of 2005 and no longer includes habitat within the action area (FWS 2005). In recent years, SWFL have consistently nested along the river corridor in the Grand Canyon as new riparian habitat, primarily tamarisk, has developed in response to altered river flow regimes (Gloss et al, 2005). This expansion of riparian vegetation may have provided additional habitat for the flycatcher, but populations in the upper river corridor persist at a very low level at only one or two sites. Resident birds have been documented in a limited stretch of Marble Canyon and the lower Canyon near the inflow to Lake Mead (Sogge et. al. 1995a, Tibbets and Johnson 1999, 2000; Unitt 1987). Population numbers have fluctuated between five breeding pairs and three territorial, but non-breeding, pairs in 1995 to one single breeding pair in more recent years. The year 2004 marked the sixth consecutive year in which surveys located a single breeding pair at the upper sites, the lowest population level since surveys began in 1982. In 2006 two nests were detected during the breeding season at the inflow area to Lake Mead (Koronkiewicz et al. 2006), but no flycatchers were found in Marble Canyon in either 2006 or 2007. Due to extreme drops in water levels in Lake Mead that started in 2000, much of the occupied habitat of the 1990s is now dead or dying. More recently, new stands of vegetation have been developing in areas exposed by receding water and this vegetation is now developing into suitable flycatcher habitat.

The SWFL is an insectivorous riparian obligate. It breeds and forages in dense, multistoried riparian vegetation near surface water or moist soil (Sferra et al. 1995; Whitmore 1977) along low gradient streams (Sogge 1995). Nesting in the Grand Canyon typically occurs in nonnative tamarisk approximately 13-23 ft (4-7 m) tall (Tibbetts and Johnson 1999). Resident birds arrive in Grand Canyon in May. Under the No Action Alternative, the SWFL are not expected to be impacted.

The bald eagle (*Haliaeetus leucocephalus*) was listed as endangered under the ESA in 1967 and down-listed to threatened in 1995. (Additionally, it was listed as endangered under the California Endangered Species Act in 1971.) It is a species of special concern in Arizona. The bald eagle was proposed for federal delisting in 1999 (FWS 1999) and was delisted on July 9, 2007 (FWS 2007).

A wintering bald eagle concentration of bald eagles was first observed in Grand Canyon in the early 1980s and numbers have increased dramatically since 1985 (Brown 1992; Brown and Stevens 1991, 1992; Brown et al. 1989). Territorial behavior, but no breeding activity, has been detected. This wintering population has been monitored since 1988 and it occurs throughout the upper half of the Grand Canyon (in Marble Canyon). Density of the Grand Canyon bald eagles during the winter peak (late February and early March) ranged from 13 to 24 birds between Glen Canyon Dam and the Little Colorado River confluence from 1993 to 1995 (Sogge et al. 1995b). A concentration of wintering bald eagles often occured in late February at the mouth of Nankoweap Creek, where large numbers of rainbow trout congregated to spawn (Gloss et al. 2005). However a flash flood recently destroyed the spawning habitat and the eagles no longer congregate there. Under no action, bald eagles are expected to benefit from current conditions and no changes are expected.

Following successful recovery efforts, the American peregrine falcon (*Falco peregrinus*) was removed from the endangered species list in 1999. The Endangered Species Act requires a minimum of five years of post-delisting monitoring to confirm recovery. Although peregrine falcons are uncommon year-round residents in the action area, the population has gradually increased since the 1970s (Brown 1991). In recent years, as many as twelve active eyries have been found in the canyon. Nest sites are usually associated with water. In Grand Canyon, common prey items in summer include white-throated swift (*Aeronautes saxatalis*), swallows, other song birds, and bats (Brown 1991), many of which feed on invertebrate species (especially Diptera) that emerge out of the Colorado River (Stevens et al. 1997b). In winter, a common prey item is waterfowl.

Under the No Action Alternative, no effects are expected to the bird community in Glen and Grand canyons.

### 3.1.10 Birds under the Proposal

Many birds using the Colorado River below Glen Canyon Dam depend on the aquatic food chain associated with green alga (*Cladophora glomerata*). No long-term adverse impacts to *Cladophora* and associated organisms are expected to result from the proposed high flow test because none were observed during the 1996 experiment (Shannon et al. 2001; Blinn et al. 1999; McKinney et al. 1999). Although other algae and submerged plants use sand or silt as substrate and may be temporarily lost, they are expected to recover relatively quickly if there is no additional disturbance.

A March high flow would probably have no negative effect on the bald eagle because wintering and migrant bald eagles have largely left the Grand Canyon region by this time (Sogge et al. 1995b). Birds were unaffected by prior high flows so no effects are expected from the proposal. Most wintering waterfowl have left the canyons by the time of the flood and would not be affected by it. However, mallard, mergansers, late migrating gadwall, and American widgeon may be present (Spence 2004). These birds are ground nesters and a spring flood might impact them, although adequate waterfowl nest cover exists at higher elevations. Furthermore, the timing of the high flow test is prior to the primary nesting period for all these species.

The SWFL are not found in the action area during the proposed high-flow test so no effects are expected. As with other endangered species, Reclamation and the FWS are currently consulting on effects to the SWFL. The steady flows during September and October are also not expected to affect SWFL. Reclamation's finding for the proposed action is "may affect, is not likely to adversely affect" the SWFL. Numbers of bald eagles would continue to fluctuate around Nankoweap Creek, with or without the proposal, and no effects are anticipated.

### 3.1.11 Mammals under No Action

Within Grand Canyon National Park 34 species of mammals have been found (Carothers and Aitchison 1976; Frey 2003, Kearsley et al. 2003, 2006; Warren and Schwable 1985). Of these mammals only three are obligate aquatic mammals—beaver (*Castor canadensis*), muskrat (*Ondatra canadensis*), and river otter (*Lutra canadensis*). Despite occasional reported sightings of river otters in Grand Canyon, no reliable documentation exists since the 1970s (Kearsley et al. 2006). River otters are classified as extirpated and muskrats are considered extremely rare.

An increase in the population size and distribution of beaver in Glen and Grand canyons has occurred since the construction of the dam, likely due to the increase in riparian vegetation and relatively stable flows (Kearsley et al. 2006). Beavers cut willows, cottonwoods, and shrubs for food and can significantly affect riparian vegetation. Beaver in Grand Canyon excavate lodges in the banks of the river with the entrance located underwater and a tunnel leading up under the bank to a living chamber. Beaver are affected by fluctuating water levels since their lodges can become flooded by increases in water levels or the entrances can be exposed by falling water levels. Both situations can expose beaver to increased predation since they are forced to abandon the lodge if flooded or predators can enter the den if the opening is exposed.

Muskrats in Grand Canyon also construct and use bank dens or old beaver dens (Perry 1982) and can be affected by fluctuating water levels. Impacts to muskrats of current flow fluctuations from Glen Canyon Dam are unknown but could result in increased stress and exposure to predation (Perry 1982).

Bats in the Grand Canyon typically roost in desert uplands, but forage on abundant insects along Lake Powell, the Colorado River and its tributaries. Bats would continue to forage on the insects present in the riparian corridor.

### 3.1.12 Mammals under the Proposal

Beaver typically mate from January through March and the kits are born in March to June (Hill 1982). Young-of-year beaver occupy the lodge with the parents until their second year, when they leave their natal range and search for unoccupied habitat to colonize (Hill 1982). Because the proposal includes a relatively high flow that beaver have not experienced in several years, it is likely that the high flow would temporarily disperse sub-adult and adult beaver. Kits born prior to the high-flow-test would likely be killed due to drowning because they would be unable to disperse from the lodge. Steady flows in September and October would have little to no effect on beaver.

Muskrats in Grand Canyon would similarly be dispersed from their bank dens by high flows during March. However, muskrats rarely give birth before May (Perry 1982), and they are polyestrous and capable of producing multiple litters within the year. Muskrats would not be affected by steady flows in September and October.

Bats could be indirectly affected by the proposal. Insect production from steady flows in September and October could be altered, which might have an impact on foraging by bats.

However, any change in insect abundance is not expected to have long-term consequences and will likely be minor.

## 3.2 Cultural Resources

Cultural resources include prehistoric and historic districts, sites, buildings, structures, and objects. The term includes sites of traditional religious and cultural significance to Indian tribes and communities. Section 106 of the National Historic Preservation Act of 1966, as amended, requires federal agencies to take into account the effects of their undertakings on those historic properties listed on or eligible for inclusion in the National Register of Historic Places. Cultural resources also include sacred sites as defined by Executive Order 13007.

### 3.2.1 Cultural Resources under No Action

Adverse effects of ongoing operations to archeological sites are currently being mitigated through a long-term treatment plan. Archaeological data recovery efforts are scheduled over the next five years. No adverse effects to sacred sites have been documented as a result of dam operations and none are expected through 2012.

### 3.2.2 Cultural Resources under the Proposal

Consultation on the proposal with the Arizona State Historic Preservation Officer and the Navajo and Hualapai Tribal Historic Preservation Officers has been initiated. Reclamation's finding is that one historic property in Glen Canyon National Recreation Area could have been adversely affected by the high flow, but archeological data recovery was conducted as a mitigating measure. No other historic properties would be affected by this undertaking.

During consultation, the Hopi, Kaibab Paiute, and other tribes expressed concern with high flows impacting the salt mines. The Hualapai Tribal Historic Preservation Officer has expressed concern with native vegetation. The two prior high flows resulted in short-term adverse impacts to native vegetation of concern to the Hualapai, but there was a long-term benefit from previous high flows. Similar long-term benefits are predicted for the proposal. Consultations with concerned Indian tribes (Table 6) are continuing.

## 3.3 Socioeconomic Resources

Social and economic conditions were examined to determine whether the proposed action would affect them. The indicators reviewed include environmental justice (E.O. 13175), Indian trust assets, population growth and housing, public health (focusing on flood risk), recreation, the regional economy (focusing on economic cost associated with altering hydropower produced), and traffic and transportation.

### 3.3.1 Hydropower

One of the primary purposes of Glen Canyon Dam, as stated in 43 USC § 620, is the generation of hydropower or electric power. Glen Canyon Dam and Powerplant are part of the Colorado River Storage Project (CRSP), a federal project from which Western markets power. The CRSPA directs that Glen Canyon Dam and other facilities be “operated in conjunction with other Federal powerplants … so as to produce the greatest practicable amount of power and energy that can be sold at firm power and energy rates.” Western's Salt Lake City Area Integrated Projects Office (SLCA/IP) annually markets more than 4.3 billion kilowatt-hours (kWhr) from Glen Canyon Powerplant. The power is sold to end-use consumers across Arizona, Colorado, Nebraska, New Mexico, Nevada, Utah, and Wyoming. The power from Glen Canyon represents about three percent of the summer capacity in this seven-state region (Harpman 1999:351).

Demand for electric energy is known as "load." Load varies on a monthly, weekly, daily, and hourly basis, with the highest demand for electricity in the winter and summer when heating and cooling needs, respectively are greatest. Load is less in the spring and fall (Harpman 1999:352). The period when demand is highest is called "on peak." In the Glen Canyon service area, the on peak period is from 7:00 a.m. to 11:00 p.m., Monday through Saturday Mountain Standard Time (MST). All other hours are off peak. During normal operations at Glen Canyon Dam, water releases fluctuate from a low base flow during off peak hours to a high flow that corresponds to the largest electrical demand, subject to the limitations established in the 1996 record of decision.

The maximum amount of electric energy than can be produced by a powerplant at a single moment in time is its "capacity," measured in megawatts (MW). Electrical energy or generation is the capacity in MW over a period of time or megawatt-hours (MWh). The rate at which a powerplant can change from one generation level to another is called a "ramp rate," measured in change in cubic feet per second (cfs) over a one-hour period.

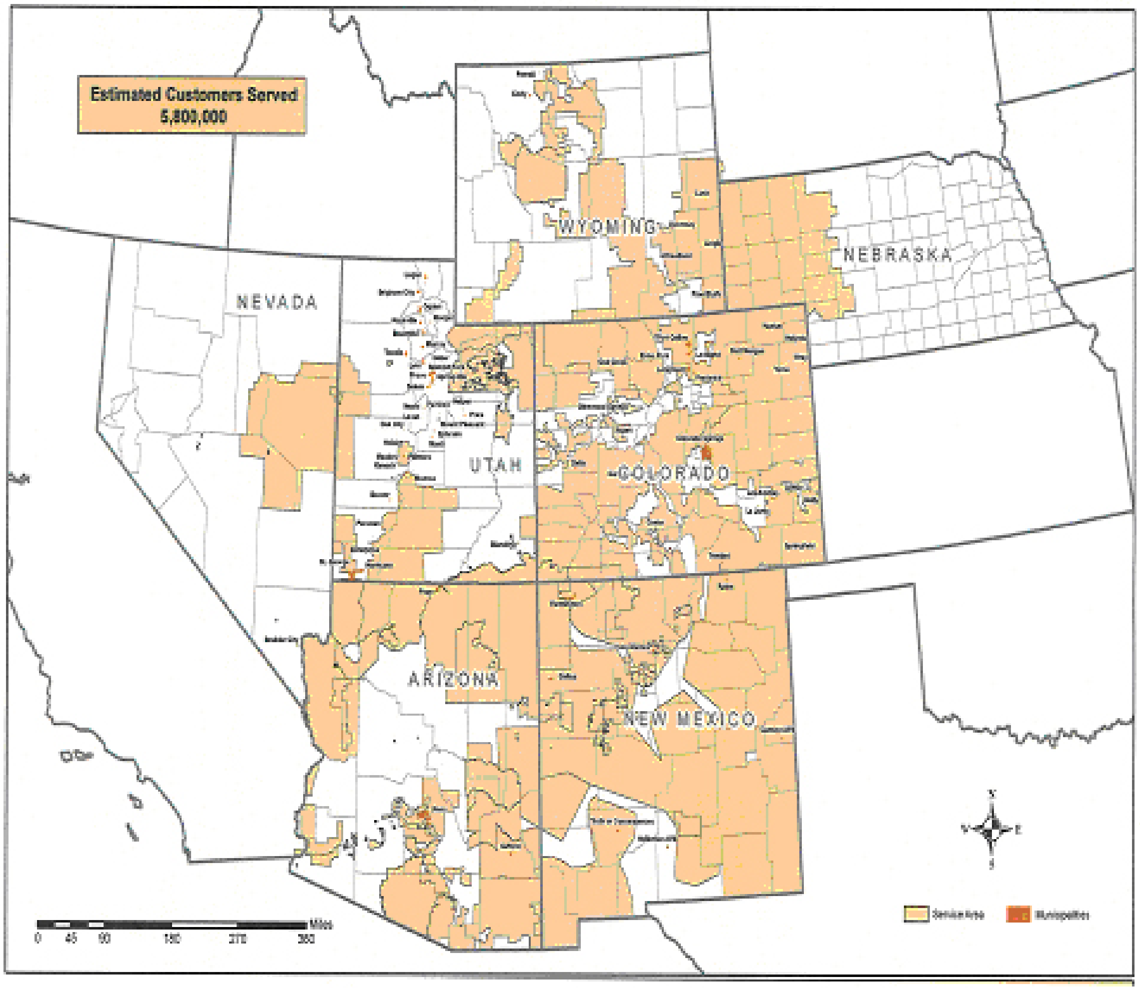


FIGURE 4 Colorado River Storage Project management center service territory. Map courtesy of Western.

#### *3.3.1.1 Effects on Hydropower under No Action*

Methods, models, and the amount of hydropower expected to be generated through 2012 are described in Reclamation (2007a:4-251-4-278). The description of the preferred alternative in that EIS serves as the description of hydropower under no action in this environmental assessment. If Reclamation takes no action, 4,481 GWh would be produced in 2008. During the period of the proposed action, additional power must be purchased to meet firm power contract provisions; in 2008 about 4,440 GWh would be produced and this additional purchase power cost is projected to be $43.5 million (Western 2008). To preserve the liquidity of the Basin Fund, increases in the firm power rate charged to power customers may need to be increased, particularly during periods of below average annual dam releases. Such a rate adjustment process is currently underway (Western 2008). This establishes a baseline against which effects of the proposal may be compared.

#### 3.3.1.2 Effects on Hydropower under the Proposal

The economic effect of past experiments has been measured in "avoided costs," essentially the opportunity cost of the experiment. The avoided cost is the difference between the cost of satisfying the demand for electric energy with and without operating the hydropower plant (Harpman 1999:353). During steady flows, the ability to fluctuate water releases to match electrical demand ceases. This means that during periods of low electrical demand power must be sold at a reduced price and during high electrical demand power must be bought at an increased price on the spot market to meet customer contracts. When the volume of water released from the dam is greater than the capacity of the powerplant, the outlet works must be used to release flows. The powerplant is bypassed and water is "spilled" through the outlet works where it is unavailable to produce electric energy. During high flows, more power may be generated than would have been the case without the experiment, depending on the circumstances of the release.

Based on projections by Western of additional purchases required to meet the SLAC/IP contractual requirements, the projected total cost of the high flow test for water year 2008 is $4.1 million, or a 9.4 percent increase in the purchase power requirement for 2008. This includes the effect of moving water from the summer months that have large electrical demand and high prices to “shoulder” months where electrical demand and prices are lower.

The steady flow portion of the experiment during September and October, 2008 - 2012 has a projected annual power replacement cost for both months of about $815,000. No adjustment of monthly water volumes occurs during the subsequent years of the experiment, other than potential minor adjustment of September release volumes. Additional scientific studies will be planned as part of the GCDAMP for the succeeding years for fall steady flows but costs for these studies have not yet been determined.

Replacement of power foregone through the experiment would likely come from carbon-producing sources such as coal or gas fired generation. Due to the reduction in annual energy generation of about 41 GWh from the high flow test, it is estimated that if this power were replaced by coal-fired power sources, this would produce additional carbon emissions of about 45,800 tons, or approximately 0.02 percent of the 261,687,000 tons annually emitted from coal-fired powerplants in the region.

### 3.3.2 Recreation

Recreational resources of concern are the trout fishing and boating from Lees Ferry to below Glen Canyon Dam, whitewater boating through Grand Canyon, and the Hualapai Indian tribe's boating enterprise at the western end of Grand Canyon and into Lake Mead. No effects are expected within Lake Mead.

#### 3.3.2.1 Fishing under No Action

The Colorado River from below the dam to Lees Ferry is a blue ribbon rainbow trout fishery, attracting anglers from the state and abroad. Most angling occurs from boats or is facilitated by boat access, including guide services, but some anglers wade in the area around Lees Ferry. Based on input from Lees Ferry fishing guides, the quality of the fishery has fallen and angler use has declined recently, but AGFD reports a significant increase in trout condition in 2006 (AGFD 2007). In 2006, angler use was approximately 13,000 user days. The monthly distribution of angling use is shown in Figure 5. The heaviest angling use in 2006 occurred in April.

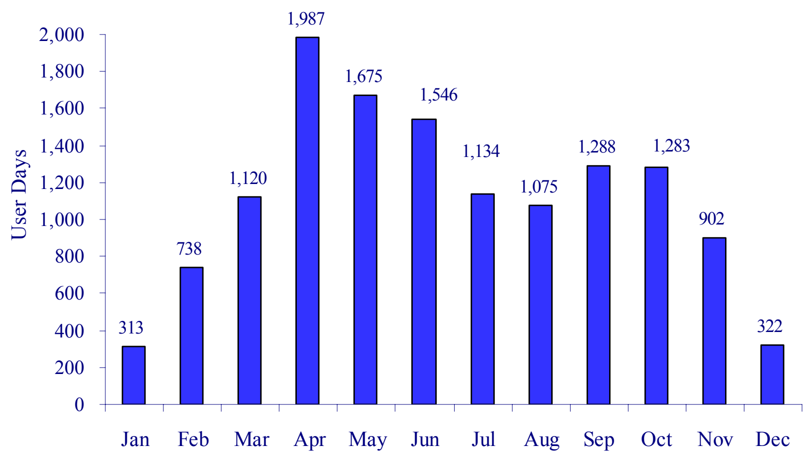


FIGURE 5  Fishing user days by month, 2006 in the Lees Ferry reach.

#### *3.3.2.2 Fishing under the Proposal*

During previous high flow tests in 1996 and 2004, most anglers elected not to fish and the same behavior would be expected under the proposal. In previous high flow tests, at least one company canceled all guided fishing trips during the high flow period (Reclamation 1998). Some anglers continued to fish, although they reported that their success was greatly reduced (Reclamation 1998:43). Many public comments received on this assessment indicated that anglers believe the fishing in the Lees Ferry area declined during and after the past high flow tests and they expect similar declines would occur should the proposal be implemented.

Data from AGFD (McKinney et al. 1999) on catch rates and condition indices of trout indicated the 1996 high flow had no effects on catch rate or condition indices of trout. Likewise, data from Shannon et al. (2001) indicates that prior high flows resulted in benthic scour and entrainment of both primary and secondary producers, but macroinvertebrates and filamentous algae recovered within three months, depending on the taxa. The 1996 test flow removed suspended particles from the water column and increased water clarity, which enhanced benthic recovery (Shannon et al. 2001:672), a benefit to the trout fishery.

Similar effects on the food base and sport fish are expected from the high flow, and the steady flow is not expected to have measurable effects on Lees Ferry fishing. To estimate effects of the high flow portion of the proposal, a minimum of three days out of March, or 108 user days, would be expected to be lost due to the experiment (Figure 5).

For those wading anglers who elect to fish during the event, rapid increases in river stage would place them at risk, if they are unaware and unprepared. Advance publicity, onsite warnings provided by management agencies, and the obvious nature of the flow would allow anglers to make personal assessments of danger during this period.

It is likely that the effects of a 2008 high flow test would be similar to the previous tests, although shorter in duration. At least three days to a week of user days would be lost, but the aquatic food base and the trout fishery would likely recover and improve within three months based on the previous research of Shannon et al. (2001) and McKinney et al. (1999.)

#### *3.3.2.3 Boating under No Action*

The 15-mile reach between Glen Canyon Dam and Lees Ferry is used by anglers who launch from Lees Ferry and visitors who take one day scenic raft trips offered by a NPS concessionaire. These commercial scenic raft trips launch at the base of Glen Canyon Dam. Day use rafting in 2006 amounted to more than 44,000 user days, as shown in Figure 6. Most day-use rafting occurs during the summer; June is typically the peak use month.

Since 2007, the NPS's (2006) Colorado River management plan has governed recreational use from the Lees Ferry reach down to Diamond Creek and upper Lake Mead. Under this plan, total whitewater boating use increased and annual distribution of use was altered. Currently, only estimated river use data are available, with Figure 6 illustrating the 2007 distribution of expected Grand Canyon whitewater boating use for trips starting at Lees Ferry.

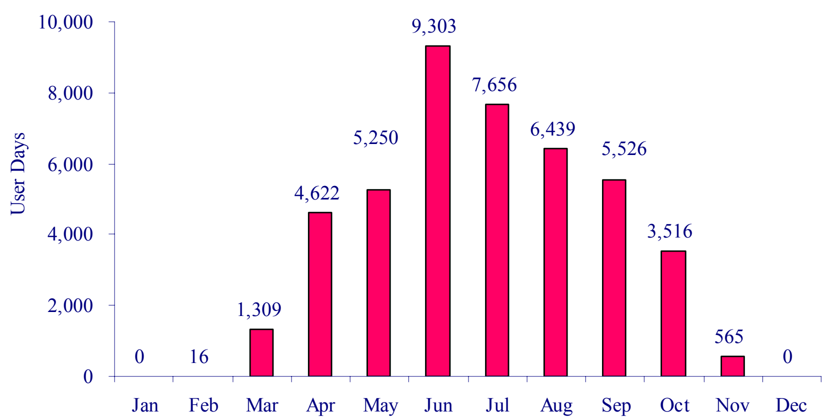


FIGURE 6 User days for day-use boaters, Lees Ferry reach, 2006.

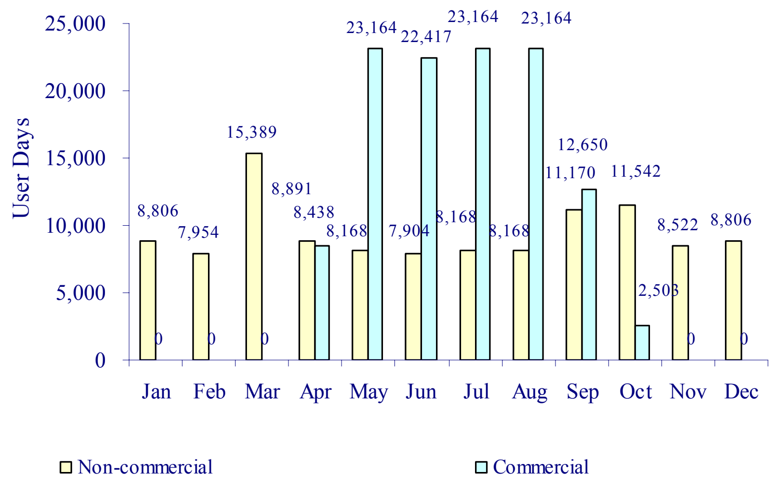


FIGURE 7 Whitewater boating user days, Grand Canyon, 2006.

Other characteristics of whitewater boating through Grand Canyon that may be affected by the proposal include wilderness values and safety. Wilderness characteristics of whitewater boating trips may be influenced by daily river fluctuations and by the conditions of beaches (Bishop et al. 1987; Shelby et al. 1992; Welsh et al. 1995). With no action taken by Reclamation, flows would vary within the constraints of the 1996 record of decision and daily change in flow would be no greater than 8,000 cfs. Reduced daily fluctuations of the 1996 record of decision makes the wilderness characteristics of a whitewater boating trip relatively high, but declines in sandbar area and volume reduce the overall recreational experience.

Whitewater boating safety depends on the type of craft, skill of the operator, the location, flow levels, and timing and variation of river stage (Brown and Hahn 1988; Jalbert 1992, 1996). Low flows make passage through some rapids difficult or impossible. High flows may create additional risks of flipping or capsizing.

The Hualapai Indian Reservation marks the southwestern end of the affected environment for this action. Diamond Creek is at about RM 227 and is a popular take out for many boating trips that begin at Lees Ferry. It is also the starting point for those commercial and noncommercial trips that originate on the Hualapai Indian Reservation. Private parties launching at this site pay launch and user fees to the Hualapai Indian Tribe. Commercial day and overnight trips run by Hualapai River Runners begin here and end at Quartermaster (RM 260) or Lake Mead (RM 277). The overnight trips make use of campsites (beaches) along the southern bank of the river (at RM 245) where the Hualapai Tribe has provided a composting toilet. There is also a concession pontoon boat operation, which uses helicopters to transport visitors into the canyon below, where they then walk down to a boat dock, and take a 20-minute, flat-water, river ride which launches and returns to Quartermaster.

Recreational use below Diamond Creek is managed in accordance with the NPS's new management plan. In 2007, the whitewater rafting season ran approximately from March 15 through October 31. During this past season, the Hualapai River Runners took over 19,000 visitors rafting on the Colorado River. The Hualapai River Runners pontoon boat operation is limited to five boats with a daily limit of 480 passengers on the water at any one time.[5] Approximately 175,200 passengers are expected annually.

#### *3.3.2.4 Boating Under the Proposal*

During the proposed 2008 high flow, no boats would be allowed to launch immediately below the dam. Day use rafting trips could still be launched from Lees Ferry and boats could move upstream under power. According to NPS estimates, approximately 190 boating user days would be lost during the proposed high flow. During the remainder of the year, day use rafting operations would be unaffected.

For the high flow portion of the proposal, the NPS studied river running risks and injuries during the 1996 experiment (Jalbert 1996). Jalbert reported that 45,000 cfs flows posed no greater risk of boating accidents than lower flows, in fact, the high flow enhanced visitor experience. She found the effects of the high flow on boaters were variable with location:  the size of some waves and holes increased, others washed out.

Judging by NPS permit data, there are likely to be about 35 white-water boating groups on the river during a March high flow. The NPS is working closely with these permit holders to provide visitation flexibility to minimize adverse visitor impacts. Boaters on these trips would need to be cautious in selecting campsites, but the duration of the experiment relative to the length of a typical non-motorized trip (18 days), suggests effects on boaters would be limited. While fluctuations have been reported to decrease wilderness values, past high flows had beneficial effects on boater experiences.

The fall steady flows should have no measurable effect on visitor experiences in the canyon. As shown by Figures 6 and 7, visitation is relatively low during these months and the magnitude of change from no action should have no measurable effect on visitor experience.

Comments received from the Grand Canyon River Guides, Grand Canyon River Runners Association, and many individual guides and commercial rafting companies supported the proposal because of its potential to improve camping beaches and overall conditions in the river corridor.

#### *3.3.2.5 Net Economic Use Value under No Action*

Net economic use value is a measure of the value over and above the costs of participating in a recreation activity. The total net economic value is related to the number of recreationists who participate in each activity, the time of year in which they participate, and the value of each trip taken (King and Mazzotta 2007; National Research Council 2004).

The net economic value of recreation in Grand Canyon was estimated for a number of different flow scenarios by Bishop et al. (1987) and reported in Reclamation (1995, 1998).

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[5] This limit could be raised to 600 passengers/day if monitoring reveals no adverse impacts to resources.

Hammer (2001) later estimated the net economic value of whitewater boating using the (secondary) data collected by Stewart et al. (2000) and Hall and Shelby (2000).

Regional economic activity refers to expenditures and their impacts within the study area. River-based recreational users, such as anglers and white-water boaters, spend large sums of money in the region purchasing gas, food, lodging, guide services, and outdoor equipment during their visits. While these expenditures do not represent a benefit measure, they nonetheless are important because they support local businesses and provide employment for local residents.

The annual regional economic activity that results from nonresident anglers, whitewater boaters, and day rafters who visit Glen and Grand canyons has been estimated (Reclamation 1995) at approximately $25.7 million (1995 nominal dollars). Douglas and Harpman (1995) estimated that Glen Canyon and Grand Canyon recreational use in the region comprised of Coconino and Mojave Counties supported approximately 585 jobs. A more recent study by Hjerpe and Kim (2003) estimated that recreational use in Coconino County supports approximately 394 jobs.

#### *3.3.2.6 Net Economic Value under the Proposal*

The net effect of the proposed high flow on regional economic activity is likely to be negative due to the loss of angling and boating user days in the Lees Ferry reach during the high flow. With the high flow test preventing at least three to five days of use in March, incomes of local fishing guides and day use rafting guides and companies would be decreased.

Using data in Kaval and Loomis (2003:12), a fishing user day has an average value (through 2003) at $42 for the NPS Intermountain Region where Glen and Grand canyons are located. Using the minimum loss of 108 fishing days, this gives a value of $4,536 in losses due to the proposed high flow experiment, although this would likely be a higher figure using current economic data. However, recent communication between NPS and the trout guides revealed an estimated financial impact of $75,000 to $100,000 (Norm Henderson personal communication).

With the estimate of 190 boating user days lost during the proposed high flow, and again using Kaval and Loomis (2003:12), $56.42 is expended per boating day, resulting in a value of at least $107,198 from the high flow portion of the experiment. Current estimates of lost revenue communicated to the NPS were $15,000, so there is some uncertainty in these estimates.

As a result of the anglers and Lees Ferry boaters who would stay away during the high flow, local hotel and restaurant revenues would be reduced during or following the test, but there could be increases in visitor use associated with scientific and media activities surrounding the high flow test. In response to concerns expressed by local guides and business owners, Reclamation will assist in implementing the measures described in section 2.2.1. The fall steady flows should have no measurable effect on the economic values of Lees Ferry angling or boating.

No net change in whitewater boating use or significant change in trip value in the Lees Ferry reach is expected to result from the proposed high flow test or the steady fall flows. Therefore, net economic value is expected to be reduced less than one percent of the annual total revenues.

### 3.3.3 Indian Trust Assets

Indian trust assets are legal interests in property held in trust by the US government for Indian tribes or individuals. Examples of such resources are lands, minerals, or water rights. Review of the alternatives revealed that water rights would not be affected, but given that the action area is bounded on the east by the Navajo Indian Reservation and on the south by the Hualapai Indian Reservation, these tribes were consulted regarding potential effects of the proposal on their trust assets and reserved rights.

During consultation, both tribes were concerned that high flows could affect trust lands. Based on the 1883 Executive Order establishing the Hualapai Indian Reservation, the northern boundary of the reservation is the high water mark of the Colorado River (NPS 2005, Appendix M). Most of the Navajo Indian Reservation is more distant from the river bank, but the tribe is still concerned with adverse impacts of the proposal.

### 3.3.4 Environmental Justice

To implement Executive Order 12898, *Environmental Justice in Minority Populations and Low Income Populations*, the Council on Environmental Quality (1997) instructs agencies to determine whether minority or low-income populations or Indian tribes might be affected by a proposal, and if so, whether there might be disproportionately high and adverse human health or environmental effects on them. The affected area is bounded by the Navajo Indian Reservation and the Hualapai Indian Reservation. Hydropower and financial impacts to the Hualapai Tribe's recreational boating operations on the Colorado River were identified as potential environmental justice issues in this environmental assessment.

Hydropower impacts are a potential issue because electricity generated by Glen Canyon Dam or CRSP power is marketed to non-profit municipalities and Indian tribes, which are generally rural and small communities. As shown in Appendix D, over 50 Indian tribes now receive the benefits of CRSP power. Within the states receiving CRSP power, Table 5 shows the number of households requiring federal energy assistance for 2005 and 2006. The number of households receiving federal energy assistance is an indicator that environmental justice concerns may be present, particularly because these numbers appear to be increasing in the CRSP service area.

The Hualapai Tribe conducts recreational boating below Diamond Creek. Previous high flow tests have interrupted normal boating operations and have dislodged a boat dock near Quartermaster Rapid. Both of these impacts have had financial impacts to the tribe.

### 3.3.5 Environmental Justice under No Action

The need for federal energy assistance continues to grow rapidly due to a combination of rising energy costs and other economic factors affecting the US economy (Wolfe 2006, 2007). Table 5 shows the number of households in states served with CRSP power that required federal heating assistance in years 2005 and 2006. As shown, the minimum statewide increase is 12 percent, the maximum is 34 percent. While the table does not reflect the actual numbers of CRSP customers requiring energy assistance, it conveys the general increase in need for federal energy assistance in the states.

TABLE 5 Number of households per state requiring heating assistance, 2005 to 2006

| State | 2,005 | 2006 | % Increase |
|---|---|---|---|
| Arizona | 18,563 | 24,824 | 33.7 |
| Colorado | 96,127 | 107,500 | 11.8 |
| Nebraska | 32,514 | 39,000 | 19.9 |
| Nevada | 17,557 | 22,177 | 26.3 |
| New Mexico | 55,685 | 67,000 | 20.3 |
| Utah | 34,647 | 40,000 | 15.5 |
| Wyoming | 9,550 | 11,653 | 22.0 |

*Source*: Wolfe 2006, 2007.

### 3.3.6 Environmental Justice under the Proposal

The proposal might increase the number of households seeking energy assistance from the federal government if the action results in an increase in the CRSP power rate. In comparing the effects of the proposal with no action, rising electric costs could create an adverse economic impact among low-income households. This impact depends entirely on whether CRSP power rates would need to be increased as a result of the proposed action, which is determined by the financial status of the Basin Fund. Although power customers are currently involved in rate increase discussions, the potential for an additional rate increase due to the proposed action is uncertain.

The proposal for high flows could interrupt the boating and helicopter operations of Grand Canyon West, a wholly-owned and operated enterprise of the Hualapai Tribe. The Hualapai Tribe is concerned that the high flows have the potential to damage or dislodge recreational facilities such as the boat dock in the Quartermaster area. In addition, the high flows could damage the boating take-out at Diamond Creek. The financial impact to the tribe could be approximately $480,000 (based on lost revenue), with additional losses should facilities need to be repaired.

## 3.4 Other NEPA Considerations

In addition to reviewing direct, indirect and cumulative effects on resources in the preceding sections, section 102(2)(C) of NEPA requires consideration of unavoidable impacts, the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity, and any irreversible and irretrievable commitments of resources. Bypassing the powerplant during the high flow test in 2008 would cause an unavoidable loss of power generation and a reduction of fishing guide and scenic day use rafting revenues. Steady flows in the fall would cause an increase in replacement power costs. However, timing of these elements of the proposal was designed to minimize economic and environmental justice impacts, while maintaining and enhancing the long-term productivity of the local environment.

Some endangered Kanab ambersnail could be inundated or displaced downstream under the proposed flood; however, these actions will be minimized or mitigated through the actions described in section 2.2.1. Non-essential foraging habitat for southwestern willow flycatcher might be impacted. However, no irreversible, long-term impact on any of these snail or bird populations is anticipated. Juvenile trout and young of year humpback chub could be displaced downstream and lost, but again, the effects to the long-term condition of the populations are not considered irreversible.

# 4.0 List of Agencies and Persons Consulted

Following requirements of 40 CFR 1508.9(b), this section lists agencies and persons consulted regarding this proposed federal action. Table 6 lists federally-recognized Indian tribes who have been or are being consulted regarding the proposal. On January 10, 2008, one multi-tribal meeting was held regarding the proposal. Formal government-to-government consultation letters and follow-up phone calls and face-to-face meetings with tribes listed in Table 6 are in progress. Table 7 lists agencies and persons and outside Reclamation who were consulted during the preparation of this environmental assessment. Of particular note is a conference call held on January 17, 2008 with members of the GCDAMP. One meeting sponsored by FWS was held with Lees Ferry fishing guides and local business owners on November 28, 2007. The report from that meeting, resulting recommendations, and FWS comments on the EA presented Reclamation with FWS input on the Lees Ferry trout fishery in lieu of a formal report under the Fish and Wildlife Coordination Act. The EA was mailed to agencies, organizations, and individuals concerned with dam operations and it was also made available on the internet at www.usbr.gov/uc/envdocs/index.html.

As of February 25, 2008, Reclamation had received 83 unique comment documents regarding the EA with the documents including written letters, e-mails, transcripts or notes of oral comments at consultation meetings (Appendix E). All comment documents received on the draft EA were reviewed and considered in preparing the final EA, with revisions made as appropriate in response to the comments. Some 20 comment documents supported the proposed action while 58 supported no action. In addition to expressing support or opposition to the proposal, most comment documents presented multiple comments.

Some 47 comments were received suggesting modifications of the proposed action. Of these 47 comments, 9 were requests to moderate the down ramp rate. There were roughly even numbers of requests to modify either the high flow portion of the proposal or the steady flow portion (7 and 8 comments respectively). There were also 6 requests to consider other ways to build beaches than through releases from the dam, including sediment augmentation. Another 35 comments were requests to supplement, improve, or modify analyses and 23 comments were requests to make factual corrections. Again, these comments were reviewed, and where possible, changes were made in the text.

TABLE 6 Federally-recognized Indian tribes being consulted

| Federally Recognized Indian Tribe |
|---|
| Havasupai Tribe of the Havasupai Reservation, Arizona |
| Hopi Tribe of Arizona |
| Hualapai Indian Tribe of the Hualapai Indian Reservation, Arizona |
| Kaibab Band of Paiute Indians of the Kaibab Indian Reservation, Arizona |
| Las Vegas Tribe of Paiute Indians of the Las Vegas Indian Colony, Nevada |
| Moapa Band of Paiute Indians of the Moapa River Indian Reservation, Nevada |
| Navajo Nation, Arizona, New Mexico & Utah |
| Paiute Indian Tribe of Utah |
| San Juan Southern Paiute Tribe of Arizona |
| Yavapai-Apache Nation of the Camp Verde Indian Reservation, Arizona |
| Zuni Tribe of the Zuni Reservation, New Mexico |

TABLE 7 List of federal and state agencies and private organizations consulted

| Agencies |
|---|
| Arizona Department of Water Resources |
| Arizona Game and Fish Department |
| Bureau of Indian Affairs |
| Colorado Division of Water Resources |
| Colorado River Board of California |
| Colorado River Commission of Nevada |
| Colorado River Energy Distributors Association |
| Department of Energy, Western Area Power Administration |
| Federation of Fly Fishers, Northern Arizona Flycasters |
| Grand Canyon River Guides |
| Grand Canyon Trust |
| Grand Canyon Wildlands Council |
| National Park Service |
| New Mexico Interstate Stream Commission |
| US Fish and Wildlife Service |
| Utah Associated Municipal Power Systems |
| Utah Division of Water Resources |
| Wyoming State Engineer |

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# 6.0 Appendices