PROPOSED EXPERIMENTAL RELEASES FROM GLEN CANYON DAM AND REMOVAL OF NON-NATIVE FISH

ENVIRONMENTAL ASSESSMENT

September 2002

U.S. Department of the Interior
Bureau of Reclamation
National Park Service
U.S. Geological Survey

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to the tribes.

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

The National Park Service preserves unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations. The Park Service cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world.

The USGS serves the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.

Proposed Experimental Releases from Glen Canyon Dam and Removal of Non-Native Fish

Proposed agency actions:	Approval of releases from Glen Canyon Dam and issuance of Federal permits for mechanical removal of non-native fish.
Type of statement:	Environmental Assessment
Joint lead agencies:	Bureau of Reclamation, Upper Colorado Region; National Park Service, Glen Canyon National Recreation Area and Grand Canyon National Park; U.S. Geological Survey, Grand Canyon Monitoring and Research Center
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Abstract:	Experimental releases of water from Glen Canyon Dam to conserve fine sediments and reduce non-native fish will be combined with mechanical removal of non-native fish to benefit native fish, particularly the endangered humpback chub.
Comments due:	October 30, 2002

Contents

Page

Executive Summary

The Grand Canyon is one of the Nation's treasures. The Department of the Interior is proposing a series of experimental actions, some of which involve modifying the operations of Glen Canyon Dam, which is located upstream of the Grand Canyon, to improve the condition of the habitat within the Grand Canyon and the species that have their home in the canyon. This proposed action was deemed necessary by the GCDAMP because endangered species and sandbars in the Grand Canyon have not responded as well as predicted to past management actions regarding the operation of Glen Canyon Dam. The proposed actions, detailed in the accompanying report, are the product of years of scientific study and would implement the recommendation of an independent advisory committee that has been studying the natural and cultural resources of the Grand Canyon since 1997. The proposed actions presented in this report are multi-faceted and complex, and have been designed to protect both the endangered species and the important beach habitat found in the Grand Canyon.

The 1996 Record of Decision (ROD) on the *Operation of Glen Canyon Dam Final Environmental Impact Statement* (FEIS) modified the operation of the dam in an effort to protect downstream resources. An adaptive management program was established by the ROD to monitor the effects of this change, perform research necessary to measure whether these resource protection objectives were met, and make recommendations to the Secretary of the Interior.

Since 1996, the non-native trout population in the Grand Canyon has tripled, the endangered humpback chub (HBC) population has declined precipitously, and tributary sediment inputs are not being conserved as expected in the FEIS. These trends are contrary to the expectations of the FEIS and the goals of the adaptive management program. If no actions are taken and current operations continue, these trends are expected to continue.

An experiment consisting of a combination of Glen Canyon Dam releases and mechanical removal of non-native fish is proposed to determine if these proposed actions can reverse current trends. The proposed dam releases are intended to conserve sediment inputs from the Paria River and reduce spawning and recruitment success of non-native trout. Mechanical removal of non-native fish is proposed in order to remove trout who feed on young chubs near the confluence of the Little Colorado River (LCR), which is the only known stream in Grand Canyon where the endangered humpback chub reproduces and survives to adulthood.

To conserve Paria sediment inputs, proposed dam releases will either be reduced to store sediment in the main channel or raised to powerplant capacity to store the sediment in eddies following Paria River inputs. In addition, dam releases up to 45,000 cubic feet per second, similar to the 1996 test flow are proposed in an attempt to rebuild beaches.

Non-native trout are known to negatively impact native fish. Daily high fluctuating releases are proposed during January-March to interrupt spawning of adult trout and to displace small trout from their preferred habitats. Proposed mechanical removal of trout by electrofishing will test whether the juvenile and adult trout population can be reduced in a 10-mile reach of Colorado River that contains the largest known number of mainstream humpback chub. About 20,000 rainbow and brown trout are expected to be removed from this river reach in each of two years under the experiment.

The environmental consequences of the Proposed Action are expected to be positive for resources intended to be benefited by the action, though due to the experimental nature of the proposal, there is some uncertainty as to the outcome. The estimated financial cost of the proposed experiment to power customers is about $1.7 million as compared with estimated 2003 power revenues of $130 million under ROD operations. Objectives of this proposed action are in agreement with the 12 management goals of the Glen Canyon Dam Adaptive Management Program and applicable provisions of federal law.

The effects of the various components of the Proposed Action on endangered species have been fully described in Section 3.8, "Endangered Species" (also see Appendix A). With respect to the Proposed Action in total, a condition of "may affect, not likely to adversely affect" is projected for the California condor, razorback sucker (RBS), and Southwestern willow flycatcher (SWWF). A condition of "may affect, likely to adversely affect" is projected for the humpback chub (HBC), Kanab ambersnail (KAS), and bald eagle. It is important to note that the Proposed Action is expected to produce an overall positive benefit to the ecosystem downstream of Glen Canyon Dam, including the endangered species, despite short-term minor impacts to some resources.

The proposed combination of experimental dam releases and non-native fish removal has been developed using knowledge gained in nearly 20 years of research and monitoring of resources in this reach of the Colorado River, first under the Glen Canyon Environmental Studies and now as part of the Adaptive Management Program. Accordingly, this EA provides analysis that builds upon the scientific information developed over this entire period.

Introduction

Three Department of the Interior agencies, the Bureau of Reclamation (Reclamation), National Park Service (NPS), and U.S. Geological Survey (USGS), are proposing a series of experimental releases of water from Glen Canyon Dam and mechanical removal of non-native fish to help native fish, particularly the endangered humpback chub. The dam releases are also designed to 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, dams 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 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.

The primary purpose and 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 (Wyoming, Utah, Colorado, New Mexico, Arizona) to deplete water from the watershed upstream of Glen Canyon Dam and utilize their apportionments of Colorado River water.

In addition to the primary purpose of water delivery, another function of the dam is to generate hydroelectric power as an incident to other purposes of Glen Canyon Dam. 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 praticable amount of power. Over time, additional considerations have arisen with respect to the operation of Glen Canyon Dam, including concerns regarding effects of Glen Canyon Dam operations on species listed pursuant to the Endangered Species Act.

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 Grand Canyon Protection Act of 1992 required the Secretary of the Interior to complete an environmental impact statement evaluating alternative operating criteria, consistent with existing law, that would determine how Glen Canyon 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 environmental impact statement (FEIS) was completed in March 1995. The Preferred Alternative (Modified Low Fluctuating Flow Alternative) was selected as the best means to operate Glen Canyon Dam in a Record of Decision (ROD) issued on October 9, 1996. Later in 1997, the Secretary adopted operating criteria for Glen Canyon Dam as required by Section 1804(c) of the Grand Canyon Protection Act of 1992.

Passage of the Grand Canyon Protection Act of 1992 also requires the Secretary of the Interior to exercise:

> *. . .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 Grand Canyon Protection Act of 1992 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 FEIS and ROD, 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 Grand Canyon Protection Act of 1992 were incorporated into the 1996 ROD 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 U.S. Geological Survey.

Monitoring and research conducted by these organizations since 1996 have shown that some of the expected benefits of dam operations under the ROD have not occurred, at least for the endangered humpback chub (*Gila cypha*) and conservation of fine sediment. In proposing these experiments, the agencies and members of the GCDAMP 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 mandated in the Grand Canyon Protection Act of 1992:

> *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 integrated document has been prepared to serve as both an environmental assessment and as a biological assessment[1] and documents current conditions in Glen, Marble, and Grand canyons below Glen Canyon Dam and describes how the Proposed Action, i.e., the experimental flows and non-native fish removal, are designed to help endangered humpback chub and conserve fine sediment along the Colorado River.

[1] While prepared as an environmental assessment (40 C.F.R. § 1508.9), this document was also prepared to provide information for the purposes of 50 C.F.R. §§ 402.13(c)(1-6). As the Proposed Action, i.e., a series of experimental flows, is not a "major construction activity," as that term is used in 50 C.F.R. § 402.12(b), preparation of a biological assessment, as defined in 50 C.F.R. § 402.02, is not required by regulation, but has been prepared to facilitate compliance with § 7(a)(2) of the Endangered Species Act.

CHAPTER 1.0

Purpose of and Need for Action

1.1 PURPOSE AND NEED

The Bureau of Reclamation, Upper Colorado Region, the National Park Service's Grand Canyon National Park and Glen Canyon National Recreation Area, and the U.S. Geological Survey Grand Canyon Monitoring and Research Center are joint lead federal agencies in assessing this Proposed Action. The Proposed Action has two components: a temporary modification of Glen Canyon Dam ROD operations and mechanical removal of non-native fish in the Colorado River between Glen Canyon Dam and Lake Mead. In light of each agency's ongoing actions, Reclamation has responsibility for the dam operations aspects of the Proposed Action while the NPS and GCMRC have responsibility for the mechanical removal aspect.

The purpose of the Proposed Action is: 1) to contribute to the conservation of endangered native fish, especially the humpback chub, by reducing populations of non-native fish who compete with and prey on native fish in the Colorado River between Glen Canyon Dam and Lake Mead (figure 1.1); 2) to conserve fine sediments that form sandbars, beaches, and habitat for young native fish by altering dam operations; and 3) to improve the Lees Ferry sport fishery by reducing the overabundance of trout. These proposals are within the constraints established by statutes (commonly known as the "Law of the River") and other applicable legal obligations.

The need for the Proposed Action arises because the Grand Canyon population of endangered humpback chub has declined to levels that threaten its viability and future existence (Coggins and Walters 2001), and fine sediment has been exported to such an extent that sandbar habitat, camping beaches and sandbars continue to be washed downstream and lost (Rubin et al. 2002). The proposed action would provide important information that will be used as additional operational and physical modifications are considered regarding future operation of Glen Canyon Dam.

1.2 RELATED DOCUMENTS, PROGRAMS, AND ACTIONS

1.2.1 Final Environmental Impact Statement and Record of Decision

Given the multiple management agencies, the tribes, the state and local interests in the Colorado River below Glen Canyon Dam, there are numerous related environmental impact statements, environmental assessments, and management plans or planning documents that involve the same geographic area as this environmental assessment.

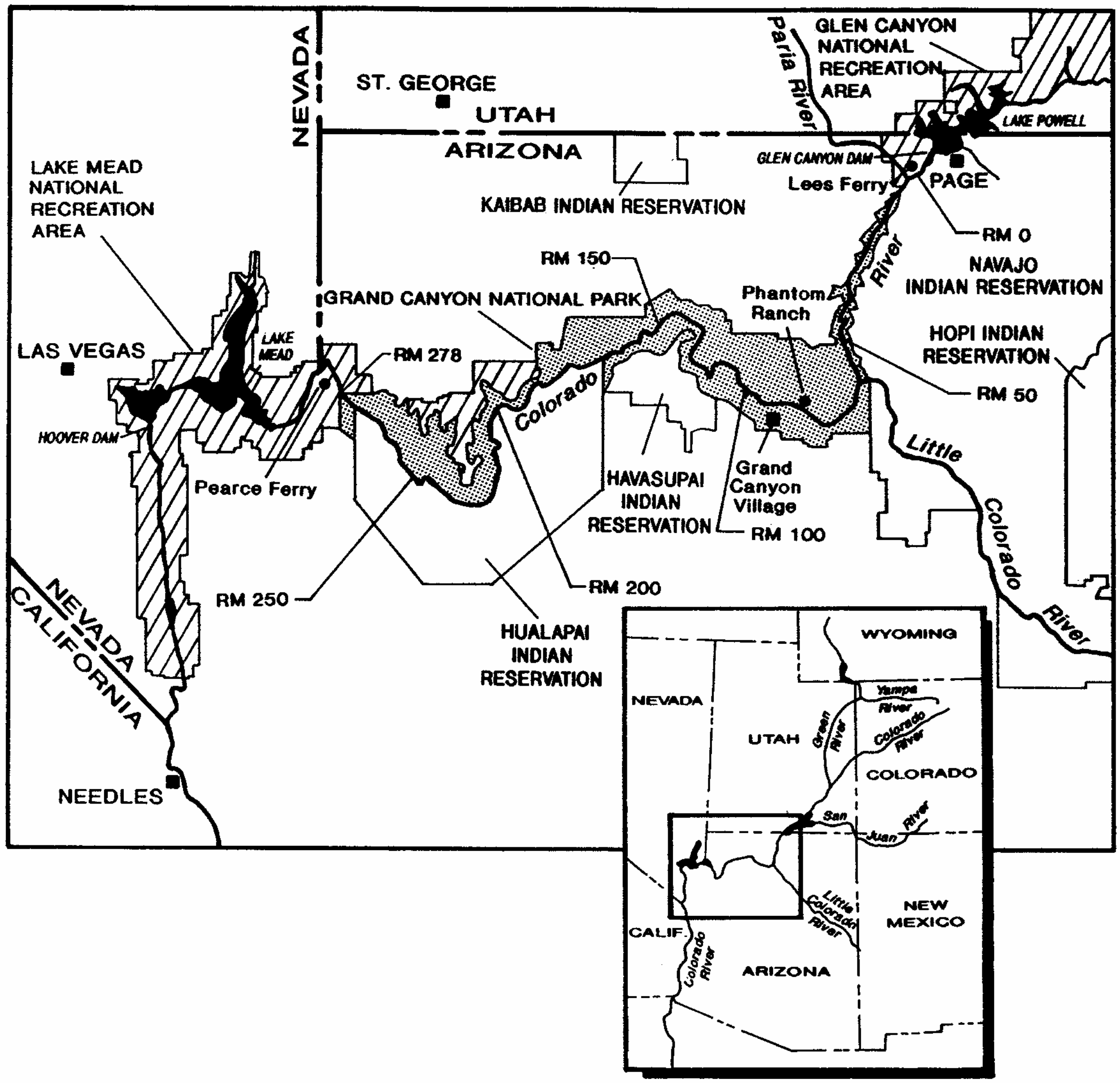

Figure 1.1—Map of the affected environment showing land jurisdiction and river miles.

This environmental assessment (EA) is tiered, as defined in 40 C.F.R. 1508.28, with the FEIS (Reclamation 1995a) for operation of Glen Canyon Dam. Some of the underlying assumptions and models in the FEIS of how Colorado River resources would respond to ROD operations have been modified or rejected based on significant additional scientific research. Therefore, we propose an experiment with specific deviations in ramp rates and daily fluctuations from the preferred alternative in the FEIS and ROD.

1.2.2 Glen Canyon Dam Adaptive Management Program

The Proposed Action Alternative in this environmental assessment has been developed within the GCDAMP. The GCDAMP was created through the ROD and applies an adaptive management framework in making recommendations to the Secretary of the Interior on Glen Canyon Dam operations. The GCDAMP has established 12 goals:

1. Protect or improve the aquatic food base so that it will support viable populations of desired species at higher trophic levels.
2. Maintain or attain viable populations of existing native fish, remove jeopardy from humpback chub and razorback sucker, and prevent adverse modification to their critical habitat.
3. Restore populations of extirpated species, as feasible and advisable.
4. Maintain a wild reproducing population of rainbow trout above the Paria River, to the extent practicable and consistent with the maintenance of viable populations of native fish.
5. Maintain or attain viable populations of Kanab ambersnail.
6. Protect or improve the biotic riparian and spring communities, including threatened and endangered species and their critical habitat.
7. Establish water temperature, quality, and flow dynamics to achieve the Adaptive Management Program ecosystem goals.
8. Maintain or attain levels of sediment storage within the main channel and along shorelines to achieve the Adaptive Management Program ecosystem goals.
9. Maintain or improve the quality of recreational experiences for users of the Colorado River ecosystem, within the framework of the Adaptive Management Program ecosystem goals.
10. Maintain power production capacity and energy generation, and increase where feasible and advisable, within the framework of the Adaptive Management Program ecosystem goals.
11. Preserve, protect, manage, and treat cultural resources for the inspiration and benefit of past, present, and future generations.
12. Maintain a high quality monitoring, research, and adaptive management program.

The Proposed Action in this environmental assessment is designed to achieve particular Goals 2, 4, and 8. The Proposed Action is designed to help achieve these goals, while not adversely impacting any important resources identified in the other GCDAMP goals. For example, although non-native fish are targeted for reduction, an important goal is maintaining the Lees Ferry trout fishery.

1.2.3 Colorado River Management Plan

One of the more important related federal actions is Grand Canyon National Park's Colorado River Management Plan. The management plan will address resource management and visitor experience along the Colorado River corridor in Grand Canyon National Park within the framework of current NPS laws and directives. River use will be regulated to ensure that the level and types of use are sustainable and that resource impacts are within acceptable limits for long-term resource preservation. Scoping for this plan began in August of 2002. Primary issues include allocation of river days to private boaters and commercial river-running companies. The NPS will seek to minimize the impacts of administrative use, which include river trips for research and monitoring of resources of concern in the GCDAMP.

1.2.4 The Lake Mead Management Plan

The overall objectives of this lake management plan are to improve the management of lakes Mead and Mohave to provide for the long-term protection of park resources while allowing a range of recreational opportunities to support visitor needs. The draft environmental impact statement was released in April 2002. It evaluates alternatives and strategies, including the management of personal watercraft, for protecting the resources and values of the Lake Mead National Recreation Area, while offering recreational opportunities as provided in the park's enabling legislation, purpose, mission, and goals. Species evaluated for impacts under this management plan that also are evaluated in the Proposed Action below Glen Canyon Dam include the endangered razorback sucker and southwestern willow flycatcher (SWWF).

1.2.5 Colorado River Recreation Management Plan, Glen Canyon National Recreation Area

The last comprehensive management plan for this segment of the river was prepared in 1984. Recent visitor contacts have revealed an increasing perception of conflict between user groups. In addition, some visitors have reported concerns with crowding and a diminished quality of experience. For these reasons, NPS has initiated a recreation management planning process for the river that will address visitors' perceptions of crowding, identify any resource conflicts, and evaluate the need for new management strategies.

1.2.6 Personal Watercraft Rule-Making, Glen Canyon National Recreation Area, Arizona and Utah

The purpose of and the need for taking this proposed action is to evaluate a range of alternatives and strategies for the management of personal watercraft use at Glen Canyon National Recreation Area. It is similar to the evaluation being conducted in the

Lake Mead Management Plan. The goal is to ensure the protection of recreation area resources and values while offering recreational opportunities as provided in the recreation area's enabling legislation, purpose, mission, and goals. A draft environmental impact statement was issued on September 13, 2002. Concerns for effects of personal watercraft use that are also evaluated in the proposed action below Glen Canyon Dam include threatened and endangered species, wildlife and wildlife use, and water quality.

1.2.7 Tamarisk Removal

Grand Canyon National Park and Glen Canyon National Recreation Area are engaging in attempts to suppress or eradicate tamarisk. Tamarisk is an exotic plant species whose distribution and abundance have increased greatly since it was introduced in the U.S. This increase has occurred at the expense of native riparian vegetation and wildlife. Park actions are occurring in side canyons, tributaries, developed areas, and springs above the pre-dam high water level. The tamarisk removal action is occurring just below the boat launch at Lees Ferry. The purpose of these actions is to restore more natural conditions and prevent any further loss or degradation of existing native plants.

1.2.8 Brown Trout Removal

Grand Canyon National Park will initiate an evaluation of removing brown trout from Bright Angel Creek in autumn 2002. Brown trout will be removed by placing a weir in Bright Angel Creek to stop the upstream migration of spawning fish. If the effort is successful, NPS will continue the effort for 4-5 years in an attempt to reduce the brown trout population. Brown trout is an exotic species brought into the U.S. from Europe and Asia early in the 20th century. Purposeful stockings of the fish were made during the 1920s and 1930s in Grand Canyon. Research and monitoring investigations in Grand Canyon have demonstrated that brown trout prey on the endangered humpback chub and other native fish species.

1.2.9 Interim Surplus Guidelines

In January 2001, the Secretary of the Interior released the Record of Decision (ROD), regarding the preferred alternative for Colorado River Interim Surplus Guidelines. The specific interim surplus guidelines are to be used annually for 15 years to determine the conditions under which the Secretary would declare the availability of surplus Colorado River water for use within the states of Arizona, California and Nevada. The selected alternative was the Basin States Alternative. Reclamation determined that the proposed project may affect, but is not likely to adversely affect, listed species in the Colorado River corridor or their critical habitat from Glen Canyon Dam to the headwaters of Lake Mead. The species of consideration include the endangered humpback chub with critical habitat, endangered razorback sucker with critical habitat, endangered southwestern willow flycatcher without critical habitat, and threatened (proposed delisted) bald eagle without critical habitat. The U.S. Fish and Wildlife Service (Service) concurred with Reclamation's determination that a 2 percent change in the long-term frequency of occurrence of 8.23 maf annual flows from Glen Canyon Dam as a result of Interim Surplus Criteria "may affect, but is not likely to adversely affect the above mentioned listed species or their critical habitat." The Service also concurred with Reclamation's determination that a change in the long-term average frequency of beach/habitat-building Flows (BHBF) through the Grand Canyon from 1 in 5 years, to 1 in every 6 years with the adoption of Interim Surplus Criteria "may affect, but is not likely to adversely affect listed species or adversely modify their critical habitat" given that BHBF's are not required to remove jeopardy to native fish, nor required to minimize incidental take, and have not proven critical to the survival or recovery of native fishes.

1.3 DECISIONS NEEDED AND PERMITS REQUIRED

The decision to be made by the joint lead agencies as the result of this EA will be one of the following:

- Finding of No Significant Impact (FONSI)
- Prepare an Environmental Impact Statement
- Withdraw the Proposed Action

A variety of permits would need to be issued should the Proposed Action be implemented. The NPS is responsible for decisions relating to the issuance of special use permits for research and monitoring activities proposed within the boundaries of Glen Canyon National Recreation Area and Grand Canyon National Park.

Any proposed activities related to this environmental assessment that would necessitate entry onto the Hualapai Indian Reservation or the Navajo Nation would require permits from the tribes and possibly from the U.S. Bureau of Indian Affairs.

All persons working with threatened or endangered species would have to obtain permits from the Service. The Service will issue a biological opinion on the Proposed Action.

The Arizona State Historic Preservation Officer, the Hualapai and Navajo Tribal Historic Preservation Officers, and the Advisory Council on Historic Preservation are being consulted on the proposed determination of effect for historic properties.

Researchers working with resident fish or wildlife species would need an Arizona Game and Fish Department permit. No other permits would be required.

1.4 PUBLIC INVOLVEMENT

The Proposed Action is based on years of data collection and continuous scientific studies since initiation of ROD operations and accordingly is based on a broader approach than previous actions. It was developed through a sequence of meetings of the advisory committees within the GCDAMP, augmented by discussions with cooperating scientists. Ad hoc experimental flow and sediment committees provided input and developed reports with recommendations to the work groups on the dam release scenarios. These deliberations resulted in recommendations to the Secretary of the Interior to initiate a Proposed Action that would provide the desired conservation and improvements to native fish and sediment.

1.4.1 Federal Advisory Committees within the GCDAMP

The GCDAMP is composed of a series of working committees chartered under the Federal Advisory Committee Act (FACA). The advisory committee meetings of the GCDAMP are publicly noticed in the *Federal Register* and open to public participation. One of those committees is the Adaptive Management Work Group (AMWG). The AMWG has responsibility for providing recommendations to the Secretary of the Interior on operation of Glen Canyon Dam. At their January 19, 2002 meeting, the AMWG reviewed evidence that the Grand Canyon population of endangered humpback chub is severely declining (Coggins and Walters 2001) and reports that sediment and sand continue to be transported out of Glen, Marble, and Grand canyons by the regulated flows of the Colorado River released through Glen Canyon Dam (Rubin et al. 2002).

Another of the working groups of the GCDAMP is composed of resource management specialists and is called the Technical Work Group (TWG). The TWG observed that the decline in the humpback chub occurred concomitantly with increases in rainbow and brown trout populations in the Colorado River below Glen Canyon Dam (McKinney et al. 2001, AGFD unpublished data). Adults of both species feed on other fish, including the endangered native species (Maddux et al. 1987; Valdez and Ryel 1995; Marsh and Douglas 1997; Valdez and Carothers 1998). The AMWG directed the GCMRC, in consultation with the TWG, to design an experiment that tests how dam operations might be modified and other management actions taken to better conserve sediment and help native fish.

On March 25, 2002, the GCMRC provided a draft proposal for the requested experimental flows which form the basis for this proposal. Stakeholders discussed the proposal at the April 24, 2002, AMWG meeting. The AMWG directed the GCMRC to proceed with all activities necessary to implement experimental flows in 2002-2003, and to work with the TWG and Science Advisors, an external peer review group who are contracted by the GCMRC to provide advice to the GCMRC and the GCDAMP. The GCMRC then developed a science plan to measure the effects of proposed experiments.

The AMWG recommendation was transmitted to the Secretary of the Interior on July 1, 2002. The TWG discussed the Proposed Action during its meetings on August 15-16, 2002. Reclamation and the other joint lead agencies subsequently developed this EA and BA.

1.4.2 Tribal Consultations

Consultations with the Hopi Tribe, Navajo Nation, Kaibab Band of Paiute Indians, Shivwits Band of the Paiute Indian Tribe of Utah, Pueblo of Zuni, and Hualapai Tribe occurred during the meetings of the GCDAMP. Government-to-government consultation meetings with the Hopi Tribe, Hualapai Tribe, and Kaibab and Shivwits Bands of Paiute Indians were held during August and September 2002.

1.4.3 Park Concessionaires

Presentations on the Proposed Action were made during meetings with the Lees Ferry fishing guides. Grand Canyon River Guides were involved in planning the Proposed Action through meetings of the GCDAMP.

1.4.4 Public Meetings

The Proposed Action was described at meetings about the Annual Operating Plan for reservoirs in the Colorado River Basin, which include representatives of the seven Colorado River Basin States (Basin States) and others during the Annual Operating Plan process. Public comments and the distribution of this document for review are designed to provide an opportunity for additional public involvement.

Meetings to inform the public of the Proposed Action and seek input will be held on October 2, 2002, in Flagstaff, Arizona, and on October 3, 2002, in Phoenix, Arizona.

CHAPTER 2.0

Description of Alternatives

This chapter describes the No Action and Proposed Action alternatives in detail and describes other alternatives eliminated from the detailed study. The No Action Alternative is the Modified Low Fluctuating Flow Alternative in the FEIS (Reclamation 1995a) and ROD (1996). These documents should be consulted for more detailed information on the Modified Low Fluctuating Flow Alternative. The Proposed Action consists of two major elements:

1. A set of hydrological scenarios and experimental dam releases that are triggered by minimum sediment inputs to the Colorado River from tributaries, and
2. Reduction of non-native fish populations, primarily rainbow and brown trout, through mechanical removal and experimental dam releases from Glen Canyon Dam.

2.1 NO ACTION ALTERNATIVE

Glen Canyon Dam is currently operated using the Modified Low Fluctuating Flow Alternative (table 2.1) from the 1995 FEIS (Reclamation 1995a). This alternative reduced daily fluctuations and the rates of increase and decrease of releases from those prior to the FEIS. The No Action alternative is not one flow, but rather includes a series of powerplant constraints, habitat maintenance flows, beach-habitat building flows, and elements of the reasonable and prudent alternative recommended by the Fish and Wildlife Service in their biological opinion (Service 1994) and accepted by Reclamation (Reclamation 1995b) and the Secretary of the Interior (ROD 1996).

Table 2.1—Powerplant operating constraints of the ROD.

Parameter	Modified low fluctuating flow
[1]Minimum releases (cfs)	8,000 between 7a.m. and 7 p.m. 5,000 at night
[2]Maximum releases (cfs)	25,000 (exceeded during habitat maintenance flows)
Allowable daily flow fluctuations (cfs/24 hours)	[3]5,000, 6,000 or 8,000
Ramp rates (cfs/hour)	4,000 up 1,500 down

[1] In high volume release months, the allowable daily change would require higher minimum releases than shown here.

[2] Maximum releases represent normal or routine limits and may necessarily be exceeded during high water years (WY) or for hydrologic reasons.

[3] Daily fluctuation limit of 5,000 cfs for monthly release volumes less than 600,000 acre-feet; 6,000 cfs for monthly release volumes of 600,000 to 800,000 acre-free; and 8,000 cfs for monthly volumes over 800,000 acre-feet

Operating criteria adopted in 1997 were designed to protect or enhance downstream resources while allowing limited flexibility for power operations. Criteria such as minimum flows, maximum flows, ramp rates, and allowable daily fluctuations were modified in the FEIS and ROD.

Annual and monthly releases implement the long-range operating criteria objectives of 8.23-million acre-feet (maf) minimum annual releases, storage equalization between Lake Powell and Lake Mead, and avoidance of anticipated spills. Annual and monthly release volumes are projected for different hydrologic conditions prior to the beginning of the water year (October-September) and are generally described in an annual operating plan. Estimated monthly release volumes under the No Action Alternative for the period September 2002-September 2004 are listed in table 2.2, while daily release patterns for this period are depicted in figure 2.1. Most probable annual release volumes as of September 2002 are 8.23 maf for the 2003 water year and 9.6 maf for the 2004 water year.

Scheduled monthly release volumes are updated at least monthly during the water year (October-September). The actual minimum and maximum releases from the dam for a given day depend on the monthly release volume, the allowable daily fluctuation, and the demand for hydroelectric power. The actual releases are usually higher than the minimum and lower than the maximum allowed under the ROD. The allowable daily fluctuation of 5,000, 6,000, or 8,000 cfs/24 hours depends on the monthly release volume and is designed to constrain the daily change in river stage.

The downramp rate in the ROD was conservatively set to reduce seepage-based erosion of sandbars in Glen and Grand canyons and to avoid stranding of fish. The upramp rate was set to further reduce operation-related impacts to canyon resources, although the processes linking ramp rates with resource effects are still under investigation.

Habitat maintenance flows are dam releases at powerplant capacity (about 31,000 cfs at full reservoir elevation) and were anticipated to occur in most years (Reclamation 1995a). Beach/habitat-building flows under the ROD exceed powerplant capacity and were expected to occur infrequently when high reservoir elevations create dam safety concerns. The two types of releases, which had similar purposes of reforming backwaters and maintaining sandbars, were not to be scheduled in the same year and neither was to occur in a year when there was concern for the effects on sensitive resources, such as sediment or endangered species.

TABLE 2.2—Monthly water volumes for sediment input scenarios[1]

Month/Year	Base Case Water (TAF)	Scenarios 1, 2, and 3 Water (TAF)
Sediment Input Year 1		
Oct. 2002	600	492
Nov. 2002	600	476
Dec. 2002	800	492
Jan. 2003	800	839
Feb. 2003	600	730
March 2003	600	810
April 2003	600	600
May 2003	600	600
June 2003	630	650
July 2003	850	870
August 2003	900	870
Sept. 2003	650	801
Total Year 1	8,230	8,230
Sediment Input Year 2		Scenario 4 Water (TAF)
Oct. 2003	600	600
Nov. 2003	600	600
Dec. 2003	800	800
Jan. 2004	800	854
Feb. 2004	800	748
March 2004	650	810
April 2004	600	600
May 2004	800	800
June 2004	900	878
July 2004	1,050	1,000
August 2004	1,050	1,000
Sept. 2004	950	910
Total Year 2	9,600	9,600

[1] Minor adjustments were made to monthly volumes in water year 2002 through the AOP process to allow for the potential initiation of the Proposed Action if Paria River sediment inputs occurred and environmental compliance was completed. This had no effect on the annual release volume from Glen Canyon Dam.

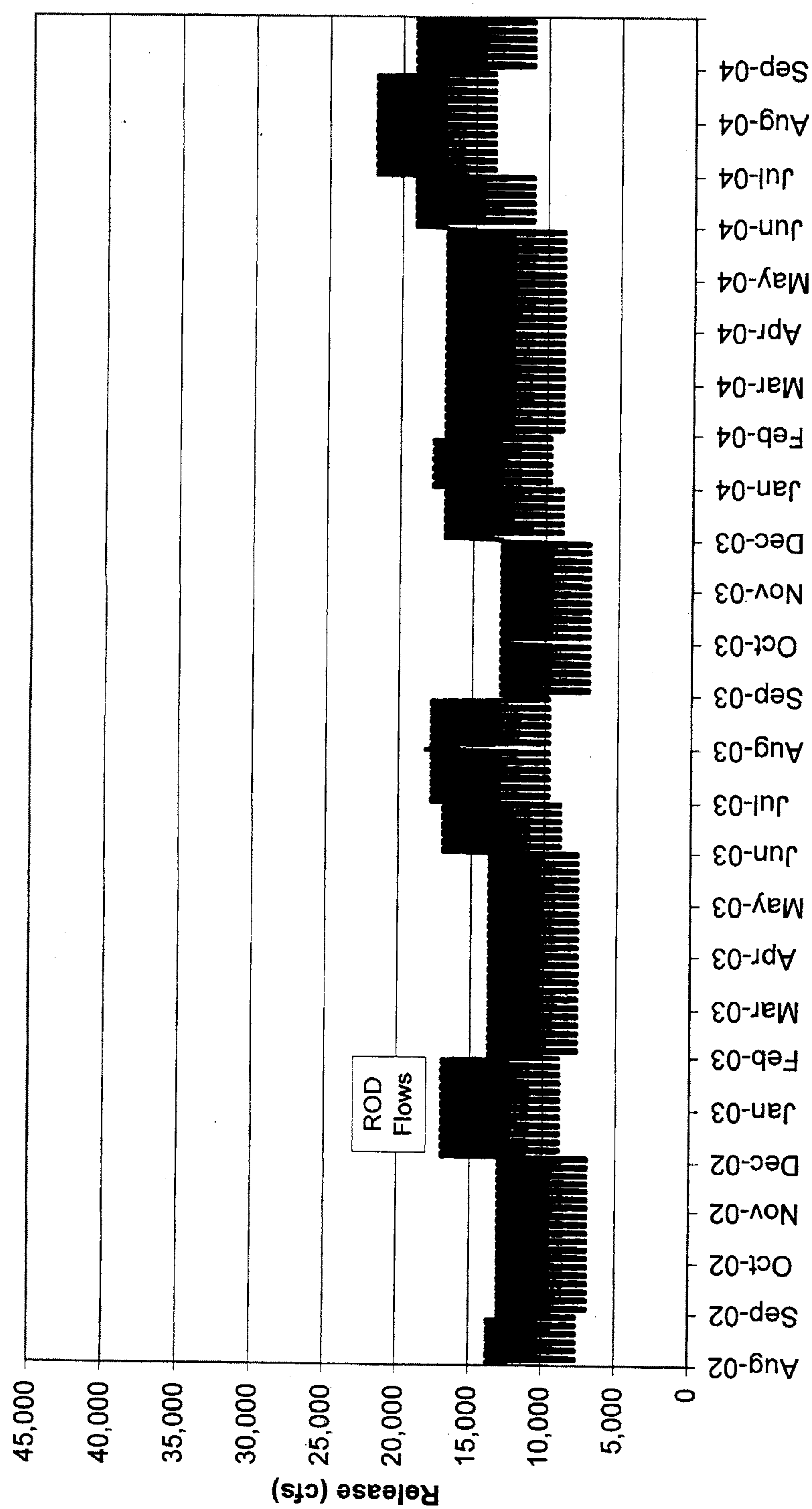

FIGURE 2.1 - No action alternative

The No Action Alternative for water years 2003 and 2004 does not anticipate beach/habitat-building flows, habitat maintenance flows, or endangered fish flows as described in the biological opinion. Present projections during this period of drought are that the Lake Powell elevation will not rise to a level that would trigger a beach/habitat-building flow by October 2004. Short-term, powerplant capacity dam releases occurred in November 1997, June 2000, and September 2000. The consensus of research scientists working within the GCDAMP is that thus far, these habitat maintenance flow releases largely have failed to achieve the objectives identified in the FEIS. Researchers believe there is a better chance of achieving sediment conservation and native fish habitat objectives if high flows are timed to be released in conjunction with tributary sediment inputs (Rubin et al. 2002). This approach occurs in one of the hydrological scenarios of the Proposed Action Alternative described below.

Endangered fish flows recommended in the biological opinion are not part of the No Action Alternative during water years 2003-2004. GCMRC and the Science Advisors recommend that non-native fish suppression is a priority. They believe competition and predation by large populations of non-native fish preclude native fish from taking advantage of potential habitat improvements brought about by dam operations. The Service (2002) has agreed it may not be wise to implement the contemplated endangered fish flows until non-native fish populations are suppressed and a temperature control device to warm the water below the dam is in place. The Proposed Action has been designed in part to reduce or suppress non-native fish populations over a two-year period.

2.2 PROPOSED ACTION

The Proposed Action has two components: modification of dam operations and mechanical removal of non-native fish, particularly trout. Hypotheses relating to these actions and additional details are provided in a science plan developed by GCMRC (2002b). The efficacy of the Proposed Action will be evaluated in April 2004, after two years of dam operations and mechanical removal of non-native fish.

2.2.1 Proposed Dam Operations

Proposed dam operations include five types of releases in addition to ROD operational flows that would occur within four hydrological scenarios over a period of two water years.

The five proposed release types are:

- 8,000 cfs steady flows,
- 6,500-9,000 cfs fluctuating flows,
- 5,000-20,000[1] cfs fluctuating non-native fish suppression flows,
- 31,000-33,000 cfs habitat maintenance flow, and
- 42,000-45,000 cfs high flows. The magnitude of these short-term releases would not exceed 45,000 cfs but they would vary below this level depending on Lake Powell elevation and generator availability.

The order in which the releases would occur depends on the amount of sediment inputs from the Paria River or ungaged tributaries in Glen Canyon and upper Marble Canyon (GCMRC 2002b). However, under the Proposed Action the fluctuating non-native fish suppression flows would occur independent of sediment availability. Given the complexity of the proposal and the many decision points, the proposal is graphically depicted in a flow diagram (figure 2.2).

The first release scenario is called the autumn sediment input scenario (figure 2.3). It would occur if three conditions are met. First, if at least 500,000 metric tons of fine sediment enters the Colorado River from the Paria River and ungaged upper Marble Canyon tributaries between July 1 and October 31, then dam releases would change from ROD operations to a series of alternating 2-week long steady 8,000 cfs releases and 2-week long 6,500-9,000 cfs fluctuating releases. If the minimum sediment input does not occur, dam releases would follow the prescription of the ROD (as described in the No Action Alternative).

Second, if at least 1,000,000 metric tons of fine sediment are present in Marble Canyon by October 31, the alternating steady and fluctuating releases would continue. If the minimum sediment input does not occur by that date, dam releases would follow the prescription of the ROD. By December 1, a comparison would be made of the effectiveness of sediment conservation by the 8,000 cfs steady releases and the 6,500-9,000 cfs low fluctuating releases. The action agencies within the Department of the Interior would decide which flow is most effective at sediment conservation and discontinue the less effective release.

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[1] However, maximum flow, upramp and downramp rates could be adjusted through the adaptive management and environmental compliance process during the second year of non-native suppression flows if the Proposed Action is not achieving the objectives of the experiment or is creating unanticipated adverse effects.

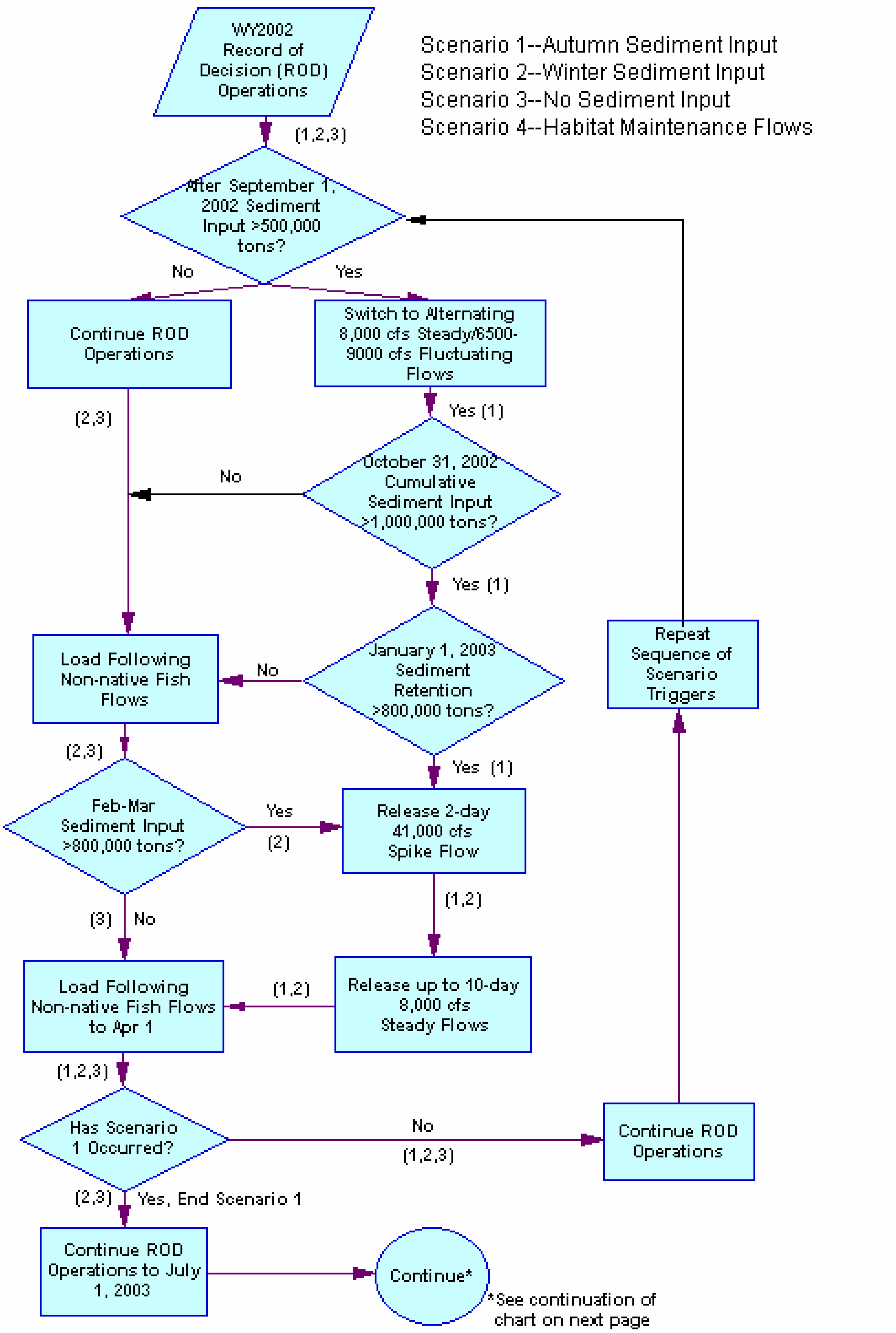
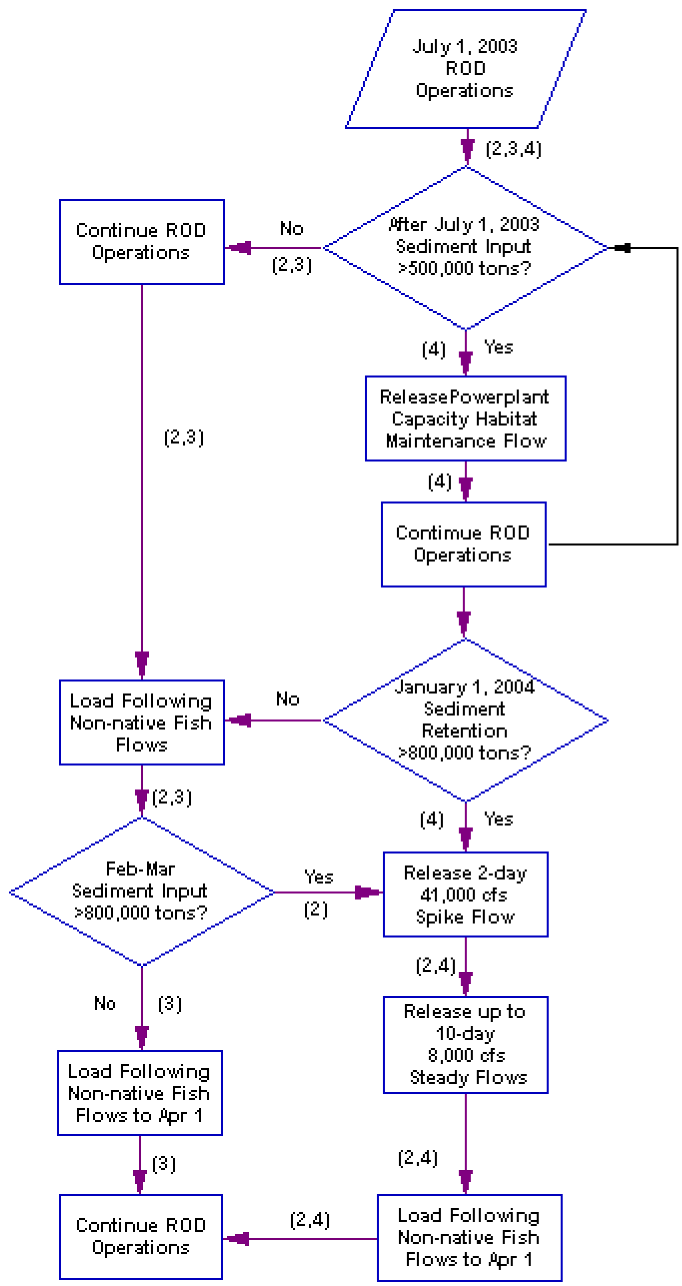


Figure 2.2—Flow Diagram.



July 1, 2003
ROD
Operations
(2,3,4)
After July 1, 2003
Sediment Input
>500,000 tons?
No
(2,3)
Continue ROD
Operations
(4)
Yes
ReleasePowerplant
Capacity Habitat
Maintenance Flow
(4)
Contimue ROD
Operations
(2,3)
January 1, 2004
Sediment
Retention
>800,000 tons?
No
Load Following
Non-native Fish
Flows
(2,3)
(4)
Yes
Feb-Mar
Sediment Input
>800,000 tons?
Yes
(2)
Release 2-day
41,000 cfs
Spike Flow
(2,4)
Release up to
10-day
8,000 cfs
Steady Flows
No
(3)
Load Following
Non-native Fish
Flows to Apr 1
(3)
(2,4)
Continue ROD
Operations
(2,4)
Load Following
Non-native Fish
Flows to Apr 1

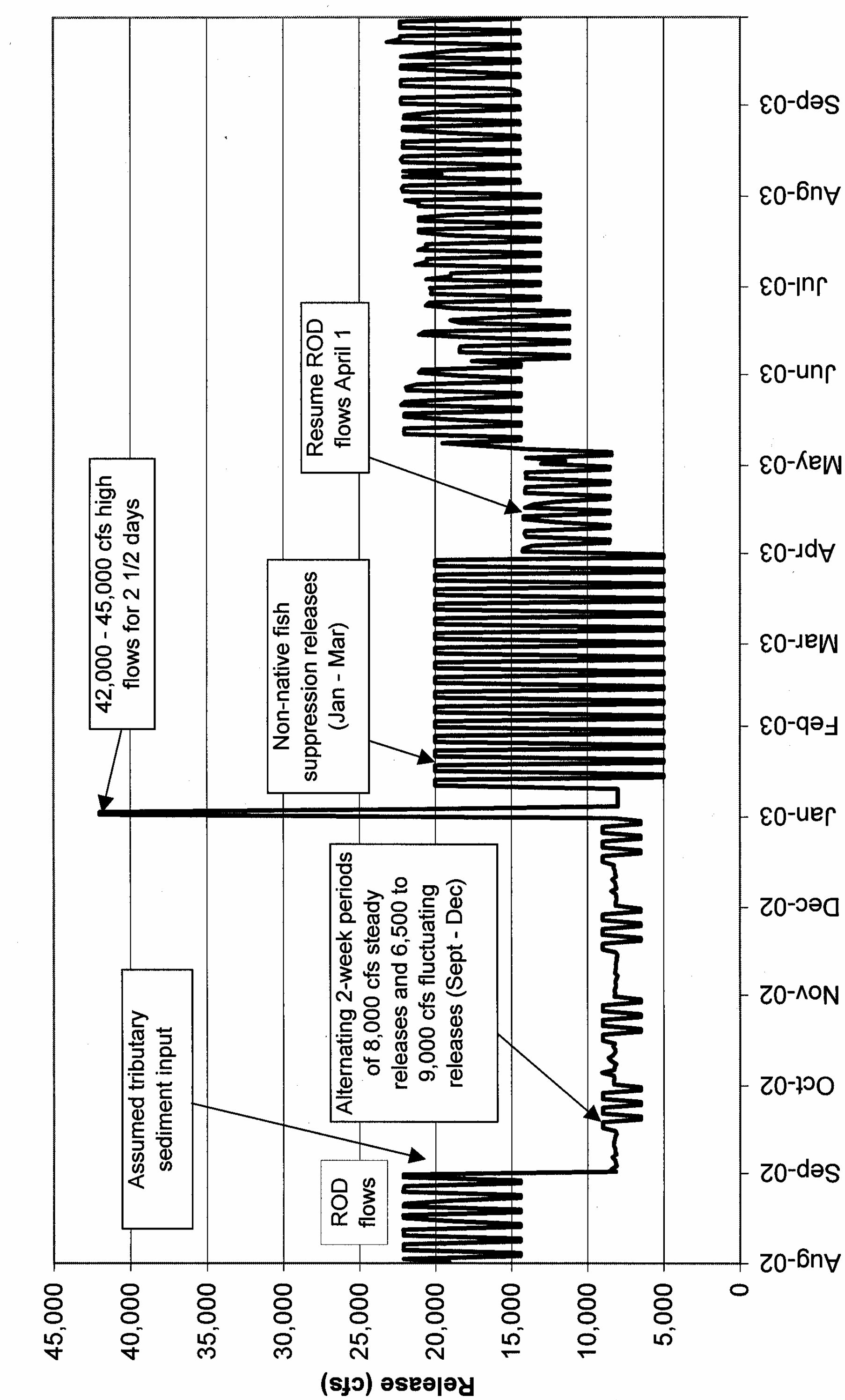


FIGURE 2.3. - Autumn sediment input scenario

Third, if at least 800,000 metric tons of sediment input are retained in the Colorado River between Glen Canyon Dam and the Little Colorado River by January 1 of the ensuing year, then a powerplant and jet tube total release between 42,000-45,000 cfs would occur in the first week of January in an effort to “bank” the conserved sediment at higher elevations within the Grand Canyon. This high flow would last for approximately 60 hours. Upramp rates for this release would be 4,000 cfs/hour for the first two hours, then 1,500 cfs/hour up to powerplant capacity, then opening one bypass tube in two steps over the course of six hours until reaching jet tube capacity. The downramp rate would be 1,500 cfs/hour from maximum releases (42,000-45,000 cfs) to 8,000 cfs and this would take about 22 hours to achieve. A steady release of 8,000 cfs would be continued for a period not to exceed 10 days during which time aerial photography and surveying would occur to document the effect of the high flow test on sediment conservation and other resources. If the minimum sediment accumulation does not occur by January 1, dam releases would change to fluctuating non-native fish suppression releases between 5,000 cfs and 20,000 cfs with an upramp rate of 5,000 cfs/hour and a downramp rate of 2,500 cfs/hour. The fluctuating non-native fish suppression flows would continue from January through March unless a minimum sediment input of 800,000 metric tons is received.

These fluctuating non-native fish suppression flows were designed to mimic pre-1990 daily fluctuations and ramp rates. Pre-1990 flows limited natural recruitment of rainbow and brown trout (Maddux et al. 1987). The proposed downramp rate of 2,500 cfs/hour was also selected to test the validity of the beach seepage model used to formulate the ROD downramp constraints.

If the minimum tributary sediment input of 800,000 metric tons occurs in the months of January-March during fluctuating non-native fish suppression flows, the winter sediment input scenario (figure 2.4) would begin with the release of 42,000-45,000 cfs. This release would have the same features as the high flow test under the autumn sediment input scenario, including the succeeding period of 8,000 cfs steady releases for aerial photography and surveying. It would interrupt the non-native fish suppression flows, but they would be resumed through the end of March following the high flow test and ensuing steady releases.

The third hydrologic scenario is the no sediment input scenario (figure 2.5). In this scenario, the minimum sediment inputs necessary to trigger the autumn sediment scenario or the winter sediment input scenario do not occur. Under these conditions ROD operations would continue until at least July 1 of that water year, except for the January to March period of fluctuating non-native fish suppression flows. Dam releases after July 1 would depend on tributary sediment inputs. If minimum tributary inputs occur and the first scenario has been completed, the fourth hydrological scenario would be initiated. If they do not occur, ROD operations would continue.

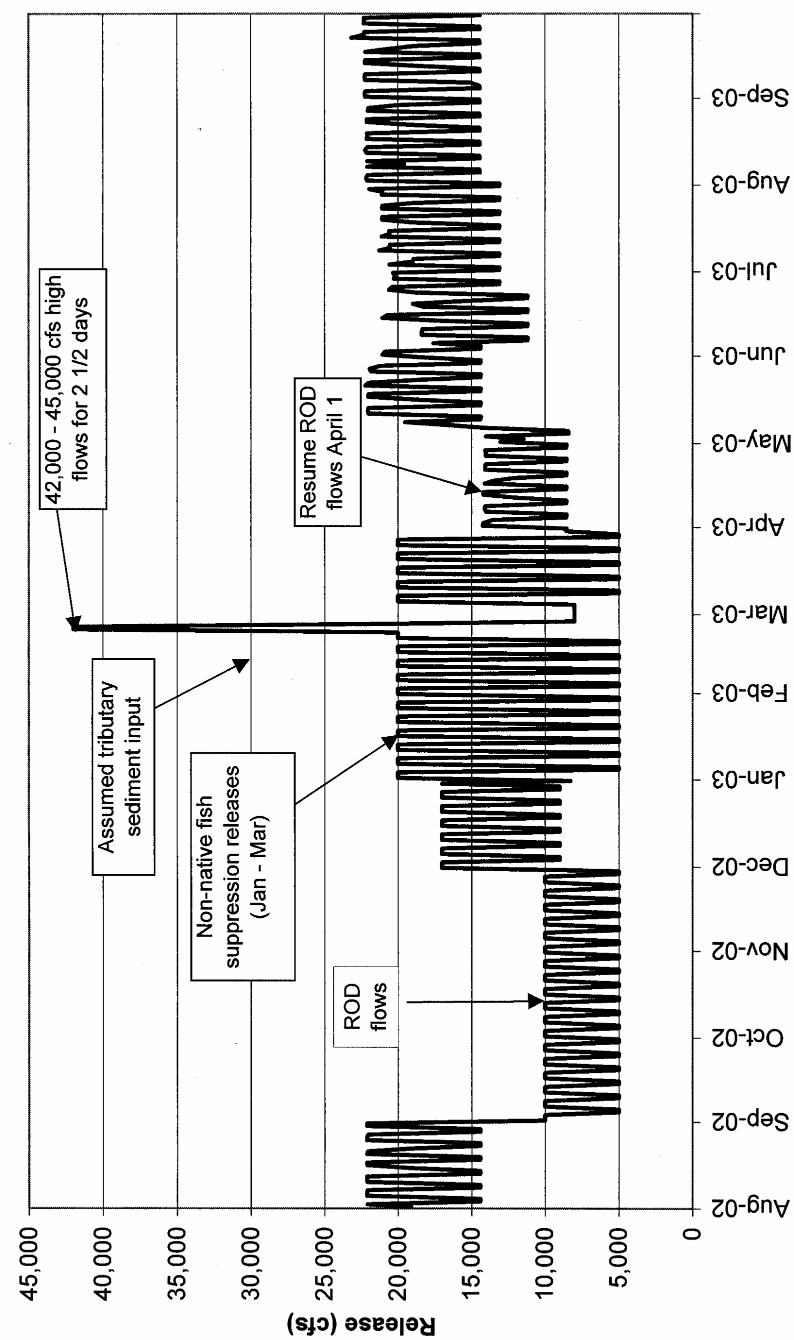


FIGURE 2.4. - Winter sediment input scenario

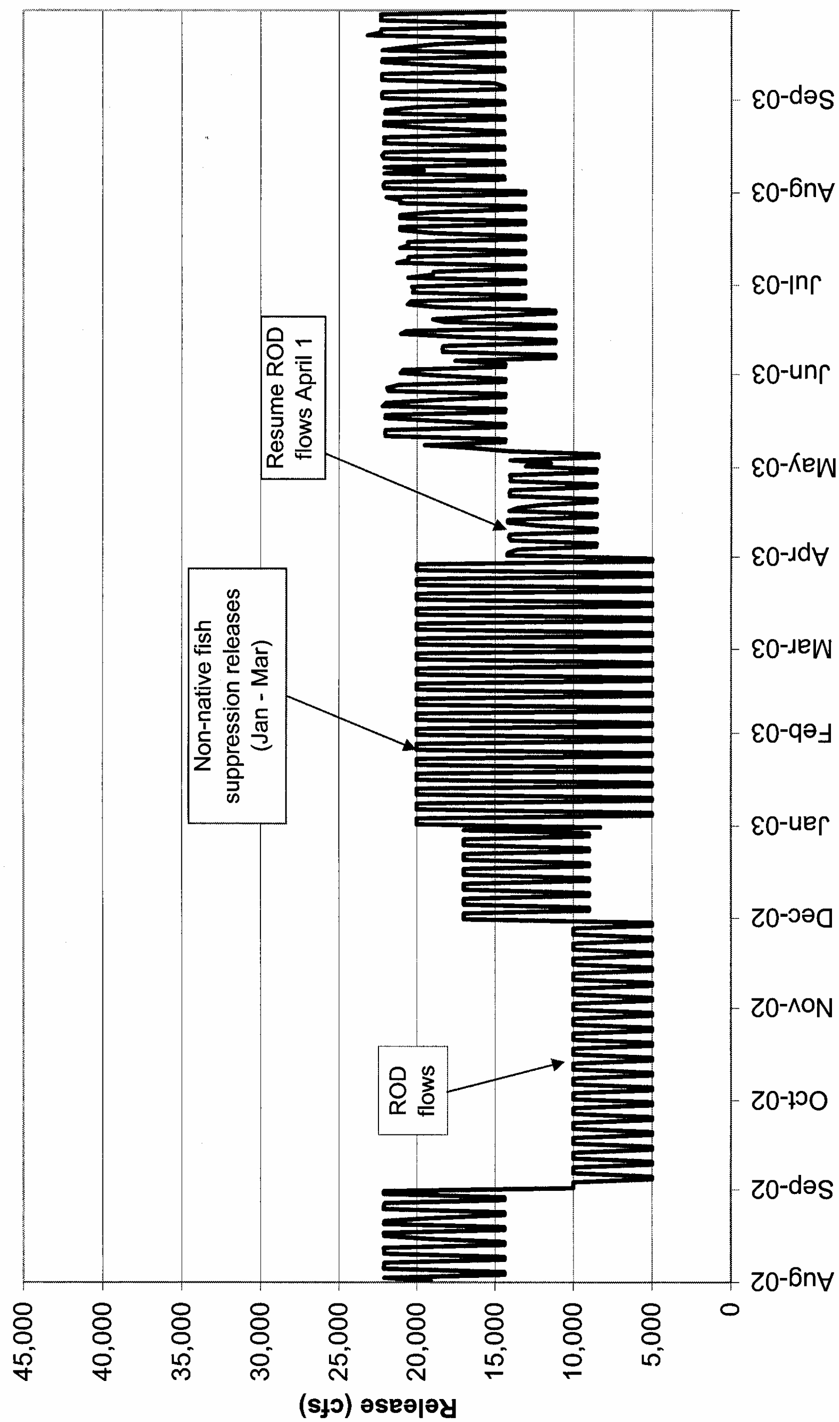


FIGURE 2.5. - No sediment input scenario

The fourth hydrological scenario is the habitat maintenance flow scenario (figure 2.6). This scenario would be implemented only under two conditions: 1) the autumn sediment input scenario must have been completed, and 2) a minimum tributary sediment input of 500,000 metric tons must occur between July1-December 31.[2] This scenario is similar to the winter sediment scenario in that a high flow test immediately follows the tributary input. The high release would be at powerplant capacity, last two days, and have 4,000 cfs/hr upramp rates and 1,500 cfs/hr downramp rates.

The Paria River flow necessary to provide the minimum sediment input would be approximately 2,500 cfs, though rare events could be as high as 12,000 cfs. Thus, the combined powerplant capacity and tributary flow would be in the approximate range of 33,500 cfs (31,000 cfs dam release + 2,500 cfs tributary inflow) to 43,000 cfs (31,000 dam release + 12,000 cfs tributary flow). If the combined flows would exceed 45,000 cfs, then dam releases would be reduced to constrain total flow to 45,000 cfs or less. The close association in timing of the sediment input and the ensuing dam release would be facilitated through installation of additional gages on the Paria River to serve as an early warning system announcing the inflow.

The habitat maintenance flow would be followed by ROD operations with daily fluctuations until January 1 unless another minimum 500,000 metric ton input occurred, in which case the powerplant capacity releases would be repeated, followed again by ROD operations. On January 1, if there was a minimum sediment retention of 800,000 metric tons in the reach of the Colorado River between Glen Canyon Dam and the Little Colorado River, a high flow of 42,000-45,000 cfs would be released from the dam having the same features as that under the autumn sediment input scenario or winter sediment input scenario. If the minimum amount of sediment is not retained above the Little Colorado River, fluctuating non-native fish suppression releases would be initiated following the January 1 evaluation. These releases would continue until April 1 unless additional sediment was received by the Colorado River sufficient to bring the sediment retained up to the 800,000 metric ton minimum. This amount of additional sediment in the system would trigger a two-day 42,000-45,000 cfs high flow having the same features as in the winter sediment input scenario. Following this high flow, the non-native fish suppression flows fluctuating between 5,000-20,000 cfs would continue through March 31. Dam releases would then revert to those prescribed under ROD operations.

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[2] If the minimum sediment input trigger does not occur during the first or ensuing years of Proposed Action operations, the autumn sediment input scenario would continue to receive the highest priority for completion in the following year.

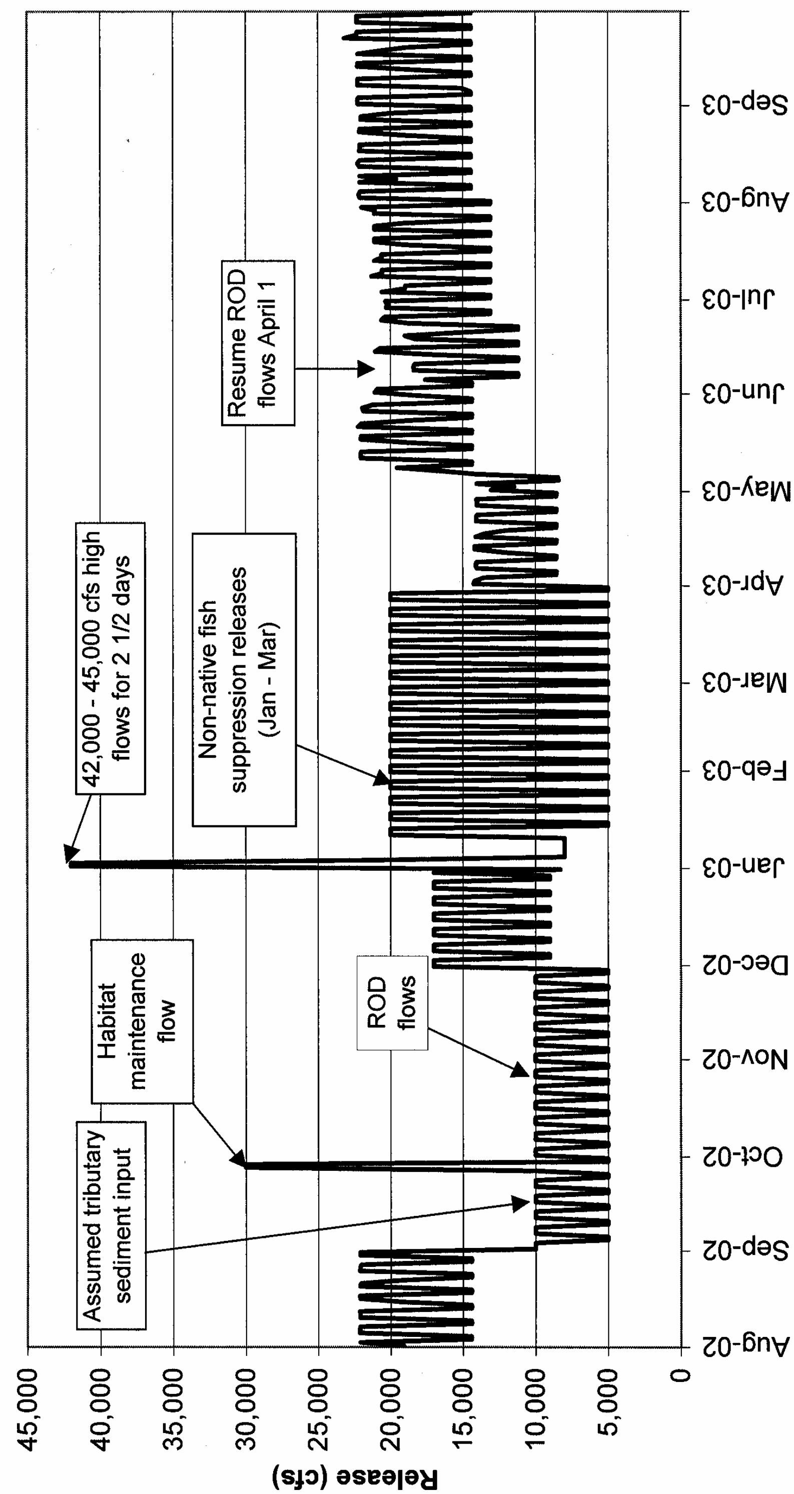

FIGURE 2.6. - Habitat maintenance flow scenario

Although the proposal is focused on water years 2003 and 2004, it could take an indeterminate number of years to implement the sediment conservation portion of the Proposed Action due to the necessary sediment input triggering involved. To ensure that development of a program of experimental flows benefits the resources of concern, the Adaptive Management Work Group has directed GCMRC to report back at six-month intervals on progress.

2.2.2 Mechanical Removal of Non-Native Fish

A second key component of the Proposed Action is assisting native fish through mechanical removal of non-native fish. Non-native fish removal is targeted at reducing adult rainbow and brown trout and other non-native fish in the Colorado River near the confluence of the Little Colorado River. The area around the confluence of the Colorado and Little Colorado rivers has the highest abundance of adult and juvenile humpback chub in the Colorado River mainstem (Maddux et al. 1987, Valdez and Ryel 1995). To help the humpback chub in this reach, an area located approximately five miles upstream (RM 56.4) to four miles downstream (RM 65.8) from the confluence of the Little Colorado and Colorado rivers has been proposed as the "depletion reach." The proposed depletion effort would be uniformly distributed within this 9.4 mile reach and repeated twice a year in the 2003-2004 water years.

Each year for two years, GCMRC is proposing to conduct three depletion trips from January to March and three depletion trips from July to September. The exact timing of these trips could be adjusted through the adaptive management process to minimize adverse effects to humpback chub. The effort would also yield information regarding abundance of young-of-year humpback chub and complement existing monitoring efforts.

During each 10-day field trip there would be five passes through the reach using four electrofishing boats that concurrently sample the river on opposing sides. Following each trip, the data would be used to construct abundance estimates for rainbow and brown trout present at the beginning of each trip. Comparisons among trip population estimates and trip catchability coefficients would be analyzed in order to evaluate if mechanical removal is an effective means to control undesirable fish species. Additionally, electrofishing results would be used to measure juvenile humpback chub relative abundance and any potential adverse effects on adult HBC.

A fish anesthetic will be used to euthanize the non-native fish. The proposed disposal mechanism for non-native fish would be to transport the fish out of the Grand Canyon. In response to concerns expressed by tribes, a beneficial use would be sought for the fish thus removed.

2.3 POTENTIAL MEANS TO ALLEVIATE ADVERSE EFFECTS OR REDUCE INCIDENTAL TAKE

Kanab Ambersnail.—The projected loss of habitat at Vaseys Paradise from the proposed action will not exceed the amount lost during the 1996 BHBF, and it will not exceed the incidental take estimated by the Service (2000), however, the GCDAMP has advocated that acceptable means be determined to meet incidental take requirements before the experimental high releases are conducted (Winfree et al. 2001). In 1996, incidental take was diminished by relocation of snails to higher elevations at Vaseys Paradise. This approach is not advocated by the GCDAMP for long-term management in conjunction with controlled high releases (Winfree et al. 2001). Two other means of reducing incidental take are establishment of a refugium or experimental population and augmentation of the upper Elves Chasm population. Establishment of an experimental population was considered by the GCDAMP and advocated "when they are needed for research that is in the species best interests" (Winfree et al. 2001). Augmentation of existing translocated populations was not ruled out by the GCDAMP if that action is "to sustain and maintain existing populations at the translocation sites and meet the original objectives of the current Recovery Plan and Biological Opinion" (Winfree et al. 2001). Therefore, both of these actions will be evaluated for reducing the incidental take from this action.

An expert panel convened in December 1999 concluded that controlled floods from Glen Canyon Dam produce little danger of extirpation for the Vaseys Paradise KAS population (Noss et al. 1999). The panel advocated that "initial take of 40% would almost certainly not threaten the persistence of the snail population." Their conclusion was based largely on the premise that this population has been present at Vaseys Paradise for millennia and has withstood the vagaries of floods of much greater magnitude and frequency in the predam era. An ad hoc committee to the Technical Work Group of the GCDAMP assessed the expert panel's findings and concluded that they did not have sufficient historical information about Vaseys Paradise or other KAS populations to concur with the expert panel on the level of take that would endanger the Vaseys Paradise population (Winfree et al. 2001). The ad hoc committee did advocate that "the potential for ecological benefits warrants continued planning for high flows and other experimental flows."

Humpback chub.—Robinson et al. (1996) investigated survival of young HBC in the perennial reach of the lower Little Colorado River above the fishes' present distribution. By isolating them in experimental cages, they determined HBC could survive in that reach. They also concluded that food and habitat in that reach were suitable, but that the fish likely were precluded from entrance to the reach by travertine barrier falls. Among their recommendations were that consideration be given to breaching the falls to allow passage of humpback chub into the unoccupied reach. The proposed action provides an opportunity to conduct an experiment at establishing a population of humpback chub in the unoccupied reach by collecting young-of-year from the reach below the falls and stocking them above the falls. This action would require the permission and cooperation of both the Service and the Navajo Nation.

2.4 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED ANALYSIS

Because the Proposed Action was developed by utilizing the best available scientific information developed through the GCDAMP process, no unique alternatives were considered but eliminated during the development of the Proposed Action. There were, however, modifications to the components of the Proposed Action that were considered and rejected. They are considered here.

In the deliberations of the various work groups and committees of the GCDAMP, many broad discussions were held and alternatives suggested that might meet the management objectives. Some of the alternatives considered, but rejected for various reasons are as follows.

Maximum releases greater than 45,000 cfs and durations longer than three days were considered for the sediment conservation portion of the Proposed Action, but were rejected for the following reasons:

- The current and projected near-term future elevations of Lake Powell would not allow the use of the spillways, which are required for releases greater than 45,000 cfs.
- There is greater scientific strength in an experiment with a peak discharge that can be more directly compared to the results of the 1996 beach/habitat building flow test, which also utilized maximum flows of 45,000 cfs.
- Durations longer than 3 days of peak release would likely cause depletion of the tributary sediment inputs and result in greater erosion and downstream transport of sediment to Lake Mead.

Winter non-native fish suppression releases with a greater range of fluctuation and greater and lesser ramp rates were considered for this portion of the Proposed Action Alternative but rejected for the following reasons:

- Fluctuations with a peak of 25,000 cfs were considered for the winter non-native fish suppression flows, but concerns were raised by the sediment researchers that such flows would likely quickly erode the sandbar deposits newly created by the sediment conservation portion of the tests.
- Unlimited up and downramp rates for the fluctuating flows were rejected because of concerns related to beach stability, sediment transport rates, and safety of canyon visitors.
- Use of ramp rates specified in the ROD was rejected because these rates would not allow sufficient hours at the maximum or minimum releases to sufficiently impact non-native fish. The hypothesis is that a hydrograph mimicking pre-ROD

releases would produce the desired effect. The downramp rate of the Proposed Action was also selected to provide empirical validation of the model used in the FEIS to estimate effects of downramp rates on beach stability.

Steady 8,000 cfs releases were considered for the autumn sediment input scenario but were rejected in favor of alternating 6,500–9,000 cfs and steady 8,000 cfs releases. Sediment researchers identified that the experiment could determine whether there are significant differences in the ability of these flows to conserve fine sediments. Therefore, the choice was made to develop the experiment so that this comparison could be made.

Grinding the carcasses of trout was considered for the disposal of fish mechanically removed from the Colorado River but was rejected for the following reasons:

- The Hopi, Hualapai, and Paiute tribes have expressed concern over the wasting of life, including the taking of non-native trout. While they have concern over the status of the endangered humpback chub, they respect trout as a living component of the ecosystem. They view all life as important. Life should not be wasted and find grinding very distasteful. The Proposed Action now proposes removal of the non-native fish from the Grand Canyon. A beneficial use for the fish thus removed would be sought.

- Some have raised water quality concerns about discharging ground trout into the mainstream Colorado River. While it is unlikely that such discharge would have significant ecological impacts (biological oxygen demand, nutrient loading, or non-native fish food source), the threat of such impacts was removed by the proposal to transport the fish out of the canyon.

CHAPTER 3.0

Affected Environment and Environmental Consequences

This chapter describes resources that are linked to dam operations and the expected or predicted effects of the Proposed Action and No Action alternatives on them. Conditions that currently exist under ROD or No Action dam operations establish the baseline for the description of the affected environment and resources. The affected resources include water, sediment, fish and wildlife, vegetation, endangered and other special status species, cultural resources, recreation, hydropower, and air quality. The indicators used for analyzing impacts on these resources are the same as those used in the FEIS (Reclamation 1995a).

Because of the experimental nature of the Proposed Action, in some cases there is uncertainty in the precise magnitude or direction of effects. Estimates of adverse and beneficial effects presented in this environmental assessment and biological assessment[3] are based on the best information currently available to the lead agencies. While there may be some short-term impacts to some resources, the Proposed Action is expected to result in a long-term benefit to the ecosystem. It is important to reiterate that the Proposed Action was designed to reverse trends in two key resources, humpback chub and sediment conservation. Both these resources have experienced significant and unexpected declines since adoption of ROD operations in 1996.

3.1 COLORADO RIVER ECOSYSTEM LINKAGES

Resources downstream from Glen Canyon Dam through Glen and Grand canyons are interrelated or linked because most of them are associated with or dependent on water and sediment (Reclamation 1995a). The proposed experimental flows would alter hydrology and sediment transport patterns from ROD operations. Changes in these two processes would, in turn, affect other resources, and the effects will vary in both intensity and duration. In general, if there are no additional disturbances, and Glen Canyon Dam operations return to ROD operations after the Proposed Action, resources would likely return to their No Action conditions after varying time spans.

Today, the ecological resources of Glen, Marble and Grand canyons depend on the water releases from the dam and variable sediment input from tributaries. A reduced sediment supply and regulated release of reservoir water now support aquatic and terrestrial systems that did not exist before Glen Canyon Dam. Table 3.1 summarizes the expected impacts from the No Action and Proposed Action Alternatives.

[3] Appendix A contains the biological assessment for the Proposed Action.

Table 3.1 Resource Matrix Comparing No Action and Proposed Action Alternatives.

Resource	No Action Alternative	Proposed Action					
		Experimental Dam Releases					Mechanical Removal
		8,000 cfs steady flow	6,500-9,000 cfs fluctuating flow	5,000-20,000 cfs fluctuating flow	31,000–33,000 cfs high flow	42,000-45,000 cfs high flow	
Water	No change to monthly or annual volumes	Lower average daily releases than No Action Oct-Nov, but higher minimum releases	Smaller daily fluctuations compared to No Action Oct-Jan; similar minimum releases	Greater daily fluctuations than No Action Jan-Mar; slightly lower minimum releases	Higher than No Action for 2 days July-Dec	Higher than No Action in January for 2 ½ days	No effect
Sediment	Tributary inputs not conserved; continued erosion of existing deposits	Estimated 90% of Paria River inputs conserved in Upper Marble Canyon	Estimated 80% of Paria River inputs conserved in Upper Marble Canyon	Potential to erode newly created beaches, but less than following 1996 BHBF test; greater downstream sediment transport than No Action	Greater potential to rebuild lower elevation sandbars than in 1997 and 2000 as sediment concentrations would be higher	More likely to rebuild sandbars and beaches than in 1996, with more diverse grain size; downstream sediment export would be less than in 1996	No effect.
Recreation: Fishing in Glen Canyon	Trout numbers increase, size & catch rate decrease	Increased numbers of trout	No effect	Moderately beneficial; reduction in angler catch rate; increase in average size (to 16 inches); occasional trout stranding	Negligible effect because of short duration	Negligible effect because of short duration	No effect

Resource	No Action Alternative	Proposed Action					
		Experimental Dam Releases					Mechanical Removal
		8,000 cfs steady flow	6,500-9,000 cfs fluctuating flow	5,000-20,000 cfs fluctuating flow	31,000–33,000 cfs high flow	42,000-45,000 cfs high flow	
Recreation: Fishing in Grand Canyon	Similar to those described for Glen Canyon	Similar to those described for Glen Canyon	Similar to those described for Glen Canyon	Similar to those described for Glen Canyon	Similar to those described for Glen Canyon	Similar to those described for Glen Canyon	Short term decline in and near the depletion reach; fishery likely to recover to pre-experimental levels without further treatment
Recreation: Boating and Camping in Glen Canyon	Boats and visitor use decrease 10%	No effect	No effect	Negligible effects on experienced users	NPS to forewarn boaters and campers; no effect on float trips	NPS to forewarn boaters and campers; no effect on float trips	No effect
Recreation: Boating and Camping in Grand Canyon	No effect	No effect	No effect on camping; minor, short-term impact (10 hrs/month) to boating at flows below 8,000 cfs, when Hance and Crystal rapids are more difficult to navigate	Could affect ca. 1% of users; some may delay trips to avoid <8,000 cfs; camp gear at some risk from high flows; low flows could strand boats on shore	Beneficial short-term impacts to recreational boating in Grand Canyon	Beneficial short-term impacts to recreational boating in Grand Canyon	Campers on 14 beaches may be affected by motorboat noise or users could be displaced and/or dissatisfied
Air Quality	Continuation of ROD flows	Similar to No Action	Somewhat less flexibility in	Greater hydropower	Negligible effect due to	Temporary increase in	No effect

Resource	No Action Alternative	Proposed Action					
		Experimental Dam Releases					Mechanical Removal
		8,000 cfs steady flow	6,500-9,000 cfs fluctuating flow	5,000-20,000 cfs fluctuating flow	31,000–33,000 cfs high flow	42,000-45,000 cfs high flow	
	which were predicted to result in overall slight regional emissions reduction		hydropower generation compared to No Action, with potential slight increase in emissions	flexibility than No Action, with possible slight decrease in emissions	short-term releases near powerplant capacity	emissions as a result of compensating for short-term bypass flows	
Aquatic Species: Plants	Phytobenthic community sustained; abundance dependent on flow, sediment, light; highest densities in summer; *Gammarus* continues decreasing trend; aquatic snails continue to increase	Reduced turbidity; increased light penetration; increased primary and secondary production; reduced nearshore desiccation; reduced drift compared to mildly fluctuating flows	Increased turbidity; reduced total wetted area; decreased benthic primary and secondary growth (limited to 6,500-cfs stage); drift may be more variable but not significant compared to 8,000 cfs	Increased drift rates; reduced total wetted area; benthic production limited to 5,000 cfs stage; same as No Action	Temporary reduction in benthic organisms; increased drift; rapid recovery	Reduction in benthos species; increased drift; primary producers expected to rapidly recover; improved production following removal of detritus	No effect
Aquatic Species: Trout	Increasing trout population numbers and negative effects on native fish	May promote increased brown and rainbow trout reproduction in mainstream	Similar to No Action; possible reduced foraging efficiency	Dewater trout redds and disturb near-shore habitat of young trout; greater lateral movement and downstream displacement of small-bodied fish; increased turbidity could	Effects similar to 42-45,000 cfs except for timing; temporarily displace small-bodied fish	May disrupt ongoing spawning but improve spawning habitat; displace small-bodied fish	Decreased population density and mean size, and increased mortality of trout; improved health and condition for

Resource	No Action Alternative	Proposed Action					
		Experimental Dam Releases					Mechanical Removal
		8,000 cfs steady flow	6,500-9,000 cfs fluctuating flow	5,000-20,000 cfs fluctuating flow	31,000–33,000 cfs high flow	42,000-45,000 cfs high flow	
				affect sight-feeders; increased suspended sediment reduces visibility for trout			remaining trout
Aquatic Species: Non-Native Fish Other than Trout	Continued successful reproduction and persistence	May promote successful spawning for small-bodied fish in west Grand Canyon	Not measurably different than No Action	Potential displacement of small-bodied fish; increased food base drift	Small bodied fish temporarily displaced	Temporary displacement of small fish downstream	Small potential for decrease within depletion reach
Aquatic Species: Native Fish - Other than Endangered	Stability in recruitment of flannelmouth sucker	Not measurably different than No Action	Not measurably different than No Action	Increased turbidity results in less predation by trout	Displacement from rearing habitats in July-Oct; decreasing effect into winter	Improved spawning and rearing habitat in following year	Small potential for temporary decrease within depletion reach
Endangered Species: Humpback Chub	Continued low recruitment and population decline; rearing habitats heavily impacted by daily fluctuating flows and	Potential for limited improved conditions in nearshore rearing habitats	Some reduction in daily fluctuations may allow increased warming in rearing habitats	Reduced minimum flow will limit food base productivity; greater daily fluctuations will increase drift of food base	Increased downstream displacement of young-of-year fish from nearshore habitats Jul-Oct; potential for some rearing habitat rejuvenation	Anticipated positive effect on nearshore rearing habitats through rejuvenation; short-term negative effect on food base; limited displacement of juvenile fish, very little	Some potential for incidental take from electrofishing; improved survivorship from reduced predation and

Resource	No Action Alternative	Proposed Action					
		Experimental Dam Releases					Mechanical Removal
		8,000 cfs steady flow	6,500-9,000 cfs fluctuating flow	5,000-20,000 cfs fluctuating flow	31,000–33,000 cfs high flow	42,000-45,000 cfs high flow	
	cold water temperatures					displacement of subadults and adults	competition in long-term; also improves critical habitat
Endangered Species: Razorback Sucker	Continued very rare; little to no successful reproduction or recruitment; negative effects from cold water, fluctuating flows, non-native fish	Potential for limited improved conditions in nearshore rearing habitats	Reduction in daily fluctuations may allow increased warming in rearing habitats	Reduced minimum flow will limit food base productivity; greater daily fluctuations will increase drift of food base	Potential downstream displacement of young of year fish from nearshore habitats Jul-Oct, but very little evidence for successful reproduction	Anticipated positive effect on nearshore rearing habitat; short-term negative effect on food base; limited displacement of juvenile fish, if present; no displacement of subadults and adults if any exist	Little likelihood of negative effect due to rarity
Endangered Species: Kanab Ambersnail	Minor losses (<10%) of primary habitat and KAS at daily fluctuating flows of 17-23,000 cfs	No effect	No effect	Minor losses (<10%) of primary habitat and KAS at daily fluctuating flows if not previously impacted by high release	Loss of up to 17% of primary habitat if not already removed by previous high release	Loss of up to 17% of primary habitat if not already removed by previous high release	No effect
Endangered Species: Southwestern Willow Flycatcher	Positive and negative habitat alteration continues;	No effect	No effect	No effect	Short-term effects through reduction in marshes,	Short-term effects through reduction in marsh vegetation, loss	No effect

Resource	No Action Alternative	Proposed Action					
		Experimental Dam Releases					Mechanical Removal
		8,000 cfs steady flow	6,500-9,000 cfs fluctuating flow	5,000-20,000 cfs fluctuating flow	31,000–33,000 cfs high flow	42,000-45,000 cfs high flow	
	reduction in backwaters and increases in woody plant establishment				loss of litter and understory vegetation at nest sites; long-term benefits to habitat through increased seedling establishment and clonal species expansion	of litter and understory vegetation at nest sites; long-term benefits to habitat through increased seedling establishment and clonal species expansion	
Threatened Species: Bald Eagle	Positive and negative effects to foraging opportunities; high flows temporarily reduce foraging- shift to tributaries, if possible; decreasing flows increase foraging opportunities.	No effect	No effect	Increase in turbidity may reduce foraging success; possible long-term effect via reduction in prey fish as the affected trout age classes reach catchable size.	Short term reduction in river foraging due to inundation of habitat and increased turbidity; may shift to foraging in tributaries; decreasing flows increase foraging opportunities	Short term reduction in river foraging due to inundation of habitat and increased turbidity; may shift to foraging in tributaries; decreasing flows increase foraging opportunities	8% reduction in foraging habitat; shift in foraging location, possibly with some eagles leaving area; if action not repeated after the 2-year test, then effect is short-term as trout population

Resource	No Action Alternative	Proposed Action					
		Experimental Dam Releases					Mechanical Removal
		8,000 cfs steady flow	6,500-9,000 cfs fluctuating flow	5,000-20,000 cfs fluctuating flow	31,000–33,000 cfs high flow	42,000-45,000 cfs high flow	
							returns to pre-experiment levels
Endangered Species: California Condor	Continue to use beaches, but without beach building flows, beach habitat continues to decline in acreage	No effect	No effect	No effect	Positive effect through relationship to increased beach building actions	Positive effect through beach building actions	No effect
Riparian and Terrestrial Vegetation	Reduced marshes; increased woody vegetation; lower water-tables; upper terrace drying; increase in drought-tolerant species at riparian zone margins; expansion of tamarisk, arrowweed and foxtail brome	Flows occur after primary growth and reproduction; expansion via vegetative growth rather than seed germination; slight increase in vegetated area	Minimum variation in area of wetted sand; expansion of plants not likely during the fall	Plants water stressed at 5,000 cfs; decrease in seed bank & marsh plant density/cover between 5,000 and 20,000 cfs; increase total wetted area & some seedling germination; drowning of phreatophytes & some aquatic and semi-aquatics in riparian zone; rapid ramp rates accelerate	Effects similar to 42-45,000 cfs flood except for timing	20% reduction in cover in riparian zone; drowning of xeric-adapted species and burying low-lying grasses and herbs; scouring weekly-rooted plants; increased distribution of seeds; seed scour may initiate germination of native riparian plants; potential ice damage of marshes and	No effect

Resource	No Action Alternative	Proposed Action					
		Experimental Dam Releases					Mechanical Removal
		8,000 cfs steady flow	6,500-9,000 cfs fluctuating flow	5,000-20,000 cfs fluctuating flow	31,000–33,000 cfs high flow	42,000-45,000 cfs high flow	
				erosion		wetlands in Glen and Marble canyons; minimum effects on lake riparian vegetation	
Wildlife: Birds	Rising flows cause some drowning of food base and loss of shelter; greatest impact to Bell's vireo, common yellowthroat, and yellow-breasted chat	Favorable due to increase in insects; increase in vegetative biomass; enhanced cover and food, but most birds migrating	Most birds migrating, so little to no effect	Some inundation of waterfowl ground nests; no effect to nests of neotropical species	Potential inundation of waterfowl and neotropical species nests if flows occur in July	No effect from winter high flow; spring high flow would inundate nests of neo-tropical species and waterfowl; riparian and aquatic food sources temporarily reduced; expected that birds find alternate food sources	No effect
Wildlife: Mammals	Direct effects of high flows may include drowning; indirect effects of high and low flows include reduced food, cover, or habitat; no	Favorable for most wildlife; increase in insects; increase in vegetative biomass; enhanced cover and food	Little to no effect	Flooding of some nests and burrows; possible increased exposure to predation during receding flows	Flooding of some habitat with potential loss of beaver lodges and/or forage	Little to no effect for January flow; loss of some litters of deer mice for Feb/Mar flow; reduced mice food source for predators; high ramp rate could	No effect

Resource	No Action Alternative	Proposed Action					
		Experimental Dam Releases					Mechanical Removal
		8,000 cfs steady flow	6,500-9,000 cfs fluctuating flow	5,000-20,000 cfs fluctuating flow	31,000–33,000 cfs high flow	42,000-45,000 cfs high flow	
	effect on livestock					trap beaver in river bank dens	
Wildlife: Herpetofaun a	Fluctuations of 3-4+ ft/day and high flows take individuals on bars & along shoreline; rising water April-July inundates nests, dens and hibernacula along shores riparian zones	Favorable due to increase in food supply, enhanced cover	Those on bars or shorelines overcome if water rises 3+ ft/day; no effect to nesting during fall	Rapid rise in flows could take individuals on cobble & alluvial bars & along the shoreline	Flooding of nests, eggs, and young could occur through August	Rapid rise in flows could result in take of individuals on cobble & alluvial bars & along the shoreline	No effect
Cultural Resources: Historic Properties	Previously mitigated	No historic properties affected	No historic properties affected	No historic properties affected	No historic properties affected	No historic properties affected	No historic properties affected
Cultural Resources & Indian Sacred Sites	On-going consultation	No effect	No effect	Minor adverse effect on tribal cultural resources	Adverse effect on tribal cultural resources	Adverse effect on tribal cultural resources (marshes, herptofauna)	Adverse effect to tribal cultural resources and sacred sites, but seek means for beneficial use of removed trout
Hydropower	Projected	Increase in fall	Increase in fall	Increase in on-	Minor	Bypass of	No effect

Resource	No Action Alternative	Proposed Action					
		Experimental Dam Releases					Mechanical Removal
		8,000 cfs steady flow	6,500-9,000 cfs fluctuating flow	5,000-20,000 cfs fluctuating flow	31,000–33,000 cfs high flow	42,000-45,000 cfs high flow	
	revenues of $280 million during 2003 - 2004	on-peak power purchase requirements. Overall cost of autumn sediment input scenario would be $2.85 million	on-peak power purchase requirements. Included in cost of autumn sediment input scenario.	peak power sales. Included in cost of all sediment input scenarios.	increase in power sales during 2-day test release; off-peak would be a cost, on-peak a benefit. Overall benefit of habitat maintenance flow would be $1.15 million.	about 93,000 af of water (ca. 1% of annual output), additional power purchase requirements during steady 8,000 cfs aerial photography flows included in cost of all sediment input scenarios.	
Environmental Justice	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Indian Trust Assets	No effect	No effect	No effect	Temporary effect on Hualapai river-running operations	Temporary wetting of Hualapai raft take-out area at Diamond Creek	Temporary wetting of Hualapai raft take-out area at Diamond Creek	No effect

3.2 WATER

3.2.1 Affected Environment

The indicators used to evaluate impacts on water are dam releases, flood flows, reservoir storage, water allocation, Upper Basin yield, and water quality. The powerplant fluctuations allowed prior to the ROD are now limited in their daily maximum and minimum, and in the rate at which they change from those upper and lower limits. Water released from the dam is now much colder than before Glen Canyon Dam was constructed (averaging 46°F) and varies only about 8°F year-round. During the summer months and lower flows, the water warms as it flows downstream. The dam releases clear water, and the river becomes muddy only when tributaries contribute sediment.

3.2.2 Environmental Consequences

Annual dam releases as determined by the Secretary's long-range operating criteria and law will be the same under both the No Action and Proposed Action alternatives; however, monthly release volumes would differ depending on when and in what order the four sediment input scenarios are implemented. Table 2.2 shows the monthly release volumes for the No Action Alternative and the various scenarios of the Proposed Action Alternative if they were to occur during water year 2003. (A "water year" runs from October 1 through September 30.) The resulting downstream water surface elevations for the various hydrologic components of the Proposed Action are listed in table 3.2 for five gauging stations locations between Glen Canyon Dam and Lake Mead.

If the Proposed Action were implemented, the fluctuating non-native fish suppression flows would cause January-March releases to be slightly higher and the October-December releases to be slightly lower than under the No Action Alternative.
The sediment conservation releases would cause January releases to be higher and the October-November releases to be slightly lower than the No Action Alternative.

Lake Powell is currently (September 2002) about 70 feet from full. This has resulted in annual releases during 2002 and expected annual releases during water year 2003 to be at the minimum objective annual release level of 8.23 maf. A return to greater precipitation in the Colorado River Basin will not likely affect fall releases until Lake Powell approaches full capacity. Should equalization releases be required after water year 2003, they would be scheduled in the summer months and would not have any effect on the experimental flows.

Table 3.2— Range in river stage (feet) under the Proposed Action.

		Daily discharge range (6,500-9,000 cfs at dam)				Annual discharge range (5,000-20,000 cfs) at dam			
Reach	River mile	Local minimum flow	Range in stage above 6,500 (ft)	Local Maximum Flow	Range in stage above 6,500 (ft)	Local Minimum Flow	Range in stage above 5,000 (ft)	Local Maximum Flow	Range in stage above 5,000 (ft)
Glen Canyon Dam	-15	6500	0.00	9000	1.13	5000	0.00	20000	5.68
Lees Ferry	0	6500	0.00	9000	0.74	5005	0.00	20000	3.53
Little Colorado River	61	6557	0.03	9000	1.17	5273	0.15	19999	5.69
Phantom Ranch	87	6611	0.09	9000	1.78	5476	0.45	19997	8.22
Diamond Creek	225	6951	0.24	8988	1.27	6941	1.09	19843	6.36

42,000-45,000 cfs high flow test

Reach	Local Maximum Flow	Range in stage above 20,000 cfs (ft)
Glen Canyon Dam	42,000	n/a
Lees Ferry	42,000	2.94
Little Colorado River	42,000	5.60
Phantom Ranch	42,000	5.94
Diamond Creek	42,000	6.01

The Proposed Action will not change the long-term frequency of powerplant bypasses in the ROD. Also, the Proposed Action does not alter the ROD reduction in the frequency of unanticipated releases greater than 45,000 cfs. Under the Proposed Action, Lake Powell storage would differ only slightly from the No Action Alternative from October through April each year[4] and would be the same at the ending of each water year.

Since the annual release volume from Glen Canyon Dam or long-term Lake Powell storage would not be affected by the Proposed Action, there would be no impact on water allocations or deliveries or on the Upper Basin yield. Further, because the releases from Glen Canyon Dam are regulated by Lake Mead, there would be no impact on Lower Basin or Mexican treaty deliveries.

Since 1996, salinity in the reservoir has dropped, and no adverse impact is expected from the withdrawal of water from the reservoir using the bypass tubes. There is the potential for turbidity in the Colorado River downstream of Glen Canyon Dam to be increased following sediment inputs. The Proposed Action will test whether these changes in turbidity will have an effect on downstream aquatic resources, particularly native fish.

As a result of lower Lake Powell elevations, dam release temperatures during the autumns of 2002 and 2003 are expected to be about 53°F, substantially warmer than the current average of 46°F. The Proposed Action reduces the monthly volumes released in September and October, and could produce water temperatures of about 59 to 61°F at the lower end of Grand Canyon. Temperatures of this magnitude could benefit the survival and recruitment of native fish.

3.3 SEDIMENT

3.3.1 Affected Environment

The indicators used to evaluate impacts of the Proposed Action on sediment resources are sandbars and beaches, main channel and eddy sand storage, high terraces, debris fans and rapids, and lake deltas.

Discussions in this environmental assessment deal mainly with clay to sand-sized particles, because their transport can most readily be affected by dam operations. Sediment is critical for stabilizing archeological sites and camping beaches, for developing and maintaining backwater fish habitats, for transporting nutrients, and for supporting vegetation that provides wildlife habitat, including habitat for endangered birds.

Sediment supply and the river's capacity to rebuild sediment deposits have been reduced

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[4] If no sediment inputs occur, only the non-native fish suppression portion of the Proposed Action would be implemented in years 2003 and 2004, resulting in a maximum difference of about 1.7 feet in Lake Powell storage at the end of November 2003.

since the dam was constructed. Approximately 90% of sediment that used to flow through Grand Canyon is trapped by Glen Canyon Dam. Now the major sources for resupplying sediment to the river below the dam are tributaries, primarily the Paria River and the Little Colorado River. Accordingly, scientists have struggled to determine the best way to conserve the remaining 10% that comes into Grand Canyon.

The 1996 beach/habitat building flow test illustrated that a controlled flood could deposit fine sediments in eddies and rebuild beaches; however, similar to beaches produced by the 1983-1986 floods, the beach/habitat building flow deposits subsequently were degraded by wind and water erosion (Hazel et al. 1999, Kearsley et al. 1999).

Recent monitoring and research indicate that tributary inputs of sand do not accumulate within the river channel over multi-year periods as predicted by the FEIS, and that a substantial amount of such inputs are transported out of the Grand Canyon within less than one year under most ROD operations. On the basis of results from the summer 2000 flow experiment, as well as historic sediment-transport data, scientists believe it is essential that new inputs of sand be retained more effectively within main channel storage sites during extended periods of dam releases at or below about 10,000 cfs (Topping et al. 2000a,b, Rubin and Topping 2001, Rubin et al. 2002). This is particularly true for the silt and finer sand portions of tributary inputs. If such operations promote retention of fine sediment, then implementation of a high flow test following such periods should be more effective in restoring and maintaining terrestrial sand bars and related resources.

The future existence of Grand Canyon sandbars depends on careful management of sand supplied from tributaries, daily water release patterns, and the long-term frequency and magnitude of beach/habitat building flow releases from the dam. High dam releases are most effective when sediment conditions are enriched rather than depleted. If they occur too frequently or are improperly timed, long-term net erosion would be the result.

The interaction between sight-feeding, predaceous non-native fish and the native fish adapted to a turbid environment is of great concern, prompting the effort to reduce the competition and predation by non-native fish. The Proposed Action seeks to retain the finer fractions of sediment inputs, perhaps increasing the turbidity of flows below the Paria River and benefiting the native fish.

3.3.2 Environmental Consequences

No Action

Under this alternative, peak flows would be less than 20,000 cfs throughout 2003. There would be little to no potential to rebuild sandbars except during a very large and rare tributary flood. In future years, releases would likely increase as lakes Powell and Mead are refilled, but these releases would be insufficient to replenish eroding sandbars below Glen Canyon Dam. Since Lake Powell may not be full within the next 5-10 years, it is unlikely the hydrologic triggers established for the release of beach/habitat building flows would be met. Sandbars would continue to slowly erode.

During 2003 and a portion of 2004, releases from Glen Canyon Dam are expected to be relatively low and, in some months, a high percentage of the hourly releases would be less than the 10,000 cfs threshold for accumulating sediment in the main channel. This accumulated sediment could then form the sediment source for future beach/habitat building flows or potential experimental flow releases. However, as powerplant releases increased in the future, this accumulated sediment would be transported downstream to Lake Mead and the sediment conservation objectives of the ROD would continue to not be achieved.

Net sediment erosion may continue in the Glen Canyon clear water reach upstream from the Paria River, but at a very slow rate. Long-term net changes in riverbed sand downstream from Phantom Ranch (RM 88) are expected to be negligible under No Action.

High terraces in Glen and Grand canyons would continue to be slowly eroded by runoff from local rainfall resulting in networks of water-carved gullies. Without high flow events greater than powerplant capacity, there is little potential for infilling of these gullies, either though direct riverine deposition or through wind transport.

Colorado River flows downstream of Glen Canyon Dam would not be able to move the large boulders in existing debris fans and rapids. If the rapids are further constricted by new debris flows, the river would have very limited capability to widen the constrictions.

Sediment would continue to accumulate in Lake Mead. Sediment loads entering the lake would tend to be greatest during the late summer thunderstorm season of July through October when the lake elevation is increasing. With the current drought, channel depths through the Lake Mead delta are expected to be relatively shallow during the near term future. Channel depths again would increase when the lake again begins to refill as hydrologic conditions return to normal.

Proposed Action

The sediment conservation portion of the Proposed Action Alternative would increase the conservation of sediment inputs from the Paria River in the Grand Canyon and not transport them to Lake Mead. The mechanical removal of non-native fish would have no effect on sediment storage or transport rates.

8,000 cfs Steady Flows.—No significant riverine erosion of existing sandbars is expected from this portion of the release. Sediment transport rates are expected to be slightly less than under the No Action Alternative.

6,500-9,000 cfs Fluctuating Flows.—Some slight additional turbidity downstream of the Paria River is possible as a result of the fluctuating flows, but no significant riverine erosion of existing sandbars is expected from this portion of the release. Sediment transport rates are expected to be slightly less than under the No Action Alternative.

5,000-20,000 cfs Fluctuating Non-Native Fish Suppression Flows.—The impact of these fluctuating flows on sediment storage will depend on whether or not a short-term high flow test occurs during 2003 or 2004. If a January short-term high flow test occurs during 2003 or 2004, the newly deposited sandbars are likely to begin to erode soon after the test and lose some portion of their volume within the first six months following the flow test. However, since these daily releases would be significantly less than during the 1996 BHBF test, less sandbar erosion would occur. When the dam is releasing 5,000 cfs, very little sediment transport would occur. If a short-term high flow does not occur in 2003 or 2004, little effect on existing sediment deposits is expected from these winter fluctuating flows.

31,000-33,000 cfs Habitat Maintenance Flow.—Since the Proposed Action would combine a powerplant capacity release with a higher sediment concentration than historic habitat maintenance flows, the resulting sediment deposition and conservation in eddies and sandbars should be greater than during 1997 and 2000.

42,000-45,000 cfs High Flow.—For both the autumn sediment input and habitat maintenance flow scenarios, the effect would be similar because the January sediment accumulation triggering conditions are identical. This short-term high flow test is expected to create sandbars more efficiently and with a more diverse grain size distribution than did the 1996 beach/habitat building flow, and is expected to transport a smaller percentage of sediment downstream than in the 1996 test in part because the duration of the Proposed Action high flow is much shorter than the 1996 experiment. The sandbars thus created would likely be more resistant to erosion and retain more nutrients than coarser grained sandbars (GCMRC 2002a).

For the winter sediment input scenario, the benefits described above for the other scenarios would be enhanced. Such a test would be nearly identical in structure but differing in time of year to that originally proposed by the sediment researchers as the most effective way to conserve sediment inputs. However, the likelihood of winter sediment inputs from the Paria River is minimal.

Because the Glen Canyon reach is armored from previous erosion in 1983 – 1986, additional erosion in this reach is expected to be minor. Remaining sediment deposits in the Glen Canyon reach have withstood numerous flood flows in past years, and they are expected to persist after the high flow test. High terraces that currently are eroding on the outside edges of river bends are expected to experience potentially higher rates of erosion during the test flow. The Glen Canyon reach still has some sediment supply from ungauged tributaries and likely has reached a near equilibrium condition.

The high flows would help reduce the navigational severity of rapids and mimic natural processes that historically have eroded and reworked new debris fans.

No extensive modification of the Lake Mead delta is expected as a result of the Proposed Action.

The Proposed Action purposely limits the duration of the January short-term high flow to ensure that the main channel sediment supply is not depleted during the test. Flows following the proposed test would likely continue to transport sediment, but the source of this transport would likely be the main channel as opposed to channel margin deposits and sandbars. Therefore, the newly created sandbars from the Proposed Action Alternative are expected to remain in place for a longer duration than the sandbars created as a result of the 1996 experimental flow test (GCMRC 2002a).

3.4 RECREATION

3.4.1 Affected Environment

Water releases from Glen Canyon Dam affect the experience of recreationists using the Colorado River in Glen Canyon and Grand Canyon, as well as those using Lake Powell and Lake Mead. The recreationists most affected along the river corridor are anglers, day rafters, and white water boaters.

The 15-mile segment of the Colorado River below Glen Canyon Dam is managed by the NPS (Glen Canyon National Recreation Area) for its recreation and primitive attributes. Anglers, boaters, day rafters, campers and some hikers routinely use this reach. Approximately 230,000 user-days of total use were recorded in 2001.

About 100,000 boaters annually use the stretch of Separation Canyon to South Cove at Lake Mead for scenic boating, camping, fishing, water-skiing and other recreational pursuits. Flows less than 8,000 cfs can create additional hazards in certain rapids (Hance and Crystal) and pose difficulties for boaters in Grand Canyon.

Recreational Fishing in Glen Canyon.—In 2001, more than 18,000 anglers fished for rainbow trout within the Glen Canyon reach of the Colorado River. The Glen Canyon reach is fished predominantly from boats launched at Lees Ferry.

Recreational Fishing in the Grand Canyon.—In contrast to the fishery in Glen Canyon, the Grand Canyon fishery is considered by the NPS to be mostly contrary to the values and purposes for which Grand Canyon National Park was established. Because of the difficult access and the general lack of promotion of recreational fishing in the Grand Canyon, only about 1200 anglers utilize the Colorado River below Navajo Bridge. Population size estimates for rainbow are difficult to determine, but over 1 million rainbow trout are thought to inhabit the 278 miles of the Colorado River within Grand Canyon National Park.

Boating, Camping, and Day Use in Glen Canyon.—The NPS estimates that in recent years approximately 500 camp-nights of use have occurred. Monthly use is commensurate with overall angling use along this stretch of river.

The number of boats on the river during any month is proportional to angler use. In addition to angler use, boat use for sightseeing purposes is very popular. A concessionaire offers 1-day float trips for the entire 15-mile stretch from Glen Canyon Dam. In 2001, nearly 40,000 passengers took advantage of this service.

Boating and Camping in Grand Canyon.— River use within Grand Canyon (initiated at Lees Ferry) consisted of 22,237 users (18,621 commercial and 3616 private) in 2001. Almost 90% of this use occurs from May through September.

The river corridor in Grand Canyon has approximately 226 beaches suitable for camping. The reach affected by the mechanical removal of non-native fish (five miles upstream and four miles downstream of the Little Colorado River) contains 14 camping beaches mostly used by boaters.

3.4.2 Environmental Consequences

No Action

Recreational Fishing in Glen Canyon.—Over the next 5-10 years, the number of fish inhabiting this reach is expected to increase and average size of fish decrease if no action is taken. This will gradually reduce the average size of fish creeled. Angler catch rates may increase as these numbers increase, but angler satisfaction would likely eventually decrease as average size decreases. Overall, the No Action Alternative is expected to have no short-term impacts but moderate, negative long-term impacts to recreational fishing.

Recreational Fishing in Grand Canyon.—No expected changes in the quality of fishing in the Grand Canyon would occur with the No Action Alternative.

Boating, Camping, and Day Use in Glen Canyon.—The number of boats and overall visitor use may decrease 10% over current numbers due to angler dissatisfaction. This decrease will cause minor, long-term, negative impacts to the camping/boating recreational resource along the Colorado River within Glen Canyon.

Boating/Camping in Grand Canyon.—No impacts to boating/camping are expected within Grand Canyon related to no-action.

Proposed Action

Recreational Fishing in Glen Canyon.—The 8,000 cfs steady flows may slightly increase the spawning success and thus increase overall fish numbers and, if so, decrease angler satisfaction.

The 6,500-9,000 cfs fluctuating flows scheduled that are part of the autumn sediment input scenario are not expected to affect non-native fish populations and thus not affect the fishing quality within Glen Canyon.

The 5,000-20,000 cfs fluctuating non-native fish suppression flows would be moderately beneficial with an overall reduction in angler catch rate (to 0.6 per hour), but increase the average size of the fish caught. It is possible that an occasional angler may get stranded despite advance warnings provided by the NPS.

The 42,000-45,000 cfs high flow test or the 31,000 habitat maintenance flow could temporarily affect spawning but the duration of these flows so short that the resultant effect to populations and long-term fishing quality would be slight.

Mechanical removal of trout from the Colorado River in the vicinity of the LCR is not expected to affect the fishing resource in Glen Canyon.

Overall, the Proposed Action is expected to cause minor adverse short-term impacts to the recreational fishery within Glen Canyon. However, it is expected to cause moderate long-term benefits.

Impacts to recreational fishing in the Grand Canyon would be similar to those described for Glen Canyon. Mechanical removal of trout from the Colorado River in the vicinity of the LCR will affect recreational fishing in or near that area. After the experiment (with no additional removal efforts), the fishery would likely recover and fishing success would likely return to its pre-experiment levels. Approximately 600 anglers may be affected by the treatment effort. However, given that the portion of the river corridor affected by the treatment is quite small, the overall impact to anglers is expected to be small as well with most of the river (90-95%) with no treatment effect.

Given the above discussion, the short-term effects of the Proposed Action to the recreational fishery in Grand Canyon are expected to be negligible, perhaps slightly adverse. There would be no long-term effects.

Boating, Camping and Day Use in Glen Canyon.—The 8,000 cfs steady flows and the 6,500-9,000 fluctuating flows proposed for the fall, as well as the mechanical removal of non-native fish near the Little Colorado River will have no effect on current boating, camping and day-use of the Colorado River in Glen Canyon. The flows are currently authorized under the Glen Canyon Dam FEIS and have been recently experienced by recreationists, fishing guides, and the concessionaire.

Several months of 5,000-20,000 cfs fluctuating non-native fish suppression flows in the winter will affect some boaters, campers, fishing guides, and the concessionaire in Glen Canyon. The effect is expected to be negligible since most experienced users have witnessed the actual flow extremes sometime in the recent past.

The proposed 42,000-45,000 high flow portion of the experiment will have some effect on boaters and campers along the river. To mitigate this concern, the NPS will inform all boaters and campers using the area at the time of the upcoming high flow test. Float trips through the Grand Canyon do not typically launch during this part of the year so they will not be affected.

Boating and Camping in Grand Canyon.—The 8,000 cfs steady flows for the late summer and fall period are not expected to affect recreational boating and camping in the Grand Canyon. The 6,500-9,000 cfs fluctuating flows will not affect camping and will only affect boating at flows below 8,000 cfs, when Hance and Crystal rapids are somewhat more difficult to navigate. However, these water levels are within the current operational range of Glen Canyon Dam and are occasionally being experienced by boaters. It is expected that approximately 10 additional hours per month of flows less than 8,000 cfs may occur with the Proposed Action. This portion of the experiment is expected to have a minor, adverse, short-term impact to recreational boating and camping.

The 5,000-20,000 cfs fluctuating non-native fish suppression flows from January through March could affect about 1% of the annual boating use as a result of high water expectedly sweeping camping gear away. Rapidly dropping water levels could strand boats on shore. The small number of trips/people potentially affected plus the advisory will, however, eliminate many of the potential consequences of this action. Flows below 8,000 cfs could occur. This will cause a small portion of the boaters to delay their trip to wait for higher water. This portion of the experiment will cause minor short-term adverse effects to boating recreation in the Grand Canyon.

The 42,000-45,000 cfs high flow test and the 31,000-33,000 cfs habitat maintenance flow are expected to have a minimal effect on the boating and camping experience in the Grand Canyon. This portion of the experiment will cause both negligible short-term adverse and beneficial long-term impacts to recreational boating in Grand Canyon.

Fourteen beaches suitable for camping exist within the nine-mile mechanical removal depletion reach. Boaters who camped at any of these sites would be subjected to electrofishing activities during five nights in each of six monthly removal episodes (January– March and July-September). Motor noise from boats traveling upstream and the electrofishing generator would be heard by any campers that happened to be camping at any of the 14 beaches. Campers hearing this noise would be annoyed because the main purpose of their trip is likely to enjoy the solitude of the Grand Canyon.

It is expected that any campers potentially annoyed by such noises would not camp at any of the 14 beaches within the treatment reach, once forewarned. During this period, 53 commercial (1,606 people) and 15 private trips (222 people) would be on the river in the vicinity of the Little Colorado River. With the most heavily used beaches being used 50% of the time, 27 commercial trips (803 people) and eight private trips (111 people) might be affected by the action and could either be displaced or dissatisfied.

The mechanical removal portion of the experimental flow proposal is expected to cause some short-term, minor adverse impacts to the camping experience along the Colorado River within Grand Canyon.

3.5 AIR QUALITY

3.5.1 Affected Environment

Glen Canyon Dam is one component of an interconnected utility system. Air quality in Grand Canyon and the surrounding region is affected by emissions of particulates, carbon compounds, sulphur dioxides (SO_2), and nitrous oxides (NO_x) from powerplants and other emission sources. It also is affected by weather, wind, and other environmental factors.

Powerplant emissions result when fossil fuel is burned to provide electric power. Annual powerplant emissions in the region rise and fall with the availability of water to generate hydropower and by the amount of water stored in Lake Powell. For example, during water year 2003 when 8.23 maf will likely be released, approximately 3.7 million MWh of hydropower will be generated at Glen Canyon Dam. During an 11.3-maf year such as 1999, when Lake Powell was full, approximately 5.6 million MWh of hydropower was generated at Glen Canyon Dam. There is a difference of 1.9 million MWh or 51% between these two years.

Differences in the amount of energy generated at Glen Canyon Dam lead to changes in generation levels at other interconnected powerplants. This results in differential emission levels in the six-State marking area.

3.5.2 Environmental Consequences

No Action

Grand Canyon enjoys some of the cleanest air in the lower 48 states, resulting in a visual range that sometimes exceeds 240 miles. However, haze—consisting of air pollution brought in to the Grand Canyon area from urban and industrial areas in the surrounding region—results in a summertime average visibility of only 100 miles. Locally significant degradation of air quality does result from the operation of some fossil-fueled powerplants.

Proposed Action

The proposed action would result in both positive and negative air quality impacts. Less hydropower would be produced during the months of October, November, December, and January than under the No Action Alternative. This would require increased levels of generation at other powerplants in the region. A least-cost mix of hydropower, coal, and gas plants would be used to replace the hydropower that would otherwise have been generated at Glen Canyon Dam. As a result, there would be an increase in the emission of SO_2 and NO_x in these months. More hydropower would be produced at Glen Canyon Dam during the months of February and March. During these months, other hydropower, coal, and gas plants would generate less electric power. As a result, there would be a decrease in the emission of SO_2 and NO_x during these months.

Compared to no action, 41,000 MWh or about 1.1% less hydropower would be produced during the water year, resulting in a net increase of SO_2 and NO_x emissions from interconnected powerplants in the region. However, compared to the annual variation in emissions due to water availability, this increase is not likely to be significant.

3.6 WILDERNESS

The superintendents at both Grand Canyon National Park and Glen Canyon National Recreation Area have recommended to the Secretary of the Interior that certain portions of the Colorado River and near shore environment should become part of the wilderness system. National Park Service policy directs that once recommended, the areas must be managed as if they were wilderness until the President and Congress act so as to ensure that wilderness values are protected.

All flows recommended within this EA are not expected to affect the existing wilderness character of the river corridor. However, the mechanical removal portion of the proposal will cause temporary short-term impact to this wilderness character through the use of boat motors and generator motors for electrofishing purposes. The superintendent at Grand Canyon National Park has determined that the use of these motors for the purposes described in the EA is the minimum requirement for the administration of the area as wilderness. The impact of this activity on wilderness character will be mitigated to a certain degree through advance warning to boaters that may be in the area during mechanical removal activities.

3.7 AQUATIC PLANTS AND ANIMALS

3.7.1 Affected Environment

The present aquatic ecosystem below Glen Canyon Dam is the result of complex interactions between organisms and their response to water flow, quality, temperature, and nutrients. Both native and non-native components exist. Three indicators have been selected to evaluate impacts of the Proposed Action on aquatic plants and animals: food base, native fish, and non-native fish.

Food Base.—Discharges of clear water from Glen Canyon Dam have allowed the establishment of the filamentous green alga, *Cladophora glomerata* in abundance down to the confluence with the Paria River. This alga provides habitat for both diatoms and invertebrates, including the amphipod *Gammarus lacustris*, chironomids, and other fly larvae

(Blinn and Cole 1991, Shannon et al. 1994, Stevens et al. 1997). This community forms the basis of a highly productive food chain below Glen Canyon Dam (Reclamation 1995a). During the last decade, *Chara* sp. and the New Zealand mud snail have also become established (GCMRC 2002b). *Cladophora* grows primarily on cobble while *Chara* grows on silt or sand substrates.

This reach of aquatic plants supplies the river immediately downstream with particulate matter in the form of plant debris and aquatic invertebrates in the current as drift. This drift feeds the higher trophic level organisms such fish. Drift is directly related to flow characteristics such as magnitude and variation or steadiness. Fluctuating flows produce greater drift of invertebrates than do steady flows (Blinn et al. 1992) while high flows produce greater drift densities of Cladophora. The 1996 beach/habitat building flow test release of 45,000 cfs scoured large percentages of both plants and invertebrates, but recovery of these resources was relatively rapid (Blinn et al. 1999). The 2000 low steady summer flow test of 8,000 cfs resulted in large increases in plant density and productivity.

Native Fish.— Four native fish, the humpback chub, flannelmouth sucker (*Catostomus latippinis*), bluehead sucker (*Pantosteus discobolus*), and the speckled dace (*Rhinichthys osculus*), definitely occur in the affected environment. A fifth species, the razorback sucker (*Xyrauchen texanus*), is very rare in this reach of the Colorado River, but definitely occurs in the upper end of Lake Mead downstream of the project area. Recent analyses of the historic native fish monitoring data suggest that the endangered humpback chub has undergone a chronic recruitment decline beginning perhaps as early as 1980 and that the Little Colorado River (LCR) population has declined from about 8000 subadult to adult fish to approximately 2000 fish (Coggins and Walters 2001). If the current recruitment pattern continues, adult humpback chub numbers could decline to fewer than 500 within the next decade. Similar analyses of flannelmouth sucker data suggest stability in the recruitment pattern of this native fish. Population dynamic evaluations have not been completed for the bluehead sucker and speckled dace. Valdez and Carothers (1998) provide a good overview of the life history requirements for these native fish species. Distribution of flannelmouth sucker and bluehead sucker seems not to have changed demonstrably since emplacement of Glen Canyon Dam, but bluehead abundances appear to be declining (Valdez and Carothers 1998). Speckled dace has been extirpated or become rare in some tributaries that contain trout during much of the year (Miller 1968).

Non-Native Fish.—Non-native fish have been present in the reach of the Colorado River below Glen Canyon Dam since the mid-1800s. Twenty-six non-native species have been reported from this reach, but many are sporadic in occurrence and persist in very low abundances. Following the impoundment of Lake Powell and continuous release of perennially cold waters from Glen Canyon Dam, the downstream river non-native fish community underwent a transition in composition from warmwater species, like carp, green sunfish, black bullhead, and red shiner, to a coldwater community dominated by rainbow trout.

Rainbow trout and brown trout were first introduced into spring-fed tributaries of the

Colorado River in Grand Canyon during the 1920s and 1930s, but they did not spread into the hostile, sediment–laden waters of the Colorado River. With the closing of Glen Canyon Dam, stocking of rainbow trout began in the tailwater below the dam and the now famous Lees Ferry sportfishery came into being. Present trout species numbers in the Colorado River between lakes Powell and Mead are estimated to be 1 million for rainbow and 75,000 for brown (AGFD 2001). Abundances of both species beyond the 15-mile Glen Canyon reach are greatest between RM 60 and 72, near the confluence of the Little Colorado River. Brown trout and, to a lesser extent, rainbow trout at larger sizes are known predators on native fish in this reach of the Colorado River. Using diet data collected from non-native fish in Grand Canyon, Valdez and Carothers (1998) estimated that annual predation on the endangered humpback chub by a combination of rainbow trout, brown trout, and channel catfish could be over 250,000 individuals.

Large-bodied warm water exotics include carp (*Cyprinus carpio*) and channel catfish (*Ictalurus punctatus*). These fish are predators of eggs, larvae, and juvenile and potentially adult native fish, depending on mouthgape size (Minckley 1991). Catfish are found throughout the corridor and are in high abundances at the Little Colorado River confluence and in the mainstem below RM 179. Catfish are long-lived species that require warm water for successful spawning and recruitment. The Little Colorado River is a likely spot for recruitment by these fish.

Small-bodied non-native fish include fathead minnow (*Pimephales promelas),* plains killifish (*Fundulus zebrinus*), and red shiner (*Cyprinella lutrensis*). All three occur primarily in protected, warm, low velocity nearshore habitats and in tributaries. They are rapid colonizers and can build their numbers to very high densities in short periods under favorable conditions. The fathead minnow occurs throughout much of Grand Canyon, plains killifish and red shiner are more restricted in distribution. All three occur in upper reaches of large watersheds like those of Kanab Creek and the Little Colorado River from which they are transported to the Colorado River in times of flood.

3.7.2 Environmental Consequences

The indicators used to evaluate impacts of the Proposed Action on aquatic plants and animals are drift, sediment, light availability, turbidity, total wetted area (TWA), invertebrates, production, colonization, biomass, composition, and abundance.

No Action

Food Base.—The increase in the minimum stage discharge level to 5,000 cfs in the night and 8,000 cfs in the day has resulted in a substantial increase in the phytobenthic community (Blinn et al. 1994). Year-to-year variance in algae, macrophytes, and macroinvertebrates is primarily due to differences in hydrology and sediment discharges from tributaries (Blinn et al. 1994, Shaver et al. 1997).

Under No Action, the food base should continue to demonstrate seasonal patterns of varying abundance dependent on the invertebrate species. Decadal trends indicate that the mean abundance of *Gammarus* would continue to decrease and snails would continue as the most abundant species in the Colorado River (GCMRC 2002b). Drift magnitudes would continue as at present under ROD flow constraints.

Native Fish.—Under the No Action Alternative, non-native salmonids would continue to benefit from the increased success in reproduction and recruitment that has resulted in large increases in their populations under ROD operations. No attempts would be made to reduce non-native salmonids that prey on native fish through either modification of dam operations or mechanical removal. Daily fluctuating flows that interrupt the warming of backwater habitats and other nearshore rearing habitats during spring, summer, and autumn months would continue to be released year-round from Glen Canyon Dam. Existing conditions that hinder successful reproduction and recruitment of humpback chub in the mainstream would continue. Larval fish displaced from backwaters would likely enter the drift during fluctuating flows and be transported downstream through major rapids. Individuals that survived the physical challenges of transport also would be subjected to predation by non-native fishes. The ongoing decline of HBC could well continue as a result of these factors. Flannelmouth sucker, bluehead sucker, and speckled dace all seem more capable than either humpback chub or razorback sucker of using tributaries in Grand Canyon for reproduction and rearing. Nonetheless, all three are captured in nearshore mainstream rearing habitats as young fish and thus will be affected by persistent fluctuating flows that prevent warming of these habitats during the rearing season. These three native species also are preyed upon by rainbow trout and brown trout, thus they will continue to suffer negative impacts from the burgeoning populations of these two predators.

Non-Native Fish.—Trends documented or hypothesized for the non-native fish species (e.g., continued successful reproduction, increased competition for resources, and predation of native fish) would likely continue. The relatively stabilized habitat in the mainstem experienced under ROD operations would continue to benefit recruitment of cold-water fishes leading to the maintenance of current or higher non-native fish densities. As long as Glen Canyon Dam continues to release perennially cold water, the downstream reach will likely be dominated by cold-water adapted fish, such as rainbow and brown trout.

There is some evidence that the rainbow trout population in the 15-mile reach below Glen Canyon Dam is reaching carrying capacity, and continued increase in numbers may well result in smaller fish in increasingly poor health (McKinney et al. 2001).

Proposed Action

8,000 cfs Steady Flows.—

Food Base.—Near shoreline stabilization has the potential for maximizing the food base production because of the absence of negative effects brought about from desiccation and dewatering that occurs in the zone of fluctuation. Invertebrate production and abundance has typically decreased during the fall and winter seasons (McKinney et al. 1999, Rogers et al. 2002).

These stabilized conditions should result in an increase in water clarity levels and may potentially provide greater opportunity for visual sight feeding fish. Drift should become more reduced than under mildly fluctuating flows (Shannon et al. 1996, Rogers et al. 2002) and steady flows should allow for greater standing biomass of aquatic plants.

Flow stabilization may allow for very high snail densities, especially if snails are invulnerable to predation.

Blinn et al. (1992) found that periods of steady flows during interim operations resulted in significantly less drift of *Cladophora* and associated invertebrates than periods of fluctuating flows. The interruption of steady flows at two week intervals by fluctuating flows differs from the year 2000 experience and limits the extent to which results from this experiment can be extrapolated.

Native Fish.—Low, steady flows during summer and autumn are viewed by the Fish and Wildlife Service (Service 1994) as being beneficial to the welfare of native fish, especially endangered fish. Others have expressed caution that these same conditions would be conducive to expansion of warmwater non-native fish populations. Nearshore habitats under steady flows have greater opportunity to stabilize and warm than under fluctuating flows. Aquatic animal and plant populations that serve as food for rearing fish are not subjected to desiccation or being flushed from nearshore habitats with the rising and falling of daily fluctuating releases. The extent to which this advantage would be compromised by alternating steady flows with fluctuating flows at two-week intervals, as prescribed in this action, is difficult to predict. The outcome will depend on the relative susceptibility of native and non-native fishes to the disruptions in stability of rearing habitats brought about by switching to fluctuating flows. By late October, young-of-year fish begin to move to offshore areas (Maddux et al. 1987, Valdez and Carothers 1998), so any potential benefits of the steady flow would diminish at that time.

Non-Native Fish.—Steady 8,000 cfs flows for two-week periods during autumn months may promote successful spawning and rearing of brown and rainbow trout in the mainstem and may also promote an additional period of reproduction and rearing activity for small-bodied, non-native fishes, particularly in western Grand Canyon. Nearshore rearing habitats used by many fish species during this period should remain relatively warm and productive compared to No Action conditions. Drift-feeding non-natives that feed in areas of current may experience relatively lower levels of food availability under low, steady flows. By late October, young-of-year fish begin to move to offshore areas, so the benefits of the steady flow would be expected to diminish (Maddux et al. 1987, Valdez and Carothers 1998).

6,500-9,000 cfs Fluctuating Flows in Fall.—

Food Base.—The wetted area of the channel would be increased over the No Action Alternative. The effect from desiccation and perhaps freezing during the late-fall and winter period will reduce the affective area for benthic growth to the 6,500 cfs stage level.

The availability of drift of invertebrates may be more variable than under a stabilized flow; however, this is not expected to be significant in comparison to stabilized 8,000 cfs steady flows. Due to the limited range in flow fluctuations, some level of disturbance is expected; however, the effect to the phytobenthic community is considered only marginal, and is well below the hydrologic forces that this community typically experiences under No Action.

Native Fish.—Anticipated impact on native fishes is most likely in nearshore habitats prior to late October or early November, when young-of-year tend to move to deeper, offshore habitats. These 6,500-9,000 cfs fluctuations are less than those that would occur under the No Action Alternative, so they could benefit young native fish relative to No Action Alternative flows. Effects on individual rearing habitats from fluctuating flows will depend on the geometry of those habitats. Desiccation of lateral areas and infusion with cold water will be greater in shallower habitats with low gradient slopes.

Non-Native Fish.—These fluctuations would occur in the fall (September to December). We anticipate the effect on non-native fishes will not be significantly different than the Proposed Action.

5,000 to 20,000 cfs Fluctuating Non-native Fish Suppression Flows.—

Food Base.—Drift rates should increase under this greater range of daily flow variation. Initial optical conditions for primary production should decrease slightly with the increased turbidity during the 20,000 cfs portion of the flow. Although an increase in stage will result in a temporary increase in total wetted area, it will not be inundated for a sufficient duration to allow for benthic colonization (Benenati 1998, Blinn et al. 1995).

A higher range in fluctuating flows is known to displace bottom-dwelling invertebrates into the drift, but these organisms usually recover quickly from these disturbances. The effect from freezing during the winter will reduce benthic growth to the minimum stage level (Shannon et al. 1994, Usher et al. 1990). We would expect that the total wetted area would be similar to that of the No Action.

Native Fish.—Effects on young native fishes will be reduced from what they would be earlier in the year, because most individuals in the mainstream will have moved to deeper habitats less affected by the fluctuations. Survivorship of young-of-year HBC through the winter in the mainstream apparently is very low, irrespective of hydrology. Little is known of overwintering survivorship in other native fish species. Higher fluctuations than those of the No Action Alternative would dislodge more organic matter and place it in the drift, where it would be more available to drift-feeding fish. An increase in turbidity that accompanies increases in flow fluctuations may benefit smaller native fishes by reducing the effectiveness of sight-feeding predators to detect their native fish prey.

Non-Native Fish.—These dam releases are intended to directly affect trout by disrupting their reproductive activities and impacting their reproductive products. Dewatering and desiccation of trout eggs, embryos, and fry are expected to occur each day during the period of declining and minimum flows. Fingerling trout also will be displaced from favorable habitats by the fluctuating flows. The combination of increased daily fluctuations and increased ramping rates is expected to reduce the overabundance of trout in the Colorado River downstream of Glen Canyon Dam.

31,000-33,000 cfs Habitat Maintenance Flow.—

Food Base.—As part of the habitat maintenance flow scenario, the Proposed Action calls for powerplant capacity releases of 31,000-33,000 cfs following Paria River inputs between July and January. Effects of these high releases would be similar to those predicted for the 42,000–45,000 cfs high flow except for issues related to magnitude and timing. An increase in drift is expected to occur due to the hydrologic disturbance; however, the heavy sediment load carried by these flows would negatively impact future aquatic production in the river.

Displacement of the food base is expected to be less for this 31,000–33,000 cfs flow than for the high flow test, a result of the lower shear stresses near the channel bottom. Plant and invertebrate recovery rates may be shorter for this fall flow than for the winter 42,000-45,000 cfs high flow test, a result of longer day lengths and warmer dam release temperatures.

Native Fish.—Small humpback chub and other native fish also would likely be displaced from nearshore rearing habitats by flows of this magnitude, particularly during the months of July-October when many occupy these habitats. We anticipate little to no effect on subadults and adults. Since few young humpback chub appear to survive in the mainstream under normal ROD operations, i.e. the No Action Alternative, little additional mortality is expected from these flows.

Non-Native Fish.—Effects of these 31,000-33,000 cfs flows would be similar to those predicted for the 42,000-45,000 cfs high flow except for issues related to the timing. A habitat maintenance flow is likely to affect small-bodied non-natives more than other non-native species. This effect, likely displacement, would only be temporary (Hoffnagle et al. 1999).

42,000-45,000 cfs High Flow.—

Food Base.—This brief disturbance should have measurable but temporary effect on the phytobenthic community. Elevated discharge typically reworks and distributes the substrate by transporting silt and sand that have accumulated over time. This process leads to a coarsening of substrate and favors recolonization by algae rather than macrophytes (Yard and

Blinn 2001).

An initial loss of phytobenthic biomass is predicted to occur due to the high flow test, with a return to increased drift following recovery periods. The standing biomass may be altered through removal of accumulated senesced growth and detritus, shearing and removal of susceptible algae and macrophytic growth (Wilson et al. 1999), and burying of primary and secondary producers. The loss of photosynthetically viable standing biomass should be rapidly replaced due to an increase in light intensities and duration of light exposure during the subsequent period of fluctuating flows.

Removal of algal overgrowth may help facilitate new algal photosynthesis and an increase in gross biomass production. Algal biomass recovery rates appear to be rapid following these large flow perturbations if algal basal holdfast structures are retained. Impacts should be similar to those experienced during the 1996 beach/habitat maintenance flow test of 45,000 cfs.

Native Fish.—Under the Proposed Action Alternative, these flows could occur during January-March when surviving young-of-year humpback chub and other native fishes have moved to deeper eddies. Subadults and adults are expected to be affected very little by these larger flows, although they do occur at a time of the year prior to the rise in the pre-dam hydrograph. Little is known about the extent to which humpback chub rely on changes in flow as a reproductive cue.

Non-Native Fish.—A flood of this magnitude in January-March may disrupt trout spawning for a brief time and transport small trout downstream (McKinney and Persons 1999). The gravels following the flood may be better suited for spawning habitat. Large-bodied exotics are unlikely to be displaced by this volume (Hoffnagle et al. 1999). Small-bodied non-native fish would likely be dispersed downstream, but recolonization from the Little Colorado River and other tributaries is likely.

Mechanical Removal of Non-Native Fish

Food Base.—No significant direct impacts to the food base are expected from mechanical removal of non-native fish.

Native Fish.—As is the case for the endangered humpback chub, other native fish will be collected by electrofishing along with the target non-native species. Studies on the effects of electrofishing on native fish have concentrated largely on federally listed species, and we assume the effects on unlisted species would be similar. Since unlisted native fish are more common than the endangered humpback chub and razorback sucker, more individuals of those species will undoubtedly be collected. Effects to these fish will be minimized by using standard collection protocols and using appropriate settings on the electronic equipment to minimize injury. Injuries to these fish cannot be completely avoided, but they would be minimized through these protocols and safety standards. We anticipate the number of captures and injuries to unlisted native fish will be proportional to those of endangered humpback chub. We do not anticipate any measurable effects on the populations of these unlisted native fish from the proposed mechanical removal.

Non-Native Fish.—The Proposed Action is designed to have a negative impact on all non-native fishes in the affected river reach (RM 56.4 to 65.8). It is anticipated that the increased mortality on non-native fishes, particularly trout, may have some minor effect on the food base in that river reach.

3.8 ENDANGERED SPECIES

A fuller description of the endangered species affected by the Proposed Action is in Appendix A.

3.8.1 Affected Environment

Kanab Ambersnail.—Surveys have reported population estimates between approximately 5,000 and 52,000 individuals (GCMRC 1999, Meretsky and Wegner 1999). Sorensen (2001) analyzed sampling and analytical techniques for these estimates and concluded that overestimation of actual population size has occurred in monitoring reports. He pointed out that these errors increase the difficulty of assessing risk to the population. Short-term reduction in primary habitat area by scouring flows does not appear to affect the long-term integrity of the KAS population.

The introduced population at upper Elves Chasm is self-sustaining. Total potential habitat for KAS at this location is approximately 25 square meters (m2). Population estimates have increased from approximately 130 in April 1999 to approximately 1900 in August 2001 (Nelson and Sorensen 2002).

Humpback Chub.—Young HBC remain in the Little Colorado River, or drift and swim into the mainstream (Robinson et al. 1998) where lack of recruitment is attributed to effects of cold temperatures and nonnative fish predators and competitors (Lupher and Clarkson 1994, Valdez and Rye1 1995, Marsh and Douglas 1997, Clarkson and Childs 2000, Robinson and Childs 2001). Very little spawning and hatching of HBC occurs in mainstream aggregations.

Razorback Sucker.—Razorback sucker is very rare in Grand Canyon and some fish biologists speculate that this species was never more than a transient member of the native fish fauna (Minckley 1991, Douglas and Marsh 1998). The largest RBS population in the Lower Colorado River Basin exists in Lake Mohave. It was estimated to be approximately 60,000 fish in 1989 (Marsh and Minckely 1989), but has declined considerably since that time (Marsh 1994). There is also a population of approximately 500 individuals that exist in Lake Mead. This population has been studied since 1996 (Holden et al. 2000.

Southwestern Willow Flycatcher.—The year 2001 marked the fourth consecutive year in which surveys located a single breeding pair and no unpaired adult willow flycatchers in the

Grand Canyon.

Bald Eagle.—A wintering bald eagle concentration was first observed in Grand Canyon in the early 1980s and has increased dramatically after 1985 (Brown et al. 1989, Brown and Stevens 1991, Brown and Stevens 1992). A concentration of wintering bald eagles occurs in late February at the mouth of Nankoweap Creek, where bald eagles forage on spawning rainbow trout (Brown et al. 1989, Brown 1993). Territorial behavior, but no breeding activity, has been detected in Grand Canyon.

California Condor.—On October 6, 1996, the Service announced the intent to reintroduce California condors into northern Arizona and southern Utah and to designate these birds as a nonessential experimental population under the Endangered Species Act (Service 1996b). Six condors were introduced into the Grand Canyon in 1996. There are 32 condors presently in the Grand Canyon. There is no critical habitat designation associated with the experimental population.

The beaches of the Colorado River through the Grand Canyon are frequently used by the Arizona and Utah experimental population of California condors (Sohie Osborn, Peregrine Fund, personal communication). Activities include drinking, bathing, preening, playing, and possibly feeding on the occasional fish carcass.

3.8.2 Environmental Consequences

No Action

Kanab Ambersnail.—The KAS population at Vaseys Paradise is not affected by dam releases unless they are high enough to flood the ambersnail habitat. The most recent measurements of releases sufficient to flood KAS habitat, which were made in April 2002, show that flooding would not occur below 17,000 cfs. The projected maximum dam releases under the No Action Alternative vary between 12,800 cfs and 22,700 cfs. Flows above 17,000 cfs would occur in 13 of the 24 months in the 2003-2004 water years. Releases above 20,000 cfs would occur in only two months, however, and no monthly releases would exceed 23,000 cfs. The maximum release would occur only during part of the day and in all months the minimum daily release would be less than 17,000 cfs. This periodic flooding could displace small numbers of KAS and carry them downstream, along with small amounts of displaced vegetation; however, we anticipate no measurable effects to the KAS population would occur from these losses.

Humpback Chub.—The HBC population in the LCR has experienced reduced recruitment and declining numbers since 1993 (Coggins and Walters 2001) under interim flow and ROD operations. Mainstream aggregations are thought to be sustained largely by influx of individuals leaving the LCR population (Valdez and Ryel 1995).

Under the No Action Alternative, non-native trout would continue to benefit from the increased success in reproduction and recruitment that has resulted in large increases in their populations under ROD operations. No attempts would be made to reduce non-native trout through either modification of dam operations or mechanical removal and their adverse effect on HBC would continue. Existing conditions, including year-round cold water temperatures that hinder successful reproduction and recruitment of humpback chub in the mainstream would continue. The ongoing decline of HBC could well continue, assuming this response is to conditions in the Colorado River rather than the LCR.

Razorback Sucker.—Under the No Action Alternative, razorback sucker is expected to remain very rare in Grand Canyon. Little to no successful reproduction or recruitment is expected to occur.

Southwestern Willow Flycatcher.—Under the No-Action Alternative, various components of SWWF habitat would continue to be affected by the flow regimes. As described in the vegetation section, backwaters would continue to fill with sediment creating conditions favorable for succession of woody plants over true wetland species. Backwaters appear to be a necessary component of SWWF habitat so it is assumed that a reduction in area would have an effect on SWWF. On the other hand, increases in woody plant establishment may offer long-term benefits through development of additional nesting structures. As current SWWF nesting trees reach old-growth stage and begin to die or not to provide proper nesting structures, then replacement vegetation becomes very important.

Dam releases of the No Action Alternative are not of the magnitude to directly affect nests, adults, or fledglings. Nests in the Grand Canyon typically lie above the 45,000 cfs stage level and therefore are well above the flows of this alternative.

In summary, there may be both negative and positive effects to SWWF habitat under the No Action Alternative; negative effects through reduction in backwaters and marsh habitat and positive effects through establishment of additional nesting habitat.

Bald Eagle.—The No Action Alternative of daily fluctuating flows would continue to provide ample foraging opportunities for bald eagle. High flows temporarily reduce eagle foraging opportunities but prey stranded in isolated pools and along shorelines become available as flows decrease. Releases at the lowest flows of ROD operations may have the effect of "beheading" Nankoweap Creek and preventing movement into the creek. Beheading occurs when the mainstem Colorado River drops below the level of the mouth of Nankoweap Creek, creating a type of waterfall for the water flowing out of the creek. If beheading were to occur, it is unlikely that these short pulses of separation would constitute enough reduction in numbers in the creek to adversely affect bald eagle foraging.

California Condor.—Under the No Action Alternative, California condors would continue to use the beaches and water of the Colorado River. Vegetation expansion onto beaches would continue until succession is reset by a natural flood flow or a beach/habitat-building flow. This trend is likely to decrease beach area available for condor use. As recreationists and condors increasingly come into more contact the effect of reduced beach area may become increasingly important.

Proposed Action

8,000 cfs Steady Flows

Kanab Ambersnail.—KAS population at Vaseys Paradise is not affected by dam releases that do not inundate the ambersnail habitat. Habitat inundation would only occur above 17,000 cfs.

Humpback Chub.—Larval and young-of-year HBC that drift or swim out of the tributary into the mainstream and make it to near shore rearing habitats during the months of June-October would experience more days of stable flow conditions under these flows than under No Action ROD fluctuations. By remaining in these habitats young fish would enjoy warmer water temperatures and a greater abundance and diversity of food resources. Larger HBC in offshore eddies might experience some diminishment in organic matter drift during this period, but it is not established how much this species feeds on drift in the current as opposed to benthic matter off of bottom substrates.

Steady 8,000 cfs flows during the period of November-December would have little effect on young HBC, who by this time in their lives have moved into deeper water habitats of eddies adjoining their earlier rearing habitats. Some diminishment of drifting organic matter could occur relative to No Action ROD fluctuations, however this effect may well be diminished by reduction in the standing crop of particulate matter if high flows were to occur prior to 8,000 cfs steady flows. Steady winter releases would likely enhance trout recruitment, with an ensuing vegetative impact on humpback chub.

Razorback Sucker.—Under all flows of the Proposed Action, razorback sucker is expected to remain very rare in Grand Canyon. Little to no successful reproduction or recruitment is expected to occur.

Southwestern Willow Flycatcher.—If the proposed test flow scenario of 8,000 cfs were to occur in July or August, SWWF would be present and possibly nesting. Water levels of the proposed release of 8,000 cfs would not be of sufficient elevation to remove nests or harm nestlings. As stated in the vegetation section, statistical analyses of the effects of the 8,000 cfs summer experiment conducted during the year 2000 are not yet available to assist in predicting what effects steady flows at 8,000 cfs would have on the riparian community and thus on SWWF habitat. But, based on observations of the effects of similar steady flows in the past, it is likely that effects to vegetation would be minimal.

Bald Eagle.—Bald eagles would not be present in the Grand Canyon during the time of the 8,000 cfs steady flow scenario. Trout, a primary food source for wintering bald eagles, would not be expected to be negatively affected by this test flow scenario.

California Condor.—The 8,000 cfs steady flows should have no effect on the condor.

6,500-9,000 cfs Fluctuating Flows

Kanab Ambersnail. —Same as entry under 8,000 cfs steady flows.

Humpback Chub.—The amount of daily change in backwater environments that occurs at fluctuations of 6,500-9,000 cfs will vary, dependent on the geometry of the return channel, with those having lesser slopes more affected. Fluctuating flows dewater portions of backwaters and, in the extreme, can temporarily dry them or isolate them from the mainstream.

Razorback Sucker.—Effects would be the same as under the 8,000 cfs steady flows.

Southwestern Willow Flycatcher.—As with the 8,000 cfs releases, these fluctuating flows would be too low to reach nests or nestlings. Habitat is not likely to be negatively affected by the small stage change. There, we conclude that there would be no effect on SWWF or designated SWWF critical habitat from 6,500-9,000 cfs flows.

Bald Eagle.—Effects of 6,500-9,000 cfs fluctuating flows would be expected to be similar to those of the 8,000 cfs steady flows in fall.

California Condor.—The 6,500-9000 cfs fluctuating flows would have no effect on the California condor.

5,000-20,000 cfs Fluctuating Non-native Fish Suppression Flows

Kanab Ambersnail.—KAS will only be affected during brief periods when fluctuating flows exceed 17,000 cfs.

Humpback Chub.—Major physical changes in environments from these flows are anticipated along shoreline habitats from regular dewatering. River stage fluctuations would be about 4 to 8 feet. Effects on humpback chub will be reduced because most individuals in the mainstream, even if the progeny of that year, will have moved to deeper habitats before the winter months.

Razorback Sucker.—Effects would be the same as under the 8,000 cfs steady flows.

Southwestern Willow Flycatcher.—Tamarisk nest stands are extremely resilient to desiccation and would not be negatively affected by the low flows or rapid ramp rates in the daily fluctuations of this test flow component. High flows of 20,000 cfs are well below the level necessary to directly remove nests or affect fledglings and nestlings.

Bald Eagle.—Fluctuating flows offer additional foraging opportunities for bald eagle through exposure of isolated pools and stranding on shorelines. A realistic estimate is that there would be a 20% reduction in young-of-year nonnative fish. This reduction in juvenile trout population would likely have no effect on bald eagles in the short-term as bald eagles usually take adult fish.

California Condor.—The 5,000-20,000 cfs fluctuating flows would have no effect on the California Condor.

31,000-33,000 cfs Habitat Maintenance Flow

Kanab Ambersnail.—Effects would be the same as under 42,000-45,000 cfs high flows for the KAS.

Humpback Chub.—Prior to moving from nearshore to deeper eddies in October-November, small humpback chub and other native fish could be displaced from rearing habitats by flows of this magnitude. Since few young HBC appear to survive in the mainstream under the cold releases of the No Action Alternative and with non-native predation, little additional mortality is expected from these flows. Anticipated effects on mainstream critical habitat from these flows is that during the flow, rearing habitats formed in soft sediments will be disturbed. The duration of the event will be short, and long-term affects on these habitats are expected to be positive.

Razorback Sucker.—Effects would be same under 8,000 cfs steady flows.

Southwestern Willow Flycatcher.—Even with input from the Paria River contributing up to an additional 12,000 cfs, this component of the test flows would still fall below the stage level that would likely flood or remove current SWWF nest trees.

Bald Eagle.—Effects to the few bald eagle that would be present during this time would be similar to the 42,000-45,000 cfs high flow test component. Under the short time span of this test flow scenario, effects to bald eagle foraging from increased turbidity would likely be minimal.

California Condor.—Habitat maintenance flows are designed to increase and restore beaches of the Colorado River through Grand Canyon. It is assumed that the results of this action would be beneficial to the California condor by increasing the amount of beach habitat available to condors.

42,000-45,000 cfs High Flows

Kanab Ambersnail.—The experimental flows that would have direct and indirect effects on KAS in Grand Canyon are the 42,000-45,000 cfs releases in January-March and combined power plant capacity and tributary releases in July-December. The latter are expected to be between 33,500 cfs and 43,000 cfs. Incidental take in a 45,000 cfs release could be as much as

17% of KAS habitat (Service 1996a). The latest estimate for KAS habitat below the 45,000 cfs stage for this evaluation is the April 2002 estimate, which was 117 m^2 , slightly less than the 120 m^2 present in March 1996 prior to the BHBF test. Irrespective of which month the high flow test occurs, we expect that it will remove or damage most of the KAS primary habitat and cause mortality of most KASs up to the stage of the flow.

Removal of KAS habitat by the first high flow will diminish habitat area, and the missing habitat and KAS will not be affected by successive releases of the same or lesser magnitude. Losses of KAS habitat and KAS at Vaseys Paradise are partially offset by the developing population at Upper Elves Chasm. The projected loss of habitat at Vaseys Paradise from the Proposed Action will not exceed the amount lost during the 1996 BHBF, and it will not exceed the incidental take estimated by the Service (2000). What incidental take does occur will be located in habitat that has grown and become established under regulated release conditions produced by Glen Canyon Dam. This habitat was not sustained in the pre-dam era.

Humpback Chub.—These flows would occur during January-March, a time of year when surviving young-of-year HBC have moved to deeper eddies. Subadults and adults are expected to be affected very little by these larger flows, although they do occur at a time of the year prior to the rise in the pre-dam hydrograph. Little is known about the extent to which HBC relies on changes in flow as a reproductive cue. The long-term effects from reduced numbers of deleterious non-native fish and rejuvenated rearing habitats are expected to be positive.

Razorback Sucker.—Effects would be the same as under 8,000 cfs steady flows, with the following additional comment. If there are reproductively active RBS in Grand Canyon, an experimental high flow in January-March might serve as an environmental cue for spawning. This high flow would also be experienced by RBS in upper Lake Mead.

Southwestern Willow Flycatcher.—Nest trees typically grow above the 45,000 cfs stage. Long-term effects of the 42,000-45,000 cfs test flow on SWWF habitat are expected to be beneficial.

Bald Eagle.—Low river flows would result in eagles capturing and scavenging proportionally more prey from isolated pools and adjacent shore habitat. As river flows increase, these habitats would be inundated, reducing or eliminating prey availability. Intermediate and high river flows would result in a shift to greater use of creek habitat, e.g. Nankoweap Creek. Eagles in the river corridor that were not near such creeks would possibly experience a temporary reduction in foraging opportunities or reduced foraging success during the 42,000-45,000 cfs two-day flood flow. As flows drop to 8,000 cfs for 10 days, additional habitat would likely become available from exposure of isolated pools.

California Condor.—These flows are designed to increase or restore beaches of the Colorado River through Grand Canyon. The results of this action would be beneficial to the California condor by increasing the amount of beach habitat available to condors.

Mechanical Removal of Non-Native Fish

Kanab Ambersnail.— The mechanical removal of non-native fish will not take place in the same reach as Vaseys Paradise. Thus, there will be no effect on KAS.

Humpback Chub.—The effort will be conducted in habitat used by humpback chub and an unknown number of humpback chub will be collected. Precise numbers of chub captured cannot be determined *a priori*. Table 3.3 presents catch rates of HBC based on electrofishing data very near the LCR confluence. Table 3.3 may overestimate the actual catch by up to two times because approximately one-half of the reach of river proposed for mechanical removal historically has yielded very few HBC and because HBC numbers have declined over the period in which the estimate was made.

Table 3-3.—Projected HBC captures for each trip from the Little Colorado River reach of the Colorado River.[1]

		Catch per unit/10 hrs[2]		Catch (number)	
	Effort (trip hrs)	HBC <200mm	HBC ≥200mm	HBC <200mm	HBC ≥200mm
Mean	320	11.94	0.45	382	15
Median	320	5.16	0.27	165	9
Minimum	320	0.00	0.00	0	0
Maximum	320	89.15	5.61	2853	180

1 Projections based on electrofishing data from an approximately 10 year period for a five mile reach of the Colorado River around the confluence with the LCR (River Miles 61-65).
2 Catch per unit refers to the number of individuals collected in a unit of time, herein 10 hours.

The proposed electrofishing activity could negatively affect the HBC in the targeted area of its critical habitat. Effects from electrofishing on individuals will vary by degree of exposure and fish size (Snyder 1992). The principle intended consequence of the proposed activity is to benefit the HBC. Nevertheless it is possible that some incidental take of HBC may occur as a consequence the proposed activity. We anticipate long-term benefits to critical habitat for this species from the removal of non-native fish.

Razorback Sucker.—The potential effect of mechanical removal on RBS is largely dependent on the probability that individuals will be impacted by the sampling gear. Based on the rarity of RBS in Grand Canyon, it appears very unlikely that any pure RBS will be in the vicinity of the LCR during the period of mechanical removal in 2003-2004.

Southwestern Willow Flycatcher.—There will be no effect on SWWF from mechanical removal of non-native fish. If any SWWF or SWWF nest trees exist in the mechanical removal reach, they will be avoided during this activity.

Bald Eagle.—The removal would affect approximately six miles of 77.5 miles of bald eagle habitat (dam to one mile below LCR). At this point in time, only a crude estimate of the level of effects to bald eagle can be made. If the assumption is made that the six miles would be substantially depleted, then it can be reasoned that 8% of bald eagle foraging habitat would be affected or largely removed, at least temporarily, from foraging opportunities. Combined with effects of other portions of the Proposed Action, effects to bald eagle would likely be measurable. While the effects of the Bald Eagle from this component of the Proposed Action may be measurable, the anticipated benefits to the conservation of the HBC support inclusion of this aspect of the Proposed Action.

California Condor.— There will be no effect on California condor from mechanical removal of non-native fish.

3.9 RIPARIAN AND TERRESTRIAL VEGETATION COMMUNITIES

3.9.1 Affected Environment

Riparian Vegetation.—The riparian vegetation zone will be directly affected by both the No Action and the Proposed Action due to inundation and alterations in the water table and due to effects of the high flow on substrates. The high flows will probably have the greatest impact because they are likely to result in increased erosion, leaching of nutrients, and scouring of weakly rooted plants.

Terrace and Hillside Vegetation.—The flows being considered here will have little, if any, effect on the vegetation in the terrace zone. Hillside plant communities are located too far from the Colorado River to be affected by the Proposed Action being evaluated here.

3.9.2 Environmental Consequences

No Action

Trends documented for the riparian community since the 92,600 cfs flood of 1983 should continue. Composition of marshes and distribution of particular species within the marsh or wetland associations are expected to change over time as part of natural successional process. Under the No Action Alternative, it is expected that return-current channels would continue to fill with coarse-grained sediment, favoring the temporal succession of woody plants over the emergent marsh vegetation. Such sedimentation of backwaters is expected to eventually lead to a reduction in marshes as herbaceous aquatic and semi-aquatic plants are replaced with more woody plants.

Under the No Action Alternative, drying conditions on the upper reaches of the terraces are expected to continue to be caused by a combination of lower water tables due to dam operations and climatic change. Willow and other relatively mesic plants located in drier areas at the margins of the riparian zone are likely to be replaced by acacia, honey mesquite, and other species requiring less water. The latter species represent climax communities.

Riparian vegetation in the upper end of Lake Mead will continue to increase as delta formation processes continue. Periodically, under the No Action Alternative this riparian vegetation would be inundated and lost as lake levels rise. Inundation would be followed by lower water levels as lake storage responds to climatic cycles and reservoir drawdowns. Sediment exposed when Lake Mead is low would continue to be colonized by riparian vegetation, as long as water-tables remain high enough to support relatively mesic riparian vegetation. Invasive perennial and annual species, including campsite invaders like tamarisk, arrowweed, and foxtail brome, will continue to expand.

Proposed Action

The different components of the proposed action will have different effects on vegetation, as described in sections below.

8,000 cfs Steady Flows.—Steady flows would occur in the fall (September to December) and are unlikely to cause changes in the riparian or terrace communities beyond natural successional processes described under the No Action Alternative.

6,500-9,000 cfs Fluctuating Flows.—Fluctuating flows would occur in the fall and are unlikely to cause changes in the riparian or terrace communities.

5,000-20,000 cfs Fluctuating Non-Native Fish Suppression Flows.—The terrace community is unlikely to be affected by these flows, but weakly rooted marsh vegetation is likely to be scoured by the higher fluctuating flows. These flows will take place prior to spring seedling emergence and vegetative growth, so it is difficult to predict the effects on germination.

31,000-33,000 cfs Habitat Maintenance Flow.—Effects of these flows would be similar to those predicted for the 42,000-45,000 cfs flood except for issues related to the timing.

42,000-45,000 cfs High Flows.—At a system-wide scale, the greatest effect of the 1996 experimental flow of 45,000 cfs was a 20% reduction in vegetation cover, with the greatest losses occurring in the riparian zone. While the proposed high flow is of shorter duration and slightly lower magnitude than that the 1996 flow, it is likely that there will be similar losses of cover caused by drowning xeric-adapted species, burying low-lying grasses and herbs with sediment, and scouring weakly-rooted plants like longleaf brickelbush (*Brickellia longifolia*), incienso (*Encelia farinosa*), snakeweed (*Gutierrezia* sp.), and seepwillow (*Baccharis wrightii*). In addition, due to the timing of the flood, marshes and wetlands in Glen and Marble canyons may suffer from ice damage. Because the high flow test is anticipated to occur in the winter, seedlings may be removed or buried, but seed distribution may result in subsequent germination.

Because of the short duration of the flow and the extensive area available for sediment deposition in Lake Mead, effects on riparian vegetation around the lake would be minimal.

The 42,000-45,000 cfs high flow test would occur before the release of noxious weed seeds, so it would not result in enhanced dispersion of undesirable plants.

3.10 WILDLIFE

3.10.1 Affected Environment

Mammals.—Wildlife that would be affected by the No Action or Proposed Action alternatives are the full-time residents of the riparian zone or animals like the beaver that move from the aquatic to the riparian zone.

Domestic Livestock.—Cattle and sheep are present on the higher terraces within the Navajo Indian Reservation in the northeastern portion of the affected environment; however, due to cliffs along Marble Canyon and grazing restrictions, they do not come down to the river or the riparian zone. Within Grand Canyon, burros are restricted to the Bright Angel and Kaibab trails. None of these domestic livestock would be affected by the alternatives considered here.

Birds.—With the development of a stabilized riparian zone since 1963, the diversity of birds using then Colorado River floodplain has increased (Brown et al. 1987). Birds such as Bell's vireo *(Vireo bellii)*, hooded oriole *(Icterus cucullatus)*, great-tailed grackle *(Quiscalus mexicanus)*, and summer tanager *(Piranga rubra)* have been able to take advantage of this stabilized habitat. Species that were present along the tributaries, like common yellowthroat *(Geothlypis trichas)*, yellow warbler *(Dendroica petechia)*, and yellow-breasted chat *(Icteria virens)*, moved down to the river corridor, increasing the number of documented bird species in the corridor to 250 (Johnson 1991). The Southwestern willow flycatcher and bald eagle reside in the canyons and are discussed under Endangered Species.

Most birds found along the Colorado River are summer residents. Today, nearly 30 species of birds nest in the floodplain; 11 of these nesting birds are referred to as obligate riparian birds due to their complete dependence on the riparian zone. Obligate riparian birds nesting within the riparian zone include the neotropical migrants American coot *(Fulica americana)*, common yellowthroat *(Geothlypis trichas)*, yellow warbler *(Dendroica petechia)*, yellow-breasted chat *(Icteria vixens)*, hooded and northern orioles *(Icterus cucullatus, I. galbula)*, and black-chinned hummingbirds *(Archilochus alexandri)*. Neotropical migration through Grand Canyon generally starts in late March. Nest building and egg laying taking place in late April and into May along the river corridor. Most birds fledge their young by mid-July to early-August.

The river corridor also is used by about 34 species of wintering waterfowl. The number of waterfowl increases in late November, peaks in December and early January, then decreases through April. During the winter of 1990-91, some 19 different species of waterfowl used the river between Lees Ferry and Soap Creek (RM 11) at a density of 136 ducks per mile. An average density of 18 ducks per mile occurred over the entire upper Grand Canyon (RM 0-77) during the same period.

Herpetofauna.—In Grand Canyon, herpetofauna (amphibians, lizards, and snakes) species density and distribution varies with plant community, microhabitat, stage in their life cycle, and along the Colorado River, with increased densities of insect populations, especially in heavily used campsites (Van Devender, Phillips, et al. 1977; Mead and Phillips 1981; Warren and Schwalbe 1986; Aitchison et al. 1977). Some 27 species of herpetofauna have been documented in the riparian zone. Within the zone, herpetofauna densities are generally highest along the river shoreline, although herpetofauna are differentially distributed among microhabitats within the zone and along the shoreline. For example, depending on the species, lizards favor vertical rock faces, sandy shores, cobble shores, or rocky shore habitats, and to some extent heavily used campgrounds.

The most common lizards in the riparian zone are side-blotched lizards *(Uta stansburiana),* Western whiptails *(Cnemidophorus tigris),* desert spiny lizards *(Sceloporus magister),* and tree lizards *(Urosaurus ornatus).* Collared lizard *(Crotaphylus insularis)* and chuckwallas *(Sauromalus obesus)* are less common in the riparian zone than in the terrace zone. Lizard densities in the riparian zone measured during June average 858 lizards per hectare versus 300 lizards per hectare in the terrace zone. This high density of lizards in the riparian zone is attributed to increased abundance of food resources due to the quantity of insects, which in turn is largely a function of the density and distribution of marshes, and to some degree of organic debris left in popular camping beaches (Aitchison et al. 1977; Warren and Schwalbe 1986).

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),* southwestern speckled rattlesnake (*C. mitchellii pyrrhus)* and desert striped whipsnake *(Masticophis taeniatus).*

Amphibians in the Colorado River ecosystem include frogs, spadefoot toads, and other toads. Important species include the desert toad *(Bufo punctatus),* Woodhouse toad *(Bufo woodhousei),* western spadefoot *(Scaphiopus hammondi),* and northern leopard frog *(Rana pipiens).* Depending on the timing of the alternative flows, amphibians may be directly affected by the alternatives being considered because their egg deposition and larval development occurs in shallow water at the boundary of the aquatic and riparian ecosystems, and larval development generally takes place near the shoreline of the river. After metamorphosis, juvenile amphibians migrate towards the terrestrial zone where they can be affected by the higher flows of the Colorado River.

Invertebrates.—A diversity of insects is found at some time during their lifecycle in the riparian zone. Common insects include dragonflies and damselflies (Odonata), true bugs (Heteroptera), beetles (Coleoptera), and members of the Hymenoptera including bees, wasps, and ants. The chironomid midges, mayflies (Ephemeroptera), simuliid black flies, and macroinvertebrates that are abundant along the river banks and in backwaters are particularly important in maintaining the productivity of the aquatic system. While important in their own right as natural components of the Colorado River ecosystem, these invertebrates serve as food for other wildlife and as pests to human visitors.

Human visitors to the canyons tend to be most concerned with the density and distribution of members of the two-winged flies (Diptera), which include mosquitoes, flies, and deerflies. Aitchison et al. (1977) have shown that populations of noxious insects have increased in heavily used campsites along the river. Harvester ants, also known as red ants *(Pogonomyrex californicus),* are attracted to organic waste left at campsites, and because of its painful sting, this species is a minor health hazard to river runners. The size and distribution of the flesh fly (Sarcophagidae) and blow fly (Calliphoridae) populations are also correlated with campsite organic debris.

3.10.2 Environmental Consequences

No Action

The forecast for low flows in the No Action Alternative ranges from 6,800 cfs in March to 13,500 cfs in August. The high flows range from 12,800 cfs in March to a possible 22,700 cfs in August. Most wildlife in the Colorado River floodplain are mobile enough that they will be unaffected by the No Action Alternative. However, the No Action Alternative can directly impact wildlife when water levels rise rapidly, drowning animals confined to their nests, burrows, dens, or other forms of shelter. Indirect effects on wildlife are caused when changes in dam operations result in reductions in the food, cover, or habitat. In other words, the rapidity of changes in Colorado River flows, the timing of high flows, and the changes that might reduce the availability of food, shelter, or habitat associated with the No Action Alternative can directly and indirectly impact wildlife.

Mammals.—Mammals most likely to be affected by the No Action Alternative are those full-time residents of the riparian zone or those who frequent the aquatic and riparian zones. These include the deer mouse (*Peromyscus maniculatus*) and beaver (*Castor canadensis*). Adverse effects on the beaver are likely to come from both low flows, which might reduce the availability of their main staple, willows, and from high flood flows. While it is not presently known whether beaver will be affected by the projected 22,700 cfs August flow, based on observations of Durant and Dean (1959), it is possible that beaver may be drowned out of their bankside burrows in high flows. Effects on deer mice are of a lesser concern because these animals also occur on terrace and hillside habitats; any effects on this species in the riparian zone are likely to be temporary.

Birds.—As noted by Rosenberg et al. (1991), bird populations throughout the Colorado River undergo marked fluctuations in numbers from season to season and year to year. Because many of the riparian birds are neotropical migrants from Mexico and Central America, resources in their wintering grounds as well as in their summer habitats affect populations. Obviously these fluctuations could be related to the Colorado River's impact on foods eaten by birds, but such causal relationships have not been fully demonstrated. In general, the presence or absence of particular bird species is based on a combination of plant association, foliage configuration, and availability of insects and other foods (Rosenberg 1991). Based on these variables, the No Action Alternative has its greatest impact on birds when shoreline invertebrates are drowned due to rising flows and when rising flows destroy marshes utilized for nesting or marsh plants for food.

Of the nesting birds, Bell's vireo, common yellowthroat, and yellow-breasted chat are the species expected to be most affected by river flows because they nest close to the shoreline in marshes located on low ground. The common yellowthroat nests are three feet or less above the ground or water surface, while Bell's vireo and yellow-breasted chat nest in tamarisk about three to five feet off the ground. Depending on the timing of flows, these nesting birds may be affected by the No Action Alternative.

Herpetofauna.—Herpetofauna experience deleterious effects of Colorado River flows during both high flows and fluctuating flows. Rising waters trap and destroy large numbers of individuals on cobble and alluvial bars and along the Colorado River shoreline, and rising water during egg-laying and breeding seasons (April to July) inundate nest, dens or hibernacula sites along the shoreline and throughout the riparian zone. Whenever the No Action Alternative results in river fluctuations of more than three to four feet per day, herpetofauna will be adversely affected.

Proposed Action

8,000 cfs Steady Flows

Steady flows in the fall are probably the most favorable condition for most wildlife. This is due to a general increase in insects with steady flows and because vegetative biomass tends to increase and provide enhanced cover and food.

6,500-9,000 cfs Fluctuating Flows

Mammals.—The magnitude of these fluctuating flows is sufficiently low that mammals should not be affected. There is some chance that small mammals like mice could become trapped on islands due to fluctuating flows; however, loss of a few individuals should have no effect on mice or small mammal populations.

Birds.—These fluctuating flows are proposed at a time when many of the birds present in the canyons are migrating. The flows should have little to no effect on bird populations.

Herpetofauna.—Because of the density of herpetofauna along the river shoreline, fluctuating flows adversely impact herpetofauna. This includes alluvial and cobble bars and along sandy shorelines, where rising water during breeding seasons from May to July inundates nest sites. Given that these fluctuating flows are proposed for fall and are less than three to four feet, most impacts on herpetofauna would be avoided.

5,000-20,000 cfs Fluctuating Non-native Fish Suppression Flows

Mammals.—Small mammals like deer mice are likely to be affected by the 5,000-20,000 cfs fluctuating flows. Their nests or burrows may be inundated by the higher flows, although as with the birds, it is likely that the mammals are mobile enough that they will be able to move higher upslope and avoid adverse effects. However, as the flows are reduced towards 5,000 cfs, it is expected that there will be increases in the distances across open space that the small mammals will need to cross to reach the river. This will provide enhanced opportunities for predation on the small mammals by owls and other predators. Thus, the fluctuating flows are likely to result in increased mortality among small mammals, with beneficial effects on predators like owls.

Birds.—Waterfowl including mallard (*Anas platyrhychos*), gadwall (*Anas strepera*), and American widgeon (*Anas americana*) are ground nesters, so their nests may be temporarily displaced by the alternating flows and subsequent short-term alterations in vegetation in the riparian zone. However, due to the relatively small increase in river stage of the proposed alternating flows, adequate nest cover for waterfowl should remain at higher elevations in the terrace zone. Numbers of these birds are highly variable from year-to-year depending on water levels and availability of pondweed and other foods. Neotropical migrants nest primarily in trees or mature woody shrubs, so no losses of their nesting habitats are anticipated due to the alternating flows.

Herpetofauna.—The magnitude of the fluctuations is probably of less importance to herpetofauna than the ramping rates. Rapid changes in river flow are likely to adversely impact herpetofauna, particularly the rattlesnakes that are in their dens. With their reduced mobility at these times, rapidly fluctuating flows might kill reptiles in the inundated part of the riparian zone. Daily fluctuations of three to four vertical feet in less than one day are likely to trap and destroy populations of the herpetofauna on cobble bars and beaches (Warren and Schwalbe 1986).

For amphibians, the period of larval development is spring to beginning of summer. These animals move to the river's edge, seeking out marshes and backwaters where water temperatures are high and vegetation is present. The risks for successful reproduction include the site drying out or the risk of predation.

31,000-33,000 cfs Habitat Maintenance Flows

Mammals.—Beaver, particularly those that might have burrowed into the river bank for their den, are likely to be adversely affected by these high flows. Young beaver are born between April and July and they have a 128-day gestation period. The habitat maintenance flows could affect the young beaver, as well as the ability of their parents to forage and provide for their young.

Birds.—According to Brown and Johnson (1988), fluctuating flows of up to 31,000 cfs have little direct effect on breeding birds. Prior flows of this amount only inundated one black-chinned hummingbird nest, representing less than 1% of the population of that species in the river corridor. One concern with the proposed 31,000-33,000 cfs flows is the timing of the flows. July is when many of the riparian birds have their second brood of the year. High flows in July could adversely impact these species, so from the standpoint of minimizing effects on birds, it would be better to delay these flows until August. High flows in late summer to fall should avoid adverse impacts on most nesting waterfowl and neotropical migrants.

Herpetofauna.—The critical season for most herpetofauna is late spring to summer when reproduction occurs. For most herpetofauna, eggs are laid from April through June with hatching and dispersal from June through August. Strong water current and cold water temperatures during a spring flood would jeopardize herpetofauna in the inundated portion of the riparian zone. If 31,000-33,000 cfs flows are released anytime from April through August, rising water and cold water would flood and destroy nests, eggs, and young herpetofauna.

42,000-45,000 cfs High Flow

Mammals.—If the high flow occurs in January, effects on small mammals would be minimal. However, if the flood occurs in February or March, the flood is likely to eliminate one of two to four annual litters of deer mice (*Peromyscus maniculatus*). Deer mice inhabiting the riparian zone frequently nest in burrows in the low-lying areas. Their home range is limited to 0.5-3 acres and their breeding season is normally February to November. It is likely that a high flood during this time would eliminate at least one of the litters. In turn, a reduction in deer mice could affect predatory mammals, birds, or reptiles.

The most serious concern with the high flow is its possible adverse effects on beaver. Some of the beaver in Grand Canyon have their dens in side canyons and tributaries, but many locate their dens in the main river banks. High flows, particularly those with rapid ramping rates, may drown beavers. High flows with rapid ramp rates are not conducive to beaver survival (Durrant and Dean 1957:87).

Birds.—Historically, dam releases over 40,000 cfs have destroyed almost all common yellowthroat (*Geothlypis trichas*) nests and substantial numbers of Bell's vireo (*Vireo bellii*) and yellow-breasted chat (*Icteria virens*) nests. In addition, flows over 40,000 cfs have inundated nests of black phoebe (*Sayornis nigricans*), Say's phoebe (*Sayornis saya*), and violet-green swallow (*Tachycineta thalassina*). If the potential 42,000-45,000 cfs high flow occurs in January or winter-time, effects on these birds will be minimal because they will not be breeding and most will not be resident in the canyons. However, wintering waterfowl nesting in the marshes close to the river are likely to be adversely affected by the proposed high winter flood.

Indirect effects of the high winter flood on bird populations are due to the impacts on marshes and riparian vegetation (and invertebrates) which provide shelter and food for wintering birds. Following Rosenberg et al. (1991:56) winter is the time of greatest ecological stress for birds due to reductions in food supplies, which in turn affect population size and distribution of both permanent and wintering seasonal birds. Wintering waterfowl subsist on a diverse mixture of seeds, vegetation, insects, *Cladophora* and associated invertebrates and algae in the aquatic community. The proposed 42,000-45,000 cfs experimental high flow may increase the downstream drift of *Cladophora* and other components of the aquatic food base, which could have a positive effect on birds, but there could also be temporary reductions in the algae and submerged plants that the birds use as food. Such adverse effects on the birds' winter food supply are expected to be temporary, and based on the previous high experimental flows, most waterfowl and neotropical migrants are mobile enough that they should not be affected. The birds of greatest concern include American coot, common yellowthroat, and Bulock's oriole (*Icterus galbula bullockii*). Effects on raptors are covered in the section on special species.

Herpetofauna.—A high winter experimental flow is likely to drown many of the herpetofauna located in flooded riparian zones in the northern, colder areas of Glen and Marble canyons. During January, most of these northern herpetofauna will be lethargic, if not completely immobile, while those to the south will be mobile and able to avoid the floods by dispersing to higher terraces as long as upramp rates are sufficiently slow.

3.11 CULTURAL RESOURCES

3.11.1 Affected Environment

Cultural resources that would be affected by the alternatives considered in this environmental assessment are located in the area from Glen Canyon Dam to Lake Mead that would be inundated by the 45,000 cfs high flow in the Proposed Action or exposed by the 5,000 cfs low flows. While this area has not been precisely mapped, it corresponds with the riparian vegetation community which measures about 10 square miles (2,500 hectares).

Historic Properties.—Based on an intensive inventory for cultural resources in the Colorado River floodplain (Fairley et al. 1994), nine historic properties are present in the area that would be inundated by a 45,000 cfs high flow. These historic properties are listed in table 3.4 and include both historic and prehistoric sites.

Table 3.4— Historic properties affected by the proposed flows.

Property No.	Name, Type
B:15:124	Parkins inscription
C:6:2	Brown inscription
C:6:4	USGS hammer inscription
C:2:11	Spencer steamboat
C:6:5	Prehistoric petroglyph

C:13:321	Prehistoric roasting feature
C:13:365	Puebloan limited activity site
C:13:371	Puebloan habitation site
C:3:10	Prehistoric limited activity site

The first four properties listed in table 3.4 are historic sites considered eligible to the National Register of Historic Places for their association with important people in Colorado River history. These historic sites lie in or close to the Colorado River and are likely to be affected by flows under either alternative. The last five historic properties listed in table 3.4 are prehistoric sites considered important because of their cultural value to Native American tribes and because of their ability to yield important archeological information.

Flooding or the possibility for either erosion or deposition of sediment on the historic and prehistoric properties in table 3.4 from implementation of either alternative constitutes an effect, and potentially an adverse effect, because the character or use of the properties could be temporarily or permanently altered. To mitigate for these adverse effects prior to the 1996 45,000 cfs beach/habitat building flow test, all of the properties listed in table 3.4 were photographed with a medium format camera and documented on standardized site forms.

In addition to the historic and prehistoric sites listed in table 3.4, Glen, Grand, and Marble canyons, the river and the prehistoric properties are potentially eligible to the National Register of Historic Places as traditional cultural properties of the Hopi Tribe, Pueblo of Zuni, Navajo Nation, Hualapai Tribe, and Kaibab, San Juan, and Shivwits Bands of Paiute Indians. Evaluations of the values these places hold for the tribes are currently in progress.

Indian Sacred Sites.—Executive Order 13007 defines Indian sacred sites as any specific, discrete, narrowly delineated location on Federal land identified as sacred by virtue of its religious significance to, or ceremonial use by Native Americans. At least six Native American tribes consider the canyons and the river sacred sites, necessitating compliance with Executive Order 13007.

Resources of Tribal Concern.—During government-to-government consultation over the No Action and Proposed Action alternatives, representatives of Native American tribes have expressed concern over how the proposed releases might affect cultural resources that do not meet the definition of National Register-eligible historic properties or sacred sites; i.e., they have expressed concerns with particular species of plants and wildlife that are valued for traditional or cultural reasons.

3.11.2 Environmental Consequences

No Action

Historic Properties.—Under the No Action Alternative, the first four historic properties listed in table 3.4 would be inundated. The next five prehistoric sites are located further away from the river and they will only be affected by the experimental high flow of the Proposed Action. However, as noted above, adverse effects of all dam operations on these historic properties were mitigated prior to the 1996 experimental flood. Before that flood, the properties listed in table 3.4 were photographed with a medium format camera and recorded on standardized site forms. These records are curated by the National Park Service. Archiving these records and photographs and allowing historians and interested members of the public to access them mitigated the adverse effects of the 1996 experimental flood and the releases being evaluated here. Furthermore, the values of the first four historic properties have been preserved through documentation of the sites in relationship to historically important persons such as Charles Spencer and Bert Loper (e.g. Topping 2000).

Archeological data recovery has also taken place at the last four prehistoric sites listed in table 3.4 (Balsom and Larralde 1996). These efforts effectively removed the valuable archeological information contained within the prehistoric properties. The Arizona State Historic Preservation Officer has agreed that no further work is necessary to preserve the information values that made the prehistoric properties eligible to the National Register of Historic Places.

Sacred Sites and Resources of Tribal Concern.—Under the No Action Alternative, the Native American tribes that consider the canyons and river sacred have been and continue to be consulted about proposed actions or Federal policies that may restrict their access or ceremonial use of the canyons and river. The tribes continue to hold dialogs with the Federal agencies and other stakeholders that are part of the GCDAMP operations, so effects on the canyons and river as sacred sites are minimized. Federal management agencies in the GCDAMP remain in compliance with Executive Order 13007 by communicating with the tribes about any potential management actions that might adversely impact the physical integrity of the sacred sites or the tribal members' ability to access the sites; likewise the tribes communicate with the agencies about their concerns.

Proposed Action

Historic Properties.—As explained under the No Action Alternative, potential adverse effects of dam operations on the historic properties listed in table 3.4 have already been mitigated. The first four historic sites were considered eligible to the National Register for their association with important persons in Colorado River history. The availability of histories documenting these associations along with archival documentation serves to mitigate any adverse effect of dam operation or ongoing natural process such as the continued sinking of the Spencer Steamboat into the bed of the Colorado River.

The prehistoric sites were considered National Register-eligible due to their ability to answer important questions about local culture history. This information was retrieved through recordation and archeological data recovery prior to the 1996 experimental flood. Providing access to the records and materials resulting from these data recovery efforts constitutes the mitigation for both the No Action and Proposed Action alternatives. No further archeological work is necessary on these sites.

Several Native American tribes have identified the prehistoric sites as having traditional cultural values in addition to their archeological information values. The tribes and agencies (including the Arizona State Historic Preservation Officer and Advisory Council on Historic Preservation) are currently consulting over whether the proposed action will adversely affect traditional values. If consultation shows that the effects of the proposed action are adverse, then the tribes and agencies will determine how to avoid, minimize, or mitigate for potential loss of traditional cultural values.

Sacred Sites and Resources of Tribal Concern.—Under Executive Order 13007, it is the policy of the Department of the Interior to accommodate tribal access to and ceremonial use of Indian sacred sites. It is also Departmental policy to avoid adversely affecting the physical integrity of sacred sites. The tribes that consider the canyons and river sacred or that have identified resources of tribal concern in the area potentially affected by the proposed action are being consulted on a government-to-government basis on the proposed action.

Four tribes have already stated that the mechanical removal component of the proposed action would compromise the physical integrity and adversely affect sacred sites and resources of tribal concern. Thus, the mechanical removal component, with the resulting death of fish and lack of beneficial use of such fish, is considered an adverse impact on resources of tribal concern and on Indian sacred sites.

Through consultation, the Hopi, Hualapai, and Paiute tribes have identified marsh vegetation below Glen Canyon Dam as resources of tribal concern. As discussed in the section on vegetation, the proposed action would have short-term adverse impacts to marshes below Glen Canyon Dam. Over time the marsh vegetation would return so the effects would be temporary, but if the proposed flows are implemented, there would be an expected 20% loss of riparian vegetation. Particular patches of emergent marsh vegetation and weakly-rooted phreatophytes would be scoured.

The tribes have also identified other resources that will be adversely affected by various components of the flow scenarios. For example, impacts to the bald eagle and herptofauna described in the section on Wildlife Environmental Consequences are also considered adverse effects to Hopi cultural resources.

3.12 HYDROPOWER

3.12.1 Affected Environment

The financial analysis of the Proposed Action encompasses water years 2003 and 2004. It was prepared by Western Area Power Administration (Western) (Palmer and Burbidge 2002). The No Action Alternative of this study simulated operations at Glen Canyon Dam under

ROD constraints, and consisted of an annual distribution of water volumes expected under most probable hydrologic conditions. For 2003 No Action was compared to autumn sediment input, winter sediment input, and no sediment input scenarios. As explained in Chapter 2, the habitat maintenance flow scenario would occur only after the autumn sediment input scenario had been completed; therefore, this financial analysis compares the No Action Alternative with the habitat maintenance flow scenario of the Proposed Action for 2004.

The scope of this financial analysis in this subsection is narrow; its focus is the financial impact to Western of power sales revenues collected and expended during the time period of each test scenario. As such, it is an estimate of the impact on the value of electrical power generation as a result of the Proposed Action.

Western has an obligation to purchase power to deliver to its contractually obligated amounts to its customers. Western makes contractual commitments to its firm power customers based on how water would have been released through Glen Canyon Dam as if no test was being conducted. Western assumes that its cash reserves in the Basin Fund established by the Colorado River Storage Project Act are adequate to support the two years of test flows under any scenario.

There is a remote possibility that Western's cash reserves would be drawn down to precariously low levels. This is especially true in conditions of volatile energy markets associated with continued drought. Therefore, the expenditure of funds to support contractual obligations during a test may result in those costs being passed on financially to customers to keep the Basin Fund solvent, thus affecting future power rates.

3.12.2 Environmental Consequences

Table 2.2 displays the monthly water volumes used in this analysis. Monthly release volume differences and Glen Canyon Dam operating restrictions account for the largest differences in power generation between the No Action and Proposed Action alternatives. Water bypassing the power plant during the high flow test in several scenarios also affects total power generation but to a much lesser extent (approximately 1.1% of annual hydropower production). Table 3.5 lists the estimated market prices used in this process for September-March. Table 3.6 lists estimated prices during April-August. These prices were weighted averages of the on- and off-peak market prices.

Table 3.5— Market prices for hydropower purchases.

Month	On-Peak Prices ($)	Off-Peak Prices ($)
September	33.50	20.75
October	32.75	19.65
November	34.00	20.40
December	34.00	20.40

January	34.00	22.00
February	34.00	22.00
March	34.00	22.00

Source: Prebon Energy 08/28/02 Palo Verde Price Quotes

Table 3.6—Estimated average market prices for hydropower purchases.

Month	Price ($)
April	24.80
May	23.82
June	26.22
July	34.64
August	30.19

Autumn Sediment Input Scenario.—Table 3.7 describes the financial impact of the autumn sediment input scenario as compared to the No Action Alternative. The results are arrayed by month for the study period, and it was assumed that this scenario would begin in calendar year 2002. The total financial cost of this scenario would be about $2.85 million over the study period. This is the net cost of purchases of electrical power to meet contractual obligations, or the cost of lost sales.

Winter Sediment Input Scenario.—Table 3.8 describes the financial impact of the winter sediment input scenario as compared to the No Action Alternative. In total, the financial cost of this scenario would be about $1.6 million.

No Sediment Input Scenario.—Table 3.9 describes the financial impact of the no sediment input scenario as compared to the No Action Alternative. In total, the financial benefit of this scenario would be about $144,000 over the study period.

Habitat Maintenance Flow Scenario.—Table 3.10 describes the financial impact of the habitat maintenance flow scenario as compared to the No Action Alternative. It was assumed that this scenario occurs in water year 2004, though it could begin as early as July 2003. In total, the financial benefit of this scenario would be about $1.15 million over the study period.

Hydropower Summary.—The total financial cost of the Proposed Action would be the sum of the impacts of the autumn sediment input and habitat maintenance flow scenarios, a total cost of about $1.7 million. During water years 2003 and 2004, revenues from the sale of power from Glen Canyon Dam are expected to be about $280 million under the No Action Alternative, thus the financial impact of the proposed action is about 0.6% of the expected total revenue.

Table 3.7—Autumn sediment input scenario impacts.

Month	Year	Study Cost/Benefit*
May	2002	-$130,816
June	2002	$1,397,656
July	2002	$728,861
August	2002	$0
September	2002	-$1,949,625
October	2002	-$1,387,863
November	2002	-$1,570,333
December	2002	-$3,832,390
January	2003	-$1,056,597
February	2003	$1,945,604
March	2003	$2,862,421
April	2003	$0
May	2003	$0
June	2003	$233,642
July	2003	$311,061
August	2003	-$404,009
Total		-$2,852,388

Minor adjustments were made to monthly volumes in water year 2002 through the AOP process to allow for the potential initiation of the Proposed Action if Paria River sediment inputs occurred and environmental compliance was completed. This had no effect on the annual release volume from Glen Canyon Dam and had a very minor financial impact.

TABLE 3.8—Winter sediment input scenario impacts

Month	Year	Study Cost/Benefit*
May	2002	-$130,816
June	2002	$1,397,656
July	2002	$728,861
August	2002	$0
September	2002	-$1,713,829
October	2002	-$1,088,740
November	2002	-$1,279,407
December	2002	-$3,422,375
January	2003	-$1,056,597
February	2003	$1,945,604
March	2003	$2,862,421
April	2003	$0
May	2003	$0
June	2003	$233,642
July	2003	$311,061
August	2003	-$404,009
Total		-$1,616,527

Minor adjustments were made to monthly volumes in water year 2002 through the AOP process to allow for the potential initiation of the Proposed Action if Paria River sediment inputs occurred and environmental compliance was completed. This had no effect on the annual release volume from Glen Canyon Dam and had a very minor financial impact.

TABLE 3.9—No sediment input scenario impacts

Month	Year	Study
May	2002	-$130,816
June	2002	$1,397,656
July	2002	$728,861
August	2002	$0
September	2002	-$1,713,829
October	2002	-$1,088,740
November	2002	-$1,279,407
December	2002	-$3,422,375
January	2003	$704,383
February	2003	$1,945,604
March	2003	$2,862,421
April	2003	$0
May	2003	$0
June	2003	$233,642
July	2003	$311,061
August	2003	-$404,009
Total		$144,454

Minor adjustments were made to monthly volumes in water year 2002 through the AOP process to allow for the potential initiation of the Proposed Action if Paria River sediment inputs occurred and environmental compliance was completed. This had no effect on the annual release volume from Glen Canyon Dam and had a very minor financial impact.

TABLE 3.10—Habitat Maintenance Flow Scenario Impacts

Month	Year	Study Cost/Benefit*
September	2003	$1,886,385
October	2003	$0
November	2003	$0
December	2003	$0
January	2004	-$730,161
February	2004	-$313,772
March	2004	$2,517,922
April	2004	$0
May	2004	$0
June	2004	-$255,467
July	2004	-$770,158
August	2004	-$667,740
September	2004	-$516,192
Total		$1,150,816

Minor adjustments were made to monthly volumes in water year 2002 through the AOP process to allow for the potential initiation of the Proposed Action if Paria River sediment inputs occurred and environmental compliance was completed. This had no effect on the annual release volume from Glen Canyon Dam and had a very minor financial impact.

3.13 ENVIRONMENTAL JUSTICE AFFECTED ENVIRONMENT

The Proposed Action does not involve facility construction, population relocation, hazardous waste, property takings, or substantial economic impacts. Neither of the alternatives analyzed in this environmental assessment would have an adverse environmental effect on minority and low income populations as defined by environmental justice policies and directives. The only adverse effects on human health are indirect: i.e., insect stings and insect-vectored disease are known to occur in the Colorado River floodplain and they will continue to occur no matter which alternative is selected. In short, there are no environmental justice implications of the proposed action.

3.14 INDIAN TRUST ASSETS

3.14.1 Affected Environment

Indian trust assets are defined as legal rights to monetary assets that are held in trust by the Federal Government (as trustee) for the benefit of an Indian tribe or tribal members (beneficiaries).

During consultation, the Hualapai Tribe has asserted that their trust lands extend beyond that which the Department of the Interior recognizes as the legal boundary of the Hualapai Reservation. The Hualapai Tribe claims that their trust lands extend to the center of the Colorado River from RM 164 to 274. This is not the position of the United States. If, at some future date, the Federal Government recognized this as Hualapai trust lands it would create about 110 miles of trust lands that would be inundated by high flows or exposed by additional low flows.

Likewise, the Navajo Nation has also described potential trust lands that are not presently recognized by the Department of the Interior. After the issuance of an Executive Order on January 8, 1900, the Navajo Reservation was extended westward to include a portion of Glen and Marble canyons. A second parcel located north of the Little Colorado River and east of the Colorado River was added to the reservation through Congressional Act on May 23, 1930. Both of these parcels terminate in cliffs adjacent to the Colorado River, so they were not considered trust assets by the Department of the Interior. With the establishment of Glen Canyon National Recreation Area and the extension of Grand Canyon National Park to include Marble Canyon, the NPS has assumed jurisdiction over the shorelines and cliffs in Glen and Marble canyons that the Navajo Nation has indicated that it believes are trust resources.

While the Department of the Interior does not recognize either the Hualapai or the Navajo claim to these trust lands, for purposes of this environmental assessment, the potential effects of the No Action and Proposed Action alternatives on these lands are evaluated and displayed for informational purposes.

3.14.2 Environmental Consequences

No Action

For the Hualapai Tribe, the river take-out at Diamond Creek is their most important legally-recognized trust asset within the area potentially affected by the alternatives being considered here. The Hualapai Tribe currently obtains revenues from boaters leaving the Colorado River at this location. The flows ranging from 6,800 to 22,700 cfs in the No Action Alternative should not alter the Hualapai Tribe's ability to manage or profit from this recognized trust resource.

While this environmental assessment has no legal implications with respect to the potential trust lands claimed by the Hualapai Tribe or Navajo Nation, flows in the No Action Alternative were evaluated for the probability of altering future abilities of the tribes to profit from or manage their potential trust lands or resources. Given the location and resources present in these areas, the No Action Alternative would not change the value, use, or enjoyment of any potential Hualapai or Navajo tribal assets.

Proposed Action

Under the Proposed Action, the upper elevation of the Colorado River will encroach on the Hualapai Tribe's boat take-out at Diamond Creek. As shown by the 45,000 cfs flow of 1996, a rise to this elevation in the river level will wet the lower portions of the Diamond Creek take-out, but there will be no lasting change in the tribe's ability to earn fees from river runners using this facility.

Under the Proposed Action, potential trust land identified by the Hualapai Tribe and the Navajo Nation during consultation would be temporarily flooded by the proposed high flow of 42,000-45,000 cfs. Potential trust lands would become exposed if the low 5,000 cfs flows were released. This narrow strip of land between the 5,000 and 45,000 cfs flows does not support grasses or forage that could be used for grazing domestic livestock, nor does it support any other marketable trust asset. Therefore, even if these lands were to be considered official trust lands recognized by the Department of Interior, the status of the land and vegetation as trust assets is dubious. No adverse effect should occur as a result of the Proposed Action.

3.15 CUMULATIVE IMPACTS

Cumulative impacts on the environment result from incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such actions. No non-Federal projects have been identified as either planned, in progress, or completed in the project area between Lake Powell and Lake Mead. Eight other Federal projects, programs, or plans were identified in Chapter 1 as related actions. The proposed action considered in this document may have cumulative impacts when judged from the baseline of the environment with the other related actions.

The GCDAMP has an ongoing monitoring and research program in which regular collections of various physical and biological resources are made. Additional collections of many of these same resources would be made under the Proposed Action. Consequences of these additional collections are considered by permitting agencies and tribes in issuing of scientific collecting permits for this work.

Several management plans in various stages of development are being produced by the

NPS for Glen Canyon National Recreation Area, Grand Canyon National Park, and Lake Mead Recreation Area. In some cases, such as for exotic species control and endangered species protection, management objectives are very similar between the GCDAMP and the NPS. Shared objectives and cooperation among the Federal agencies, state agencies, tribes, and stakeholder groups should result in more effective and efficient management of these resources. The brown trout removal project being undertaken by Grand Canyon National Park is illustrative of shared objectives between the park and other members of the GCDAMP.

There is a slight reduction in frequency of beach/habitat-building flows for the duration of the Interim Surplus Criteria ROD that has a minor impact on the frequency of those flows. The Proposed Action includes experimental high flows of the same magnitude would allow more effective planning and execution of future beach/habitat-building flows.

Power

Water year 2002 has been one of the driest on record and, as it closes, Lake Powell is more than 70 ft below maximum pool. Compared to the No Action Alternative, 93,000 af would be released through jet tubes and bypass the powerplant. This amount of water could generate approximately 41,000 MWh of electricity if not bypassed or about 1.1% of the total Glen Canyon Dam output. Total cost of the Proposed Action Alternative in lost generation or replaced power if the autumn sediment input scenario and habitat maintenance flow scenario occur in the next 2 years is estimated at $1.7 million. This is approximately 0.6% of the estimated $280 million hydropower revenue that will be generated during 2003-2004.

Air Quality

The proposed action would result in more emissions than No Action; however, compared to the typical monthly variation in emissions resulting from differential levels of hydropower generation, the difference would be negligible. The 1.1% less hydropower produced under the Proposed Action Alternative would result in a net increase of SO_2 and NO_x emissions from interconnected powerplants in the region. When compared to the annual variation in emissions due to water availability, however, this increase is not likely to be significant.

3.16 UNAVOIDABLE ADVERSE IMPACTS

Some unavoidable adverse impacts occur to HBC, bald eagle, trout, KAS, and northern leopard frogs. These impacts are described earlier in this chapter. Also, bypassing the powerplant with approximately 15,000 cfs of water for two and a half days would cause an unavoidable loss of power generation of approximately 1.1% of annual hydropower production.

3.17 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Under the proposed action, some cultural resources would be damaged or lost; however, these are not the National Register-eligible properties.

Some endangered KAS are likely to be inundated or displaced downstream under the proposed action. However, no significant impact on the population is anticipated. Also, a small population of leopard frogs in Glen Canyon would be inundated or displaced downstream. There is a good chance that a portion of this population would be lost.

During the test flow, 93,000 acre-feet of water would not be used to generate power through the project's generators. Under the Proposed Action, the opportunity to generate this power at Glen Canyon Dam would be irretrievably lost. This amount of hydropower represents approximately 1.1% of the anticipated hydropower production over the two-year period of the high flow tests.

3.18 IMPAIRMENT TO NATIONAL PARK SERVICE RESOURCES

Based on a comprehensive evaluation of the impacts predicted through the environmental consequences sections and the cumulative effects of ongoing activities, no impairment to the resources of Grand Canyon National Park or Glen Canyon National Recreation Area will occur as a result of the proposed action.

CHAPTER 4.0

Consultation and Coordination

4.1 FISH AND WILDLIFE COORDINATION

Consultation with the Service and coordination with the Arizona Game and Fish Department were conducted throughout the development of the Proposed Action, and they were included in the formulation of the test flow plans. Both agencies participated as part of the AMWG and TWG. The Fish and Wildlife Service Coordination Act report dated June 28, 1994, and the biological opinion dated December 21, 1994—written in connection with the FEIS—both strongly supported the release of high flows and the use of monitoring, research, and experimentation to accomplish the FEIS commitments.

4.2 CULTURAL RESOURCES

Consultation was conducted with the Arizona State Historic Preservation Officer, Hualapai and Navajo Tribal Historic Preservation Officers, and Advisory Council on Historic Preservation, as well as other signatories to a programmatic agreement for cultural resources affected by Glen Canyon Dam operations. The determination of these consulting parties was that no historic properties would be affected by implementation of the preferred alternative. Consultation is ongoing with Indian tribes regarding their traditional cultural properties and sacred sites which might be affected by dam operations or related actions.

4.3 FLOOD PLAINS AND WETLANDS

Executive Order 11988 requires Federal agency avoidance of long- and short-term adverse impacts to flood plains; and Executive Order 11990 requires minimization of the destruction, loss, or degradation of wetlands and preservation and enhancement of the natural and beneficial values of wetlands. The proposed action is part of the research necessary to determine the best management practices for the ecological health and well-being of the flood plains and wetlands of Glen and Grand canyons. The public review required by both Executive Orders has been achieved through the adaptive management process, additional public meetings, and the AOP process.

4.4 DISTRIBUTION LIST

4.4.1 Federal Agencies

Department of the Army
  Corps of Engineers, Dallas, Texas; Salt Lake City, Utah; Phoenix, Arizona
Department of Energy
  Western Area Power Administration, Sacramento, California; Golden and Loveland, Colorado, Salt Lake City, Utah; Phoenix, Arizona
Department of the Interior
  Bureau of Indian Affairs; Hopi Agency, Keams Canyon, Arizona; Truxon Canon Agency, Valentine, Arizona; Navajo Area Office, Gallup, New Mexico; Southern Paiute Field Station, St. George, Utah
  U.S. Fish and Wildlife Service, Phoenix, Arizona; Flagstaff, Arizona; Pinetop, Arizona
  U.S. Geological Survey, Tucson and Flagstaff, Arizona; Boulder, Colorado; Menlo Park, California
  National Biological Service, Fort Collins, Colorado
  National Park Service, Washington, DC; Fort Collins, Colorado; Flagstaff, Arizona; Grand Canyon National Park, Grand Canyon, Arizona; Lake Mead National Recreation Area, Boulder City, Nevada; Glen Canyon National Recreation Area, Page, Arizona; Canyonlands National Park, Moab, Utah
  Office of Environmental Policy and Compliance, Washington, DC
  Office of the Field Solicitor, Phoenix, Arizona
Department of Justice, Denver, Colorado
Environmental Protection Agency, Region VIII, Denver, Colorado; Region IX, San Francisco, California
U.S. General Accounting Office, Washington, DC; Denver, Colorado

4.4.2 State and Local Agencies

Arizona State Government, Phoenix
  Governor
  Commerce Department
  Environmental Quality, Department of
  Game and Fish Department
  State Historic Preservation Officer
  Parks Recreation Council
  Water Resources, Department of
California State Government, Sacramento
  Governor
  Colorado River Board of California, Glendale
Colorado State Government, Denver

Governor
Colorado Water Conservation Board
Nevada State Government, Carson City,
Governor
Interstate Stream Commission
New Mexico State Government, Santa Fe
Governor
Interstate Stream Commission
Utah State Government, Salt Lake City
Governor
Water Resources, Division of
Wyoming State Government, Cheyenne
Governor
State Engineer

4.4.3 Indian Tribes

Havasupai Tribe, Supai, Arizona
Hopi Tribe, Kykotsmovi, Arizona
Hualapai Tribe, Peach Springs, Arizona
Navajo Nation, Window Rock, Arizona
Paiute Tribe of Utah, Cedar City, Utah
San Juan Southern Paiute Tribe, Tuba City, Arizona
Kaibab Band of Paiute Indians, Pipe Springs, Arizona
Zuni Pueblo, Zuni, New Mexico

4.4.4 Schools

Arizona State University, Tempe, Arizona
Northern Arizona University, Flagstaff, Arizona
University of Utah, Salt Lake City, Utah
Utah State University, Logan, Utah

4.4.5 Interested Organizations and Individuals

American Fisheries Society, Bethesda, Maryland; Olympia,Washington; McCall, Idaho; Albuquerque, New Mexico
America Outdoors, Flagstaff, Arizona
American Rivers, Washington, DC
Applied Technology Associates, Inc., Flagstaff, Arizona
Argonne National Laboratory, Lakewood, Colorado; Argonne, Illinois
Arizona Municipal Power Users Association, Phoenix, Arizona
Arizona Nature Conservancy, Tucson, Arizona
Arizona Power Authority, Phoenix, Arizona
Arizona Power Pooling Association, Phoenix and Mesa, Arizona
Arizona River Runners, Phoenix, Arizona
Arizona Wildlife Federation, Mesa, Arizona

Audubon Society, Coordinating Counsel of Utah, Clearfield, Utah; Maricopa, Phoenix, Arizona; Napa-Sonoma, Napa, California; Northern Arizona, Flagstaff and Sedona, Arizona; Prescott, Prescott, Arizona; Yosemite Area Chapter, Mariposa, California
Bio/West, Inc., Logan, Utah
Bountiful City Light and Power Department, Bountiful, Utah
Canyoneers, Inc., Flagstaff, Arizona
Colorado River Resource Coalition, Salt Lake City, Utah; Desert Hot Springs, California
Colorado River Energy Distributors Association, Salt Lake City, Utah; Phoenix, Arizona
Dixie Escalante Rural Electric Association, St. George and Beryl, Utah
Desert Flycasters, Chandler, Arizona
Eco-Plan Associates, Mesa, Arizona
Environmental Defense Fund, Inc., New York, New York; Oakland, California; Boulder, Colorado; Austin, Texas
Friends of the Colorado River, Flagstaff, Arizona
Friends of the River, Inc. (and Foundation), San Francisco and Sacramento, California
Grand Canyon River Guides Association, Flagstaff, Arizona
Grand Canyon Trust, Flagstaff, Arizona
High Country River Rafters, Golden, Colorado
Intermountain Consumer Power Association, Sandy, Utah
Los Angeles Department of Water and Power, Los Angeles, California
Maricopa Water District, Waddell, Arizona
Murray City Power, Murray, Utah
Natural Resources Defense Council, Inc., New York, New York; San Francisco, California
Sierra Club Southwest Office, Phoenix, Arizona
SWCA, Inc., Flagstaff, Arizona
Tri-State Generation and Transmission Association, Inc., Denver, Colorado
Trout Unlimited, Vienna, Virginia; Rocky Mountain Region, Wheat Ridge, Colorado; West Coast Region, Fairfax, California; Arizona Council, Flagstaff, Glendale, and Phoenix, Arizona
Upper Colorado River Commission, Salt Lake City, Utah
Wilderness Society, The, Bethesda, Maryland

Listing of individuals available upon request

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Chris Cutler	Hydrologist	Flow routing
Steve Gloss	Biologist	Biology
Norm Henderson	Ecologist	Recreation, Park resources
Dennis Kubly	Biologist	Biology
Ted Melis	Geologist	Sediment
Tony Morton	Biologist	Biology
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Randall Peterson	Hydrologist	Water, Sediment
Barbara Ralston	Biologist	Vegetation and Wildlife
Tom Ryan	Hydrologist	Water
Mike Yard	Biologist	Food Base

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APPENDIX A

Biological Assessment

INTRODUCTION

The following biological assessment, when considered with the information provided in the accompanying environmental assessment, provides the analysis of the Proposed Action Alternative necessary to comply with Section 7 of the Endangered Species Act of 1973, as amended. In brief, the Bureau of Reclamation (Upper Colorado Region; Reclamation), the National Park Service (Glen Canyon National Recreation Area and Grand Canyon National Park), and the U.S. Geological Survey (Grand Canyon Monitoring and Research Center; GCMRC) propose to conduct experimental releases from Glen Canyon Dam (test flows) in combination with mechanical removal of non-native fish in 2003-2004.

The action agencies seek to provide long-term benefits to native fish and sediment-based resources, and to allow for collection of data for use in determining future dam operations. The Proposed Action Alternative has been developed under the auspices of the Glen Canyon Dam Adaptive Management Program through a cooperative effort among the Grand Canyon Monitoring and Research Center, the Adaptive Management Work Group, the Technical Work Group, the Science Advisors, and participating scientists. The proposed combination of experimental dam releases and non-native fish removal has been developed using knowledge gained in nearly 20 years of research and monitoring of resources in this reach of the Colorado River, first under the Glen Canyon Environmental Studies and now as part of the Adaptive Management Program. It is important to note that the Proposed Action is expected to produce an overall positive benefit to the ecosystem downstream of Glen Canyon Dam, including the endangered species, despite short-term minor impacts to some resources.

Six species identified as threatened or endangered are addressed in this biological assessment: Kanab ambersnail (*Oxyloma haydeni kanabensis*), humpback chub (*Gila cypha*), razorback sucker (*Xyrauchen texanus*), southwestern willow flycatcher (*Empidonax trailii extimus*), bald eagle (*Haliaeetus leucocephalus*), and California condor (*Gymnogyps californianus*). Critical habitat also is considered for humpback chub, razorback sucker, and southwestern willow flycatcher. The list of species is based on discussions with the Fish and Wildlife Service (Service) and previous consultations. Impacts of the test flow and mechanical removal on endangered species may result from: physical displacement, injury, or death; loss or alteration of habitat; reduction in food availability; or alteration of interactions with other species (Reclamation 1995). This assessment summarizes the distribution and abundance, life requisites, and potential impacts of the test flow and mechanical removal on these species and their habitats. Summary affect determinations are provided in table A-1.

Table A.1.—Affect determinations for federally listed species and their critical habitats under the Proposed Action.

Federally Listed Species/ Critical Habitat	Proposed Action
Kanab ambersnail	May affect, likely to adversely affect
Humpback chub w/critical habitat	May affect, likely to adversely affect
Razorback sucker w/critical habitat	May affect, not likely to adversely affect
SW willow flycatcher w/critical habitat	May affect, not likely to adversely affect
Bald eagle	May affect, likely to adversely affect
California condor	May affect, not likely to adversely affect

Kanab Ambersnail Species Account

Experimental releases under the Proposed Action include steady releases, fluctuating releases, and high releases at and above power plant capacity. Depending on the scenario, some of the four proposed flows may occur at more than one time of year. Thus, it is appropriate to evaluate the effects of each of the flows, as they differ in hydrology and in time.

Distribution and Abundance

The genus *Oxyloma* has a broad distribution (North America, Europe and South Africa), but the taxonomy, which previously has been based entirely on internal anatomy and shell morphology, is being revisited through molecular genetic techniques. Two species presently are recognized in the southwestern U.S., *O. retusa* in New Mexico and *O. haydeni* in Arizona and Utah. Within *O. haydeni* there are two subspecies, the Niobrara ambersnail (*O. h. haydeni*) and the Kanab ambersnail (*O. h. kanabensis*). Both are found in Arizona and Utah. Harris and Hubricht (1982) identified both subspecies, as *O. haydeni* and *O. kanabensis*, as occurring in Alberta, Canada, however, subsequent genetic analyses of individuals from these populations suggest they are not closely related to the Arizona and Utah populations (Stevens et al. 2000).

Kanab ambersnail (KAS: Succineidae: *Oxyloma haydeni kanabensis* Pilsbry 1948) is a federally endangered wetland snail that was proposed for emergency listing in 1991 (England 1991a, 1991b) and officially listed in 1992 (England 1992). In the southwestern U.S., extant populations of ambersnails morphologically and anatomically congruent with descriptions of KAS are presently known from two springs: one at Three Lakes, near Kanab, Utah, and the other at Vaseys Paradise, a spring and hanging garden at Colorado River Mile 31.5R, in Grand Canyon, Arizona (Spamer and Bogan 1993a, 1993b). Two populations formerly occurred in the Kanab area, but one population was extirpated by desiccation of its habitat. The remaining Utah population at Three Lakes occurs at several small spring-fed ponds on cattail (*Typha* sp.; Clarke 1991). The Three Lakes site is privately-owned and the land owner is commercially developing the property. Recent genetic studies have revealed departures from identifications of subspecies and populations within the taxon currently recognized as *Oxyloma haydeni*, including the populations of *O. h. kanabensis* at Three Lakes and Vaseys Paradise. Results indicate that the Utah and Arizona populations considered to be the endangered subspecies are not as closely related as was indicated by morphological and anatomical comparisons (Miller et al. 2000, Stevens et al. 2000). The taxon at Vaseys Paradise may well be unique.

KAS was first collected at Vaseys Paradise in 1991 (Blinn et al. 1992) and an interagency team first examined KAS ecology there in 1995 (Stevens et al. 1997). Vaseys Paradise is a popular water source and attraction site for Colorado River rafters; however, access is limited by the dense cover of poison ivy (*Toxicodendron rydbergii)* and the nearly vertical terrain in much of the area (Stevens et al. 1997). Rematched historic photographs of Vaseys Paradise (e.g. Turner and Karpiscak 1980:58-59) reveal that vegetative cover has increased greatly at lower stage elevations since completion of Glen Canyon Dam.

Vaseys Paradise is characterized by a fast-flowing, cool, dolomitic-type spring, with abundant wetland and phreatophytic vegetation, including native crimson monkey-flower and poison ivy, and non-native water-cress. Crimson monkey-flower (*Mimulus cardinalis*) and water-cress (*Nasturtium officinale*) are perennial wetland plants or hydrophytes (Kearney and Peebles 1960). Within the Grand Canyon region, KAS apparently is restricted to Vaseys Paradise. No KAS were observed at more than 150 springs and seeps in tributary canyons to the Colorado River that were surveyed from 1991 to 2000 (Sorensen and Kubly 1997, 1998, Meretsky 2000, Meretsky and North 2000, Webb and Fridell 2000).

Stevens et al. (1997) defined primary habitat at Vaseys Paradise as crimson monkey-flower and non-native water-cress and secondary, or marginal, habitat as patches of other species of riparian vegetation that are little or not used by KAS. Surveys in 1995 revealed rapid changes in vegetation cover over the growing season, with 5.9 percent (%) to 9.3% of the primary habitat occurring below the 33,000 cubic feet per second (cfs) stage, and 11.2% to 16.1 % occurring below the 45,000 cfs stage. Area of primary habitat varied from 850 m^2 to 905 m^2 from March-September 1995. The same vegetation occupied from 7.0 to 12.5% of the area below 45,000 cfs from 1996-1999 following a 45,000 cfs beach/habitat building flow (BHBF) test (GCMRC 1999).

The total estimated Vaseys Paradise KAS population rose from approximately 18,500 snails in March 1995 up to 104,000 snails in September 1995 as reproduction took place in mid-summer (Stevens et al. 1997). The proportion of the total estimated KAS population occurring below the 33,000 cfs stage rose from 1.0% in March to 7.3% in September, and that occurring below the 45,000 cfs stage was 3.3% in March, 11.4% in

June, and 16.4% in September, 1995. Subsequent surveys have reported population estimates of between approximately 5,000 and 52,000 individuals (Interagency Kanab Ambersnail Monitoring Team 1997, 1998 GCMRC 1999, Meretsky and Wegner 1999). Sorensen (2001) analyzed sampling and analytical techniques used for these estimates and concluded that overestimation of actual population size has occurred in monitoring reports. He pointed out that these errors make more difficult the assessment of risk to the population.

Introduction of non-native water-cress and construction and operation of Glen Canyon Dam increased the primary KAS habitat area by more than 40% over the pre-dam area and likely also allowed the increase of KAS by a similar amount. Plants forming primary habitat for KAS previously could not grow at levels below about 90,000 cfs because of recurring, scouring floods in the Colorado River at or above that level. The KAS population at Vaseys Paradise survived and recovered from innumerable similar and higher flows during the pre-dam era, and has survived seven flows in excess of 45,000 cfs during the post-dam era (i.e., 1965, 1980, 1983-1986, and 1996). Two full growing seasons were necessary for regrowth of the area of KAS habitat (vegetation) lost during the 1996 BHBF (Interagency Kanab Ambersnail Monitoring Team 1998). The composition of primary habitat remained different for a longer period as monkeyflower lagged behind water-cress in recovering. Population estimates for KAS have very wide confidence intervals and, therefore, are less useful for comparisons of loss and recovery. Meretsky and Wegner (1999) suspected that by spring 1998 the Vaseys Paradise KAS population had recovered to pre-BHBF levels, however, no measurements were made of individuals above the 100,000 cfs stage. On this basis, short-term reduction in primary habitat area by scouring flows does not appear to affect the long-term integrity of the KAS population.

In September 1998, Kanab ambersnails from Vaseys Paradise were translocated to three new sites in Grand Canyon National Park in an attempt to establish new populations fully protected under the Endangered Species Act. Supplementation of all populations occurred in 1999 and in two of the populations in 2000. The most recent report on the new populations indicates that two may not have been successful, but the third, at Upper Elves Chasm, is self-sustaining. Habitat at Upper Elves Chasm is all above the 100,000 cfs stage of the river and is predominately of monkeyflower and maidenhair fern (*Adiantum capillus-veneris*), with lesser amounts of sedges (*Carex aquatilis*), rushes (*Juncus* sp.), cattails (*Typha* sp.), water-cress, helleborine orchids (*Epipactis gigantea*) and grasses. Total habitat for KAS at this location is approximately 25 m^2. Population estimates have increased from approximately 130 in April 1999 to approximately 1900 in August 2001 (Nelson and Sorensen 2002).

Life Requisites

Demographic analyses based on size class distribution indicated that KAS is essentially an annual species, with much of the population maturing and reproducing in mid-summer (July and August), and most snails over-wintering as small size classes (Stevens et al. 1997, Nelson 2001). In some years with relatively warm winters, more than one reproductive period can occur. Loose, gelatinous egg masses are laid on the undersides of moist to wet live stems, on the roots of water-cress, and on dead or decadent stems of crimson monkey-flower. Summer populations are comprised predominantly of maturing individuals. Adult mortality increases in late summer and autumn leaving the overwintering population dominated by subadults. KAS become dormant in winter, secreting a mucoid plug and attaching themselves to vegetative material or rock surfaces.

Nelson (2001) investigated aspects of the life cycle of KAS from Vaseys Paradise in the laboratory. He found variation in the life history between individuals reared in the laboratory on watercress and those raised on monkey-flower. Snail fecundity and growth rates were greater on water-cress than on monkey-flower, but hatching success, survivorship, size at first reproduction, and size at death were very similar.

Mortality of KAS from dam releases is caused by scouring and sediment deposition over the inundated habitat, and by drowning of ambersnails carried downstream in high flows. No evidence has been found for survival of any individuals carried downstream from Vaseys Paradise by high flows. There are several known sources of mortality for Vaseys Paradise KAS in addition to that caused by dam releases. KAS at Vaseys Paradise are parasitized by a trematode, tentatively identified as *Leucochloridium* sp., with 8.3 to 9.5% of the mature snails expressing sporocysts in August, 1995 (Stevens et al. 1997). Potential vertebrate predators include rainbow trout (*Oncorhynchus mykiss*) in the stream mouth, summer breeding Say's and black phoebe (*Savornis savi* and *S. niaricans*), canyon wren (*Catherpes mexicanus*), winter resident American dipper (*Cinclus mexicanus*), and canyon mice (*Peromyscus crinitus*). A pour-out in the Redwall limestone above Vaseys Paradise drains a portion of the valley above and occasionally produces flash floods that scour and bury KAS habitat and animals. Mortality in laboratory populations occurs predominately in early life stages, whereas in field studies, up to 80% of observed mortality appears to occur during the period of winter dormancy. Extrapolations from laboratory populations indicated that KAS grown on monkey-flower would decline over time, whereas a population grown on water-cress would experience net growth.

Impacts of the Proposed Action Alternative: Experimental Test Flows

8,000 cfs Steady Flows.— KAS is affected by dam releases only when flows rise above the minimum stage at which it occurs. Our most recent information (B. Ralston, personal communication) places the flow for that stage at 17,000 cfs. Thus, 8,000 cfs steady releases will have no effect on KAS.

6,500 to 9,000 cfs Fluctuating Flows.— KAS is affected by dam releases only when flows rise above the minimum stage at which it occurs. Our most recent information (B. Ralston, personal communication) places the flow for that stage at 17,000 cfs. Thus, 6,500 to 9,000 cfs fluctuating releases will have no effect on KAS.

5,000-20,000 cfs Fluctuating Non-Native Fish Suppression Flows.— These releases will occur irrespective of whether sediment triggers are met. If they occur within two years of either a 31,000-33,000 cfs habitat maintenance flow or a 42,000-45,000 cfs high flow, they will have little effect because KAS habitat will have been scoured by the higher flows and not fully regrown. If they occur previous to these flows, or in a no sediment scenario year, there will be a loss of KAS habitat estimated to be less than 10%.

31,000-33,000 cfs Habitat Maintenance Flows.— Under the Proposed Action Alternative, these flows will occur in a year following that of the autumn sediment input scenario, and thus the effect of the July-December habitat maintenance flow will be diminished from what it would have otherwise been if the habitat had not been lost during the previous flow. Based on previous experience this diminishment will disappear in approximately two growing seasons. If KAS habitat has recovered from the preceding autumn sediment input scenario high flow, the habitat maintenance flows, which are to be purposefully combined with a sediment-laden tributary input of from 2,500 cfs to 12,000 cfs, will scour and cover with sediment between 10% and 17% of the KAS primary habitat at Vaseys Paradise.

42,000-45,000 cfs High Flows.— Experimental dam releases of 42,000-45,000 cfs could occur in January, February, or March under the Proposed Action Alternative. With sufficient sediment inputs they could occur in two successive years, a rate that exceeds the once in five year frequency identified in the Glen Canyon Dam EIS (Reclamation 1995). During the normal course of events in any given year, KAS primary habitat is expected to increase somewhat as new growth begins, probably by mid-February. The most proximate estimate for KAS habitat below the 45,000 cfs stage for this evaluation is the April 2002 estimate, which was 117 m^2 (B. Ralston, personal communication), slightly less than the 120 m^2 present in March 1996 prior to the BHBF. Irrespective of which month the experimental spike flow occurs, we expect that it will remove or damage most of the KAS primary habitat and cause mortality of most KAS up to the stage of the flow. The actual number of KAS lost due to the flood will depend greatly on the amount of winter mortality, which can vary dramatically among years dependent on the severity of winter temperatures (Stevens et al. 1997, IKAMT 1998). Based on best available data, the area of primary habitat will not exceed the amount that was present in late March of 1996 when the 45,000 cfs BHBF occurred and thus the amount of incidental take (17%) identified by the Service (2000) will not be exceeded.

In its December 21, 1994, Final Biological Opinion, the Service evaluated impacts to KAS from the operation of Glen Canyon Dam according to operating and other criteria of the preferred alternative contained in the FEIS. The Service determined implementation of the preferred alternative would not jeopardize the continued existence of the Vaseys Paradise KAS population. This opinion also supported the concept of a beach/habitat building flow of 40,000 to 45,000 cfs, which is part of the preferred alternative. At the time of the 1994 biological opinion, the Service thought that 10% of KAS habitat would be lost in a 45,000 cfs flow and set this amount, as vegetation rather than number of snails, to be the expected incidental take. Information obtained in ensuing investigations showed that the incidental take in a 45,000 cfs release could be as much as 17% of KAS habitat (Service 1996), and, pursuant to that finding, the Service adjusted the incidental take to be 17% (Service 2000). The present assessment examines (1) the probability of exceeding the incidental take level during the experimental flows and (2) the potential for higher than maximum power plant releases (beach-habitat building flows) occurring at a frequency exceeding the once in five years assumed for the analysis of impacts used in the FEIS.

Losses of KAS habitat and KAS at Vaseys Paradise are partially offset by the developing population at Upper Elves Chasm. Long-term success of this population cannot be assured, but it has now persisted and grown for four years. The amount of occupied habitat at upper Elves Chasm, estimated at 25 m^2, is approximately 20% of the occupied habitat expected to be temporarily lost at Vasey's Paradise due to the proposed action.

Mechanical Removal of Non-Native Fish

The mechanical removal component of the Proposed Action would not affect the Kanab ambersnail.

Conclusion

Given the above considerations, it is our assessment that the Proposed Action may affect, and is likely to adversely affect, the Vaseys Paradise population of Kanab ambersnail.

Humpback Chub Species Account

Distribution and Abundance

The humpback chub (HBC) is a cyprinid fish species found only in the Colorado River Basin and described by Miller (1946) from specimens collected in Grand Canyon. Earliest evidence of humpback chub in Grand Canyon comes from non-fossilized remains about 4,000 years old that were collected in Stanton's Cave (Miller 1955) at RM 31.5 approximately 46 miles below Glen Canyon Dam. HBC was apparently widely distributed in canyon reaches of the Colorado River, at least down to 24 miles (39 km) below the present site of Hoover Dam (Miller 1955). Present distribution in the Colorado mainstream in Grand Canyon has been reduced about 25% from the pre-dam period and is largely limited to small aggregations of adult fish. Valdez and Ryel (1995) identified nine distinct aggregations in the mainstream Colorado River downstream from Glen Canyon Dam, including: 30-Mile, Little Colorado River (LCR) inflows, Lava/Chuar to Hance Rapids, Bright Angel Creek mouth, Shinumo Creek mouth, Stephens Aisle, Middle Granite Gorge, Havasu Creek mouth and Pumpkin Spring.

The largest aggregation of HBC is located within the LCR. HBC occupy approximately 8 miles of the 12 miles of perennial flowing water in the tributary above its confluence with the Colorado River. Lack of HBC in the upper 4 miles has been attributed to high concentrations of free carbon dioxide from the springs that provide the perennial flows, however Robinson et al. (1996) provided evidence that physical obstructions, i.e. travertine dams, may be precluding occupation of that reach.

HBC was listed as an endangered species in 1967 (32 FR 4001; March 11, 1967) and critical habitat was prescribed in 1994 (Service 1994). Critical habitat includes the

Colorado River in Coconino County, Arizona, from Nautiloid Canyon (RM34) to Granite Park (RM208) and the lower 8 miles of the LCR. Primary constituent elements include water quantity and quality, habitat for spawning, feeding, and rearing, or corridors between these areas, and, in the biological environment, food supply, predation, and competition. Instream alteration, including flow modification, diversion for irrigation, channelization, and fragmentation by reservoirs, and introduction of non-native fish competitors and predators, with their attendant diseases and parasites, have been suggested as being responsible for declining populations of HBC throughout the Colorado River Basin (Colorado River Fishes Recovery Team 1990, Valdez and Carothers 1998).

Five HBC populations remain in canyon-bound reaches of the upper Colorado River basin: Black Rocks and Westwater Canyon in the Colorado River, Cataract Canyon and Desolation/Gray canyons in the Green River, and the Yampa River population. The Grand Canyon population is the only successfully reproducing HBC population in the lower Colorado River Basin (Kaeding and Zimmerman 1983, Valdez and Ryel 1995).

The first population estimate for HBC in Grand Canyon was made by Kaeding and Zimmerman (1982), who gave a rough estimate of 7,000-8,000 individuals larger than 200 mm in the LCR and a 19 mile (32 km) reach of the mainstream in the vicinity of the confluence. Valdez and Ryel (1995) estimated that 3000 to 3500 adult (>200 mm total length) HBC occupied the mainstream Colorado River in 1991-1993, most of which were concentrated within 4.2 miles of the mouth of the LCR. Douglas and Marsh (1996) estimated the LCR population size in 1992 for HBC greater than 150 mm total length at approximately 4,500 individuals, using a closed population model. Since a portion of the HBC population moves back and forth between the LCR and mainstream, some individuals may have been counted twice. Thus, the total population was less than the sum of these estimates. Coggins and Walters (2001) have identified a decline in LCR humpback chub numbers beginning in 1993. Their most recent estimate, for 2001, indicates the population of HBC >150 mm total length in the LCR has declined to about 2100 individuals.

Population estimates have not been made for the mainstream aggregations since 1993, but their numbers are thought to be sustained largely by influx of individuals leaving the LCR population (Valdez and Ryel 1995). The response of HBC to the year 2000 experimental native fish flows can not be determined using the stock assessment approach, because fish hatched in 2000 are not yet recruited to the population. Potential causes of the decline in HBC include: 1) Colorado and Little Colorado River hydrology, 2) infestation of juvenile HBC by Asian tapeworm, 3) predation by or competition with warm-water native cyprinids and catastomids and non-native cyprinids and ictalurids within the LCR, 4) predation by or competition with cold-water non-native salmonids within the Colorado River and (5) perennially cold hypolimnial releases from Lake Powell through Glen Canyon Dam (Service 1994a, Clarkson and Childs 2000, Robinson and Childs 2001, GCMRC 2002b).

Habitat use by HBC varies across age classes. Individual adult HBC demonstrate high microsite fidelity (Valdez and Ryel 1995), but young HBC may drift for relatively long distances (Tuegel et al. 1995). Young HBC in the mainstream commonly use return current channels and other backwater habitats. Backwaters offer low velocity, relatively warm, protected, food-rich habitats when compared to nearby mainstream habitats (Kennedy 1979, Grabowski and Hiebert 1989, Arizona Game and Fish Department 1996, Hoffnagle 1996). HBC use of these habitats in Grand Canyon has been compromised by fluctuating flows and perennially cold dam releases, which reduce warming and create unstable conditions (Maddux et al. 1987, Hoffnagle 1996). Backwater numbers and area generally have been reduced under ROD operations in Grand Canyon, but this process is interrupted by periods of increase in response to changes in hydrology and sediment inputs (McGuinn-Robbins 1995, Stevens and Hoffnagle 1999).

Gorman (1994) found shifts in habitat use among HBC in the LCR of different size and age. As fish grew, they tended to move from nearshore to offshore waters having greater depth, current velocity, average substrate coarseness, and amount of vertical structure. Childs et al. (1998) revealed habitat partitioning among small (<30 mm total length) native fish, including HBC, in the LCR. Subadult HBC in the Colorado River mainstream often use irregular shorelines as habitat, and adult HBC often occur in or near eddies (Valdez and Ryel 1995, Converse 1996). Adult radio-tagged HBC demonstrated a consistent pattern of greater near-surface activity during the spawning season and at night, and day-night differences decreased during turbid flows (Valdez and Ryel 1995).

Life Requisites

The life history and ecology of HBC in Grand Canyon has been intensively studied (Suttkus and Clemmer 1977, Kaeding and Zimmerman 1983, Carothers and Minckley 1981, Maddux et al. 1987, Gorman 1994, Valdez and Ryel 1995, Valdez and Carothers 1998). A key issue is lack of recruitment to the adult population from low survivorship of young fish (Valdez and Ryel 1995). Perennially cold mainstream water temperatures are strongly implicated as being responsible for unsuccessful mainstream reproduction. The minimum water temperature for successful reproduction is 16°C(Hamman 1982, Marsh 1985), well above the commonly observed 10°-12°C summer mainstream temperatures. Mortality of larval and postlarval humpback chub emerging from the warm waters of the LCR has been ascribed to thermal shock and enhanced susceptibility to predation from the more protracted debilitating effects of cold water on swimming ability and growth (Lupher and Clarkson 1994, Clarkson and Childs 2001, Robinson and Childs 2001, Ward et al. 2002).

Sexual maturity of female chubs begins at approximately 250-280 mm total length, which is at about three years of age for HBC in the LCR (Kaeding and Zimmerman 1983). Gonadal development is rapid in the LCR and Colorado River between December and February to April, at which time indices reached highest levels (Kaeding and Zimmerman (1983). Most successful spawning by HBC in Grand Canyon occurs in the lower 8 miles of the LCR from March through May. Adult fish initially stage for spawning runs in large eddies near the confluence of the LCR in February and March. They make spawning runs that average 17 days into the tributary from March through May. Spawning has not been observed, but ripe males have been seen aggregating in areas of complex habitat structure (boulders, travertine masses, and other sources of angular variation), and it is thought that ripe females move to these aggregations to spawn (Gorman and Stone 1999). After spawning, some adult chub return to specific microsites in the mainstream and others remain in the LCR.

As LCR flows decrease, warm, and clear, reproduction increases and larval fish appear (Valdez and Ryel 1995). Young HBC remain in the Little Colorado River, or drift and swim into the mainstream (Robinson et al. 1998) where lack of recruitment is attributed to effects of cold mainstream temperatures and non-native fish predators and competitors (Lupher and Clarkson 1994, Valdez and Ryel 1995, Marsh and Douglas 1997, Clarkson and Childs 2000, Robinson and Childs 2001). During the summer the young HBC that survive in the mainstream occupy low-velocity, vegetated shoreline habitats, including backwaters; however, low survivorship over the year virtually eliminates the young of the year HBC in the mainstream. Therefore, few if any HBC spawned during the previous year are present in the mainstream in March of the following year.

Limited spawning and hatching of HBC occurs in mainstream aggregations. Valdez and Ryel (1995) documented limited spawning success near the warm spring at 30-Mile in upper Marble Canyon. Young-of-year HBC in the size range of 10-30 mm have been collected sporadically at considerable distances below the LCR, usually beginning in June (Kubly 1990, Arizona Game and Fish Department 1996, Brouder et al. 1997). The combination of larval to postlarval sizes and the low probability these fish surviving the extreme rapids of the inner gorge in Grand Canyon suggests strongly that their source was below the LCR. Some limited reproduction may occur in other smaller tributaries. Young HBC have been collected in or near Bright Angel Creek, Shinumo Creek, Kanab Creek, and Havasu Creek (Maddux et al. 1987, Kubly 1990, Arizona Game and Fish Department 1996, Brouder et al. 1997).

Dietary analyses reveal HBC to be opportunistic feeders, largely feeding on algae and aquatic and terrestrial invertebrates (Kaeding and Zimmerman 1982, Kubly 1990, Valdez and Ryel 1995). HBC diet changes over the course of the year in response to food availability and turbidity-related decreases in benthic standing biomass over distance downstream from Glen Canyon Dam (Blinn et al. 1992). Non-native *Gammarus lacustris* occasionally comprises a large proportion of HBC diet, and *Gammarus* selectively feeds on epiphytes (i.e., diatoms) associated with *Cladophora glomerata*, the dominant alga in the upper reaches where clear water conditions often prevail.

Kaeding and Zimmerman (1983) identified 13 species of bacteria, six protozoans, and a fungus from HBC in Grand Canyon. In 1990 the Asian tapeworm (*Bothriocephalus acheilognathi*), an introduced parasite, was first identified from HBC in the LCR (Clarkson et al. 1997). This tapeworm is particularly worrisome, because it infects HBC at a high rate and has been reported to be pathogenic and potentially fatal in a variety of other fish (Hoffman and Schubert 1984, Hoffnagle et al. 2000).

Impacts of the Proposed Action Alternative: Experimental Test Flows

8,000 cfs Steady Flows.—Steady 8,000 cfs releases can occur for two-week periods during the months of September-December, and for up to 10 days following experimental spike releases during the months of January-March. In the first case, they are interspersed with equivalent periods of fluctuating 6,500-9,000 cfs releases. In the latter, they are preceded by experimental spike releases of 42,000-45,000 cfs and followed by non-native fish control releases fluctuating between 5,000 and 20,000 cfs.

Larval and young-of-year HBC that drift or swim out of the tributary into the mainstream and make it to nearshore rearing habitats during the months of June-October would experience more days of stable flow conditions under these releases than under No Action ROD fluctuations. By remaining in these habitats young fish would enjoy warmer water temperatures and a greater abundance and diversity of food resources. Preliminary results from the year 2000 experimental flow research (Fritzinger et al. 2000) indicate that feared large increases of non-native fish in these rearing habitats during steady 8,000 cfs releases were not realized, and that mainstream reproduction was suspected by three native fish—flannelmouth sucker, bluehead sucker, and HBC (Trammell et al. 2001). Larger HBC in offshore eddies might experience some diminishment in organic matter drift during this period, but it is not established how much this species feeds on drift in the current as opposed to benthic matter off of bottom substrates. This flow would not be less than the minimum allowable under ROD operations, and therefore wetted area available for primary and secondary productivity would not be diminished.

The interruption of steady releases at two-week intervals by fluctuating releases differs from the year 2000 experience, and limits the extent to which results from this experiment can be extrapolated. Expectations for changes in rearing habitats during the 6,500-9,000 cfs autumn fluctuating releases are provided below.

Steady 8,000 cfs releases during the period of January-March would have little effect on young HBC, who by this time in their lives have moved into deeper water habitats of eddies adjoining their earlier rearing habitats. Adult HBC in pre-spawning condition are congregated near the mouth of the LCR for at least the early part of this period, but they assumedly are keying more on flows emerging from the tributary than on those in the mainstream. Some diminishment of drifting organic matter could occur relative to No Action ROD fluctuations, however this effect may well be reduced by reduction in the standing crop of particulate matter during the preceding experimental spike release.

6,500-9,000 cfs Fluctuating Flows.—Under the Proposed Action Alternative, these releases can occur for two-week periods from September-December in the autumn sediment input scenario. In this scenario, they would alternate with two week periods of steady 8,000 cfs releases. Anticipated stage changes downstream of Glen Canyon Dam from these fluctuations are from 0.7-1.8 feet depending on location below Glen Canyon Dam (table 3.1). Exact changes in rearing habitats brought about by these fluctuations can not be determined in advance. Past reports of environmental conditions in backwaters reveal that they have warmer water temperatures than the mainstream during summer and autumn months, and that warming of backwaters is diminished by fluctuating flows (Arizona Game and Fish Department 1996, Hoffnagle 1996, Brouder et al. 1997). Backwater habitats also contain much higher densities of planktonic and benthic food organisms than other nearshore habitats accessible to young fish (Kubly 1990, Brouder et al. 1997). Fluctuating flows dewater portions of backwaters at low releases, and in the extreme can temporarily dry them or isolate them from the mainstream. When releases increase, warmer backwaters are infused with cold mainstream water released from the depths of Lake Powell. These cyclical changes disrupt the stability of the rearing environment for young native warm water fish (Kennedy 1979, Ward 1976). The amount of daily change in backwater environments that occurs at fluctuations of 6,500-9,000 cfs will vary dependent on the geometry of the return channel, with those having lesser slopes being more affected.

5,000-20,000 cfs Fluctuating Non-Native Fish Suppression Flows.—Non-native fish suppression flows would occur from January-March under the Proposed Action. Stage changes at stream gages for this release fluctuation are approximately 3.6 ft at Lees Ferry, 5.7 ft at the LCR, and 8.2 ft at Grand Canyon. These fluctuations would exceed those under the No Action Alternative. Major physical changes in environments from these flows are anticipated along shorelines and in shoreward habitats from regular dewatering. Effects on humpback chub will be reduced, however, because most individuals in the mainstream, even if the progeny of the preceding year, will already have moved to deeper habitats further off shore by late autumn. Some local displacement may occur in shallower eddies, potentially resulting in increased energy expenditure for the few fish that would be affected. Survivorship of young-of-year through the winter apparently is very low, however, irrespective of hydrology (Valdez and Ryel 1995). Low survivorship may well be as much a consequence of cold water temperature as of hydrology, although it is clear that these physical parameters are tightly linked, particularly in rearing habitats. Long-term benefits are expected from reduced trout predation as a consequence of these flows.

31,000-33,000 cfs Habitat Maintenance Flows.—Under the Proposed Action, these flows can occur from July-December. For such a flow to occur, a minimum sediment trigger of 500,000 metric tons must be reached, but this trigger could occur more than once in a season. Small native fish, including humpback chub, are present in nearshore rearing habitats from approximately May-October, then as nearshore water temperatures cool and the fish reach juvenile to subadult sizes they move to deeper eddies (Maddux et al. 1987, Converse 1996). Prior to this transition in habitat use, small humpback chub and other native fish could be displaced from rearing habitats by flows of this magnitude. Similar effects were observed after the early September habitat maintenance flow in year 2000 (M. Trammel, SWCA, personal communication). Since few young HBC appear to survive in the mainstream under normal ROD operations, i.e., the No Action Alternative, little additional mortality is expected from these flows.

Anticipated effects on mainstream critical habitat from these flows are that during the flows, rearing habitats formed in soft sediments will be disturbed. Some backwaters will be deepened by erosional processes and others will be partially filled by depositional processes. A desired effect of these flows is the accumulation of fine sediments in eddies and on beaches. It is likely that organic matter, both from the river and of terrestrial origin, will be buried in areas where sediment deposition is predominant. This organic matter may provide important nutrients in local environments through decomposition and nutrient mobilization similar to that seen following the 1996 BHBF (Parnell et al. 1999). Sediment-laden water at high flows also will cover and scour algae, macrophytes, and invertebrates that provide food for native and non-native fish. This effect will be offset at least partially by entrainment of both river-produced and terrestrially-produced organic matter food materials. The duration of the event will be short, and long-term effects on these habitats are expected to be positive.

42,000-45,000 cfs High Flows.—These flows could occur during January-March, a time of year by which surviving young-of-year HBC have moved to deeper eddies. Subadults and adults are expected to be little affected by these larger flows, although they do occur at a time of the year prior to the rise in the predam hydrograph. Little is known about the extent to which HBC rely on changes in flow as a reproductive cue. Valdez and Ryel (1995) held that neither water quantity or quality serve as cues for gonadal development or staging behavior in HBC; rather they hypothesized that climatic factors, such as photoperiod, were important. Humpback chub typically begin to spawn on the receding hydrograph as water temperatures start to rise (Tyus and Karp 1989, Kaeding and Zimmerman 1983, Valdez and Ryel 1995, Kaeding et al. 1990), but the LCR population also spawns in years with little appreciable runoff.

Effects on critical habitat from these flows should be similar to the BHBF of 1996. One difference between the two events will be the amount of fine sediment in the system to be mobilized, but we perceive no significant negative impact on HBC from this change. There will be mobilization and redistribution of fine sediment that forms native fish rearing habitat, but this effect, which is to rejuvenate these habitats, should have a beneficial effect. The anticipated outcome of the high winter flows following a period of sediment conservation is that they will succeed in attaining this desired outcome to a greater extent than the spring 1996 flows.

The Reasonable and Prudent alternative of the 1994 biological opinion (Service 1994) includes habitat/beach building flows; however, the Service determined some HBC would be taken during such an event. The discussion of incidental take in the biological opinion considers testing and studies to determine impacts of flows on young humpback. One goal of the test flow is redistribution of channel bottom sediment to the channel margins to establish and maintain habitats for young life stages of HBC in the mainstream. This hypothesis will be examined through the test flow.

In summary, we anticipate incidental take of HBC and short-term effects on critical habitat as a result of these test flows. The long-term effects on HBC from reduced numbers of deleterious non-native fish and rejuvenated rearing habitats are expected to be positive.

Mechanical Removal of Non-Native Fish

The flow treatments discussed above, as related to non-native fish reduction, center around the hypothesis of improving future HBC recruitment by reducing the number of adult rainbow trout and brown trout residing in the Colorado River downstream of Glen Canyon Dam. Conceptually, this is to be accomplished primarily by reducing rainbow and brown trout recruitment by increasing the early life mortality rate of these fishes with highly fluctuating flows during their winter and spring spawning and rearing seasons. The other experimental treatment calls for the reduction of adult rainbow and brown trout abundance in the Colorado River mainstream near the confluence of the Little Colorado River (LCR) via electrofishing and mechanical removal. The mechanical removal of salmonids and its potential effects on the endangered HBC are described in this section.

GCMRC proposes to use electrofishing as a collection method for this effort. It is important to state here that electrofishing itself is not intended to be lethal to fish but only to disable a fish's normal swimming ability to allow its capture and use for other purposes. GCMRC and its predecessor organizations have developed electrofishing techniques designed specifically to optimize capture and minimize incidental mortality as a result of sampling. They also have a specific set of fish handling protocols. All GCMRC staff and cooperating investigators adhere to these procedures

Two types of electrofishing boats will be utilized. The first is the standard electrofishing boat developed and used during the GCES Phase II research and monitoring effort. The boat is an Achilles SU-16, outfitted with the Coffelt CPS electrofishing system. The second type of electrofishing boat is a rigid hull aluminum sport boat constructed by Osprey. This boat has been recently permitted for use in Grand Canyon National Park and has proven to be a safe and more efficient working platform than the Achilles SU-16. Like the Achilles SU-16, the Osprey boat will be outfitted with the Coffelt CPS electrofishing system.

The Coffelt CPS system generates a pulse train of three 240 Hz, 1.6-ms pulses every 1/15 second and is quite effective at reducing electrofishing induced injuries related to the use of this equipment (Sharber and Carothers 1988, Valdez et al. 1993, Snyder 1992, Cowdell and Valdez 1994, Sharber and Black 1999). Cowdell and Valdez (1994) found hemorrhaging along the spine of two out of 40 adult roundtail chub using the CPS system, but no vertebral damage was observed in lateral xrays. Ruppert and Muth (1997) exposed juvenile humpback chub and bonytail to electrofishing and found no significant difference in results for the two species. They found no mortalities, external injuries, or vertebral injuries in any of the fish. Spinal hemorrhages were found in 13% (46 of 360) of shocked bonytails. Only one treatment could be applied to the few HBC available for that test. In that test, using CPS, 6 of 30 treatment HBC and 1 of 30 control HBC had spinal hemorrhages. Hemorrhages were described as class 2 with wounds on the spine being the width of two or less vertebrae and ranged from one to eight per fish. In all experiments, fish subjected to enough electricity to induce strong muscle contractions produced more injuries than those subjected to an amount causing paralysis. Early life stages of HBC have not been subjected to electrofishing experiments. Embryos and larvae of razorback sucker have been studied by Muth and Ruppert (1996).

They found reduced survival in embryos and diminished growth in larvae subjected to electrical current.

The effort will be conducted in habitat used by humpback chub and an unknown number of humpback chub will be collected. Precise numbers of chub captured cannot be determined *a priori*. However, GCMRC has considerable data from previous electrofishing efforts in the LCR reach that allow estimation of the likely range of capture rates. The following table A-2 presents projected humpback chub electrofishing capture data from the LCR reach of the Colorado River based on data from an approximately 10-year period for river miles 61-65. This area does not correspond precisely to the intended 9.5 mile mechanical removal area for non-native salmonids, which is somewhat larger. We believe HBC are less abundant in the additional reach included for mechanical removal procedures and HBC numbers have declined in the last 10 years. Therefore, the range of capture rates presented here is biased high and may be up to two times the actual catch rates for HBC.

Table A-2.—Projected HBC captures for each trip from the LCR reach of the Colorado River.[1]

		CPUE/10 hrs[2]		CATCH (number)	
	Effort (trip hrs)	HBC <200mm	HBC ≥200mm	HBC <200mm	HBC ≥200mm
Mean	320	11.94	0.45	382	15
Median	320	5.16	0.27	165	9
Minimum	320	0.00	0.00	0	0
Maximum	320	89.15	5.61	2853	180

[1] Projections based on electrofishing data from an approximately 10 year period for a 5-mile reach of the Colorado River around the confluence with the LCR (River Miles 61-65).

[2]CPUE refers to the number of individuals collected in a unit of time, herein 10 hours.

Captures of adult (HBC ≥200mm) are estimated to range from a mean derived value of 15 to a high of 180 fish per trip. Juvenile and sub-adult capture rates would be higher, ranging from perhaps 165 to 2853 fish. It is not possible to estimate precisely what rate of incidental mortality might be incurred in these fish. We have little evidence of direct mortality resulting from electrofishing sampling of HBC. It is GCMRC's supposition that median values from historical data represent the best projected numbers for likely capture rate. The following table A-3 provides a summary of the planned removal trips.

All HBC captured will be handled according to procedures specified in the GCMRC fish handling protocol and marked as appropriate for research purposes, which will yield additional information regarding this population. GCMRC estimates that one-quarter of 1 percent of juvenile fish may suffer mortality from electrofishing and that less than 1 percent of adults will suffer mortality. Using median capture values this would represent a take of less than one-tenth adult fish per trip and less than one-half a juvenile fish per trip. Reasonable limits on lethal incidental take for all trips combined during 2003 and 2004 might be 10 adult and 50 juvenile fish.

Table A-3.—Summary of sampling schedule for rainbow and brown trout mechanical removal trips, 2003-2004.

Trip Type	Trip Date	FY-Year	Trip Length	Electrofishing Passes/Trip
Electrofishing Depletion	15 – 30 Jan	2003	15 - day	5
Electrofishing Depletion	15 – 30 Feb	2003	15 - day	5
Electrofishing Depletion	15 – 30 March	2003	15 - day	5
Electrofishing Depletion	1- 15 Jul	2003	15 - day	5
Electrofishing Depletion	1- 15 Aug	2003	15 - day	5
Electrofishing Depletion	1- 15 Sept	2003	15 - day	5
Electrofishing Depletion	3 trips Jan-Mar	2004	15 - day	5
Electrofishing Depletion	3 trips Jul-Sep	2004	15 - day	5

Based on literature findings, effects from electrofishing on individuals will vary by degree of exposure and size. The principal intended consequence of the proposed activity is to benefit HBC. Nevertheless, some incidental take of HBC may occur as a consequence the mechanical removal of non-native fish by electrofishing.

Other Related Actions

The GCMRC, in its role as provider of technical and scientific information to the Glen Canyon Adaptive Management Program, participates in and/or coordinates monitoring activities intended to provide information regarding the status and trends of fish species in the Colorado River and its tributaries in Grand Canyon. Cooperators in these activities are the Arizona Game & Fish Department, the U. S. Fish & Wildlife Service, and the consulting firm SWCA, Inc. Each of these parties holds research permits pertaining to its activities. Although personnel from all of the organizations participate in sampling trips in a reciprocal manner, each organization has a lead responsibility for certain monitoring activities under contract with GCMRC. The planned sampling trips are detailed in table A-4. Some adjustment of these sampling dates may be necessary to avoid overlapping with the mechanical removal analyzed in this biological assessment. Adjustments will be made as needed to ensure that sampling activities occur at least 2-4 weeks earlier or later than electrofishing mechanical removal efforts, since the additional research being conducted through GCMRC also will involved capture and handling of HBC. The sampling schedule for this work is based on six Colorado River mainstem trips and five trips in the Little Colorado River during 2003, and four Colorado River mainstream trips and six trips in the Little Colorado River during 2004.

Table A-4. Related research and monitoring field trips for sampling of endangered humpback and other fishes in Grand Canyon during 2003-2004.

2003-Trip No.	Location	Date	Description	Agency
2003-1	Mainstream CR	January	juvenile humpback chub mortality monitoring	USFWS
2003-2	Mainstream CR	February	trout and carp monitoring	AGFD
2003-3	Mainstream CR	April	trout and carp monitoring	AGFD
2003-4	LCR	April	humpback chub mark-recapture	USFWS
2003-5	LCR	April-May	humpback chub lower 1200 m monitoring	AGFD
2003-6	LCR	May	humpback chub mark-recapture	USFWS
2003-7	LCR	September.	humpback chub mark-recapture	USFWS
2003-8	LCR	October	humpback chub mark-recapture	USFWS
2003-9	Mainstream CR	July	native fish monitoring	SWCA
2003-10	Mainstream CR	September	native fish monitoring	SWCA
2003-11	Mainstream CR	November	juvenile humpback chub mortality monitoring	USFWS

2004/Trip No.	Location	Date	Description	Agency
2004-1	Mainstream CR	14-Feb – 4 Mar	trout and carp monitoring	AGFD
2004-2	Mainstream CR	4 – 21 Apr	trout and carp monitoring	AGFD
2004-3	LCR	8 - 19 April	humpback chub mark-recapture	USFWS
2004-4	LCR	18 April – 24 May	humpback chub lower 1200 m monitoring	AGFD
2004-5	LCR	13 – 24 May	humpback chub mark-recapture	USFWS
2004-6	LCR	24 Jun – 3 Jul	catfish and carp gear evaluation	AGFD
2004-7	Mainstream CR	17 July –2 Aug	native fish monitoring	SWCA
2004-8	Mainstream CR	11-27 Sep	native fish monitoring	SWCA
2004-9	LCR	16 - 27 Sept.	humpback chub mark-recapture	USFWS
2004-10	LCR	21 Oct. - 1 Nov	humpback chub mark-recapture	USFWS

Conclusion

It is our conclusion that the Proposed Action Alternative may affect, and is likely to adversely affect, humpback chub and its critical habitat. Both humpback chub and the biological component of its critical habitat are expected to benefit in the future from removal of these non-native fish.

Razorback Sucker Species Account

Distribution and Abundance

Razorback sucker (RBS; Catostomidae) is part of the highly endemic native fish fauna of the Colorado River Basin. RBS formerly occurred throughout the Colorado River, from Wyoming to northwestern Mexico, (Minckley et al. 1986), but its distribution has declined dramatically since 1930 with the increasing fragmentation and regulation of the Colorado River (Dill 1944, Minckley 1991). The decline of RBS has been attributed to water temperature changes, altered spawning habitat, fragmentation of river systems by reservoirs, and introduction of non-native fish species, which have cumulatively resulted in wide-scale recruitment failure (Bestgen 1990, Minckley 1991). The species is listed as endangered with critical habitat under the Endangered Species Act (Service 1991, 1994b). Critical habitat includes the Colorado River and its 100-year flood plain from the confluence with the Paria River to Hoover Dam, including the full pool elevation of Lake Mead. Primary constituent elements include water quantity and quality, habitat for spawning, feeding, and rearing, or corridors between these areas, and in the biological environment, food supply, predation, and competition.

The largest RBS population in the Lower Colorado River Basin exists in Lake Mohave. That population was estimated to be approximately 60,000 fish in 1989 (Marsh and Minckley 1989), but it has declined considerably since that time (Marsh 1994). A second RBS population of approximately 500 individuals occurs in Lake Mead. In the Upper Colorado River Basin, RBS occurs regularly in the upper Green and lower Yampa rivers (Tyus 1987). RBS have been collected at rare intervals in the Colorado River near Grand Junction, Colorado, and in the major tributary arms of Lake Powell. Most wild-caught RBS are old individuals (RBS live from 20 to 50 years), and recruitment failure may lead to the rapid demise of this species (McCarthy and Minckley 1987, Minckley 1991). Experimental releases in the Upper Basin and attempts to propagate RBS in Lower Colorado River Basin reservoirs are encouraging, but the predam remnant mainstream populations continue to decline.

Based on available literature, RBS is very rare in Grand Canyon and genes from the taxon are present largely in hybrids with flannelmouth sucker (Douglas and Marsh 1998). Some fish biologists speculate that this species was never more than a transient member of the native fish fauna there (Minckley 1991, Douglas and Marsh 1998). Recent observations are those of Carothers and Minckley (1981) who reported four RBS from the Paria River in 1978-1979. Maddux et al. (1987) reported one blind female RBS at

Upper Bass Camp (Colorado River Mile 107.5) in 1984, and Minckley (1991) reported records of 5 additional RBS captured in the lower Little Colorado River from 1989-1990. Putative hybrids between flannelmouth sucker (Catostomus latipinnis) and RBS have been reported from the Little Colorado River (Suttkus and Clemmer 1979, Carothers and Minckley 1981). Douglas and Marsh (1998) confirmed the presence of such hybrids and estimated their numbers between 8 and 136.

The population of RBS in Lake Mead has been studied since 1996 (Holden et al. 2000). During the first four years, 115 individuals were collected, not counting larvae. In August 1999, an adult RBS was found in upper Lake Mead at the western side of the mouth of Grand Wash. This discovery was followed in 2000 by collection of larval RBS in the far eastern part of Lake Mead. Holden et al. (2000) concluded that "spawning occurred in the lake, either near the Colorado River inflow area or in the actual Colorado River before it enters the lake." Douglas and Douglas (2000) reported a larval RBS identified by the Colorado State University Larval Fish Laboratory from collections made at the mouth of Havasu Creek in Grand Canyon. They admitted the possibility that this could have been of a hybrid between RBS and flannelmouth sucker, but noted that all known hybrids occur considerably higher in the system, in Marble Canyon and the LCR.

Life Requisites

RBS are generally associated with calm river reaches, and since damming of the Colorado River, with reservoirs (Tyus 1987). Riverine spawning typically occurs in shallow water over gravelly substrates, often in areas of inflowing streams where gravel sorting has occurred (Minckley 1983, Mueller 1989). RBS spawn earlier in the season than do most other native, warm water Colorado River fish (Minckley 1973, 1991). Lake Mohave RBS spawn from November into May, with the peak of spawning activity between January and March when water temperatures are in a range from 10-15°C (50 to 59°F) (Bozek et al. 1984). Marsh (1985) demonstrated in the laboratory that the highest successful hatching percentage for RBS occurs at 20°C, and that the hatch declines considerably at 15°C with complete mortality at 10°C. In riverine situations in the Upper Basin, RBS begins spawning on the rising limb of the spring (April-May) hydrograph and continues for an extended period through the spring runoff. Although spawning occurs throughout the day, it is most intense at dusk.

Larval RBS drift downstream from the spawning habitat, using quiet shorelines, and concentrate in warm, low-velocity areas (e.g. flooded bottoms). These areas also support post-larval RBS. Mainchannel and mid-stream river habitats floored by fine-grained alluvium are important to subsequent RBS life stages (Minckley 1983, 1991, Tyus and Karp 1989). Springtime concentrations of adult RBS have been noted in side-channels, off-channel impoundments, and in tributaries (Bestgen 1990, Minckley 1991). The optimal thermal range for RBS is 22-25°C (72-77°F) (Bulkley and Pimentel 1983); however, RBS occurs in widely varying temperatures. RBS habitats in the Upper Colorado River Basin are ice-covered during winter, while the temperatures of mainstream habitats in the Lower Colorado River exceed 32°C(90°F) in summer (Dill 1944).

RBS diet varies by age class and habitat type, but few data are available on the diet of larval and juvenile RBS (Bestgen 1990). Larval RBS are known to feed on phytoplankton and zooplankton, and (in fluvial habitats) on chironomid larvae. Papoulias and Minckley (1990) determined densities of plankton leading to starvation in larval RBS in the laboratory. Adult RBS in lentic habitats engage in both planktivorous and benthic feeding on a variety of zooplankton, phytoplankton, filamentous algae, and detritus (Marsh 1987), while adult RBS in rivers feed primarily on benthic algae and invertebrates (Banks 1964).

Growth among individuals in the same cohort is highly variable (Minckley et al. 1991), and this variation may represent divergent strategies in this long-lived fish for dealing with the highly unpredictable environment of desert rivers in southwestern U.S. Growth is rapid for approximately the first six years, but then it slows dramatically (McCarthy and Minckley 1987).

A variety of bacteria, protozoans, cestodes, trematodes, nematodes, and copepods is known to infect RBS, but there seems to be little overall impact on health or mortality (Minckley et al. 1991). Many captured individuals are aged and afflicted with tumors, blindness or other maladies (Minckley 1983, Bestgen 1990).

Predation on RBS by non-native fish, primarily ictalurids, is well documented (Marsh and Brooks 1989). Larval RBS are highly susceptible to predation by non-native fish and invertebrates (Marsh and Langhorst 1988, Horn et al. 1994), but there is evidence that their susceptibility can be lessened by turbidity from suspended sediments (Johnson and Hines 1999). Recent efforts at conservation include rearing fish in grow out ponds to a size where predation is reduced and then placing them in reservoirs.

Impacts of the Proposed Action Alternative: Experimental Flows

8,000 cfs Steady Flows.—Steady releases that follow spawning by any remaining RBS in Grand Canyon would provide one of the required elements for successful RBS rearing, but even with steady releases, larval fish in the mainstream would face challenges of limited rearing habitat. Flooded bottomlands that are characteristic rearing habitat for this fish are largely lacking in Grand Canyon. Also, no tributaries in the affected reach appear to have suitable conditions for successful spawning and rearing by RBS.

6,500-9,000 cfs Fluctuating Flows.—Under the Proposed Action Alternative, these releases could occur between September and January, alternating in two-week long releases with steady 8,000 cfs releases. Any backwaters inhabited by larval RBS would be subject to daily inflow of cold mainstream water under the fluctuating releases. Larval fish displaced from backwaters would likely enter the drift and be transported downstream through major rapids. Individuals that survived the physical challenges of transport also would be subjected to predation by non-native fishes.

5,000-20,000 cfs Fluctuating Non-Native Fish Suppression Flows.—Under the Proposed Action Alternative, these releases are implemented during January–March and are independent of sediment inputs. They follow either ROD operations or the 8,000 cfs releases that have followed a 42,000-45,000 cfs peak release. There would likely be little effect on RBS as the releases would precede spawning and any subsequent occupation of backwater habitats by juvenile RBS.

31,000 cfs-33,000 cfs Habitat Maintenance Flows.—Under the Proposed Action Alternative, these flows could occur anytime between July and January and would last for two days. Any backwaters inhabited by larval RBS in late summer or early autumn would likely be converted to eddies as stage increased. They and other nearshore habitats would be subjected to large increases in current velocity. Larval fish displaced from backwaters would likely enter the drift and be transported downstream through major rapids. Individuals that survived the physical challenges of transport also would be subjected to predation by non-native fishes.

42,000-45,000 cfs High Flows.—Almost all RBS remaining in Grand Canyon are likely mature or senile fish, which survived comparable or higher mainstream flows in 1965, 1980, 1983-1986, and 1996. Based on the decline in the Lake Mohave population, very few RBS hatched prior to emplacement of Glen Canyon Dam are likely to be alive in 2002. If older fish do exist in Grand Canyon, they are likely capable of finding suitable refugia from high flows and unlikely to use nearshore areas affected by fluctuating flows.

If there are reproductively active RBS in Grand Canyon, an experimental high flow in January-March might serve as an environmental cue for spawning. This high flow would also be experienced by RBS in upper Lake Mead. However, historically, RBS in Grand Canyon most likely received their cue to begin spawning on the rising limb of the spring (April-May) hydrograph. Also, the short duration of the flow (60 hours) would contrast greatly with the long-term winter snowmelt peak of the pre-dam era, and it may not evoke any change in RBS behavior or physiology.

RBS feed on a wide variety of planktonic and benthic food sources. Dam releases under the proposed action may result in positive effects to the RBS food base. Results of the 1996 beach/habitat-building flow showed two major responses in eddy recirculation zones: (1) deposition and infilling in many small recirculation zones, and (2) extensive scouring of low elevation deposits in large recirculation zones (Hazel et al. 1999). Deposited fine sediments buried organic matter produced in the river and subsequent decomposition of this organic matter produced enriched nutrients that stimulated primary production (Parnell et al. 1999). Similar effects from the proposed action releases could increase the size and depth of larger backwater rearing habitats and increase their productivity in months following the high release.

Mechanical Removal of Non-Native Fish

The potential effect of mechanical removal of non-native fish on RBS is largely dependent on the probability that individuals will be in the zone of electrofishing effect. Minckley (1991) reported five RBS collected from the mouth of the LCR in 1989-1990. We know of no meristic or genetic analyses conducted on these specimens to ascertain whether they were pure RBS or RBS-flannelmouth sucker hybrids. Valdez and Ryel (1995) collected 2,197 adult flannelmouth suckers, five adult hybrids, and no RBS from the mainstream during 1990-1993. Douglas and Marsh (1998) reported 41 putative RBS/flannelmouth sucker hybrids from 2619 unique individuals collected in the LCR from 1991-1995. Twelve of 41 individuals were examined genetically by restricted endonuclease analysis of mtDNA and nine of these were assayed electrophoretically. Of the nine, eight were of hybrid origin and the remaining individual was a flannelmouth sucker. In their discussion, Douglas and Marsh (1998) discussed difficulties of field personnel in consistently identifying these individuals as flannelmouth, razorback, or hybrids.

Adult RBS use a wide variety of habitats, including eddy complexes and runs that would be sampled during the mechanical removal effort. If present, individuals could be subjected to electrical shock at a rate similar to that experienced by HBC. Unlike HBC, however, RBS do not exhibit high site fidelity and thus the potential for multiple exposures to electricity should be reduced in RBS. Based on published reports cited above as evidence of the rarity of RBS in Grand Canyon, it appears very unlikely that any pure RBS will be in the vicinity of the LCR during the period of mechanical removal in 2003-2004. In addition, reduction of the salmonid population in the reach of the Colorado River above and below the confluence with the LCR could reduce predation on RBS or hybrids of RBS that occur in Marble and Grand canyons.

Conclusion

Based on the information above, we conclude that the Proposed Action Alternative may affect, but is not likely to adversely affect, RBS or its critical habitat.

Southwestern Willow Flycatcher Species Account

Distribution and Abundance

The southwestern willow flycatcher (Tyrannidae: Empidonax traillii extimus) was added to the federal endangered species list on February 27, 1995 (Service 1995). A draft recovery plan was published in April of 2001 but has yet to be finalized. In 1997, critical habitat was designated along the Colorado River from River Mile 39 to River Mile 71.5 below Glen Canyon Dam (Service 1997). The boundaries of critical habitat include the main river channel and associated side channels, backwaters, and pools and marshes throughout the March to September breeding season, as well as areas within 100 meters of the edges of the surface water.

The southwestern willow flycatcher (SWWF) is a neotropical migrant with a broad breeding range, extending from Nova Scotia to British Columbia and south to Baja California. The SWWF is an obligate riparian insectivore, preferring habitat near open water, marshes, or backwaters (Gorski 1969, Sogge 1995). The historic breeding range includes Arizona, New Mexico, western Texas, southern California, and southern portions of Nevada, Utah, and perhaps southwestern Colorado (Service 1993). It winters from Mexico to Panama, with historical accounts from Colombia (Phillips 1948). The SWWF is distinguished from other subspecies by distribution, morphology and color, nesting ecology, and possibly by song dialect (Aldrich 1953, King 1955, Phillips 1948, Sogge 1995).

Although never common, SWWF population declines have been noted for nearly 50 years, corresponding with loss and modification of riparian habitats (Phillips 1948). Southwestern riparian ecosystems support a rich avian fauna (Johnson and Haight 1987) and habitat changes have resulted in reduction or extirpation of many avian species. Modification and fragmentation of these systems through development and livestock grazing have precipitated devastating changes to SWWF populations. Destruction of native willow/cottonwood vegetation has provided opportunity for invasion by non-native plant species, notably tamarisk or saltcedar (Tamarix ramosissima). Habitat fragmentation and modification has benefited some southwestern avian species, especially cowbirds (Molothrus sp.), which parasitize SWWF nests, thus contributing to the precipitous population declines of SWWF (Brown 1994, Johnson and Sogge 1995, Sogge et al. 1995a). SWWF habitat loss in Central and South America also has undoubtedly contributed to recent SWWF population declines.

The SWWF has been extirpated from much of its former range (Hunter et al. 1987) and has experienced a sharp reduction in abundance since 1950. The SWWF is more rare than most other currently listed avian species (Unitt 1987). An estimated 915 territories exist in the United States (Service 2001). It has been given endangered species status by the Game and Fish Departments in Arizona, New Mexico, and California.

SWWF arrive in the Grand Canyon area in mid-May, but may be confused with another subspecies, the more common E. t. brewsteri, which migrates through to more northern breeding grounds (Aldrich 1951, Unitt 1987). E. t. brewsteri sings during migration, making sub-species distinctions difficult until mid-June (Brown 1991b). Males arrive earlier than females and set up territories. The characteristic territorial call is a "fitz-bew," most frequently heard in the morning before 10 AM (Tibbitts et al. 1994). The four subspecies may be differentiated by characteristics of this call.

Distribution of the Grand Canyon population fluctuates between Colorado River Miles 47 and 54, and at River Mile 71 (Sogge et al.1995a, Tibbitts and Johnson 1999, Tibbitts and Johnson 2000, Unitt 1987). Nesting SWWF were common in Glen Canyon in the 1950s (Behle and Higgins 1959). This area was inundated by Lake Powell, and no singing male SWWF were detected in a 1991 survey below Glen Canyon Dam (Brown 1991a). In an earlier six-year study, Brown (1988) noted a brief population increase in the Grand Canyon from two in 1982, to a maximum of 11 (two in Cardenas Marsh), with a subsequent decline to seven in 1987. Only two pairs were noted in 1991 (Brown 1991b). Surveys in 1992 detected seven SWWF. In 1999 and again in 2000 and 2001, a single nesting pair was detected and monitored (Tibbitts and Johnson 1999; Johnson and Abeita 2000). This site of this nesting has been occupied annually since 1993 (table A-5). The 1999 and 2000 nest was located within several meters of the locations of the nests located in this patch in 1993-1998.

The year 2001 marked the fourth consecutive year in which surveys located a single breeding pair and no unpaired adult willow flycatchers in the Grand Canyon. These last four years represent the lowest population levels since surveys began in 1982. The continued presence of the SWWF in the Grand Canyon appears
to be tenuous (Tibbitts and Johnson 1999, Johnson and Albeita 2000). The number of resident adults available to breed has steadily decreased since a high point of 8 and 9 (in 1993 and 1994, respectively) to a single pair in 1998 through 2001.

SWWF return to wintering grounds in August and September (Brown 1991b). Willow flycatchers have strong winter site fidelity (Koronkiewicz and Sogge 2000). Recent survey and ecology work (Kornonkiewicz and Whitfield 1999, Lynn and Whitfield 2000, Koronkiewicz and Sogge 2000) suggests that wintering flycatchers are not habitat generalists and that suitable and/or high quality wintering habitat is very rare on a landscape level.

Life Requisites

SWWF are highly territorial. Nest building begins in May after breeding territories are established. The nest is placed in a fork or horizontal branch 1-5 meters above ground (Tibbitts et al. 1994). A clutch of three or four eggs is laid from late May through July; in Grand Canyon two or three eggs (usually three) are the norm (Sogge 1995). Breeding generally extends into mid-July but may continue into August.

After a 12-14 day incubation, nestlings spend 12 or 13 days in the nest before fledging (Brown 1988, Tibbitts et al.1994). One clutch is typical, however re-nesting has been known to occur if the initial nest is destroyed or parasitized (Brown 1988).

Riparian modification, destruction and fragmentation provide new foraging habitat for brown-headed cowbirds (*Molothrus ater*) and populations of brown-headed cowbirds continue to expand (Hanka 1985, Harris 1991). Brood parasitism remains one of the greatest threats to SWWF and probably many other neotropical migrants (Bohning-Gaese et al.1993, Sogge et al.1995a). Over half the nests in Brown's study (1988) contained brown-headed cowbird eggs. Cowbirds may remove flycatcher eggs, but their eggs also hatch earlier and the larger cowbird nestlings are more competitive in the nest. Brown-headed cowbirds occur extensively around mule corrals on the rim of the canyon and travel down to the Colorado River.

The SWWF breeds and forages in dense, multistoried riparian vegetation near surface water or moist soil along low gradient streams (Whitmore 1977, Sferra et al. 1995, Sogge 1995). Nesting in the Grand Canyon typically occurs in non-native tamarisk approximately 4-7 meters tall (13-23 feet), with a dense volume of foliage 0-4 meters from the ground (Tibbitts et al. 1994). While tamarisk is ubiquitous along the river corridor, the few sites occupied by SWWF are somewhat distinct. In these locations, the tamarisk thickets tend to extend relatively far back from the riverbank, in the range of approximately 30 to 50 meters, and are comprised of dense stands of large, old tamarisk. This contrasts with most of the river corridor, where tamarisk thickets exists as relatively narrow strips close by the water’s edge. From above, occupied thickets tend to be broad oval or crescent-shaped areas and have a much greater ratio of interior volume to edge when compared to the thin, linear strip of tamarisk that are common throughout the corridor. Occupied sites also tend to have relatively quiet water, and/or eddies adjacent to them, and notable growths of emergent aquatic vegetation (*Equisetum sp*., *Scirpus* sp.) at the edge of the habitat patch (Tibbitts and Johnson 1999, Johnson and Albeita 2000).

Table A-5.—History of occupied willow flycatcher sites from 1992-2000[1] in Grand Canyon National Park, Arizona.

Site	1992	1993	1994	1995	1996	1997	1998	1999	2000
RM 46.5 R	Vacant	2 single. Banded.	Vacant	Vacant	Vacant	Vacant	Vacant	Vacant	Vacant
RM 50.5 L	Vacant	Polygynous and 2; fledged 1 BHCO	2 pairs; failed	Pair (fledged 1 WIFL) Single	Pair (fledged 1 WIFL) Single	Pair (fledged 1 BHCO) Single	Pair w/ 3 nestlings, fledge unlikely	Pair w/ wifl nestlings, outcome unknown	Pair w/1 bhco, 2 wifl nestlings, fledged 1 wifl
RM 51.4 L	Single ?	Vacant	2 pairs; failed	Single	Single	Single	Vacant	Vacant	Vacant
RM 65.3 L	Vacant	Not surveyed	Single	Single	Vacant	Vacant	Vacant	Vacant	Vacant
RM 71.1 L	2 pairs; 3 young fledging	Pair (failed) Single	Vacant	Vacant	Vacant (Single on 1 June visit)	Vacant	Vacant	Vacant	Vacant
RM 72.0 R	Vacant	Vacant	Vacant	Vacant	Vacant	Vacant	Vacant	Vacant	Single
RM 195.5 R	Vacant	Vacant	Vacant	Vacant	Vacant	Vacant	Vacant	Vacant	Single
Total Adults[2]	5	8	9	5	4	4	2	2	4
Adult Pairs	2	2.5	4	1	1	1	1	1	1
Young Fledged	3	0	0	1	1	0	0	1?	1

[1] Table from Johnson and Albeita, 2000. Sources for data are: Sogge and Tibbitts 1992, Sogge et al. 1993, Sogge and Tibbitts 1994, Sogge et al. 1995a, Petterson and Sogge 1996, Sogge 1998 (for 1997 data), Tibbitts and Johnson 1999 (for 1998 data), Johnson and Albeita, 2000.

[2] Resident adults detected on more than one visit (likely migrants excluded).

Proximity to standing water, exposed sand bars, or nearby fluvial marshes appears to be an important component of SWWF habitat and may be related to food supplies. The SWWF is primarily an insectivore that feeds on a variety of winged, and, to a lesser extent, non-flying insects (Droust et al. 1997). It typically hovers and gleans insects from foliage, or catches flies from conspicuous perches. SWWF also forage on sandbars, near backwaters, and at the waters edge in the Grand Canyon (Tibbitts et al.1994).

Impacts of the Proposed Action Alternative

Experimental Test Flows

8,000 cfs Steady Flows.—The 8,000 cfs steady releases are anticipated to have no direct effects to SWWF as this species completes nesting by fall and fledglings would be almost fully independent by the time these releases would occur. Analyses of the effects of the steady 8,000 cfs experiment conducted during summer of 2000 are not yet available to assist in predicting what effects steady releases at 8,000 cfs would have on the riparian community and thus on SWWF habitat. Based on observations of the effects of similar steady flows in the past, it is likely that there would be no affect on SWWF or SWWF critical habitat from this component of the proposed action alternative.

6,500 to 9,000 cfs Fluctuating Flows.—Effects to SWWF from the 6,500 to 9,000 cfs fluctuating releases would be similar to the 8,000 cfs steady releases test. Like the 8,000 cfs releases, these fluctuating releases would occur in the fall and would be too low to reach nests or nestlings; therefore no affects to SWWF or SWWF critical habitat are anticipated.

5,000-20,000 cfs Fluctuating Non-Native Fish Suppression Flows .—Tamarisk nest stands are extremely resistant to desiccation and would not be negatively affected by the low flows or rapid ramp rates in the daily fluctuations. High flows of 20,000 cfs are well below the level necessary to directly remove nests or affect fledglings and nestlings.

31,000-33,000 cfs Habitat Maintenance Flow.—Southwestern willow flycatchers would be nesting and fledging young during the time period of this test flow scenario. Even with input from the Paria River contributing up to an additional 12,000 cfs, this component of the test flows would still fall below the 45,000 cfs stage level that would be likely to flood SWWF nests or remove current SWWF nest trees.

42,000 - 45,000 cfs High Flows.—The 42,000–45,000 cfs high flow tests would occur in January through March, well before the arrival of SWWF and the establishment of territories. In Grand Canyon, SWWF generally nest in tamarisk trees. Nest trees typically lie above the 45,000 cfs stage. Tamarisk nest trees would be unlikely to sustain direct damage from the flooding event. Stevens and Waring (1988) demonstrated that tamarisk is exceptionally tolerant of flooding in the Grand Canyon, persisting through many weeks of inundation. The tamarisk trees in which the SWWF presently nest survived the >92,600 cfs flows of 1983 and therefore would not likely be scoured by these lower flows.

The wetlands and low-lying areas near SWWF nesting habitats would likely be temporarily altered by the test flow (Stevens and Ayers 1992, Stevens et al.1996). Monitoring and assessment of effects to four SWWF habitat sites following the 1996 test flow (a one-week release of 45,000 cfs) found that marshes associated with SWWF habitat were reduced in area (cover) by 13.2% to 81% by the test flow (Stevens et al.1996). Some sites recovered rapidly, surpassing pre-flood area by 6%. Other marsh areas had only regained 3% of the original area six months after the test flow.

All sites lost litter in the inundation zone. The proportion of bare ground increased significantly at half of the sites (RM 50.5L and RM 51.5L). The 50.5L site is the only site in the Grand Canyon that has been continually occupied in the last five years. This site has also had several years of successful reproduction. We assume, therefore, that the loss of litter has not interfered with successful reproduction at 50.5L. Lack of detailed site descriptions and measurements for all sites prevent applying this assumption to other SWWF sites.

The 1996 test flood also removed lower branches and scoured or buried understory vegetation and ground cover from the lower elevation areas of the SWWF habitat sites. Significant losses of understory vegetation occurred at one site, 50.5L. Again, successful reproduction since the 1996 test flood has occurred only at the 50.5L site; it can therefore be assumed that reduction in understory vegetation has not negatively impacted SWWF nesting success at 50.5L.

Long-term effects of the 42,000–45,000 cfs test flow on SWWF habitat are expected to be beneficial. Flood flows would likely rejuvenate riverside and wetland habitat, resetting the successional vegetation and creating new seedling establishment sites and expansion areas for clonal species, i.e., willow. Impacts to food resources would be minimal because SWWF forage mostly on adult, terrestrial (non-aquatic) flying invertebrates that are unlikely to be affected by the test flow or would recover promptly after the event. Diet studies by Stevens (1985) reported that riparian, plant-dwelling invertebrate populations increased rapidly following a flow comparable to the test flow in 1980 (Reclamation 1990).

Mechanical Removal of Non-Native Fish

There would be no affect on SWWF or SWWF critical habitat from mechanical removal of non-native fish. If any nesting or rearing SWWF or occupied SWWF nest trees are identified in the electrofishing reach, they would be avoided during mechanical removal activities.

Conclusion

We conclude that the Proposed Action may affect, but it is not likely to adversely affect, SWWF and SWWF critical habitat.

Bald Eagle Species Account

Distribution and Abundance

Throughout its range, the bald eagle (Accipitridae: *Haliaeetus leucocephalus*) has suffered population declines from habitat loss, mortality from shooting and poisoning, and reduced reproductive success from ingestion of contaminants (Service 1983). As a result, the bald eagle was federally listed as endangered on March 11, 1967 (Service 1967). Although bald eagles face numerous threats throughout the 48 states, they have recovered from dramatic population declines over the past several decades. Consequently, on July 12, 1995, the bald eagle was dowlisted to threatened status (Service 1995). On July 6, 1999, further improvement in the bald eagle population made it possible for the Service to propose delisting of the species (64 Federal Register 36453-36464). This action is still in progress.

The bald eagle occurs throughout North America from Alaska to northern Mexico, and commonly breeds in the northern portion of its range (Stahlmaster 1987). The Service (1999) estimated that the breeding population exceeded 5,748 occupied breeding areas in 1998 and that the bald eagle population has essentially doubled every 7 to 8 years during the past 30 years.

A wintering bald eagle concentration was first observed in Grand Canyon in the early 1980s and has increased dramatically after 1985 (Brown et al. 1989, Brown and Stevens 1991, Brown and Stevens 1992). The wintering bald eagle population was monitored until 1995. It occurs throughout the upper half of the Grand Canyon (in Marble Canyon) and on both Lake Powell and Lake Mead. Density of the Grand Canyon bald eagles during the winter peak (in 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). In some years, a concentration of wintering bald eagles occurs in late February at the mouth of Nankoweap Creek, where bald eagles forage on spawning rainbow trout (Brown et al. 1989, Brown 1993). Bald eagle density there ranged from 6 in 1987 to 26 in 1990, and 18 bald eagles occurred at Nankoweap Creek in 1995 (Sogge et al. 1995b). Territorial behavior, but no breeding activity, has been detected in Grand Canyon.

Life Requisites

Bald eagles are opportunistic feeders, preying on fish, waterfowl, rabbit and road-killed game (Stahlmaster 1987). Wintering bald eagles frequent rivers, reservoirs and lakes, including western reservoirs (Detrich 1987), and their distribution is dependent on prey availability, perch suitability, weather and human disturbance intensity (Ohmart and Sell 1980). Changes in environmental conditions affect foraging strategies and success of wintering bald eagles (Knight and Skagen 1988). Fluctuating flows affect eagle foraging location and strategies. On the Colorado River, most foraging occurs less than 5 meters from shore, often in isolated pools. Brown and Stevens (1992) found that fluctuating dam releases appear to influence foraging behavior of bald eagles and birds tend to shift foraging locations during changes in flow. In Grand Canyon, when conditions allow, wintering bald eagles preferentially capture rainbow trout in Nankoweap Creek rather than in the mainstream where foraging success is lower (Brown 1993, Sogge et al. 1995b). A lower mainstream success rate may be related to water depth as well as velocity and turbidity.

Eagle density was correlated with trout density in the lower 0.5 km of Nankoweap Creek, and trout density was correlated with tributary stream water temperature (Sogge et al. 1995b). Bald eagles there prefer roosting and feeding areas that are relatively free of vegetation. The eagle population consists of all age classes, with considerable piracy and other interactions between individuals (Brown and Leibfried 1992). The ease and relative safety of foraging in Nankoweap Creek affords wintering bald eagles the opportunity to accumulate energy reserves needed for their long, northward migration flights and initiation of nesting.

Impacts of the Proposed Action Alternative: Experimental Test Flows

8,000 cfs Steady Flows.—Bald eagles would not be present in the Grand Canyon during the time of the 8,000 cfs steady release scenario**.**

6,500-9,000 cfs Fluctuating Flows.—Effects of 6,500 cfs to 9,000 cfs fluctuating release would be expected to be similar to those of the 8,000 cfs steady flows in fall.

5,000-20,000 cfs Fluctuating Non-Native Fish Suppression Flows.—Fluctuating releases offer additional foraging opportunities for bald eagle through exposure of isolated pools and stranded trout on shorelines. Sogge et al. (1995b) found a statistically significant inverse correlation between trout numbers in Nankoweap Creek and previous days dam releases; more trout were detected in Nankoweap Creek as river flows decreased. Yet, no significant correlation was detected between the number of eagles present at Nankoweap Creek and the daily minimum and maximum flow releases. No correlation was found between Colorado River flows (minimum and maximum flows) and eagle abundance in Grand Canyon. Minimum flows during Sogge's study were not as low as in this component of the Proposed Action (8,343 cfs vs. 5,000 cfs).

During studies in 1991-1995, trout populations in the creek varied greatly with some years having very low populations (unrelated to Colorado River flows). Bald eagle were not attracted to Nankoweap Creek during these times and foraged instead in the Colorado River and other tributaries.

Fluctuating releases of this scenario are designed to reduce trout populations by interfering with and disrupting spawning and through reduction in recruitment of young fish. A realistic estimate is that there would be a 20% reduction in young-of-year trout. This reduction in trout population would likely have no affect on bald eagles in the short-term as bald eagles usually take adult fish. There may be long-term effects, however, resulting in a reduced number of available prey fish as this age class reaches catchable size. Coupled with multi-year mechanical removal of non-native fish, long-term effects would likely reduce available bald eagle prey. We conclude that the 5,000-20,000 cfs fluctuating non-native fish suppression flows may affect bald eagles, but we anticipate this affect would not occur until after the two-year period of this component of the Proposed Action.

31,000-33,000 cfs Habitat Maintenance Flow.—Bald eagles would not be present during most of the time period under which this test flow would occur (July - December). Bald eagles begin arriving in Grand Canyon in late November. High flows would likely increase turbidity, but Colorado River water would already have been made turbid from the tributary inflow. Given the short time span of this test flow and its low likelihood of occurring before bald eagles enter Grand Canyon, it is unlikely that bald eagles would be affected by these flows.

***42,000–45,000 cfs High Flows.*—**Wintering bald eagles would be present in Grand Canyon during this scheduled test flow. Eagle abundance tends to peak in February and then rapidly declines with birds usually gone by the end of March. Foraging conditions in river, shore, and isolated pool habitats are highly variable and are directly influenced by river flows. Low river flows result in eagles capturing and scavenging proportionally more prey from isolated pools and adjacent shore habitat. As river flows increase, these habitats are inundated, reducing or eliminating prey availability. Intermediate and high river flows result in a shift to greater use of creek habitat, e.g. Nankoweap Creek. Increased turbidity and velocity of flood flows likely also play a role in foraging success and location, tending to lower the success rate as these factors increase (Knight and Skagen 1988). The opportunistic nature of bald eagle foraging suggests that eagles may be able to compensate for a loss of prey from isolated pools by foraging in Nankoweap (or other creeks with trout populations). This form of compensation is only possible if spawning trout are present in the creek(s). Eagles in the river corridor that were not near such creeks would possibly experience a temporary reduction in foraging opportunities or reduced foraging success during the 42,000–45,000 cfs two-day high flow. As flows drop to 8,000 cfs for aerial photography purposes, trout may become more available if they are stranded in isolated pools.

Turbidity in the Colorado River would increase during this high flow scenario. But, due to the short time span of this test flow, increased turbidity would not affect bald eagle foraging beyond the two days of this test flow. Bald eagles would likely increase tributary foraging.

Mechanical Removal of Trout

The goal of the mechanical removal component of the proposed action alternative is to reduce the trout population around the Little Colorado River. GCMRC estimates a removal of 3000–9000 rainbow trout with the first mechanical removal trip (S. Gloss, GCMRC, written communication). A total of six trips, covering 10 miles above and below the Little Colorado River are planned for the first year of the proposed action. It is unknown if trout from adjoining reaches would move into the newly available habitat, thereby depleting adjoining reaches, nor is the length of time known before the reach is repopulated to pre-treatment levels.

Part of the Little Colorado River reach is considered wintering bald eagle foraging habitat. The removal would affect approximately 6 miles of 77.5 miles of bald eagle habitat (dam to 1 mile below LCR). At this time, only a crude estimate of the effects to bald eagle can be made. If the assumption is made that the 6 miles would be substantially depleted of trout, then it can be reasoned that 8% of bald eagle foraging habitat would be affected or largely removed, at least temporarily, from foraging opportunities.

Short-term effects of mechanical removal will differ from those of dam releases. Many of the trout removed by mechanical removal will be in the size range of individuals chosen by bald eagles for food, whereas fluctuating dam releases will have their greatest effects on eggs, embryos, and fry not used by these birds. Also, the effects of mechanical removal will likely be concentrated in a reach of the Colorado River where bald eagles are known to forage, whereas the effects of dam releases will be widespread along the river. Only in the longer term, beyond the two years proposed for this test, is it likely that the combined effects of dam releases and mechanical removal would be evidenced to the bald eagle population. This longer term effect will need to be measured through monitoring as part of the adaptive management program.

Conclusion

We conclude that the Proposed Action may affect, and is likely to adversely affect, the bald eagle in Grand Canyon.

California Condor Species Account

Distribution and Abundance

The California condor (*Gymnogyps californianus*) was listed as endangered on March 11, 1967, in a final rule published by the Service (32 FR 4001). On October 6, 1996, the Service announced its intent to reintroduce California condors into northern Arizona/southern Utah and to designate these birds as a nonessential experimental population (equivalent to a "threatened" status)[1] under the Endangered Species Act (Service 1996). There is no critical habitat designation associated with the experimental population.

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[1] The conditions under which a population can be designated as experimental are: the population must be geographically disjunct from any other wild populations of the same species, and the Service determines that the release will further the conservation and recovery of the species (USFWS 1996). Before an experimental population can be released, section 10(j) of the Endangered Species Act (the Act) requires that a determination be made by the Service whether the population is either "essential" or "nonessential" to the continued existence of the species. An experimental population determined to be essential is treated as a threatened species. An experimental population determined to be nonessential is treated as a species proposed for listing as threatened. The exception is a nonessential population located within the National Park System or National Wildlife Refuge System lands will be treated as a threatened species for purposes of section 7(a)(2) of the Act. A designation of nonessential experimental limits the application of section 7(a)(2) of the Act. For the purposes of section 7, the nonessential experimental population is treated as a proposed species except on National Wildlife Refuge System and National Park System lands.

The reintroduction area consists of remote Federal and Native American Reservation lands with limited private lands. The designated experimental population area of the California condor includes portions of three states - Arizona, Nevada, and Utah. As part of the management strategy for this population the Service will relocate any condor within the experimental population area, including the National Park System, to avoid conflicts with ongoing or proposed activities (Service 1996).

On October 29, 1996, six California condors were released at Vermillion Cliffs in northern Arizona. Since then, there have been additional releases and the current (spring 2002) experimental population stands at 32 (California Condor Reintroduction Program 2002).

Life Requisites

California condors are among the largest flying birds in the world. Adults weigh approximately 10 kilograms (22 pounds) and have a wingspan up to 9 ½ feet (2.9 meters) (Kofer 1953, Wilbur 1978). California condors nest in various types of rock formations including protected crevices, overhung ledges, and potholes; nest sites are usually remote and at elevations far above the valley floor. Condors reach sexual maturity and attain adult plumage and coloration by 5-6 years of age. Breeding is likely between 6-8 years of age. If the nesting cycle is successful, pairs produce one egg, usually every other year. Average incubation period for a condor egg is about 56 days. Parental care is lengthy and fledglings may not become fully independent until the following spring (Kofer 1953, Snyder and Snyder 1989, Service 1996).

California condors are carrion-eaters. They are opportunistic scavengers, preferring carcasses of large mammals (Kofer, Wilbur 1976) but will feed on rodents and, more rarely, fish. Ungulates, including the carcasses of domestic livestock, are expected to be the primary sources of food for condors released at the Vermilion Cliffs (Service 1996). Mule deer (*Odocoileus hemionus*) , desert bighorn sheep (*Ovis canadensis nelsoni*), and pronghorn (*Antilocapra americana*) are residents of the region. These ungulates become available to condors as natural mortalities, hunter kills and road kills. Most California condor foraging occurs in open terrain. California condors apparently do not locate food by smell. Typical foraging behavior includes long-distance reconnaissance flights, lengthy circling flights over a carcass, and lengthy waits at a roost or on the ground near a carcass (Service 1996). Condors will also cue into the activity of ravens and other scavengers to locate food sources.

Depending upon weather conditions and the hunger of the bird, a California condor may spend most of its time perched at a roost. Roosting provides opportunity for preening and other maintenance activities, rest, and possibly facilitates certain social functions (Service 1996). California condors often use traditional roosting sites near important foraging grounds. Cliffs and tall conifers, including dead snags, are generally used as roost sites in nesting areas. Although most roost sites are near nesting or foraging areas, scattered roost sites are located throughout the range.

The beaches of the Colorado River through the Grand Canyon are frequently used by the Arizona/Utah experimental population of California condors (Sohie Osborn, Peregrine Fund, personal communication). Activities include drinking, bathing, preening, playing, and possibly feeding on the occasional fish carcass. Condor monitors are noting an increase in interaction between rafters and condors in 2002 as rafting parties seek out unused beaches for lunch stops, exploration, and close observance of condors. There have also been several instances of the immature condors approaching campsites, possible keying into ravens who are experienced camp raiders.

The decline in California condor numbers has been attributed to illegal collection of eggs and birds, poisoning from predator control, lead poisoning, effects of DDT and other organochlorines, and the increase in roads and houses in open country needed by condors for foraging (Kiff et al.1979, Service 1996). Their slow rate of reproduction and high number of years spent reaching breeding maturity make the condor population as a whole more vulnerable to these threats.

Impacts of the Proposed Action Alternative: Experimental Test Flows

There would likely be no adverse effect to condors from the various flow scenarios described in the action alternative. Condors do not routinely forage along the river corridor nor do they appear to rely on any particular vegetation component associated with beach use. Nesting occurs far above the river corridor. California condors do use the Colorado River and beaches for bathing, drinking, resting, and playing. Habitat maintenance flows and the short-term high flow are designed to increase and/or restore beaches of the Colorado River through Grand Canyon. It is assumed that the results of these flows will be beneficial to the California condor by increasing the amount of beach habitat available to condors.

In summary, the Proposed Action Alternative may have short-term and possibly long-term affects on California condors through providing them with an increased area of beach habitat. There are no known negative effects or cumulative concerns associated with the California condor and this action.

Mechanical Removal of Non-Native Fish

The mechanical removal of non-native fish would occur during night time when California condors are not foraging and very likely not near the river. Disposal of trout would be accomplished in such a way that no carrion is created that would create attractive nuisance for condors.

Conclusion

It is our conclusion that the Proposed Action Alternative may affect, but is not likely to adversely affect, California condors.

Acronym List

AMWG	Adaptive Management Work Group
Basin States	seven Colorado River Basin States
BHBF	Beach/Habitat-Building Flows
cfs	cubic feet per second
CRSPA	Colorado River Storage Project Act
EA	environmental assessment
FACA	Federal Advisory Committee Act
FEIS	final environmental statement
FONSI	Finding of No Significant Impacts
GCDAMP	Glen Canyon Dam Adaptive Management Program
GCMRC	Grand Canyon Monitoring and Research Center
GCPA	Grand Canyon Protection Act
HBC	humpback chub
KAS	Kanab ambersnail
LCR	Little Colorado River
maf	million acre-feet
MWh	megawatthour
NO_x	Nitrous oxides
NPS	National Park Service
RBS	razorback sucker
Reclamation	Bureau of Reclamation
ROD	record of decision
Service	U.S. Fish and Wildlife Service
SO_2	sulfur dioxides
SWWF	Southwestern willow flycatcher
TAF	thousand acre-feet
TWG	Technical Work Group
USGS	United States Geological Survey
Western	Western Area Power Administration