GLEN CANYON DAM
INTERIM OPERATING CRITERIA

DRAFT ENVIRONMENTAL ASSESSMENT

SEPTEMBER 1991

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION
UPPER COLORADO REGION

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GLEN CANYON DAM INTERIM FLOWS
DRAFT ENVIRONMENTAL ASSESSMENT

CONTENTS

	Page
Table of Contents	i
Tables	iii
Figures	iii
CHAPTER 1 Purpose and Need	I-1
Background	I-1
Development of Alternatives	I-1
Other Related Actions	I-4
Glen Canyon Dam EIS	I-4
Glen Canyon Environmental Studies	I-4
Western's EIS	I-4
CHAPTER 2 Proposed Action and Alternatives	II-1
No Action	II-1
Low Fluctuating Flow Alternative (Proposed Action)	II-1
Financial Exception Criteria Option	II-2
Flow Monitoring Program	II-3
Alternatives Considered but Eliminated	II-4
Intermediate Fluctuating Flow Alternative	II-4
Sustained Fluctuating Flow Alternative	II-4
Environmental Impacts	II-4
CHAPTER 3 Affected Environment and Environmental Consequences	III-1
Introduction	III-1
Assumptions	III-1
Location	III-3
Immediate Area	III-3
Area of General Influence	III-3
Colorado River Flows	III-3
Resources	III-3
Sediment	III-5
Affected Environment/No Action Alternative Consequences	III-5
Erosion of Sand Bars	III-5
Replenishment of Sand Bar Deposits	III-7
Low Fluctuating Flow Alternative Consequences	III-8
Erosion of Sand Bars	III-8
Replenishment of Sand Bar Deposits	III-8
Financial Exception Criteria Option	III-9
Biological Resources	III-9
Vegetation	III-9
Affected Environment/No Action Alternative Consequences	III-9

CONTENTS—Continued

Page

CHAPTER 3 (Continued)
Biological Resources (Continued)
Vegetation (Continued)
Low Fluctuating Flow Alternative Consequences III-10
Wildlife III-11
Affected Environment/No Action Alternative Consequences III-11
Low Fluctuating Flow Alternative Consequences III-11
Fisheries III-12
Affected Environment/No Action Alternative Consequences III-12
Low Fluctuating Flow Alternative Consequences III-12
Threatened and Endangered Species III-13
Peregrine Falcon III-13
Bald Eagle III-14
Southwestern Willow Flycatcher III-15
Humpback Chub III-15
Razorback Sucker III-15
Flaveria Mcdougalli III-16
Arizona Species of Concern III-17
Cultural Resources III-17
Affected Environment/No Action Alternative Consequences III-17
Low Fluctuating Flow Alternative Consequences III-17
Financial Exception Criteria Option III-18
Recreational Resources III-18
Anglers and Day-Use Rafters III-18
Affected Environment/No Action Alternative Consequences III-18
Affected Environment Low Fluctuating Flow Alternative Consequences III-19
White-Water Boaters III-20
Affected Environment/No Action Alternative Consequences III-20
Low Fluctuating Flow Alternative Consequences III-21
Hydropower Resources III-21
Affected Environment/No Action Alternative Consequences III-21
Physical Resources III-21
Low Fluctuating Flow Alternative Consequences III-23
Economic Impacts III-23
Financial (Marketing) Impacts III-23
Cumulative Impacts III-24

CONTENTS—Continued

	Page
CHAPTER 3 (Continued)	
Preliminary Findings of Test Flow Impacts	III-24
Findings by Resource Category	III-24
Sediment	III-25
Endangered Species	III-25
Trout	III-25
Cultural Resources	III-26
Recreation	III-26
CHAPTER 4 Consultation and Coordination	IV-1
Summary	IV-1
Fish and Wildlife Coordination	IV-1
Cultural Resources	IV-2
Executive Orders	IV-3
Distribution List	IV-3
References	R-1
Attachment A Environmental Commitments	
Attachment B Endangered Species Act Memorandum	
Attachment C Fish and Wildlife Coordination Act Memorandum and Letter from Arizona Game and Fish Department to the U.S. Fish and Wildlife Service	

TABLES

Number		
1	Parameters of R/S, E/RM, and Test Flow Proposals	I-3
2	Glen Canyon Dam Alternatives for Interim Operations	II-5
3	Comparison of environmental impacts	II-6

FIGURES

1	Procedure to Establish Interim Operations - Glen Canyon Dam	I-2
2	Glen Canyon Monthly Releases	III-2
3	Vicinity Map	III-4
4	Flow Patterns in a Typical Recirculation Zone	III-6

CHAPTER I

PURPOSE AND NEED

INTRODUCTION

The purpose of this environmental assessment is to identify and evaluate the environmental impacts that would occur with the establishment of interim operating criteria for Glen Canyon Dam for about 3 years beginning November 1, 1991. This assessment is prepared in accordance with the National Environmental Policy Act (NEPA) and current Department of the Interior and Bureau of Reclamation (Reclamation) guidelines. This action is needed for protection of downstream resources pending completion of the Glen Canyon Dam Environmental Impact Statement (GCDEIS) and the selection and implementation of final operating criteria for Glen Canyon Dam.

BACKGROUND

On July 27, 1989, the Secretary of the Interior directed the preparation of an environmental impact statement on the effects of the operation of Glen Canyon Dam on the downstream environmental and ecological resources of the Glen Canyon National Recreation Area and Grand Canyon National Park. The GCDEIS and associated Glen Canyon Environmental Studies (GCES) are currently being prepared to evaluate the impacts of current and alternative dam operations on the downstream resources. As part of the GCES, research flows were carried out from June 1990 through July 1991 to help determine the impact of Glen Canyon Dam operations. The preparation of the GCDEIS and subsequent Record of Decision will lead to implementation of final operating criteria for Glen Canyon Dam.

Although the commitment to prepare the GCDEIS initiated a process to resolve environmental issues, the issue of interim protection of downstream resources remained outstanding. Accordingly, the Secretary of the Interior has committed to implement interim flows within 90 days of completion of the GCES research flows. These flows from Glen Canyon Dam are to be implemented by November 1, 1991, and continue until a final decision on future operating criteria is made.

The primary issues to be evaluated in this document are: sediment problems and biological, cultural, recreation, and hydropower resources.

DEVELOPMENT OF ALTERNATIVES

The administrative process to develop interim operating criteria was initiated in February 1991. Figure 1 shows the basic process. It included input from the research/scientific group (R/S Group), the ecological/resource managers (E/RM Group), and power/water managers (P/WM Group). As lead agency, Reclamation coordinated the activities of all groups, working closely with all cooperating agencies and utilizing the public involvement process which had been established as a part of the GCDEIS structure.

Figure 1.

Procedure to Establish Interim Operations - Glen Canyon Dam

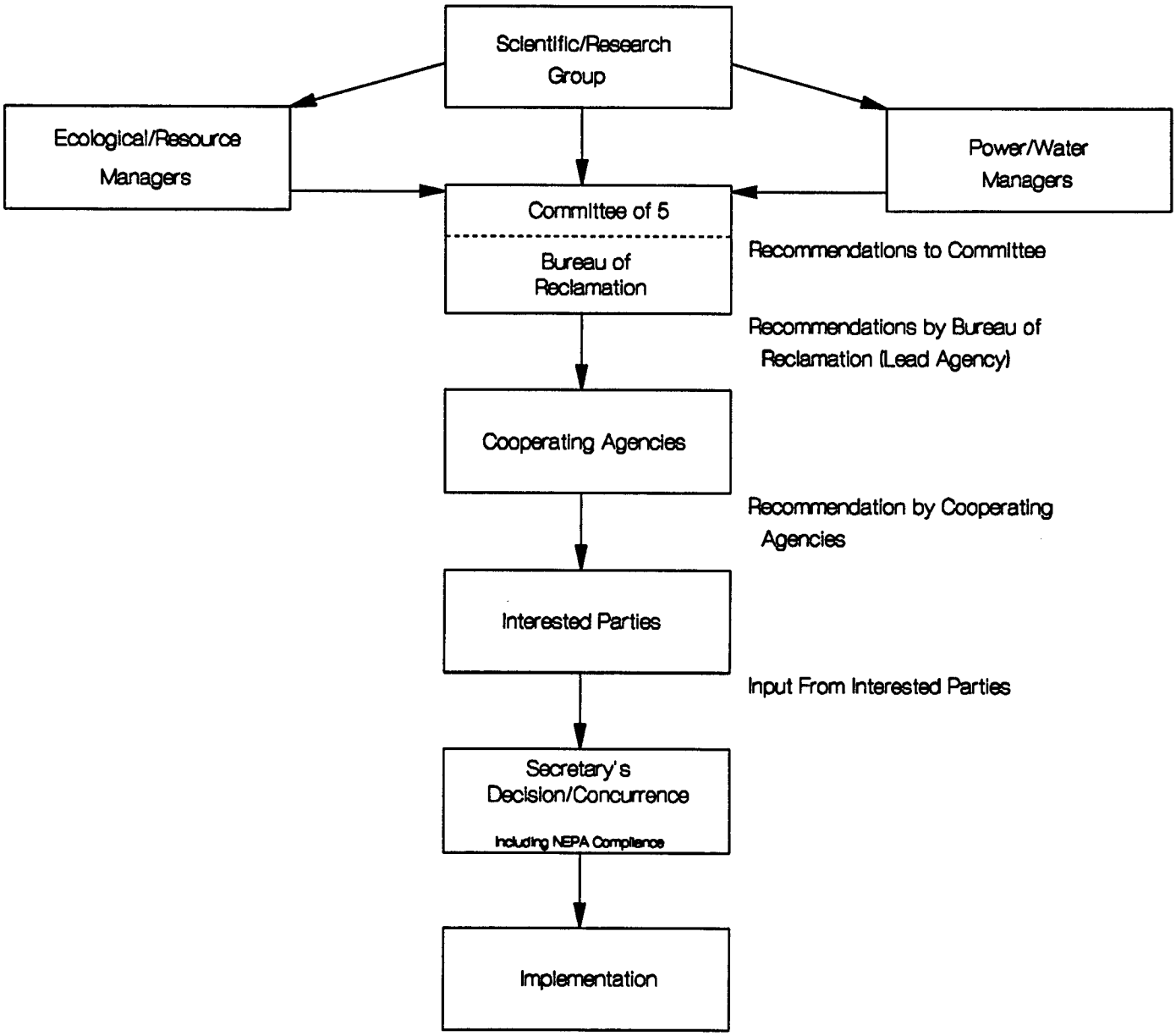

Figure 1.

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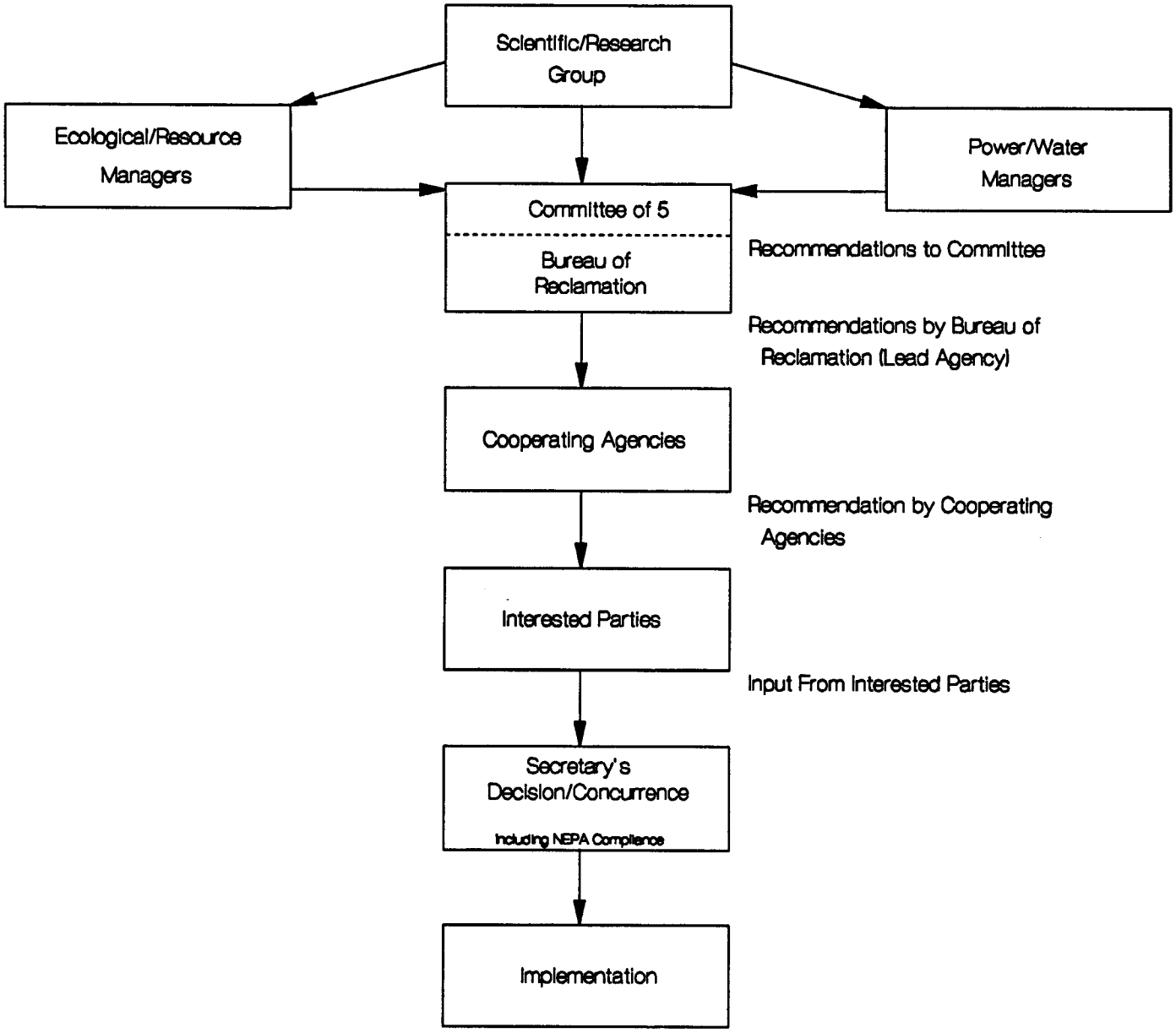

Building on the recommendations of a small group of scientists familiar with the impacts of current dam operations, the R/S Group developed an alternative that was their best estimate for a flow regime to protect the downstream resources in the short term. The E/RM Group—which was composed of state and Federal officials charged with managing the downstream environmental resources– developed an alternative that was very similar to that of the R/S Group.

The Western Area Power Administration (Western) developed an alternative (termed the Sustained Fluctuating Flow Alternative in this document) which would provide some protection to downstream resources, while preserving most of the power generation capacity and flexibility of current operations (no action). Since there was considerable difference between the R/S, E/RM, and Western proposals, Reclamation developed an alternative (termed the Intermediate Fluctuating Flow Alternative) that sought to balance the overall management responsibilities of the Secretary of the Interior by providing significant protection to downstream resources while also preserving a substantial amount of peaking power.

On July 30, 1991 the Commissioner of Reclamation announced that on August 1, 1991, Reclamation would begin testing proposed interim operating criteria (hereafter called test flows) for Glen Canyon Dam. This testing period was to allow time to more fully evaluate data from the research flows and to carry out NEPA compliance for implementation of interim operating criteria. The test flows are very similar to both the R/S and E/RM Group proposals as shown below:

Table 1.—Parameters of R/S, E/RM, and Test Flow Proposals
(cfs per hour)

Parameter	R/S Group	E/RM Group	Test
Maximum release (cfs)	20,000	20,000	20,000
Minimum release (cfs)	5,000 (night) 8,000 (daily)	8,000	5,000/8,000
Ramp rates (cfs/hr)			
Up	2,000	2,000	8,000/4 hr; 2,500 max./1 hr
Down	1,000	1,000	1,500
Daily change (cfs)	5,000	5,000	5,000 low months 6,000 med. months 8,000 high months

The R/S and E/RM Groups' alternatives contributed to develop most of the test flows. Reclamation's findings also were used. These recommendations became the Low Fluctuating Flow Alternative in this document.

OTHER RELATED ACTIONS

A number of other current actions also potentially affect the environmental and ecological resources downstream of Glen Canyon Dam.

GLEN CANYON DAM EIS

Glen Canyon Dam was completed in 1963 prior to enactment of the National Environmental Policy Act. In July 1989, the Secretary of the Interior directed Reclamation to prepare an environmental impact statement (EIS) to determine the impact of Glen Canyon Dam operations on downstream ecological and environmental resources within Glen Canyon National Recreation Area and Grand Canyon National Park. The EIS will discuss alternatives to current dam operations and reduce any adverse impacts in a manner consistent with the laws of the Colorado River, statutory requirements for hydropower production, and protection of the area's resources. The action proposed in this environmental assessment (EA) would provide interim protection to the resources for the short term until a decision is reached, following the EIS process, on final operating criteria.

GLEN CANYON ENVIRONMENTAL STUDIES

Phase I (1982-88) of the GCES began as an interagency effort to study the conditions downstream from Glen Canyon Dam related to whether (1) current dam operations, through control of Colorado River flows, adversely affect the existing river-related environmental and recreation resources, and (2) alternative dam operations, consistent with interstate compact and statutory water storage and delivery requirements, would protect these resources. To accomplish these goals, over 30 technical studies in the fields of biology, recreation, sediment, and hydrology were conducted (U.S. Department of the Interior, 1988).

Phase II (1988-present) of the GCES was initiated to more fully respond to the initial questions and to provide needed additional information. The schedule for these studies was accelerated with the use of the research flows to better provide data for the EIS.

WESTERN'S EIS

Western is preparing a separate EIS on its Salt Lake City Area (SLCA) Integrated Projects Post-1989 General Power Marketing and Allocation Criteria. The criteria will establish the terms to be used for allocating capacity and energy from the dams of the SLCA Integrated Projects, including Glen Canyon Dam. The EIS will consider issues related to system-wide power marketing and will account for alternative operations of Glen Canyon Dam. The action proposed in this EA is related to operation of the dam and may affect power marketing.

CHAPTER II

PROPOSED ACTION AND ALTERNATIVES

Four actions were considered: No Action, Low Fluctuating Flow Alternative (proposed action), Intermediate Fluctuating Flow Alternative, and Sustained Fluctuating Flow Alternative. All the alternatives would release the same volume of water on a monthly basis.

NO ACTION

Annual releases are a function of inflow and space available in Lake Powell. From 1966 to 1989, releases ranged from a minimum of 8.23 to a maximum of 20.4 million acre-feet (maf) (1984). Monthly and annual releases are scheduled to avoid spills, to maintain storage, to balance storage between Lake Powell and Lake Mead, and to meet power system conditions and electrical energy loads.

Average monthly releases have ranged from about 550,000 acre-feet in February to about 900,000 acre-feet in August. When the reservoir is full, scheduled monthly releases for the remainder of the year are recomputed as necessary based on updated streamflow forecast information.

The No Action Alternative would continue the operating practices which were in effect before the initiation of research flows in June 1990. Under those criteria, peak discharges are limited to 31,500 cubic feet per second (cfs), although full powerplant capacity is 33,200 cfs. These limits are exceeded only when releases are made to avoid anticipated spills. Minimum flows are 1,000 cfs from Labor Day until Easter; from Easter until Labor Day, recreation flows were to average not less than 8,000 cfs from 8 a.m. until midnight and 3,000 cfs during the remainder of the day.

Ramping rates under this alternative would be unrestricted and have been as high as 19,000 cfs per hour; however, typical maximum hourly ramping rates average 4,000-6,000 cfs hourly in a given day. The typical ramping rate is, therefore, about 5,000 cfs per hour.

LOW FLUCTUATING FLOW ALTERNATIVE (PROPOSED ACTION)

This alternative was developed to protect downstream resources. It would permit fluctuating flows for power generation well below existing levels (see table 2 at end of chapter). This alternative reflects release of water from Glen Canyon Dam in a manner that would decrease the magnitude of daily fluctuating flows and ramping rates in order to reduce the adverse effects of current powerplant operations on downstream beaches, sediment-dependent resources, and aquatic resources.

This alternative would limit daily fluctuations to 5,000, 6,000, or 8,000 cfs, depending on monthly release volumes. Flows could be fluctuated up to 20,000 cfs; any release greater than 20,000 cfs, if necessary to avoid anticipated spills, would be steady flow.

Minimum flows would be 5,000 cfs between 7 p.m. and 7 a.m. and 8,000 cfs between 7 a.m. and 7 p.m. The duration of 5,000-cfs flows would be limited to 6 hours. Ramping rates would be limited to 2,500 cfs per hour for increasing flows and 1,500 cfs per hour for decreasing flows.

The scheduled annual and monthly release volumes would be determined using existing practices based on considerations for maintaining conservation storage, avoiding spills, balancing storage between Lakes Powell and Mead, and when possible, meeting power needs.

OPERATIONAL EXCEPTION CRITERIA

There would be times when the criteria discussed above would be exceeded. Therefore, certain exception criteria have been developed. Exception criteria permit the unloaded capacity at Glen Canyon Dam (that operable capacity which is physically available but not presently serving load) to be available to Western (1) for response to system disturbances or other emergency conditions; (2) for system regulation; and (3) as a means of avoiding the expense of purchasing replacement firm capacity and energy. Items (1) and (2) are included in the Low Fluctuating Flow Alternative; item (3) is an option that may or may not be included in the proposed action.

Items (1) and (2) relate to Western's responsibilities as a member of the North American Electric Reliability Council, the Western Systems Coordinating Council, and the Inland Power Pool. These groups make up an interconnected power system in the Western United States that ensures the scheduled delivery of power resources to utilities and their consumers in exact amounts, at exact times, at particular voltages, and at a standard frequency (60 cycles per second).

The exceptions to the Low Fluctuating Flow Alternative criteria for system disturbances or other emergency conditions and system regulation were taken into account in the analysis of impacts for the proposed action. Generally, the exception criteria would permit the Low Fluctuating Flow Alternative criteria to be exceeded only for short periods of time, usually less than 1 hour, and almost never exceeding 4 hours.

FINANCIAL EXCEPTION CRITERIA OPTION

Item (3) relates to Western's having the ability to demonstrate that unloaded capacity at Glen Canyon Dam is available for generation. As demonstrated during the research flows, this does not necessarily mean that such capacity would be used. What is important is that the capacity not be deemed to be unavailable for purposes of meeting *firm load* obligations.

Because these exceptions would be used for financial purposes and not for system disturbances or regulation, Western has agreed to several conditions which would limit exceedance of the proposed action as much as practicable. These conditions are:

- The interim operating criteria would not be exceeded for more than 3 percent of the time (22 hours) in any consecutive 30-day period, with no carryovers.

- Flows would be bypassed either through the turbines or the outlet tubes to avoid noncompliance with the down-ramp rate and minimum releases.

- Specifics of how to return to the requirements of the interim operating criteria after exceedance would be worked out.

- A review of the exception criteria would be conducted every 3 months with a view toward necessary changes or possible termination.

- These financial exception criteria would not set a precedent for future operations that may result from the GCDEIS.

- Interim operating criteria monitoring would be paid from power revenues.

- Cooperating agencies would review the results of the monitoring program and be informed of any exceedance of the interim operating criteria due to the financial exception criteria.

The financial exception criteria, like the other two exceptions, would allow the interim operating criteria to be exceeded for relatively short periods of time, but they could be in effect for as long as 12 to 14 hours in a single day.

MONITORING PROGRAM

The objective of the monitoring program is to identify and quantify the responses of the ecosystem elements of Glen and Grand Canyons to the interim operating criteria for Glen Canyon Dam. The economic relationships associated with the power and recreation resources would also be assessed.

The basis of this monitoring program would be the ecosystem processes and responses. The program is built around monitoring both critical and representative elements already being evaluated through the ongoing GCES research. Due to the limited duration of the interim operating criteria, the focus would be on the short-term responses and the specific ecosystem elements.

An interim flow monitoring plan has been developed and would be integrated with the interim flow program. Specific elements of the monitoring program would be implemented concurrently with the GCES research program. No new research efforts are anticipated to support the assessments of the interim operating criteria.

The monitoring plan would focus on the three elements: (1) evaluation of the performance of the interim operating criteria; (2) evaluation of the impacts of the exception criteria on the flows and on the resources; and, (3) evaluation of the general resource responses to the interim criteria. In addition, the following elements would be evaluated: sediment, endangered species, native fish, sediment transport, cultural resources, wetlands, trout, recreation, and economics. A specific timetable and report development process has been developed and would be implemented.

ALTERNATIVES CONSIDERED BUT ELIMINATED

INTERMEDIATE FLUCTUATING FLOW ALTERNATIVE

Intermediate fluctuating flows would require a year-round minimum release rate of 5,000 cfs. The maximum release rate would be restricted to between 20,000 cfs and 22,000 cfs, depending on monthly volume. Restrictions on fluctuations would be imposed each hour, every 4 hours, and each day, again depending on monthly volume. The daily change would be limited to 8,000 cfs in low volume months, 11,000 cfs in intermediate volume months, and 15,000 cfs in high volume months. Over any 4-hour period, an increase in flow would be limited to 8,000 cfs in all months. A decrease would be limited to 4,800 cfs in any 4-hour period, not to exceed 2,000 cfs per hour in low volume months, and 8,000 cfs over 4 hours with a 1-hour limitation of 2,000 cfs per hour in intermediate and high volume months. Over any 1-hour period, an increase would be limited to 4,000 cfs in all months, while a decrease would be limited to 4,800 cfs in low volume months and 8,000 cfs in intermediate and high volume months (see table 2). Ramping rates would vary from 2,000 cfs to a limit of 8,000 cfs.

This alternative was eliminated because substantial impacts on downstream resources would still occur.

SUSTAINED FLUCTUATING FLOW ALTERNATIVE

This alternative, proposed by Western, would require a minimum flow of at least 3,000 cfs and a maximum hourly decrease in flow of, at most, 5,000 cfs per hour. Western proposed tightening these parameters only if "favorable market conditions exist." There would be no limit on the rate of flow increases. The maximum of 31,500 cfs would be retained.

This alternative was eliminated because it was essentially the same as the existing operation, and it did not meet the objective of protection of the downstream resource (see table 2).

ENVIRONMENTAL IMPACTS

Table 3 compares summaries of assessed impacts to various resources under the No Action and Low Fluctuating Flow Alternatives. Detailed treatment of environmental impacts follows in chapter 3.

Table 2.–Glen Canyon Dam
Alternatives for Interim Operations
(in cubic feet per second (cfs))

PARAMETER	ALTERNATIVES		CONSIDERED BUT ELIMINATED	
	No Action	Low Fluctuating Flow	Intermediate Fluctuating Flow	Sustained Fluctuating Flow
Maximum release (cfs)	31,500	20,000	20,000-22,000 (depending on monthly vol.)	31,500
Minimum release (cfs)	3,000/summer 1,000/winter	5,000/night 8,000/day	5,000	3,000/
Maximum rate of fluctuation (ramp rate) (cfs)		Ascending		
	No limit	8,000/4 hr Not to exceed (NTE) 2,500/hr	8,000/4hr Not to exceed 4,000/hr	No limit
		Descending		
	No limit	1,500/hr	Low vol.: 4,800/4 hrs NTE 2,000/1 hr Medium and high vol.: 8,000/4 hr NTE 2,500/1 hr	Low vol.: 4,000/hr. High vol.: 5,000/hr
Maximum Daily change (cfs)	30,500	5,000 low vol. month[1] 6,000 med. vol.month[1] 8,000 high vol. month[1]	8,000 low vol. month[1] 11,000 med. vol. month[1] 15,000 high vol. month[1]	No limit

1 Low monthly volume: less than 600,000 acre-feet; medium monthly volume: 600,000 to 800,000 acre-feet; high monthly volume: over 800,000 acre-feet.

Table 3.—Comparison of environmental impacts

RESOURCE	NO ACTION = EXISTING ENVIRONMENT	LOW FLUCTUATING FLOWS (W/O FINANCIAL EXCEPTION OPTION)
SEDIMENT RESOURCES	**No change** - continued beach erosion and a net accumulation of sand in main channel pools and eddies	Moderately decreased rates of beach erosion and increased rates of sand accumulation in main channel pools and eddies[4]
VEGETATION	**No change** - **OHWZ**[1] - decline in areal coverage **NHWZ**[2] - continued development Fluctuating zone - unstable	**OHWZ** - no change[3] **NHWZ** - moderate increase[3] **Fluctuating zone** - moderate increase[3]
WILDLIFE (HABITAT)	**No change** - **OHWZ** - decline in areal coverage **NHWZ** - continued development **Fluctuating zone** - unstable	**OHWZ** - no change[3] **NHWZ**- moderate increase[3] **Fluctuating zone** - moderate increase[3]
FISHERIES	**No change** - **Native fish** - rapid flooding/ dewatering of backwaters impacts young **Trout** - redds dewatered by low flows; adults stranded by rapid downramping	**Native fishes** - moderate increase[4] **Trout** - moderate increase[4]
THREATENED AND ENDANGERED SPECIES	**No change** - **Birds** - dependent upon river productivity (insects and trout) and riparian habitat **Fish** - dependent upon temperature and seasonal flow regimes	**Birds** - minimal increase[3] **Fish** - no change[4]
CULTURAL RESOURCES	**No change** - exposure of site foundations to erosion and exposure and scouring of historic boat remains	Decreased site erosion and virtual elimination of exposure and scouring of historic boat remains[4]
RECREATIONAL RESOURCES	**No change** - fishing, day-rafting, and white water recreationists exposed to unpredictable flow fluctuations	Reduced flow fluctuations[3] improve fishing[2] and day-use rafting[4] and white water rafting; improved safety,[4] accessibility, and wilderness values[3]
HYDROPOWER RESOURCES	**No change** - continued pattern of wide hourly, daily, and seasonal flow fluctuations for power optimization	Decreased on-peak generation,[3] minor system-wide increased power production costs.[3] Reduced ability to respond to power system demands[3], significantly increased power purchase costs.[5]

[1] Old high water zone influenced by historic flooding.
[2] New high water zone influenced by dam's control of historic flooding.
[3] With financial exception criteria - no change.
[4] With financial exception criteria - slight adverse.
[5] With financial exception criteria - savings of $19 million in power purchase costs by Western.

CHAPTER III

AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

INTRODUCTION

This chapter describes the general setting and existing environmental resources, and analyzes the impacts of implementation of the proposed interim operating criteria. The existing conditions described are the No Action Alternative and serve as the baseline for the determination of the effects of the proposed action.

ASSUMPTIONS

With the facts in hand, interim operating conditions should lead to the flows described in this chapter and to the following assumptions. The analysis of impacts in this chapter is based on the following assumptions:

- The impacts of the No Action Alternative are considered to be equivalent to the continuing impacts under the existing conditions because of the brief duration of the proposed action.

- Since the monthly and annual release volumes would be the same under all alternatives, there would be no impacts to lake elevations, water quality, recreation, and fisheries in Lakes Powell and Mead.

- Pursuant to statutory requirements, Lake Powell is operated to meet downstream release requirements, equalize storage with Lake Mead, avoid spills, and fill the reservoir if possible.

- Lake Powell is currently drawn down about 70 feet (lake elevation of 3,630 feet) or 9.6 maf from full reservoir. The probability of filling the reservoir in the next 3 years is only about 35 percent. Therefore, in this EA, annual release volumes from Glen Canyon Dam of 8.23 maf have been used as the basis for assessment of impacts. Volumes are shown on the following figure 2.

- The greatest difference in environmental impacts between alternatives occurs during a minimum release year (8.23 maf). As annual release volumes increase, releases from the dam, and therefore impacts of alternatives, tend to be similar.

- Biological and physical resources are linked, with sediment as the key parameter; therefore, impacts on biological resources would, in general, follow impacts on sediment.

Based on these assumptions and the interim operating criteria, the monthly release volumes shown on accompanying figure 2 are projected.

GLEN CANYON MONTHLY RELEASES

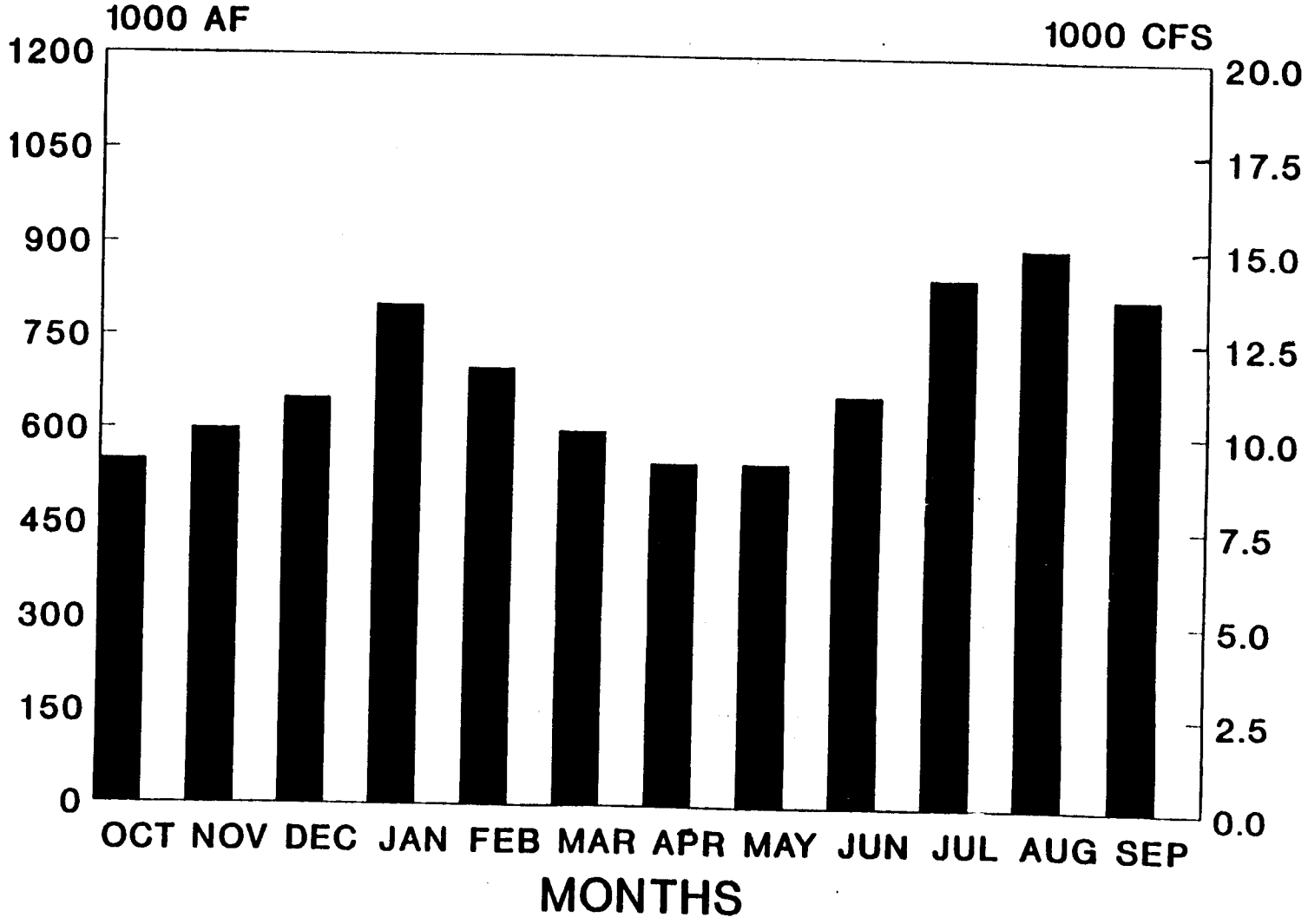

Figure 2

LOCATION

The affected area analyzed in this EA can be viewed from two perspectives, that of the immediate Colorado River area and that of the adjacent area of general influence (see figure 3).

Immediate Area

This area encompasses the Colorado River and adjoining canyon areas in northwestern Arizona between Glen Canyon Dam and Separation Canyon near the inflow to Lake Mead, including the Grand Canyon, as shown on figure 3. While nearly all the area is within Grand Canyon National Park, parts of both Glen Canyon National Recreation Area and Indian reservation lands are also affected. Physical, biological, cultural, or recreation-related impacts would be limited to this area.

Area of General Influence

This area equates to the wider area of influence of the water and power resources of Glen Canyon Dam. The area encompasses the six western states served by Western: Arizona, Utah, Wyoming, Colorado, New Mexico, and Nevada. Hydropower-related impacts would occur in this area.

COLORADO RIVER FLOWS

Glen Canyon Dam has had a significant effect on downstream resources. Before the dam was completed in 1963, the river reached a maximum flow in May or June, then receded during the remainder of the year. Since 1963, the flow below the dam has been primarily dependent on the release of water from Lake Powell. The regulation of flow by Glen Canyon Dam has resulted in a slight increase in intermediate flows and a great decrease in the number and magnitude of annual flood peaks. Fluctuating releases are made when the dam is being operated to produce peaking power. Since demands for hydroelectric power determine the hourly schedule of discharges, the dam releases vary over a 24-hour cycle.

RESOURCES

Some resources would not affect or be affected by the proposed action. These resources, which will not be discussed, include: climate, geology/topography, esthetics, water supply, water quality, and air quality.

The parameters analyzed are those relating to sediment, biology, cultural resources, recreation, and hydropower resources. The effects of the alternatives on each resource are shown in table 3.

The resources are primarily analyzed qualitatively; when quantitative data were available, they were included.

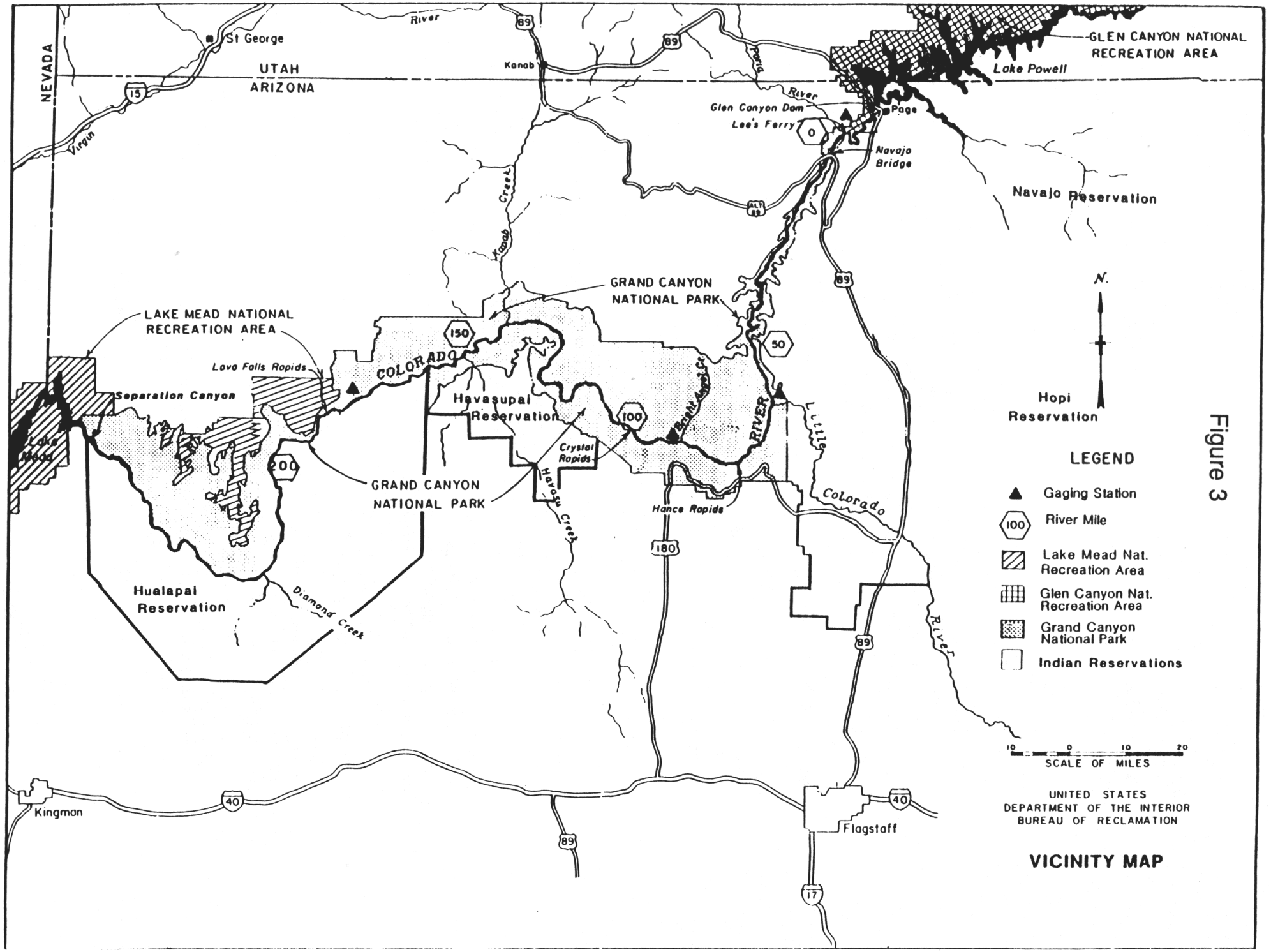
NEVADA
UTAH
ARIZONA
St George
Virgin River
Kanab
Kanab Creek
Glen Canyon Dam
Lee's Ferry
Page
Lake Powell
GLEN CANYON NATIONAL RECREATION AREA
Navajo Bridge
Navajo Reservation
GRAND CANYON NATIONAL PARK
LAKE MEAD NATIONAL RECREATION AREA
Lava Falls Rapids
Separation Canyon
COLORADO RIVER
Havasupai Reservation
Bright Angel Ck
Crystal Rapids
Havasu Creek
Hance Rapids
Little Colorado River
Hopi Reservation
Hualapai Reservation
Diamond Creek
Lake Mead
Kingman
Flagstaff
N.
LEGEND
Gaging Station
River Mile
Lake Mead Nat. Recreation Area
Glen Canyon Nat. Recreation Area
Grand Canyon National Park
Indian Reservations
SCALE OF MILES
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VICINITY MAP

Figure 3

SEDIMENT

Sediment deposits (beaches) exposed along the Colorado River corridor are the foundation for the biological and recreational resources of the river through Glen Canyon National Recreation Area and Grand Canyon National Park.

Current maximum water releases are significantly less than the peak floodflows that occurred before construction of the dam. Therefore, the river's capacity to transport sediment has been reduced along with the sediment supply though the clear-water releases from the dam are erosive. The only sources of sediment that resupply sand to the river below Glen Canyon Dam are the tributaries, with the primary sources of sand being the Paria and Little Colorado Rivers and Kanab Creek. The long-term average annual sand load from all tributaries within the Grand Canyon is estimated at 3.7 million tons per year (mty) (Randle and Pemberton, 1988).

Following construction of Glen Canyon Dam, downstream beaches underwent a process of net erosion (beginning in 1965), with slower rates of erosion in the mid 1970s, then changed considerably after the high flows in 1983. For example, some beaches aggraded as much as 10 feet, while others disappeared. If high flow releases from Glen Canyon Dam are infrequent in the future, sand supplied from Grand Canyon tributaries will maintain a net balance of river channel sand over the long term.

AFFECTED ENVIRONMENT/NO ACTION ALTERNATIVE CONSEQUENCES

The following discussion is based on the GCES report: "Interim Flows for Grand Canyon, Recommendations for Interim Operating Procedures for Glen Canyon Dam," (U.S. Department of the Interior, 1991.)

Erosion of Sand Bars

The No Action regime of fluctuating flows has been shown to cause erosion of the sand bars, beaches, and other sediment deposits. The range of daily fluctuations in discharge, the rate of the changes in daily discharges, and the maximum daily discharge are significant factors affecting erosion rates.

Daily Discharge Fluctuations.—Some of the greatest flow fluctuations occur in the month of August (typically one of the highest volume release months). The average daily change in flow for the month of August has been 14,900 cfs for the period 1966-89. This is based upon average minimum releases of 8,700 cfs and maximum releases of 23,600 cfs. The corresponding change in river stage (assuming no flow attenuation) at Colorado River gauging stations is 4.8 feet below Glen Canyon Dam, 2.9 feet at Lees Ferry, and 6.5 feet near Grand Canyon. The range of daily fluctuations in discharge increases sand bar and beach erosion in an exponential relationship to the magnitude of fluctuation. In other words, a constant daily discharge causes the least erosion, and increasingly wide fluctuations in instantaneous discharge cause progressively larger rates of erosion. Erosion of beach deposits occurs primarily when the area of the recirculating zone decreases and the deposit of sand (beach) is exposed to the primary downstream current (see figure 4). The area of a

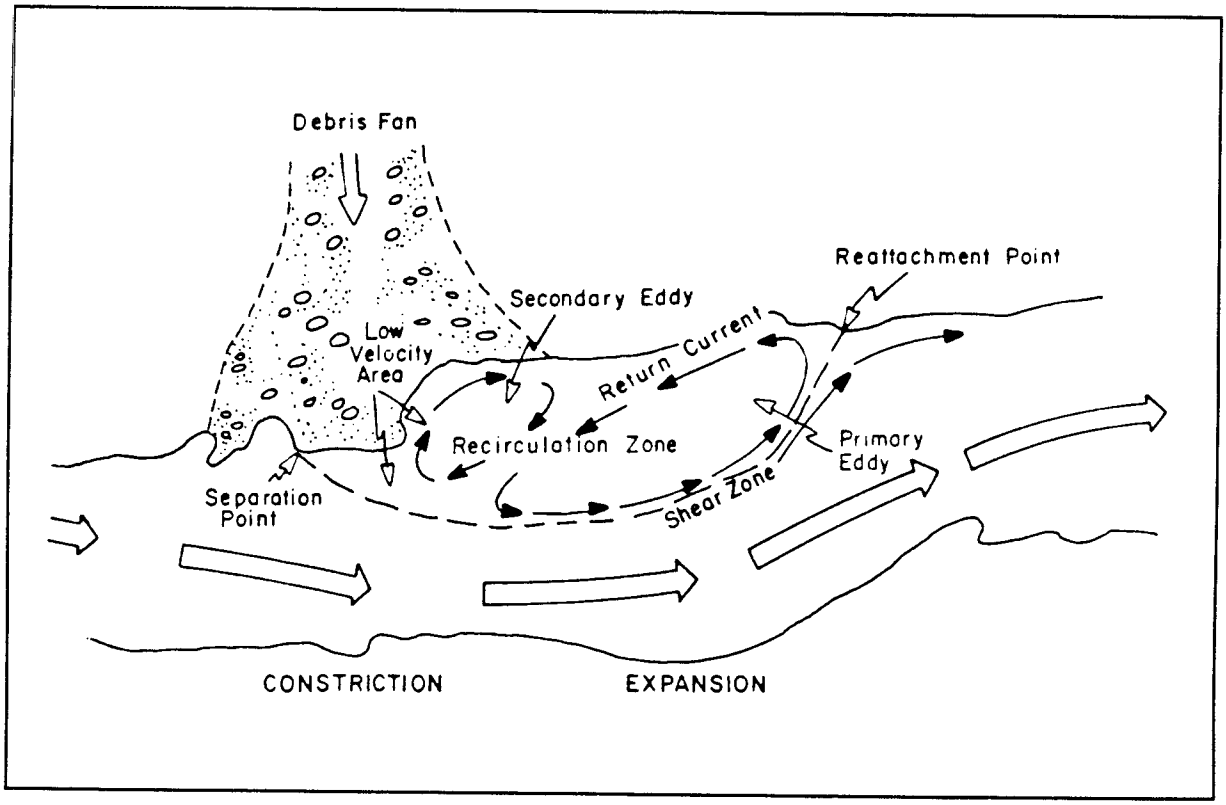

Figure 4.—Flow patterns in a typical recirculation zone.
(After Schmidt and Graf, figure 3A, 1990.)

recirculating zone is determined by local channel topography and discharges. As discharge decreases, the point at which the primary downstream current reattaches to the bank moves upstream. The zones of recirculating flow (eddies) where the sand bars are deposited decrease in size, and a portion of the channel which was previously within the recirculating zone is exposed to the much higher flow velocities of the primary downstream current. The downstream acceleration of flow along the bank can result in direct erosion of sand banks or the erosion of sand which slumps into the channel from higher elevations. Erosion of areas downstream from the reattachment points was described by Schmidt and Graf (1990). Sand transported by relatively high-velocity main channel flows would likely deposit in the slower velocity recirculating zones. Beaches or sand bars may rebuild when flows are greater than normal maximum powerplant releases for a duration of 1 to 2 weeks.

Discharge Change Rate.—The rate of change in instantaneous discharge (ramping rate) also has been shown to influence the erosion rate of the sand bars and beaches; the steeper the ramping rate, the greater the rate of material removal. A ramping rate of 3,600 cubic feet per second per hour (cfs/hr), which was used as the "low" ramping rate under the 1990-91 research flows, produced considerable erosion. This rate is actually closer to intermediate to high ramping rates under normal operations. Down-ramping has a much greater influence on sand bar and beach erosion than up-ramping. A rapid decrease in river stage leaves the sand bar saturated with excess

water, reducing the effective strength of the sand bar and promoting bank failure. This seepage-driven erosion appears greatest when Glen Canyon Dam ramping rates exceed 1,000 to 2,000 cfs/hr for decreasing flows. Maximum daily ramping rates exceeded 5,000 cfs/hr (1-hour duration) about 50 percent of the time between 1965-90. Ramp rates exceeded 3,000 cfs/hr (3-hour duration) about 50 percent of the time for the same period.

Maximum Daily Discharge.—The maximum discharge determines the highest river stage in which sediment transport and depositional processes occur. The daily ebb and rise to this maximum discharge will cause erosion of yet higher sand deposits created during the very high flow years of 1983-1986. Preliminary data indicate that discharges above 20,000 cfs accelerate erosion of perched beach sand deposits, and cause lateral bank erosion. Reconnaissance observations made in 1990 and 1991 in Grand Canyon indicate that discharges of about 20,000-22,000 cfs will begin to erode the base of the high flow deposits.

Replenishment of Sand Bar Deposits

Erosion of sand bar deposits occurs under any flow conditions. Therefore, replenishment of sand and rebuilding sand bars is essential to maintaining this resource. Replenishment of sand bar material lost to erosion requires an available supply of sand in the river reach, and a sufficient flow to deposit sand to an elevation above the normal river stage.

Available Sand Supply.—The quantity of sand stored in a given river reach, and thus available for deposition on sand bars, depends upon the supply of sand to the reach from the upstream channel and tributaries and the rate at which sand is removed from the reach by transport downstream.

Randle and Pemberton (1988) and Pemberton (1988) calculated the supply of sand to reaches of the Colorado River though Grand Canyon National Park. On average, 1.1 million tons of sand annually are supplied to the reach between the Paria and the Little Colorado Rivers and 1.5 million tons of sand, on average, are supplied to the reach between the Little Colorado River and the U.S. Geological Survey (GS) gauge just above the mouth of Bright Angel Creek (Grand Canyon gauge) (Burkham, 1987). The amount of sand transported by the main channel is proportional to the river flow raised to the third or fourth power.

River Flow.—A steady constant flow of 11,387 cfs (8.23 maf per year) will transport approximately 200,000 tons of suspended sand per year at the GS gauge near Grand Canyon. The same annual flow (8.23 maf) with daily fluctuations of the No Action-operating regime would transport approximately 500,000 tons per year of suspended sand past the gauge near Grand Canyon. This 250 percent increase in annual suspended sand load by the same annual flow is due to the exponential increase in transport with discharge. Under most possible operating regimes where the annual flow is 8.23 maf, the inflow and outflow of sediment to the reach of the Colorado River between the Paria River and the Little Colorado River will be approximately in equilibrium and the reach from the Little Colorado River to the Grand Canyon gauge

will be aggrading (will display a net accumulation of sediment). Sand that has aggraded in the channel pools and eddies may be available to rebuild beaches and sand bars during periods of high releases.

LOW FLUCTUATING FLOW ALTERNATIVE CONSEQUENCES

Erosion of Sand Bars

Under this alternative the rate of beach erosion would be less than under the No Action Alternative. The upper range of fluctuations would be from 12,000 cfs to 20,000 cfs under normal operations. The shape and size of recirculation zones would be more stable throughout a 24-hour period, and less sediment would be eroded from these zones than under the No Action Alternative. Flows greater than 20,000 cfs could be released under emergency conditions for short periods of time. Maximum discharges could be as high as 30,000 cfs with durations ranging from a few minutes to about 2 hours. Peak releases of short duration would be expected to attenuate rapidly downstream. The greatest impact of these emergency operations would occur during times of rapidly decreasing flow coupled with a decrease in flow of more than 8,000 cfs over a 24-hour period. The consequences of these emergency releases would be of a similar nature to consequences under the No Action Alternative. However, the cumulative impact of these events is thought to be minor, because they would occur infrequently and because of rapid attenuation downstream.

The average daily change for the month of August under the Low Fluctuating Flow Alternative would be 8,000 cfs. During the August 1991 Test Flows, releases typically ranged from 10,000 to 18,000 cfs. The corresponding change in river stage (assuming no flow attenuation) at Colorado River gauging stations is 2.7 feet below Glen Canyon Dam, 1.7 feet at Lees Ferry, and 3.8 feet near Grand Canyon. This relatively narrow range in river stage fluctuations would reduce the amount of excess water pressure within a saturated sediment deposit and thus reduce the potential for bank erosion. Also, the maximum rate at which the flow would decrease (1,500 cfs/hr) under this alternative would more closely match the rate at which the ground-water elevation in a sediment deposit can respond to changes in river stage. This would lessen the potential for seepage-based erosion relative to the No Action Alternative.

Replenishment of Sand Bar Deposits

With this alternative the amount of sediment transported by the river would be less, and the quantity of sand stored in the river channel pools and eddies would be greater than under the No Action Alternative. The Low Fluctuating Flow Alternative would transport about 250,000 tons of suspended sand per year past the Grand Canyon gauging station. This amount is one-half of the sediment transported under the No Action Alternative. Both the Low Fluctuating Flow and the No Action Alternatives would allow the river channel pools and eddies (between the gauges at Lees Ferry and above Little Colorado River) to accumulate sand in years where annual releases from Glen Canyon Dam are less than 12 maf (Randle and Pemberton, 1988). However, the river channel would aggrade at a faster rate under conditions of the Low Fluctuating Flow Alternative when compared to the No Action Alternative. Channel aggradation of pools and eddies is important in the rare context of spills. Sand that is stored in

channel pools may be available for transport during spills and may result in aggradation of sand bars and other sediment deposits with less accompanying impact on the remaining beaches. Although spills may be considered damaging to most downstream resources (GCES Final Report, 1988), spills are less damaging and are perhaps beneficial when sand bars can be rebuilt with sand that previously accumulated in the channel. Infrequent emergency operations would have either minimal or almost no impact on the annual sand-load of the river or the quantity of sand stored in the channel.

Financial Exception Criteria Option

A small increase in the frequency of flows greater than 20,000 cfs could occur under this optional condition of the Low Fluctuating Flow Alternative. The greatest impact of these operations would occur during times of rapidly decreasing flow coupled with a decrease in flow of more than 8,000 cfs over a 24-hour period. The consequences of these releases would be similar to consequences under the No Action Alternative. However, the cumulative impact of this option is thought to be minimal because of the infrequent occurrence projected (fewer than 22 hours per month). Also, the bypassing of flows to avoid noncompliance with the down-ramping rate would mitigate this impact.

BIOLOGICAL RESOURCES

VEGETATION

Affected Environment/No Action Alternative Consequences

Plant communities affected by releases from Glen Canyon Dam are located in a restricted zone adjacent to the Colorado River. This riparian zone exists in the interface between the river's strictly aquatic communities and upland plants adapted to desert conditions. This zone often supports plants found nowhere else in the region.

Riparian zones are dynamic, adjusting to the range of physical and biological conditions that constrain them. For example, following completion of Glen Canyon Dam, riparian vegetation at selected sites increased at the rate of 1/2 acre per river mile per year between 1965 and 1973 (Carothers and Brown, 1991). Between 1973 and 1980, the rate of increase slowed to 1/4 acre per mile per year. Riparian development was interrupted and perhaps redirected by high flood flows in 1983. Riparian vegetation within the Grand Canyon is advancing toward an equilibrium following the flood flows of the mid-1980's, and the future composition of this zone is unknown (Carothers and Brown, 1991).

Vegetation aids in bank stabilization by trapping nutrients during high flows while providing a structural diversity that makes riparian zones some of the most important wildlife habitat in the region. Riparian vegetation supplies cover and food for the abundant insects hatching and emerging from the river and, in turn, supports numerous mammals, birds, reptiles and amphibians, and other invertebrates (Carothers and Brown, 1991). Additional species rely on organisms produced in riparian zones as prey items.

Woody Plants.—Both native and exotic woody plants are important components of riparian zones along the Colorado River. The old high water zone (OHWZ) was influenced historically by high spring flows and climate. The zone is characterized by plants that require periodic flooding or roots that reach the water table. For example, the OHWZ is dominated by netleaf hackberry in upper reaches of Marble Canyon, with honey mesquite and catclaw acacia most common in the lower reaches of the river. Mesquite and acacia have long taproots that anchor the plants in place during flood flows and reach water tables during lower flows.

Current dam operations affect plants in the OHWZ by reducing the frequency and magnitude of flood events (flows greater than 31,500 cfs). Without periodic inundation, plant germination in the OHWZ is limited and growth of established plants is affected. The OHWZ is declining in area coverage (U.S. Bureau of Reclamation, 1991), and dying trees are evident along some river reaches.

The new high water zone (NHWZ) exists from the OHWZ down to approximately the 30,000 cfs flow stage. Common woody plants include both native and exotic species: seep-willow, arrowweed, desert broom, coyote and Goodding willow, and tamarisk (Carothers and Brown, 1991). Tamarisk is the dominant woody plant in the NHWZ. Some invasion of honey mesquite and catclaw acacia into the NHWZ from the OHWZ is occurring. The NHWZ is the most valuable component of the riparian zone as wildlife habitat.

Aquatic Vegetation.—Aquatic vegetation can be found along some beaches, associated with some backwaters, and in other isolated sites within the fluctuating zone, or the area currently influenced by fluctuating flows. Common species include cattails, scouring rush, bulrush, and rushes. Coyote willow, arrowweed, and seep-willow are often associated with such sites. Tamarisk is also common in the fluctuating zone. Although limited in areal coverage, marshes are very productive sites in terms of local food chains. For example, 1 acre of marsh would be expected to produce insect biomass equivalent to several miles of river channel.

Another result of reductions in flood events would be the continued establishment of riparian vegetation in the NHWZ and fluctuating zone. However, this trend is complicated by daily fluctuations in flows. Although relationships between vegetation and operational flows are still under investigation, researchers with GCES believe that flows greater than 20,000 to 22,000 cfs cause accelerated erosion of high beaches (U.S. Bureau of Reclamation, 1991). Such erosion affects shallow-rooted plants like arrowweed, coyote willow, giant reed, and cattail.

Low Fluctuating Flow Alternative Consequences

This analysis assumes no spills (flows greater than 31,500 cfs) during the short time the interim operating criteria would be in effect. The Low Fluctuating Flow Alternative would contribute to the continued decline of OHWZ vegetation, but is not expected to increase the rate of decline during the short duration of the interim criteria.

The NHWZ and fluctuating zone would benefit from the proposed interim flows. A maximum flow of 20,000 cfs would be below the level where accelerated beach erosion

begins, and reduced ramp rates would decrease the incidence of beach erosion (U.S. Bureau of Reclamation, 1991). The proposed action would improve conditions, when compared to No Action, for both beaches and vegetation associated with the NHWZ and fluctuating zone.

Financial Exception Criteria Option.—Under this condition, there would be no measurable difference in the affected vegetation, as compared to the Low Fluctuating Flow Alternative.

WILDLIFE

Affected Environment/No Action Alternative Consequences

Carothers and Brown (1991) list 114 species of amphibians, reptiles, birds, and mammals (river otter excluded) that inhabit the river corridor. Of these, only the Canyon treefrog, white-throated woodrat, desert woodrat, and 17 birds do not use riparian vegetation as habitat. Thirty-five species are recorded only in the riparian zone.

The importance of riparian vegetation as wildlife habitat, specifically the NHWZ, is readily exemplified by bird use. Of the 114 species listed by Carothers and Brown (1991), 51 are birds. Some 15 species use both the OHWZ and NHWZ, with an additional 12 species restricted to the NHWZ. Only three species use the OHWZ exclusively. Four species—Bell's vireo, summer tanager, hooded oriole, and great-tailed grackle—have expanded their nesting ranges into the Grand Canyon in response to increases in riparian vegetation (Carothers and Brown, 1991). Lizards are more abundant in the NHWZ than in any other canyon habitat type.

Wildlife use of the fluctuating zone is generally limited to foraging because of flow-stage fluctuations. Some lizard species, such as the western whiptail, exploit the "intertidal" area of fluctuating flows for emerging insects, stranded invertebrates *Gammarus*, and other food items (Carothers and Brown, 1991).

Low Fluctuating Flow Alternative Consequences

Because wildlife along the river corridor is so closely tied to the habitat requirements supplied by riparian vegetation, it is assumed that impacts to riparian vegetation can be used to represent impacts to wildlife habitat.

One of the most important events in recent history in the Grand Canyon was the naturally high flood flows of 1983. These flows affected beach deposits, riparian vegetation, and wildlife using these sites as habitat. Where vegetation was removed, habitat was removed, and many species are still adjusting to those changes (Carothers and Brown, 1991). As under the No Action Alternative, the projected absence of flood flows during the interim period would permit continued adjustments toward post-flood equilibrium in habitat and wildlife populations.

The proposed action would not accelerate the rate of decline currently experienced by the OHWZ under the No Action Alternative.

Reduced beach erosion under the Low Fluctuating Flow Alternative would provide improved conditions for riparian vegetation and thus wildlife habitat and wildlife in the NHWZ and fluctuating flow zone.

Financial Exception Criteria Option.—Due to the short-term, and infrequent nature of flow fluctuations associated with this option, the impacts would be less than the No Action Alternative and comparable to the Low Fluctuating Flow Alternative.

FISHERIES

Affected Environment/No Action Alternative Consequences

Native Fishes.—Three native fishes—the speckled dace, bluehead sucker, and flannelmouth sucker—are common in the Colorado River below Glen Canyon. They spawn in the mainstem and tributaries from late spring to early summer (Maddux et al., 1987). Spawning often occurs over shallow gravel bars, particularly for bluehead suckers. Flow fluctuations subject these areas to dewatering with resulting high mortality of eggs and larvae. Backwaters are attractive to early life stages of these species because of their low velocity and higher temperatures. Rapid down-ramping from Glen Canyon Dam strands native fishes in backwaters or while high flows inundate backwaters, forcing fish into suboptimal habitats where they are susceptible to predation and excessive energy expenditures.

Rainbow Trout.—Since completion of Glen Canyon Dam, the 15-mile reach from the dam to Lees Ferry has become a renowned trout fishery (Carothers and Brown, 1991). Like native fishes, trout are susceptible to stranding from rapid down-ramping. Strandings are most common during the spawning season (November to April) because trout are reluctant to abandon their spawning beds (redds) (U.S. Department of the Interior, 1988). Wegner (1988) reported that as flows increased above 12,000 cfs in the Lees Ferry reach, trout-fry habitat decreased to the point that at 25,000 cfs virtually all habitat was gone. Current releases reach 31,500 cfs. The existing flow regime also impacts the trout population by dewatering redds, resulting in extensive mortality to eggs and young. Flows of at least 8,000 cfs are required to prevent dewatering of spawning sites (Persons et al., 1985). Current minimum flows range between 1,000 and 3,000 cfs. Fluctuations do, however, benefit the trout population by dislodging the filamentous algae *Cladophora* and associated invertebrates such as *Gammarus*. This drift becomes an important food source for downstream trout.

Low Fluctuating Flow Alternative Consequences

The frequency and duration of flows which have adverse impacts on fishes constitute the principal difference between the No Action and Proposed Action scenarios. This alternative would reduce the severity of these impacts. Water chemistry and temperature regimes are not expected to differ between the two alternatives.

Native Fishes.—Fluctuations associated with the Proposed Action would increase the longevity of backwaters essential to young-of-the-year native fishes. Mortality of the early life stages is expected to be lower than under existing conditions because zooplankton would be more abundant. The proposed action would provide a more

favorable habitat during the early life stages that are typically a period of high mortality. Thereafter, young-of-the-year are better adapted to conditions in the channel.

Rainbow Trout.—Daily fluctuations increase invertebrate drift, making prey more accessible to trout. However, a wide range of fluctuation can result in stranding, dewatering of redds, and loss of habitat (U.S. Bureau of Reclamation, 1991). By moderating minimum and maximum flows, the proposed action would increase trout fry habitat and reduce the likelihood of dewatering spawning sites. The population would be enhanced by greater spawning success and early life stage survival.

Financial Exception Criteria Option.—The flow fluctuations associated with this option would adversely impact fishes during their spawning and early life stages by dewatering redds or inundating backwaters. However, these flows would be less frequent and of a shorter duration than the No-Action Alternative. The impact of this option is comparable to the Low Fluctuating Flow Alternative.

THREATENED AND ENDANGERED SPECIES

Endangered species and Category 1 and 2 Candidates[1] considered in this report include the American peregrine falcon, bald eagle, southwestern willow flycatcher, humpback chub, razorback sucker, and *Flaveria mcdougalli.*

Peregrine Falcon

The American peregrine falcon was listed as Endangered in 1970.

Affected Environment/No Action Alternative Consequences.—Grand Canyon National Park supports the largest breeding population of peregrine falcons in the contiguous United States, with the majority nesting along the river corridor (Carothers and Brown, 1991). Although still under investigation, it is assumed that the peregrine falcon's success in the canyon is linked to an abundant prey base: violet-green swallows, white-throated swifts, and several species of bats. The prey species are abundant because of insect populations produced in the clear river water. Peregrines also take waterfowl that use pools between rapids during their migrations.

Low Fluctuating Flow Alternative Consequences.—The assumed absence of flood flows during the interim period would benefit riparian vegetation that is used by insects for food and cover. This, in turn, aids the growth of insect populations, which translates into benefits for swallows, swifts, bats, and, ultimately, peregrine falcons.

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[1] "Endangered species" is a species in danger of extinction throughout all or a significant portion of its range. "Category 1 Candidate" is a taxa (species or subspecies) for which there is substantial information to support the biological appropriateness of proposing to list as threatened or endangered. "Category 2 Candidate" is a taxa for which some information may indicate that listing is possibly appropriate, but biological data on vulnerability and threat are not currently available.

Reduced beach erosion under the Low Fluctuating Flow Alternative (as compared to the No Action condition) would also permit improved conditions for riparian vegetation. As discussed above, these conditions would benefit peregrine falcons.

Primary productivity within the river is controlled by many factors (Carothers and Brown, 1991), but the proposed action would affect only light transmittance through changes in water clarity. Mixing actions on pool and beach sediments from fluctuating flows and sediment augmentation from tributaries both affect river water clarity. The proposed action may affect sediment mixing through reduced fluctuations. If such effects occur, they should improve water clarity somewhat over No Action conditions. Improvements in water clarity should translate into benefits to peregrine falcon populations through the food chain linkages discussed above.

Financial Exception Criteria Option.—The increased supply of food for peregrines associated with the Low Fluctuating Flow Alternative would also be true of this option except for short-term and infrequent periods of high fluctuating flows. During these periods, impacts would be similar to those of the No-Action Alternative. The overall impact is expected to be indistinguishable from the Low Fluctuating Flow Alternative.

Bald Eagle

The bald eagle was listed as Endangered in 1967.

Affected Environment/No Action Alternative Consequences.—Bald eagles exploit winter spawning trout at Nankoweap Creek. While eagles are capable of taking fish from the river channel, they were not often observed in the Grand Canyon until after the trout fishery became established. Eagles first appeared in the winter of 1985-1986 (four birds) and have increased to a high of 26 birds in a single day in the winter of 1989-1990. Some 70-100 endangered eagles moved through the area in February and March of 1990 (Brown and Leibfried, 1990). While research is still underway, it appears that the number of eagles at Nankoweap Creek may be related to the abundance of spawning trout. Eagle numbers were down in 1990-1991 as were the number of spawning trout. Rapid down-ramping causes stranding of spawning trout under certain conditions, and low flows over extended periods affect *Cladophora* and *Gammarus* resources (U.S. Bureau of Reclamation, 1991).

Low Fluctuating Flow Alternative Consequences.—It is assumed that use of the Grand Canyon is linked to the abundance of trout attempting to spawn in Nankoweap Creek. Any factors that affect trout would therefore probably affect bald eagles.

Constraints on ramp rates and minimum flow restrictions imposed under the Low Fluctuating Flow Alternative would improve habitat conditions for trout over those existing under the No Action condition. Improved habitat conditions for trout are assumed to translate into more trout attempting to spawn at Nankoweap Creek and a larger prey base for bald eagles.

Financial Exception Criteria Option.—The fluctuating flows associated with this option could adversely impact trout spawning and larval development, which

would reduce forage for bald eagles. However, this reduction would occur less frequently and be of a shorter duration than the No-Action Alternative. The impact of this option is comparable to the Low Fluctuating Flow Alternative.

Southwestern Willow Flycatcher

The southwestern willow flycatcher is a Category 2 Candidate for listing.

Affected Environment/No Action Alternative Consequences.—Although limited to a few dozen pairs in the Grand Canyon, this is the largest population of this species in Arizona. Carothers and Brown (1991) attribute this population to increases in the riparian vegetation following reductions in high flood flows produced by Glen Canyon Dam operations. This species nests in the NHWZ in tamarisk.

Low Fluctuating Flow Alternative Consequences.—As stated previously, it is assumed that the absence of flood flows during the interim period would permit adjustments toward post-flood (1983) equilibrium in both habitat and wildlife populations, including the willow flycatcher.

Reduced beach erosion under the Low Fluctuating Flow Alternative would permit improved conditions for riparian vegetation and thus improve willow flycatcher habitat.

Financial Exception Criteria Option.—Except for infrequent and short-term periods of high fluctuation, this option would have impacts similar to those of the Low Fluctuating Flow Alternative. The infrequency and short duration of peaking power releases suggest that this option would be less detrimental to the southwestern willow flycatcher than the No-Action Alternative.

Humpback Chub

The humpback chub is listed as Endangered because its population is severely reduced in isolated remnants of its original range.

Affected Environment/No Action Alternative Consequences.—The Grand Canyon population of humpback chubs spawn in the Little Colorado River between March and June (U.S. Department of the Interior, 1988). Cold water releases from Glen Canyon Dam are believed to limit or prevent reproduction in the Colorado River and limited the ability of fish to survive. Larval and juvenile development occurs in the lower reaches of the Little Colorado and backwaters of the mainstem Colorado River. Although they are rarely stranded by fluctuating flows, they are displaced from their preferred backwater habitats where they are more susceptible to predation and excessive energy expenditures (U.S. Department of the Interior, 1988). The instability of backwaters as a result of flow fluctuations may limit food availability by disrupting zooplankton reproduction.

Low Fluctuating Flow Alternative Consequences.—The short-term duration of the interim flows, their moderation of the existing flow regime, and the long-lived character of humpback chubs (30 years) suggest that the interim flows would not have

a long-term adverse impact on the species (U.S. Bureau of Reclamation, 1991). No change in water temperature in the Colorado River would occur. Early life stages would be forced to less-than-optimal habitats as backwaters were dewatered and inundated as a result of the interim flow fluctuations; however, these adverse impacts would occur less frequently than under existing conditions.

Financial Exception Criteria Option.—The flow fluctuations associated with this option would adversely impact young-of-the-year humpback chubs in the mainstem Colorado River by dewatering or inundating their preferred habitat. However, flows having adverse impacts would occur infrequently and for a short duration. The impact of this option would be similar to the Low Fluctuating Flow Alternative and less than the No-Action Alternative.

Razorback Sucker

The razorback sucker is a Category 1 Candidate.

Affected Environment/No Action Alternative Consequences.—The razorback sucker has a longevity in excess of 50 years (Carothers and Brown, 1991). This species' range is severely reduced and it frequently fails to reproduce or rear young to maturity. A small reproductive population occurs in Lake Mead but no young and very few adults have been collected in the riverine reaches below Glen Canyon. The limited number of sightings suggests that the existing conditions in the canyon are not favorable, but the impact of the current flow regime is unknown.

Low Fluctuating Flow Alternative Consequences.—The razorback sucker, like the humpback chub, is a long-lived species. Its longevity and the relatively short term of the interim flows suggest that adverse impacts would be minimal. As reproduction has not been documented, there would be no benefit for larval and young razorbacks.

Financial Exception Criteria Option.—The impact of this option would be similar to the Low Fluctuating Flow Alternative because of similar flow regimes. During the infrequent and short-term periods of high fluctuation, adult razorbacks would be unlikely to experience significant adverse impacts because of their adaptation to high flows.

Flaveria Mcdougalli

Flaveria mcdougalli is a Category 1 Candidate.

Affected Environment/No Action Alternative Consequences.—This plant is thought to be limited to the Grand Canyon in the Inner Gorge between Matkatamiba Rapids and Lava Falls. It is found in permanently moist seeps at elevations between approximately 1,640- and 1,970-feet elevation.

Low Fluctuating Flow Alternative Consequences.—It is assumed that most Flaveria habitat is above the scour zone; therefore, the absence of flood flows during the interim period would be beneficial to these populations. If populations exist in the upper scour zone, constraints on maximum flows (20,000 cfs) in the proposed action

would reduce risk from inundation and erosion. If populations of Flaveria occur below the 20,000-cfs flow stage, impacts from the proposed action would probably equal those occurring under No Action conditions.

Financial Exception Criteria Option.—Plants in the upper fluctuating zone could experience short-term and infrequent inundation as a result of this option; however, the adverse impacts associated with inundation would not be as severe as those under the No Action Alternative. The impact to the majority of the populations which occurs above the upper scour zone, would be similar to those occurring under the No Action Alternative.

Arizona Species of Concern

Arizona lists three Species of Concern that may occasionally use the river corridor in the Grand Canyon: osprey, belted kingfisher, and river otter. The osprey is assumed to be a transient visitor to the canyon and its ability to take fish from the river would not change between the No Action and Low Fluctuating Flow Alternatives. The belted kingfisher is also a transient visitor along the river. Changes between the two alternatives would not affect this species. The river otter has not been sighted in the Grand Canyon since 1983. If otters are present, lower fluctuations under the proposed action should improve habitat conditions for this species.

CULTURAL RESOURCES

AFFECTED ENVIRONMENT/NO ACTION ALTERNATIVE CONSEQUENCES

Approximately 475 archeological sites have been recorded in the Grand Canyon. Under existing operating criteria, 12 to 15 are directly subject to flow-caused erosion of the sediment which has acted as foundation for these near-river sites. Long periods of flooding in 1983 and resumption of fluctuating flows uncovered many sites, making them more susceptible to erosion of support material. The No Action Alternative would be a continuation of this condition.

The Charles H. Spencer paddle wheel steamboat has been designated a National Historic Site (Carrel, 1987). Several feet of the upper hull are exposed at discharges of 5,000 cfs and are subjected to rapid wetting and drying from waves which increase the rate of decay of the wood, as well as intensifying exposure to vandalism. At discharges of 20,000 cfs to 25,000 cfs, the hull is susceptible to scour by sand and drifting vegetation. Therefore, under the No Action Alternative—with low flows of 1,000 cfs in winter and 3,000 cfs in summer, along with high flows of 31,500 cfs—the steamboat is subjected to extreme adverse conditions daily.

LOW FLUCTUATING FLOW ALTERNATIVE CONSEQUENCES

The Low Fluctuating Flow Alternative would be less damaging overall. It would reduce the number of archeological sites directly subject to flow-caused erosion by approximately 15 to 20 percent.

Under the Low Fluctuating Flow Alternative the hull of the Charles H. Spencer steamboat would rarely be exposed and scouring would be almost nonexistent.

Chapter IV explains how compliance with Section 106 of the National Historic Preservation Act is being accomplished.

Financial Exception Criteria Option

Under this option, there would be a greater risk of erosion of the foundation sediments of near-river archeological sites. However, the risk would be minimized because down-ramping and minimum flow criteria would be maintained by bypasses. This potential impact would be less than that with the No Action Alternative.

The Charles H. Spencer paddle wheel steamboat would be subjected to scouring if flows exceeded 20,000 cfs. Minimum flows would be maintained. Again, this impact would be less than that with the No Action Alternative.

RECREATIONAL RESOURCES

Within the study area, three groups account for almost all of the recreational use of the river: anglers, white-water boaters, and day-use rafters in the Glen Canyon reach. For purposes of analysis, anglers and day-use rafters have been combined since the major impacts occur in the Glen Canyon reach upstream of Lees Ferry.

ANGLERS AND DAY-USE RAFTERS

Affected Environment/No Action Alternative Consequences

Following completion of Glen Canyon Dam, the first 15 miles between the dam and Lees Ferry were stocked with trout and became a blue ribbon trout fishery. This section of the river is flat water and is fished predominantly from boats which are launched at Lees Ferry and from the banks near Lees Ferry.

Judging from the number of large fish (over 23 inches) caught, the fishery peaked in 1978. Due to increased fishing pressure and a changing fishery, the average weight of fish caught declined between 1978 and 1984 but has since increased somewhat. Usage peaked in 1983 at 52,000 angler-days.

Since 1983, use has dropped steadily in response both to poorer fishing and to more restrictive fishing regulations implemented in 1978 and 1980 (Janisch, 1985). In 1985, the area recorded only 15,000 angler-days.

Trout fishing does occur downstream in Grand Canyon, but it is a relatively minor activity at present in terms of user-days.

In 1985, 8,469 visitors took half-day commercial raft trips on the 15-mile flat-water section of the Colorado River between the dam and Lees Ferry. These flat water tours are extremely safe, with no reported accidents. On these short trips, river flows affect

only the point of departure. At flow levels less than powerplant capacity, 20-person tours depart from a dock near the dam and float down to Lees Ferry. When releases are made above powerplant capacity trips depart from Lees Ferry with 10 passengers and motor part way upstream before floating back downstream. At that point, trips become unprofitable for rafting companies, due to increased fuel usage, and are generally not offered.

At flows of 3,000 cfs or less, large boats cannot get past the sand and gravel bar 3 miles upstream from Lees Ferry, and even very small boats may have to be dragged over slippery rock gravel bars. Consequently, under these conditions, nearly all fishing occurs in the 3 miles just above Lees Ferry. However, low water tends to concentrate fish, and bank anglers can find large areas of exposed gravel and rocks, leaving a great deal of space between the water and the edge of the vegetation.

Fluctuating water levels add additional difficulties. Falling water may make it difficult for boats to return downstream over rocks and gravel bars that had more water over them on the trip upriver. Rising water may increase the likelihood of swamping a boat while anchored or while the bow is pulled up on shore. A few anglers favor fluctuating flows, believing that rising water may stimulate feeding by fish.

Low Fluctuating Flow Alternative Consequences

From an economic perspective, to the extent that flows affect the quality of downstream recreation, those effects would be reflected in recreational values. Low fluctuating flow conditions would produce higher values than the No Action Alternative assuming that National Park Service (NPS) policies—such as those governing total recreational use of the Grand Canyon and launch schedules—and fishery management decisions of the Arizona Department of Game and Fish (ADGF) are not changed. Water levels would improve access to the Glen Canyon reach for angling and day-use rafters.

The higher water associated with No Action disperses the fish, which may reduce fishing success. It also creates stronger currents, increasing problems for boat handling. Thus, a steady, low fluctuating flow would provide a safe, consistent, and predictable recreation area for anglers, except when the infrequent emergency criteria would be used.

Financial Exception Criteria Option.—The quality of angler experiences in the Glen Canyon reach would be slightly reduced compared to the Low Fluctuating Flow Alternative due to increased frequency of higher and lower flows. Day-use rafting would also be slightly adversely impacted with periodic, yet unscheduled fluctuating flows. Although adverse impacts to safety would be minimal, the effects would be greater than those under the Low Fluctuating Flow Alternative.

WHITE-WATER BOATERS

Affected Environment/No Action Alternative Consequences

The Grand Canyon white-water section of the Colorado River begins at Lees Ferry and continues for over 200 miles through Grand Canyon National Park. It is one of the premier white-water rafting areas in the world because of the numerous challenging rapids and the magnificent natural setting in one of the longest stretches of remote backcountry in the United States.

From 1960 to 1972, the number of boaters annually running the river grew from 205 persons to 16,432. In 1972, increasing problems with the management of human waste and trash along the river, damage to fragile soils and vegetation, and destruction of prehistoric sites prompted the NPS to establish a ceiling on the number of user days allowed each year and to institute stricter river-use regulations to help minimize impacts by river runners.

For the past 5 years the NPS has limited total white-water user-days to 115,500 per year for passengers on trips provided by commercial outfitters and 54,450 user-days for private individuals. Partly as a result of the flow regulation of Glen Canyon Dam, this has grown into a $14 million-a-year industry according to NPS records.

Many types of boats are used: small 14-to 18-foot oar-powered rafts (roughly 45 percent), motorized 30-foot rafts (25 percent), kayaks (20 percent), and dories (6 percent). Motorized trips vary from a 3- to 4-day trip between Lees Ferry and Phantom Ranch (approximately 90 river miles), to a 7- to 10-day trip through the entire Grand Canyon to Lake Mead (approximately 250 river miles).

White-water boaters camp each night on sand bars which provide relatively level campsites free of vegetation and rocks. Sand bars are also utilized for day-time stops when the riparian vegetation can provide shade.

Fluctuations are generally detrimental to white-water boating. Fluctuations impair the naturalness of the setting and make the management of white-water trips difficult.

There are indications that certain types of flow patterns in the long term may reduce the number of sandy beaches in the Grand Canyon (U.S. Department of the Interior, 1989). At present, the area between Hance Rapids and Havasu Falls has fewer beaches than other parts of the canyon. Trip leaders must plan schedules very closely to ensure a good campsite in this area. As beaches disappear, this careful planning would have to be extended to other parts of the canyon. This might mean missing some attraction sites or camping near or sharing a beach with other parties, and possibly making some camps in areas without any sand.

With large daily fluctuations from 10,000 cfs to 31,500 cfs, around an average daily flow of 19,000 cfs, boatmen have to take care in selecting mooring and camping sites. Due to low morning water levels, gear may have to be carried (perhaps across rocky areas) to the boats. Boatmen may wait above certain rapids for the water level to rise or may have to hurry to get to a certain rapid before the water level falls. In addition, some rapids may be difficult due to exposed rocks at low water levels and other rapids might be quite large at high water levels; it is likely that passengers may have to walk

around a few of the rapids. When the water is high or rising, however, the standing waves in some of the major rapids become larger, resulting in a bigger "roller coaster" ride.

Low Fluctuating Flow Alternative Consequences

A major concern of white-water boaters is the potential loss of beaches in the Grand Canyon due to the erosive effects of flood flows and the fact that the supply of beach sediment has been greatly reduced by the presence of Glen Canyon Dam. The Low Fluctuating Flow Alternative would reduce the rate of beach erosion and maintain or improve camping opportunities.

Higher minimum flows would permit easier trip scheduling through rapids and more time to stop and visit attractions, thus improving the quality of the trip. Equipment damage would be less if low flows are avoided, and passenger safety would be improved if flows above 20,000 cfs are avoided.

Financial Exception Criteria Option.—There would be no measurable difference in the quality of white-water rafting on the river downstream of Lees Ferry compared to the Low Fluctuating Flow Alternative.

HYDROPOWER RESOURCES

AFFECTED ENVIRONMENT/NO ACTION ALTERNATIVE CONSEQUENCES

Physical Resources

Capacity/Energy.—Glen Canyon Powerplant has eight generating units with a maximum capacity totaling 1,356 kilowatts (kW); four have capacity up to 165 megawatts (MW) each, and four have capacity of 173 MW each.

Power is generated by releases from Glen Canyon Dam on a fluctuating (peaking power) basis to conserve fuel resources, reduce air emissions, and increase the value of Glen Canyon Powerplant electricity produced by generating during high-use daytime periods. Fluctuating releases also are suited to hydropower, which is more flexible than other forms of electrical generation. In addition, when possible, higher releases to generate more electricity are scheduled in demand-intensive core winter and summer months.

Presently the marketing plan for the hydropower resource at Glen Canyon Dam consists of 1,270 MW of capacity and 3,028,882 megawatt hours (MWh) of energy in summer, and 1,291 MW of capacity 2,672,826 MWh of energy in winter.[2] Approximately 12 percent of the energy and capacity is delivered to Western's Upper Colorado

[2] Under a court-approved interim marketing plan, Western has contractual commitments for these energy and capacity amounts from SLCA/IP (National Wildlife Federation v. Western Area Power Administration, November, 1989).

Load Control Area[3] customers, and the remainder is exported to six adjoining areas for Salt Lake City Area Integrated Projects' (SLCA/IP)[4] customers. More than half the consumers are rural electric associations and small municipalities.

Area Served.—Power produced at Glen Canyon Powerplant is marketed both in the immediate area indicated on the frontispiece vicinity map and in a wider area that is an integral part of the electrical power system of the western United States, including the states of Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming. Part of this area is served by the Colorado River Storage Project (CRSP) transmission system operated by Western's Salt Lake City Area Office which also administers the Western Upper Colorado Load Control Area.

Transmission.—Within the Western Upper Colorado Load Control Area, Reclamation operates the Federal hydroelectric generating units and Western operates the Federal transmission system that primarily consists of the CRSP transmission system. The CRSP transmission system includes about 1,800 miles of high-voltage line from southern Wyoming through western Colorado and eastern Utah and into parts of New Mexico and Arizona. Because of benefits from interconnection, the western United States and parts of Canada are electrically connected and operated under coordinated guidelines.

Scheduling and Regulation.—Scheduling is conducted in the load control area to help ensure that utility generation and load control area exports and imports are adequate for electrical demands. However, electrical demand is dynamic, and regulation is necessary to sense variations in demand and other dynamic conditions and to adjust generation levels to match these changes. Emergency conditions can also affect scheduling and regulation. As a safeguard in the event of an emergency and to provide regulation, unloaded or reserve generating capacity is maintained.

Marketing.—Western markets power and transmission services: the sale of long- and short-term firm power, nonfirm power, and transmission service (wheeling).[5]

Long-term commitments include energy/capacity amounts, and are generally contracts for 10 years or more; they are based on estimates of the long-term availability of power. Long-term sales require Western to balance its CRSP Act mandate to market the greatest practicable amount of power that can be sold at firm power rates with the risk of having less water than forecasted to produce power. Effective October 1, 1990, the SLCA/IP combined power rate became 14.5 mills per kWh at a load factor[6] of 58.2 percent in addition to a transmission charge.

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[3] A load control area is a part of a power system, or a combination of systems, to which a common generation control scheme is applied.

[4] For administrative and rate-making purposes, the Salt Lake City Area combined the Colorado River Storage Project, the Collbran Project, and the Rio Grande Project into the Salt Lake City Integrated Projects. The Provo River Project is also marketed with the SLCA/IP.

[5] "Wheeling" is a transmission service required when one utility agrees to purchase or sell power to a second utility, and the two utilities are not directly interconnected but must make arrangements to use a third party's transmission system.

[6] Load factor is the ratio of the average load during a designated period to the peak or maximum load occurring in that period.

Western offers short-term firm power sales, which are for a season or on a month-by-month basis when power available exceeds the demand. Nonfirm energy sales typically are for durations ranging from a month to several hours and follow market prices for various energy sources. Western offers firm transmission service, reserved capacity over the CRSP system, and nonfirm transmission service which, like nonfirm power sales, is interruptible on short notice.

LOW FLUCTUATING FLOW ALTERNATIVE CONSEQUENCES

Economic Impacts

From a national economic perspective, the economic impacts of the Low Fluctuating Flow Alternative are measured by the difference in production cost to the overall Pacific Southwest region electric power system compared to the No Action Alternative. Such studies are done using production expansion models which develop the lowest production costs given a range of possible power resources. Studies are currently underway to address this issue for the GCDEIS as part of the GCES II Research Program. Conclusive data are not yet available; however, in the short-term covering the 3-year period of the interim flows, it is likely that some excess capacity exists in the system. If so, this capacity, which is likely thermal plants, could be used. There would be increased fuel and operating costs. Glen Canyon Powerplant would shift to a more baseload operation and would substitute for some existing thermal plants. There may be additional costs of using surplus thermal capacity for peaking if the equipment is not designed as a peaking facility. However, in the short run, the net effect on the cost of power from the overall system is estimated to be a relatively minor increase.

Financial Exception Criteria Option.—There would be no significant difference in the economic cost of generating power in the regional electric power system compared to the Low Fluctuating Flow Alternative.

Financial (Marketing) Impacts

The consequences of the Low Fluctuating Flow Alternative in the near future would involve impacts to Western and, to the extent that Western passes its costs on, to Western's customers in terms of service and the financial cost and funding of replacement power as a result of interim operating criteria.

A shift in generation from on-peak to off-peak periods in most months would be anticipated. Assuming a fixed monthly amount of water, the change corresponds to off-peak water releases displacing water from on-peak to off-peak periods, leaving less water available on a daily basis for on-peak electric load generation; this, in turn, would require more on-peak purchases.

Under the interim flow regime, Western could not meet its firm load obligation with Federal hydropower, and projects a change in the timing, magnitude, and expense of projected purchases required to satisfy those firm contractual commitments. If Western cannot modify its contracts, Western's estimate of cost to purchase

replacement energy and capacity is $22 million in FY 1992. These added costs to the Federal Government would have to be covered by increased costs to Western's customers.

The $22 million in added costs would be blended with the existing rate structure to Western's customers. The customers would, in turn, blend the rate increase with their other sources of power and energy. Detailed data on the effect on Western's customers are not available. Depending upon the customers' reliance on Western Power as a resource, financial impacts could range from negligible to significant. It has been estimated that the average increase to the final consumer could be less than .3 percent.

Nonfirm sales could be adversely affected by a shift of releases from on-peak to off-peak periods. Additionally, ramping rates and the maximum daily change would restrict Western's ability to respond to power system demands.

Financial Exception Criteria Option.—Financial exception criteria would permit temporary violations of the flow criteria (not to exceed 3 percent of the time) to permit Western to meet its pooled utility obligations to provide system capacity when called upon. Under this procedure, capacity at Glen Canyon Powerplant idled as a result of interim flow criteria would be available to Western 22 hours per month as a means of avoiding the expense of purchasing replacement firm capacity and energy. It is estimated that by having the ability to purchase nonfirm power Western's costs would be $3 million; thus, Western would save $19 million as compared to the Low Fluctuating Flow Alternative.

CUMULATIVE IMPACTS

Due to the short-term nature of the proposed action, and the fact that any actions outside those described in the proposed action are unlikely, any cumulative impacts are expected to be minimal and of short duration.

PRELIMINARY FINDINGS OF TEST FLOW IMPACTS

FINDINGS BY RESOURCE CATEGORY

Testing of proposed interim operating criteria was instituted on August 1, 1991. It is the objective of this discussion to *qualitatively* address the effects of this test on the natural and recreation resources in the Grand Canyon. Only a qualitative, not quantitative, assessment is possible due to the very limited time for ecosystem response and limited GCES scientific effort that has gone into determining the impacts of the test. Ecosystem responses and biological processes take longer to manifest themselves than a month.

The effects of the test flows are outlined by category.

Sediment

The proposed interim operating criteria were designed to modify two critical parameters of operation that have detrimental impact to the sediment resources in the Grand Canyon—the ramping rate and the total change in flow level over a daily period. The intent was to limit the fluctuations both in terms of change per day and rate of change.

The effects seen to date are as follows:

1. A reduction in the overall erosion rates at the beaches in the Grand Canyon. This reduction has been manifested in a reduced amount of rill erosion, reduced bank seepage, and reduced slumping of the sediment resources. There has been a reduction, but not a total cessation, of the erosion process.

2. The sediment erosion processes are still ongoing in the Grand Canyon and will continue as a result of the limited sediment supply, the changing flow levels, and variable ramping rates. Bank failures and bank slumping are still occurring in the Grand Canyon related to the drying out of beach sediments and perhaps enhanced by the formation of steep slopes with little main channel support. It is possible that such ancillary activities as side channel debris flows or rainstorm activity may be acting with the flow regime in a cumulative effect on the sediment resources.

3. To date, the marshes that have started to reestablish themselves in the Grand Canyon have not shown a definitive response. Time and flow levels will dictate how the marshes respond.

Endangered Species

There has not been enough time to determine any specific ecological impacts on any of the endangered or special status species.

Trout

There has not been enough time to document the specific effects of the test on the trout that live in the Colorado River. The effects will fall into the three broad categories of biological processes, food resources, and physical habitat.

Biological Processes.—Trout growth has not shown any change.

Food Resources.—The food base in the area above Lees Ferry has shown some initial signs of recovery under the test. Specifically, the diatoms have begun to recolonize the rocks at the 5,000 cfs level and are building up in layers. There has not been enough time to document any specific changes in the *Cladophora glomerata* or the *Gammarus lacustris* populations.

Physical Habitat.—A limited amount of information has been collected to document the impacts of the test on the physical habitat utilized by the trout species. The majority of the habitat issues will be focused on the winter spawning period. To date,

with a reduction in fluctuations, the physical habitat has been increased for the juvenile and adult trout. Limited areas still exist for naturally reproduced fish.

Cultural Resources

A limited amount of information has been collected on the effects of the test on cultural resources. Specific areas of concern are the cultural sites contained within the sediment resources in the canyon and the exposure of the Spencer paddle wheel steamboat above Lees Ferry.

The sediment resources in the Grand Canyon have begun to stabilize in the Canyon. Sediment erosion has been reduced and therefore the loss of cultural resources has been reduced. During the first month of the test the minimum flows were above 8,000 cfs, and therefore the Spencer steamboat was covered by water and exposure was minimal.

Recreation

The effects of the test on recreation in the Grand Canyon have been positive to date. Reduced fluctuations and higher minimum flows have allowed for a safer passage of river trips through the Grand Canyon.

CHAPTER IV

CONSULTATION AND COORDINATION

SUMMARY

The process to develop interim operating criteria was begun in February 1991, and has involved numerous government agencies (both State and Federal), Native American tribes, and private organizations. These participants are identified in the distribution list at the end of this chapter.

The process of developing and implementing interim operating criteria was presented to the cooperating agencies for the GCDEIS on February 28, 1991. It was further discussed at cooperating agencies meetings April 3 and 4, June 13 and 14, July 1 and 2, and September 16, 17, and 18. It was also presented at interested parties meetings April 3, June 13, July 1, and September 17. During these meetings, participants were given the opportunity to present data and voice opinions about interim flows. These meetings—along with this document's distribution for review and comment—constitute appropriate public involvement.

FISH AND WILDLIFE COORDINATION

Consultation with the U.S. Fish and Wildlife Service (FWS) and the ADGF was conducted throughout the process, and they were included in the formulation of the proposed interim operating criteria. This consultation resulted in two memoranda (attachments B and C) indicating compliance with the Endangered Species Act and the Fish and Wildlife Coordination Act (FWCA).

The FWCA Draft Planning Aid Report contains the following recommendations and conclusions:

RECOMMENDATIONS AND CONCLUSIONS

> It appears that the Proposed Action will accomplish its objectives to decrease the effects of river operations on the terrestrial and aquatic ecosystems of Glen and Grand Canyons.
>
> There are several conditions related to financial exception criteria that need to be resolved. As indicated earlier, the FWS questions the appropriateness of financial exception criteria at this time. In most cases, the exceptions exercised should be transitory events that would have little effect upon the expected benefits of the Proposed Action. However, as those events become chronic (either through frequent repetition or extended duration) or acute, their importance would be elevated. As a result, we suggest the following:

(1) The FWS supports exceptions for system emergencies and system regulation only. The FWS does not support financial exception criteria at this time. We do not believe financial exceptions would be inconsonance with the intent of the interim flow legislation ". . .to protect, mitigate adverse impacts to, and improve the condition of, the environmental, cultural, and recreational resources of Grand Canyon National Park and Glen Canyon National Recreation Area downstream of Glen Canyon Dam. . ." (U.S. H.R. 814, 1991).

(2) The effects of all exceptions should be closely documented for both environmental and financial costs where possible. Monitoring over the life of this 3 year project should be keyed to specific measurable indicators. The results of monitoring should be used to amend exception criteria and adapt operations, were appropriate.

(3) Recovery from exception conditions should be ameliorated to the extent practicable. While the trigger for an exception event may be sudden and unplanned for, recovery should take place along pre-planned guidelines with an emphasis on ramping rates and daily fluctuation limits.

(4) Bypass should be evaluated as a mechanism to ameliorate any rapid down ramp employed during exceptions when practicable, and bypass and spinning should be incorporated in all exceptions to maintain minimum flows.

As shown in chapter II, the conditions placed on the financial exception criteria and which would, in fact, be in effect for the system emergency and system regulation exceptions, would minimize any adverse effects of these exceptions to the Low Fluctuating Flow Alternative. Recommendations 2, 3, and 4 are essentially included in the exception criteria conditions.

Reclamation believes that with these conditions the financial exception criteria would be in consonance with the intent of the draft legislation (U.S. H.R. 814, 1991) cited in the first recommendations of FWS.

Also contained in attachment C is a letter from ADGF to FWS indicating their preliminary position on financial exception criteria.

CULTURAL RESOURCES

The National Park Service, in consultation with the Arizona State Historic Preservation Officer and the Advisory Council on Historic Preservation, is in the process of determining the eligibility of the 475 archeological sites for listing on the National Register of Historic Places. This consultation will lead to a Memorandum of Agreement and a proposed treatment of the sites to mitigate impacts, and is part of the overall effort for the GCDEIS. This will constitute compliance with Section 106 of the National Historic Preservation Act.

Reclamation recognizes that implementing the interim operating criteria would affect the Charles H. Spencer Paddle Wheel Steamboat. Reclamation is in the process of complying with Section 106 on this property in consultation with the Arizona State Historic Preservation Officer and the Advisory Council.

EXECUTIVE ORDERS

Executive Order 11988 requires Federal agency avoidance of long- and short-term adverse impacts to floodplains, 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 interim operating criteria would provide short-term protection to the Colorado River floodplain and associated wetlands below the dam, as described in the sediment and vegetation sections of chapter III, until implementation of final operating criteria for Glen Canyon Dam. The public review required by both executive orders has been achieved through the public scoping and cooperating agency meetings for the GCDEIS.

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ATTACHMENT A

ENVIRONMENTAL COMMITMENTS

ATTACHMENT A

ENVIRONMENTAL COMMITMENTS

The following commitments would be carried out if the proposed action is implemented.

1. An environmental monitoring program, including periodic reports, would be carried out for the duration of the interim flows to include evaluation of the following:

    - Evaluation of the flow characteristics of the interim releases;
    - Evaluation of the impacts of the exception criteria on the flows and on the resources; and
    - Evaluation of the resource responses to interim flow and the impacts to the following resource components:

        1. Sediment deposits/change
        2. Sediment transport rates
        3. Archeological impacts by site and by area
        4. Trout stranding and population dynamics
        5. Aquatic food base changes
        6. Native fish - habitat and population dynamics
        7. Vegetation and marshes changes
        8. Recreation and accident rates
        9. Terrestrial habitats change
        10. Water quality response
        11. Economic (financial) consequences.

2. All required permits would be obtained.

ATTACHMENT B

ENDANGERED SPECIES ACT MEMORANDUM

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
3616 W. Thomas, Suite 6
Phoenix, Arizona 85019

September 17, 1991

Memorandum

To: Regional Director, Bureau of Reclamation, Salt Lake City, UT

From: Acting Field Supervisor

Subject: Endangered Species Considerations of Interim Flow Proposal

This is in response to a September 9, 1991, telephone request from Gordon Lind of your staff for Fish and Wildlife Service (FWS) guidance on procedures for endangered species compliance on the interim flow proposal for Glen Canyon Dam.

The Secretary of the Interior directed on July 27, 1989, that an environmental impact statement (EIS) be prepared on the operation of Glen Canyon Dam. The Bureau of Reclamation (Reclamation) is lead, and the FWS is one of the nine other Cooperating Agencies in the preparation of the EIS. With announcement of the EIS for Glen Canyon Dam, FWS Regional Director Spear advised Reclamation that preparation of the biological opinion on the operation of Glen Canyon Dam should be based on the preferred alternative for the EIS. The writing of the EIS has begun, and Reclamation is continuing consultation under Section 7 of the Endangered Species Act.

Pending legislation and concerns regarding impacts of continuing the existing operation of Glen Canyon Dam on downstream resources led to the development of proposed interim criteria for operation of the dam. These criteria will remain in effect until the final decision on dam operations, based on the findings of the EIS, are implemented. The interim flow recommendations were developed within the framework of existing operations to reduce detrimental impacts to downstream resources, particularly sediment. The Cooperating Agencies and the Senior Scientist for the Glen Canyon Environmental Studies have contributed to the recommendations.

At your request, we recommend the following for your consideration in preparation of the environmental assessment on interim operations. We believe that a separate biological opinion will not be necessary since Section 7 consultation is continuing on the action Reclamation and the Cooperating Agencies will be proposing in the EIS. Proposed interim operations have been designed to assist in reducing adverse impacts to downstream natural resources and to endangered, threatened, or proposed endangered species, while keeping this action within the existing operation of Glen Canyon Dam.

If we can be of further assistance, please contact Frank Baucom, Debra Bills, or Sam F. Spiller, Field Supervisor (602/379-4720 or FTS 261-4720).

Frank M. Baucom

cc: Regional Director, Fish and Wildlife Service, Albuquerque, NM (FWE/SE/HC)
Regional Director, Fish and Wildlife Service, Denver, CO
Superintendent, Grand Canyon National Park, Grand Canyon, AZ
Superintendent, Glen Canyon National Recreation Area, Page, AZ
Director, Arizona Game and Fish Department, Phoenix, AZ
Senior Scientist, Glen Canyon Environmental Studies, Arizona State University, Tempe, AZ
Program Manager, Glen Canyon Environmental Studies, Bureau of Reclamation, Flagstaff, AZ
Regional Environmental Officer, Department of the Interior, San Francisco, CA
Area Manager, Western Area Power Administration, Salt Lake City, UT
Regional Administrator, Environmental Protection Agency, San Francisco, CA
Area Director, Phoenix Area Office, Bureau of Indian Affairs, Phoenix, AZ
Chairman, Havasupai Tribe, Supai, AZ
Chairman, Hopi Tribe, Kykotsmovi, AZ
Chairman, Hualapai Tribe, Peach Springs, AZ
Chairman, Navajo Nation, Window Rock, AZ
Field Solicitor, Field Solicitor's Office, Phoenix, AZ
Project Leader, Fish and Wildlife Service, Pinetop, AZ
Unit Leader, Cooperative Fish and Wildlife Research Unit, Tucson, AZ

ATTACHMENT C

FISH AND WILDLIFE COORDINATION ACT MEMORANDUM
AND
LETTER FROM ARIZONA GAME AND FISH DEPARTMENT
TO THE U.S. FISH AND WILDLIFE SERVICE

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
3616 W. Thomas, Suite 6
Phoenix, Arizona 85019

September 25, 1991

MEMORANDUM

TO: Regional Director, Bureau of Reclamation, Salt Lake City, Utah
(Attn: UC-1500)

FROM: Field Supervisor

SUBJECT: Interim Flows for Glen Canyon Dam Operations - Draft Planning Aid Report

Attached for your review is the subject draft planning aid report. We understand that you will append this report to the environmental assessment (EA) you are now preparing. We will be coordinating this report with the Arizona Game and Fish Department.

Please review this draft as soon as you can and provide us any comments you may have so we can finalize it before you finalize your EA.

We appreciate you assistance during the preparation of this report. If you have any questions, please contact Debra Bills or me (FTS 261-4720).

Sam F. Spiller

Sam F. Spiller

Attachment

cc: Regional Director, Fish and Wildlife Service, Albuquerque, New Mexico (FWE/HC) (w/draft report)
Director, Arizona Game and Fish Department, Phoenix, Arizona (w/draft report)

Suggested cc list:

cc: Regional Director, Fish and Wildlife Service, Albuquerque, NM
Director, Arizona Game and Fish Department, Phoenix, Arizona
Superintendent, Grand Canyon National Park, Grand Canyon, Arizona (Attn: Jerry Mitchell)
Superintendent, Glen Canyon National Recreation Area, Page, Arizona (Attn: Chuck Wood)
Program Manager, Glen Canyon Environmental Studies, Flagstaff, Arizona
Director, Bureau of Indian Affairs, Phoenix, Arizona (Attn: Amy Heuslein)
Pat Port, Department of the Interior, Environmental Affairs
Don Bay, Hualapai Tribal Council, Peach Springs, Arizona
Kurt Dongoske, Hopi Tribal Council, Flagstaff, Arizona
Alan Donner, Navajo Nation, Window Rock, Arizona
Environmental Protection Agency, San Francisco, California (Attn: Wendy Pulling)
Western Area Power Administration, Salt Lake City, Utah

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
3616 W. Thomas, Suite 6
Phoenix, Arizona 85019

DRAFT

September 25, 1991

MEMORANDUM

TO: Regional Director, Bureau of Reclamation, Salt Lake City, Utah (Attn: UC 1500)

FROM: Field Supervisor

SUBJECT: Interim Flows for Glen Canyon Dam Operations - Draft Planning Aid Report

INTRODUCTION

This draft planning aid report is intended to advise the Bureau of Reclamation (Reclamation) of potential resource concerns and study needs for fish and wildlife resources in Glen and Grand Canyons including threatened and endangered species in the Colorado River affected by Interim Flows for Glen Canyon Dam. This document is prepared under authority of the Fish and Wildlife Coordination Act (FWCA) but does not fulfill the requirements of the final report pursuant to Section 2(b) of the FWCA (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). A final planning aid report on the subject project will be coordinated with the final Environmental Assessment (EA). A draft and final FWCA 2(b) report will be submitted to Reclamation corresponding to the Interim Flow Environmental Impact Statement (EIS) schedule. This report is being coordinated with the Arizona Game and Fish Department (AGFD). Comments on this draft document should be submitted directly to the Fish and Wildlife Service (FWS).

FUTURE WITHOUT THE PROJECT - THE NO ACTION ALTERNATIVE

Conditions without the project under the No Action Alternative would consist of historic operations of Glen Canyon Dam prior to the implementation of "Research Flows" in June of 1990. The only restrictions would be minimum flows of 1,000 cfs from Labor Day to Easter and 3,000 minimum from Easter to Labor Day and maximum flows 31,500. Flood flows are currently estimated at 1 in 20 years.

SPECIAL STATUS SPECIES

Of critical importance is the potential effect of current operations on federally listed or candidate species. A jeopardy opinion is currently in effect for humpback chub with respect to operations of Glen Canyon Dam. Consultation is continuing for a Biological Opinion necessary for the EIS.

This following review is important because the FWS indicated to Reclamation in its letter of September 17, 1991 that "a separate biological opinion will not be necessary [for this Environmental Assessment] since consultation is continuing on the action that Reclamation and the Cooperating Agencies will be proposing in the EIS."

Humpback chub

The humpback chub (Gila cypha), a federally listed endangered species, utilizes mainstem habitats in the Colorado River through Grand Canyon. The center of their distribution appears to be in the vicinity of the Little Colorado River (LCR) (Maddux et al. 1987). In recent years, humpback chub have been absent from the tailwater area below Glen Canyon Dam and rare below National Canyon. Adult fish appear to utilize eddy habitats in the mainstem in Grand Canyon (Maddux et al. 1987). Suitability analyses from the upper Colorado River suggest that adults actually utilize a wide range of depths, but prefer areas of greater than 7 feet depth with relatively slow water velocities (Valdez et al. 1990). The LCR appears to be the primary site of chub reproduction and recruitment for the Grand Canyon population (Minckley 1987). Temperatures in the main channel would be lethal to chub ova (Hamman 1982). Backwater areas downstream from the LCR are important nursery areas for young of year and subadult chub.

Under No Action humbpack chub spawning and recruitment area would continue to be restricted to the LCR. Backwater areas downstream of the LCR would continue to be important nursery areas for young of year and juvenile fish.

Razorback Sucker

The razorback sucker (Xyrauchen texanus) has been proposed for federal listing. Once thought extirpated from Grand Canyon, the razorback has been captured on several occasions in recent years. Little is known of the reasons for the decline of razorback sucker. Construction of large reservoirs that eliminated much of its original physical habitat and introduction of nonnative species that compete with or prey upon larval razorbacks are probable factors. Carothers and Minckley (1981) and Hendrickson (pers. comm.) have suggested the use of both mainstem and tributary habitats in Glen and Grand Canyons by adult razorbacks. Carothers and Minckley (1981) noted springtime movement into the Paria River, and in 1987 Dean Hendrickson noted the species in Bright Angel Creek.

The remaining populations of razorback in the lower basin of the Colorado River, including the Grand Canyon, appear to be limited to very old, adult fishes. No reproduction has been documented from these fishes, although they have received little attention. If this is the case, it is questionable whether or not the remaining resident razorback sucker population could maintain itself under No Action. The potential for recruitment of young to the population is unknown.

Bald Eagle

The use of the mainstem of the Colorado River as a winter foraging area for bald eagle (Haliaeetus leucocephalus) is a relatively recent development. This development appears to be related to a large congregation of rainbow trout at Nankoweap Creek during winter spawning runs. This trout spawn provides an opportunistic prey source for a winter migrating population. Preliminary studies in 1990 estimated use of the trout prey resource in or near the mouth of Nankoweap Creek by 70 to 100 different eagles during February and March of 1990 (Brown and Leibfried 1990), although figures for 1991 were much less (Debra Bills, pers. comm.).

Effects of No Action on trout availability to bald eagles at the mouth of Nankoweap Creek is unknown.

Peregrine Falcon

Peregrine falcon (Falcon peregrinis anatum), a federally endangered species, utilizes cliffs for nesting sites. Surveys suggest that the Grand Canyon

population of peregrine may be among the largest in the contiguous United States. This predatory bird is dependent upon smaller birds, bats, and potentially waterfowl as its prey base. Changes in the extent and productivity of riparian areas may result in indirect effects upon peregrine falcon.

Under the No Action Alternative, some continued declines nay occur in beach and bar deposits due to continued erosional forces upon those deposits (Avery et al. 1990). As the areal extent and stability of deposits declines, the suitability for riparian development likewise declines. Peregrine falcon appear indirectly tied to the avian production of riparian development, and in turn may be negatively effected by No Action.

FISHERIES RESOURCES

Rainbow Trout

A trout fishery was developed below Glen Canyon Dam as a recreational resource in the 15 mile tailwater area of Lee's Ferry. The thermal modification of waters released below the dam and associated management by the AGFD has made the area conducive to trout growth. The trout fishery, dominated by rainbow trout, extends into Grand Canyon where naturally reproducing populations have established themselves.

Under No Action, the trout population should be reminiscent of the successful fishery in the latter portion of the 1980's.

Spawning, Stranding, and Recruitment

Temperatures in the tailwater area below Glen Canyon Dam are near optimal for spawning rainbow trout (10 - 15 C) (Scott and Crossman 1973). Daily fluctuation in water surface elevation has been a subject of concern with respect to the success of that spawning and the survival of the spawners. During a three day low flow experiment (5000 cfs) in 1984, Maddux et al. (1987) identified approximately 800 stranded trout. Mortalities associated with isolated pools related to oxygen depletion, thermal stress in isolated backwaters, increased predation by terrestrial animals, and desiccation when fish are exposed directly to the atmosphere were documented.

Adults appear to be most susceptible during winter months while spawning. Persons et al. (1985) suggested the mechanism whereby fluctuating flows effect adult trout would likewise compromise rainbow trout fry. Exposure of trout redds in the tailwater for periods of 10 hours or more would cause near total mortality of eggs in an exposed redd (Maddux et al. 1987).

The No Action Alternative would continue to subject adult trout to stranding; post-emergence fry to stranding, desiccation, or entrainment in high velocity flow; and trout eggs to potential desiccation. The additional ramification of adult mortality is that the reproductive potential of the population could be reduced. Mortality to eggs and larval trout would further reduce recruitment.

Food Resources and Growth

Trout tend to be opportunistic feeders and often display distinct trophic shifts in foods. In the project area trout fry appear to be dependent upon zooplankton. Adults utilized chironomid midge larvae, Cladophora, Gammarus, and detrital material [fish material appeared in a very small proportion of stomach samples less than 1 percent (%)] (Maddux et al. 1987). The contribution of Cladophora to the diet of adult rainbow trout generally declined from upstream populations

at Lee's Ferry to downstream populations in the lower Grand Canyon. This was probably a reflection of availability. Trout appear to benefit from ingestion of Cladophora because of the epiphytic diatoms that colonize it. The Cladophora forms the habitat for the energy rich diatoms and macroinvertebrates that inhabit it (Montgomery et al. 1986). Leibfried and Blinn (1986) and Usher et al. (1986) indicated that the beds of Cladophora below Glen Canyon Dam were susceptible to desiccation as a result of periodic dewatering.

Under No Action river operations may allow beds of Cladophora to be dewatered and desiccated over extended periods of time, especially over weekend periods of low flow. Maddux et al. (1987) observed that under drastically reduced flows, Gammarus were forced from cover and entrained in the drift making them available as forage to trout and other predators. This suggests that the No Action Alternative could reduce the breadth of diet available to salmonids. Decreasing flows may increase the availability of Gammarus to trout, but continued fluctuation over a longer term may reduce the overall productivity and in turn reduce the long term availability to trout.

Maddux et al. (1987) used length frequency distribution to estimate trout growth. In general, the growth rate and size of individual trout seems to be reflective of the part of the river they inhabit. Fish from Lee's Ferry and reaches above the confluence with the LCR are larger and grow faster than those from below the confluence area. The variation in growth may be associated with decreasing quantity and quality of food resources as nutrients are distributed downstream or decreasing primary productivity below the confluence with the LCR due to increased turbidity. There may also be genetic differences between the upstream and downstream populations of trout that could be reflected in growth differences (Claussen and Phillipp 1986).

The fluctuating flows of No Action may limit production of algae and associated food organisms resulting in direct effects upon the potential for growth of rainbow trout (Leibfried and Blinn 1986, Usher et al. 1986). The periodic dewatering of stream banks and wide range of velocities across stream beds resulting from fluctuating flows have reduced macroinvertebrate abundance and community complexity in streams (Fisher and LaVoy 1972).

Native Fishes

Historically, the Colorado River through Glen and Grand Canyons supported a diverse native, big river fish fauna (See Table).

Table. Fish species in Glen and Grand Canyons that are on the Federal Endangered Species Act (ESA) List and/or State of Arizona Threatened and Native Wildlife in Arizona (TNW) List.

SPECIES	ESA STATUS	TNW STATUS
humpback chub		
Gila cypha	endangered	endangered
Colorado roundtail		
Gila robusta robusta	Candidate; Category 2	not listed
bonytail chub		
Gila elegans	extirpated	endangered
Colorado River squawfish		
Ptychocheilus lucius	endangered	endangered
razorback sucker		
Xyrauchen texanus	proposed	endangered

bluehead sucker *Catostomus discobolus*	not listed	not listed
flannelmouth sucker *Catostomus latipinnis*	Candidate; Category 2	not listed

The humpback chub and razorback sucker were discussed in the Special Species section. The bonytail chub, Colorado River squawfish, and roundtail chub have been extirpated from the project area. The remaining two, bluehead sucker and flannelmouth sucker, continue to persist in the area.

Spawning, Recruitment, and Habitat Suitability

Maddux *et al*. (1987) found ripe bluehead suckers in the lower reaches of Grand Canyon during the spring seasons. Flannelmouth suckers were found in reproductive condition in nearly all seasons except the autumn.

Although both tributaries and main channel habitats are important spawning and nursery areas Minckley (1978); Carothers and Minckley (1981) reported highest densities of flannelmouth in and near tributary mouths. The highest concentration of reproductive flannelmouth were found in connected backwaters. Although flannelmouth in reproductive condition were sampled in all reaches of the river, viable larvae were only collected below Bright Angel Creek.

Habitat suitability for bluehead sucker appears to increase with distance from Glen Canyon Dam. Maddux *et al*. (1987) sampled bluehead sucker most frequently below National Canyon. Flannelmouth sucker were found most frequently in the lower reaches of the Grand Canyon, although they were captured in the both in the Lee's Ferry area and the lower reaches of the Canyon.

Maddux *et al*. (1987) indicated that runs over sand bottoms were apparently attractive habitats for adult as well as subadult blueheads and flannelmouth. Eddies were also utilized by these native fishes. In the Lee's Ferry reach, adult flannelmouth exhibited a preference for backwater areas. Larval bluehead and flannelmouth sucker were most often encountered in backwater areas. The backwater areas where larval bluehead sucker were captured were typically warmer than mainstem habitats, suggesting selection for warmer refugia.

Of particular importance relative to No Action, Maddux *et al*. (1987) noted that the number of eddies generally increased when flows dropped from 28,000 cfs to 4 00 cfs. At low flows backwater areas increased four fold over high flow c ditions.

Food Resources and Growth

Both the flannelmouth and bluehead suckers are omnivorous (Carothers and Minckley 1981). Stomach contents of adult fish taken from the mainstem include midges, *Gammarus*, organic detritus, diatoms, and *Cladophora*.

Fisher and LaVoy (1972) indicate that macroinvertebrates and community complexity generally decline in response to fluctuations below hydropower facilities. Declining community complexity and productivity may result in a diminished food resource.

Under No Action, broad daily ranges of fluctuations would flush warmed backwaters with cold mainstem waters, resulting in fluctuating temperature and velocity conditions within important nursery areas.

Little is known about growth patterns of many of Arizona's native species. Most native fish continue to utilize backwater areas, although by October they attain a size where they are less susceptible to fluctuating flows (Maddux et. al 1987). Maddux et al. (1987) noted that growth of the warmwater flannelmouth sucker was slow and variable for adult fish in the mainstem. Growth, and in turn recruitment, of larval native fishes may rely upon finding productive, warmer water refugia, like backwaters. Fluctuations under No Action may be more damaging during the reproduction or rearing seasons.

RIPARIAN AND WETLAND RESOURCES

The understanding of the importance of riparian and wetland habitats in the Southwest has grown considerably over the last two decades. It is now understood to be among the most productive of wildlife habitats. AGFD categorizes these habitats as Resource Category I, unique and irreplaceable on a regional or statewide basis.

The vegetation along the Colorado River between Glen Canyon Dam and Lake Mead has changed radically since closure of the dam (Turner and Karpiscak 1980). The reduction of peak annual discharge has resulted in the vegetation of areas where riparian vegetation was absent because of the scouring effects of large annual floods. This new riparian area, called the New High Water Zone (NHWZ), is characterized by increased density of many species including exotics like salt cedar (Tamarix ramossissima) and camelthorn ( ), and natives like arrowweed (Tessaria sericea), desert broom (Baccharis salicolia), and cattail (Typha sp.). Changes have also occurred in the deposits of sand and silt along the banks of the Colorado. Stevens and Waring (1988) suggested significant losses in riparian vegetation in the NHWZ as a result of spill operations. They also indicated that flooding seemed to stimulate germination of NHWZ species, with salt cedar as a primary beneficiary.

The previous riparian zone, sometimes referred to as the Old High Water Zone (OHWZ) is dominated by species including hackberry (Celtis sp.), mesquite (Prosopis), and acacia (Acacia sp.). This zone was determined by historic flood conditions and is now well above normal dam operational stages. This zone appears to be in slow decline, lacking the annual flooding conditions necessary for recruitment. Chronic declines in the OHWZ have been noted for some time because of the lack of flood driven regeneration in that area.

There are at least two factors that influence the areal extent of riparian and wetland resources in Glen and Grand Canyons. Those are the range of daily and monthly variation in flows and the erosion of the beach deposits that form the lower components of these communities. Reduction in the areal extent of the riparian community through either of these processes translates to a correlative effect upon terrestrial wildlife resources.

It was concluded in the final report of the Glen Canyon Environmental Studies Phase I (USDI et al. 1988) that the direct effects upon terrestrial resources are most evident from flood operations. There may, however, be ongoing chronic effects of river operations under fluctuating flows that Phase I studies did not address. There is not yet the mechanism to measure the incremental portion of chronic effects of fluctuating releases upon these riparian and wetland communities.

Under the No Action Alternative, the concern persists that broadly fluctuating river operations would reduce above water alluvial deposits (beaches and bars) in turn reducing riparian and wetland maintenance and associated wildlife communities in Glen and Grand Canyons.

FUTURE WITH THE PROJECT - PROPOSED ACTION

Modified flows consist of a minimum of 5,000 cfs, maximum flows of 20,000, ascending ramp rates of 2,500, descending ramp rates of 1,500, and daily fluctuation limits of 5,000, 6,000 or 8,000 cfs, depending on the volume of a low, medium, and high water month.

The FWS understands that exception criteria will be included in the Proposed Action to allow for system regulation, system emergencies, and potentially for financial emergencies. At this time, the FWS does not support the addition of financial exception emergency criteria. We understand that the initiation of interim flows were to utilize GCES data and input to reduce environmental degradation in the Canyon and allow Reclamation in association and Cooperating Agencies to evaluate research flow data. Furthermore, the FWS does not believe that sufficient economic justification has been developed to warrant a 3% financial allowance. The FWS supports exception criteria for system regulation and system emergencies similar to the criteria used for GCES Research flows.

It is still undecided exactly how those exception criteria might be implemented as part of the Proposed Action. We understand that the financial exception criteria may include a 3% or 22-hour a month exception for power production. We understand that this exception, if implemented, is not likely to occur more than one hour a month, and almost never more than 4 hours. However, a possibility exists for full peaking power for a day.

The purpose of the Proposed Action is to reduce impacts of power operations on downstream physical and biological resources. Among the primary intents of this Proposed Action are to reduce flow related beach erosion, and beach wasting; to maintain spawning habitat for rainbow trout and backwater habitats for native fishes, and production of aquatic food resources; and to maintain a program of monitoring to insure that interim flows can be adapted, where necessary.

SPECIAL STATUS SPECIES

Humpback chub

It is unlikely that modification of operations as described by the Proposed Action will have detrimental direct effects upon the long lived population of adult humpback chub or have a more serious effect upon recruitment of chub than No Action (Patten et al. 1991). One concern is that if the Proposed Action with financial exception criteria dropped minimum flows below 5,000 cfs whereby backwaters utilized as nursery areas may become isolated from the main channel. The potential for impact, while no greater than No Action would persist and not meet the purpose of the Proposed Action.

Razorback Sucker

Like the humpback chub, direct impacts on resident adults of this are not anticipated. The likelihood of impact from the Proposed Action may not be greater than the No Action Alternative.

Bald Eagle

The Proposed Action may result in fewer stranded fish in the area of the mouth Nankoweap Creek. However, with the intent of maintaining and restoring the production of the aquatic food base for trout, the Proposed Action should improve the quality of forage available to eagles. As long as maximum daily stage is high enough to allow trout to attempt to ascend the creek for spawning, forage for bald eagle should be maintained.

Peregrine Falcon

Effects to peregrine falcon would parallel those to riparian and wetland areas. Because the Proposed Action is designed to reduce the detrimental erosional effects of fluctuating flows on above water alluvial deposits in the river corridor through institution of decreased maximum flows and reduced down ramp rates, riparian and wetland areas in the NHWZ would be expected to be better maintained over the time span of Interim Operations. Maintenance of riparian and wetland areas and peregrine forage species should be improved.

FISHERY RESOURCES

Aquatic species can be expected to be directly affected by river operations. Main channel, thermal characteristics are not anticipated to change during interim operations; however, where stable backwaters develop, some differential warming would be expected in those areas.

Rainbow Trout

There are several habitat factors that may change as a result of Interim Flows Minimum flows would maintain a broader zone for Cladophora colonization and its associated food resources and should maintain broader coverage of some spawning bars during the winter months. The reduced maximum flow would reduce discharge related velocities maintaining habitat availability for some life stages. Lastly, reduced down ramping rates may reduce the entrapment of trout in stranding pools. The Proposed Action should be advantageous over No Action.

Spawning, Stranding, and Recruitment

Increased minimum flows would provide additional coverage of spawning bars allowing for redd success. Reduced down ramp rates would provide trout improved opportunity to abandon dewatering redd sites that may became isolated. Reduced discharge velocities and reliably inundated redd sites have the potential to significantly improve habitat suitability for larval and juvenile trout. Persons et al. (1985) indicated the potential for entrainment of post-emergence fry in higher velocity main channel currents as a potential source of difficulty in recruitment.

The Proposed Action could reduce the mortality of adult fish due to stranding, and potentially increase recruitment of naturally spawned trout. Reduced mortality of adults and increased recruitment of naturally spawned trout should be realizable during the time span of the Proposed Action.

Food Resources and Growth

Liebfried and Blinn (1986) indicated that the aquatic food base was dependent on substrate stability and that fluctuating flows eroded those substrates. Patten et al. (1991) asserted that while the liberation of organic material (Cladophora, Gammarus, and other potential food items) into the drift at higher rates might be advantageous over the short term, the food base could be decimated over the long term. Cladophora beds are maintained up to the level of minimum river stage, but if desiccated over periods exceeding 12 hours may show significant degradation. Higher minimum flows of the Proposed Action were

intended to restore the integrity of Cladophora beds which should provide improved habitat for associated aquatic food resources.

Higher minimum flows and reduced discharge related velocity changes should improve the stability and productivity of the benthic food resources. It is probable to realize changes during the time span of the Proposed Action. The improved stability and diversity of those food resources should result in improved growth and condition factor of rainbow trout.

Native Fishes

The native fishes discussed in the preceding section of this report (bluehead sucker and flannelmouth sucker) are similar to the special status fishes in being long lived species. Resident adults will not likely be affected by the Proposed Action. The majority of effects will be related to reproduction and recruitment.

Spawning, Recruitment, and Habitat Suitability

Access to spawning sites probably will not change. Creek mouths will likely be no more nor no less accessible to spawners under the Proposed Action. High steady spring time flows make those habitats most accessible.

Larval recruits will likely be dependent upon the same habitats. Backwaters and return flow channels where some differential warming is possible will continue to be most important for annual recruitment. Low flow conditions (below 8,000 cfs) suggest a limitation of available habitat. This would probably be exacerbated by financial exception criteria which would decrease the minimum flow below 5,000 cfs for extended periods of time.

Food Resources and Growth

It is anticipated that improved diversity and stability of the aquatic food resource as described for trout will improve conditions for natives fishes. Further, consideration must be given to the spiraling of nutrients in fluvial systems. It is likely that increased upstream productivity will result in increased drift of coarse particulate organic matter into less productive downstream reaches. Native fishes may benefit from improvement of in stream production of food organisms under the Proposed Action.

Improved condition associated with improving forage base should be notable within the duration of the Proposed Action, although actual changes in size distribution of native fishes may not be documentable.

RIPARIAN AND WETLAND RESOURCES

The reduced ramping rates (especially down ramps) and reduced maximum flows of the Proposed Action are designed to reduce the direct effects of river operations on above water alluvial deposits. Thus, as the Proposed Action would meet its objective of preserving those alluvial deposits, the integrity of existing NHWZ riparian areas would be maintained with all of the terrestrial associated wildlife. Fluctuating flows can, under some circumstances, result in direct loss of individual animals. The net effect of those incidental losses could be minimal as long as the net value and function of the riparian system is maintained.

The OHWZ will not be affected. Erosion of wetland and adjacent riparian habitats should be reduced by the Proposed Action.

DRAFT

RECOMMENDATIONS AND CONCLUSIONS

It appears that the Proposed Action will accomplish its objectives to decrease the effects of river operations on the terrestrial and aquatic ecosystems of Glen and Grand Canyons.

There are several conditions related to financial exception criteria that need to be resolved. As indicated earlier, the FWS questions the appropriateness of financial exception criteria at this time. In most cases, the exceptions exercised should be transitory events that would have little effect upon the expected benefits of the Proposed Action. However, as those events become chronic (either through frequent repetition or extended duration) or acute, their importance would be elevated. As a result, we suggest the following:

1) The FWS supports exceptions for system emergencies and system regulation only. The FWS does not support financial exception criteria at this time. We do not believe financial exceptions would be in consonance with the intent of the interim flow legislation "...to protect, mitigate adverse impacts to, and improve the condition of, the environmental, cultural, and recreational resources of Grand Canyon National Park and Glen Canyon National Recreation Area downstream of Glen Canyon Dam..." (U.S. H.R. 814, 1991).

2) The effects of all exceptions should be closely documented for both environmental and financial costs where possible. Monitoring over the life of this three year project should be keyed to specific measurable indicators. The results of monitoring should be used to amend exception criteria and adapt operations, where appropriate.

3) Recovery from exception conditions should be ameliorated to the extent practicable. While the trigger for an exception event may be sudden and unplanned for, recovery should take place along pre-planned guidelines with an emphasis on ramping rates and daily fluctuation limits.

4) Bypass should be evaluated as a mechanism to ameliorate any rapid down ramp employed during exceptions when practicable, and bypass and spinning should be incorporated in all exceptions to maintain minimum flows.

The FWS appreciates the efforts of Reclamation and the Cooperating Agencies to develop a well-coordinated Interim Flow plan and the opportunity to provide this planning assistance to Reclamation. We look forward to further coordination in all aspects of the Interim Flow process. If we can be of further assistance, please contact Debra Bills or me (602/372-4720 or FTS 261-4720).

Sam F. Spiller

cc: Regional Director, Fish and Wildlife Service, Albuquerque, NM
Director, Arizona Game and Fish Department, Phoenix, Arizona

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THE STATE OF ARIZONA

GAME & FISH DEPARTMENT

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September 25, 1991

Sam Spiller
US Fish and Wildlife Service
Ecological Services
3616 West Thomas Road, Suite 6
Phoenix, Arizona 85017

Dear Sam:

Re: Interim Flows on Glen Canyon Dam - Planning Aid Report

The Department has reviewed the draft Planning Aid Memorandum that will be transmitted to Reclamation today. We feel that the document has merit especially in light of the very short time available to prepare it. On the whole we agree with the memo, although I am certain that there are technical considerations that can be improved as we continue to coordinate and seek concurrence between our agencies on a final Memorandum.

The Department does, however, disagree with a portion of one of the recommendations being forwarded as part of the Planning Aid Memorandum. Recommendation one (1) indicates the position that the Service "does not support financial exception criteria." The Memorandum goes on to say that financial exception criteria do not meet the purpose and intent of draft federal legislation "...to protect, mitigate adverse impacts to, and improve the condition of, the environmental, cultural, and recreational resources of Grand Canyon National Park and Glen Canyon National Recreation Area downstream of Glen Canyon Dam..." The Arizona Game and Fish Department does not fully concur with that position. We agree with the objectives laid out in the draft legislation and attempt to focus upon them.

If transitory exceptions for emergencies or for system regulation are consistent with those objectives, then perhaps transitory exceptions for financial reasons can also be consistent with those objectives. The Department maintains that if the effects of financial exceptions are short in duration with transitory or benign effects rather than chronic or acute effects, and the exercise of those financial exceptions is unlikely, then they may not be contrary to meeting the objectives of draft legislation.

If the Service proposes to indicate its own position on financial exceptions in the draft Planning Aid Memorandum, which the Department does not concur with; then I think it would be

appropriate for the Service to likewise indicate the Department's perspective as indicated in the paragraph above. My phone discussion with Mr. Spear indicated that this would be an appropriate course of action.

I appreciate your willingness to incorporate the Department's perspective, and I look forward to continued coordination with respect to reviewing this draft Memorandum.

Sincerely,

Duane L. Shroufe
Director

DLS:LR:lr

cc: Mike Spear, Regional Director, US Fish and Wildlife Service
Rick Gold, Assistant Regional Director, Upper Colorado Region
US Bureau of Reclamation