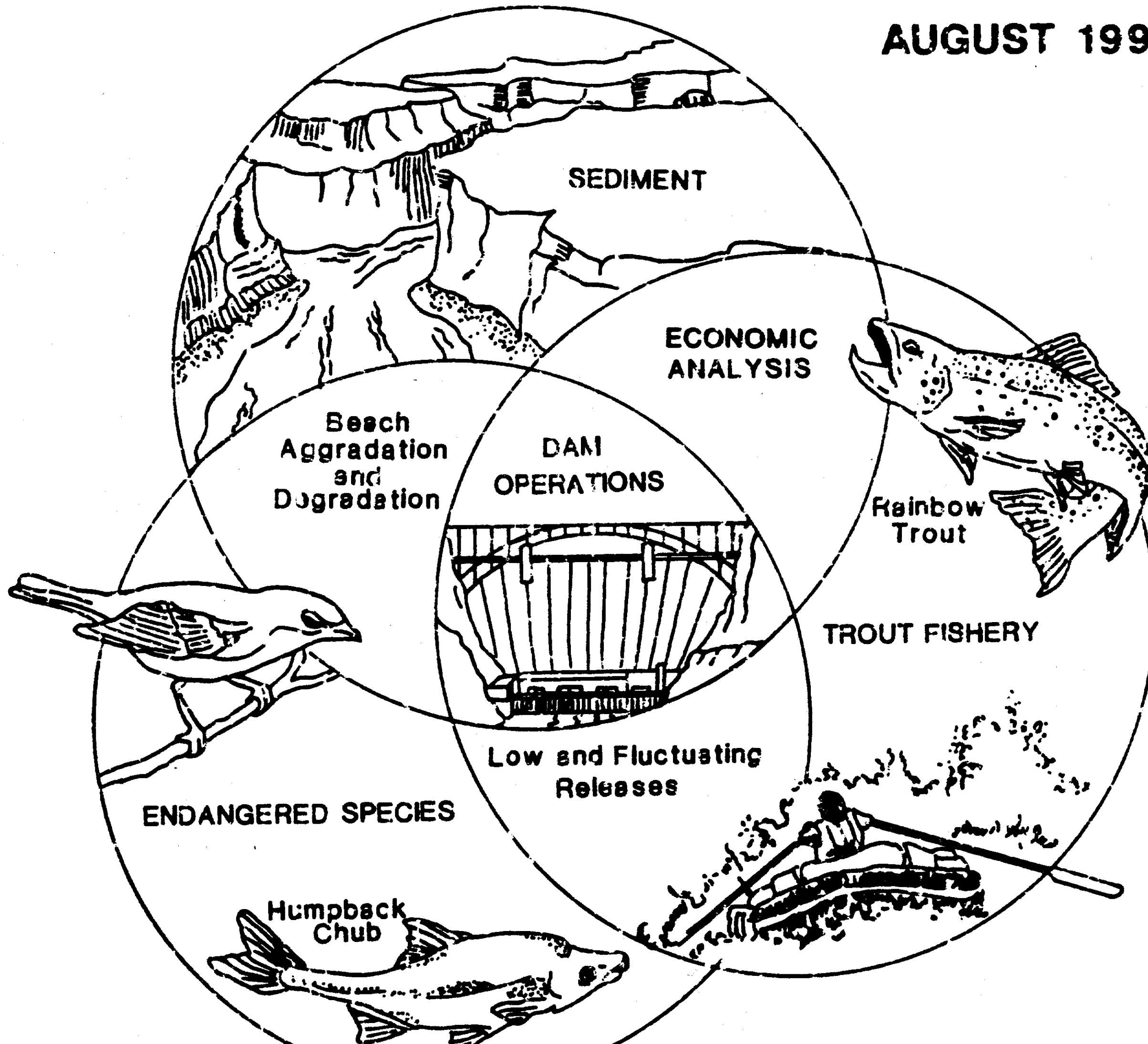
GLEN CANYON DAM INTERIM OPERATING CRITERIA

SUPPORTING DOCUMENT

AUGUST 1991



UPPER COLORADO REGION

BUREAU OF RECLAMATION

GLEN CANYON DAM INTERIM OPERATING CRITERIA
BUREAU OF RECLAMATION
July 30, 1991

Supporting Documents

Testing of Proposed Glen Canyon Dam Interim Operating Criteria - July 30, 1991

News Release - July 30, 1991

Interim Flow Process

Recommendations For Interim Operating Procedures For Glen Canyon Dam - April 10, 1991 - Scientific/Research Group

Review of Interim Flow Recommendations by Ecological/Resource Managers - March 29, 1991 - Letter Report

Letter and Concept of Interim Operating Criteria for Glen Canyon Dam - Western Area Power Administration - May 22, 1991

Colorado River Energy Distribution Association Letter - May 29, 1991

Upper Colorado River Commission Letter - May 29, 1991

Financial Assessment of U.S. Bureau of Reclamation's Proposal Western Area Power Administration - June 21, 1991 Draft

Hualapai Tribal Council - Letter and Resolution 37-91 Passed July 6,1991

The Hopi Tribe Letter - July 12, 1991

Bureau of Reclamation - Option For Interim Operations - Glen Canyon Dam - July 15, 1991

Geological Survey Letter To GCES Cooperators - July 15, 1991

Estimates of Power System Impacts of Proposed Interim Flow Release Patterns at Glen Canyon Dam - Environmental Defense Fund - July 17,1991

Additional Information In Support of The Scientific Recommendation For Interim Operations of Glen Canyon Dam - July 21, 1991

Western Area Power Administration Letter - Updating Costs For Implementing Interim Operations (Without Draft Exception Criteria) - July 25, 1991

Analysis of Various Channel Cross-Sections In The Lees Ferry - Little Colorado Reach - Randy Peterson - July 25, 1991

TESTING OF PROPOSED
GLEN CANYON DAM INTERIM OPERATING CRITERIA
BUREAU OF RECLAMATION
July 30, 1991

Background

On July 27, 1989, the Secretary of the Interior directed that an environmental impact statement be prepared on the effect 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 Bureau of Reclamation was designated as the lead agency for preparation of the Glen Canyon Dam Environmental Impact Statement (GCDEIS). Cooperating agencies include Arizona Game and Fish Department, The Hualapai Tribe, National Park Service, Western Area Power Administration, Bureau of Indian Affairs, Department of Interior Office of Environmental Affairs, The Havasupai Tribe, The Navajo Nation, The Hopi Tribe, and the U.S. Fish and Wildlife Service.

The GCDEIS and associated Glen Canyon Environmental Studies (GCES) are on schedule to evaluate the impacts of current and alternative dam operations on the downstream environmental and ecological resources of the Glen Canyon National Recreational Area and Grand Canyon National Park. As part of the GCES, research flows were designed for June 1990 through July 1991 to help determine the impact of Glen Canyon Dam operations. The preparation of the GCDEIS will lead to a long-range plan for operating Glen Canyon Dam by late 1993.

Although the commitment to prepare an EIS initiated a resolution process, the issue of interim protection of the downstream environmental and ecological resources remained outstanding.

The Commissioner of Reclamation testified before Congress, on behalf of the Secretary of the Interior, that the Secretary will implement interim flows within 90 days of completion of the GCES research flows. The research flows will be concluded by July 31, 1991. Accordingly, interim flows at Glen Canyon Dam should be implemented by November 1, 1991, and remain in place until the final decision is made.

An administrative process to develop interim operating criteria for Glen Canyon Dam was initiated in February 1991, and presented to the cooperating agencies for the GCDEIS on February 28, 1991. The interim criteria were further discussed at cooperating agencies meetings held on April 3 and 4, 1991, June 13 and 14, 1991, and July 1 and 2, 1991, and were presented at interested parties meetings the evenings of April 3, 1991, June 13, 1991, and July 1, 1991.

The process to develop interim operating criteria included input from the Research/Scientific Group, the Ecological/Resource Managers, and the Power/Water Managers. Recommendations of these groups primarily focus on protection of resources for which they have management responsibilities or other vested interests. Reclamation developed an option focused on balancing the management and use of resources and in pursuit of an implementable plan. These preliminary proposals are summarized in an attachment to this issue document.

Four parameters which relate to potential impacts on downstream resources are the focus of Glen Canyon Dam operations. These include: maximum flow, minimum flow, daily fluctuation of flow, and the rate of change in flows over a 1-hour period (referred to as ramp rates). Limiting flood related damages, as current operations provide, during the interim period is common to all proposals. Interim operating criteria would not interfere with water deliveries pursuant to interstate compacts and other applicable laws or with operations to avoid anticipated spills (often referred to as flood control releases).

Issues

Primary issues that relate to interim operating criteria for Glen Canyon Dam are as follows:

1) Reduction of impacts on the environmental and ecological resources in Glen Canyon and Grand Canyon associated with operational change.
2) Potential impacts on Western's customers in terms of service and costs.
3) Financial cost and funding of replacement power as a result of interim operating criteria.
4) NEPA compliance.

The issue of impacts on environmental and ecological resources in the Glen and Grand Canyons has been highly publicized and relate to: erosion of elevated beaches, replenishment of sand deposits in the river channel, endangered and native fish and trout, aquatic food base, and terrestrial vegetation.

Impacts on power customers are related to contract commitments, transmission, interconnected system responsibility, rate implications, and replacement power.

The financial cost of interim operating criteria is of concern during this period of drought when revenues are low. Funding is currently inadequate to support normal operation and maintenance, EIS, and study costs. Further costs associated with interim criteria will make the situation worse.

NEPA compliance is an important issue in terms of implementing interim operating criteria. What form NEPA compliance will take depends upon the ultimate decision as to interim operating criteria.

Evaluations

The evaluation performed to date of interim flow proposals has been limited to utilizing the best scientific and research data available and the best judgment of those involved in research efforts, recognizing that GCES are still in progress. In most instances, evaluations are necessarily limited to qualitative rather than a more desirable quantitative assessment. Further, it must be recognized that interim flows will be a short-term measure, pending completion of the EIS. Accordingly, assessment will be more limited than might otherwise be expected. Evaluations to date of the proposals have been made on the basis of the operating parameters in the paragraphs that follow.

Maximum flow - The maximum release is based on two primary objectives: (1) to reduce erosion of elevated sand beaches, and (2) to limit the sand being transported out of the system. Another objective is to reduce impacts on Native American cultural sites. Maximum releases in the order of 20,000 cfs are supported by the information available as of July 21, 1991. The 20,000 cfs maximum is sufficient to make water deliveries of 8.23 million acre-feet (maf) to the Lower Basin. Annual deliveries significantly over 8.23 maf could require some upward adjustment in the maximum release. However, the probability of annual deliveries greater than 8.23 maf is very low in 1992 and into 1993. The limitation restricts peak energy production and precludes the use of available generating capacity except for emergency exceptions.

Minimum flow - The minimum release is based on sufficient flow to: (1) reduce impacts on trout spawning and from stranding pools, (2) reduce impacts on native fishes, (3) reduce impacts on aquatic vegetation, (4) reduce impacts on vegetation and, (5) reduce impacts on recreation. A minimum flow of 5,000 cfs appears to meet these objectives. A minimum mean daily flow of 8,000 cfs has been recommended by the Ecological Resource Managers to support aquatic vegetation and facilitate more effective habitat in backwater areas. Accomplishment of these objectives could be achieved by adopting a 8,000 cfs minimum flow from 7 a.m. to 7 p.m. and no less than 5,000 cfs during the night. The changes would be made in accordance with adopted ramp rates.

Daily fluctuations - The reasons for limiting daily fluctuations are to: (1) reduce impacts on elevated beach erosion and associated sediment transport, (2) reduce impacts on fishes associated with spawning, stranding and backwater areas. From preliminary research data set forth in a supporting document of July 21, 1991, a daily fluctuation of 5,000 cfs would alleviate much, but not all, of the erosion impacts on elevated beaches. Some flexibility in daily fluctuation appears to be possible in recognition of stage-discharge relationships in accordance with the additional information documented as of July 21, 1991. A stage change limitation of 3 feet could restrict daily change to 5,000 cfs for maximum release in the magnitude of 10,000 cfs. However, for flows of the 20,000 cfs magnitude, fluctuation up to 8,000 cfs fall within the 3 foot stage limit. Due to variability of cross sections, beach formations, and the location of beaches, there is a variance in stage-discharge relationships. Generally, a maximum fluctuation of 5,000 cfs during low release months, 6,000 for medium release months, and 8,000 cfs for high release months would likely reduce beach erosion to tolerable levels. The daily fluctuation limitation restricts power demands, limits energy resource potential, and impacts energy commitments. The daily fluctuation limitation has the most severe impact on energy production of any of the interim flow parameters.

Ramp rates - Ramp rates, or the flow fluctuation over a 1-hour period impact on: (1) erosion of elevated sand beaches and in other critical areas and, (2) trout spawning and stranding native fishes in the backwater areas. Ascending ramp rates of 4,000 cfs is an approximate threshold level above which impacts are accelerated. Reclamation proposed a limit of 8,000 cfs over a 4-hour period. This longer term limitation may, or may not, be important depending upon the daily fluctuation allowed. Ascending rates of 2,500 cfs/hour closely approximate the Scientific recommendation when considering attenuation. Descending ramp rates are more critical in protecting the resources impacted by fluctuations. Based on the reduction in daily fluctuations and attenuation effects, 1,500 cfs/hour appears to be a reasonable descending ramp rate.

Recommendations

Based on the latest information available and the preceding evaluations, Reclamation proposes the following interim operating criteria:

Parameter	
Maximum Flow	20,000 cfs[1]
Minimum Flow	5,000 cfs - nighttime 8,000 cfs - 7 a.m. to 7 p.m.
Ramp Rates	
Ascending	8,000 cfs/4 hours not to exceed 2,500 cfs/hour
Descending	1,500 cfs/hour
Daily Fluctuations	5,000/8,000 cfs[2]

Research flows are scheduled to end on July 31, 1991, and interim operating criteria are to be implemented by November 1, 1991. During that 90-day period, appropriate NEPA compliance will be completed. With high visibility and interest in protecting resources in Glen and Grand Canyons, testing of the proposed interim operating criteria prior to their implementation is desirable.

The test will be conducted as follows:

(1) The above proposed interim operating criteria for Glen Canyon Dam will be implemented on a test basis on August 1, 1991. It is recognized that a transition period may be necessary in recognition of power contracts, replacement energy, and other arrangements which are associated with modified operations. This transition period will be as short as possible.

(2) A monitoring program will evaluate performance of the proposed criteria. The monitoring will focus on identifying residual problems. Local protective measures, in addition to modification of operations, will be considered to reduce residual impacts during interim flows as appropriate.

(3) Exception criteria used during research flows will be extended for the test period beginning August 1, 1991. By August 15 it is anticipated that Reclamation and Western, with input from the Department of Interior, will draft and agree to revised exception criteria to be put in place at that time. This will also provide a test of the exception criteria.

By November 1, 1991, we anticipate the completion of any necessary NEPA compliance which will allow for final implementation of interim operating criteria.

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[1] To be evaluated and potentially increased as necessary for years when delivery to the Lower Basin exceeds 8.23 maf.

[2] Daily fluctuation limit of 5,000 cfs for months with release volumes less than 600,000 af, 6,000 cfs for monthly release volumes of 600,000 to 800,000 af and 8,000 cfs for monthly volumes over 800,000 af.

ATTACHMENT

GLEN CANYON DAM INTERIM OPERATING CRITERIA

SUMMARY OF PRELIMINARY PROPOSALS

June 25, 1991

Parameter	Historical	R/S Group	E/RM Group	USBR Option	WAPA
Max. Release (cfs)	31,500	20,000	20,000	20,000(1)(2) 22,000(3)	31,500
Min. Release (cfs)	3,000/1000	5,000	8,000	5,000(4)	3,000/ 5,000
Ramp Rates cfs/hr.				<u>4 hour/1 hour</u>	
Up	No Limit	2,000	2,000	8,000/4,000(4)	No Limit
Down	No Limit	1,000	1,000	4,800/2,000(1) 8,000/2,500(2) (3)	4,000/ 5,000
Daily Change (cfs)	30,500	5,000	5,000	8,000(1) 11,000(2) 15,000(3)	No Limit

R/S Group = Research /Scientific Group - Recommendations For Interim Operating Procedures For Glen Canyon Dam - April 10, 1991

E/RM Group = Ecological/Resource Managers - Letter Report - Review of Interim Flow Recommendations - March 29, 1991

USBR = Bureau of Reclamation - Presented at Cooperating Agencies meeting on June 13 - 14, 1991, including a phased approach which was dropped from consideration.

WAPA = Western Area Power Administration - Letter and Concept of Interim Operating Criteria - May 22, 1991 - Comments on the WAPA concept was submitted by the Colorado River Energy Distribution Association and the Upper Colorado River Commission on May 29, 1991.

Notes:
(1) Low monthly volume - less than 600,000 acre-feet
(2) Medium monthly volume - 600,000 to 800,000 acre-feet
(3) High monthly volume - over 800,000 acre-feet
(4) All months

News Release

Upper Colorado Region

Salt Lake City, Utah
Barry D. Wirth (801)524-5403
For Release July 30, 1991

RECLAMATION IMPLEMENTS INTERIM FLOW TEST AT GLEN CANYON DAM

Commissioner of Reclamation Dennis B. Underwood today announced that, on August 1, 1991, the Bureau of Reclamation will begin testing proposed interim flows at Glen Canyon Dam on the Colorado River.

"The test will be used to determine the suitability of the proposed interim flows," Underwood said. "The interim flows which Secretary of the Interior Manual Lujan is to announce by November 1, 1991, will remain in effect until the Glen Canyon Dam Environmental Impact Statement (GCDEIS) is completed in late 1993 and final criteria for operation of the facility are approved and implemented."

On July 27, 1989, Lujan directed Reclamation to prepare an EIS to determine the impacts of Glen Canyon Dam operations on the downstream ecological and environmental resources within Grand Canyon National Park and Glen Canyon National Recreation Area. As part of this process, research flows were initiated at the dam in June 1990 so scientists could study specific, known flow releases and their effects on the resources of the two areas. The research flows will conclude on July 31, 1991.

"The interim test period will allow the Bureau of Reclamation time to more fully evaluate data from research flows and to carry out National Environmental Policy Act compliance for the final implementation of interim flows. This protects one of our nation's greatest resources while meeting basic water and power needs," said Lujan.

For the 90-day test period, maximum flows from the dam will be restricted to 20,000 cubic feet per second (cfs), with a minimum flow of 8,000 cfs between 7 a.m. and 7 p.m., and a minimum nighttime flow of 5,000 cfs. Flows will not be allowed to increase more than 2,500 cfs each hour, or decrease more than 1,500 cfs each hour. In addition, maximum daily fluctuations would be limited to 5,000 - 8,000 cfs, depending on the monthly volume of water to be released from the dam. Criteria have been established that would allow these flows to be exceeded for short periods during emergency situations. The test of interim flows will not interfere with water deliveries, pursuant to interstate compacts and other applicable laws.

The Bureau of Reclamation is the lead agency of a cooperative effort to produce the GCDEIS. The cooperating agencies include (Department of the Interior) U.S. Fish and Wildlife Service, National Park Service and Bureau of Indian Affairs; (Department of Energy) Western Area Power Administration; (State of Arizona) Arizona Game and Fish Department; The Navajo Nation; and the Hopi, Havasupai, and Hualapai Tribes.

Work on the GCDEIS is progressing. A draft document is expected to be distributed for public comment in mid-1992.

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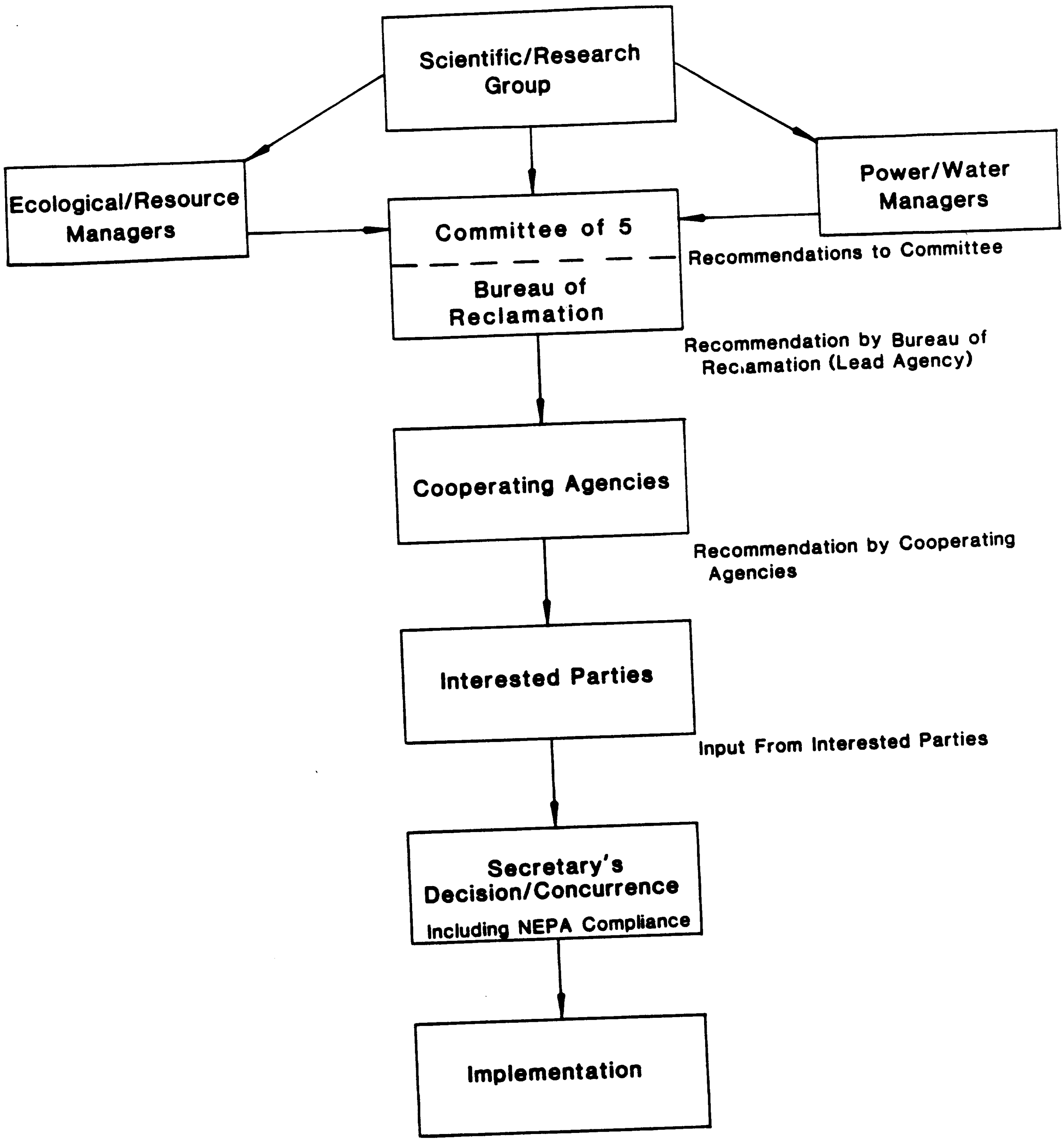
Procedure To Establish Interim Operations - Glen Canyon Dam



INTERIM FLOWS FOR GRAND CANYON

RECOMMENDATIONS FOR INTERIM OPERATING PROCEDURES FOR GLEN CANYON DAM

Prepared for the Bureau of Reclamation and the Glen Canyon Studies Cooperating Agencies

By

The Glen Canyon Environmental Studies Senior Scientist,
The Glen Canyon Environmental Studies Program Manager
And A Small Group of Scientific Experts

Reviewed by the Glen Canyon Environmental Studies Scientific Core Group

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April 10, 1991

INTERIM FLOWS FOR GRAND CANYON

Recommendations for Interim Operating Procedures for Glen Canyon Dam

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INTERIM FLOWS FOR GRAND CANYON

Recommendations for Interim Operating Procedures for Glen Canyon Dam

I. Introduction

The Bureau of Reclamation plans on initiating Interim Operating Procedures (Interim Flows) for Glen Canyon Dam following the termination of controlled research flows under the Glen Canyon Environmental Studies (GCES). Reclamation has established an administrative procedure for developing the recommendation for Interim Flows which includes recommendations from both the scientific and power/water communities with reviews by the cooperating agencies and the public. This recommendation was initiated by a small group of scientists, called together by the GCES Senior Scientist. It has been reviewed by the GCES Scientific Core Group.

This small group of scientists was familiar with the adverse impacts of current dam operations (i.e., 1963-1991) on the downstream aquatic and riparian resources of Grand Canyon National Park and Glen Canyon National Recreation Area. The recognition of past impacts and this assessment were based on data from GCES I (Final Report and Technical Reports), GCES II (preliminary findings), the National Academy report (River and Dam Management), the open literature and their scientific experience. The flow recommendations respond to proposed federal legislation on protecting the Grand Canyon and represent their best estimate for a flow regime that will protect the resources in the short term interim period by reducing the rate of further degradation. It may not, however, provide the optimum protection for the long term. The interim period was considered to extend from the end of the research flows (July 1991) until a "Record of Decision" is implemented based on the EIS (ca. late 1993).

This report presents the initial, scientifically based recommendations and rationale for the Interim Operating Flows. It does not represent a final administrative position, and does not include integration of other water and power concerns. It is considered a conservative position to halt degradation of downstream resources.

The recommendations from this report were presented to the GCES Scientific Core Group on March 15, 1991. Additional development of the recommendations has been reviewed by the Core Group which has made some additional technical and procedural suggestions which have been incorporated into this report.

II. Development of Recommendations

The recommendations were determined by analyzing the Grand Canyon, Colorado River resource system primarily from the abiotic (sediment) and biotic (biological attributes) resource responses and secondarily from the human resource response. These represent the downstream resources that are addressed in proposed federal legislation.

The primary resources or attributes of the Canyon are natural components of the aquatic and riparian systems including beaches and other sediment (sand, silt and clay), native and endangered fish, introduced fish (trout) and other species, the aquatic food base and riparian vegetation. There are many other attributes that could have been considered in developing Interim Flow recommendations, such as other threatened or endangered species, but those used are foremost in the functioning of the Grand Canyon ecosystem and in the concerns of the public.

The secondary attributes were human oriented uses or components of the system. These included recreation (whitewater rafting and trout fishing), historical use of the area and archaeological and cultural resources along the Colorado River corridor.

The assessment process followed a Delphi approach. The group reviewed the characteristics of the attributes and their responses to components of dam operations and came to a consensus on recommendations on dam operations that would minimize adverse downstream impacts. In the process of developing the recommendations in this report, the scientists initially discussed stream flows (discharges) that would optimally minimize degradation of downstream resources. Conditions considered helpful to the system included steady daily flows, seasonal fluctuations and high spring flows. The final recommendations developed by the group recognized the need to stay within "normal" operating procedures of Glen Canyon Dam and yet offer some potential for changes in power demands. The recommendations in this report are thus compromise recommendations and are not to be considered a starting point for negotiations on interim flows.

A. Sediment Response

Large sand bars (beaches) and other sediment deposits exposed along the Colorado River corridor under normally occurring flows are one of the most important biological and recreational resources of the Colorado River through Grand Canyon National Park and Glen Canyon National Recreation Area. Since 1963, there has been progressive loss of sand from beaches and a corresponding decrease in beach area (GCES I, Schmidt and Graf 1990, Schmidt, Moore and Rubin 1989). The current regime of flow releases accelerates erosion of beaches, and does not replenish beaches with new sand. Stability of beaches and other sediment deposits depends upon reducing the rate of erosion and increasing the rate of replenishment. Replenishment of sand beaches requires (1) a sufficient quantity of sand be maintained within channel and (2) streamflows of a magnitude and duration sufficient to deposit sand above the range of normal operating flows. It is possible to minimize the loss of existing beaches by minimizing the rate of sand loss, and providing enough deposition of sand to balance the erosion which cannot be eliminated.

1. Accelerated Erosion of Sand Bars

The current operating regime of Glen Canyon Dam has been shown to cause an increase in the 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 and minimum daily discharge are significant factors controlling erosion rates.

a. 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 is exposed to the primary downstream current. The area of a 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 elevation. Erosion of areas downstream from reattachment points was described by Schmidt and Graf (1990, fig. 20). This process likely continues until such time that nearly stagnant, nonaccelerating flow exists opposite the sandy banks.

b. The rate of the 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. Ramping rates of 3600 cfs/hr, which are being used as the "low" ramping rate under the present regime of research flows, are producing considerable erosion. This rate is actually closer to medium to high ramping rates under normal operations. Down ramping, or the decrease in discharge, has a much greater influence on sand bar and beach erosion than up ramping. A rapid decrease in the water surface elevation causes high positive pore pressure in the river bank material, reducing the effective material strength and promoting bank failure.

The effect of ramping rates on erosion is being studied in GCES-II through empirical and modeling approaches. Studies in other systems demonstrated that seepage-driven erosional forces are responsible for significant, rapid erosion of earthen-filled dams and banks (Finn 1967, France et al. 1971, Desai 1972). Seepage-driven erosion appears greatest when Glen Canyon Dam ramping rates are fast and ramping rates in excess of 19,000 cfs/hr occur several time per year in the Colorado River corridor (Table 1).

Because seepage forces are suspected to be a significant erosional mechanism in this system, and because data are limited, a conservative approach is recommended. Mean and median ramping rates are listed in Table 1 for low-runoff, moderate-runoff and high-runoff years, and indicate that average ramping rates fall in the 1,000 to 2,000 cfs/hr range. Up ramping rates should not exceed 2,000 cfs/hr. Because down ramping rates are more critical in seepage erosion, down ramping rates should not exceed 1,000 cfs/hr. Ramping rates of 1,000 to 2,000 cfs/hr will mean stages will change no more than about 0.5 to 1.0 ft/hr in wide and narrow reaches, respectively.

Table 1. Mean and median ramping rates for Glen Canyon Dam during low-runoff, normal and high-runoff years (Information from the Bureau of Reclamation.)

RAMPING RATE (CFS/HR)	LOW RUNOFF YEAR (1989)	NORMAL RUNOFF YEAR (1980)	HIGH RUNOFF YEAR (1986)
Median	1,000-2,000	1,000-2,000	< 1,000
Mean	2,291	2,445	1,823
Std. Deviation	1,778	2,012	1,717
Sample Size	8,760	8,784	8,760
Number of Times/yr Ramping Rates Exceeded 19,000 cfs/hr	0	5	3

c. **The rate of** sediment transport increases dramatically at **discharges above** 17,000 cfs (Figures 1 and 2). The maximum discharge **determines** the highest elevation exposed to sediment transport and depositional processes. 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 (Pemberton 1988). 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 very high flow deposits (Schmidt pers. comm.). Because erosion rates appear to be rapid, a conservative ceiling to maximum discharge is merited. A maximum discharge of 20,000 cfs appropriately fits this conservative ceiling.

2. Replenishment of Sand Bar Deposits

Erosion of sand bar deposits will occur 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 so that it is exposed during the normal range of dam releases.

a. The quantity of sand stored in a given 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 through Grand Canyon National Park. On average, 1.1 million tons of sand annually is supplied to the reach between the Paria and the Little Colorado Rivers and 2.7 million tons of sand, on average, is supplied to the reach between the Little Colorado River and the U.S.G.S. gage just above the mouth of Bright Angel Creek (Grand Canyon gage) (Burkham 1987).

The quantity of sand transported by various discharges determined from samples collected at the Grand Canyon gage between 1983 and 1986 is shown in figure 1 with a calculated regression curve. The analysis of sand transport prepared independently for this report produced relationships similar to those found by Randle and Pemberton (1988). A steady constant flow of 11,387 cfs (8.25 million acre ft/yr) will transport approximately 200,000 tons of sand per year at the Grand Canyon gage. The same daily mean flow (11,387 cfs), but with a daily peak of 26,000 cfs for 6 hours and daily minimum of 3,000 cfs for 6 hours will transport approximately one million tons of sand per year. The five fold increase in annual sand transport by the same mean annual flow is due to the very rapid increase in transport rate for a relatively small increase in discharge (see figure 2). Under most possible operating regimes where the mean annual flow is 8.25 million acre feet and instantaneous daily peaks are less than about 24,000 cfs, the inflow and outflow of sediment to the reach of the Colorado River between the Paria River and the LCR will be approximate in equilibrium and the reach from the LCR to the Grand Canyon gage will be aggrading (net accumulation of sediment). An operating regime of daily peak discharge of 31,500 cfs for several hours a day and daily mean discharge of 11,387 cfs, however will cause net long term deletion of sand stored in both reaches. The amount of sand calculated to be transported under any particular discharge regime assumes that sand is available for transport. If the bed is sufficiently degraded by discharges whose magnitude and duration is sufficient to transport more sediment than is typically stored on the bed, then succeeding flows will carry less sediment. Preliminary models developed by the National Park Service Water Resources Division indicate that, because there is no assurance of sediment input from the Paria during the interim period, discharges should be sufficiently low to prevent sand loss from the channel in the Paria-LCR reach (NPS 1991).

b. As long as sand is available and is being transported, sand bars will be deposited in recirculating zones at any discharge. Over time the sand bar surface will grow until it is within a foot or so of the water surface. Sand bars must be exposed a few feet or more above the range of normal operating flow in order for the bar surface to be dry and suitable for camping and as terrestrial habitat. Consequently, the sand bar must be deposited and formed by discharges somewhat greater than the normal operating range. Water surface elevation increases by roughly 1 foot for a discharge increase of 2,500 cfs between 20,000 cfs and 45,000 cfs. Thus, beach building discharges must exceed the peak of the normal operating range of the dam by about 10,000 cfs to deposit bars which will stand 4 feet above the operating range. Observation by Schmidt and Graf (1990) show that the surface of a sand bar will aggrade at a rate of a few to several inches per day.

B. Biotic Attributes

1. Native Fishes.

Native fishes include the endangered humpback chub, as well as others that are yet to be listed. Minckley (in press) reviewed ecology of fishes in the Grand Canyon region, and formed the basis of the general comments given here.

a. Humpback chub. This species has survived in the Colorado

River below the Glen Canyon Dam site for millennia, but their geographic distribution in that reach has presumably contracted since closure of the dam. Humpback Chub is a long lived fish (ca. 30 years), thus relatively minor changes in their environment over a short period, such as two years, probably will have little impact on the present population of adults. Young humpback chub may be impacted by daily fluctuating discharges as they use backwaters and creek mouths which can be greatly modified by water-level variations that influence sand bar dynamics and backwater water supply. Backwaters are progressively lost as flows decline below 8,000-10,000 cfs, although more backwaters were found to be present at 4,800 cfs than 28,000 cfs (Anderson et al. 1986). At 5,000 cfs, return channel portions of backwaters are virtually drained (Maddux et al. 1987).

b. Other Native Fishes. With the exception of speckled dace, which is short-lived, other native fishes remaining in the Canyon also are long lived. Adult populations will probably not be influenced by a two-year period. They nonetheless require backwaters and creek mouths for survival of annual recruits. Substantial daily fluctuations will negatively influence their access to creek mouths, where they spawn. Speckled dace also spawn in creeks, and young forced into the mainstem of the Colorado River by fluctuating flows are placed in greater jeopardy of predation, as well as a greater energy demand (in absence of suitable food) in the channel.

2. Introduced Fishes.

Introduced fishes include trout and other non-native fish, such as the striped bass or channel catfish.

a. Trout. Trout have been introduced to various tributaries as well as the Lee's Ferry reach. They are found throughout the Canyon and are used for sport as well as acting as a food resource for predatory birds (e.g., bald eagle). Daily fluctuations increase organic drift which might be a benefit for trout and other fish downstream (Usher and Blinn, 1990). However, daily fluctuations, especially wide ranges, are detrimental to natural reproduction of the trout. Daily fluctuations modify available aquatic habitat (Wegner 1987) and lead to the stranding of adults as well as eggs and larvae, the former is accentuated by rapid down ramping. Other mobile aquatic organisms also might not have the chance to seek refuge at high down ramping rates.

b. Other non-native fish. Constant cold water in the Colorado River is detrimental to most introduced warm water fishes. On the other hand, a lack of fluctuations between seasons (relative stability) tends to enhance survival of non-native fish. Periodic floods either eliminate or greatly reduce populations of non-native fish in smaller canyon streams

(Minckley and Meffe 1987), and presumably do so in the Colorado River mainstem. Daily fluctuations within normal operations may function more like constant flows for non-native fishes than the wide fluctuations that occurred prior to the construction of the dam.

3. Aquatic Food Base.

The aquatic food base is dependent on the stability of the sediment and biotic substrates to which it is attached. Daily fluctuations tend to erode these substrates releasing organic debris (Liebfried and Blinn 1986, Usher and Blinn 1990). This might be advantageous in the short term but the food base could be lost over the long term. Many hours of low flow, generally below 5000 cfs, has also been shown to be detrimental to *Cladophora*, a result of dewatering and desiccation. *Cladophora* provides essential cover and serves as a substratum for attached diatoms and aquatic macroinvertebrates which make up the food base for fishes. For example, spawning trout which are preyed upon at Nankoweap Creek by wintering bald eagles have a diet that consists almost entirely of *Cladophora* and macroinvertebrates derived from the river (Brown et al. 1989). Part of the terrestrial system is also supported by aquatic Diptera which emerge from the river. *Cladophora* colonizes to the typical lowest discharge stage, presently about the 3,000 cfs level and at diminishing rates above the elevation of minimum discharge, thus minimum flows regulate biological productivity in this system, particularly in the Lee's Ferry trout fishery. Exposure of more than 12 hours has been shown to result in 25-75% loss of *Cladophora* biomass in the laboratory (Usher and Blinn 1990). Extended losses of *Cladophora* have occurred in the Canyon during extended periods of low constant flow (e.g., 5,000 cfs evaluation periods during research flows). Daily fluctuations in flow from 10,000 to 20,000 cfs have negative effects on the standing crop of *Cladaphora glomerata* and associated epiphytes at Lee's Ferry (Pinney 1991).

4. Vegetation.

Riparian vegetation serves to stabilize banks (Grelsson 1984), contributes to soil formation, and supports a great diversity of vertebrate and invertebrate life (Brock 1985, Stevens and Waring 1988). In this system riparian vegetation is comprised of three communities, the Old High Water Zone (OHWZ), the New High Water Zone (NHWZ), and Palustrine (riverside) Marsh Zone (Carothers et al. 1979, Stevens 1984). These three communities support at least 5,000 species of plants and animals (Carothers and Aitchison 1976, Stevens 1984, Brown et al. 1987, Phillips et al. 1987) and constitute a significant benefit of impoundment to regional biodiversity. Dam operations influence all three riparian communities, but in different ways.

a. Dam operations (flood control) limits germination and growth rates of OHWZ plant species (Anderson and Ruffner 1988. The OHWZ is presently declining in areal extent and may be lost in this system (Pucherelli 1988).

b. Dam operations directly affect NHWZ vegetation by scouring and removal of vegetation (Stevens and Waring 1985). Dam operations also affect the NHWZ by accelerating soil erosion and leaching of nutrients and fine particles that enhance soil moisture retention and germination (Stevens and Waring 1988, Stevens 1989).

c. Riverside marshes have been created by settlement of tributary-derived sediments in backwaters, and are largely a function of dam operations (Schmidt et al. submitted). Because wetlands, and especially marsh habitats, are the most productive terrestrial environments and support unique flora and fauna, such habitats merit consideration in management.

C. Secondary Attributes

1. Recreation

a. Whitewater rafting. Preferable discharges for whitewater rafting are in range of 8,000 to 24,000 cfs. Constant discharges below 8,000 cfs (e.g., 5,000 cfs) have caused boat damage and logistical problems at Hance, Horn Creek and other rapids.

b. Trout fishing. Rapid ramping rates cause some problems for anglers. Approximately 25% of boats had trouble going up stream at Lee's Ferry when the water was a constant 5,000 cfs (GCES II). In addition, some anglers become stranded on sand bars during rapid up ramping. In contrast, fluctuations increase drift which may improve fishing success.

2. Historical Sites.

a. Charles Spencer boat. The Charles H. Spencer paddle wheel steamboat has been designated as a National Historic Site (Carrell 1987). The upper several feet of the hull is exposed at discharges of 5,000 cfs and is subjected to rapid wetting and drying from waves which increase the rate of decay of the wood, as well as exposure to vandalism. At discharges of 20,000 cfs to 25,000cfs the hull is susceptible to scour by sand and drifting vegetation.

3. Archaeological Sites.

Wide fluctuations in dam discharge are eroding the sediment which has acted as foundation for many near-river archaeological sites. Long periods of flooding in 1983 and resumption of fluctuating flows uncovered many sites making them more susceptible to erosion of support material. Any dam operations which accelerate erosion of the foundation sediments will have major impacts on archaeological resources.

III. Summary of Responses.

The above discussion can be summarized in Table 2 which should be used only for general review of the various responses of Canyon attributes to different discharge rates.

Table 2. A summary of the influence of different dam discharges on attributes in the Grand Canyon.

Attribute	Discharge Conditions			
	Constant	Seasonal Flux	Daily Flux	
			High	Low
Beaches	OK	Better	Poor	OK
Native Fish	OK	Better	Poor	OK
Endangered Fish	OK	Better	Poor	?
Exotic Fish	Enhanced	Poor	?	Enhncd
Trout	Good	Good	Poor	OK
Aquatic Food Base	OK	OK	Poor	OK
Vegetation	Poor	Good	Ok-Poor	OK
Whitewater Rafting	OK (>8,000cfs)	OK	Poor	Good
Fishing Success	Poor	Good	Poor	Good
Historical Site	OK (10-20K cfs)	OK	Poor	OK
Archaeology	OK	OK	Poor	Poor

? = Uncertainty of response.

IV. Recommended Interim Operating Procedures

The following interim operating procedure recommendations are made on the assumption that the Annual Operating Plan, that is the annual and monthly releases of water from Glen Canyon Dam, will continue to be determined based on downstream water needs, but also with consideration for downstream environmental and recreational resources (Federal Register). Therefore, although there are no recommendations on seasonal discharges, they should be considered when based on additional information from GCES II. The rationale statements used to support the recommendations briefly cover the more important reasons for the recommendation. More detail can be found in the preceding text.

A. Maximum and minimum discharges.

1. Maximum discharge should be no more than 20,000 cfs.

Rationale: Discharges greater than 20,000 to 22,000 cfs erode high elevation sand deposits. The greater the discharge, the greater the amount of sand transported. The increase is logarithmic), for example, daily sand transport in tons for a daily constant discharge of 25,000 cfs equals about 8,650, for 20,000 cfs it is about 4,000 and for 15,000 cfs it is about 1,500.

2. Minimum discharge should be no lower than 5,000 cfs with the average daily discharge no lower than 8,000 cfs. There should be no extended 5,000 cfs constant flow. A constant flow of 5,000 cfs should not exceed 8 hours and should occur only between 7 pm and 6 am.

Rationale: A constant 5,000 cfs exposes much of the aquatic food base to desiccation. Spawning problems for trout and degradation of the aquatic food base progressively worsen as discharges drop from 10,000 cfs to 5,000 cfs, while discharges below 5,000 cfs increase the length of time that mass wasting takes place on the lower faces of the exposed sand bars. Backwaters are dewatered at prolonged flows of 5000 cfs or lower. Recreational impacts of discharges below 5000 cfs include reduced angler access, problems with passage of motorized rigs through rapids and logistical delays.

B. Daily fluctuation.

1. The daily fluctuation range should not exceed 5,000 cfs.

Rationale: Wide fluctuations are detrimental to nearly all canyon attributes. As the fluctuation spread increases, there is a concomitant need for steeper ramping rates. Steep ramping rates, especially steep down ramping is significantly detrimental to sediment deposits. Also, the ability of the Cladaphora glomerata to withstand flow stress is decreased.

C. Ramping rates.

1. Up ramping rate should be no greater than 2,000 cfs/hour. This change to take place over the normal 20 minute time span that an hourly change occurs.

Rationale: Greater ramping rates cause calving of beach faces. Rapid up ramping can also cause problems for anglers.

2. Down ramping rate should be no greater than 1,000 cfs/hour. This change to take place over the normal 20 minute time span.

Rationale: The down ramping rate is most critical in beach face wasting. A rate of 1000 cfs would reduce the amount of sand lost into the channel where it can be removed from the system by high discharges. (Monitoring of the impacts of this level of down ramping should allow possible upscaling during the second or third year of the interim flows.)

D. Beach Building Flows.

1. There should be a spring season high flow with a discharge of 31,500 cfs the maximum discharge presently obtainable through turbine operations. The high flow should be of sufficient length to permit beach building (e.g., 6 days to 2 weeks). The flows would be elevated gradually over a few day period to prevent erosion caused by the equivalent of steep ramping. The flows should be dropped more rapidly because this process tends to enhance the storage of sand deposits on elevated sand bars (Schmidt, pers. comm.). This beach or habitat building flow might be considered as a research flow with careful monitoring of the consequences of controlled high flows of this type.

Rationale: If it is possible to create a nondegradation situation for the sand deposited in the canyon system, then it would be advisable to create an occasional high flow to store the sand up on the beaches, not only for preservation of the sand reserve in the canyon but for recreational and vegetation support purposes. Any high flow beach building event should be closely monitored. High flow events should be timed to avoid enhancement of recruitment of exotic vegetation.

V. Monitoring and Research.

1. A monitoring program should be in place during the interim flow period to determine the relative levels of impact caused by the interim flows selected. The interim flow period should also be used to continue studies of the impacts of various discharge regimes from Glen Canyon Dam.

Rationale: It is possible that a selected interim flow will cause unanticipated changes in the resources downstream from Glen Canyon Dam. It is imperative that this knowledge be available before the end of the interim flow period, especially if the interim period is extended due to delays in implementation of the "Record of Decision". The interim flows may be sufficiently different from past, peak load, high fluctuating releases to warrant studies of the impacts on downstream resources that will add to the information base for final EIS decision making.

VI. Modifications.

1. Modifications in interim flows should be made if monitoring indicates impacts on downstream resources are greater than anticipated, as based on existing information.

Rationale: Establishment of interim flows will be based on the best scientific information and expertise available. New information, from future monitoring and research, or unpredicted consequences of the interim flows should be analyzed by the scientific community and used to recommend adjustments in the interim flows to better minimize degradation of downstream resources.

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Figure 1. Sand transported by various discharges determined at the Grand Canyon gage 1983-1986. Regression equation is ln (LD) = -14.1 + 3.53 ln (Q). R2 = 0.88.

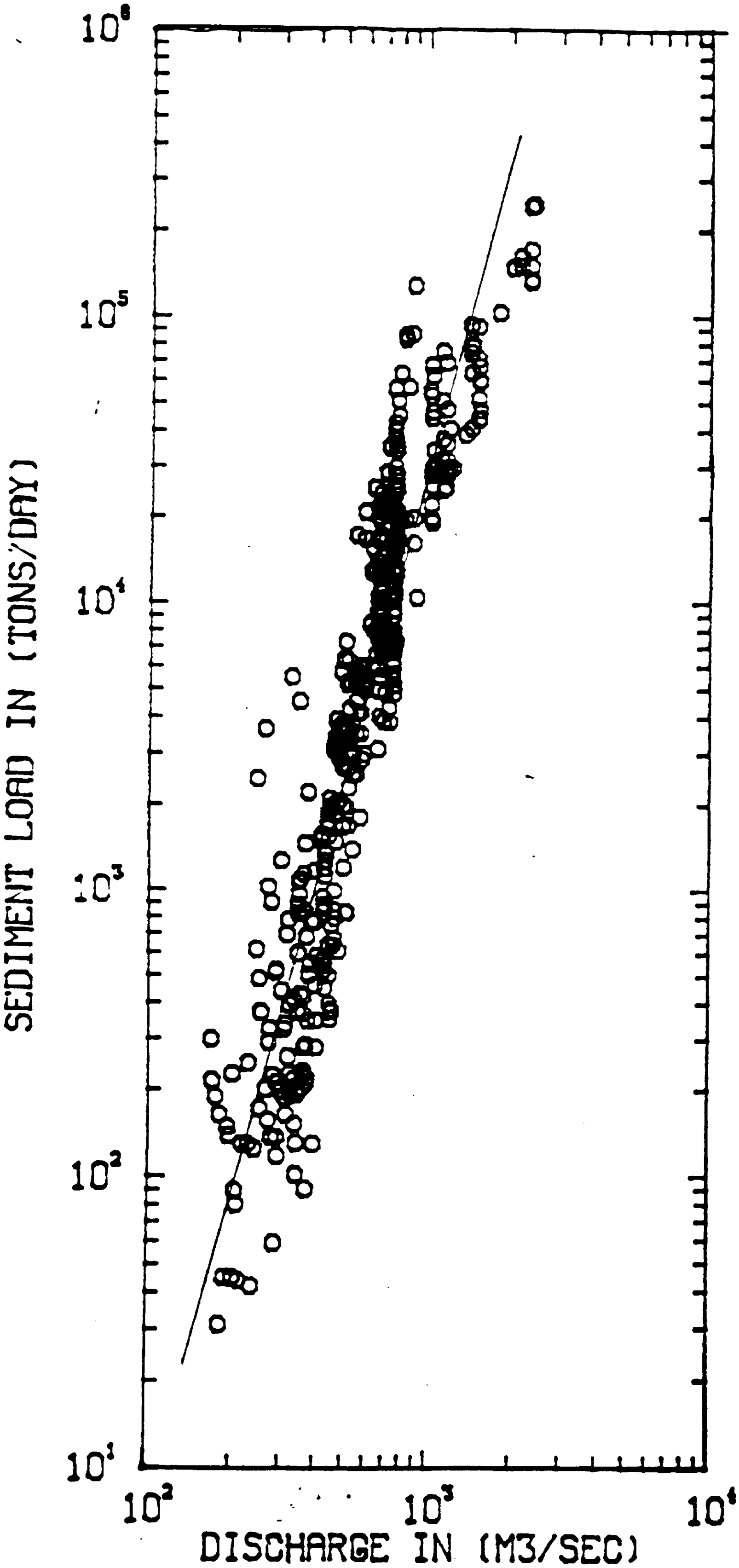
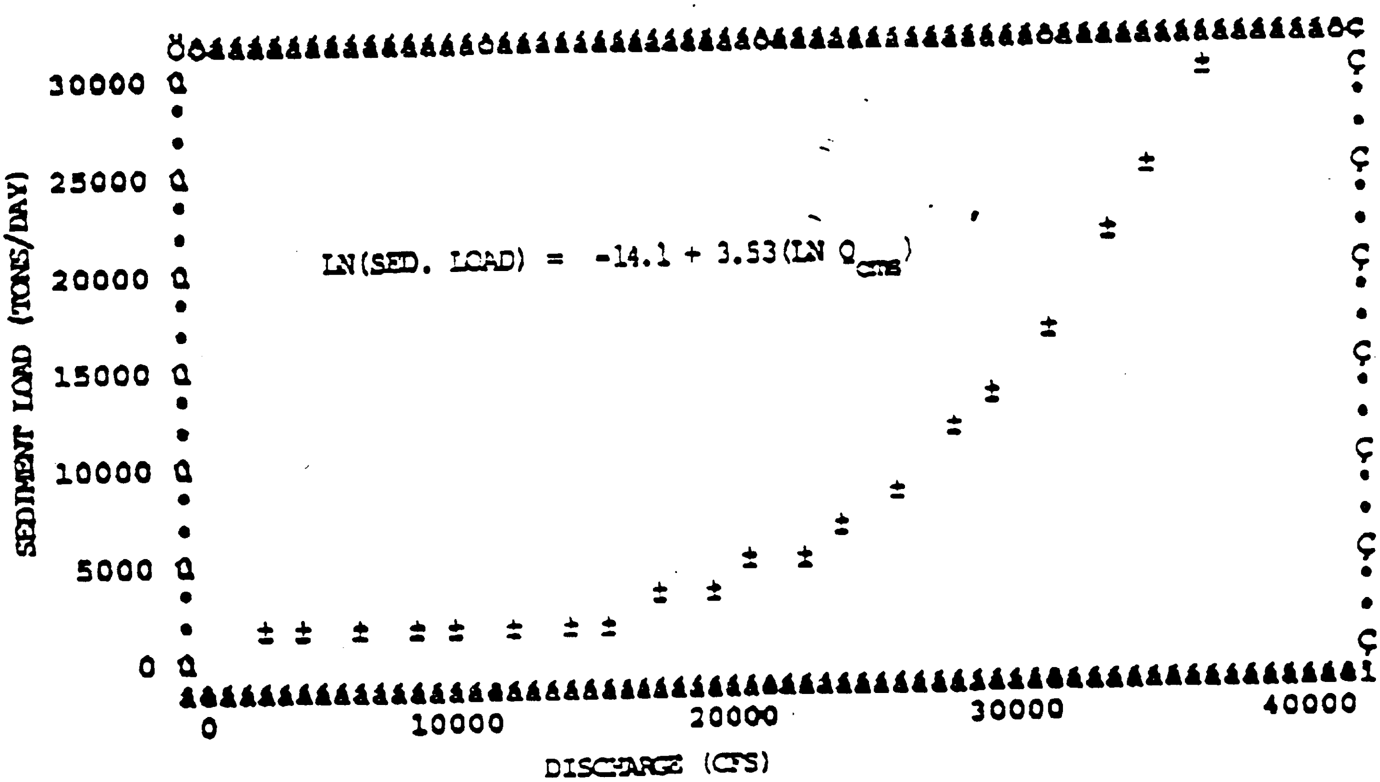


Figure 2. Sediment load transport per day as function of discharge. Data taken from regression curve calculated in figure 1.

QCMS	QCFS	SEDLOAD
50.000	1766.784	0.748
100.000	3533.569	8.640
150.000	5300.353	36.150
200.000	7067.138	99.790
250.000	8833.922	219.370
300.000	10600.707	417.530
350.000	12367.491	719.460
400.000	14134.276	1152.710
450.000	15901.060	1746.980
500.000	17667.845	2534.030
550.000	19434.629	3547.550
600.000	21201.413	4823.050
650.000	22968.198	6397.820
700.000	24734.982	8310.820
750.000	26501.767	10602.640
800.000	28268.551	13315.440
850.000	30035.336	16492.880
900.000	31802.120	20180.130
950.000	33568.905	24423.740
1000.000	35335.689	29271.690



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March 29, 1991

Mr. Lee McQuivey
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PO Box 11568
Salt Lake City, Utah 84147

Dear Mr. Mcquivey:

Re: Review of Interim Flow Recommendation by Ecological/Resource Managers. **(Interim Flows)** (Glen Canyon Dam).

At the last Cooperators meeting there was considerable discussion of the process for development of Interim Flows from Glen Canyon Dam. Among the modifications made to the process was a step that included review of the recommendation of the Scientific/Research Group by Ecological/Resource Managers and Power/Water Managers. On March 28th, a meeting was convened among Ecological/Resource Managers to discuss the recommendation as we understood it.

The agencies that were represented at the meeting (NPS - Grand Canyon National Park and Glen Canyon National Recreation Area, US Fish and Wildlife Service, the Hualapai Nation, and the Arizona Game and Fish Department) have management responsibilities or concerns for natural or cultural resources potentially affected by this recommendation. Because of the rapid pace under which the recommendation is to be reviewed and the necessity to forward response to you before April 1st, I have prepared this record of our discussion and consensus from the meeting. Recognize that this report has not had the review of upper level management from any of the agencies but does report the views of Ecological/Resource Managers at the field level as discussed at our meeting. These views would represent our advice to agency upper level management and the representatives among the Cooperating Agencies. I would assume that this advice will constitute some of the discussion among the Cooperators at their meeting May 1st and 2nd.

Our objective at the meeting on March 28th was to identify concerns related to the recommendation, make suggestions for improving the recommendation, and prepare our advice to the Committee of 5 and the Cooperating Agencies.

Our discussion began with a status review and brief overview of the recommendation. It was our understanding from the overview that the period of duration of interim flows would extend up to the Record of Decision for the EIS. With this background in mind, we approached our review of the interim flow recommendation on a point by point basis. The remainder of this letter constitutes a summary of our discussions of the recommendation.

Maximum Discharge Should Not Exceed 20,000 cfs

There was general consensus that a 20,000 cfs cap on interim flows was justified. The primary justification was velocity related transport of sediments. Based upon the justification being prepared by Dr. Patten and the Scientific/Research Group, it was our understanding that flows above 20,000 cfs would negatively influence the sediment balance downstream of Glen Canyon Dam.

A major point raised relating to this portion of the interim flow recommendation was the longevity of interim flow operations. Expected hydrologic conditions today may differ from those three years from now. The recommendation is based upon current reservoir elevations and current forecast. It is uncertain how the recommendation might have to change under different conditions (i.e., years when more than 8.23 maf might have to be delivered). This is accentuated should interim flows extend longer than the anticipated 24 to 36 months.

Suggestion: This point of the recommendation is well justified and acceptable from the perspective of Ecological/Resource Managers.

Minimum Discharge Should Not Be Lower Than 5,000 cfs

There is considerable information available about the effects of flows of 5,000 cfs. Much of the justification of a 5,000 cfs minimum is based upon that information. Ecological/Resource Managers were not in total agreement with a 5,000 cfs minimum. The concerns identified included:

PRIMARY: At flows of 5,000 cfs an important cultural/historical resource, the steamboat Charles H. Spenser (at Lee's Ferry) is exposed to the air. At flows of 8,000 cfs it is entirely submerged. Exposure to the air accelerates oxidation and degradation of the boiler and remaining superstructure.

At flows of 5,000 cfs backwater return channels in the Grand Canyon are drained, while at 8,000 cfs they still hold water. Values of backwaters to native fishes, including endangered species may be reduced at 5,000 cfs.

SECONDARY: GCES I reported that trout spawning bars in the Lee's Ferry reach are entirely inundated at 8,000 cfs. It is likely that natural recruitment of trout will be improved at 5,000 cfs minimum flows, however it would be more assured at 8,000 cfs minimum flows.

Dramatic rafting accidents in the Grand Canyon are more likely at 5,000 cfs than they are at 8,000 cfs. While the 5,000 cfs trough would pass the Lee's Ferry Reach during the night time hours, that trough (though somewhat attenuated) would be encountered during the day time by recreational rafters in the Grand Canyon.

Suggestion: This point of the recommendation is justified based upon the information currently available to GCES Researchers. From the perspective of Resource and Recreation Managers, however, a more conservative approach of 8,000 cfs seems justifiable. The importance of historic/cultural resources, the value of backwaters to native fishes including the endangered species, and recreational concerns associated with the trout fishery and recreational rafting led the group to suggest that an 8,000 cfs minimum be considered.

Average Daily Discharge No Lower Than 8,000 cfs

The 8,000 cfs average daily discharge is important in the context of a 5,000 cfs minimum flow. The consensus was that it was well justified in that context. If the suggestion of an 8,000 cfs minimum flow was incorporated into the final recommendation, an Average Daily Discharge limit may need to be reassessed.

Constant Flows of 5,000 cfs Should Not Exceed 8 hours and Should Only Occur Between 7pm and 6am

Among the important justifications for this restriction on the minimum is the effect of desiccation on Cladophora. Research has indicated that after 12 hours of exposure significant losses of Cladophora may be realized. This restriction would reduce the effects of low flows upon the aquatic food base. If the suggestion of an 8,000 cfs minimum was incorporated into the recommendation, a similar duration limitation should apply.

Suggestion: This point of the recommendation is well justified and acceptable from the perspective of Ecological/Resource Managers.

The Daily Fluctuation Should Not Exceed 5,000 cfs

Ramping Rates Should Not Exceed:
2,000 cfs per hour on the up ramp
1,000 cfs per hour on the down ramp

These two points of the recommendation appeared to the Ecological/Resource Managers to be inextricably linked. Based upon the background presented and our understanding of that information, if the daily fluctuation range was increased then the allowable ramp rates would have to be decreased. The daily range works together with the down ramp rate to reduce the incidence of mass wasting of beaches and banks. Cut banks in the Lee's Ferry Reach appear to be among the most sensitive sites because of their relative steepness and the cultural resources that they house.

Suggestion: These points of the recommendation are well justified and acceptable from the perspective of Ecological/Resource Managers.

There Should Be a Spring Habitat Development Flow of 31,500 cfs of 6 Days to 2 Weeks in Duration

This point of the recommendation was among the most controversial discussed. The Ecological/Resource Managers recognize potential risk associated with this habitat development event. The concern lies in the uncertainty of its effectiveness and the possibility of accelerated erosion of cut banks. Primarily this erosion concern is centered in the Lee's Ferry Reach, and is accentuated by the cultural resources, riparian vegetation, and emergent marsh vegetation losses that could accompany erosion of those banks. Ned Andrews (USGS) has indicated his opinion that this effect would be unlikely. Concerns over the complexity that this event might add to NEPA compliance for the interim flows were also voiced. (Cultural surveys in the Lee's Ferry Reach are nearing completion and should cast some light on the susceptibility of sites to a 31,500 cfs event.)

Discussion also turned to the timing of this event. Several managers felt it might be better timed to coincide with flows of major tributaries (Paria, Little Colorado River) if the objective was to build beaches. Timing of this event with a major tributary flow would mix silt and clay materials with bed load sand, which would establish a more stable beach deposit. Further, timing of the release with inflows from major tributaries could reduce the magnitude of release necessary from the dam and thus reduce possible effects to sediment deposits in the Lee's Ferry Reach.

Suggestion: This point of the recommendation carries both assets and liabilities. As we understand it, the habitat development flow would deposit sediments on beaches above the typical fluctuation zone, would flush and refurbish backwaters that may be filling with sediments and debris, could serve to cue spawning activity by native fishes, but could potentially erode steep cut banks in the Lee's Ferry reach affecting some cultural resources. This point is justified as a one-time evaluation event that could be monitored while researchers are still in the field. Effects of the habitat development flow could be documented, which would provide important insight to development and assessment of alternatives in the EIS. This feature could be included as part of the interim flow package, or could be justified as a separate research/evaluation event.

There were several concerns that the Ecological/Resource Managers brought up in the course of our discussion. They are listed as follows:

Recovery from Emergency Situations

It is understood that operations may be temporarily modified to respond to a power, water, or human emergency. This is a reasonable qualification. However, ramp restrictions should probably apply on the up or down ramp recovery from decreased or increased delivery due to an emergency response. While rapid response to an emergency situation is essential, recovery following that response should be no more damaging than interim flows.

Flexibility Within Interim Flows for Research/Evaluation/Monitoring

A statement of flexibility would be desirable, which would allow deviation from interim flows for research or evaluation necessary for analysis of impacts for the EIS.

Research and evaluation should be continued upon the interim flows themselves to determine if they are in fact meeting their objectives.

When and How Do We Revisit and Revise Interim Flows

There may be a need to revise interim flows in response to impacts identified in the course of GCES research or in response to unanticipated changes in forecasted inflow. Further, if the interim flows must remain in place longer than anticipated because of delay or inability to implement an alternative from the EIS, reanalysis and revision of the interim flows may be essential.

Monitoring of interim flows will be essential. It may be necessary to create a monitoring mechanism for those features that are not scheduled for continued research through the interim period (Cultural Resources and Sediments). Monitoring requirements beyond the scheduled conclusion of GCES and preceding implementation of long term monitoring associated with conclusion of the EIS will need to be considered along with mechanisms for funding such monitoring.

An annual report of monitoring should be made to the GCES Scientific Core Team, who would in turn would make recommendations to the Cooperating Agencies for modification of interim flows. The review and consideration of those recommendations could coincide with review of the Annual Operating Plan.

In concluding, let me reemphasize that this review and associated suggestions have not yet been subject to approval by agency management. This letter advises you of the results of our meeting of March 28th, and will be reviewed with agency management prior to the Cooperators meetings of May 1st and 2nd. I hope this proves useful as you prepare to forward the final recommendation to the Committee of 5 and the Cooperating Agencies.

Sincerely,

Larry Riley
Aquatic Habitat Coordinator

LR:lr

cc: Dr. Duncan Patten, GCES Senior Scientist
Cooperating Agencies

Department of Energy
Western Area Power Administration
P.O. Box 11606
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MAY 22 1991

Mr. Rick Gold
Assistant Regional Director
Bureau of Reclamation
125 South State Street
Salt Lake City, UT 84138

Dear Rick,

Enclosed with this letter is Western Area Power Administration's concept of interim operating criteria for Glen Canyon Dam during the period in which the environmental impact statement (EIS) for dam operations is under preparation. In concert with Commissioner Underwood's congressional testimony, this concept reflects our best efforts to balance the competing resource demands on Glen Canyon Dam, given the state of scientific and economic information available at this time.

We believe that the National Academy of Science's Water and Science Technology Board made an excellent point in its report on GCES Phase I studies, River and Dam Management.

> The committee believes that management of resources is feasible but it demands ecological understanding. Such understanding in this case will require sustained research because (1) management of the Colorado River will make use of the control afforded by the dam, (2) the river ecosystem is in disequilibrium because of the dam construction itself, and thus (3) operational decisions will require continuous checking to confirm that the desired effects are being achieved.

In keeping with the board's points, Western believes that the key objectives in formulating interim flows (in the sense of the next 1-3 years) center on (1) making changes that potentially have substantial, short-term benefits in terms of resource maintenance, (2) understanding and quantifying those benefits, (3) making further adjustments over time as additional scientific information is produced, and (4) above all, avoiding those actions which mask the effects of the changes being made or which could lead to substantial negative consequences given the very limited state of knowledge that presently exists.

As you will see, the enclosed concept addressing operational criteria centers on those potential changes which appear to us to have some immediate benefits. Our concerns center on the potential gains and losses to the resources associated with the dam and the canyon, and not so much on the financial cost of accommodating interim operations. As you know, the financial burden of accommodating research releases has been substantial, and has been absorbed by Colorado River Storage Project (CRSP) revenues in the spirit of furthering quality scientific research in the Grand Canyon riverine corridor. That spirit of cooperation continues in our concept of interim operations.

It has been widely acknowledged that the riverine ecologies have been significantly changed since the construction of Glen Canyon Dam. Coupled with wide swings in hydrologic conditions in only two decades, it is evident no one will clearly understand the post-dam environmental equilibrium for many years to come. Completion of GCES Phase II studies and institution of long-term monitoring are key elements in the eventual understanding of resource responses to Glen Canyon operations, the existence of the dam, and the many other factors (wind, people, etc.) that impact the Grand Canyon riverine corridor. However, let us not lose sight of the substantial improvement in environmental and recreational benefits that have evolved under present operating conditions. Establishment of a world-class trout fishery, maintenance of a viable population of humpback chub, increasing use of the canyon by peregrine falcons and bald eagles, and the substantial growth of the white-water rafting industry are but a few of the positive changes that have come about due to the presence of the dam and the manner in which it is operated.

Our concept of interim flows takes on a whole new dimension. In addition to focusing on short-term preservation of certain critical resources, it addresses the need to ensure that changes that are made now or over the next few years do not impair the benefits that have been gained to date.

Our concept centers on modification of two operational parameters--downramping rates and minimum releases. In terms of downramping, the rate of change could be constrained to either 4,000 cfs/hour or 5,000 cfs/hour depending on hydrology, electric load, and power market conditions. Minimum releases could be set at 3,000 cfs or 5,000 cfs, again dependent on hydrology, electric load and power market conditions.

We believe that changes in these parameters should have beneficial impacts to canyon resources. Shallower downramps are expected to have benefits in terms of reducing the hydrostatic pressure on sandbar faces and decreased stranding of trout. Increased minimum releases should have beneficial impacts to recreation, trout spawning and survival, and perhaps other resources. We remind you that these are changes in limits. Actual operations as they now exist or as they would occur under our concept would actually reach these boundaries only a small percentage of the time. As you will see in the enclosure, present and constrained operations normally fall well within these boundaries.

The development of this concept has been challenging. We have the advantage of knowing our own resource needs well, as well as the probable effects of changing dam operations on power system integrity and costs, and to some extent, other potential environmental and economic effects. However, the process of conceptualizing changes in operating parameters has been difficult because so much more scientific data and analysis about downstream environmental effects of various flow regimes is needed.

As you know, we had posed a series of questions in my letter to Lee McQuivey of April 2, 1991. In addition, as we agreed in the last meeting of the Cooperating Agencies, we held a meeting among our technical representatives and members of the scientific and research group to share information and better understand the scientific basis for operational constraints. The responses we received to our written questions and the impressions we received in the scientific/technical meeting were inconclusive in terms of supporting extreme changes in operating parameters.

Given the present and near-term limitations of quality information on resource responses to dam operations, we must advocate a phased approach to instituting new operational parameters. As I indicated before, Western is amenable to phasing in operational changes over the next few years or even farther into the future. This phasing in of changes must be supported by solid, scientific data and analysis which demonstrate the real benefits to be garnered by operational changes, and which allow decision-makers to make objective decisions on the balancing of those benefits with the costs that will be incurred, whether those costs are financial, ecological, or recreational. In particular, we are reluctant to support large, wholesale changes in multiple operational parameters. Such dramatic changes may lead to unintended losses in environmental or recreational benefits, or may lead to long-term or permanent damage to the evolving ecosystems in the canyon.

In addition, a phased approach to changes will be advantageous to us all in two substantial ways. First, better scientific data gathering and analysis can be accomplished if only limited, gradual changes are made in operations. If a more radical approach is adopted, it will be more difficult or impossible to continue relevant research into cause-and-effect relationships in the Grand Canyon riverine corridor. By initially changing only one or two operational parameters, research can continue to quantify the effects of the components of different operating regimes. Other changes to operational parameters can be considered as adequate scientific research and analysis is completed or as a result of long-term monitoring.

Second, a phased approach will permit Western to gain operating experience and take other substantive measures to accommodate further justifiable changes when scientific evidence supports the benefits of such changes. In addition, we fully expect that hydrology and resulting releases will change over the next few years (hopefully for the better), and we need to retain the flexibility to take advantage of better water conditions, or rethink our decisions if conditions worsen.

As we indicate in the enclosed document, we firmly believe that the procedural requirements of the National Environmental Policy Act (NEPA) are fully applicable to interim flow proposals. Among other requirements, we particularly call your attention to sections 1502.2(f) and 1506.1 of the Council on Environmental Quality's implementing regulations. If our concept of interim flows is adopted, we anticipate that both Reclamation's and Western's NEPA compliance will be swiftly and creditably accomplished. More radical departures from present operating parameters could move us all past a threshold where we cannot avoid a determination that such changes represent a "major Federal action significantly affecting the quality of the human environment."

We are prepared to initiate NEPA compliance activities based on the assumption that interim flows will be instituted in the fall. Also, as we point out in the enclosed document, it is critical that other procedural and substantive initiatives be undertaken in order to effect interim operations. The extent of such procedural and substantive activities are partially dependent on the degree in which operating parameters are altered.

As you know, the cash position of the CRSP Basin Fund remains critical. It will be very difficult to support FY 1992 funding levels for all anticipated Reclamation and Western programs even without an additional burden of interim release restrictions.

Finally, please note that we are marketing firm power under a court-approved interim marketing plan. A condition under which that interim plan was approved by the court was "Maintenance of the status quo as to water release patterns by operation by WAPA or recommendations by WAPA to the Bureau of Reclamation for operation of CRSP dams in terms of water release patterns. Operations and water release to be performed essentially in the same manner as now performed under the existing contractual arrangements." Given this directive, we are responding to your request in the spirit of providing information for your deliberations on a recommendation to the Secretary of the Interior for interim operating criteria.

We believe the concept we have presented in the enclosed document will have immediate and substantial benefits to the downstream ecological and recreational resources in the Grand Canyon, and will minimize any risk of negatively impacting the positive attributes that have developed in the canyon. The changes we have set forth are reasonable given the level of scientific information currently available, and can be further adjusted as additional information comes to light. We are confident these changes are implementable within the timeframe set by Commissioner Underwood in his testimony to the Congress.

We will be pleased to discuss this proposal with you and others at the upcoming meeting of the cooperating agencies or in other forums.

Sincerely,

(SGD.) Kenneth G. Maxey

Kenneth G. Maxey
Deputy Area Manager

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WESTERN AREA POWER ADMINISTRATION
CONCEPTUAL DISCUSSION OF INTERIM OPERATING CONDITIONS
FOR GLEN CANYON DAM

I. Introduction

This document constitutes a conceptual discussion by Western Area Power Administration (Western) concerning interim operating procedures for Glen Canyon Dam during the period from the end of research releases to the record of decision for the Glen Canyon Dam Environmental Impact Statement (GCD-EIS). Also included is a summary discussion of the constraints which must be considered in formulating and adopting a set of interim operating procedures.

Western is willing to support modifications to current operations to the extent scientific data and analysis, not observations alone, support the benefits of such changes. Additionally, all parties to the discussion of interim operating procedures must recognize that changes in one electrical generating resource will mean that electrical load must be met from some other resource. The electrical demand does not go away. Replacement power will have to be found on the integrated system.

Nonetheless, Western suggests that implementation of interim operations be the first step of a phased approach leading ultimately to possible modifications of operations should that be an outcome of the record of decision for the GCD-EIS.

As explained later, Western would commit to enacting further modifications to Glen Canyon Dam operations during the interim period as the validated results of current studies indicate the explicit need for such changes and when time allowances are provided to execute those changes.

Extensive changes to current operations are difficult to implement within short timeframes; however, Western's Montrose District Office has, during the research releases, has been able to develop creative approaches to meeting Western's commitments when provided ample time to develop those solutions.

The adoption of such operational changes also would necessitate allowing adequate time to study the environmental impact of each change on the various downstream resources. Although the perception is that wholesale changes in operations will have nothing but positive effects on the natural resources of the Grand Canyon, no one should forget that the current environment has evolved under current dam operations. Therefore, a wise approach would anticipate that changes to operations may have detrimental impacts on certain environmental resources, as well as beneficial impacts. Proceeding incrementally and with caution is prudent.

Western also will commit to study its current and future operations through the interim operating period to determine where additional flexibility may reside. This may permit the continual phasing in of operational changes while protecting customer and operational commitments.

Western's suggested conceptual changes to operations are designed to facilitate the actual implementation of the interim operations by avoiding initial changes of such a magnitude that extensive procedural requirements under the National Environmental Policy Act of 1969 (NEPA) would delay or preclude that implementation. This is extremely important if all parties are earnest in facilitating changes in a timely fashion.

Finally, with regard to the natural resources which now exist within the Grand Canyon below Glen Canyon Dam, no one must lose sight of the positive, beneficial changes that have occurred as a result of the dam. Prior to the dam, the rafting industry was tenuous at best. Now there exists a thriving year-round concern which brings thousands of people through the canyon. Endangered species have proliferated with thriving populations of such endangered birds such as the bald eagle and the peregrine falcon now utilizing the canyon. One of the foremost trout fisheries in the world is located immediately below the dam. The floral diversity is clearly expanding along the river supporting an ever expanding faunal structure. Even the endangered humpback chub have been located in greater numbers in recent years than they were in the past.

II. Description of Western's Approach to Development of This Interim Operating Procedure

Before discussing our concept, the basic criteria Western has used in fashioning this approach need to be addressed. The following points should provide the foundation for developing conceptual interim operating procedures.

First, only those primary natural resources that could be significantly impacted by present operations over the interim period should be considered in formulating interim operating parameters. Western does not believe it is appropriate to consider immediate enhancement as an objective in the interim period. The focus of interim operations should be prevention, to the extent reasonably possible, of the degradation of important natural resources pending the completion of the GCD-EIS and implementation of long-term operating procedures.

Second, any interim operation package needs to consider all resources, including power generation, as stated in Commissioner Underwood's Congressional testimony. "The interim power operating criteria will be based upon careful evaluation of all relevant research as well as potential impacts on river regulation, reservoir uses, existing power contracts, Colorado River Storage Project (CRSP) system repayment, and operating revenues." In so doing, operational flexibility for power generation should be retained to limit probable primary and assured secondary environmental impacts from replacing environmentally clean hydropower with thermal-generated power.

Third, interim operating procedures are subject to the procedural requirements of the NEPA. By definition, interim flows will impact the physical environment. If they do not result in maintenance of primary natural resources, then they should not be considered. Additionally, physical environmental effects will occur due to the forced shift in generation from hydro to thermal, particularly if the shift includes changes in available capacity as well as energy. The NEPA process must address the direct, indirect, beneficial, detrimental, and cumulative impacts of the interim operating procedures that the Bureau of Reclamation (Reclamation) ultimately recommends, including the effects resulting from shifts in generation on the integrated power system and replacement of lost capacity by existing or new sources as well as the need for transmission to deliver the power. If possible, the interim operating procedures should not be so significant as to be construed as a major Federal action under NEPA. Finally, the interim operating procedures must not violate Council on Environmental Quality (CEQ) regulations concerning actions taken during an ongoing NEPA process by limiting alternatives or prejudicing the final decision.

Fourth, as mentioned, Western advocates a "phased" approach to interim flows, thereby taking measured, incremental steps. These incremental changes can be monitored by ongoing studies to assess impacts in enacting any changes which can be demonstrated to be both beneficial and non-threatening to natural resources as well as to power resources.

Finally, and most importantly, the interim operating procedures must include explicit "exception criteria" such as were included during the period of research releases. These "exception criteria" are necessary to preserve power system reliability and reservoir operations. Should the interim operating procedures differ significantly from current operations, the exception criteria must include economic exception criteria which would prevent significant financial impacts to Western's customers.

Given the basic criteria stated above, Western initiated the process of conceptualizing an interim operating procedure. The first step was to identify the natural resources which needed protection during the interim period. Natural resources evaluated included sediment (transport) and beaches, nonnative fish, native and endangered fish, fish habitat requirements, aquatic vegetation and food production, recreation, safety, and archaeological and cultural sites. Unfortunately, this assessment of natural resource needs is considerably hampered by the lack of scientific data and analysis on which to base a more comprehensive interim release proposal. Western has attempted to secure the justifying analysis for the proposal that was presented by the Glen Canyon Environmental Studies (GCES) researchers March 15 by asking a number of clarifying questions and meeting with GCES research representatives. However, these queries were not fruitful. It is apparent to us that little or no analysis exists that supports such a change in dam releases. Apparently, what does exist is raw data, some guesswork, and a heavy, but misplaced, reliance on GCES Phase I results; results which have been questioned by the National Academy of Sciences. This is insufficient information on which to base a multimillion-dollar decision, which also might include potentially severe environmental impacts.

With all of this in mind, Western has proceeded to delineate interim procedures which focus on the seasonal and monthly nature of (1) natural resources (2) water-release requirements including hydrologic conditions, (3) customer loads, and (4) the amount and price of available power on the current wholesale market. These procedures attempt to reach a realistic compromise when all of the pertinent processes, procedures, as well as environmental impacts, are considered. Incorporation of these concepts will enable the interim operating procedures to be implemented in the timeframe envisioned by the Secretary of the Interior. Section IV of this discussion summarily describes the relevant processes and procedures which Western has analyzed in developing this package and which must be considered for any final set of interim operating procedures.

III. Western's Concepts for the Interim Operation of Glen Canyon Dam

This section presents possible interim operating procedures. These procedures should be viewed as being comprised of four interactive parameters which must be considered to accommodate all interests. A description of power operational parameters which were utilized in developing both these procedures and the GCES researchers' proposal also is included. Finally, the GCES researchers' proposal is briefly analyzed presenting the impacts of that proposal upon Western's power operations.

A. Western's procedures are dynamic in that the operating conditions would vary depending on four critical parameters: (1) natural resources, (2) hydrology, (3) load, and (4) market conditions. The intent is that these restrictions would achieve goals similar to the GCES researchers' proposal; i.e., preservation of natural resources without serious consequences to those natural resources or to the power system.

Western initially supports modification of only two of the operational aspects of Glen Canyon Dam: the minimum water release and the descending ramp rate, both of which have been identified by the GCES researchers as factors affecting the erosion of sand deposits and transport of sediment out of the Colorado River system into Lake Mead.

The modification of these two operational aspects is in keeping with the thoughts outlined within Section II above that the focus of interim operations is prevention, to the extent reasonably possible, of significant degradation based upon scientific analysis of natural resources requirements, while fully considering the points emphasized within Commissioner Underwood's testimony to the Congress. Western's position is that the following changes are "reasonable"; since to go beyond those changes (i.e., more drastic operational changes) will cross the threshold in which the process and procedural constraints outlined in Section IV will delay or preclude implementation of any form of interim operations.

Western's suggestion, therefore, is:

- Minimum Release: 3,000 cfs (integrated across the hour) when the monthly water release is less than 650 thousand acre-feet (KAF), market conditions are unfavorable, and monthly firm load is above 500 gigawatthours (GWh);

  5,000 cfs (integrated across the hour) under all other conditions.

- Down Ramp: 4,000 cfs/hour when market conditions are favorable and monthly firm load is less than 500 GWh;

  5,000 cfs/hour under all other conditions.

The minimum release level of 3,000 cfs was chosen primarily because it is the most reasonable minimum release level that could be implemented in low-release volume hydrology, unfavorable market, and high-load conditions without having a significant impact on operations. It represents a significant increase above the 1,000-cfs winter minimum currently in place. Historically[1], during low-release volume conditions, releases have been below 3,000 cfs approximately 11 percent of the time. This percentage would be even higher during months like December and January.

The 5,000-cfs/hour minimum release was chosen because it coincides with the minimum release proposed by GCES researchers. A 5,000-cfs minimum can be accommodated given the criteria stated above.

The goal of the proposed descending ramp rate restrictions, in part, is to ameliorate the erosion process to certain sand deposits which is being blamed on fluctuating flows, while at the same time avoiding a severe restriction in real-time operations. The current research releases have studied only two descending ramp rates, one at 3,600 cfs/hour and another at 7,200 cfs/hour. Western's proposal of 4,000 cfs/5,000 cfs/hour then falls within the analyzed range and near the minimum studied.

Paramount to any interim release restriction is the ability to adjust the restriction criteria for emergency purposes and/or to maintain system integrity. Therefore, the restrictions listed above are subject to specific emergency criteria such as are in place during the current research releases. In addition, these restrictions are subject to the current definition of an hourly operating level in that they would be integrated across the hour.

There would be two major impacts to power associated with the interim release described above:

1. A shift in water from onpeak to offpeak, particularly during low-water release months.

2. A reduction in the real-time flexibility of power operations.

[1]Using data from WY 1980 to WY 1989.

The actual expense of the above changes is difficult to determine. Western estimates that it would increase the net purchase power expense somewhere between $200,000 and $7.2 million for the 14-month period covering August 1991 to September 1992. These estimates represent extremes, calculated using a basic load and resource balancing method. The actual impacts would depend on the price of energy available to meet load. These estimates provide a reasonable range of impacts to purchase-power expense. It should be noted that these estimates do not reflect foregone opportunity costs of nonfirm sales or impacts to other aspects of power operations.

B. Conditions Pertinent to the Interim Operating Procedures

As briefly mentioned, this procedure is structured to be dynamic in that the proposed restrictions would vary depending on four critical parameters: (1) natural resources, (2) hydrology, (3) load, and (4) market conditions. It is envisioned that the four parameters would play an interactive role in delineation of the actual operations of Glen Canyon Dam on a monthly, seasonal, and yearly basis. Each of those parameters are briefly described below.

1. Natural Resources - As mentioned, Western has sought clarification and scientific evidence to establish thresholds for impacts brought about by each of the operational aspects described herein. Western shares the concern that where operations can be demonstrated to negatively impact specific environmental resources, then changes should be considered. Through ongoing dialogue with GCES researchers and other scientists, evidence is amassing which circumstantially points towards minimum release and descending ramp rates as a source of impacts to certain resources; i.e., sediment transport and sand-deposit erosion. Arguments can be made that the evidence is not complete and that other modifying factors, such as wind, release attenuation, side-canyon discharge, and debris flows also impact both sediment transport and sand deposits.

Based on preliminary results of earlier studies by Reclamation of flow attenuation below Glen Canyon, it is known that the shape (maximum, minimum, ascending, and descending releases) of a period of water release is attenuated further downstream from the dam. The degree of attenuation is strongly influenced by such factors as the magnitude of release levels, the duration of and time between releases, channel characteristics, and distance from the dam. Further, it could be possible to simulate the hourly release hydrograph from Glen Canyon under a range of possible release volumes with and without interim release restrictions using current technology (i.e., SSARR model), and to assess the degree of attenuation at various resource sites downstream. It may then be possible to allow greater flexibility of release constraints at the dam which, after considering flow attenuation, could be shown to result in less impacts to these critical resources at those sites of concern.

It is therefore proposed that studies be performed by Reclamation using the SSARR model, or similar tool, that would consider the effects of flow attenuation associated with Western's proposal (or concept of interim operations and with other potential iterations. Prior to any simulation modeling, the levels of flow-rate change and their effects on resources first should be better understood.

Western would initially agree to modify Glen Canyon operations for the interim period to accommodate the preservation of those particular natural resources i.e., sediments and sand deposits within the Grand Canyon. As also mentioned, all other natural resources appear to be maintained under present conditions; it is assumed that these changes would enhance some other environmental and recreational resources such as trout spawning and river rafting.

As the results of the current GCES studies proceed and results which definitively demonstrate that power operations are continuing to significantly impact environmental resources in the

Grand Canyon, additional modifications to operations could be made in a timeframe as the other factors permit.

2. Hydrology - Hydrology plays a principal role in determining all aspects of power operations. Western's operations are determined primarily by the annual hydrologic conditions. Where release volumes are to be low or high, the flexibility of the power operations is limited. In other words, low-release volumes require careful consideration to prevent over-releasing. On the other hand, high-release requirements limit the minimum to a higher level leaving a narrow band within which to operate. For example, when the monthly release volume from Glen Canyon is less than 650 KAF, hourly releases are below 5,000 cfs approximately 26 percent of the time.[2] As monthly water releases increase, so do the minimum release levels. For releases between 650 and 850 KAF, hourly releases are below 5,000 cfs 14 percent of the time, 7 percent of the time for releases between 850 and 1,000 KAF, and only 1 percent of the time for high releases above 1,000 KAF.

   In addition, hydrology is a factor in determining maximum release rates. Dam releases for power operations do not fluctuate to the fullest extent of their capability every day; i.e., 1,000 cfs to 31,500 cfs. In low-release volume months (monthly releases less than 650 KAF), maximum releases are generally below 17,000 cfs approximately 90 percent of the time. Even in moderately high release months (between 850 and 1,000 KAF), maximum releases are below 23,000 cfs approximately 90 percent of the time.

   Given the relationship between hourly/daily operations and hydrology, it is important to define when this relationship is at a critical stage, especially in terms of implementing any type of restriction. Minimum release levels are especially critical

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[2]Based on actual hourly release data from WY 1980 to WY 1989 provided by the Bureau of Reclamation.

during low-release volume conditions. Since there is a small amount of water to begin with, any water moved unnecessarily from onpeak to offpeak by a minimum release restriction produces a larger impact than it would under moderate or wet conditions. A minimum release restriction of 3,000 cfs during a 650 KAF (or lower) release month would impact operations approximately 11 percent of the time; a 5,000-cfs minimum would impact operations approximately 26 percent of the time and move a substantial amount of water/generation from onpeak to offpeak. Therefore, any sort of minimum release restriction should be contingent, at least in part, on the volume of the monthly release, especially when the release is less than 650 KAF.

3. Market Conditions - Market conditions are vital to power operations because the market essentially determines the availability and therefore the cost of replacement power for the generation from Glen Canyon. It should be noted that this includes, to a certain extent, system conditions along with market conditions. By including system conditions, we are incorporating the ability to transmit a purchased resource, as well as to unload any possible surplus generation.

   "Market condition" is a very broad term that encompasses many aspects of not only Western's operations, but the condition of the power system as a whole. In order to determine and define market conditions, the relative level of the nonfirm on-peak purchase prices for a certain period of time could be compared, and the level of market "favorability" or "unfavorability" then could be established.

   The definition of "favorable" and "unfavorable" market conditions is acknowledged to be potentially more subjective than the quantification of other factors such as load and monthly release volume. To reduce the degree of subjectivity, a suggested approach is presented below:

1. Planning -- Western would initiate purchase planning discussions during the formulation of alternative annual operation plans for CRSP, anticipated to be in early July. Discussions would conclude with projected purchase power prices for that amount of energy needed in the upcoming water year.

2. Assessment -- Western, in coordination with Reclamation, would establish an acceptable approach to compare the projected purchase prices against those prices for the most recent historical period taking into account known and measurable changes (i.e., compare projected prices vs. historical winter season prices). Criteria could be developed which would establish a confidence level (i.e., +/- __ percent) which would indicate a change in market condition classification; for example, if the projected winter purchase prices were a certain percent higher than those prices for the previous winter season, then market conditions would be classified as "unfavorable."

3. Initial Action -- Decisions would be made as to the classification of market conditions (favorable vs. unfavorable), the appropriate interim release constraints applied, and would be reflected in the initial annual operating plan recommended to the Secretary of the Interior in consultation with the Basin States.

4. Adjustment -- Provisions would be in place that would allow for adjustment in the market condition "forecast" based upon the best available information. Modifications also would coincide with monthly modifications to the annual operating plan made by Reclamation, made to account for changes in the water supply forecast.

5. Communication -- These changes would then be communicated throughout Reclamation and Western and to affected parties.

During unfavorable market conditions, more flexibility at Glen Canyon would be required and, therefore, less severe restrictions would be imposed. With respect to Western's concept and assuming other conditions of load and hydrology listed earlier, a 3,000-cfs minimum and a 5,000-cfs down-ramp restriction would be imposed during unfavorable market conditions. Under favorable market conditions, more restrictive criteria would be imposed; a 5,000-cfs minimum and 4,000-cfs down-ramp restriction.

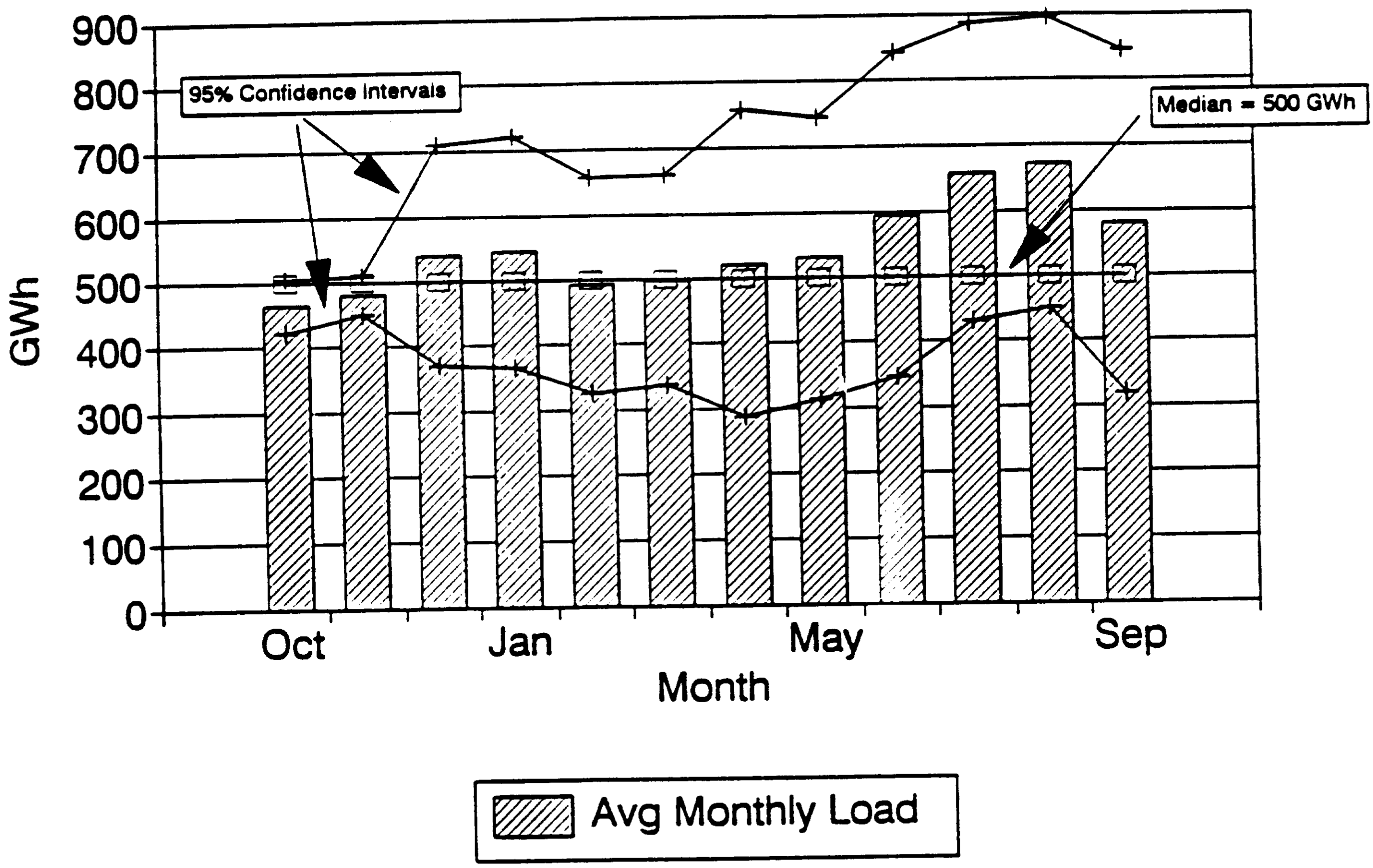
Recognizing market conditions in developing a set of interim restrictions will reduce the impact to power operations significantly.

As interim operating criteria are further delineated, Western would be willing to set out specific guidelines so that there will be no misunderstanding of the decision rules for both down-ramping and minimum releases.

4. Load - Load, along with hydrology and market conditions, determine the shape of power operations. The level of load, in conjunction with hydrology, decides how much energy will be required on the system. Additionally, market conditions determine the availability and, therefore, the value of that energy.

In order to determine distinct levels of load, monthly firm load amounts were analyzed using data from WY 1986 through WY 1990. Firm load data from this period generally are representative of current conditions and should serve as a good indicator of what can be expected in the near term.

Monthly Firm Load
WY 1986 through WY 1990



This graph is a statistical summary of firm load data from WY 1986 through WY 1990. Firm load typically follows a seasonal pattern, although there can be a great deal of variation (as illustrated by the relatively wide confidence intervals). The median monthly firm load amount is approximately 500 GWh. During peak months[3], monthly firm load is typically above 500 GWh; in shoulder months, firm load is generally less than 500 GWh. Therefore, a monthly firm load of 500 GWh is a threshold that would be used to determine the level of interim restrictions that would be imposed for each particular month. The threshold of 500 GWh would have to be reevaluated periodically and possibly adjusted to reflect any changes in operations.

C. Discussion of Operational Parameters

There are a number of parameters that define daily and hourly operations at Glen Canyon Dam. These include maximum and minimum releases, magnitude of daily fluctuation, and ramping rates. This section describes, in general, the importance of these parameters to power operations and how restrictions on these parameters impact power operations. Following this section is a brief discussion on the GCES researchers' proposal as it pertains to these operational parameters.

1. Minimum Releases - In order to discuss the importance of minimum releases, the concept of the spot energy market and off-peak and on-peak periods must first be explained.

   When a utility's load is higher than its generation at any given time, the utility usually has the option of purchasing energy from the spot market to make up the difference provided that utility can comply with certain specific requirements. The demand for energy is structured in such a way as to create two distinct periods, offpeak and onpeak. An off-peak period is usually characterized by relatively low demand and high energy availability. On a daily basis, this usually occurs between midnight and 7 a.m. Conversely, an on-peak period is usually characterized by high demand and less surplus energy being available to meet that demand. This usually occurs between 8 a.m.

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[3]Peak months are usually June, July, August, December, and January.

and 11 p.m. The availability and, therefore, the price paid for energy differs substantially between the off-peak and on-peak periods, and this is where minimum releases become important. The range and flexibility of water releases allow hydro-electric generation to take advantage of the difference between off-peak and on-peak availability in the spot market. With respect to Glen Canyon, water is usually saved during the off-peak periods, when it is of less value, and released during the on-peak periods. Because of the limited volume of water that may be used on a daily basis, the primary impact of a restriction on minimum release rates is the shift of water from onpeak to offpeak. This would (1) limit resources when system demand is the greatest (onpeak), (2) decrease on-peak nonfirm sales when they are of most value, and (3) increase the risk of "dumping" energy offpeak; i.e., having to accept a very low price for energy generated during the off-peak periods.

2. Maximum Releases - Maximum releases are crucial to power operations for many reasons. First, maximum release levels play a role in delineating the capacity available to serve load. Capacity is defined as the maximum available output of a generator. A utility must have the equivalent amount of capacity as it has peak firm load plus a certain amount of capacity as "reserves." Available capacity is crucial in determining load serving capability. Second, maximum release levels determine not only the amount of energy that is required to be purchased to make up for any under-generation, but also the type and price of that energy. Third, maximum releases heavily influence nonfirm and emergency operations.

   Restrictions on maximum releases have a tremendous impact on power operations. Depending on the level and flexibility of a maximum release restriction, the integrated system may experience a capacity loss that must somehow be replaced. Capacity is very expensive with the cost depending on the type and duration of the capacity purchase. If Western was required to purchase capacity, the cost of any interim release proposal would increase substantially.

A maximum release restriction also affects the amount and type of energy that Western would need to purchase to serve load. A good illustration of this fact occurred on June 29, 1990. Because of the research releases from Glen Canyon Dam, there was a 5,000-cfs constant release from the dam. In addition, since June is a summer month, loads were fairly high. These circumstances combined to produce huge energy deficits; 565 megawatts per hour (MW/hour) on average during the on-peak period for this day. Because of the magnitude of the deficits, relatively cheap resources of approximately $20-21/MW/hour were quickly exhausted. As the magnitude of the deficits increased, and alternative resources became scarcer, so did the purchase price increase; $25/MWh, $37/MWh, $38/MWh, and finally $42/MWh as Western had to "purchase" a combustion turbine (i.e., lease of capacity and energy available from a specific unit) during the on-peak period in order to meet its load commitments.

Although this is an extreme case, it exemplifies this particular effect of a maximum release restriction, that is, such a restriction increases the requirement for additional energy and capacity (and, therefore, price) of that energy.

Finally, a restriction on maximum releases, like that proposed by the researchers, would severely impact nonfirm sales. In FY 1989, Western's nonfirm sales revenue was approximately $17.5 million. Nonfirm sales are essential to offset the cost of the power resource.

3. Ascending Ramp Rates - Ramp rates are important for several reasons, but in a broad sense, they represent the flexibility of a hydroelectric unit. Ascending ramp rates are crucial in responding to day-to-day changes in load, emergency situations, and variations in real-time operations. They also affect the

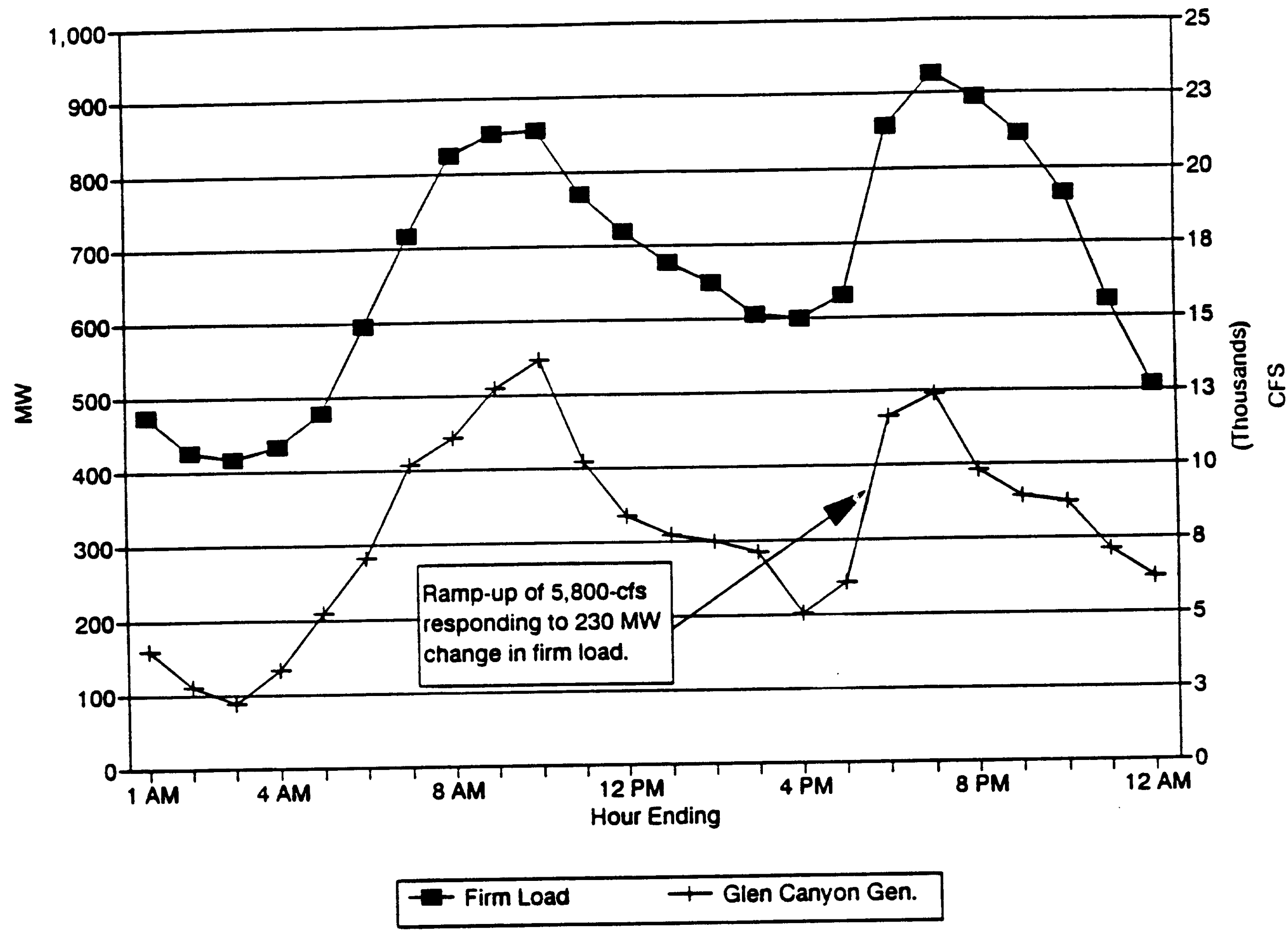
level that a particular minimum or maximum release can be sustained and, therefore, affect capacity as well. For example, a high-maximum release restriction of 28,000 cfs would be meaningless if the ascending ramp rate were restricted to 2,000 cfs. In other words, ramping at a rate of 2,000 cfs/hour beginning at some low level, i.e., 5,000 cfs, would mean Western could only use the capacity that it had reached by the time the peak load starts to drop.

On a general note, the ability of hydrogeneration to rapidly respond to increases in load sets this type of generation apart from thermal-based generation such as coal or nuclear. Those thermal-based resources have a relatively slow response time (i.e., ascending ramp rate) and are not generally used for load following. Glen Canyon Dam, in particular, has significant importance to the Western United States with regard to responses to system requirements. Due to its size and ability to respond to immediate increase in load, the Western United States will feel a significant peaking capacity shortfall as a result of major changes in Glen Canyon operations.

Ascending ramp rates occur as generation follows load. To help explain the nature and importance of ascending ramp rates, an example of a daily load and generation pattern is provided in the following graph.

This is a snapshot of a relatively uneventful day in January. Between 5 p.m. and 6 p.m., there is a rather large jump in firm load. This probably can be attributed to a pickup in residential load. Glen Canyon responds with a 5,800-cfs up-ramp to pick up this change in load. While a change in load to a certain extent can be met through generation at other CRSP plants, the ability to up-ramp at Glen Canyon is vital because it represents the largest single Salt Lake City Area resource. It should be noted that ascending ramp rates in excess of 5,800 cfs happen fairly infrequently; less than 5 percent of the time. However, when they do occur, it is during transition periods changing from off-peak

Daily Pattern
Example: January



to on-peak periods, or vice-versa, or for emergency situations. Therefore, they are a critical component of power operations.

Another important function of ascending ramp rates is the ability to adjust to variations in real-time operations. Power dispatchers generally make operational decisions based on scheduled load, that is, load that is scheduled to occur at least 1 day in advance. However, on a real-time basis, actual load typically deviates from scheduled load. Ascending ramp rates are important when real-time load picks up faster than scheduled, creating a situation where the scheduled resources (owned or purchased) may be insufficient to meet load. At this point, it may be difficult for a dispatcher to meet this load with any other resource than Glen Canyon, so the dispatcher will ramp up in order to cover this deviation.

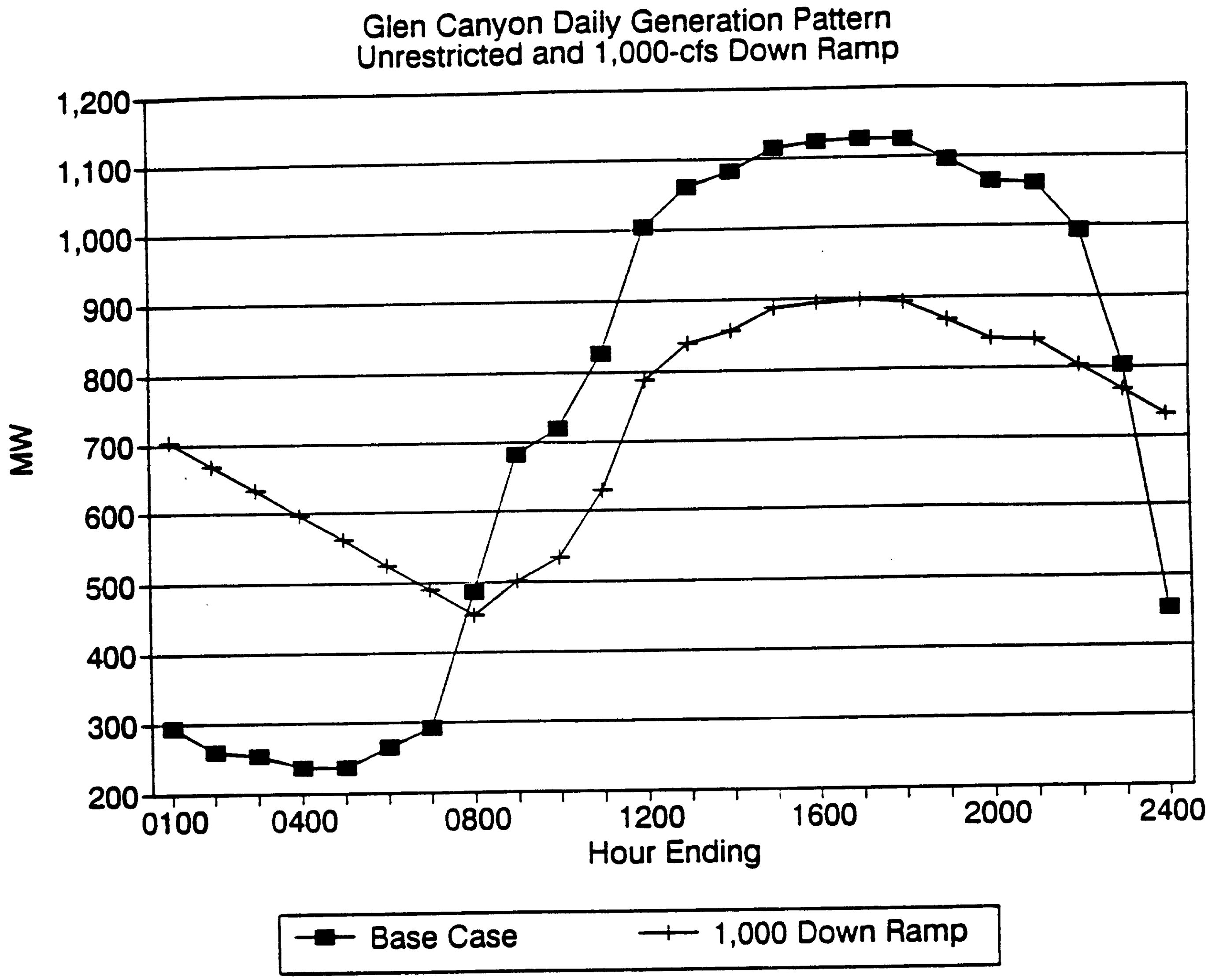
Restrictions on up-ramping increase on-peak energy purchases and also the requirement to purchase capacity.

Finally, restricted up-ramping effectively raises minimum releases and lowers maximum releases by limiting the amount of generation that can be attained during the peak period.

4. Descending Ramp Rates - Descending ramp rates are similar to ascending ramp rates in that they are crucial in determining the overall flexibility and efficiency of Glen Canyon Dam. Many of the factors addressed above concerning the importance of ascending ramp rates also apply to descending ramp rates and will not be repeated. There is slightly more flexibility in constraining down-ramp rates since Western's ability to secure replacement resources is improved as system resource move from on-peak to off-peak periods. However, since descending ramp rates also play an important role in determining the effective minimum and maximum release levels (a fact that is often overlooked), this aspect of their function will be explained in greater detail.

   The graph on the next page illustrates the effect of a restricted down ramp.

   This graph represents a modeled daily generation pattern under base-case conditions (3,000-cfs minimum only), as well as a daily pattern under the same conditions, but with an additional 1,000-cfs down-ramp restriction. The 1,000-cfs down-ramp restriction effectively lowers the maximum release level by approximately 200 MW (5,500 cfs); raises the minimum release level by approximately 225 MW (6,300 cfs); changes the pattern of



generation substantially; and moves a substantial amount of generation from onpeak to offpeak.

While this is an unusually high fluctuation under base case conditions compared to a severe down ramping restriction, it does depict the relationship of the minimum and maximum release levels.

5. Daily Fluctuation - Daily fluctuation should not be considered an operational parameter per se because it is easily controlled by restricting the other parameters described above. Restrictions in daily fluctuations as mentioned are achieved through restrictions in the minimum and maximum release rates and/or ramp rates. Conversely, a restricted daily fluctuation will produce at least some of the complications described above, depending on the severity of the restriction.

6. Resource Integration

The concept of possible increased resource integration either through the use of existing resources (Hoover Powerplant) or the use of future generating facilities (Spring Canyon Pumped Storage) has been mentioned in several earlier discussions and hearings on interim release constraints. In the case of Hoover, Western's initial response to this concept was that since the generation was fully committed through long-term contract to other utilities, little potential peaking resource at Hoover remains as replacement for lost flexibility (reduced operating capability) at Glen Canyon Dam. On the other hand, the Spring Canyon project has yet to proceed beyond the planning stages due to limited economic benefit to potential project participants and could only represent a long-term solution to replacement capacity.

However, some potential may exist in either pursuing greater resource coordination with existing peaking facilities such as Western's Loveland Area Projects, in particular Mount Elbert pumped storage. This pumped storage project, or other similar existing peaking facilities, may be able to provide a reliable source of peaking power during periods when Glen Canyon Dam is constrained. It is conceivable, however, that changes in the operations at Glen Canyon Dam may result in changed operations at other facilities with as yet unquantified environmental impacts. An important consideration in the effective use of pumped storage is the ability to locate and arrange for an economic source of pump-back energy during off-peak periods. The reliability and the cost effectiveness would be central considerations in the feasibility of such integration with CRSP resources.

The potential may exist for Western to seek participation in construction, operation, and/or maintenance of new peaking facilities. Concepts should be investigated such as Western's potential acquisition of small-scale (5-MW or smaller) combustion turbine(s) or participation in large-scale (100-MW or greater) peaking facilities as a result of recent advances in renewable technologies such as compressed air.

D. Discussion of the GCES Researchers' Interim Release Proposal

The GCES researchers' proposal is a static recommendation for a complex and highly dynamic condition. It does not factor in any water, power, or regional environmental concerns and, instead, focuses only on these environmental resources immediately below Glen Canyon Dam thought to be affected by power operations. Additionally, the researchers base a number of their interim release restrictions on speculation, not on empirical data. For example, the researchers have proposed a down-ramp restriction of 1,000 cfs/hour. The lowest ramping rate restriction being formally evaluated under research release conditions is 3,600 cfs/hour. This rate is substantially higher than that being proposed as an interim restriction, so the environmental effects of the proposed restriction are currently unknown and may actually be harmful.

The real constraints of the GCES researchers' proposal are even more severe than is readily apparent. For example, the proposal lists the minimum and maximum releases at 5,000 cfs and 20,000 cfs, respectively. If the daily limitation proposed by the researchers is disregarded under current hydrological conditions, the minimum and maximum restrictions themselves are more limiting. With respect to FY 1992, the effective or "sustainable"[4] minimum release levels would range

[4]Sustainable is defined as the level that can be reached and held on a consistent basis, factoring in hydrology and release restrictions.

between 7,500 cfs and 13,900 cfs, depending on the amount of water available each month. The maximum release levels that could be sustained would range between approximately 11,000 cfs and 18,000 cfs, again, depending on the amount of water available in the month.

The researchers also have proposed a beach-building flow of a 6-day-to-2-week, 31,500 cfs, constant flow which would, in and of itself, have a profound impact on all resources. For purposes of analysis, it was assumed that such a flow would be for a 6-day duration, and that all other restrictions proposed by the researchers would be adhered to. This means that operations would still be restricted by the 2,000 cfs up-ramp and 5,000 cfs/day criteria, creating a gradual ascent to the high-constant flow.

Based on this analysis, approximately 184,000 AF would have to be shifted from other periods of the year directly to the period of time for the beach-building flow. If the duration of the high flow were extended past the 6 days, obviously more water would have to be shifted among the months, creating significant problems for both water and power operations.

The nature of the researchers' interim release restrictions would cause substantial financial impacts. That interim release proposal would increase Western's purchase power expense from $16.3 to $33.4 million for the 14-month period covering August 1991 to September 1992 (between $14.1 and $29.7 million for just FY 1992). The range of impact would depend on the availability and price of energy, as well as capacity to make up for the reduction at Glen Canyon. The impact to nonfirm sales, or to other areas of power operations, is <u>not</u> included in this estimate. However, should those restrictions be implemented, real-time flexibility would be lost with an obvious impact to nonfirm sales. Finally, without the flexibility to operate for emergency conditions, significant system impacts will be felt throughout the Western United States (see Section IV).

IV. Summary of Institutional, Procedural, and Process Constraints

This section deals with the various factors and constraints which must be considered in the formulation and implementation of any interim operating procedures. It is not intended to be either exhaustive or all-inclusive, but rather to provide an overview of those potential factors and constraints that must be considered by the decision maker. The section addresses legal and regulatory issues, power system responsibility, and Western's contractual responsibilities. Many of these issues could be considered "fatal flaws" in terms of implementing the interim flows on a timely basis if not appropriately recognized and adequately addressed through this process.

A. Legal and Regulatory Issues and Concerns

1. The Law of the River - the CRSP Act

Section 7 of the CRSP Act states that the powerplants must be operated "so as to produce the greatest practicable amount of power and energy that can be sold at firm power and energy rates." This provision was so important to Congress that it reiterated it when enacting the Colorado River Basin Project Act of 1968 (CRBPA). Moreover, §601 of the CRBPA states that nothing in it shall be construed to alter, amend, repeal, modify, or conflict with, among other things, the Boulder Canyon Project Act or the <u>CRSP Act</u>.

The operating criteria (i.e., criteria for coordinated long-range operation of Colorado River reservoirs pursuant to the CRBPA) does not repeat the language about maximizing firm power production of the CRSP Act and the CRBPA. This was because the operating criteria state that they are <u>promulgated in compliance with §602</u> of the CRBPA and "will be administered consistent with applicable Federal laws."

2. Anti-Deficiency Act

Under the Anti-Deficiency Act, no Federal employee may make or authorize an expenditure or obligate the payment of money exceeding amounts available in appropriations or funds for the expenditure or obligation. Both Western and Reclamation depend on revenue in the Basin Fund to cover CRSP operations, maintenance, replacement, and emergency expenditures. The Basin Fund is extremely short of cash and changes in interim flows which seriously deplete CRSP revenue and increase expenses make us concerned about avoiding a violation of the Anti-Deficiency Act. Increases in revenues to offset any deficiency legally cannot be implemented without increasing power rates or supplemental appropriations, both of which have established procedures including public involvement and require substantially more time than just a few short months.

The grim reality remains that unfavorable hydrology, increasing costs, and other factors combine to bring the CRSP revolving fund to the brink of insolvency. Constrained operations at Glen Canyon will only exacerbate this critical situation.

3. Rate Implementation

The implementation of a new power rate for the Salt Lake City Area Integrated Projects (SLCA/IP) is estimated to take 10 to 16 months in order to satisfy the requisite notice and comment procedures, the FERC filing requirements, the rate-setting provisions of RA 6120.2, and the provisions of DOE Delegation Order No. 204-108, as amended. This point and the discussion provided in section 2 above are particularly relevant when consideration is given to interim operating procedures which are significantly different from the current operating procedures and which might impact the rates Western charges for its firm power.

4. NEPA Compliance

NEPA requires the completion of an environmental impact statement (EIS) before implementation of a proposed major Federal action significantly affecting the quality of the human environment. A number of legal cases suggest that the requirement to prepare an EIS is not triggered by actions which maintain the environmental status quo. The cases involving dam operations, in which no EIS was required, concerned operations based on the same operating parameters (i.e., minimum and maximum flow rates, ramping rates, etc.) as existed previously. Changes in operating parameters would alter the environmental status quo and could trigger the EIS requirement. What is critical is the possibility of significantly affecting the environment. Such changes could adversely affect natural resources downstream from Glen Canyon Dam or could be more indirect.

We question the degree of certainty that apparently exists that nothing adverse will happen to particular resources as a result of radical interim releases being instituted; similarly, endangered humpback chub seem to be doing quite well. Will a radical change in the status quo lead to unintended jeopardy to this population of chub?

Also, we particularly call attention to §1506.1 of the CEQ regulations. The requirements and constraints embodied in that section are obviously applicable to interim release criteria.

5. The Court Order From the District Court for Salt Lake City, National Wildlife Federation (NWF) v. Western

Within a September 29, 1989, order in the NWF lawsuit, Judge Greene ordered Western to submit an interim power marketing plan for his approval pending completion of an EIS, which would, among other things, achieve "[m]aintenance of the status quo as to water release patterns by operation by WAPA or recommendations by WAPA to the Bureau of Reclamation for operation of CRSP dams in terms of water release patterns. Operations and water release to be performed essentially in the same manner as now performed under the existing contractual arrangements."

Area Manager Lloyd Greiner subsequently filed an affidavit with the court submitting the interim power marketing plan stating "implementation of the interim plan will not change the status quo as to water release patterns for operations of [CRSP] dams . . . since minimum and maximum release requirements at each powerplant remain unchanged . . . and the operational characteristics of the hydroelectric powerplants remain unchanged by the interim plan."

Judge Greene then issued an order dated November 22, 1989, based on the Greiner affidavit and other evidence accepting the interim power marketing plan and preserving the remainder of the September 29 Order of Injunction which prevents Western from materially increasing the long-term firm power sales pending completion of an EIS. The order also required the power contracts to include a clause permitting changes arising from Western's EIS or from any final administrative decision requiring change in [CRSP] operations resulting from the Secretary of the Interior's GCD-EIS ordered on July 26, 1989. The contracts are "also subject to further orders of the Court in the lawsuit consistent with [NEPA] and prior orders of the Court."

There is a real question as to Western's obligation to report to the district court concerning operational changes that are imposed on Western, or which Western must institute for reliability or economic reasons. This question may not be resolved until the Secretary of the Interior has made his decision on interim flows.

B. Interconnected System Responsibility

Western has multiple responsibilities as a member of various organizations such as Western Systems Coordinating Council and the Inland Power Pool, which specify requirements for operating reliability criteria, power supply design criteria, and system design criteria. Western, as a member of these organizations, must satisfy specific obligations particularly regarding reserves and reserve sharing. The ability to meet these obligations is dependent on the use of Western's resources including Glen Canyon. Should the flexibility of Glen Canyon be constrained or lost, the ability for Western to meet its obligations will likewise be constrained or lost.

C. Emergency Services

The Salt Lake City Area of Western historically has offered emergency service contracts to SLCA/IP firm contractors who have installed generation capacities below 5 MW per unit to supplement their own system requirements. Western has provided this service in lieu of customers obtaining the capacity from an alternate supplier, which in many cases has been significantly more expensive. In most instances, when a utility is forced to rely on an alternate supplier to meet load above contract commitment, the utility receives a "ratchet," which increases its demand payment for the entire month even though the need may have only existed for an hour. Although this service has been provided by Salt Lake City Area on an as-available basis, Salt Lake City Area has never refused it to anyone. This resource is scheduled on an hourly basis, and could be affected by ramping and maximum release limitations.

D. Western's System Responsibilities

1. Long-Term Firm Electric Service Contracts and the Post-1989 Marketing Criteria

Amendment No. 2, which was initiated as a result of the NWF v. Western lawsuit, provided for the addition of a new Article 16 to the post-1989 contracts. "Western may modify this Contract in any respect as a result of the EIS process now being engaged in by Western and the Department of Interior in its EIS, including modifications of the amount of the Seasonal Energy and the Contract Rate of Delivery, based on (i) any final decisions made by Western in light of Western's EIS on the Criteria or (ii) the Court's order of injunction for Western Area Power Administration dated September 29, 1989, or (iii) any final administrative decision requiring changes in Colorado River Storage Project operations resulting from the Secretary of the Department of the Interior's EIS ordered on July 26, 1989, or from the current Recovery Implementation Program for Endangered Species in the Upper Colorado River Basin. The Contract is also subject to further order of the Court in the NWF lawsuit consistent with the NEPA of 1969 and prior orders of the Court."

Western cannot, unless so specified, unilaterally modify provisions of the contract. A lengthy public process beginning May 22, 1980, included thousands of hours, meetings, and written comments from Western's customers from the Salt Lake City, Loveland, and Phoenix Areas resulted in the marketing and allocation criteria applied to the Post-1989 contracts. Additionally, time requirements are necessary in order to renegotiate contract provisions. Contract provisions, such as those negotiated in the post-1989 contracts, were ongoing for nearly 8 years before agreement between the parties.

It is conceivable that, in the case of severe restrictions from interim operations, Western would have to amend the post-1989 allocation criteria and the specific contract provisions relating to scheduling, amounts, rates of delivery, etc. Note that these issues and concerns are central to Western's electric power marketing EIS.

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CREDA

COLORADO RIVER ENERGY DISTRIBUTORS ASSOCIATION

CLIFFORD BARRETT
Executive Director
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175 East 400 South
Salt Lake City, Utah 84111
Phone 801-350-9090
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May 29, 1991

Mr. Rick Gold
Assistant Regional Director
Bureau of Reclamation
125 South State Street
Salt Lake City, UT 84138

Dear Mr. Gold:

The purpose of this letter is to present the views of the Colorado River Energy Distributors Association (CREDA) concerning interim action that the Bureau of Reclamation is preparing to suggest to the Secretary of the Interior prior to the completion of the Glen Canyon Dam Environmental Impact Statement. We believe that the interim action the Secretary should take should be to establish a management plan and not merely undertake an interim operational adjustment to operating criteria for Glen Canyon Dam.

We believe this interim plan should feature:

(a) Initial interim changes to current operating criteria and practices that are:
   (1) Done in such a way that the results of such changes are <u>observable</u>;
   (2) <u>Limited in type</u> so that the results of such changes are <u>not masked</u> (i.e., too many variables to trace cause and effect); and
   (3) <u>Incremental</u> to prevent unintended consequences and to allow observation of thresholds.

(b) Non-operational activities that should include:
   (1) Minor adjustments at Lees Ferry and above that can totally avoid future trout stranding;
   (2) Armoring of steep inclines on beaches with adjacent river rock using hand labor, as was done by the National Park Service at a beach above Phantom Ranch; and
   (3) Park Service consideration of salvage and protection of archaeological resources during this interim period.

(c) Monitoring and annual review of operational and non-operational changes during this interim period. Additional changes or adjustments should be considered at such annual review.

The above plan concept starts from the premise stated by the National Academy of Science that the ecosystem below Glen Canyon Dam has not reached equilibrium. We are also mindful that the focus of this Environmental Impact Statement is on impacts resulting from operation of Glen Canyon Dam and not its existence. Thus, any interim action plan must focus on impacts associated with operations and differentiate such impacts from those related to the existence of the dam itself.

We are also mindful that current operational criteria are expressed as limits to minimum releases and maximum releases. There are not current criteria as such for upramping, downramping or daily fluctuations. Operational history shows limits in practice to these parameters which can be treated as defining the status quo.

With the above premise in mind, we have reviewed the May 22, 1991 letter from the Western Area Power Administration to you on this subject. We believe their proposal is headed in the right direction as far as operational limits are concerned. We believe their proposal concerning focusing on minimum releases and downramping suggests changes that will be observable, that are sufficiently different in characteristic so as to not mask each other as to result, and that the incremental approach they suggest is appropriate. Adjusting these two parameters, coupled with the non-operational actions we have suggested (and others that we haven't suggested but may be compatible) can be a valuable step in protecting resources while learning more about this dynamic and complex ecosystem.

We hasten to add a note of caution in making changes to current operating criteria. As you know, even the drafts of reports from the test releases will not be done until at least December and only raw, unvalidated measurements currently exist. None of this raw data has been made available for the EIS team, the cooperating agencies or interested parties. Until the scientific data has been collected and analyzed, caution should prevail. The law of unintended consequences has operated on the Lees Ferry trout fishery already. The 5,000 CFS three-day constant releases used by the scientists to create brackets between test flows substantially reduced the amount of food sources available to the trout fishery and had a substantial adverse impact on that resource. None of this was intended or even contemplated, but it happened. The sheer complexity of the ecosystem argues strongly against radical changes.

We would be remiss, also, if we didn't add a word of caution about the Western proposal. We are concerned about the wide range of possible economic impacts that the Western proposal contains. Without knowing more about the assumptions that would drive that proposal to the high end of that economic impact range, we cannot evaluate for ourselves the relative significance of that impact upon the power consumers in the basin. We believe the Bureau of Reclamation should evaluate Western's proposal with a view toward establishing an interim plan that would attempt to avoid the circumstances under which the higher levels of economic impact might be experienced.

Mr. Rick Gold
Assistant Regional Director
Bureau of Reclamation

We hope that our comments have been helpful to you. We look forward to continuing to work with you on this important subject.

Sincerely yours,

Clifford Barrett
Executive Director

jca

UPPER COLORADO RIVER COMMISSION

355 South Fourth East Street • Salt Lake City • Utah 84111 • 801-531-1150 • FAX 801-531-9705

May 29, 1991

Mr. Rick Gold
Assistant Regional Director
Upper Colorado Region
Bureau of Reclamation
125 South State Street
Salt Lake City, UT 84138

Dear Mr. Gold:

The Commission staff recently had the opportunity to review the May 22, 1991, Western proposal for interim operating conditions at Glen Canyon Dam. We find the document well done and a rather exhaustive discussion of the problems being faced by the power customers in considering interim changes in power plant operating criteria.

We believe that the criteria, as suggested by Western, would pose no operational constraint or risk to the monthly operations necessary to carry out annual operation plans or react to changes in forecasts to meet the principal mandate of water conservation. (This is as opposed to the criteria proposed by the Scientific/Research Group which could create constraint or risk on monthly operations and the ability to modify these plans due to forecast changes.) These risks were discussed in the Water and Power Committee memorandum of April 2, 1991 and briefing materials provided by the Commission to the attendees of your April 17, 1991 meeting in Phoenix, Arizona.

We also feel strongly that the criteria which must be considered in evaluating any such proposed changes be that criteria contained in Commissioner Underwood's testimony to congress.

We are concerned that too much emphasis to date may have been placed on achieving the near post EIS operating conditions rather than focusing on changes to the extent reasonably possible that could be implemented without a time consuming NEPA compliance process. The proposal suggested by Western may in fact be as much as can be achieved within the expected time frame of implementation by October 1991.

We sincerely appreciate the opportunity to be involved in these discussions and offer the resources of the Commission staff to assist Reclamation in determining these interim operating conditions.

If we can be of further help please let us know.

Sincerely yours,

Wayne E. Cook

Wayne E. Cook
Executive Director

WEC:pj

cc: Upper Colorado River Commissioners
Western Area Power Association
Colorado River Energy Distributors Assn.

DRAFT 06/21/91

FINANCIAL ASSESSMENT
U.S. BUREAU OF RECLAMATION'S PROPOSAL
Interim Releases at Glen Canyon Dam

June 13, 1991

Definition

- Interim Release Proposal 1/

Parameter	Monthly Release		
	Low	Moderate	High
Maximum (cfs)	20,000	20,000	22,000
Minimum (cfs)	5,000	5,000	5,000
Average Daily (cfs/day)	8,000	11,000	15,000
Up Ramp (cfs/hour)	4,000	4,000	4,000
Down Ramp (cfs/hour)	2,000	2,500	2,500

Findings

The proposed interim release parameters would result in :

A. A shift in generation from the on-peak to the off-peak period in most months.

B. A significant change in the timing, magnitude, and nature (expense) of projected purchases required to satisfy existing firm contractual commitments.

C. Probable reductions in reserve capability and responsibility.

D. Certain changes to surplus sales and other services (e.g., emergency assistance).

1/ Based on June 13 Reclamation concept, Year 1 (FY 1992).

For an upper range of pricing assumptions, the total projected 12-month net expense would be $21.1 million in FY 1992. This pricing assumes purchases of firm energy with an associated capacity or demand component. For a lower range of pricing assumptions, the total projected 12-month net expense would be $9.7 million. This pricing assumes purchases of firm energy only.

Tables 1 and 2 provide a detailed monthly summary of net expenses.

The financial impact associated with reductions in nonfirm sales, though significant, is difficult to quantify and is not included in this assessment. However, between 50 and 60 percent of Salt Lake City Area's (SLCA) nonfirm energy sales would be adversely affected by these constraints. These constraints would result in a required shift of releases from onpeak to offpeak when nonfirm sales are of lesser value and significant reductions in real-time operational flexibility to take advantage of pricing variation. If large amounts of water (and resulting generation) are moved offpeak, the possibility of "dumping" energy at lower values (e.g., 10-12 mills/kWh) increases.

Reductions in reserve capability and responsibility are potentially significant, but have not been quantified in this assessment. An adequate reserve margin would become a serious concern during peak-load months without the purchase of energy with full reserves from others. With restrictions as proposed, impacts to the determination of the largest single hazard for the WAUC is also uncertain. The reserve responsibility for the WAUC as a member of the Inland Power Pool would most definitely be affected (reduced). The ability of units at Glen Canyon to be used for AGC would also be limited.

Methodology

Type of Assessment

- Financial, based on hourly SLCA/IP loads vs. resource balancing.

Period of Study

- 12-month period, October 1991 through September 1992.

Monthly Inflow and Power Releases

- Glen Canyon and other SLCA/IP reservoir site operations based on Reclamation's March 14, 1991, Annual Operating Plan for WY 1992.

Hourly Generation

- Glen Canyon hourly generation (with and without interim release constraints) developed through application of EDF "peak-shaving" algorithm.

- Projected Other SLCA/IP hourly generation developed through assumption of load-patterned releases.

Hourly Load

- Projected firm load is based on latest projections for FY 1992, adjusted to reflect FY 1990 actual hourly firm load patterns.

Pricing

- Pricing of surplus sales and purchases without interim release constraints are based upon operational experience and assumptions for future market conditions (see Table 3).

- Upper and lower ranges of pricing assumed for surplus generation/sales and purchases with interim release constraints are presented in Table 4 and Table 5, respectively, and are based on projected power operations and expectations of future market conditions.

Table 1

FINANCIAL ASSESSMENT
U.S. BUREAU OF RECLAMATION'S PROPOSAL
Interim Releases at Glen Canyon Dam

June 13, 1991

Net Expense Summary

Month	Water Year	Base Case Pricing Operations Without Restriction			Lower Range of Pricing Operations With Restriction			Difference Lower Range vs. Base Case
		Purchase Expense	Surplus Sales Revenue	Net Expense	Purchase Expense	Surplus Sales Revenue	Net Expense	
October	1992	($ 2,526,088)	$ 0	($ 2,526,088)	($ 2,703,112)	$ 3,502	($ 2,699,609)	($ 173,521)
November	1992	(2,498,428)	0	(2,498,428)	(2,935,750)	17,294	(2,918,456)	(420,028)
December	1992	(1,945,948)	0	(1,945,948)	(3,731,007)	254	(3,730,753)	(1,784,805)
January	1992	(1,000,813)	0	(1,000,813)	(1,965,617)	24,821	(1,940,796)	(939,983)
February	1992	(684,477)	16,535	(667,942)	(1,460,105)	13,988	(1,446,117)	(778,175)
March	1992	(1,835,665)	0	(1,835,665)	(2,323,889)	1,697	(2,322,192)	(486,527)
April	1992	(1,959,163)	0	(1,959,163)	(2,436,769)	585	(2,436,184)	(477,021)
May	1992	(1,748,249)	0	(1,748,249)	(2,713,552)	457	(2,713,095)	(964,846)
June	1992	(1,492,337)	442	(1,491,895)	(2,540,463)	5,624	(2,534,839)	(1,042,944)
July	1992	(868,468)	199,576	(668,892)	(1,718,368)	72,233	(1,646,135)	(977,243)
August	1992	(636,108)	388,331	(247,777)	(1,521,421)	101,270	(1,402,152)	(1,172,375)
September	1992	(168,519)	734,802	566,283	(351,122)	443,942	92,820	(473,463)
Total FY 92		($17,364,263)	$1,339,686	($16,024,577)	($26,401,175)	$685,667	($25,715,508)	($9,690,931)

Table 2

FINANCIAL ASSESSMENT
U.S. BUREAU OF RECLAMATION'S PROPOSAL
Interim Releases at Glen Canyon Dam

June 13, 1991

Net Expense Summary

		Base Case Pricing Operations Without Restriction			Upper Range of Pricing Operations With Restriction			
Month	Water Year	Purchase Expense	Surplus Sales Revenue	Net Expense	Purchase Expense	Surplus Sales Revenue	Net Expense	Difference Upper Range vs. Base Case
October	1992	($ 2,526,088)	$ 0	($ 2,526,088)	($ 4,127,339)	$ 3,502	($ 4,123,837)	($1,597,749)
November	1992	(2,498,428)	0	(2,498,428)	(4,555,164)	17,294	(4,537,870)	(2,039,442)
December	1992	(1,945,948)	0	(1,945,948)	(5,285,875)	254	(5,285,620)	(3,339,672)
January	1992	(1,000,813)	0	(1,000,813)	(2,750,850)	24,821	(2,726,029)	(1,725,216)
February	1992	(684,477)	16,535	(667,942)	(2,055,527)	13,988	(2,041,540)	(1,373,598)
March	1992	(1,835,665)	0	(1,835,665)	(3,409,618)	1,697	(3,407,921)	(1,572,256)
April	1992	(1,959,163)	0	(1,959,163)	(3,609,618)	585	(3,609,033)	(1,649,300)
May	1992	(1,748,249)	0	(1,748,249)	(4,041,006)	457	(4,040,549)	(2,292,300)
June	1992	(1,492,337)	442	(1,491,895)	(3,575,543)	5,624	(3,569,919)	(2,078,024)
July	1992	(868,468)	199,576	(668,892)	(2,125,918)	72,233	(2,053,685)	(1,384,793)
August	1992	(636,108)	388,331	(247,777)	(1,892,856)	101,270	(1,791,586)	(1,543,809)
September	1992	(168,519)	734,802	566,283	(431,062)	443,942	12,880	(553,403)
Total FY 92		($17,364,263)	$1,339,686	($16,024,577)	($37,860,376)	$685,667	($37,173,709)	($21,150,132)

Table 3

FINANCIAL ASSESSMENT
U.S. BUREAU OF RECLAMATION'S PROPOSAL
Interim Releases at Glen Canyon Dam

June 13, 1991

Summary of Pricing Assumptions
Without Interim Release Restrictions
(m/kWh)

		Surplus Sales		Purchases	
		Offpeak	Onpeak	Offpeak	Onpeak
August	1991	16.00	27.00	16.00	20.00
September	1991	16.00	27.00	16.00	20.00
October	1992	14.00	22.00	14.00	18.00
November	1992	14.00	19.00	14.00	17.00
December	1992	14.00	23.00	14.00	17.00
January	1992	14.00	24.00	14.00	17.00
February	1992	14.00	21.00	14.00	17.00
March	1992	14.00	21.00	14.00	18.00
April	1992	16.00	24.00	16.00	19.00
May	1992	16.00	24.00	16.00	20.00
June	1992	16.00	24.00	16.00	20.00
July	1992	16.00	27.00	16.00	20.00
August	1992	16.00	27.00	16.00	20.00
September	1992	16.00	27.00	16.00	20.00
Average		15.14	24.07	15.14	18.79

Table 4

FINANCIAL ASSESSMENT
U.S. BUREAU OF RECLAMATION'S PROPOSAL
Interim Releases at Glen Canyon Dam

June 13, 1991

Summary of Pricing Assumptions
With Interim Release Restrictions

Lower Range
(m/kWh)

		Surplus Sales		Purchases	
		Offpeak	Onpeak	Offpeak	Onpeak
August	1991	12.00	27.00	16.00	35.00
September	1991	12.00	27.00	16.00	30.00
October	1992	12.00	22.00	14.00	28.00
November	1992	12.00	19.00	14.00	28.00
December	1992	12.00	23.00	14.00	30.00
January	1992	12.00	24.00	14.00	30.00
February	1992	12.00	21.00	14.00	30.00
March	1992	12.00	21.00	14.00	28.00
April	1992	12.00	24.00	16.00	28.00
May	1992	12.00	24.00	16.00	28.00
June	1992	12.00	24.00	16.00	30.00
July	1992	12.00	27.00	16.00	35.00
August	1992	12.00	27.00	16.00	35.00
September	1992	12.00	27.00	16.00	30.00
Average		12.00	24.07	15.14	30.36

Table 5

FINANCIAL ASSESSMENT
U.S. BUREAU OF RECLAMATION'S PROPOSAL
Interim Releases at Glen Canyon Dam

June 13, 1991

Summary of Pricing Assumptions
With Interim Release Restrictions

Upper Range
(m/kWh)

		Surplus Sales		Purchases	
		Offpeak	Onpeak	Offpeak	Onpeak
August	1991	12.00	27.00	16.00	45.00
September	1991	12.00	27.00	16.00	45.00
October	1992	12.00	22.00	14.00	45.00
November	1992	12.00	19.00	14.00	45.00
December	1992	12.00	23.00	14.00	45.00
January	1992	12.00	24.00	14.00	45.00
February	1992	12.00	21.00	14.00	45.00
March	1992	12.00	21.00	14.00	45.00
April	1992	12.00	24.00	16.00	45.00
May	1992	12.00	24.00	16.00	45.00
June	1992	12.00	24.00	16.00	45.00
July	1992	12.00	27.00	16.00	45.00
August	1992	12.00	27.00	16.00	45.00
September	1992	12.00	27.00	16.00	45.00
Average		12.00	24.07	15.14	45.00

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HUALAPAI TRIBAL COUNCIL

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The Great Spirit created Man and Woman in his own image. In doing so, both were created as equals. Both depending on each other in order to survive. Great respect was shown for each other; in doing so, happiness and contentment was achieved then, as it should be now.

The connecting of the Hair makes them one person, for happiness or contentment can not be achieved without each other.

[illegible]

Mr. Manuel Lujan
U.S. Department of the Interior
Office of the Secretary
18th and C Street, N.W.
Washington, D.C. 20240

Dear Mr. Lujan:

Enclosed you will find a copy of Resolution 37-91 of the Hualapai Tribal Council endorsing the Senior Scientist and Scientific Core Teams Interium Flow Recommendations for the Glen Canyon Dam.

Mr. Secretary we hope you implement the Majority Opinion of the Cooperating Agencies Interium Flow Recommendations at the end of Research Flows.

Sincerely,

Earl Havatone

Earl Havatone, Chairman
Hualapai Tribal Council

xc: President George Bush
Senator John McCain
Sentator Dennis DeConcini
Senator John Rhodes
Senator William Bradley
Roland Robison, Bureau of Reclamation, Salt Lake City
Dennis Underwood, Commissioner, Bureau of Reclamation
Daniel McGovern, U.S. EPA, San Francisco, CA
Alan Downer, Navajo Nation
Kurt Dongoske, Hopi Cultural Preservation Office

NOTICE: IF YOU DETACH ENCLOSURES PLEASE INSERT CODE NO. ________

Mr. Jack Davis, Superintendent
Grand Canyon National Park
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Mr. Anderson Morgan
The Navajo Nation
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Window Rock, AZ 86515

Mr. Jacobson,(W-6640 7620-MIB)
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Mr. Raymond Gunn UC-1503
Bureau of Reclamation
P.O. Box 11568
Salt Lake City, UT 84147

HUALAPAI TRIBAL COUNCIL
RESOLUTION NO. 37-91
OF THE GOVERNING BODY OF THE
HUALAPAI TRIBE OF THE HUALAPAI RESERVATION

WHEREAS the Hualapai Tribe is a federally recognized Indian Tribe, located within the boundaries of the State of Arizona; and

WHEREAS, the Hualapai Tribe is a full cooperating agency member in the Glen Canyon Dam Environmental Impact Statement (GCDEIS) and, also, involved in the Glen Canyon Dam Environmental Studies (GCDES); and

WHEREAS, the Hualapai Tribe has jurisdiction over 108 miles along the Colorado River contained in GCDES study area or approximately 20% of the total study area.

WHEREAS, GCDES Phase I Studies and current GCDES Phase II Research have proven that fluctuating flows from the Glen Canyon Dam operations had detrimental effects on downstream resources.

WHEREAS, the Hualapai Tribe resources are down stream from Glen Canyon Dam and these negative impacts must be mitigated through interim flows for the time being until the EIS is completed and the Secretary of the Interior reaches a record of decision on the Glen Canyon Dam Environmental Statement.

WHEREAS, the Hualapai Tribe has grave concerns about the condition of their Wildlife Resources, Fisheries Resources, Water Resources, Recreation Resources, Beaches, Sediment, Riparian and most importantly their Cultural Resources which are being affected by the operation of the Glen Canyon Dam managed by the Bureau of Reclamation.

WHEREAS, all Departments of the Interior (BIA, FWS, NPS, USGS, EPA) Cooperating Agencies have Trust responsibilities for the Hualapai Tribe it is imperative that the Secretary of the Interior implement interim flows within 90 days of the end of research flows to prevent degradation of the Hualapai Resources or force litigation in the courts.

THEREFORE BE IT RESOLVED THAT the Hualapai Tribe supports the majority opinion of the cooperating agencies to implement the Senior Scientists and Scientific Core Teams Interim Flow Recommendations without exception criteria for WAPA. This majority opinion of the Cooperating Agencies would include the Hualapai Tribe, the Hopi Tribe, the National Park Service, the Fish and Wildlife Service, Arizona Game and Fish and Bureau of Indian Affairs. Unfortunately the lead agency BOR, EPA, Navajo Nation and WAPA will issue a minority decision.

FURTHER BE IT RESOLVED THAT, the Hualapai Tribe expects to be funded in FY 92 and FY 93 to complete their environmental studies and long term monitoring of the affects of Glen Canyon Dam operations on their down stream resources.

C E R T I F I C A T I O N

I, the undersigned, as Chairman of the Hualapai Tribal Council, hereby certify that the Hualapai Tribal Council of the Hualapai Tribe is composed of nine members of whom _9__ constituting a quorum were present at a **Regular Meeting** held this **6th day of July, 1991**; and that the foregoing resolution was duly adopted by a vote of _6_ for, _0_ against, _3_not voting, and _0_ excused, pursuant to authority of Article V, Section(a) of the Constitution of the Hualapai Tribe approved March 13, 1991.

Earl Havatone, Chairman
Hualapai Tribal Council

ATTEST:

Christine Lee, Secretary
Hualapai Tribal Council

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THE HOPI TRIBE

CONT. # 91015625

FLDR # 470

Vernon Masayesva
CHAIRMAN

Patrick C. Dallas
VICE-CHAIRMAN

July 12, 1991

Mr. Roland Robison, Regional Director
Bureau of Reclamation
Upper Colorado Regional Office
P.O. Box 11568
Salt Lake City, Utah 84147

Dear Mr. Robison:

The result of the last Cooperating Agencies meeting, held July 1 and 2, 1991, ended in failure to reach a concensus concerning the Interim Flows that are to be adopted while the Glen Canyon Environmental Impact Statement is being completed. A compromise Interim Flow recommendation has been presented by the Senior Scientist and his advisors by altering their original Interim Flow recommendation to make it more appealing to Western Area Power Administration and the Bureau of Reclamation. This revised Interim Flow recommendation by the Scientific Research Group is acceptable to the majority of the Cooperating Agencies (e.g., the U.S. Fish and Wildlife Service, Arizona Game and Fish Department, the Bureau of Indian Affairs, the Hopi, the Hualapai, the Havasupai, the Navajo, and the National Park Service); however, only the Bureau of Reclamation and the Western Area Power Administration have failed to indicate their support.

The Interim Flows are designed to minimize the current damage to the Grand Canyon and the cultural, natural, and recreational resources therein until an alternative operation is decided on by the Secretary of the Interior. More importantly, the Grand Canyon represents the most spiritually significant place to the Hopi people, as well as the other Native American groups involved as Cooperating Agencies. Failure to reach concensus on the Interim Flows decrees the Grand Canyon to continued mutilation by the "business as usual" operations of the dam.

The Hopi Tribe's position is in agreement with that of Mr. Davis, Grand Canyon Superintendent, that there is concensus among the Cooperating Agencies, but there has been a failure by the

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Bureau of Reclamation and the Western Area Power Administration to recognize and/or accept that fact. Moreover, the Hopi Tribe requests that the Bureau of Reclamation give serious consideration to the recent suggestion by Mr. Davis in which the Interim Flows advanced by the Senior Scientist and his advisors be implemented and that the Secretary of the Interior and Western Area Power Administration work together to mitigate any financial shortfalls that may result.

Sincerely,

Vernon Masayesva, Chairman
Chief Executive Officer
The Hopi Tribe

xc:

Mr. Rick Gold, Upper Colorado Region, Bureau of Reclamation, P.O. Box 11944, Salt Lake City, Utah 84174-0944

Ms. Patricia Port, U.S. Department of the Interior, P.O. Box 36098, Room 14448, San Francisco, Califorina 94102

Mr. Jim Young, Assistant Regional Director, U.S. Fish and Wildlife Service, 500 Gold Avenue S.W., Room 3018, Albuquerque, New Mexico 87102

Mr. Ken Maxie, Deputy Area Manager, Western Area Power Administration, P.O. Box 11606, Salt Lake City, Utah 84147

Ms. Amy Hueslein, Environmental Protection Officer, Bureau of Indian Affairs, P.O. Box 10, Phoenix, Arizona 85001

Mr. Thom Slater, EIS Team Leader, Bureau of Reclamation, P.O. Box 11568, Salt Lake City, Utah 84147

Mr. Dave Wegner, Program Manager, Glen Canyon Environmental Studies, P.O. Box 1811, Flagstaff, Arizona 86002

Mr. Bob Moeller, Office of the Solicitor, 2 North Central, Suite 500, Phoenix, Arizona 85004

Superintendent, Glen Canyon National Recreation Area, P.O. Box 1507, Page, Arizona 86040

Mr. Chuck Wood, Glen Canyon National Recreation Area, P.O. Box 1507, Page, Arizona 86040

Mr. Ray Gunn, P.O. Box 11944, Salt Lake City, Utah 84147

Mr. Sam Spiller, U.S. Fish and Wildlife Service, 3616 West Thomas, Suite 6, Phoenix, Arizona 85019

Mr. Duane Shroufe, Attn: Bruce Taubert, Arizona Game and Fish, 2222 West Greenway, Phoenix, Arizona 85023

Dr. Duncan Patten, Senior Scientist, Glen Canyon Environmental Studies, Center for Environmental Studies, Arizona State University, Tempe, Arizona 85281

Mr. John Davis, Superintendent, Grand Canyon National Park, P.O. Box 129, Grand Canyon, Arizona 86023

Hualapai Tribal Chairman, Attn: Don Bay and Clay Bravo, P.O. Box 300, Peach Springs, Arizona 86434

Mr. Peterson Zah, Navajo Nation Tribal Chairman, Attn: Dr. Alan Downer, P.O. Box 2898, Window Rock, Arizona 85615

Havasupai Tribal Council, P.O. Box 10, Supai, Arizona 86435

Mr. Manuel Lujan Jr., Secretary of the Interior, Main Interior Building, Mail Stop 6217, 1849 C Street NW, Washington DC 20240

Senator John McCain, 111 SROB, Washington DC 20510 0303

Senator Dennis DeConcini, 328 SHOB, Washington DC 20510-0302

Senator Bill Bradley, Water and Power Subcommittee, SH-731 Hart Senate Office Building, Washington DC 20510-3001

Dr. Harlan Watson, Deputy Assistant Secretary for Water and Science, Department of the Interior, Washington DC 20240

Mr. Kurt Dongoske, Tribal Archaeologist, Cultural Preservation Office, The Hopi Tribe, P.O. Box 123, Kykotsmovi, Arizona 86039

BUREAU OF RECLAMATION

OPTION FOR INTERIM OPERATIONS

GLEN CANYON DAM
July 15, 1991

Introduction

This document describes an option developed by the Bureau of Reclamation (Reclamation) to the interim operating criteria recommended by: (1) the Research/Scientific Group (R/S), (2) the Ecological/Resource Managers Group (E/RM), and (3) Western Area Power Administration (WAPA). Recommendations of the technical groups were primarily focused on protection of the specific resource interests of the groups represented. The R/S and E/RM recommendations focus on protection of the downstream resources while the WAPA recommendations would continue the production of peaking power with only minor restraint to reduce potential impacts on downstream resources. Accordingly, the recommendations are markedly different. The Reclamation proposal was developed at the field level to address the overall array of resource management responsibilities of the Secretary of The Interior and to avail an, "inbetween", option for consideration by all interests. The option incorporates criteria to reduce impacts on the downstream resources, preserve a reasonable amount of peaking power and seek an implementable plan from a National Environmental Policy Act (NEPA) perspective.

Operating criteria for the option was distributed to the Cooperating Agencies for the Glen Canyon Dam Environmental Impact Statement by letters of June 24 and June 26, 1991 as a basis for discussion at the July 1-2, 1991 Cooperating Agencies meeting in Phoenix, Arizona. The following paragraphs document the data and rationale associated with the development of Reclamation's option along with evaluations of the options and comparisons with the other recommendations under consideration.

Development of Reclamation's Option

Formulation of the Reclamation option included a review of historical operations of Glen Canyon Dam over the 1965 to 1989 period. Exceedence data for maximum releases, minimum releases, daily fluctuations, and ramp rates were developed. Sediment transport analysis were also completed based on best available data.

Historical evaluations (1965 to 1989), based on Glen Canyon Dam hourly releases, were developed for maximum daily releases, minimum daily releases, daily fluctuations, and ramp rates. The data is depicted in the following referenced figures:

The data was extracted to reflect the normal range in monthly volumes experienced for the historical operations. The plots depict the percent of time that flow rates have been exceeded. As an example, maximum flows of 14,000 cfs or greater have occurred during about 50 percent of the days within the period of study for a monthly volume of 500,000 acre-feet. Maximum flow of 20,000 cfs has been exceeded about 10 percent of the time in months of 500,000 acre-feet and about 85 percent of the time for monthly volume of 1,000,000 acre-feet. Many of the other figures presented in this review use this exceedence approach to display the effects of interim operations in comparison to historic operations at Glen Canyon Dam.

Interim impacts can be reduced by placing restrictive operating criteria on the releases and the flow fluctuations. As an example, by reducing the maximum release to 20,000 cfs in low and medium volume months[1] flow rates greater than 20,000 cfs, occurring 25 percent of the time, would be eliminated. Limiting the maximum release to 22,000 cfs in a high volume month would restrict releases 50 to 80 percent of the time, depending on the actual monthly volume. Similarly, adopting a 5,000 cfs minimum flow would eliminate lesser flows about 50 percent of the time for low volume months. Daily fluctuations of 11,000 to 17,000 cfs are exceeded 50 percent of the time depending upon the monthly volume. Regarding descending ramp rates, rates of about 5,000 cfs per hour have been exceeded 50 percent of the time. Limitations on ramp rates of 5,000 cfs or less would reduce damages associated with the higher rates.

Water deliveries from Lake Powell to Lake Mead are accomplished through a monthly schedule of water release volumes designed to meet an annual goal. That monthly schedule is largely determined to avoid spills from Lake Powell as it approaches complete filling. In years when Lake Powell is not expected to fill, that monthly schedule of water release volumes is largely determined by electrical power demand.

In selecting operating criteria, consideration was given to the Law of the River and associated water deliveries. Accordingly, the preliminary annual operating plan for 1992, shown on Figure 6, was used to ensure that the criteria meets water delivery requirements.

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[1] Low volume month - less than 600,000 acre-feet
Medium volume month - 600,000 to 800,000 acre-feet
High volume month - over 800,000 acre-feet

Selection of operating criteria, based on reducing the most threatening impacts, was developed and is shown in the following table.

GLEN CANYON DAM INTERIM OPERATION OPTION

Parameters	Unit: cfs
Low Volume Months	
Maximum	20,000
Minimum	5,000[2]
Daily Range	8,000
Up ramp over 4 hours	8,000
Not to exceed per hour	4,000
Down ramp over 4 hours	4,800
Not to exceed per hour	2,000
Medium Volume Months	
Maximum	20,000
Minimum	5,000
Daily Range	11,000
Up ramp over 4 hours	8,000
Not to exceed per hour	4,000
Down ramp over 4 hours	8,000
Not to exceed per hour	2,500
High Volume Months	
Maximum	22,000
Minimum	5,000
Daily Range	15,000
Up ramp over 4 hours	8,000
Not to exceed per hour	4,000
Down ramp over 4 hours	8,000
Not to exceed per hour	2,500

Rationale for the selected criteria are described briefly by parameter.

<u>Maximum flow</u> - The maximum flow rate of 20,000 to 22,000 cfs was selected to limit sediment transport, particularly in the reach above the Little Colorado River confluence, to ensure accumulation of sediment during the interim period even if below average inflow conditions occur. Restricting maximum flow would also reduce damages to the cultural and archeological sites in the Grand Canyon area. The 22,000 cfs limit for the high volume months would provide greater flexibility in the releases for water delivery and power purposes and would result in peak flows no greater than 20,000 cfs in the critical canyon reach due to attenuation. The selected range of 20,000 to 22,000 cfs is well below the 31,500 cfs historical maximum release rate and would reduce critical impacts associated with high flow periods.

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[2] 5,000 cfs minima are for no more than 6 hours at night.

Minimum flow - The minimum flow rate of 5,000 cfs and an average daily flow of 8,000 cfs or greater would provide a flow rate sufficient to reasonably reduce impacts on the fish, wildlife and recreation activities and is consistent with the R/S recommendation. The selected minimum flow represents an increase in the minimum flow of 2,000 cfs in the summer months and 4,000 cfs in the winter months.

Daily Range- The daily range in flow from 8,000 to 15,000 cfs was adopted to eliminate higher fluctuations, up to 30,500 cfs, which have occurred about 50 percent of the time based on historical operations. The range varies for monthly volumes to permit greater flexibility of power operations during the peak use months. The historical fluctuation rate up to 30,500 cfs resulted in stage change of up to 13 feet in the Grand Canyon area. Restrictions of 8,000 to 15,000 cfs
would result in a maximum daily stage change of about 4.7 feet in low volume months up to about 7.8 feet in high volume months.

Ramp Rates - The maximum hourly ascending ramp rate not to exceed 4,000 cfs was selected to be below the threshold of 4,000 to 5,000 cfs/hour rate break point for impacts. Limiting the rate to 8,000 cfs over a 4 hour period would further reduced erosion. The maximum descending rate not to exceed 2,500 to 2,000 cfs per hour would reduce erosion of sand beaches during periods of lowering river stages. The 8,000 cfs rate over a 4 hour period would further reduce damages and when attenuation is taken into account reduces the change to about 2,000 cfs/hour for locations below Lees Ferry.

In addition to the specified parameters above, other important provisions of the option are identified in the following three paragraphs.

High Flow Years. In years with more than 8.23 million acre feet release, the rates recommended for the high volume months would be used for other months, where appropriate. If the releases were higher than those that could be released using the high volume month rates, new, but similar, rates would be established for very high volume months.

Exception Criteria. "Exception criteria" related to power operations would be established to accompany the above operation criteria. These exception criteria will be essentially to those used during the research flows.

Monitoring and Research. Monitoring would accompany the above operation criteria to evaluate the effectiveness on meeting objectives. Research necessary to support evaluation of the monitoring data should also continue. A review of interim operations would be conducted as warranted based upon this information with an eye toward changes if necessary.

Examples of rates that would satisfy the water releases and operational criteria on a typical day of low, medium, and high volume months for 1992 are shown below.

	Unit: cfs
Low Volume Months	
Maximum	13,000
Minimum	5,000[3]
Daily Range	8,000
Up ramp over 4 hours	8,000
Not to exceed per hour	4,000
Down ramp over 4 hour	4,800
Not to exceed per hour	2,000
Medium Volume Months	
Maximum	18,000
Minimum	7,000
Daily Range	11,000
Up ramp over 4 hours	8,000
Not to exceed per hour	4,000
Down ramp over 4 hours	8,000
Not to exceed per hour	2,500
High Volume Months	
Maximum	22,000
Minimum	7,000
Daily Range	15,000
Up ramp over 4 hours	8,000
Not to exceed per hour	4,000
Down ramp over 4 hours	8,000
Not to exceed per hour	2,500

The option is within the range of the recommendations made by the other technical groups, is tailored to reduce environmental impacts on an interim basis, and is believed to reasonably avoid potentially serious impacts on power contracts and deliveries associated with the Glen Canyon Dam Unit of the Colorado River Storage Project. Comparison of the Reclamation option with the other recommendations is shown in Figure 7.

Evaluation and Comparison of Reclamation's Option

Evaluations of the option have been made to the extent possible on a quanlitative basis for each parameter within the operating criteria as described in the following paragraphs.

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[3] 5,000 cfs minima are for no more than 6 hours at night.

Maximum Flow- The maximum flow in conjunction with the duration of the flows determines erosion, sediment transport, and associated impacts. Sediment transport has been used as the basic comparison of Reclamation's option with the historical 1989 condition and the other recommendations. Figure 8 illustrates the comparative flow duration relationships and Figures 9, 10, 11, and 12 show the sediment transported past the Colorado River at the Little Colorado confluence gaging station. The sediment load associated with an annual 8.23 million acre-foot delivery to the Lower Basin ranges from about 234,000 to 369,000 tons per year for the R/S recommendation and the historical 1989 operation. Reclamation's option would yield about 284,000 tons per year. The range of values are all within the median sediment contribution above Little Colorado River of about 700,000 tons per year. The maximum flow rate of about 20,000 to 22,000 cfs is the estimated thresh hold level for substantial increases in erosion and impacts on cultural and archeological sites based on best available data. Reclamation's option is nearly the same as the R/S recommendation except for the higher flow permitted during high volume months.

Minimum Flow- The minimum flow of 5,000 cfs in Reclamation's option is consistent with the R/S and E/RM recommendations and is based on the same considerations as those proposals, i.e., fish, aquatic food base, and recreation.

Daily Range- The daily range in fluctuating flow varies from 8,000 to 11,000 to 15,000 cfs depending on the volume of monthly discharge. The rationale for varying the fluctuation is to provide greater flexibility in meeting power commitments during the high energy use months which establish the high volume months. Minimizing the duration of the higher fluctuations reduces the impacts on the sand beaches and other affected resources. Historically the maximum fluctuation has been as high as 28,500 cfs for short periods of time in the summer months resulting in a river stage change of nearly 13 feet. The R/S and E/RM recommendations would result in a daily stage change of about 3.2 feet. By comparison the Reclamation option would result in a maximum stage change at the Grand Canyon gaging station varying from 4.7 to 6.1 to 7.8 feet respectively for low, medium and high volume months. Over the year this would relate to an average maximum change of about 6 feet which is much lower than the historical change and in respect to overall impacts was selected as reasonable for interim operations. Figure 13 shows a comparison of the R/S recommendation and the Reclamation option fluctuation restrictions in terms of historical probabilities. The R/S maximum daily fluctuation has been exceeded 95 percent of the time over the 1965 to 1989 period whereas the Reclamation (BR) limitations have been exceeded for 70 to 90 percent of the time depending on the monthly volume.

Ramp Rates- The ascending ramp rate not to exceed 4,000 cfs for one hour was set below the threshold level of 4,000 to 5,000 cfs while the 4 hour rate was set so as to not exceed an average rate of 2,000 cfs per hour. The descending rates were selected not to exceed of 2,000 to 2,500 cfs per hour to permit some flexibility in the power operation while at the same time eliminating the majority of the impacts through a combination of reduction of rates and duration as compared with the historical operation.

Figure 14 shows a comparison of the limitations placed by the R/S recommendation and the Reclamation option compared with historical probabilities for a 1-hour period. Reclamation's option would eliminate about 90 percent of the higher historical ramp rates. Similarly as depicted on Figure 15, Reclamation's option would eliminate over 90 percent of the higher ramp rates which have occurred historically for a 4-hour period.

Financial Costs- The financial cost of implementing interim operations for the technical groups recommendations and Reclamations option has been estimated by WAPA in a June 21, 1991, draft Financial Assessment. Financial costs are shown for two conditions. One assuming energy replacement costs only and secondly, the cost of energy and capacity replacement. A tabulation comparing the economic costs is included below.

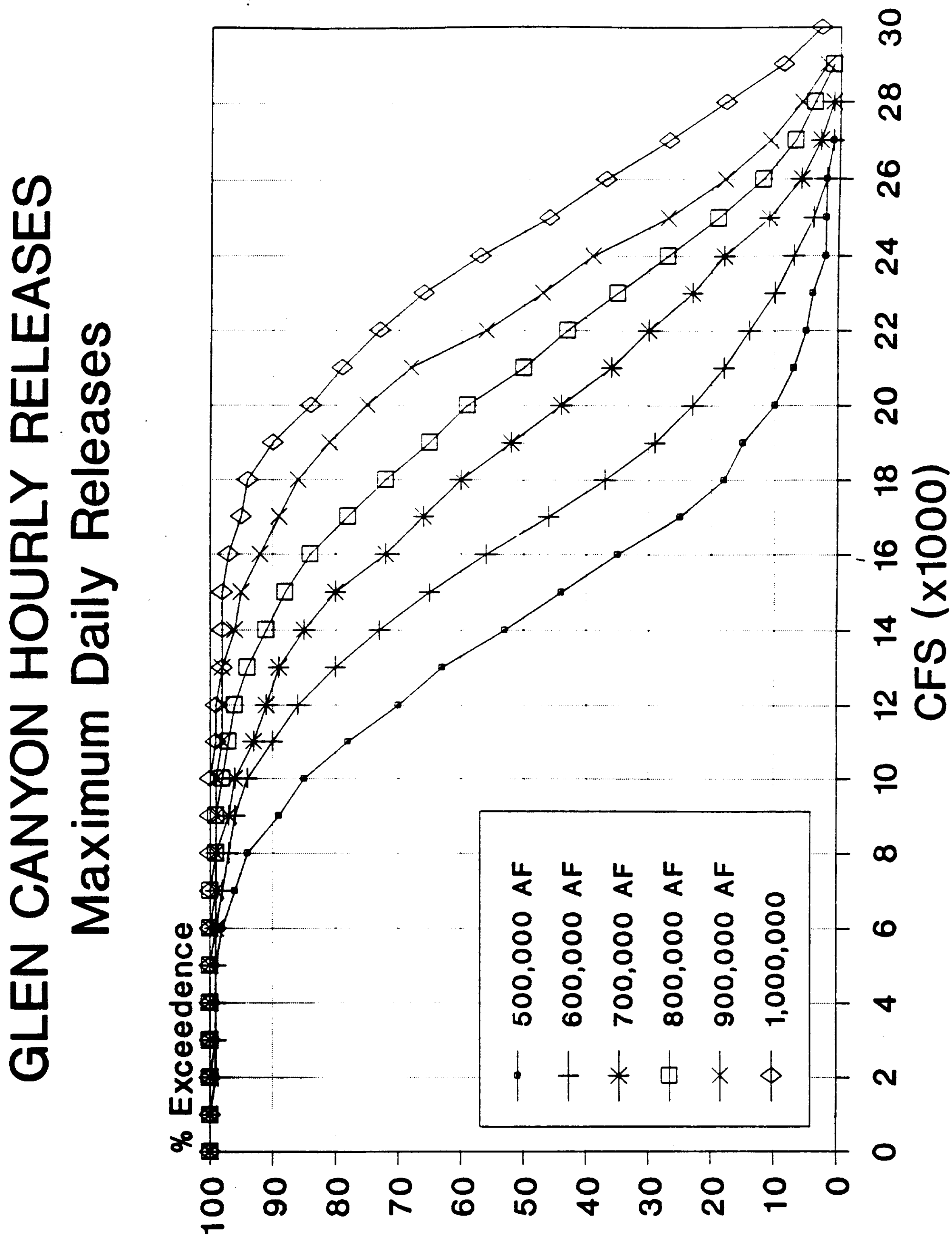
	R/S Criteria	Reclamation	WAPA
Energy Replacement	$15 million	$ 9 million	$ .2 million
Energy & Capacity Replacement	$30 million	$21 million	$ 7 million

During research flows costs have been limited to power replacement because of exception or emergency criteria which would permit disruption of research flows and operations of the Glen Canyon power plant as needed within capacity to met emergency or other conditions to avoid power brownouts or blackouts. Reclamation assumed that exception criteria similar to that used during research flow would be adopted. General agreement was reached that purchasing capacity on an interim basis should be avoided, if possible, through adoption of exception criteria. Accordingly, the financial costs could be limited to the energy replacement component.

National Environmental Policy Act (NEPA)- NEPA compliance for interim operations was an important consideration in the formulation of the Reclamation option. Consideration has been given to NEPA compliance by tempering impacts and developing operating criteria acceptable to the various parties involved. Accordingly, a balance has been sought to reduce impacts on the natural resources through the development and adoption of operating criteria which, on an interim basis, would eliminate irreparable damages to resources and yet not cause serious impacts to the power operations and the associated contracts and commitments. While this has been one of the objectives in developing the Reclamation option, environmental compliance will be completed, as appropriate prior to implementation of interim operations.

Conclusions

The Reclamation option seeks a balance of resource management responsibilities of the Secretary of The Interior associated with the operation of Glen Canyon Dam and associated resources. Further, the option provides an "inbetween" reference for evaluating and ultimately adopting interim operations of the dam. To a large extent, the option was formulated based on reducing interim impacts on the downstream resources by means of restrictive operational criteria. Considerable judgement was used in the absence of response curves. The option varies considerably from historical operations and meets the overall objectives of interim operations including reducing maximum releases, increasing minimum releases, reducing fluctuations rates and daily fluctuations. It also includes flexibility for future operations and provisions for monitoring and review.



GLEN CANYON HOURLY RELEASES
Maximum Daily Releases
% Exceedence
CFS (x1000)
500,000 AF
600,000 AF
700,000 AF
800,000 AF
900,000 AF
1,000,000
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

Figure 1

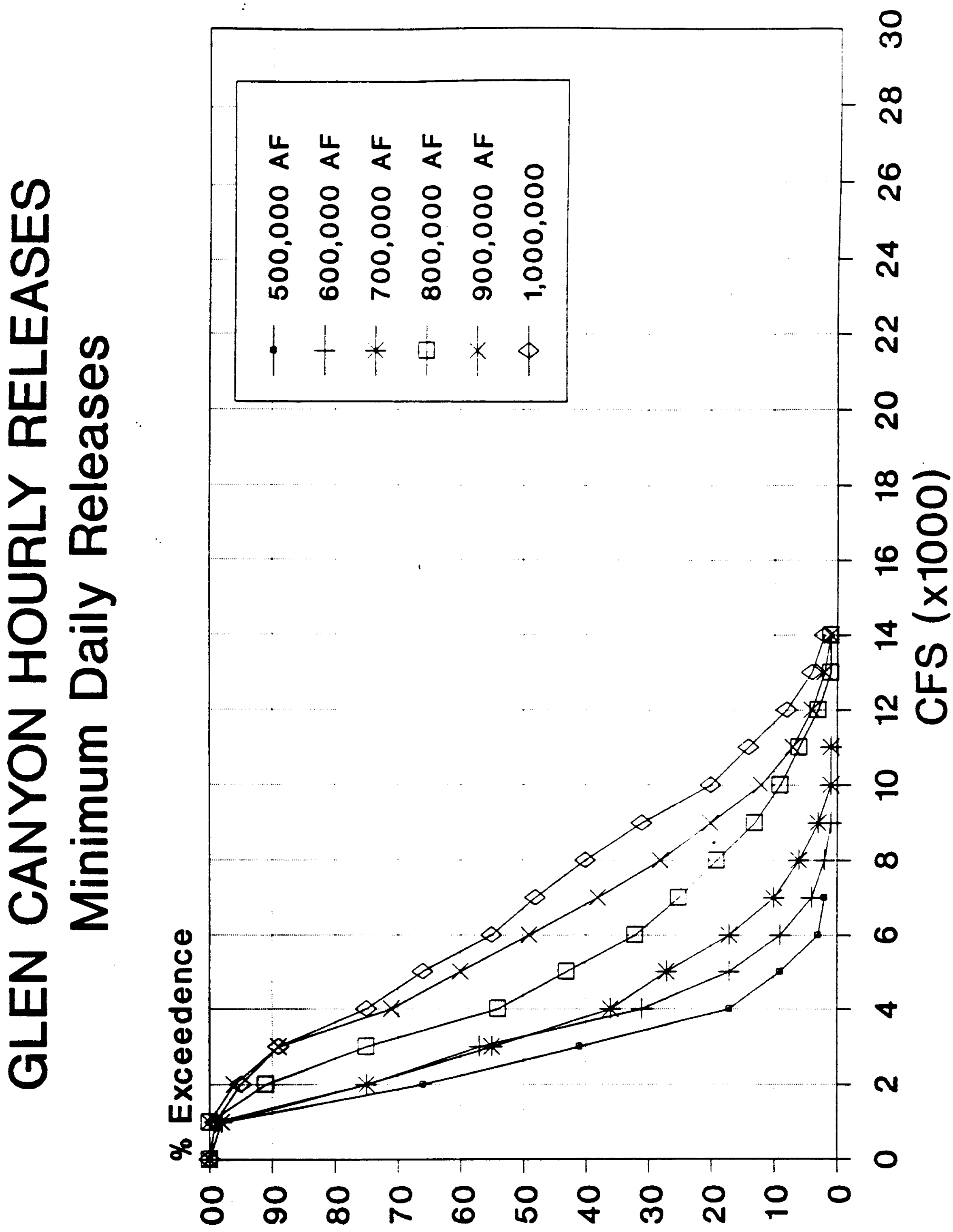
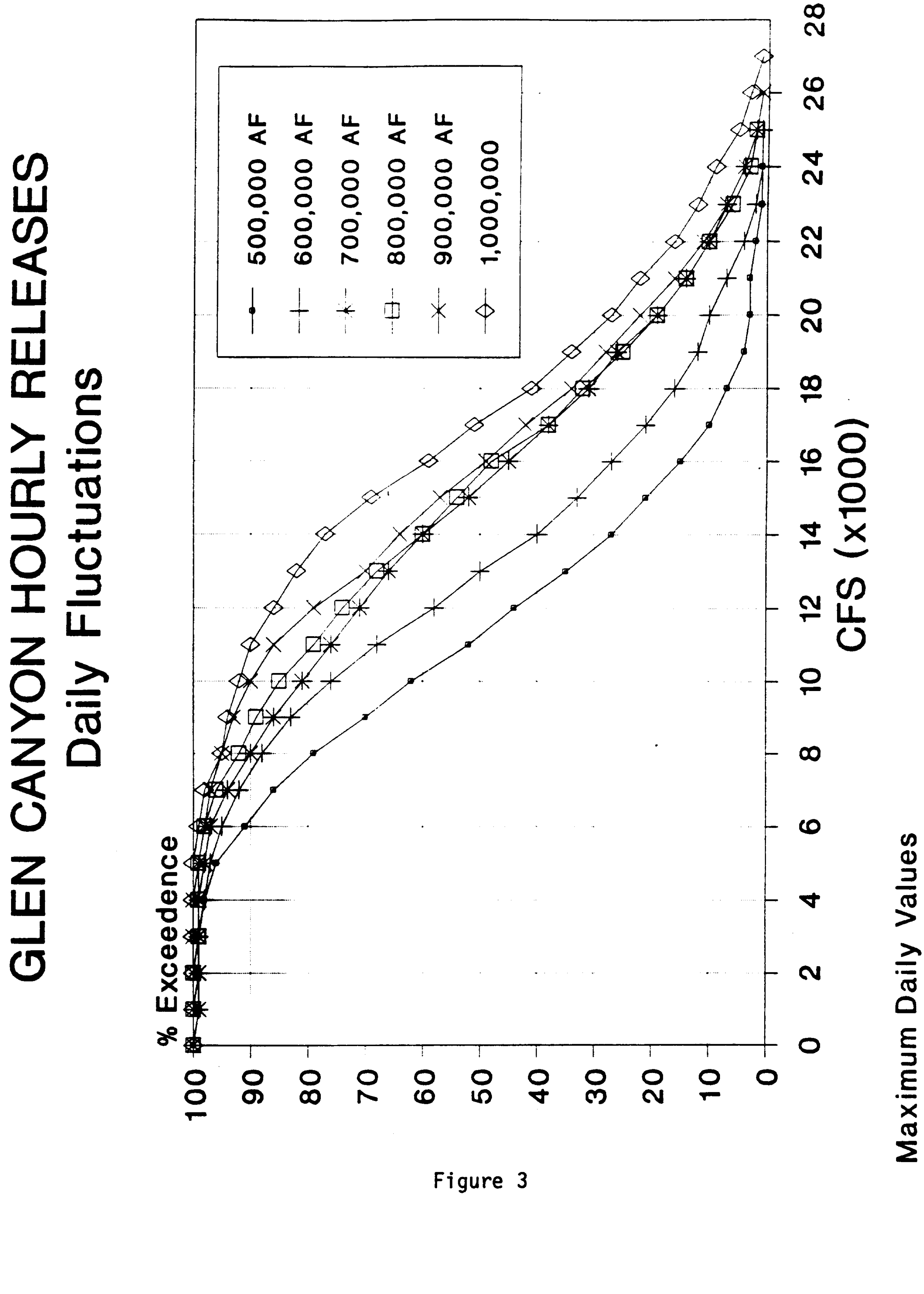

GLEN CANYON HOURLY RELEASES
Minimum Daily Releases
% Exceedence
CFS (x1000)
500,000 AF
600,000 AF
700,000 AF
800,000 AF
900,000 AF
1,000,000
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

Figure 2



GLEN CANYON HOURLY RELEASES
Daily Fluctuations
% Exceedence
500,000 AF
600,000 AF
700,000 AF
800,000 AF
900,000 AF
1,000,000
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
CFS (x1000)
Maximum Daily Values

Figure 3

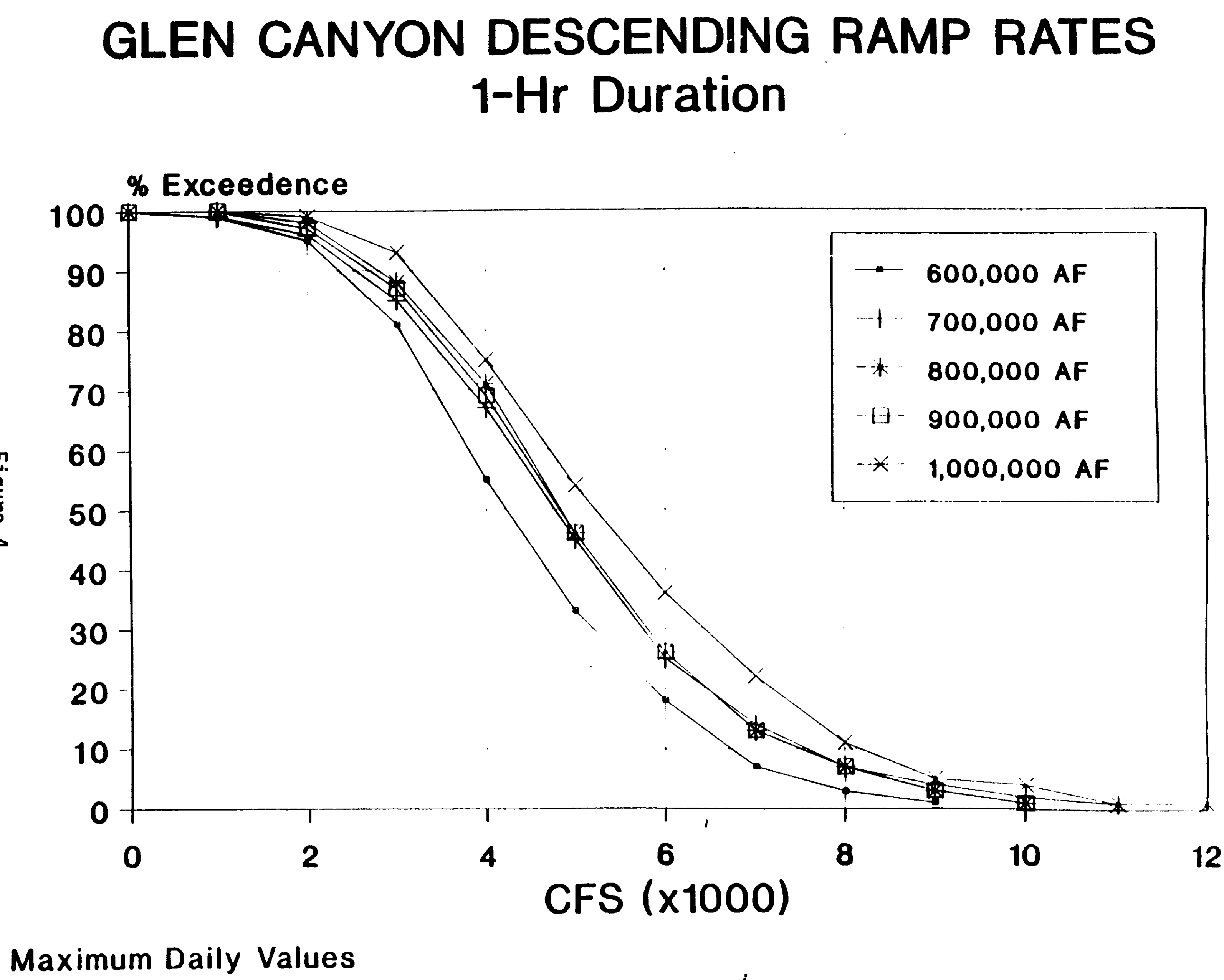
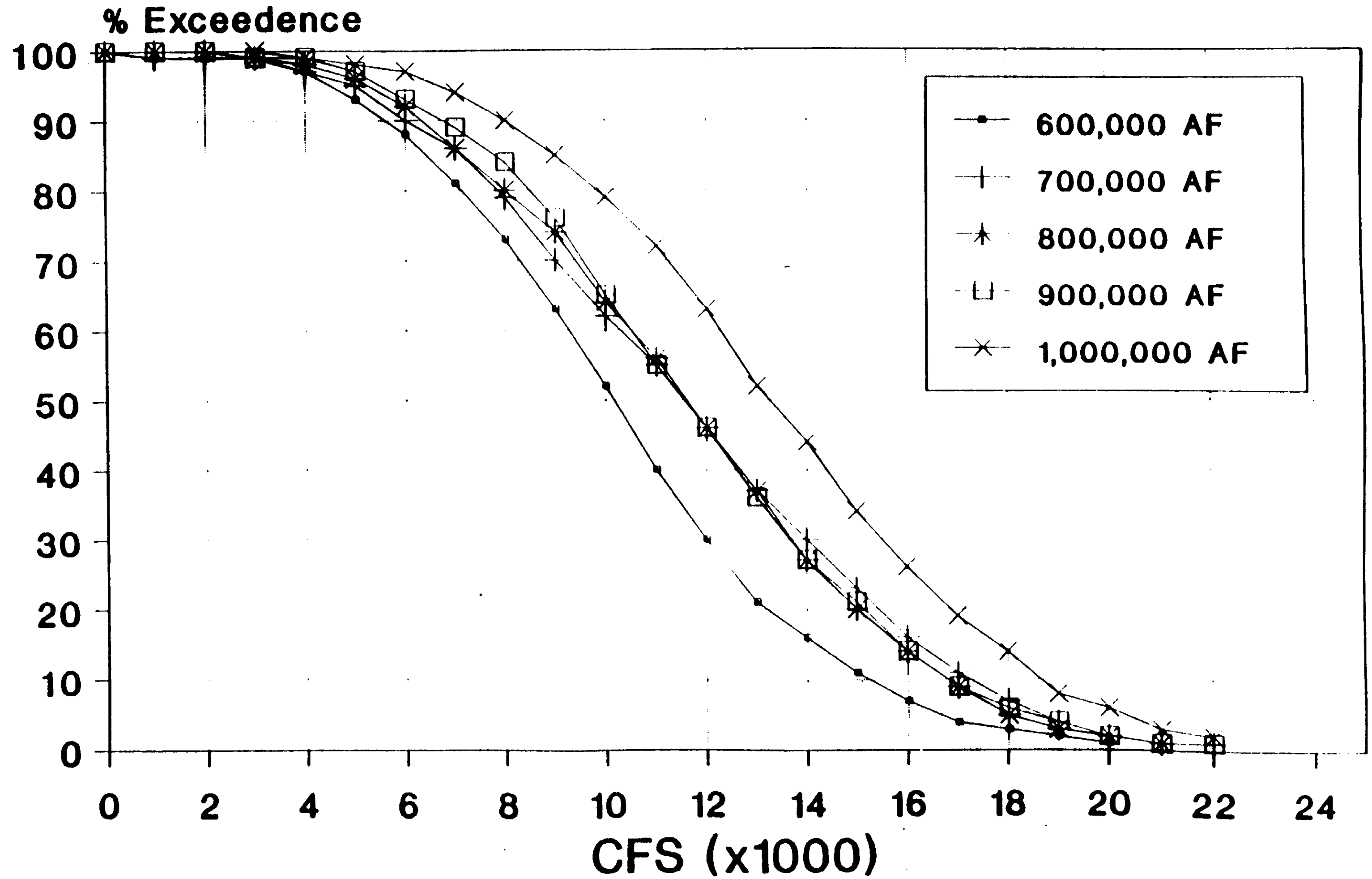

GLEN CANYON DESCENDING RAMP RATES
1-Hr Duration
% Exceedence
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
CFS (x1000)
600,000 AF
700,000 AF
800,000 AF
900,000 AF
1,000,000 AF
Maximum Daily Values

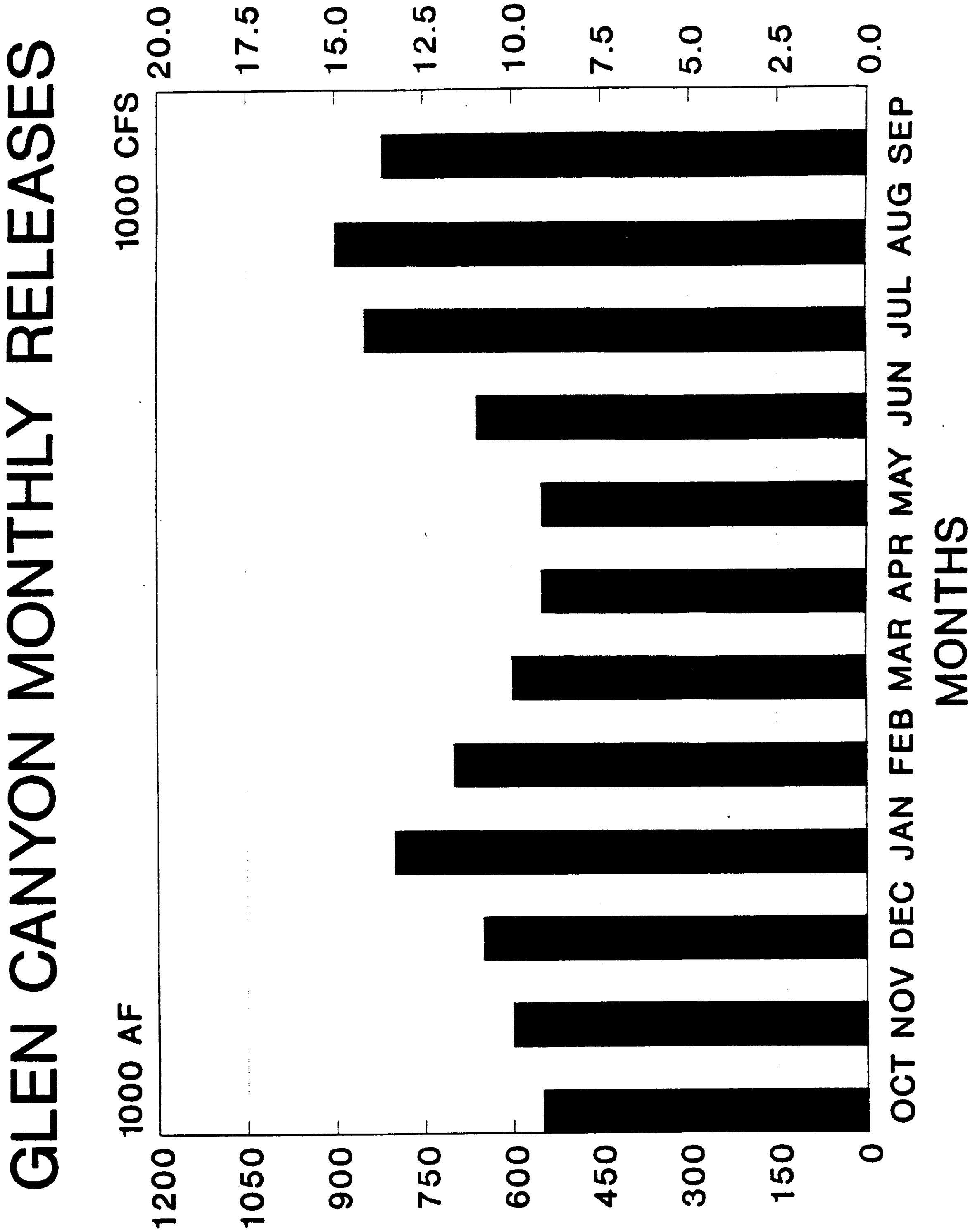
Figure 4

GLEN CANYON DESCENDING RAMP RATES
4-Hr Duration



Maximum Daily Values

Figure 5



GLEN CANYON MONTHLY RELEASES
1000 AF
1000 CFS
1200
1050
900
750
600
450
300
150
0
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
MONTHS

Figure 6

GLEN CANYON DAM INTERIM FLOWS

SUMMARY OF OPERATING CRITERIA RECOMMENDATIONS

June 25, 1991

Parameter	Historical	R/S Group	E/RM Group	USBR Option	WAPA
Max. Release (cfs)	31,500	20,000	20,000	20,000(1)(2) 22,000(3)	31,500
Min. Release (cfs)	3,000/1000	5,000	8,000(5)	5,000(4)	3,000/ 5,000
Ramp Rates cfs/hr.				<u>4 hour/1 hour</u>	
Up	No Limit	2,000	2,000	8,000/4,000(4)	No Limit
Down	No Limit	1,000	1,000	4,800/2,000(1) 8,000/2,500(2) (3)	4,000/ 5,000
Daily Change (cfs)	30,500	5,000	5,000	8,000(1) 11,000(2) 15,000(3)	No Limit

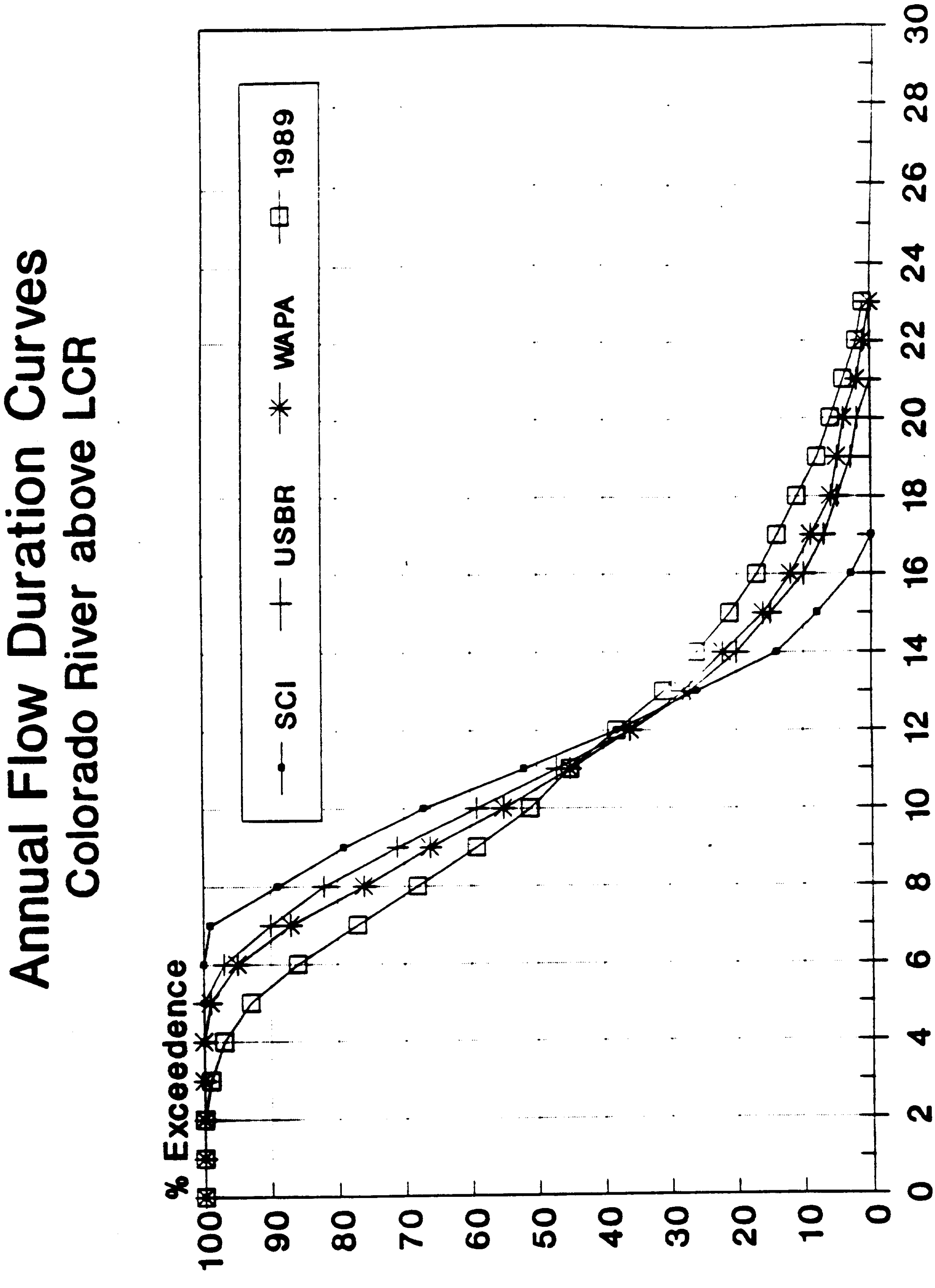
R/S Group = Research /Scientific Group - Recommendations For Interim Operating Procedures For Glen Canyon Dam - April 10, 1991

E/RM Group = Ecological/Resource Managers - Letter Report - Review of Interim Flow Recommendations - March 29, 1991

USBR = Bureau of Reclamation - Presented at Cooperating Agencies meeting on June 13-14, 1991, including a phased approach which was dropped from consideration

WAPA = Western Area Power Administration - Letter and Concept of Interim Operating Criteria - May 22, 1991 - Comments on the WAPA concept was submitted by the Colorado River Energy Distribution Association and the Upper Colorado River Commission on May 29, 1991.

Notes:
(1) Low monthly volume - less than 600,000 acre-feet
(2) Medium monthly volume - 600,000 to 800,000 acre-feet
(3) High monthly volume - over 800,000 acre-feet
(4) All months
(5) Minimum discharge should be no lower than 5,000 cfs with the average daily discharge no lower than 8,000 cfs



Annual Flow Duration Curves
Colorado River above LCR
% Exceedence
100
90
80
70
60
50
40
30
20
10
0
SCI
USBR
WAPA
1989
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
1000 CFS

Figure 8

Flow and Sediment regime above Little Colorado River
1989 Historic Flows

Q cfs	Q cms	sediment load (tons/day)	# hours at flow	# days at flow	sediment load tons
500.00	14.16	0.01	0.00	0.00	0.00
1500.00	42.49	0.42	0.00	0.00	0.00
2500.00	70.82	2.56	49.00	2.04	5.22
3500.00	99.15	8.38	193.00	8.04	67.41
4500.00	127.48	20.35	356.00	14.83	301.91
5500.00	155.81	41.33	601.00	25.04	1035.01
6500.00	184.14	74.54	783.00	32.63	2431.86
7500.00	212.46	123.53	804.00	33.50	4138.23
8500.00	240.79	192.16	751.00	31.29	6012.85
9500.00	269.12	284.56	711.00	29.63	8429.97
10500.00	297.45	405.14	549.00	22.88	9267.50
11500.00	325.78	558.56	608.00	25.33	14150.08
12500.00	354.11	749.71	597.00	24.88	18649.13
13500.00	382.44	983.74	453.00	18.88	18568.13
14500.00	410.76	1266.00	432.00	18.00	22787.92
15500.00	439.09	1602.04	330.00	13.75	22028.08
16500.00	467.42	1997.66	293.00	12.21	24388.09
17500.00	495.75	2458.82	243.00	10.13	24895.59
18500.00	524.08	2991.71	235.00	9.79	29293.81
19500.00	552.41	3602.68	208.00	8.67	31223.20
20500.00	580.74	4298.28	171.00	7.13	30625.21
21500.00	609.07	5085.23	161.00	6.71	34113.44
22500.00	637.39	5970.45	107.00	4.46	26618.28
23500.00	665.72	6961.02	71.00	2.96	20593.01
24500.00	694.05	8064.16	32.00	1.33	10752.22
25500.00	722.38	9287.31	17.00	0.71	6578.51
26500.00	750.71	10638.03	4.00	0.17	1773.00
27500.00	779.04	12124.04	1.00	0.04	505.17
28500.00	807.37	13753.25	0.00	0.00	0.00
29500.00	835.69	15533.70	0.00	0.00	0.00
30500.00	864.02	17473.57	0.00	0.00	0.00
31500.00	892.35	19581.20	0.00	0.00	0.00
totals			8760.00	365.00	369232.82

Figure 9

Flow and Sediment regime above Little Colorado River
Scientific Proposal

Q cfs	Q cms	sediment load (tons/day)	# hours at flow	# days at flow	sediment load tons
500.00	14.16	0.01	0.00	0.00	0.00
1500.00	42.49	0.42	0.00	0.00	0.00
2500.00	70.82	2.56	0.00	0.00	0.00
3500.00	99.15	8.38	0.00	0.00	0.00
4500.00	127.48	20.35	0.00	0.00	0.00
5500.00	155.81	41.33	0.00	0.00	0.00
6500.00	184.14	74.54	14.00	0.58	43.48
7500.00	212.46	123.53	907.00	37.79	4668.37
8500.00	240.79	192.16	911.00	37.96	7293.89
9500.00	269.12	284.56	1020.00	42.50	12093.62
10500.00	297.45	405.14	1267.00	52.79	21387.83
11500.00	325.78	558.56	1300.00	54.17	30255.10
12500.00	354.11	749.71	1043.00	43.46	32581.31
13500.00	382.44	983.74	989.00	41.21	40538.38
14500.00	410.76	1266.00	544.00	22.67	28695.90
15500.00	439.09	1602.04	459.00	19.13	30639.06
16500.00	467.42	1997.66	306.00	12.75	25470.16
17500.00	495.75	2458.82	0.00	0.00	0.00
18500.00	524.08	2991.71	0.00	0.00	0.00
19500.00	552.41	3602.68	0.00	0.00	0.00
20500.00	580.74	4298.28	0.00	0.00	0.00
21500.00	609.07	5085.23	0.00	0.00	0.00
22500.00	637.39	5970.45	0.00	0.00	0.00
23500.00	665.72	6961.02	0.00	0.00	0.00
24500.00	694.05	8064.16	0.00	0.00	0.00
25500.00	722.38	9287.31	0.00	0.00	0.00
26500.00	750.71	10638.03	0.00	0.00	0.00
27500.00	779.04	12124.04	0.00	0.00	0.00
28500.00	807.37	13753.25	0.00	0.00	0.00
29500.00	835.69	15533.70	0.00	0.00	0.00
30500.00	864.02	17473.57	0.00	0.00	0.00
31500.00	892.35	19581.20	0.00	0.00	0.00
totals			8760.00	365.00	233667.08

Figure 10

Flow and Sediment regime above Little Colorado River Reclamation Proposal

Q cfs	Q cms	sediment load (tons/day)	# hours at flow	# days at flow	sediment load tons
500.00	14.16	0.01	0.00	0.00	0.00
1500.00	42.49	0.42	0.00	0.00	0.00
2500.00	70.82	2.56	0.00	0.00	0.00
3500.00	99.15	8.38	0.00	0.00	0.00
4500.00	127.48	20.35	0.00	0.00	0.00
5500.00	155.81	41.33	249.00	10.38	428.82
6500.00	184.14	74.54	575.00	23.96	1785.85
7500.00	212.46	123.53	741.00	30.88	3813.96
8500.00	240.79	192.16	911.00	37.96	7293.89
9500.00	269.12	284.56	1064.00	44.33	12615.31
10500.00	297.45	405.14	1031.00	42.96	17403.99
11500.00	325.78	558.56	999.00	41.63	23249.88
12500.00	354.11	749.71	800.00	33.33	24990.46
13500.00	382.44	983.74	579.00	24.13	23732.78
14500.00	410.76	1266.00	477.00	19.88	25161.66
15500.00	439.09	1602.04	403.00	16.79	26900.96
16500.00	467.42	1997.66	286.00	11.92	23805.44
17500.00	495.75	2458.82	152.00	6.33	15572.55
18500.00	524.08	2991.71	148.00	6.17	18448.87
19500.00	552.41	3602.68	158.00	6.58	23717.62
20500.00	580.74	4298.28	152.00	6.33	27222.41
21500.00	609.07	5085.23	35.00	1.46	7415.96
22500.00	637.39	5970.45	0.00	0.00	0.00
23500.00	665.72	6961.02	0.00	0.00	0.00
24500.00	694.05	8064.16	0.00	0.00	0.00
25500.00	722.38	9287.31	0.00	0.00	0.00
26500.00	750.71	10638.03	0.00	0.00	0.00
27500.00	779.04	12124.04	0.00	0.00	0.00
28500.00	807.37	13753.25	0.00	0.00	0.00
29500.00	835.69	15533.70	0.00	0.00	0.00
30500.00	864.02	17473.57	0.00	0.00	0.00
31500.00	892.35	19581.20	0.00	0.00	0.00
totals			8760.00	365.00	283560.40

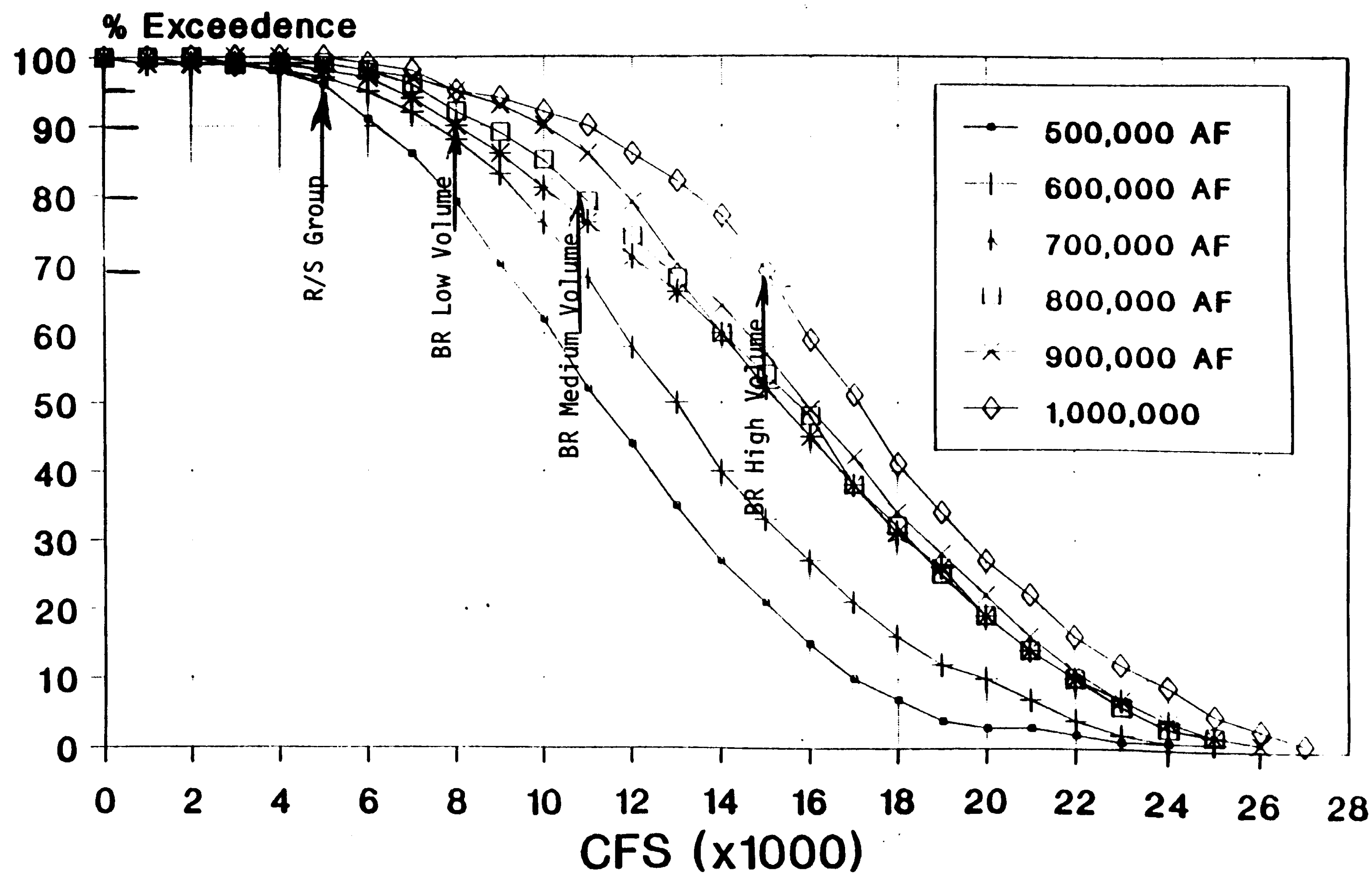
Figure 11

Flow and Sediment regime above Little Colorado River
Western Area Power Proposal

Q cfs	Q cms	sediment load (tons/day)	# hours at flow	# days at flow	sediment load tons
500.00	14.16	0.01	0.00	0.00	0.00
1500.00	42.49	0.42	0.00	0.00	0.00
2500.00	70.82	2.56	0.00	0.00	0.00
3500.00	99.15	8.38	0.00	0.00	0.00
4500.00	127.48	20.35	13.00	0.54	11.02
5500.00	155.81	41.33	346.00	14.42	595.87
6500.00	184.14	74.54	762.00	31.75	2366.63
7500.00	212.46	123.53	895.00	37.29	4606.61
8500.00	240.79	192.16	891.00	37.13	7133.76
9500.00	269.12	284.56	971.00	40.46	11512.65
10500.00	297.45	405.14	867.00	36.13	14635.55
11500.00	325.78	558.56	817.00	34.04	19014.17
12500.00	354.11	749.71	669.00	27.88	20898.27
13500.00	382.44	983.74	553.00	23.04	22667.06
14500.00	410.76	1266.00	495.00	20.63	26111.16
15500.00	439.09	1602.04	376.00	15.67	25098.66
16500.00	467.42	1997.66	284.00	11.83	23638.97
17500.00	495.75	2458.82	220.00	9.17	22539.22
18500.00	524.08	2991.71	144.00	6.00	17950.25
19500.00	552.41	3602.68	103.00	4.29	15461.49
20500.00	580.74	4298.28	118.00	4.92	21133.19
21500.00	609.07	5085.23	102.00	4.25	21612.24
22500.00	637.39	5970.45	65.00	2.71	16169.98
23500.00	665.72	6961.02	43.00	1.79	12471.82
24500.00	694.05	8064.16	24.00	1.00	8064.16
25500.00	722.38	9287.31	2.00	0.08	773.94
26500.00	750.71	10638.03	0.00	0.00	0.00
27500.00	779.04	12124.04	0.00	0.00	0.00
28500.00	807.37	13753.25	0.00	0.00	0.00
29500.00	835.69	15533.70	0.00	0.00	0.00
30500.00	864.02	17473.57	0.00	0.00	0.00
31500.00	892.35	19581.20	0.00	0.00	0.00
totals			8760.00	365.00	314466.67

Figure 12

GLEN CANYON HOURLY RELEASES
Daily Fluctuations



Maximum Daily Values

Figure 13

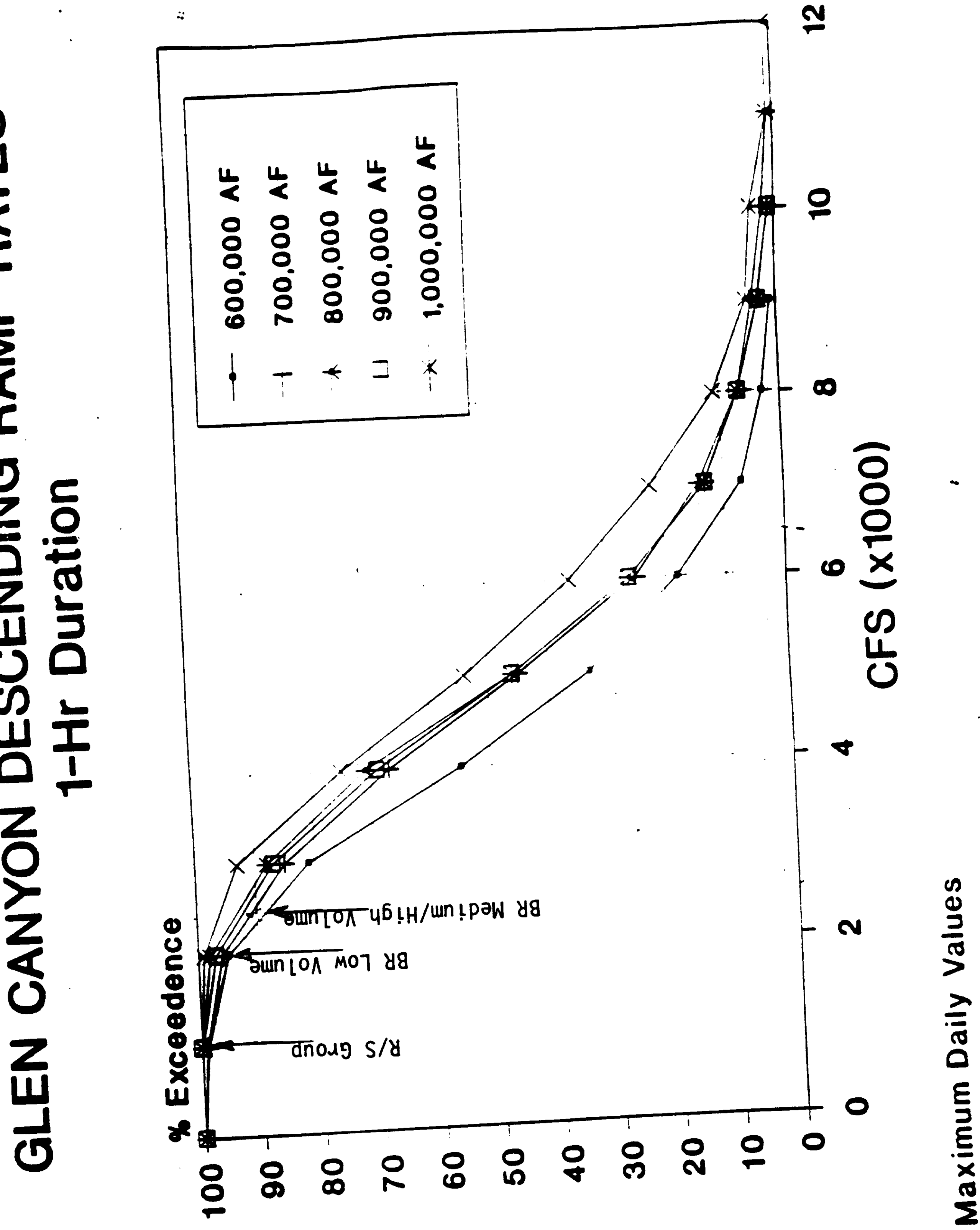
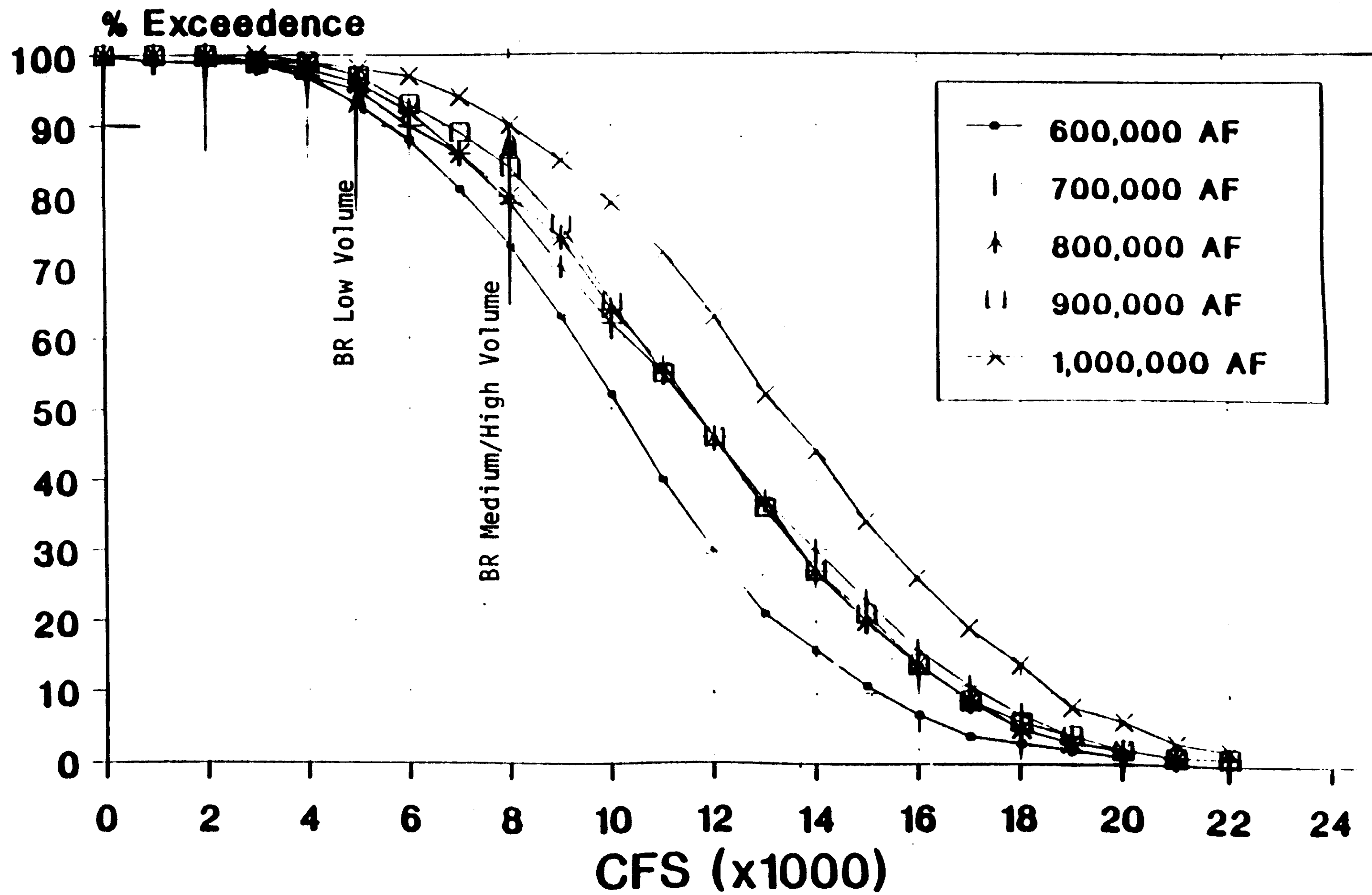

GLEN CANYON DESCENDING RAMP RATES
1-Hr Duration
% Exceedence
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
CFS (x1000)
Maximum Daily Values
600,000 AF
700,000 AF
800,000 AF
900,000 AF
1,000,000 AF
R/S Group
BR Low Volume
BR Medium/High Volume

Figure 14

GLEN CANYON DESCENDING RAMP RATES
4-Hr Duration



Maximum Daily Values

Figure 15

United States Department of the Interior

GEOLOGICAL SURVEY

Water Resources Division
375 South Euclid
Tucson, Arizona 85719

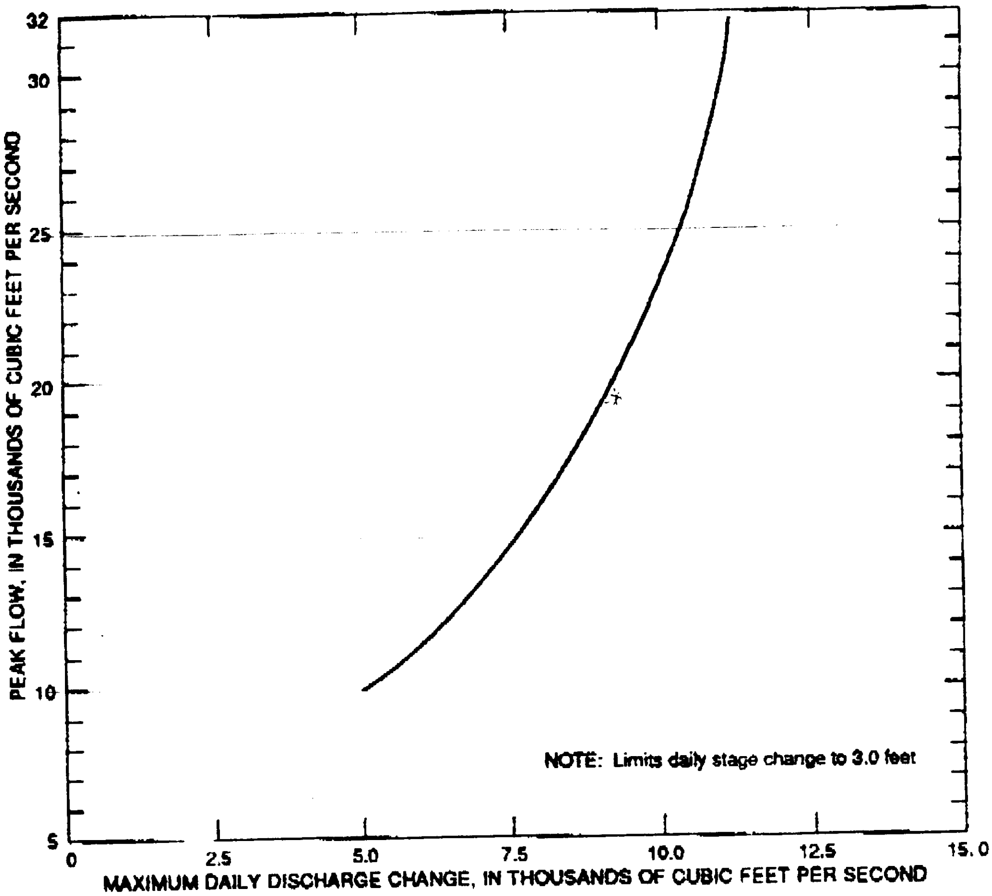
July 15, 1991

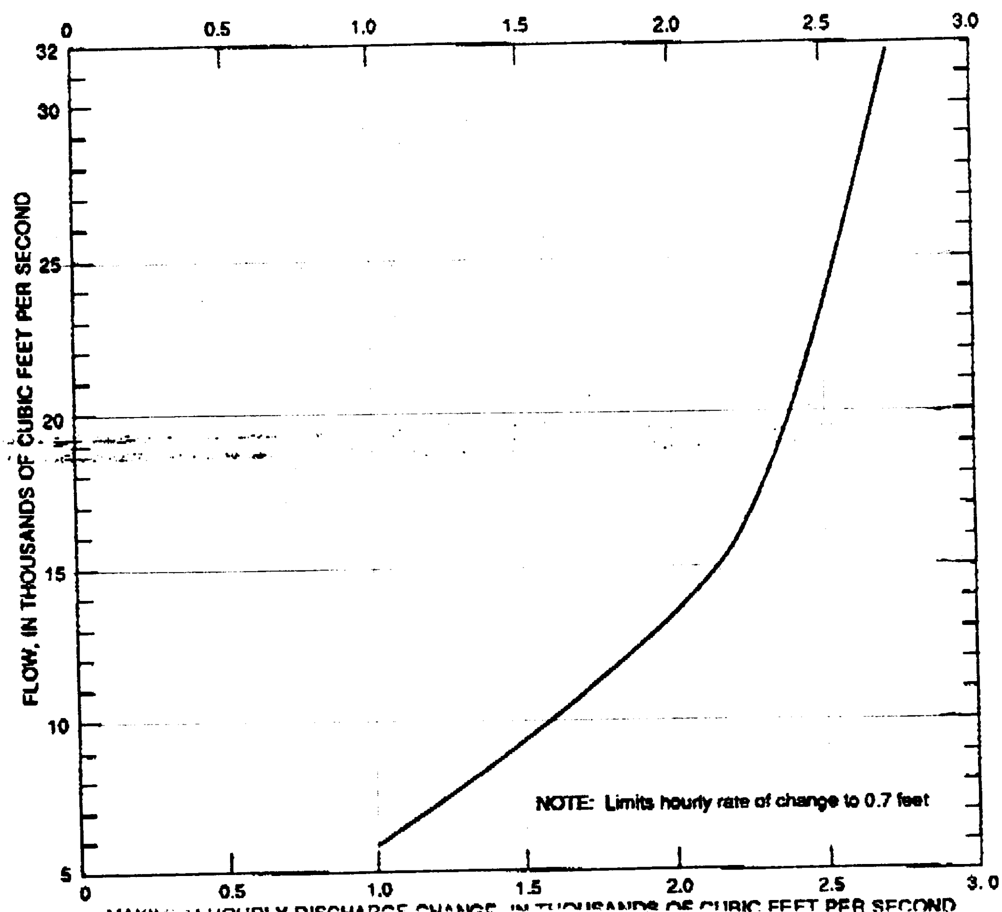
To: GCES Cooperators

I wanted to clarify my remarks on the morning of July 2 at the GCES cooperators meeting in Phoenix regarding the USGS preference on the interim flow options. The USGS supports the R/S group recommendations, but we feel there may be some modifications that would be acceptable. Duncan was not present at this session, and thus could not speak for the biologic and resource management folks and the modifications we would find acceptable from the sediment aspects may not be acceptable to those other interests.

Basically the sediment issues are main channel transport which moves sediment down river, and beach degradation which moves sediment into the river. Considering the management parameters, the main impact on main channel transport and shear stress that can erode beaches is the maximum flow, and in the present absence of definitive quantitative measures of the effects of high flows the consensus of opinion at about 20,000 cfs can neither be supported nor disputed. The sediment transport studies presently underway will provide a better definition of the discharge-transport relationships in the main channel in time for use in the EIS. It is important to note that beach building occurs at high flows, and occasional flows above the normal operating range will be necessary to periodically rebuild beaches in the future.

In the case of flow related beach degradation, another physical control is the difference in elevation of ground water in the beach and the elevation of the river surface. The greater the difference (when ground-water levels are higher than the river surface), the greater the stresses contributing to beach degradation. This physical control is affected by two management parameters, the down ramp rates and the daily change of flow. (Though there is no definitive evidence, there is no strong support that up ramp rates have a significant effect on beach degradation.) In considering the down ramp rates and the change in flow it is significant that cfs was used as a surrogate measure of stage. Since the driving forces are directly related to stage, it is worth exploring the relationship of stage to discharge over the range of discharges. For instance, changing from 6,000 cfs to 5,000 cfs results in a stage change of .65′ at the Colorado River above LCR, and .74′ at Phantom Ranch. At Lees Ferry, the comparable stage change is only .37′, although Lees Ferry is somewhat an atypical river reach. By taking the R/S recommendation of a 1000 cfs/hr down ramp rate at the low end of the operating range one might assume that the worst case rate of change of stage should not exceed .70′/hr down ramp. Looking at the stage/discharge relationship at CR above LCR we find that near the 20,000 cfs flow, we could reduce discharge by over 2,000 cfs/hr and be within that rate of stage change (.70′/hr). Similar results are obtained at Phantom Ranch.


PEAK FLOW, IN THOUSANDS OF CUBIC FEET PER SECOND
32
30
25
20
15
10
5
0
2.5
5.0
7.5
10.0
12.5
15.0
MAXIMUM DAILY DISCHARGE CHANGE, IN THOUSANDS OF CUBIC FEET PER SECOND
NOTE: Limits daily stage change to 3.0 feet


FLOW, IN THOUSANDS OF CUBIC FEET PER SECOND
32
30
25
20
15
10
5
0
0.5
1.0
1.5
2.0
2.5
3.0
NOTE: Limits hourly rate of change to 0.7 feet

Similarly, we can evaluate maximum daily change in discharge. The maximum stage differential over the diurnal range occurs between 5,000 cfs and 10,000 cfs (using the R/S group maximum daily change and minimum flow). At CR above LCR the stage change is 2.63′ while at Phantom it is 3.17. If we assume an acceptable daily maximum stage differential is about 3.0′ then at the maximum interim flow the range in discharge could be from 20,000 cfs to 12,840 cfs at Phantom and from 20,000 cfs to 10,560 cfs at CR above LCR.

On the basis of these two stations then, we could infer that there would be no significant variation in the rate of change in stage and thus no difference in erosive stress on the beaches resulting from stage differentials if both down ramp rates and maximum daily change in discharge were allowed to vary with flow.

To illustrate this concept I have prepared graphs for CR above LCR relating the flow with both hourly discharge change rates associated with down ramping and daily maximum discharge change. Allowing load following on the up ramp to a peak discharge for a day, one can use the upper graph to determine the maximum change in discharge for that day's peak flow and the lower graph to determine limitations on hourly down ramp rates over that range of discharge to insure that the maximum stresses of 0.7′/hr and 3.0′/day are not exceeded.

The use of data from other main stem stations might be used to obtain averages that might better represent entire the Grand Canyon, although the most sensitive area from a sediment balance standpoint is the Lees Ferry to LCR reach. Due to attenuation of amplitude of hydrographs downstream, what is "acceptable" in that upper reach will be even more so in the lower reaches. At any rate, the R/S group as well as the groups concerned with biological aspects, resource management, and recreation might want to reevaluate their position on the parameters chosen, taking into account that discharge is not linearly related to stage.

Robert D. Mac Nish
District Chief

Attachment

Estimates of Power System Impacts of Proposed Interim Flow Release Patterns at Glen Canyon Dam

for the

U.S. Bureau of Reclamation

Department of the Interior

Environmental Defense Fund
Oakland, California
(415) 658 8008

July 17, 1991

Executive Summary

The Secretary of Interior is considering implementation of flow release constraints at Glen Canyon Dam on an interim basis, pending completion of the Environmental Impact Statement assessing the effect of current operations and alternatives on the Grand Canyon. This study uses a computer-based simulation model to examine the net economic impacts of changes in power system operations resulting from a set of alternative release requirement scenarios over a period beginning in October 1991 and ending in September 1995. In addition, emissions impacts of the changes are also examined.

Flow release constraints at Glen Canyon Dam do not change the overall amount of electric energy that can be generated; instead, this energy is generated at different times. There is an economic cost because there is a loss in the operating flexibility of the hydroelectric generating plant.

Four alternative flow release requirement scenarios were examined. They are presented in order of least to greatest in both magnitude of change and cost of change to users of electricity. In order, the four scenarios are those proposed by the Western Area Power Administration (Western), the Bureau of Reclamation (USBR), the Glen Canyon Environmental Studies Research/Scientific Team (GCES), and the Ecological/Resource Managers (E/RM).

The proposed scenarios, as well as the results, are explained in detail in the main body of the report. Basically, Western's proposal advocates little change in operations, including no change to maximum flow, at an estimated cost of $1.1 million in 1992 compared to current operations. USBR proposes greater restrictions in operations, including limiting maximum flow to no more than 22,000 cubic feet per second (cfs), at a cost estimated to be $8.5 million in 1992. The GCES team proposes yet greater restrictions, especially in limiting fluctuations in flow on both an hourly and a daily basis. The estimated cost for their scenario is $9.3 million in 1992. Finally, the cost of the E/RM proposal, which differs from the GCES proposal only in an increased minimum flow, is $9.4 million in 1992. Estimated costs for all scenarios increase in the years beyond 1992.

These costs are a very small percentage -- significantly less than 1% -- of overall power system costs, even when allocated entirely to the utilities which currently receive Glen Canyon power.

All costs estimated in this study are those incurred by supplementing loss of operating flexibility at Glen Canyon Dam with less efficient operation of fossil fuel-fired power plants. Thus, the estimated costs are net economic impacts across all utilities rather than from the perspective of any limited group of utilities. The text of the report includes a discussion of differences between the methodology used in this "economic" study and that which has been used in Western's "financial" analyses.

The power from Glen Canyon Dam is sold to preferential customers at below market rates. Assuming that all costs are incurred by these preferential customers, any rate increase would still leave the rate at well below market level. Therefore, the power would still be sold, there would be no impact on the U.S. Treasury, and the preferential customers would still be getting a bargain.

Improvements in energy efficiency (often called "demand-side management"), the preferred least-cost new resource option for many electric utilities today, were not considered in this study due to the short length of the study period. They should be given full consideration in the power studies portion of the EIS.

Emissions impacts are even smaller, and in several cases positive. The change in operations slightly increases sulfur dioxide emissions, while nitrogen oxide and carbon dioxide emissions generally decrease.

Estimates of Power System Impacts of Proposed Interim Flow Release Patterns at Glen Canyon Dam[1]

I. Introduction

The United States Department of the Interior is currently preparing an Environmental Impact Statement to assess flow release patterns and proposed changes in release requirements at Glen Canyon dam. Since current operations -- which are largely geared toward optimizing power production -- are causing environmental damage within the Grand Canyon, agencies of the United States government have proposed imposing various release requirements on an interim basis, pending completion of the Environmental Impact Statement. Such interim requirements would restrict the extent to which releases would be optimized only for power production purposes, and thus could be expected to increase the economic costs of meeting power demands in the Southwest region. This study uses a computer-based utility system simulation model to forecast the magnitude of potential cost increases under several different flow release requirement scenarios.

In addition, the effects of the different release requirements on powerplant emissions of sulfur oxides, nitrogen oxides, and carbon dioxide are also forecast during the interim period 1992 through 1995.

The alternative flow release scenarios examined in this study can be compared to current operations at Glen Canyon dam. Current operations allow water to be released from the dam at a maximum rate of 31,500 cubic feet per second (cfs) for power generation purposes. (This rate can be exceeded if flood control needs require it.) The release rate must be at least 1,000 cfs in winter (October through March) and at least 3,000 cfs in summer (April through September). There is no restriction on how fast releases can be changed from hour to hour (the "ramp rate").

The alternative flow release scenarios illustrate the range of impacts that may occur as a result of interim flow release requirements at Glen Canyon dam. A total of four different alternative release scenarios have been examined, each supported by at least one governmental agency. They are described below in order of least to greatest change from current operating criteria. The proposed criteria are also summarized in table 1.

The first alternative release scenario, as proposed by the Western Area Power Administration (Western), would require an increased minimum flow of at

[1] The methodology for this study and the text for this report are very similar to those used in EDF's earlier report, <u>Estimates of Economic Impacts of Implementing Interim Flow Release Patterns at Glen Canyon Dam</u>, Environmental Defense Fund, July 12, 1990, which was prepared at the request of the U.S. House of Representatives, Committee on Interior and Insular Affairs, Subcommittee on Water, Power and Offshore Energy Resources.

TABLE 1

GLEN CANYON DAM INTERIM OPERATIONS

SUMMARY OF OPERATING CRITERIA RECOMMENDATIONS

June 25, 1991

Parameter	Historical	R/S Group	E/RM Group	USBR Option	WAPA
Max. Release (cfs)	31,500	20,000	20,000	20,000(1)(2) 22,000(3)	31,500
Min. Release (cfs)	3,000/1000	5,000	8,000	5,000(4)	3,000/ 5,000
Ramp Rates cfs/hr.				4 hour/1 hour	
Up	No Limit	2,000	2,000	8,000/4,000(4)	No Limit
Down	No Limit	1,000	1,000	4,800/2,000(1) 8,000/2,500(2) (3)	4,000/ 5,000
Daily Change (cfs)	30,500	5,000	5,000	8,000(1) 11,000(2) 15,000(3)	No Limit
Flooding	1 in 20 yrs.	Minimize	Minimize	Minimize	Minimize

R/S Group = Research /Scientific Group - Recommendations For Interim Operating Procedures For Glen Canyon Dam - April 10, 1991

E/RM Group = Ecological/Resource Managers - Letter Report - Review of Interim Flow Recommendations - March 29, 1991

USBR = Bureau of Reclamation (Committee of Five) - Presented at Cooperating Agencies meeting on June 13-14, 1991, including a phased approach which was dropped from consideration

WAPA = Western Area Power Administration - Letter and Concept of Interim Operating Criteria - May 22, 1991 - Comments on the WAPA concept was submitted by the Colorado River Energy Distribution Association and the Upper Colorado River Commission on May 29, 1991.

Notes:
(1) Low monthly volume - less than 600,000 acre-feet
(2) Medium monthly volume - 600,000 to 800,000 acre-feet
(3) High monthly volume - over 800,000 acre-feet
(4) All months

least 3000 cubic feet per second (cfs), and a maximum hourly decrease in flow of at most 5000 cfs/hour. Western proposes modifying these parameters a if "favorable market conditions exist", but the computer modeling was done assuming the former less restrictive parameters for dam operations. The maximum rate of 31,500 cfs would be retained.

The second alternative release scenario, as proposed by the Bureau of Reclamation (USBR) would require a minimum release rate of 5,000 cfs year round. The maximum release rate would be restricted between 20,000 cfs and 22,000 cfs, depending on monthly volume. Restrictions on fluctuations would be imposed each hour, every four 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 medium volume months, and 15,000 in high volume months. Over any four hour period, an increase in flow would be limited to 8,000 cfs in all months, and a decrease would be limited to 4,800 cfs in low volume months and 8,000 cfs in medium and high volume months. Over any one hour period, an increase would be limited to 4,000 in all months, and a decrease would be limited to 4,800 in low volume months and 8,000 in medium and high volume months.

A third alternative, proposed by the Glen Canyon Environmental Studies Research/Scientific Group (GCES) would require a minimum release rate of 5,000 cfs and a maximum release rate of 20,000 cfs. The daily change would be limited to 5,000 cfs. Over any one hour period, increases would be limited to 2,000 cfs and decrease limited to 1,000 cfs. In addition, the average flow for any day must be at least 8,000 cfs.

A fourth alternative, proposed by Ecological/Resource Managers (E/RM), a group that includes the National Park Service, United States Fish and Wildlife, Arizona Game and Fish, as well as Native American groups, is the same as the GCES proposal, but would require a minimum release rate of 8,000 cfs.

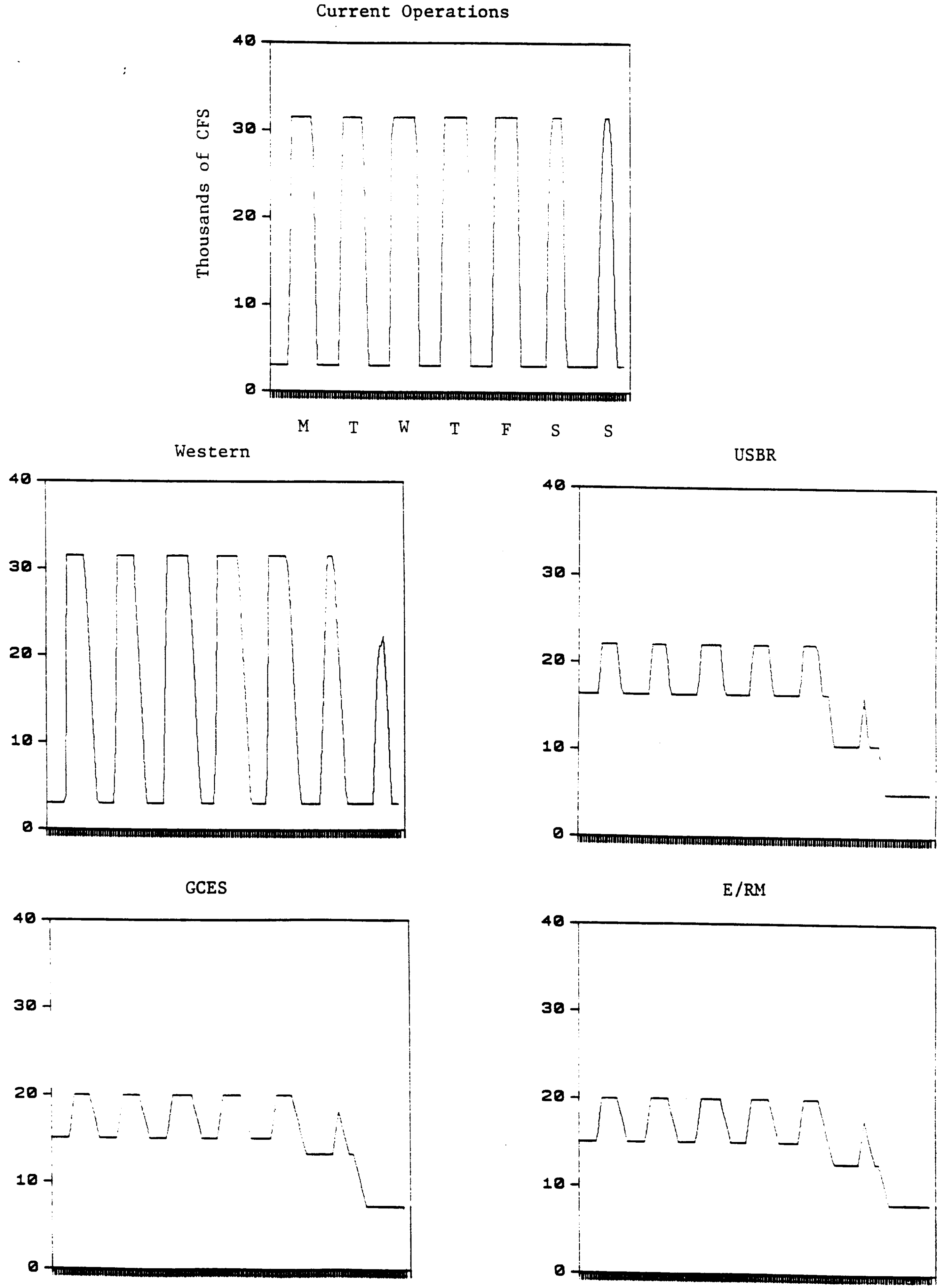
How do these different release requirements affect power generation costs? Electric generation is most valuable at peak-load times (such as summer afternoons when air-conditioning requirements are greatest) because electric utilities typically have to call upon higher-cost generation resources to meet these higher loads. In a typical month water supply will not be great enough to allow a 31,500 cfs release rate around the clock. Instead, the value of water for power generation can be maximized by releasing the limited amount of water preferentially at peak-load times, and as little as possible at other times. The current operations release requirements allow a great deal of flexibility to do this. The resulting fluctuating flows are the subject of the current environmental investigations.

Under all proposed alternatives, operations at Glen Canyon Dam would be more restricted. While there is no difference in the total amount of water released from the dam in a month, and thus no difference in the total amount of energy generated, less of that total is available to be scheduled at peak-load times. Thus all alternatives shift some energy generation from peak load times to non-peak-load times. Other, higher-cost coal and natural gas resources must be turned on at peak load times, thus increasing costs. The additional hydroelectric generation at non-peak times means that fossil-fuel plants will generate less at these times, thereby saving money. Since the cost of fossil-fuel generation is less at off-peak times than on-peak times, the off-peak savings will not be as great as the on-peak costs.

Figure 1 shows an example of how the Elfin model simulated the operation of Glen Canyon Dam for the current operations case and each of the four alternative scenarios. In each case, the model used the available water for each month, subject to the appropriate operating restrictions, to serve peak electrical loads as efficiently as possible. The examples in Figure 1 all

Figure 1

Dam Operations - July 1992



represent a week in July 1992. Maximum and minimum flow rates are most obvious, but daily and hourly restrictions can be seen as well. Factors other than the restrictions may affect the simulated operations, e.g. USBR's proposal would have allowed a daily fluctuation of up to 15,000 cfs in the month shown, but the relatively large amount of water available, combined with the four hour restriction, limited the actual daily fluctuation to much less.

II. Study Method

This study calculates the economic effects of changes in the hour-to-hour scheduling of Glen Canyon Dam generation by simulating the operation of the most directly affected electric systems of which the Glen Canyon powerplant is a component. The interconnected western power grid which includes Glen Canyon Dam is a far-flung entity extending through British Columbia. Power from the Colorado River Storage Project (CRSP), a set of dams on the Colorado River, of which Glen Canyon is by far the major component, has regularly been sold as far away as California. This study restricts attention to the power systems most directly affected by changes in Glen Canyon generation. These include customers of Colorado River Storage Project power (municipal and publicly-owned utilities in Arizona, New Mexico, Utah, Colorado, and southern Nevada), and, for those customers which do not have their own generating plants, their alternative suppliers (generally investor-owned utilities in the same region).

The electric system simulation used in this study focuses on the actual economic costs of changing operations. That is, the simulation examines the physical and resource changes involved in burning fuel and generating electricity, rather than financial changes that come with different power transactions. Thus, the increased profit that utility A may be able to make when it increases sales to utility B is <u>not</u> a subject of this study. The cost of the additional fuel that utility A burns to supply utility B is. This study takes a net economic impacts perspective across utilities rather than the perspective of any single utility or limited group of utilities.

A single utility or entity such as the Western Area Power Administration (which markets and distributes Colorado River Storage Project Power) will consider only its own "wins" and "losses" which result from power transactions. These transactions will ordinarily include a mark-up component (which, from an economic perspective, represents a transfer payment rather than a resource cost). "Winners" and "losers" may largely balance out when all such entities are considered. This study considers only the net loss over all such entities; it does not calculate any single entity's position.

There are several aspects of the distribution of the net economic cost that are known, however. Increases in power costs will fall on Colorado River Storage Project firm customers in either of two ways. One possibility is that the firm customers' share of Glen Canyon resources will be changed in accordance with changes in Glen Canyon operations, thereby making the power less valuable and requiring these utilities to generate or purchase make-up power at on-peak times. Alternatively, the Western Area Power Administration could continue to supply power in accord with pre-existing contracts and will itself purchase make-up power. In this case rates to firm customers will increase to cover Western's costs. For these reasons the net cost impacts per kilowatt-hour are most appropriately attributed to those kilowatt-hours delivered to firm customers.

An additional aspect of the distribution of net economic costs that is also known is the effect on the federal treasury. Since Western currently markets Glen Canyon power at a cost well below its free-market value, Western will be able to adjust firm power rates to recover any increases in its costs. Aside from slight differences in the timing of the repayment of Western's costs there is no effect on Western's payments to the federal treasury.

The simulation of the power systems is performed through the use of the Elfin computer model. The Elfin electric utility simulation model was developed by the Environmental Defense Fund, and is currently widely used in California and elsewhere in the country. Some of the users and uses of the Elfin model are summarized in Appendix 1. In this study the Elfin model simulates the operation of more than one hundred generating units in the Southwest region.

III. Comparison with Western's Methodology

The Western Area Power Administration is the federal agency responsible with marketing the power from Glen Canyon, and other dams. They have more than 100 customer with contracts for firm power. Most of these customers are small utilities without sources of generation who purchase power from larger utilities as well as Western. However, a some of Western's customers are large utilities who do have their own sources of generation.

During many years, Western's firm contracts commit them to supply more energy than they can generate. Western buys fossil-fuel generated power from other utilities for this purpose. The cost of this purchase power is blended into the rate Western charges its firm customers. Currently most of this power is bought at off-peak times. Typically, off-peak power is sold at the cost of production, i.e. fuel costs plus costs of operations and maintenance.

Under the alternatives, Western would have to purchase more power at peak-load times and less at off-peak times. Costs of production at peak times are greater. Moreover, with more demand for power at peak load times, sellers of power may want to charge more than the costs of production, they may try to charge "capacity payments", to recoup some of their investments in their power plants.

The principal estimates in Western's financial analyses are the increased costs of purchased power. These estimates include both the increased costs of production and capacity payments. EDF's estimates of increased costs include only the costs of production, since they represent the only physical change to how the power system is operated .

From an economic perspective, these capacity payments are transfer payments. There is a financial cost to the buyer and a financial benefit to the seller, but no net overall economic impact. If capacity payments are made, the sellers will benefit. Western is not measuring these benefits. The sellers may, in fact, be some of Western's firm customers, as some of them do have excess generating capability. At any rate, according to the federal Principles and Guidelines, decisions should be based on overall net economic impacts rather than impacts to a select group.

Additionally, Western's latest studies have shown considerable uncertainty in the extent to which they would have to make capacity payments to obtain peak-load power.[2] Certainly Western must err on the conservative side to be sure that they can meet firm contracts, but their estimates for capacity payments may be overstated.

---

[2] Cooperating Agencies meeting, July 1, 1991, Phoenix AZ. Western was represented by Lloyd Greiner, Ken Maxey, Jeff McCoy and Ken Ackerman.

IV. **Results**

The Elfin model measures the total costs of producing electricity for the simulated power systems for each year of the study period under each case. These costs include the costs of powerplant fuel and variable operation and maintenance expenses. (These costs do not include fixed costs such as interest, or costs such as administrative and general expenses which are not expected to change as a result of changes in Glen Canyon operations.) Table 2 shows these total production costs for each flow release scenario and year from 1992 through 1995.

In addition, table 2 calculates the change in total production costs in each case compared to the current operations case. Thus, alternative I, Western's proposal, results in increased costs of $1.1 million in 1992 compared to current operations. Similarly, alternatives II, III and IV, representing proposals by USBR, GCES and E/RM result in increased costs of $8.5 million, $9.3 million and $9.4 million in 1992 compared to current operations.

Table 1 also shows the cost increases compared to the base case as a percentage of total costs. In general, the percentage impacts increase over time. This occurs as the result of two factors: first, power system loads are forecast to increase approximately 3% per year during this period; and second, Glen Canyon hydroelectric generation is also forecast to increase, since reservoirs are currently low and water supplies are expected to increase under expected average hydrologic conditions. The first factor makes hydroelectric generation relatively more valuable over time, since increasing loads means that higher-cost thermal resources must be used to meet these loads. The second factor means that Glen Canyon hydroelectric generation is a larger share of the generation "mix," and any constraint on the operational flexibility of this resource will have a greater relative impact.

Finally, the last section of table 2 shows the impact of the cost increases on Colorado River Storage Project firm customers. These impacts are calculated on a cost per kilowatt-hour basis. For example, alternative I would increase costs to CRSP firm customers by 0.02 cents per kilowatt-hour in 1992. Since the rates for CRSP firm power average approximately 1.5 cent per kilowatt-hour currently, this represents an approximately 3% increase in the cost of CRSP power. These figures overstate the cost impact of the changes, however. The cost of CRSP power represents on average only a small fraction of the total costs of the utilities which receive this power. These utilities generate or purchase the balance of their power requirements from other sources, and in addition have interest costs, distribution system costs, operation and maintenance costs, and so forth. Thus, the increase in rates to the residential and business customers of these utilities is small indeed; on average less than 0.3% in this case.

Figure 2 charts the change in total costs for each case compared to current operations by year.

Tables 3 through 5 show powerplant emissions results under each case. Table 3 shows sulfur dioxide emissions, table 4 shows nitrogen oxide emissions, and table 5 shows carbon dioxide emissions. Sulfur dioxide emissions increase in most of the alternative cases, while in most cases nitrogen oxide emissions decrease. Carbon dioxide emissions decrease in most of the alternative cases. The decreases in carbon dioxide emissions occur because of shifts from coal-fired generation (which emits proportionately more carbon dioxide) to natural gas-fired generation. Carbon dioxide emission rates per Btu of fuel do not vary significantly among coal plants, nor do they vary among natural gas plants. On the other hand, sulfur dioxide emission rates vary from coal plant to coal plant depending on the sulfur content of the coal fuel. These increases would be relatively easy and inexpensive to

Table 2

Total Production Costs by Flow Release Pattern
and Water Year *

Total Costs (million $)

	1992	1993	1994	1995
Current Operations	1794.2	1946.8	2105.7	2301.9
Alternatives:				
I - Western Proposal	1795.3	1948.2	2107.4	2304.1
II - USBR Proposal	1802.8	1957.7	2119.6	2317.2
III - GCES Proposal	1803.5	1958.6	2120.6	2317.9
IV - E/RM Proposal	1803.6	1958.6	2120.6	2317.9

Change From Current Operations (million $)

	1992	1993	1994	1995
I - Western Proposal	1.1	1.4	1.7	2.1
II - USBR Proposal	8.5	10.9	13.9	15.3
III - GCES Proposal	9.3	11.8	15.0	16.0
IV - E/RM Proposal	9.4	11.8	15.0	16.0

Change From Current Operations (percent)

	1992	1993	1994	1995
I - Western Proposal	0.06%	0.07%	0.08%	0.09%
II - USBR Proposal	0.48%	0.56%	0.66%	0.66%
III - GCES Proposal	0.52%	0.60%	0.71%	0.69%
IV - E/RM Proposal	0.52%	0.60%	0.71%	0.69%

Cost per kWh of Firm Sales (cents per KWH)

	1992	1993	1994	1995
I - Western Proposal	0.02	0.02	0.03	0.04
II - USBR Proposal	0.15	0.19	0.24	0.27
III - GCES Proposal	0.16	0.20	0.26	0.28
IV - E/RM Proposal	0.16	0.20	0.26	0.28

* Water year 1992 equals October 1991 through September 1992

FIGURE 2

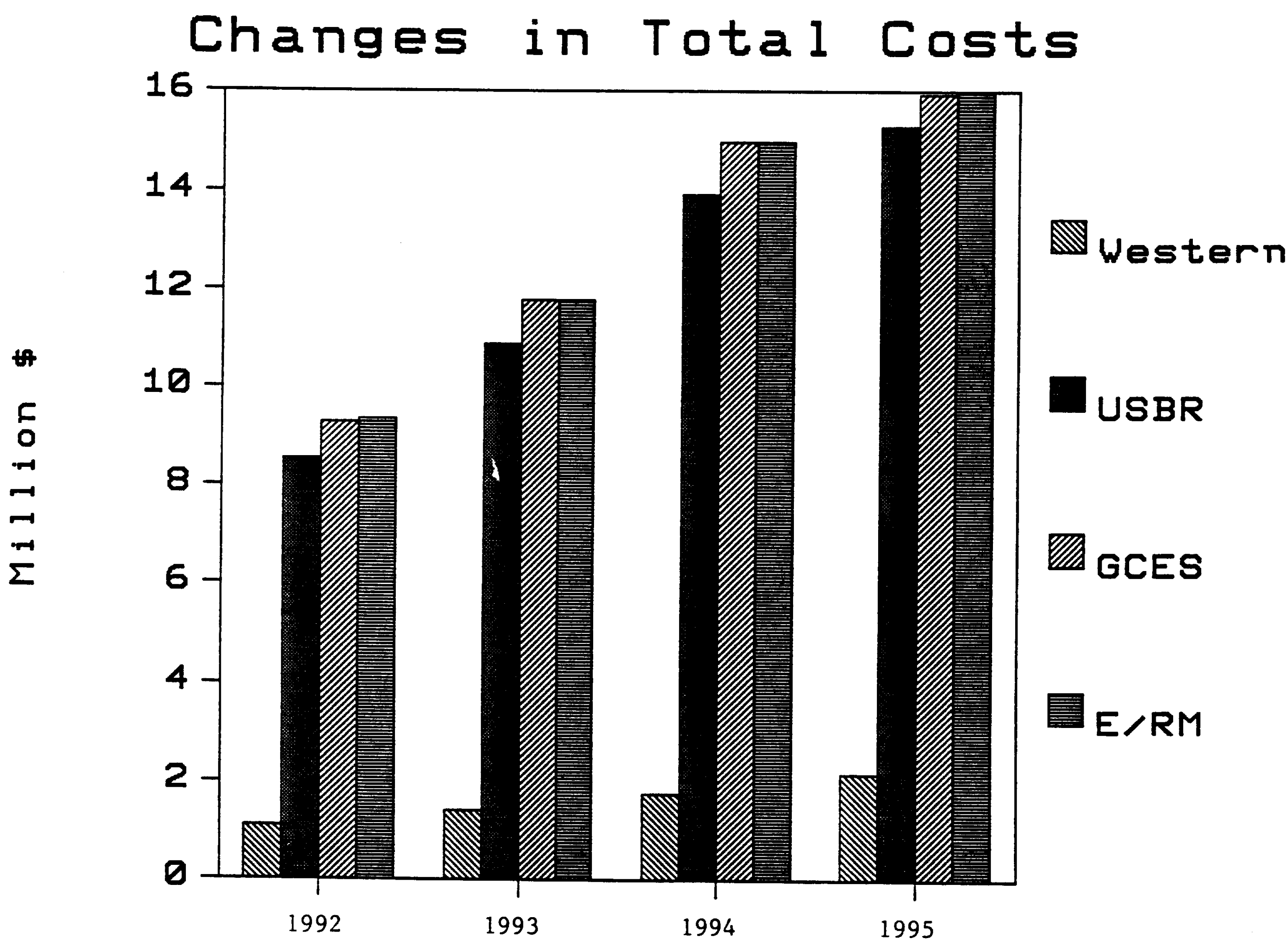

Changes in Total Costs
Million $
16
14
12
10
8
6
4
2
0
1992
1993
1994
1995
Western
USBR
GCES
E/RM

Table 3

SO2 Emissions by Flow Pattern and Year

System SO2 (tons)

	1992	1993	1994	1995
Current Operations	261009	266155	273134	281000
I - Western Proposal	261047	266325	273418	281292
II - USBR Proposal	260919	266966	273983	282282
III - GCES Proposal	260879	266811	273968	282265
IV - E/RM Proposal	260894	266819	273972	282264

Change From Current Operations (tons)

	1992	1993	1994	1995
I - Western Proposal	38	170	283	293
II - USBR Proposal	-91	812	849	1282
III - GCES Proposal	-131	657	834	1266
IV - E/RM Proposal	-115	664	837	1264

Change From Current Operations (percent)

	1992	1993	1994	1995
I - Western Proposal	0.01%	0.06%	0.10%	0.10%
II - USBR Proposal	-0.03%	0.30%	0.31%	0.46%
III - GCES Proposal	-0.05%	0.25%	0.30%	0.45%
IV - E/RM Proposal	-0.04%	0.25%	0.31%	0.45%

TABLE 4

NOx Emissions by Flow Pattern and Release Year

System NOx

	1992	1993	1994	1995
Current Operations	342848	348424	356280	363761
I - Western Proposal	342763	348334	356207	363708
II - USBR Proposal	342329	348294	356035	363787
III - GCES Proposal	342282	348289	356048	363967
IV - E/RM Proposal	342279	348291	356053	363971

Cahnges From Current Operations (tons)

I - Western Proposal	-85	-90	-73	-53
II - USBR Proposal	-519	-130	-245	26
III - GCES Proposal	-566	-135	-232	207
IV - E/RM Proposal	-569	-133	-228	210

Changes From Current Operations (percent)

I - Western Proposal	-0.02%	-0.03%	-0.02%	-0.01%
II - USBR Proposal	-0.15%	-0.04%	-0.07%	0.01%
III - GCES Proposal	-0.17%	-0.04%	-0.07%	0.06%
IV - E/RM Proposal	-0.17%	-0.04%	-0.06%	0.06%

Table 5

CO2 Emissions by Flow Release Pattern and Year

	System CO2 (millions of tons)			
	1992	1993	1994	1995
Current Operations	100.48	102.29	104.47	106.71
I - Western Proposal	100.47	102.29	104.47	106.71
II - USBR Proposal	100.41	102.26	104.43	106.73
III - GCES Proposal	100.40	102.26	104.43	106.73
IV - E/RM Proposal	100.40	102.26	104.43	106.73
	Changes from Current Operations (millions of tons)			
I - Western Proposal	-0.01	-0.00	-0.00	-0.00
II - USBR Proposal	-0.07	-0.03	-0.04	0.02
III - GCES Proposal	-0.08	-0.03	-0.04	0.02
IV - E/RM Proposal	-0.08	-0.03	-0.04	0.02
	Changes From Current Operations (percent)			
I - Western Proposal	-0.01%	-0.00%	-0.00%	-0.00%
II - USBR Proposal	-0.07%	-0.03%	-0.04%	0.02%
III - GCES Proposal	-0.08%	-0.03%	-0.04%	0.02%
IV - E/RM Proposal	-0.08%	-0.03%	-0.04%	0.02%

mitigate by including emissions factors in the optimization criteria used to operate the power system.

IV. Conclusion

Changes in flow release patterns at Glen Canyon dam which restrict the degree to which these flow releases can be optimized purely for power generation purposes do increase power system generating costs in the southwest region. More restrictive flow release patterns cause greater increases in cost. The cost increases range from $1.1 million dollars in 1992 under Western's proposal to a maximum of $9.4 million dollars under the E/RM proposal.

No operating flexibility was considered in this study. The simulation did not allow maximum release rates to be exceeded for emergency purposes. There are other methods of increasing operating flexibility which should be considered for both power generation and environmental goals. For example, monthly water releases are determined by the Bureau of Reclamation considering goals primarily for water delivery and flood control. To the extent there is remaining flexibility in month-to-month water releases these will be scheduled to optimize power generation. With changes in daily flow release patterns these month-to-month schedules could be re-optimized. Such re-optimization, which could further reduce the costs of changing flow release patterns, was not examined in this study.

An additional method of ameliorating cost impacts was also not considered in this study: energy efficiency improvements. Given the low price of Colorado River Storage Project power, utility customers have had relatively little incentive to promote energy conservation and load management among their residential and business consumers. Current research points to significant remaining potentials for energy efficiency improvements among electricity users at costs below the costs of thermal generation. Load management, by cutting peak-period electric demands, has the potential to directly mitigate the effects of restricting peak-period generation at Glen Canyon dam. Potential cost savings from increased energy efficiency would quickly outweigh the cost increases due to changing flow release patterns at Glen Canyon dam.

Appendix 1

Study Method

A. Power Systems Simulation

1. The Elfin Model

The method used in this study to calculate the economic costs of changing operations at Glen Canyon dam is to simulate changes in Glen Canyon electric generation within the context of the power systems most directly affected by those changes. Since these power systems involve more than a hundred electric generating units in portions of seven states, and since power system operations are extremely complex, a computer-based model is necessary for this task.

The "Elfin" electric utility production cost simulation model is used in this study. The Elfin model was developed by the Environmental Defense Fund. The model is currently the primary analysis tool used by the staffs of both the California Public Utilities Commission and the California Energy Commission. The Southern California Edison Company uses Elfin as its primary tool for long-range planning. In addition, Elfin is used by a number of consulting and engineering firms in California and elsewhere.

The Elfin model is used by these organizations for a variety of purposes related to the operation of electric generation systems. For example, before the California Public Utilities Commission Elfin is used to make short-term (one year) forecasts of fuel use and marginal energy costs for purposes of setting electric rates and "Qualifying Facility" (cogeneration and independent power producer) purchase prices. The model is also used by both of the California regulatory commissions and others to do long-term planning. For example, the model is used to determine what new plants would be most cost effective. It is also used to determine what levels of conservation and demand-side management would be most cost effective.

In addition, the Elfin model has been recommended for use, along with the Electric Power Research Institute's EGEAS model, in the Department of Interior's Environmental Impact Statement process currently under way for Glen Canyon operations. The Glen Canyon Environmental Studies' Power Economics Team, of which the Environmental Defense Fund is a participating member, conducted "prototype" studies to determine acceptable methods for calculating the economic impacts of changes in operations at Glen Canyon dam. Three different methods were compared: the Western Area Power Administration's "Alternative Thermal Plant" method; the EGEAS model; and the Elfin model. The prototype studies using each of these methods were conducted by Western Area Power Administration, Stone & Webster Management Associates, and the Environmental Defense Fund, respectively. The Alternative Thermal Plant method was judged to be less useful than either of the models because only the models could take into account the complexity and range of impacts involved in the power system. The EGEAS model was favored because of its ability to make "optimum generation expansion decisions" in the long run, when new generating capacity may be necessary to replace lost peaking capacity from Glen Canyon (since there is currently significant excess capacity in the southwest region the issue of new generating capacity is not particularly relevant to interim operating conditions at Glen Canyon). The Elfin model was recommended as a valuable cross-check for EGEAS results.

2. What the Elfin Model Does

The Elfin electric utility production simulation model simulates the production of electricity by generating units to meet customer demands. The Elfin model begins with the "load shape" -- the hour-by-hour demand for electricity. The model then uses data on the electric generating plants available to meet load to simulate how these plants will be operated. Data such as the capacity of each plant, the type and cost of fuel each plant uses (or the availability of water for hydroelectric generation), the efficiency of each plant, and the maintenance requirements and reliability of each plant are used in the simulation. The simulation is "probabilistic;" an important factor in the operation of electric systems is the outages of generating units due to mechanical breakdowns. Since such outages cannot be forecast except on an average, expected basis, the model weighs the probability of each combination of outage events in calculating its results.

The model simulates the operation of electric systems with essentially the same goal as power system operators: to meet electric needs at minimum cost subject to constraints on reliability, operating flexibility, and other factors. The Elfin model includes a "commitment" algorithm and a "spinning reserve" algorithm. The commitment algorithm decides when slow-start plants must be committed for reliability purposes (that is, when each slow-start plant must be started up, with the constraint that in order to be available for peak-period loads, such plants must remain running at a minimum level during non-peak times). The spinning reserve algorithm decides when quick-start units (such as combustion turbines), which would otherwise not be economic, must be brought on-line to meet operating reserve requirements.

B. System Definition for the Elfin Simulations

In this study, the Elfin model simulates operations on a month-by-month basis, with each month represented by a "typical week" within that month.

This monthly simulation is conducted for power systems covering portions of seven states. The Colorado River Storage Project (CRSP), of which Glen Canyon dam is the major component, has over one-hundred customers for firm electric power, mostly in Arizona, New Mexico, Utah, Colorado and southern Nevada. Most of these customers are small utilities which have no generating resources of their own, but purchase power from larger neighboring utilities when they have needs in excess of their firm contract power. Consequently all major utilities and thermal generating units in these states are potentially affected by a change in operations at Glen Canyon. (Interconnected utilities also own plants or portions of plants in Wyoming and Texas.)

The simulated system consists of 70 coal-fired units, 3 nuclear generating units, 58 oil- or gas-fired steam turbines or combined-cycle units, a large number of combustion turbines, all CRSP units (including, of course, Glen Canyon), most of the non-federally owned hydro projects in the region and two pumped-storage plants.

All of these systems are modelled as an interconnected, bulk system in the Elfin simulations for this study. While significant portions of the system are subject to a formal power pooling agreement that coordinates reserve capacity sharing and economy energy transactions, there are still significant transmission constraints and coordination constraints within the larger interconnected area. The transmission and coordination constraints have been approximated within this study's Elfin simulations by insuring that certain minimum levels of local generation would occur in each sub-area. This is accomplished by making plants in each sub-area "must-run" plants, which must be committed for local generation and reliability purposes regardless of economics.

The bulk-system simulation used in this study is not as sophisticated as the approach recommended for the Environmental Impact Statement by the Power Economics Team. The recommended approach is to model a number of utilities which receive Glen Canyon power on a utility-by-utility basis, taking specific account of their interconnections with neighboring utilities. This detailed approach is deemed necessary in order to measure utility-specific impacts of both changes in Glen Canyon generation and changes in Colorado River Storage Project firm contracts. Neither sufficiently detailed data nor time were available for such a detailed approach in this study; since neither utility-specific impacts nor changes in firm contracts are of interest in this study, such a detailed approach was deemed unnecessary.

The Western Area Power Administration (Western) is in charge of marketing and distributing CRSP power. Since actual energy and capacity available from CRSP generating units varies from year-to-year with hydrological conditions, and this energy and capacity may be greater or less than Western's firm contract obligations, Western also conducts transactions in order to meet its firm contract obligations, or to sell surpluses above the firm contract amounts. The Elfin simulations do not separate these transactions in any special way. Instead, such transactions are modelled concurrently with other system power flows.

C. Notes on Data and Sources

As described above, the Elfin production cost model dispatches generating resources subject to operating constraints in order to serve customer load as economically as possible. Thus, both loads and resources must be specified in the system input data file.

Specifications for thermal plants include:

maximum capacity
minimum capacity
minimum down time
heat rates at various capacity levels
maintenance rates
forced outage rates
fuel costs
operation and maintenance costs

Specifications for hydro plants include:

maximum capacity
minimum capacity
available energy
ramp rate restrictions (Glen Canyon alternative case only)

Specifications for customer load include:

A "typical week" load curve of 168 points, each representing 1 hour, for each month.

Data sources include:

Western Area Power Administration, letter dated July 9, 1990, from Lloyd Greiner to Thomas J. Graff.

Summary of Loads and Resources, Western Systems Coordinating Council, Jan 1, 1990

Electrical World, Directory of Electrical Utilities, Mcgraw Hill, 1990.

National Utility Reference File (NURF) database, U.S. Environmental Protection Agency, 1985, 1986, 1987.

Input data file for SERAM, Southwest Energy and Resource Availability Model, California Energy Commission, 1990.

Fuels Report, California Energy Commission, November 1989.

Elfin input data files for Southern California Edison and Los Angeles Department of Water and Power, Electricity Report 90, California Energy Commission, June 1990.

Elfin input data file for Southern California Edison, California Public Utilities Commission case U 338-E, "Forecast of Operations of the Energy Cost Adjustment Clause for a January 1, 1991 Revision Date (Workpapers)," Southern California Edison Company, June 1990.

EGEAS data file summaries, Stone & Webster Management Associates, for the following utilities:

Salt River Project
Arizona Public Service
Tucson Electric Power Company
Public Service Company of New Mexico
Public Service Company of Colorado
Tri-State Generation and Transmission
Plains Electric and Transmission
Platte River Power Authority
City of Colorado Springs
Colorado Ute Electric Association
Nevada Power Company
Utah Power and Light

Load data were derived from the SERAM input file, which provides state-by-state loads and resources for Arizona, New Mexico, Utah, and Colorado, and includes Tri-State Generation and Transmission Co-op (which includes a portion of Wyoming) and El Paso Electric Company (which includes a portion of Texas). Load data for southern Nevada were derived from the EGEAS summaries. Aggregate load growth in the 1992 through 1995 period averages 2.9% per year for peak loads, and 3.1% per year for energy.

Spinning reserve requirements and commitment targets were set to Western Systems Coordinating Council criteria of 7% of load.

Monthly operating plan data for Glen Canyon were developed by the Bureau of Reclamation and provided by the Western Area Power Administration.

Monthly generation figures for other CRSP projects and SLCA/IP units were held at average levels for each month.

Plant data were derived primarily from the EGEAS summaries, and were cross-checked against the SERAM file, the Electrical World Directory, and the NURF database.

Fuel cost data for coal-fired units were derived primarily from the SERAM data file prepared by the California Energy Commission. These figures are based primarily on Energy Information Administration (EIA) data for 1989, plus escalation rates forecast by the California Energy Commission. Since the EIA data report average fuel prices, which include both fixed- and variable-cost components, these fuel prices tend to overestimate the cost effect of changes in coal-fired generation. Exceptions were fuel costs for the Mohave, Four Corners, and Intermountain units, where variable-cost prices in 1991 were available from the Elfin file created by Southern California Edison Company.

Natural gas fuel cost data were based on the "California Border Price" forecast of the California Energy Commission Fuels Report. These data exclude transportation costs within California. Since these figures include all transportation charges to the California border, and most southwest gas-fired units are closer to the natural gas sources, it is likely that these prices overestimate the cost effect of changes in gas-fired generation.

The following table presents the average coal and gas prices used in the Elfin base-case simulation. Since coal prices are plant-specific the table presents generation-weighted average prices. The natural gas price applies to all gas-fired plants in the simulation.

Fuel Prices

(nominal $/MBtu)

Water year*	Coal	Natural Gas
1992	1.32	2.19
1993	1.42	2.36
1994	1.51	2.56
1995	1.61	2.78
Average escalation rate, 1992-1995	6.8%/yr	8.3%/yr

* 1992 = October 1991 through September 1992

Appendix 2

Results -- Details

Table A1 presents generation by fuel type in each of the cases.

Table A2 presents system marginal costs by time-of-day period and month in the current operations case.

Table A1

Generation by Fuel Type and by Flow Release Pattern and Year (GWh)

Current Operations	1992	1993	1994	1995
Nuclear	16331.5	16307.2	16327.9	16313.3
Coal	85499.2	86799.7	88592.1	90241.6
Gas/Oil	3837.8	4398.1	5171.1	5964.8

Western Proposal	1992	1993	1994	1995
Nuclear.	16331.5	16307.2	16327.9	16313.3
Coal	85442.9	86729.8	88523.8	90176.7
Gas/Oil	3905.8	4480.6	5252.9	6044.3

USBR Proposal	1992	1993	1994	1995
Nuclear	16323.9	16307.0	16327.9	16300.1
Coal	85104.2	86362.8	88122.8	89831.0
Gas/Oil	4301.0	4896.2	5700.3	6449.4

GCES Proposal	1992	1993	1994	1995
Nuclear	16329.3	16306.9	16327.9	16313.4
Coal	85061.0	86345.4	88093.4	89793.8
Gas/Oil	4338.8	4915.8	5730.1	6476.8

E/RM Proposal	1992	1993	1994	1995
Nuclear	16329.3	16306.9	16327.9	16313.4
Coal	85058.3	86345.6	88094.3	89793.3
Gas/Oil	4341.9	4915.7	5729.1	6477.1

Table A2

Average Marginal Costs by Subperiod and Month

(mills/kWh)

1992

	Annual	Month 10	11	12	1	2	3	4	5	6	7	8	9
Weekday peak	21.2	20.6	19.6	19.8	21.3	22.3	22.6	21.7	21.5	20.6	22.0	22.5	19.6
Weeknights	16.7	15.3	16.1	16.9	18.5	19.4	18.7	16.9	15.8	14.6	16.2	16.7	15.4
Sat. day	20.6	19.9	19.4	19.7	21.2	22.2	22.4	20.8	21.0	19.6	22.0	21.2	18.5
Weekend other	18.1	17.0	17.4	17.9	19.4	20.0	19.8	18.2	17.4	16.6	18.7	18.3	15.9
Average	19.5	18.6	18.4	18.8	20.3	21.2	21.2	19.8	19.4	18.4	20.1	20.3	17.8

1993

	Annual	Month 10	11	12	1	2	3	4	5	6	7	8	9
Weekday peak	23.2	22.0	21.2	21.2	23.5	24.4	24.6	23.8	23.7	23.3	24.3	24.4	22.1
Weeknights	18.2	16.2	17.1	18.1	20.5	21.3	20.6	18.7	17.3	16.1	17.6	18.2	16.9
Sat. day	22.6	21.2	20.9	21.1	23.3	24.3	24.4	22.5	22.9	22.0	24.6	23.9	20.4
Weekend other	19.8	18.1	18.6	19.2	21.4	22.0	21.7	20.0	19.0	18.4	20.8	20.4	17.5
Average	21.4	19.9	19.8	20.1	22.4	23.3	23.1	21.8	21.3	20.6	22.2	22.2	19.8

1994

	Annual	Month 10	11	12	1	2	3	4	5	6	7	8	9
Weekday peak	25.5	24.7	23.7	23.6	25.7	27.0	27.2	26.1	26.0	24.8	26.3	26.3	24.0
Weeknights	19.7	18.0	19.2	20.2	22.1	23.4	22.4	19.9	18.5	17.2	18.7	19.3	18.2
Sat. day	24.9	23.7	23.3	23.4	25.4	26.9	27.0	24.8	25.3	23.8	27.0	26.1	22.0
Weekend other	21.6	20.1	20.8	21.5	23.2	24.2	23.7	21.6	20.6	19.8	22.5	22.0	18.9
Average	23.4	22.2	22.1	22.4	24.4	25.6	25.4	23.8	23.2	22.1	24.0	24.0	21.5

1995

	Annual	Month 10	11	12	1	2	3	4	5	6	7	8	9
Weekday peak	28.2	27.3	26.2	26.0	28.8	30.6	30.5	29.4	29.2	26.6	28.9	28.6	26.6
Weeknights	21.5	19.2	20.6	21.8	24.7	26.3	24.9	22.1	20.1	18.3	20.1	20.7	19.8
Sat. day	27.7	26.4	25.8	25.8	28.4	30.3	30.3	27.9	28.3	26.4	30.0	28.7	24.1
Weekend other	23.8	21.9	22.6	23.4	25.8	27.1	26.5	24.1	22.6	21.7	24.8	24.1	20.6
Average	25.8	24.4	24.2	24.5	27.3	28.9	28.4	26.6	25.8	23.8	26.4	26.0	23.7

July 21, 1991

ADDITIONAL INFORMATION IN SUPPORT OF THE SCIENTIFIC RECOMMENDATION FOR INTERIM OPERATIONS OF GLEN CANYON DAM

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Maximum Release of 20,000 cfs

The recommendation to limit maximum releases from Glen Canyon Dam to 20,000 cfs was based on two primary premises: (1) sand is being transported out of the system by high flows, and (2) high flows erode elevated beach deposits.

Sand Transport. The sand transport rating curve (presented in the initial scientific recommendation document) showed that the amount of sand being transported through the system increased exponentially with increasing flow velocity. Although analyses of various operational scenarios demonstrate that less sand potentially will be removed from the system above LCR than is replaced by mean inputs from Paria, there is no guarantee that the mean inputs will be achieved. In fact, sediment inputs from the Paria occur sporadically (Figure 1) and two or three year periods with little or no sediment input from the Paria are not unusual. Sand may accumulate in the channel under the various operational scenarios, but the source of this sand is, in all probability, from the elevated sand deposits (beaches).

Elevated Beach Erosion. Ongoing studies by Dr. Jack Schmidt of Middlebury College on long term changes in beach face profiles has demonstrated that high flows (i.e., flows exceeding 20,000 cfs), appear to have a greater detrimental affect on sand loss from elevated sand deposits than lower velocity flows. This phenomenon did not have the same effect universally across all beaches in the Canyon, but some effect occurred at most types of beaches to support the recommendation for limiting the maximum releases from Glen Canyon Dam. In a series of figures developed from many years of measuring beach profiles, Dr. Schmidt has been able to draw some preliminary conclusions about the action of various discharge levels. In the preliminary figures he has made available (Figs. 2-6), he notes that at each profile between 1986 and 1990 changes occurred while daily discharges occasionally, but not regularly, reached 31,500 cfs. Differences occurred at different beaches. At Grapevine Rapids (Figs 2 and 3) bank erosion occurred even at elevations higher than maximum power plant operations (31,500 cfs), presumably due to slumping, bank caving, and groundwater sapping (rill erosion). This tells us that erosion of the toe of slopes can affect areas beyond those merely wetted by daily fluctuations.

On many bars there is a well-defined break-in-slope between the eroding high-discharge deposit and lower elevation areas regularly reworked by powerplant flows. At 122 Mile Creek, that break-in-slope, was about at the 20,000 cfs discharge level (Figs. 4 and 5). This illustrates that if discharges are less than about 20,000 cfs, the base of the high-discharge deposits (i.e., high elevation sand deposits) will be unaffected by dam operations. These high elevation deposits are often the ones that form the foundation for the sediment deposits protecting archaeological sites. In some cases, such as at a reattachment bar opposite Nineteen Mile Canyon (Fig. 6), discharges greater than 20,000 cfs were sufficient to overtop the upper platform of the bar and submerge large areas.

Daily Fluctuation of 5,000 cfs.

The daily fluctuation in discharge from Glen Canyon Dam is determined as the difference between the maximum release (in cfs) and the minimum release (in cfs) for a particular day. Thus, the daily fluctuation, at the dam is measured in cfs. At any location down the Canyon, this cfs fluctuation can be converted to stage fluctuation per day. The fluctuation in stage at any location thus is a function of the fluctuation in daily water discharge from the dam, the actual flow, the geometry of the canyon cross-section and the distance down stream from the dam (fluctuations in releases attenuate downstream). Daily fluctuation recommendations therefore can be made based on vertical fluctuations in the river (i.e., stage changes) in place of fluctuations in discharge (i.e., a cfs range). In discussing the concept of change in stage related to flow (and indirectly canyon geometry), the USGS presented data based on a stage-flow model at Grand Canyon gage. The curve presented in Figure 7a is based on a stage change limit of 3 ft (ca. 1 m). It shows that at the Grand Canyon gage a daily stage change of 3 ft is equivalent to a 5,000 cfs daily fluctuation at flows of about 10,000 cfs, and a 10,000 cfs daily fluctuation at flows of about 22,000 cfs. A similar relationship is shown for hourly fluctuations (limited to 0.7 ft/hr) in Figure 7b. The GCES Office is developing stage-flow curves for LCR and Lee's Ferry based on long term data, and preliminary curves for 43 Mile Beach to determine the relationships between daily fluctuation, river flow and stage changes in this sensitive reach of the Colorado River system below Glen Canyon Dam.

From preliminary data from 43 Mile Beach and observations at other beaches (some being closely monitored but without early preliminary data available), it is possible to develop a response curve showing the relationship between beach erosion rates and daily change in stage (Fig. 8). These data were generated in April when peak discharges from the dam were not as high as in summer months. As an example of the affects of different flow scenarios on beach erosion, changes over time of two transects surveyed on 43 Mile Beach are shown in Figure 9. These measurements were made in April 1991. On Friday (Fig. 9), the daily fluctuation was slightly over 5,000 cfs 9 (about a 1m stage change) and the ramping rates were shallow (probably tied to small daily fluctuation). On this day there was little or no beach loss from rill erosion, erosion caused by water seepage from the beach when the beach face is exposed well below the perched water stored in the beach. On Saturday at this beach, the daily fluctuation was about 10,000 cfs (about 1.8m stage change) and the ramping rates were relatively steep. On this day, beach erosion averaged about 0.01 m, an apparently small amount until it is calculated on a yearly basis.

Based on these data and observations, the response curve (Fig. 8) shows that beach erosion dramatically increases as the daily stage change goes above one meter (ca. 3 ft.). Because this curve is based on non-high peak discharges, the approximate daily flow fluctuations (cfs) are presented for comparison. The development for stage-flow curves will more accurately present these relationships. The affects of very high stage change (e.g., 3m/day) are not as well known as for lower stage changes (i.e., 1-2m/day).

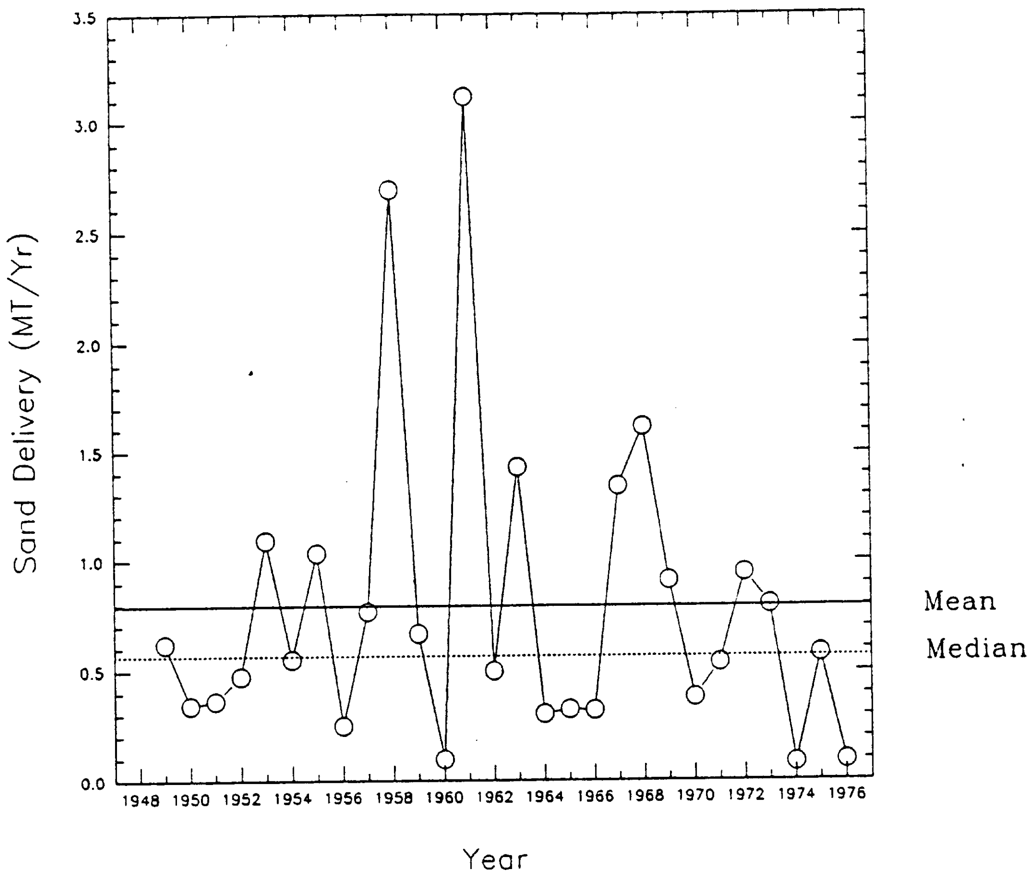
The conclusions drawn from information being analyzed from the beaches studied during research flows and normal operations is that beach face erosion (i.e., rill erosion, slumping and caving) is primarily a function of (1) the amount of water stored in the beach which is a function of recharge and down-ramp (time related factors), and (2) the vertical distance between the perched water in the beach and the lowest level of the river which is directly related to daily stage change. Information continued to be obtained from wells in the beaches and micro-surveying of beach faces should further illuminate these relationships.

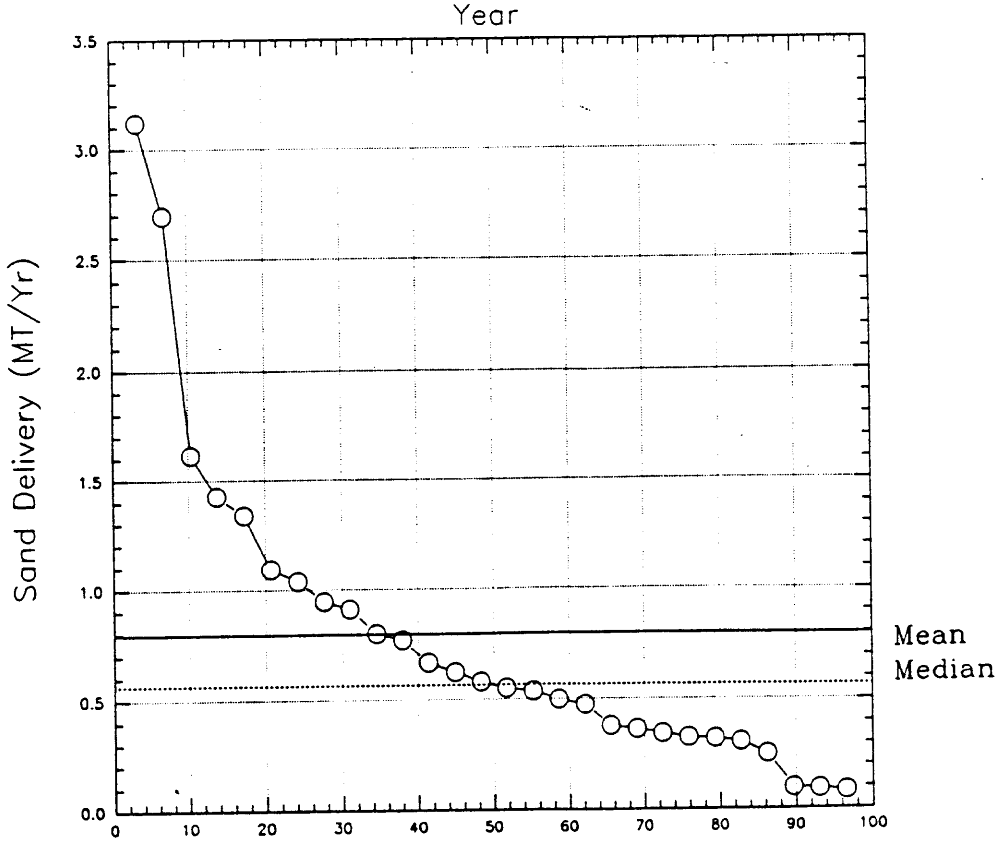
Concluding Comments.

Sediment deposits will continue to erode and be transported at some rate regardless of controls of the discharge rates from Glen Canyon Dam. High energy clear water and shear forces, alone, will erode and move particles in the system. It is thus the responsibility of those selecting flows and dam operations, whether interim or permanent, to make decisions relative to all attributes of the system. The above additional material is primarily oriented toward loss and erosion of sediments and beaches, resources that may be irreplaceable. Biological resources were addressed in the earlier recommendation report and their omission in this addendum does not indicate that they are of any lesser importance to the integrity of the Canyon ecosystem than the sediment.

FIGURE 1.

Sand Delivery (Million Tons/Year) from Paria River into the Colorado River (1948–1975)





Prob. (%) of Exceedance

Source: National Park Service, Water Resources Division

FIGURE 2.

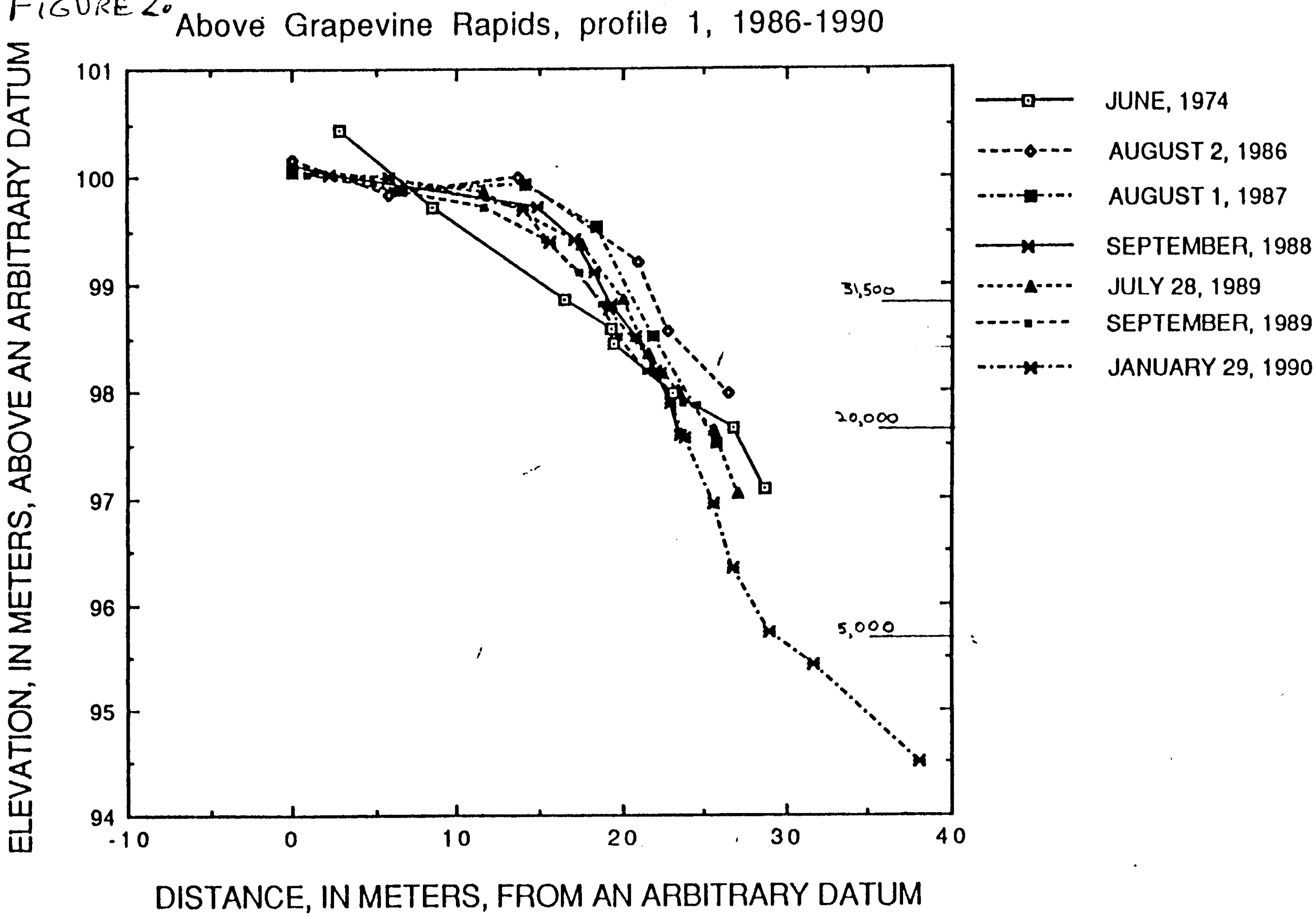

Above Grapevine Rapids, profile 1, 1986-1990
ELEVATION, IN METERS, ABOVE AN ARBITRARY DATUM
DISTANCE, IN METERS, FROM AN ARBITRARY DATUM
101
100
99
98
97
96
95
94
-10
0
10
20
30
40
31,500
20,000
5,000
JUNE, 1974
AUGUST 2, 1986
AUGUST 1, 1987
SEPTEMBER, 1988
JULY 28, 1989
SEPTEMBER, 1989
JANUARY 29, 1990

FIGURE 3. Above Grapevine Rapids, profile 2, 1986-1990

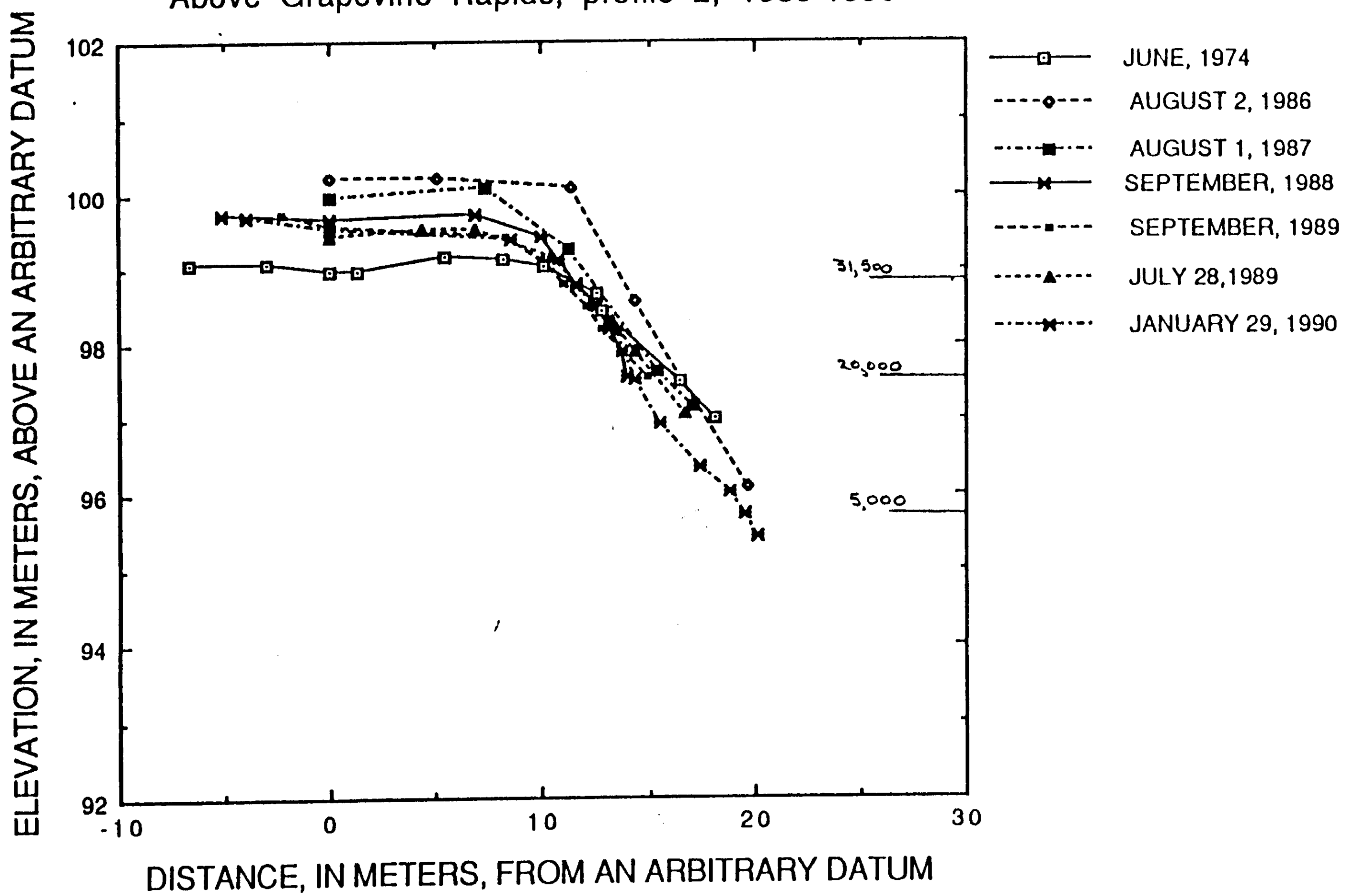


FIGURE 4. 122 MILE, CROSS SECTION 1

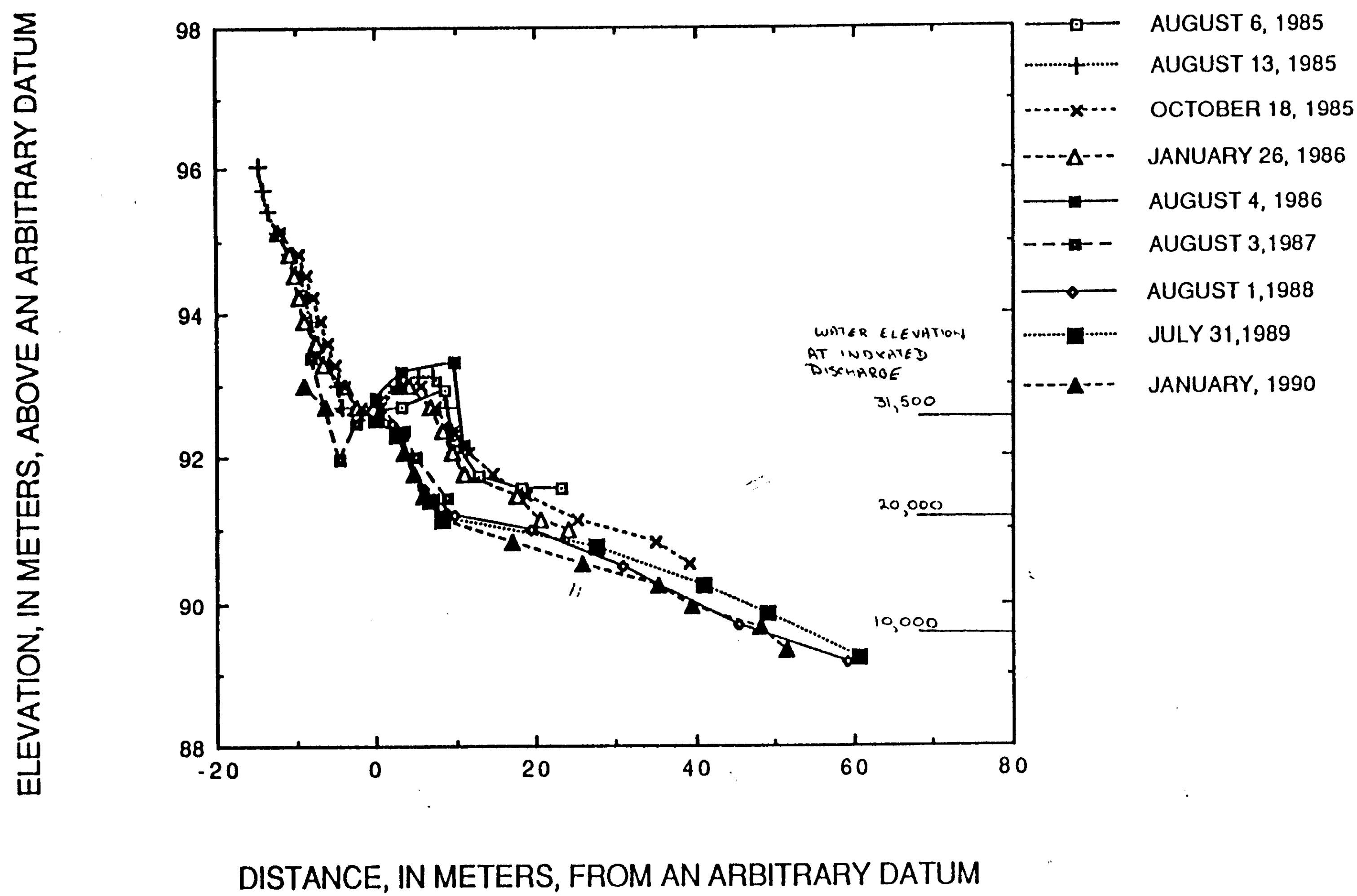


FIGURE 5. 122 MILE, CROSS SECTION 2

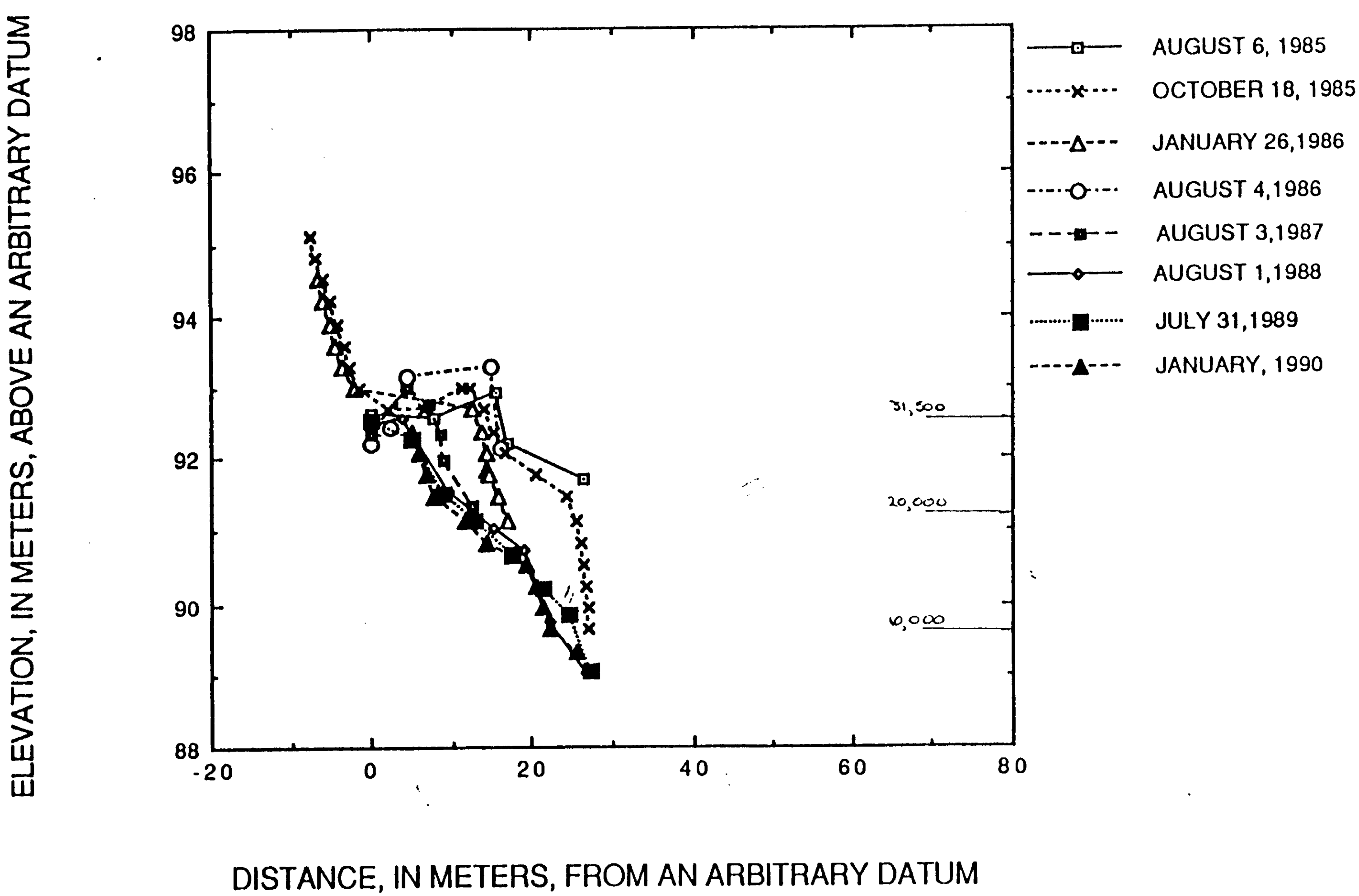


FIGURE 6. Opposite Nineteen Mile Canyon: Cross-Section 1, 1985-89

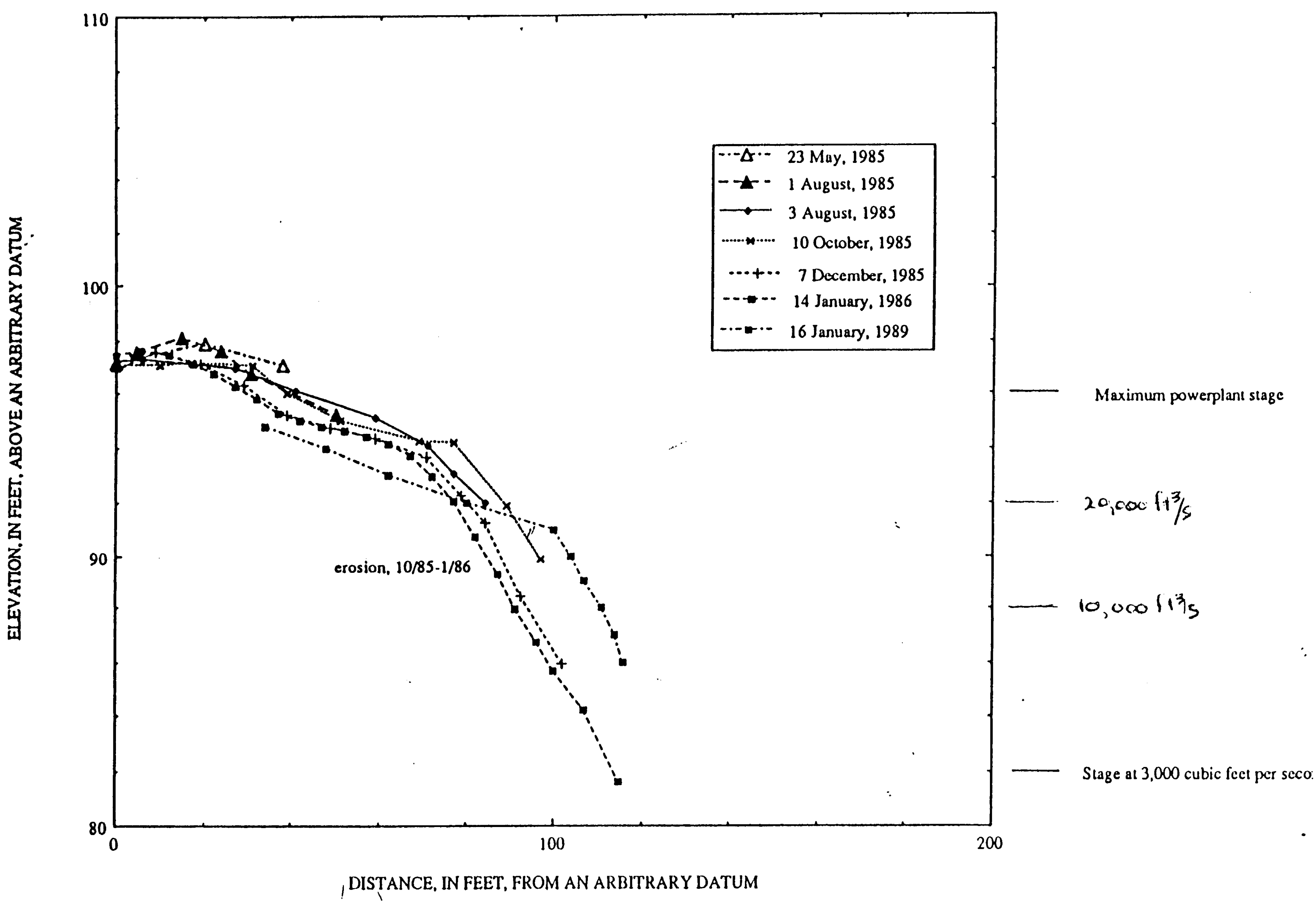
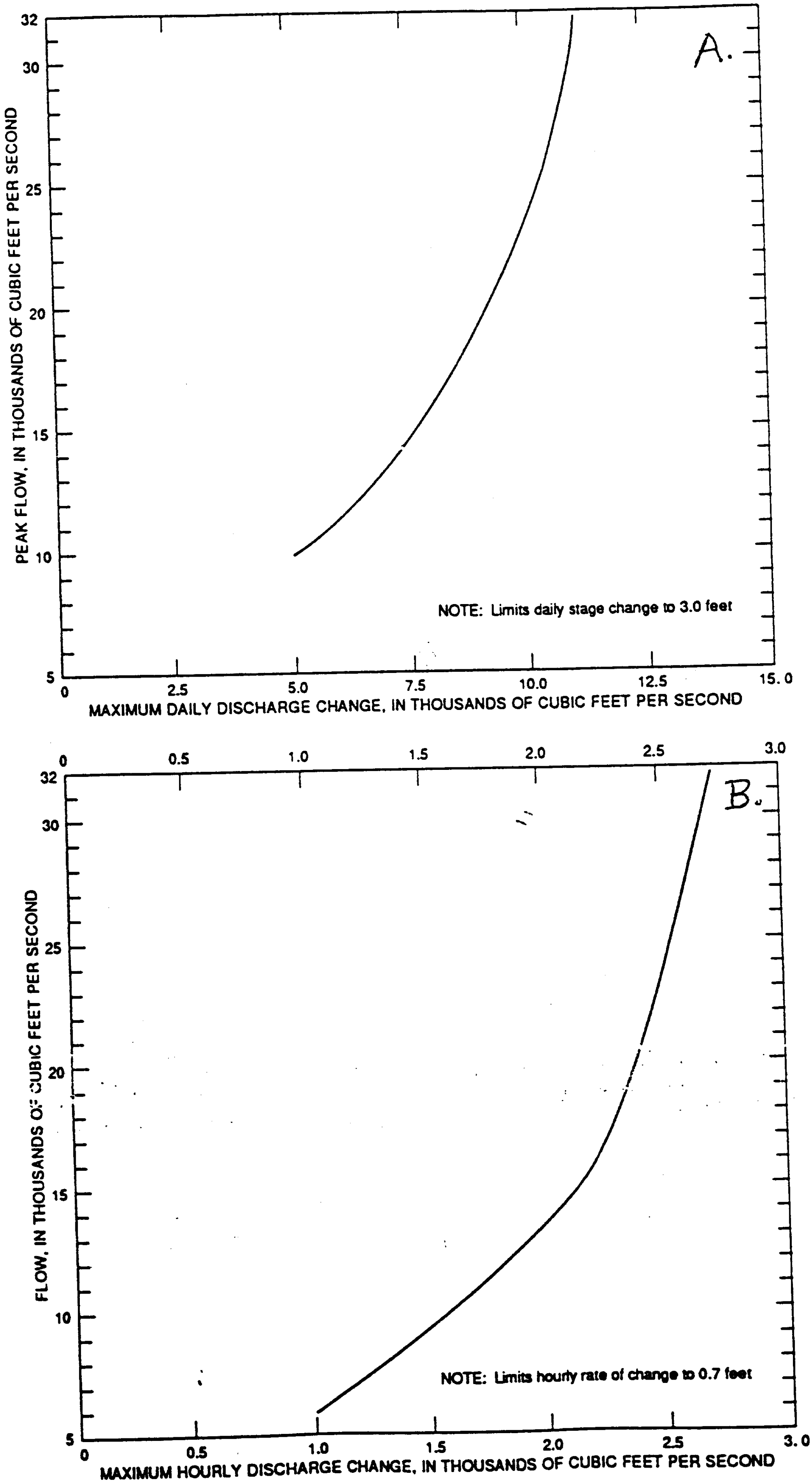


FIGURE 7.



A.
PEAK FLOW, IN THOUSANDS OF CUBIC FEET PER SECOND
5
10
15
20
25
30
32
0
2.5
5.0
7.5
10.0
12.5
15.0
MAXIMUM DAILY DISCHARGE CHANGE, IN THOUSANDS OF CUBIC FEET PER SECOND
NOTE: Limits daily stage change to 3.0 feet
B.
FLOW, IN THOUSANDS OF CUBIC FEET PER SECOND
0
0.5
1.0
1.5
2.0
2.5
3.0
MAXIMUM HOURLY DISCHARGE CHANGE, IN THOUSANDS OF CUBIC FEET PER SECOND
NOTE: Limits hourly rate of change to 0.7 feet

FIGURE 8.

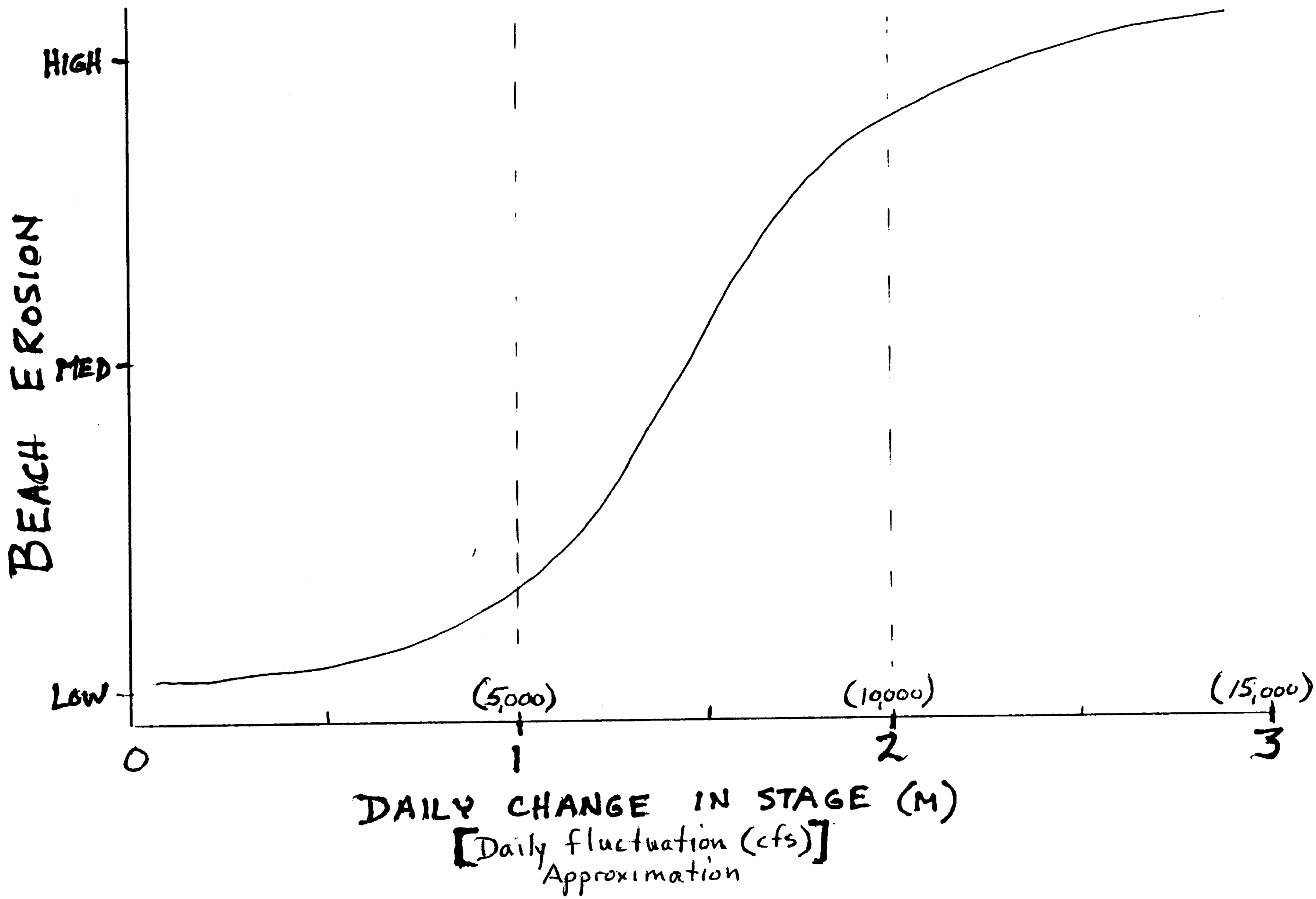
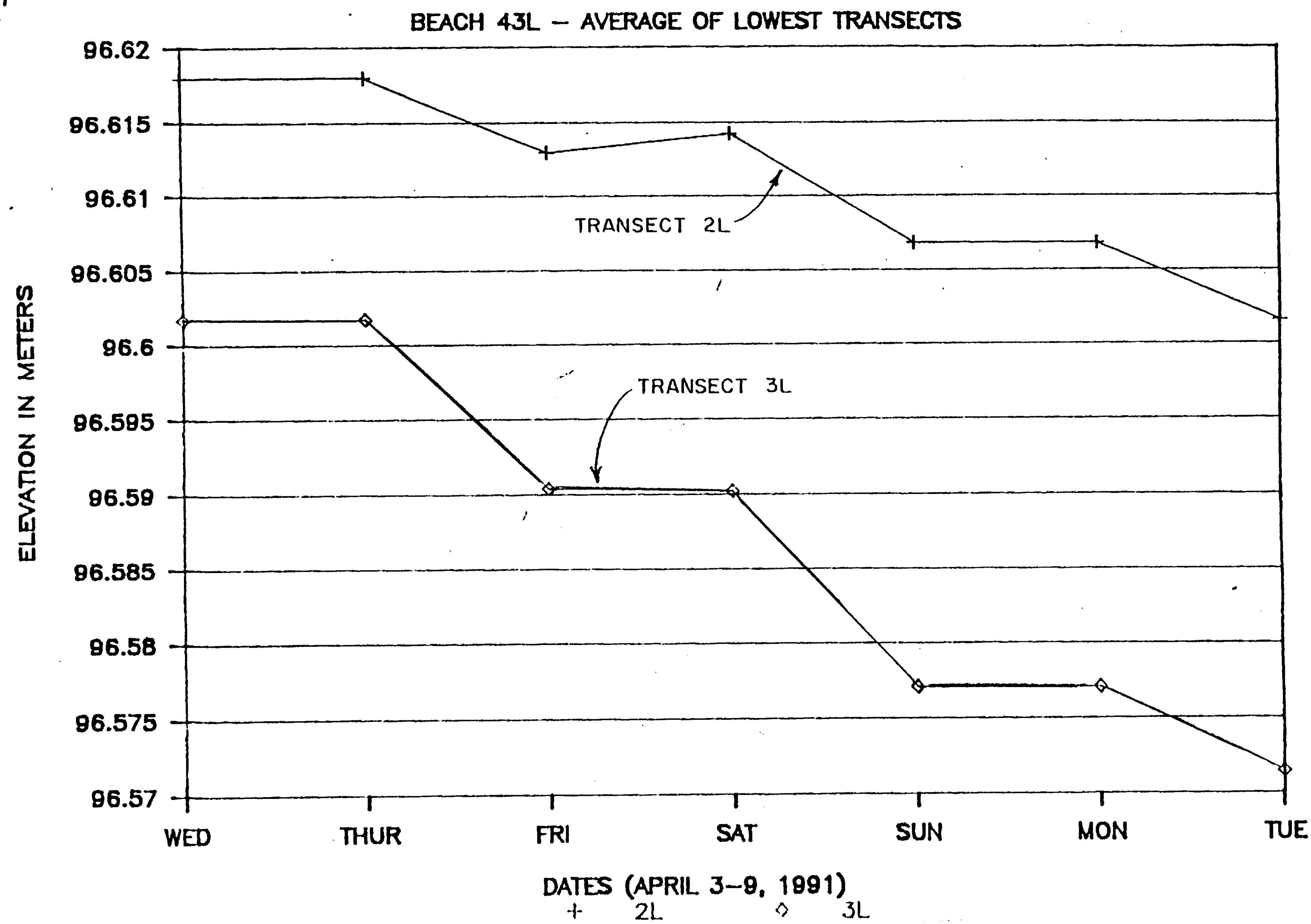

BEACH EROSION
HIGH
MED
LOW
0
1
2
3
(5,000)
(10,000)
(15,000)
DAILY CHANGE IN STAGE (M)
[Daily fluctuation (cfs)]
Approximation

FIGURE 9. GROUND ELEVATION DIFFERENTIAL GAGE



Department of Energy
Western Area Power Administration
P.O. Box 11606
Salt Lake City, UT 84147-0606

JUL 25 1991

Mr. Rick Gold
Assistant Regional Director
Bureau of Reclamation
125 State Street
Salt Lake City, UT 84147

Dear Rick,

This letter is to supplement our submittal of May 22, 1991, regarding interim releases from Glen Canyon Dam. Its purpose is to consolidate into one document the information in several letters sent to you subsequent to May 22.

Let me reiterate that it is our position that our May 22 concept of interim releases is consistent with the Secretary of the Interior's commitment to balance various resource responsibilities in the riverine corridor below Glen Canyon Dam. Also, given the status of data collection and analysis, it remains our view that making small operational adjustments and assessing the effects of such is the most prudent course of action available to the Secretary. Making large operational changes under the technical researchers' proposal or the Bureau of Reclamation's (Reclamation) "in-between" proposal may lead to unintended environmental consequences or mask the cause-and-effect relationships among dam operations, other factors (e.g., wind, people, presence of the dam) and recreational, cultural and ecological resources.

Not specifically addressed in our concept, but set forth in a supporting letter from Mr. Cliff Barrett of the Colorado River Energy Distributors Association, was the inclusion of non-operational measures as part of the protective measures to be adopted during the interim period. We continue to strongly believe that such non-operational measures represent reasonable opportunities to protect specific resources during this interim period and in the long run. In this interim period, consideration should be afforded to the relocation of rocks in the river channel to solve most or all of the trout stranding problems alleged to be caused by low flows. Destranding measures appear to be a reasonable management action that should be addressed in your NEPA compliance documentation and implemented. Similarly, stabilization of important cultural resource sites should be addressed in the NEPA documentation and subsequently implemented.

We have previously sent you letters dated July 18, 1991, and July 24, 1991, regarding "exception criteria" for interim releases. We are attaching our 7/24/91 draft "Interim Operating Procedures" and providing the following explanation of exception criteria for your inclusion into your submittal to the Secretary of the Interior.

Exception Criteria

In developing a recommendation to the Secretary of the Interior, Reclamation is charged with balancing all the Federal resources involved, including water, power and downstream resources. Reclamation already has recognized this balancing requirement by restricting discussion of possible interim water release restrictions from the dam to those that will not violate the Annual Operating Plan for the Colorado River. Reclamation has further recognized this balancing requirement as it relates to power, in part, by agreeing to some exception criteria to the 13 months of research releases that will conclude at the end of this month. These "exception criteria" (i.e., conditions under which Western could deviate from the research release parameters) were primarily limited to system emergencies and related functional requirements. As you know, Western agreed that every effort should be made to meet the research release requirements, and committed to that objective by purchasing and interchanging energy at significant additional cost. Even so, the exception criteria for research releases did include recognition of financial costs as one condition by which those releases could be rescheduled.

Now we are entering a new phase of the EIS schedule which includes setting interim operating parameters (limits) for daily and hourly water releases from the dam. The balancing of resources requires a continuation of the current exception criteria. Such balancing also requires consideration of other factors in exception criteria.

We believe that most or all of the other cooperating agencies should not object to exception criteria that preserves the reliability and integrity of the interconnected bulk electric power system of which Glen Canyon is a key component. Our obligations under North American Electric Reliability Council (NERC) operating criteria, Western Systems Coordinating Council (WSCC) operating criteria, and Inland Power Pool operating agreements are critical in ensuring the continuous delivery of electric power in the Western United States. Additionally, Western's utility responsibilities mandate that consideration be given to the adequacy, reliability, security, and safety of the CRSP, as well as to the interconnected system. If Western is denied the flexibility of meeting system integrity and reliability needs, then the repercussions of such denial can be severe. While we can continue to discuss and debate the financial and economic aspects of interim flow decisions, if Glen Canyon fails to respond to system operating requirements, and the system fails in part or in whole because of those constraints, then we have failed in our efforts to balance resources.

We are enclosing a list of incidents that have occurred over the past two years in which Glen Canyon Dam was called upon to assist in meeting an emergency condition on the interconnected bulk power system in the West. As you can see, Glen Canyon's response to these incidents lasted from a few minutes to several hours in length. We realize that this list is not very descriptive of the nature of the emergencies responded to. We have supplemented this list with a description of those conditions which could require significant and immediate changes in Glen Canyon generation. Please note that Glen Canyon's flexibility is extremely important in immediately responding to system disturbances and assisting in restoring system integrity.

What appears to be of most concern is exception criteria for financial reasons. Basically, this amounts to providing Western with the flexibility to avoid purchases of firm power to replace generation lost at Glen Canyon Dam because of interim operating criteria. Currently, we purchase nonfirm (interruptible) power to make up lost generation due to reduced water releases and, over the last 12 months, to facilitate research releases. We are able to purchase nonfirm power because we can demonstrate that Glen Canyon capacity was available in any hour to support our energy deliveries. If interim operating parameters are inviolate, then we will be unable to claim the capacity that, on occasion, would require releases in excess of interim operating parameters. The result will be that capacity (firm power) would need to be purchased at a considerably greater cost.

This additional flexibility in the exception criteria will produce substantial financial savings, stabilize CRSP cash flow to meet obligations, and do so without meaningful deviation from recreation and environmental protection goals. For instance, using the July 1 Reclamation proposal, financial impacts to CRSP power consumers could be reduced from about $20 million to the $2-6 million range. Such costs can be kept low and the risk of exceeding interim operating parameters can be minimized if it is clear to the rest of the utility industry that Western can use its installed capacity, as necessary.

It is worth emphasizing that Western intends to make every effort to operate within whatever parameters are implemented. We do not intend to use exception criteria as justification for arbitrarily violating the operating parameters. I also need to emphasize that even with exception criteria, Western's responsibilities under interim operating criteria will be a far cry from "business as usual" in meeting our contractual obligations. Our dispatchers will be challenged by the need to adhere to operating parameters significantly different and much more restrictive from what they have experienced in the past. The financial estimates provided below do not reflect the lost revenues associated with nonfirm sales, a substantial source of revenue to the Basin Fund which will be foregone under interim operating procedures. Similarly, Western's customers with delivery responsibilities will be required to incur an increased operating and financial risk which is not reflected in our financial estimates for implementing the various interim release concepts. Our customers will be required to preschedule their deliveries several days in advance instead of just one day in advance. In addition, they will be limited in their flexibility to request additional deliveries of power on an hour-by-hour basis. These constraints severely limit the flexibility of utilities to meet their customer loads, and require them to secure alternative (and likely more expensive) resources to meet load on a day-to-day basis.

Balancing consideration for all resources by allowing this additional flexibility under these defined circumstances retains the ability of the power system to meet its financial obligations and is compatible with goals for protection of downstream resources. It also enhances the probability of early implementation of interim operating procedures by substantially lessening the impacts of on power system reliability and costs which can be reflected in the NEPA compliance process for those parameters.

As you can see from the enclosed "Interim Operating Procedures" document, we have drafted it in the form of an agreement between Reclamation and Western, similar to the agreement for research releases. We have made a number of attempts to develop financial thresholds which will serve as decision rules in assessing whether interim releases constraints would need to be exceeded. However, in the final analysis, it is a cash flow problem over the next fiscal year. Therefore, we intend to use available revenues to operate within the adopted parameters.

Financial Assessment

Western's expected additional net expenses of implementing each of the interim flow concepts for FY 1992 are as follows. In each case, we have provided a range of costs.

Proposal	Concept with exception criteria	Concept without exception criteria
Technical Researchers'	$3,800,000	$29,800,000
Reclamation's "In-between"	1,600,000	21,200,000
Western's	400,000	6,800,000

The lower end of the range represents a situation in which Western has the benefit of full exception criteria; i.e., we have the ability to exceed interim flow parameters in order to avoid purchase of firm power to replace foregone generation. The higher end of the range represents a situation in which Western does not have the benefit of such exception criteria. Let me again point out that affording Western exception criteria for financial reasons is not tantamount to providing a license for frequent exceedence of the adopted interim criteria. With regard to the funding schedule attached to the "Interim Operating Procedures," we intend to provide a financial buffer so that the probability of exceeding the interim release parameters for financial reasons is minimized as much as practicable.

Sincerely,

Kenneth G. Maxey

Kenneth G. Maxey
Deputy Area Manager

Enclosures

cc:
Mr. Clifford I. Barrett
Executive Director
Colorado River Energy
Distributors Association
400 South 175 East, Suite 1000
Salt Lake City, UT 84111

Mr. Wayne Cook
Executive Director
Upper Colorado River Commission
355 South 400 East
Salt Lake City, UT 84111

DRAFT 07/25/91

CHANGES IN GENERATION AT GLEN CANYON

Significant changes in generation at Glen Canyon can be attributed to the following unusual conditions:

1. Loss of generation, either single or multiple units, within the Western Area Upper Colorado (WAUC) control area.

2. Scheduled or unscheduled loss of generation, either single or multiple units, outside of but interconnected with the WAUC control area, which results in the need for either schedule outage or emergency outage assistance.

3. Control area disturbances, such as loss of significant transmission element(s), which require implementation of remedial action schemes and reduction in WAUC generation.

4. Major WSCC system disturbances.

5. Changes (increase or decrease) in hourly import schedules associated with WAUC purchase power activities that occur at transition hours between on-peak and off-peak periods.

6. Humanitarian reasons.

The first condition may occur when (1) any one of three 428-MW Craig units is lost, or (2) the 420-MW Bonanza unit is lost and the WAUC must increase CRSP generation or increase imports within the hour to cover the change in schedule.

The second condition may occur when a member of the Inland Power Pool, such as Arizona Public Service, schedules maintenance on a significant generation unit or declares a system emergency due to an unscheduled outage and calls on WAUC to provide needed generation.

The third condition may occur when a significant CRSP transmission element, such as either one or both of the Glen Canyon-Flagstaff or one or both of the Flagstaff-Pinnacle Peak 345-kV lines, are removed from service by relay action. This relay action initiates a remedial action scheme which instantaneously reduces Glen Canyon generation to a predetermined level. This reduction could be as large as 1,000 MW (most severe) to 0 MW (no change). Likewise, this same type of scheme is utilized on the Bonanza-Mona 345-kV line which could create a lost of 428 MWs and affect Glen Canyon generation directly opposite to the aforementioned relay action.

The fourth condition may occur naturally due to components of the power system being stressed beyond their limits or by remedial action scheme. In either case, the interconnected electrical system of the WSCC becomes split or islanded causing two or more distinct electrical systems in the WSCC. Generally when this happens, heavy load areas (Southern California and Arizona) are isolated from heavy generation areas (Pacific Northwest, Colorado, Wyoming, Montana). When these conditions exist, Glen Canyon is generally isolated with the heavy load area and is used extensively to maintain service to and/or restore service to the Arizona/Southern California area. In these cases, Glen Canyon could swing from minimum generation levels to maximum plant capability responding to the WSCC system disturbance.

For the fifth condition, the frequency of change in Glen Canyon generation is primarily associated with the hydrologic conditions in the Upper Colorado River Basin at the time and the contractual firm (and other) load commitments. Under dry conditions such as occurred in 1988, it could be inferred that the frequency of hourly changes in Glen Canyon generation exceeding 200 MW per hour may be attributed to changes in import schedules. Under wet conditions when little or no flexibility exists to pattern water releases, it could be inferred that the frequency of hourly changes in Glen Canyon generation exceeding 200 MW per hour may be attributed to emergency conditions either within or outside of the WAUC control area.

The sixth condition may occur when a drowning or serious injury occurs to visitors within the canyon itself. The Glen Canyon generation may be reduced or increased significantly to facilitate the search, recovery, or rescue operations below Glen Canyon Dam.

DATE/TIME		CAUSE	UNITS TRIPPED	MW	OUTAGE LENGTH
6-4-88	1353	FLG-PPK #2	#8	140	4 min
7-19-88	1911	FLG-PPK #1	#1,3,4,7	360	15 min
8-2-88	1704	GC-FLG #1	#1,2,3	400	9 min
8-24-88	1524	GC-FLG #2	#1,3	285	9 min
11-15-88	1209	False Level 1 trip sig.	#4	90	25 min
11-16-88	2038	False Level 1 trip sig.	#2,3	280	5 min
1-4-89	1350	GC-FLG #2	#1	120	8 min
1-25-89	0904	FLG-PPK #2	#4	130	3 min
7-11-89	1612	GC-FLG #1	#1,2,8	460	17 min
7-17-89	1835	GC-FLG-PPK #2	#1,2,4,6	490	14 min
7-22-89	1227	GC-FLG #1	#1,2	190	11 min
7-23-89	1422	GC-FLG #2	#1,3	270	6 min
8-1-89	1544	GC-FLG #2	#2,4,6,7	480	6 min
8-15-89	2054	FLG-PPK #2	#1,2,3,6	460	EXTENDED
9-4-89	1304	Arcing Disc @ FLG	#1,2,3	340	EXTENDED
1-4-90	1255	Transformer fault @ PPK	#3,8	220	3 hr 19 min
1-5-90	1651	False transformer Diff @ PPK	#2,4	190	4 hr 6 min
1-24-90	0850	FLG-PPK #2	#5,7	280	2 hr 54 min
1-25-90	0931	FLG-PPK #2 (XFMR DIFF)	#1,8	260	2 hr 15 min
2-28-90	1346	Fire @ PPK on Cap Bank	#1,3,8	375	56 min
3-30-90	1300	PPK Transformer trouble	#1	120	3 hr 17 min
3-31-90	1646	GC-FLG #1 & 2	#1,5	210	12 min
4-25-90	1549	FLG-PPK #2	#1	90	4 min
5-1-90	1253	GC-FLG #1 & 2	#5,6	248	18 min
6-24-90	2056	FLG-PPK #1 (Xfmr trouble @ PPK)	#1,3	240	EXTENDED
7-2-90	1438	GC-FLG #2	#1,3,7	402	4 min
8-6-90	1849	PITT (Fires under 500kv lines in Calif.)	#8	135	8 hr 20 min
8-7-90	1836	" " " "	#7	140	1 hr 7 min
8-7-90	2110	" " " "	#8	100	1 hr 18 min
9-7-90	1518	PITT (Trouble @ BPA	#8	135	1 hr 19 min
9-23-90	1513	GC-FLG #2	#2	125	4 MIN
12-21-90	1437	FLG-PPK #1 & 2 (Xfmr @ PPK)	#3,5	205	2 hr 53 min
5-5-90	0907	GC-FLG-PPK #1 & 2	#4,5	185	1 hr 7 min
6-1-90	0512	GC-FLG-PPK #1 & 2	#4	90	2 hr 21 min

Other system trouble that would cause the Glen Canyon generation to fluctuate would be the loss of any of the steam units in the WAUC control area. These units are Craig unit 1, 2 & 3 which are rated at 425 MW each, Hayden units 1 & 2, rated at 184 and 262 MW respectively and Bonanza unit rated at 425 MW. The loss of any of WAUC's generating units would also cause Glen Canyon generation changes.
The response to system frequency excursions and the request by search and rescue units below Glen Canyon dam are other causes the generation at Glen Canyon will change.

Interim Operating Procedures Parameters

Beginning ______________, 1991, the following interim operating parameters will be implemented at Glen Canyon Dam in accordance with secretarial decision dated ____________, subject to the following conditions and provisions provided herein:

- Maximum Release
- Minimum Release
- Daily Fluctuation
- Ascending Ramp Rate
- Descending Ramp Rate

Power System Operations

As required pursuant to Western's firm electric service contractual commitments and according to North American Electrical Reliability Council (NERC)[1], Western Systems Coordinating Council (WSCC)[2], and the revised Inland Power Pool (IPP) operating agreement[3], adequate generating capacity must be available[4] to meet system regulation needs, maintain transmission reliability, maintain reserve requirements, and serve firm load requirements. If system capacity is deemed inoperable[5] due to a restriction in generation capability, and that restriction causes operating capacity to fall below what is required to serve hourly firm load commitments and/or reserve requirements, supplemental firm operating capacity must be acquired from another source.

Western shall have the ability to access Glen Canyon capacity, in order to claim it as operating capacity and operate within utility industry standards in order to avoid purchasing higher cost firm capacity for replacement power. Therefore, in order to at least meet minimum criteria to provide adequacy, reliability, and security of services, and to avoid large system capacity purchases, which would become necessary if the proposed Glen Canyon interim release parameters were adopted without exception, the following interim operating procedures at Glen Canyon will be implemented.

System Emergencies

Glen Canyon generation shall respond to all CRSP system emergencies, as well as to all applicable interconnected system emergencies[6] as currently defined by NERC, WSCC, or as required pursuant to the existing IPP Agreement. If there is a major system disturbance which requires change to Glen Canyon generation outside of interim operating procedures, Western will attempt to restore Glen Canyon generation to levels consistent with interim operating procedures parameters as soon as practicable. (Many times this can be accomplished within 15 minutes.) By-pass jets will be opened to restore the minimum release level only after it has been determined that generation cannot be restored within a 1-hour timeframe.

The Page Supervisory Control and Data Acquisition system will be the official measure of all interim release flows from Glen Canyon.

Regulation

Adequate generation will be provided for regulation purposes pursuant to current power system operation practices, and measured as an integrated value across the hour.

Operations Under Interim Operating Procedures Constraints

The shared objective of these interim operating procedures is to minimize the revenue and rate impacts on the Colorado River Basins Power Marketing Fund through the interim period, i.e., the period from the date of execution of these interim operating procedures until implementation of the Record of Decision in the Glen Canyon Dam EIS. A purchase power program totally dependent on nonfirm energy purchases results in a cost reduction of ____ percent over firm power purchases. The program will not be financially driven, but will use these cost estimates as its goal.

Western will make every effort to observe interim operating procedure parameters under system operating conditions. Pursuant to the conditions herein, Western will purchase nonfirm energy (interruptible without capacity) to satisfy its contractual energy requirements. Unloaded capacity at Glen Canyon shall be available so that energy purchases can be made on a nonfirm basis to avoid the higher cost of firm power purchases.

Changes to Glen Canyon generation which would deviate from interim release constraints will be made under the following conditions:

1. If access to or availability of any critical energy purchase supply does not exist or is lost or a loss of firm demand occurs, due to transmission-related limitations or any other physical conditions beyond Western's control; or

2. If potential violation of the Anti-Deficiency Act is likely or if availability of funds to Western for energy purchases does not exist for purchases needed to maintain interim releases; or

3. If the adequacy, reliability, security, or safety of the CRSP and/or interconnected system is jeopardized.

When analysis of future net expenses and available cash resources indicate the potential for violation of the Anti-Deficiency Act, appropriate measures, such as, but not limited to, rate adjustments, supplemental appropriations, and modified interim release constraints, would be taken so the year-end balance in the Colorado River Basins Power Marketing Fund is not deficient.

For purposes of determining the adequacy of funds, the attached monthly estimated expense summary, Schedule A, will be used as an established guideline for monthly nonfirm energy purchases. This schedule A will be revised annually. If actual expenses, together with future estimated expenses, exceed the estimate of available funds, Western shall call on unloaded capacity at Glen Canyon, within available water supply, to avoid violation of the Anti-Deficiency Act.

Coordination and Reporting

On a quarterly basis, the Area Manager of Western and the Regional Director of Reclamation will meet to discuss interim releases and the effects of the releases on the proposed purchase power budget as listed on "Schedule A" as attached. Operational communications between Western and Reclamation will continue as currently reported through daily morning reports submitted by Western. These morning reports list any system disturbances which may have affected Glen Canyon operations during the interim release period.

Safety

Human safety will not be compromised in order to preserve interim release requirements.

Concur:

By: ______________________________
Lloyd Greiner, Area Manager
Western Area Power Administration

By: ______________________________
Roland Robison, Regional Director
Bureau of Reclamation

L6300:JMcCoy:dw:x5399:07/16/91
Revised:07/16/91:dw
Revised:07/17/91:dw
Revised:07/23/91:dw
Revised:07/24/91:dw
PMO:JAMTEMP

Schedule A

Estimated Expense Summary

FY 1992
($ x 1000)

Month	Purchase Power Expense ($)	Cumulative Purchase Power Expense ($)
October		
November		
December		
January		
February		
March		
April		
May		
June		
July		
August		
September		
TOTAL		

ENDNOTES

1. Includes NERC operating guides, control performance criteria, and the minimum criteria for operating reliability. January 1, 1990.

2. WSCC Operational Guidelines and Minimum Operating Criteria.

3. Revised Inland Power Pool Agreement, November 23, 1983.

4. Available capacity is operable capacity (i.e., total installed capacity less inoperable capacity) expected to be available during peak periods without restrictions.

5. Inoperable capacity is capacity expected to be unavailable for an undetermined length of time due to: environmental restriction legal or regulatory restriction; extensive and/or lengthy modifications repair or "mothballing"; known transmission limitations, and/or derating due to the planned postponement of the repair of a failed component. Capacity and Demand Concepts and Reporting Procedures, January 1987.

6. Guide III Emergency operations NERC Operation Manual, January 1, 1990.

July 24, 1991

ANALYSIS OF VARIOUS CHANNEL CROSS-SECTIONS IN THE LEES FERRY - LITTLE COLORADO REACH

RANDY PETERSON, BUREAU OF RECLAMATION

The small scientific group consulted by Dr. Duncan Patten and Dave Wegner in response to a request for interim flow recommendations gave as their best judgment constraints on fluctuations, maximums, minimums, and ramp rates to limit ecological degradation downstream of Glen Canyon Dam. Subsequent analyses have estimated the resulting impacts from various magnitudes of constraints with respect to main channel sediment transport and beach degradation while many of the resources have not been numerically evaluated due a current lack of finalized data.

Differences in main channel transport between the various proposals are relatively minor, but estimated beach erosion has shown perhaps significant differences. With a very limited amount of data currently available (1 week of measurements at the water's edge on 1 beach), release fluctuations of 5,000 cfs in the flow range of 5,000 to 10,000 cfs seem to have negligible effect on beach degradation. Stage changes of about 3 feet were observed at beach 43-L that corresponded to these release fluctuations.

Dr. Patten's statement this week that such stage changes are likely to be the controlling factor rather than absolute cfs has led to an evaluation of the change in allowable fluctuation levels that occur as the mean flow level increases. This change occurs as a result of an expanding top width as the depth of the cross-section increases. Thus, at higher mean river stages, fluctuations of 5,000 cfs produce a smaller stage change than it does at lower mean flow levels.

The attached spreadsheet lists these changes for 7 different cross-sections in the Lees Ferry - Little Colorado River reach of the Colorado River. These sections were graciously provided by Bob Hart of the U.S. Geological Survey. The canyon consists of a wide variety of cross-section types and these estimates provide both an absolute and a relative comparison with the stage impacts of the previous recommendation of a 5,000 cfs limit on daily fluctuations.

Rating curve were prepared at these sites using the SSARR routing model calibrated for the Phase 1 report. Historic data from February and March 1991 were used in conjunction with USGS-collected stage data at these sites, and a geometric regression (average R^2 of 0.995) produced the attached curves. "Typical" release hydrographs were constructed using the fluctuation parameters listed on the attached table, down ramp rates of 1,500 cfs/hr, up ramp rates of 2,000 cfs/hr, minimum flows of 5,000 cfs, and maximum flows of 20,000 cfs. These hydrographs were routed downstream and the resulting flow fluctuations at each of the cross-sections were estimated using a linear decay with distance between the calibrated gauges at Lees Ferry and Little Colorado River.

The maximum/minimum flows at these sites were applied to the constructed rating tables, producing maximum and minimum stages as well as total changes in stage. This approach produced the following conclusions:

1. Release hydrographs varying between 5,000 and 10,000 cfs would likely occur during monthly volumes less than 500,000 acre-feet unless much of the day were spent at 10,000 cfs, producing little fluctuations. Monthly volumes of this magnitude are

currently avoided due to the environmental impact of sustained low flows. A more likely release scenario would be releases in the 550,000 to 600,000 acre-feet range and is illustrated in the 7,000 to 13,000 cfs scenario. This fluctuating scenario produces changes of 6,000 cfs and results in slightly higher stage changes at all sites than does the base case of 5,000 to 10,000 cfs releases.

It is therefore recommended that low volume months be constrained to total daily fluctuations of 5,000 cfs, consistent with the scientific recommendation.

2. Medium volumes months, about 750,000 acre-feet, are typified by the 8,000 to 16,000 cfs scenario and the 10,000 to 16,000 cfs scenario. The scenario with the 8,000 cfs daily fluctuation shows increased stage change at all sites, while the 6,000 cfs daily fluctuation scenario shows stage changes both slightly lower and slightly higher than the base case depending on the particular cross-section. It would therefore seem appropriate that for these types of months, allowable fluctuations of 6,000 to 7,000 cfs would be consistent with the scientific recommendation.

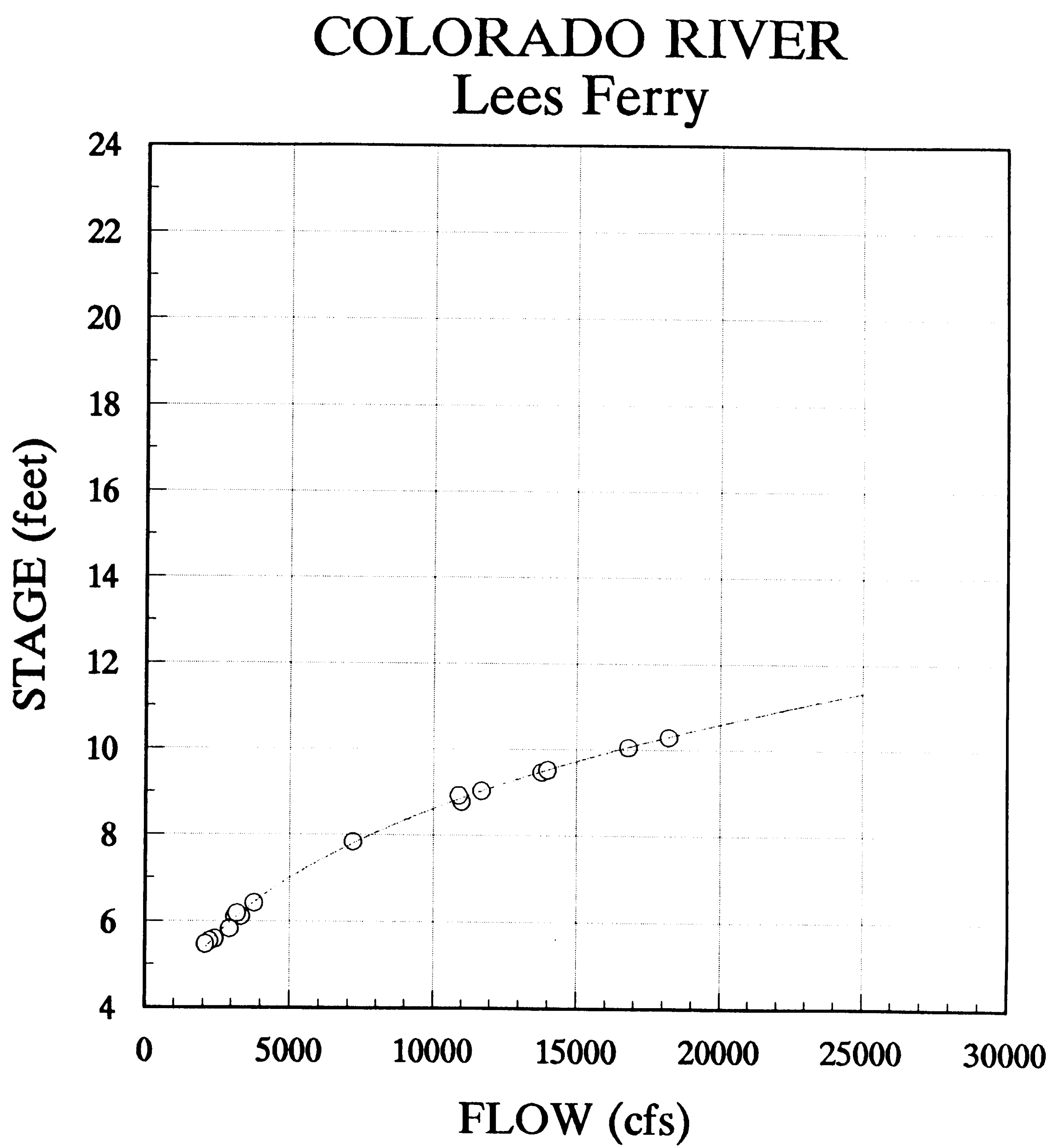
3. For high volume months, the 10,000 to 20,000 cfs scenario and the 12,000 to 20,000 cfs scenario illustrate the impacts of increased allowable fluctuation. The 10,000 cfs fluctuation produces higher fluctuations at all sites while the 8,000 cfs fluctuation produces greater stage changes at 4 sites and lower stage changes at 3 sites. It is recommended that 8,000 cfs be established as the upper limit for high volume months. Bob McNish of the USGS recently recommended that up to 10,000 cfs daily fluctuation could be allowed based on an analysis of the Lees Ferry and LCR gauge rating curves. It appears that the use of only these two sites would produce a liberal estimate of allowable fluctuation in light of the other cross-sections and we feel that this analysis provides a more representative sample of the canyon geometry. We agree with Bob's premise that this type of approach is the correct way to look at allowable fluctuations at various mean river flows.

4. It is important to recognize that such idealistic modeling does not account for the daily variations that will occur during interim flows due to changing firm load. The EDF peak shaving algorithm should be used in conjunction with SSARR routings and the beach response curve to exactly define the expected beach impacts once the beach degradation report is published this fall. Already completed modeling has found that differences in interim flow alternatives are much smaller than expected when analyses are prepared assuming an idealized release pattern.

Since the beach degradation issue has risen to the highest priority with respect to interim flows, it will be important to accurately assess the expected level of resource protection afforded by the enacted powerplant release constraints.

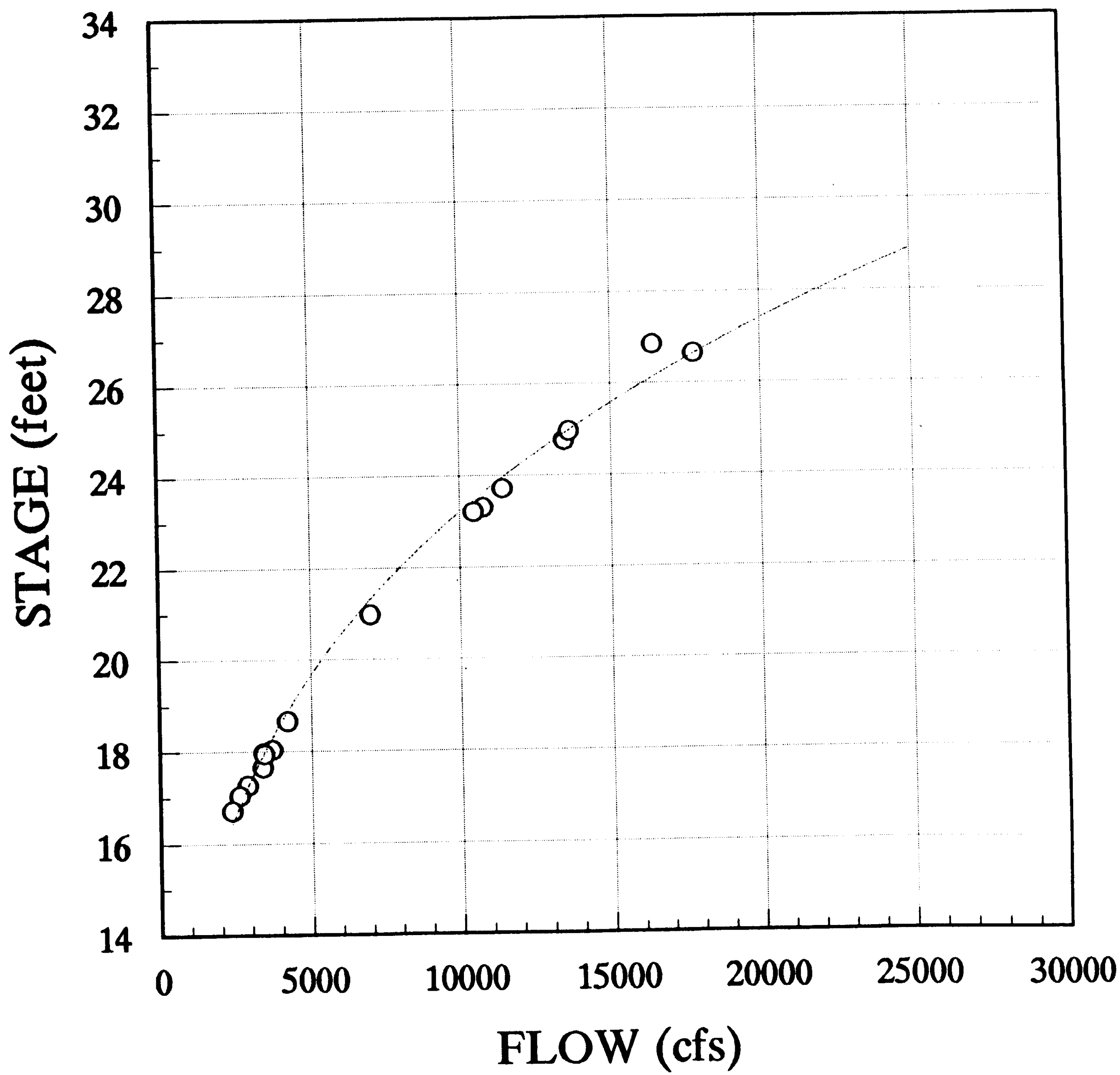
FLOW AND STAGE CHANGES RESULTING FROM FLUCTUATING POWERPLANT RELEASES
GLEN CANYON DAM

	LEES FERRY	10 MILE	15 MILE	30 MILE	45 MILE	55 MILE	LITTLE COLORADO RIVER
5K - 10K SCENARIO							
CFS	4760	4547	4440	4121	3800	3590	3740
STAGE	1.51	3.15	3.72	3.32	2.23	1.6	1.78
7K - 13K SCENARIO							
CFS	5880	5660	5553	5227	4900	4680	4530
STAGE	1.55	3.22	4.26	3.84	2.55	1.81	1.93
10K - 16K SCENARIO							
CFS	5700	5475	5360	5025	4685	4460	4300
STAGE	1.24	2.55	3.75	3.33	2.14	2.02	1.48
8K - 16K SCENARIO							
CFS	7800	7555	7430	7064	6700	6450	6280
STAGE	1.81	3.72	5.33	4.81	3.11	2.17	2.21
10K - 20K SCENARIO							
CFS	9700	9390	9241	8780	8320	8015	7800
STAGE	1.92	3.93	6.16	5.52	3.47	2.36	2.30
12K - 20K SCENARIO							
CFS	7800	7575	7460	7110	6785	6560	6400
STAGE	1.47	3.00	4.83	4.33	2.72	2.17	1.77

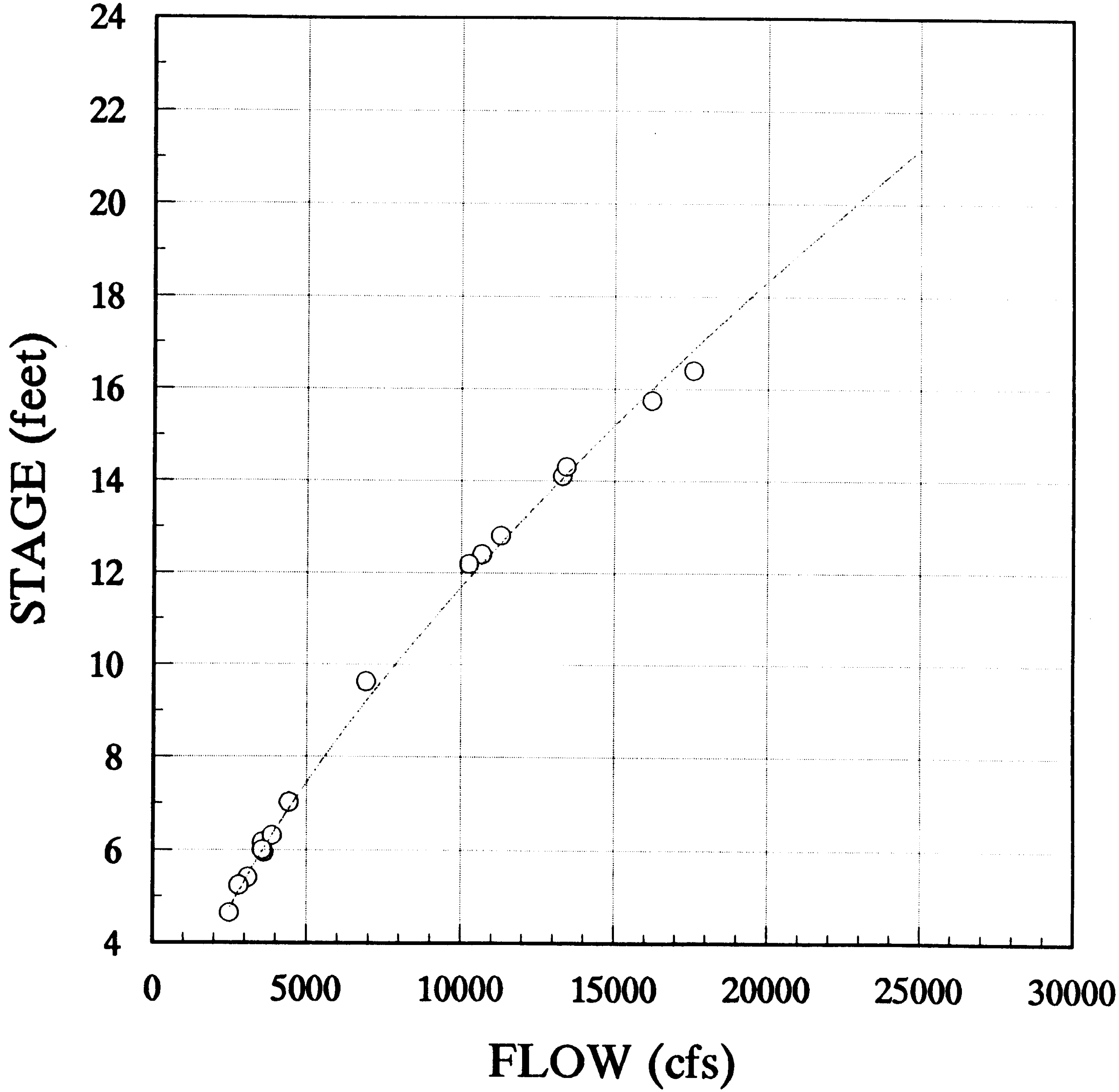


COLORADO RIVER
Lees Ferry
STAGE (feet)
24
22
20
18
16
14
12
10
8
6
4
FLOW (cfs)
0
5000
10000
15000
20000
25000
30000

COLORADO RIVER
River Mile 10

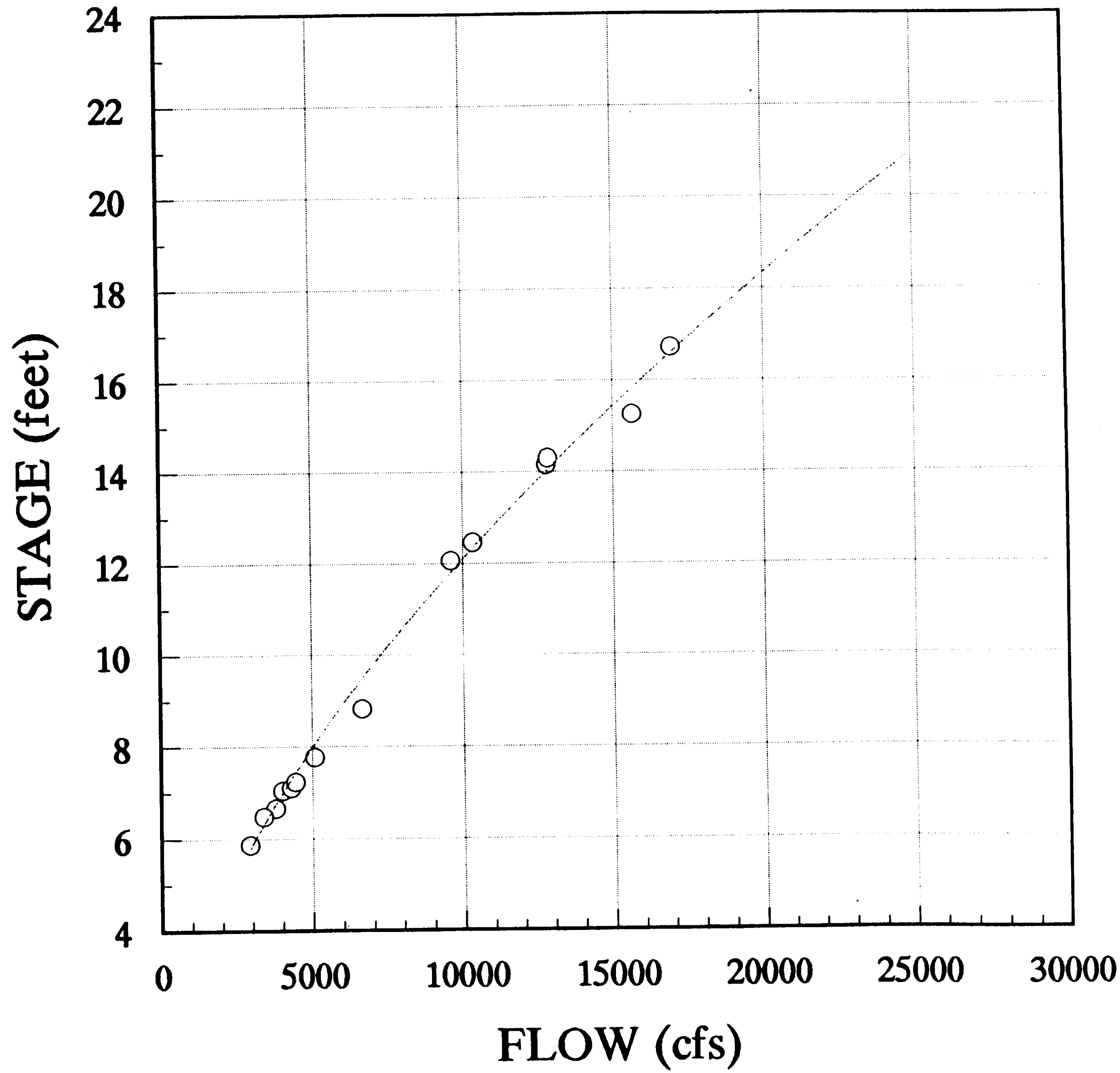


COLORADO RIVER
River Mile 15

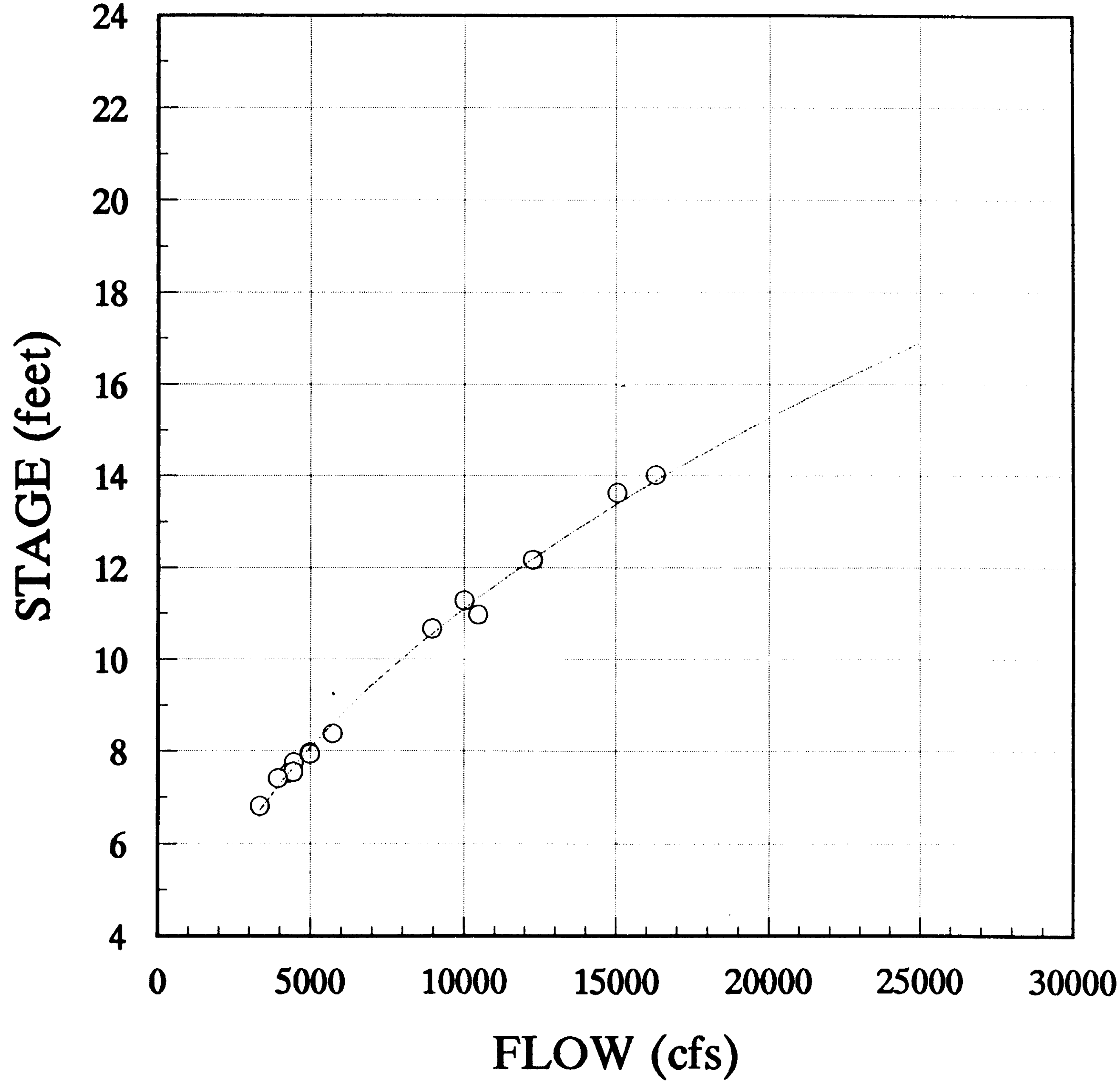


7

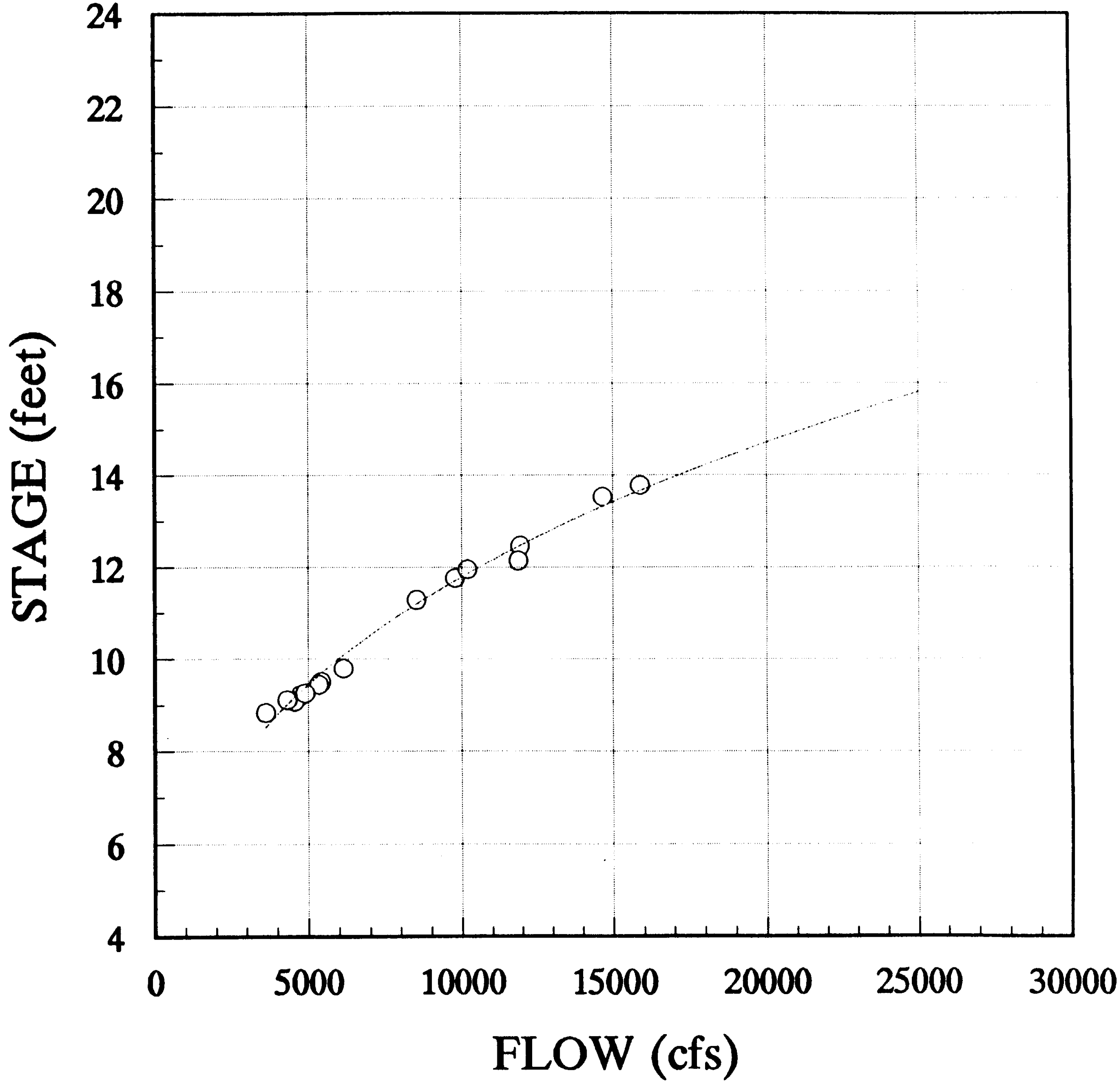
COLORADO RIVER
River Mile 30

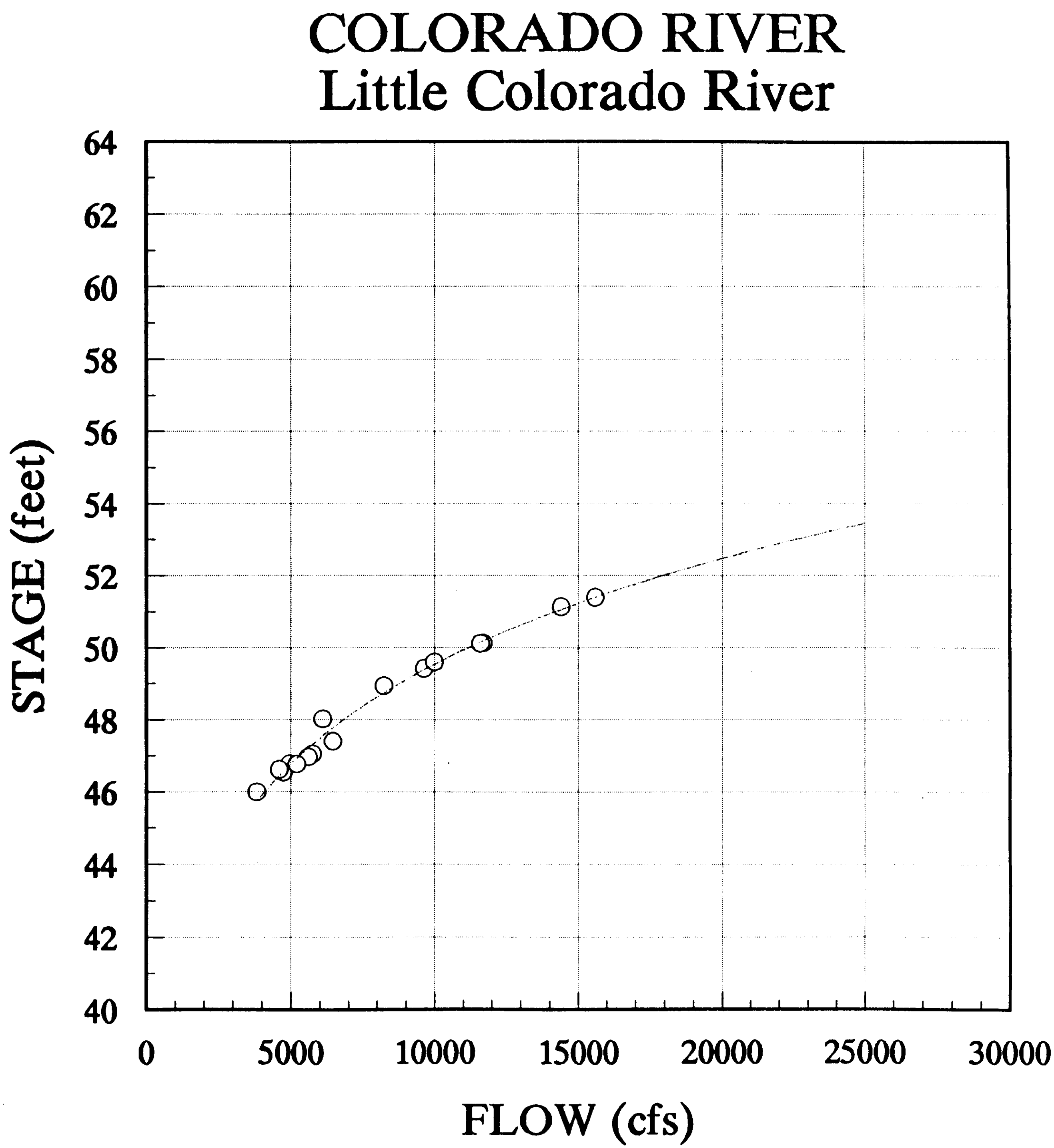


COLORADO RIVER
River Mile 45



COLORADO RIVER
River Mile 55





COLORADO RIVER
Little Colorado River
STAGE (feet)
64
62
60
58
56
54
52
50
48
46
44
42
40
0
5000
10000
15000
20000
25000
30000
FLOW (cfs)