PRELIMINARY SUBJECT TO REVIEW

IMPACTS OF THE GLEN CANYON DAM BEACH/HABITAT BUILDING FLOW ON RECREATION AND HYDROPOWER

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ABSTRACT

The Beach/Habitat-Building Flow (BHBF) of 1996 had relatively little impact on annual recreation use, whitewater boating safety, the net economic value of recreation or the regional economy. The BHBF had no effect on whitewater boating use and no significant difference in boating safety was observed. During the 8 days when flows exceeded powerplant capacity, day use rafting was suspended and angling was largely curtailed. The income of some local businesses which depend on anglers and day use rafters was adversely affected by the BHBF. However local expenditures by researchers, government officials, and the press more than offset these losses to the regional economy. The BHBF affected the hydropower system not only during the event itself but also during the remainder of water year 1996. The BHBF reduced the economic value of the hydropower generated at Glen Canyon Dam by $2.52 million or 3.3 percent. In addition, research associated with the test flow cost an additional $1.5 million. Future BHBF's may have more or less effect depending on their timing and design.

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INTRODUCTION

This chapter describes the physical and economic impacts of the Glen Canyon Dam beach/habitat-building test flow (BHBF) on two disparate activities; recreation and the production of hydropower. The timing of the BHBF was carefully planned to avoid the high use recreation season. Consequently, little recreational impact was expected and only limited resources were devoted to primary studies. Conversely, the experimental test flow affected hydropower production not only during the experiment itself, but also across most of water year 1996.

RECREATION

The principal recreation activities affected by the BHBF were fishing, day use rafting and white-water boating. The physical effects on these pursuits resulted in changes in their economic value and affected regional economic activity.

Fishing

The present aquatic ecosystem below Glen Canyon Dam is the result of complex interactions between released water, habitat, and the native and non-native organisms that inhabit it. The biological foundation of the aquatic system is *Cladophora glomerata*, a filamentous green algae. River conditions created by the dam make possible the abundant growth of *Cladophora*. Together, *Cladophora*, diatoms, associated invertebrates particularly the freshwater shrimp, *Gammarus lacustris*, and various insects provide an important food source for other organisms in the aquatic food chain. Both native and non-native fish, as well as terrestrial organisms, depend on this food base.

These postdam conditions, including the *Cladophora-Gammarus* food chain, support a blue ribbon non-native rainbow trout fishery in the Glen Canyon reach and for some distance downstream.

Fishing in Glen Canyon occurs mostly from boats, but some anglers wade in the area around Lee's Ferry. High velocity flows and rapid increases in river stage may place these wading anglers at risk.

The number of anglers affected by the test flow was estimated to be relatively small—approximately 3% of the annual use over the 8-day high flow period (Reclamation 1996). Increased water velocity during the test flow made boat handling and wading markedly more difficult. However, advance publicity, onsite warnings provided by management agencies, and the obvious nature of the test flows allowed anglers to make personal assessments of danger during this period. No wading or fishing boat accidents are known to have been reported during the BHBF.

Fishing quality, as measured by the number of fish caught, was affected by the BHBF. The nature and extent of this impact, if any, remains the subject of discussion. During the 4 days of low steady flows preceding and following the 45,000 cfs release, angling success was quite good. During the high release, high water velocities, increased stream width, and extremely turbid conditions made angling difficult. Angler success was substantially reduced and at least one company canceled all guided fishing trips during this period (Gunn 1996a).

It was feared the test flow would cause downstream displacement of larval and juvenile trout, adversely affecting the future population of catchable-size trout. However, there was no immediate negative impact on the distribution, density, and health of the non-native trout fishery in Glen Canyon. A subsequent localized decline in the condition of some fish was noted, although this was followed by relatively rapid recovery (McKinney, et al. 1996).

It was postulated the test flow would cause a decrease in the abundance and distribution of the food sources preferred by trout. Evidence suggests the standing stock of *Cladophora* and the associated populations of *Gammarus* were initially reduced. However, populations returned to pre-test flow levels within a short time after the event (McKinney, et al. 1996).

Day use rafting

Day use rafting takes place in the reach from Glen Canyon Dam down to Lee's Ferry. These are primarily flatwater scenic trips and only flows above 33,200 cfs affect their quality (Bishop et al.

1987). During these rare floodflows, use of dam outlet works and/or spillways prevents launching from the site below the dam. Day use rafters must motor upstream from Lee's Ferry and then float back down to the starting point, which reduces the trip quality for many users.

Relatively few day use rafters (less than 1% of the annual total) were affected by the BHBF (Reclamation 1996). During the 8 day high flow period, the outlet works were in constant use. This precluded launching day use rafting trips from dam. Trips could have been launched from Lee's Ferry and boats moved upstream under power. However, the concessionaire chose to suspend all trips during this period (Crane 1996).

White-water boating

White-water boating in the Grand Canyon is world renowned. Private boaters typically must wait for 10 years or more before obtaining a permit to run the Grand Canyon.

Approximately 148 commercial white-water boaters (approximately 0.7 percent of the 1996 total) and 116 private white-water boaters (approximately 3.3 percent of the 1996 total) were on the river during the high flow portion of the BHBF (Jalbert 1997). Private boaters were notified in advance if their trip coincided with the BHBF. The National Park Service (NPS) did not allow parties to change their dates (Cherry, verbal communication 1995). But, as described by Sides (1996), at least some boaters sought out the opportunity to experience the high flows.

White-water trip safety depends both on flow levels and on the timing and variation in river stage. Very low flows may make some rapids impassable, and very high flows may create additional risks of capsizing.

It was hypothesized that the safety of white-water boating would decrease somewhat during the test flow. Water velocities would be much higher, and the size and strength of some waves would greatly increase. At other locations, increases in river stage would "wash out" some rapids and make white-water boating safer.

The safety of the approximately 23,289 white-water boaters (1996 total usage) who annually take trips within the Canyon is a concern of the NPS and there have been several previous studies of boating safety (Brown and Hahn 1988, Underhill, Hoffman, and Borkan 1988). The BHBF represented a unique opportunity to collect data outside of the flow range of these existing studies. During the high flow portion of the BHBF there were 18 trips with approximately 264 people on the river. Of these, 7 were commercial trips and 11 were private trips. After analyzing a sample of observed and reported boating accidents for the high flow period, Jalbert (1996) concluded that although there was a relationship between certain accident variables and trip management actions, the accident rate during the BHBF was not significantly different from the accident rate under a normal range of flows.

Several studies have shown the wilderness characteristics of white-water boating trips in the Grand Canyon are influenced by fluctuating river stages and by the conditions of beaches, vegetation, and other features of the riparian zone (Shelby, Brown, and Baumgartner 1992, et al.

1995). High flows and large fluctuations in river stage limit usable beaches by completely inundating some and reducing the usable area of others. Useable camping beach area is particularly limited in narrow reaches of the canyon (Kearsley, Schmidt, and Warren 1994).

As described in elsewhere in this issue, during the BHBF, sand was scoured from the deepest part of the channel and eddies and deposited along the channel margins. Some new sandbars were created, some sandbars increased in size, some remained essentially unchanged, and some sandbars decreased in size. Some riparian vegetation was scoured from sediment deposits. Other vegetation was buried under new sediment deposits. Of the camping beaches assessed, 50% increased in size, 39% remained the same, and 11% were reduced in size (Kearsley 1997). Similar results were reported by Thompson, Burke, and Potochnik (1997).

Jalbert (1996) concluded the BHBF enhanced the overall quality of the visitor experience for most users. The NPS cannot eliminate or control risks in a wilderness setting but can provide information on general conditions and potential risks. Jalbert recommended that internal NPS policies on trip scheduling and education be adapted for management flows outside the normal range of powerplant operations.

Net economic value of recreation

Net economic value, a measure of the value over and above the costs of participating in a recreation activity, is related to the number of recreationists who participate in each activity, the time of year in which they participate, and the value of each trip taken.

In the absence of the BHBF, the net economic value of recreation in Glen and Grand Canyons during water year 1996 was estimated to be $12.9 million (1995 nominal dollars) (Reclamation 1996). Because resources were limited and since little change in the annual net economic value of recreation was expected, no primary were undertaken.

The BHBF was scheduled in March and April, in part, to avoid impacts during the summer when recreation is at its peak. As anticipated, only a relatively small number of private and commercial white-water boating trips were on the river during the high flow period. While there was surely some effect on individual trip value, only a relatively small number of individuals comprising a small percentage of annual use were involved. This suggests that any change in the annual net economic value of white-water boating was quite limited.

High flows during the BHBF did have adverse effects on both the quality of angling and the number of anglers in the Glen Canyon reach. Conversely, angling during the 4 days before and after the event was much better than average. Ascertaining the resulting direction and magnitude of the net effect on economic value, if any, would be problematic.

Regional economic activity

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

The regional economic activity that results from nonresident anglers, white-water boaters, and day rafters who visit the region has been estimated (USDI 1995) at approximately $25.7 million (1995 nominal dollars). As discussed in Douglas and Harpman (1995), recreational use in the region comprised of Coconino and Mojave Counties supports approximately 585 jobs. Of this total, there are approximately 21 licensed fishing guides (Gunn 1996b).

During the 8 days of high flows, little if any angling took place and all day use rafting was suspended. This change in recreation use had an adverse effect on regional economic activity. Based on 1991 nonresident recreation use, and assumpting these recreators did not visit at any other time of the year, approximately 328 (1% of annual) fewer day rafting trips and 308 (3% of annual) fewer fishing trips resulted. Applying the 1991 per trip expenditures (USDI 1995) to this change in visitation and using the appropriate Consumer Price Index (1.114) indicates that lost recreational expenditures could have approximated $100,000 (1995 nominal dollars).

During water year 1996, research activities associated with the test flow resulted in an increase in regional economic activity. As described in Reclamation (1996), research expenditures for the BHBF totaled approximately $1.5 million. A substantial portion of this sum was spent in the region by locally based researchers, institutions, and contractors. In addition, members of the press, Government officials, and other researchers stayed in the area during the test flow. Consequently, although some sectors and specific business establishments were adversely affected, the net effect of the test flow on regional economic activity was positive.

HYDROPOWER

Glen Canyon Dam and Powerplant are part of the Colorado River Storage Project (CRSP), one of the Federal projects from which Western Area Power Administration (Western) markets power. Glen Canyon Dam generates approximately 70% of total CRSP power.

The total annual amount of energy produced by the dam is based on actual water conditions. Western's Salt Lake City Area Integrated Project (SLCA/IP) annually markets more than 4 billion kilowatt hours (kWhr) from Glen Canyon Powerplant to 198 entities principally in the six-state area shown in figure **.

Figure ** goes here

Hydropower plants such as Glen Canyon can generate electricity without causing air pollution or using nonrenewable fuels. In addition, they are able to rapidly change generation levels to satisfy changes in the demand for electricity. This capability is termed "load following."

Power is most valuable when it's most in demand—during the day when people are awake and industry and businesses are operating. Water from Glen Canyon Dam is used for load following as much as possible, particularly during this onpeak period of the day. For purposes of this analysis, the onpeak period is defined as the hours from 7 a.m. to 11 p.m.

There are approximately 5.6 million end use retail consumers (residential, agricultural, commercial, and industrial) in the six-state area where power from Glen Canyon Powerplant is sold. Approximately 3.9 million (70%) of these end users do not receive power from the dam. Nearly 1.3 million (23% of the total) end users are served by large systems that have their own generation capability and rely on Federal power for a relatively small proportion of their energy needs. The remaining 0.4 million (7% of the total) end users are served by small systems that rely heavily on Federal power to supply their needs.

Water year 1996 monthly release volumes from Glen Canyon Dam were planned at the beginning of the water year during the AOP process (Reclamation 1995b). The actual monthly release volumes during water year 1996 are listed in Table 2; hourly operations were restricted under interim flows as described in table 1.

Table ** (interim flow criteria) goes here

Several features of the BHBF affected power operations at Glen Canyon Dam. The resulting impacts can be categorized into two periods: impacts during the months the test flow occurred and impacts during the other months in the water year.

There were four sources of impact during the test flow period itself. First, during the 4 days of steady flows preceding the high release, on average, less power was generated than needed to supply firm load (see Chapter ** figure 2). Second, during the high release, the outlet works were used to release flows in excess of 30,000 cfs, bypassing the powerplant. Water released through the outlet works is considered "spilled" and is unavailable to produce electricity at Glen Canyon Dam. In Chapter ** figure 2, all releases above the 30,000-cfs line are considered spilled. Third, during the high release, more power was generated than needed to supply system firm load. Finally, during the 4 days of steady flows following the high release, on average, less power was generated than needed to supply firm load (see Chapter ** figure 2).

Impacts on the power system also occurred during the other months in water year 1996. These impacts resulted because water volumes were shifted from the months of January and February to March and April for the test flow. There were also differences in monthly release volumes following the BHBF (see Harpman 1997). From a power perspective, the resulting pattern of monthly release volumes was less desirable. For example, with the BHBF, there was less water available in January—a peak power demand month—than there would have been without the BHBF.

Both an economic and a financial analysis of BHBF impacts were conducted by Reclamation. For purposes of this publication, only the economic impacts of the BHBF are described.

Extensive discussions of the (financial) impacts on Western's revenue, potential rate impacts, and the role of the Grand Canyon Protection Act of 1992 in determining these financial impacts are found in Reclamation (1996) and Harpman (1997).

Economic impacts are the dollar value of real resources committed by the United States as a result of the test flow, including the additional use of fuels such as gas and coal. The economic analysis described here illustrates the estimated cost of the BHBF to the citizens of the United States. Explicitly omitted from this, and all economic analyses, is consideration of investments made prior to the period of analysis. These expenditures are considered sunk or fixed costs. This concept is relevant to the short-term analysis presented here because the price of replacement power may contain both a fixed and a variable cost component. The fixed cost component of replacement power is a prorated sunk cost. This component of the cost of purchased power was excluded from the economic analysis through the use of spot market prices which reflect only the variable cost of generation.

A rather extensive *ex post* analysis of the impacts of the BHBF on the power system was undertaken by Harpman (1997) who employed a constrained optimization framework to simulate the short-run economic impacts of the BHBF using market based prices. Using the procedures described there, the hourly pattern of generation both with and without the BHBF was simulated for water year 1996. A summary of monthly generation for both the with and without test flow cases is shown in table ***.

Table ** (energy table) goes here

As shown in table **, approximately 109,000 MWhr (2 percent) less energy was generated due to the BHBF. The difference between the simulated generation with and without the BHBF reflects the approximately 217,000 acre-feet of water spilled during the test flow.

As shown in Table **, compared to the without BHBF case, there was no economic impact from the test flow during the months of October, November, and December. Compared to the without BHBF case, additional economic costs were incurred during the months of January, February, July, August, and September. The costs during these months resulted from unfavorable shifts in monthly release volumes. Economic benefits were realized during the months of March, April, May and June, primarily due to additional spot market sales during these months. As discussed in previous and subsequent sections of this report, compared to the without BHBF case, additional releases were made during the months of April, May, and June. This resulted in additional generation in these 3 months. Unfortunately, these releases were made in lieu of releases in July and August which are peak power demand months. Consequently, these additional releases had a marked economic impact.

Across the water year, the economic cost of the test flow was $2.52 million. This represents a 3.3% reduction in the economic value of the power produced at Glen Canyon during water year 1996. This estimate reflects the opportunity cost of generating lost onpeak and offpeak energy at other existing powerplants.

Table ** (economic impacts) goes here

The costs of research are not included in table **. Although not discussed here, research on the physical and biological effects of this experiment is estimated to have cost an additional $1.5 million.

CONCLUSIONS

The BHBF of 1996 was conducted to test hypotheses about the dynamic nature of geomorphic processes and the aquatic and terrestrial habitats which are dependent on them. This experiment provided an unparalleled opportunity to measure large river sediment erosion, transport, and deposition processes, to observe the effects on the aquatic and terrestrial ecosystems, and to measure the economic effects of a controlled flood event on the power system. By design, this experiment had limited impact on recreation. Nonetheless, there were temporary but locally significant effects particularly on anglers, day use rafters, and related business. The BHBF reduced the economic value of the hydropower generated at Glen Canyon Dam by $2.52 million or 3.3 percent. In addition, the research detailed in this issue cost an additional $1.5 million. Depending on the design of future beach/habitat-building flows, the effects on the recreation sector and on hydropower production may be less than or greater than those of the water year 1996 experiment.

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Table **. Energy Generated at Glen Canyon Dam by Month With and Without the Test Flow.

	Without Test Flow (MWhr)	With Test Flow (MWhr)	Change From Without (MWhr)
October	443,326	443,326	0
November	423,264	423,264	0
December	448,163	448,163	0
January	534,911	473,458	(61,453)
February	459,489	391,779	(67,710)
March	410,050	462,118	52,068
April	399,249	505,826	106,577
May	479,833	514,776	34,943
June	498,441	512,375	13,934
July	546,303	486,923	(59,380)
August	540,755	447,603	(93,152)
September	440,008	404,846	(35,162)
TOTAL	5,623,792	5,514,457	(109,335)

Table **. Economic Impact of Test Flow.

	Without Test Flow ($)	With Test Flow ($)	Change ($)
October	5,996,602	5,996,602	0
November	5,493,721	5,493,721	0
December	4,820,530	4,820,530	0
January	7,062,147	6,261,675	(800,472)
February	5,157,175	4,425,779	(731,396)
March	4,292,289	4,861,921	569,632
April	4,889,132	6,126,815	1,237,683
May	5,239,161	5,646,230	407,069
June	6,213,590	6,388,805	175,215
July	8,999,129	8,015,148	(983,982)
August	10,671,828	8,849,360	(1,822,468)
September	6,908,529	6,337,683	(570,846)
TOTAL	75,743,833	73,224,268	(2,519,564)

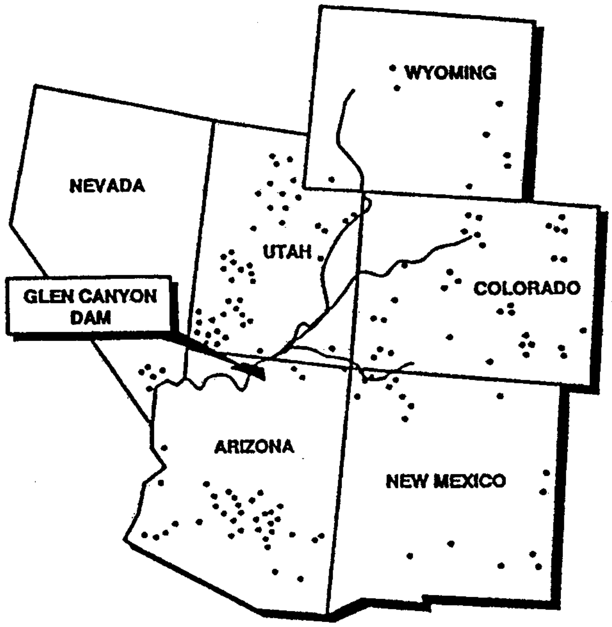

*Figure **.—Power from Glen Canyon Dam is sold over a six-state area.*