Version 2.0
Experimental Flow Scenarios for WY 2002-2003
Prepared by GCMRC
(DRAFT March 15, 2002)

For Consideration by the Technical Work Group (TWG) on Their Conference Call on March 20, 2002

I. INTRODUCTION

This document addresses the Motion passed at the Adaptive Management Work Group (AMWG) Meeting on January 18, 2002. That motion instructed the Grand Canyon Monitoring and Research Center (GCMRC), in consultation with the TWG to design experimental flows for WY 2002 – 2003. The full motion states:

In concert with RPA flows for native fish during 2002-2003 request that the GCMRC, in consultation with the TWG, design an experimental flows sequence that tests hypotheses for conservation of sediment. Report to AMWG in April 2002 on the proposed flow sequence.

This document was prepared by GCMRC staff in consultation with the TWG and constitutes GCMRC's recommendation to the AMWG for an experimental flow release pattern from Glen Canyon Dam for WY 2002 – 2003. The recommendation will be presented to the AMWG at their April 24-25, 2002 meeting. The WY 2002 – 2003 experimental flow is intended to test hypotheses related to Glen Canyon Dam operating alternatives designed to:

1) improve retention of sediment in the Colorado River Ecosystem (CRE), and
2) benefit native fish populations, primarily Humpback Chub (HBC).

In addition these recommendations consider impacts to other resource areas. The recommendations are consistent with goals of the AMP, especially Goals 2 & 8 [preserve native fishes, and restore and maintain sand resources needed to achieve other related goals].[1]

Specific objectives of the WY 2002 – 2003 experimental flows recommendation include:

A) Sediment related:

[1] A broader set of recommendations for experimental flows that should be tried over the next five to ten-years whether the hydrology is wet or dry is also being developed. The experimental flows being recommended here are consistent with that larger program of flows.

- decrease downstream export of tributary input sediment from Marble Canyon, and

- increase retention of sediment stored in channel through Beach/Habitat-Building Flows (BHBF's) or Habitat Maintenance Flows (HMF's).

B) Native fish related:

- improve survival and recruitment of HBC by reducing competition and predation from non-native fish (primarily rainbow trout)[2], and

- improve and maintain habitat for young native fish.

II. BACKGROUND

A. Process to develop these scenarios

January 18, 2002 -AMWG Motion Passed

February 7, 2002-GCMRC Experimental Flow Scenarios, Version 1.1 sent to TWG

February 8, 2002-GCMRC/TWG conference call to discuss Experimental Flow Scenarios, Version 1.1 and begin development of Frequently Asked Questions and Answers

February 11, 2002-GCMRC provides a response to the Grand Canyon River Guides (GCRG) Memo of Inquiry

February 12, 2002- Arizona Game and Fish Department (AGFD) and GCMRC met with Lees Ferry Fishing Guides at Lees Ferry

February 15, 2002 -GCMRC Mailing to TWG of Experimental Flow Scenarios, Version 1.2 and Frequently Asked Questions and Answers

February 20, 2002- GCMRC Met with Grand Canyon River Outfitters Association (GCROA)

February 26-27, 2002-TWG Meeting

- Purposes for experimental flows were agreed upon by TWG, including working hypotheses and objectives.

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[2] It is anticipated that reducing the population numbers of RBT will increase the average size of fish in the Glen Canyon reach and may lead to improvement in the overall quality of the Lees Ferry trout fishery.

- ♦ The basic concepts of the Experimental Flow Scenarios, Version 1.2 experimental design were supported by TWG **(pending tradeoff analyses)**

March 18, 2002 - GCMRC will revise the Experimental Flow Scenarios by this date and will e-mail, FAX, FEDEX to the TWG

March 20, 2002 - A conference call with the TWG will be held to discuss the Experimental Flow Scenarios, Version 2.0 document.

March 22, 2002 - GCMRC will revise the Experimental Flow Scenarios, Version 2.0 based on the TWG comments and mail to AMWG.

April 24 – 25, 2002 – Experimental Flow Scenarios, Version 2.1 will be reviewed by AMWG and they will make a motion to the Secretary of the Interior regarding an experiment for WY 2002 - 2003.

B. State of Resources in Response to Record of Decision Dam Operations

- Data and trends on Sediment Storage and Transport

Sediment Transport and Sand-Bar Topographic Data – Early sediment-transport studies conducted below Glen Canyon Dam in the 1970s, predicted an insidious process of sand loss from the Colorado River ecosystem, with sand bar losses continuing over a period as long as 200 years (Laursen et al., 1976). Monitoring of fine-sediment resources since implementation of "interim" and later "ROD" operations from Glen Canyon Dam indicate that sand storage within the active zone has decreased under MLFF operations (NAU time series data for 30 sand bars system-wide). This response was predicted in the Operations of Glen Canyon Dam – Final EIS (DOI, 1995). The EIS also predicted a high probability that tributary sand inputs would accumulate within the river channel (at elevations within the active zone and below) over multi-year periods. Monitoring data refute this EIS prediction over the 1991-2001, period, despite operations over a full range of hydrologic conditions associated with the MLFF alternative. During the Interim Flow and MLFF periods, sediment storage increased above the active zone twice; once during a natural flood from the Little Colorado River (LCR) in winter 1993, and again during a controlled spill from Glen Canyon Dam. In both cases, these bar responses were limited by the maximum elevation associated with stage. Much of the bar deposition associated with these high flows was temporary; suggesting that sand-bar maintenance needs to occur relatively frequently to be effective. Sand-Bar deposition associated with LCR flooding in 1993, resulted from both elevated stage and dramatically increased suspended-sediment concentrations in the main channel – conditions that somewhat mimicked pre-dam sediment-transport conditions. However, these seemingly natural conditions lasted for only a brief period. While eddies below the LCR filled dramatically with sand during the 1993 floods, sand within eddies was quickly removed by dam operations that followed. In contrast, the controlled flood experiment of 1996, deposited significant amounts of sand up to the 45,000 cfs stage, but research results showed that the sand supply for building BHBF bars came from pre-existing sand bars at lower elevations within eddies, and not from supplies that had accumulated within the main channel between August 1991 and March 1996 - as was predicted in the EIS – (Rubin and Topping, 2001; Rubin et al., 1998; Webb et al., 1999; DOI, 1995).

Results from three experimental dam releases of 31,500 cfs (basically, peak power-plant operations that occurred in November 1997, and June and September 2000), have shown very limited-to-no enhancement of storage within eddies (Hazel et al., 2000a, see Figures 7-8 and 11; 2000b, see Figure 3), even under conditions when the sediment supply of the system was enhanced significantly by tributary inputs (fall 1997). This minimal response has been attributed to the relatively limited "accommodation" space available within eddies and channel margins at elevations within power-plant operating range (Hazel et al., 2000b, see Figure 4). Comparison of sand-bar data indicates that accommodation space above peak power-plant range within monitoring sites increased dramatically during the 1996 controlled flood test when flows peaked at 45,000 cfs. The relationship between increasing accommodation space and stage is believed to be a direct result of lower-valley characteristics associated with channel geometry, and these characteristics vary abruptly in response to changing geology, as does sediment supply below the dam. Accommodation space for sand-bar deposition along shorelines is predicted to be even greater at stages above 45,000 cfs, on the basis of recent sand-bar simulations (Wiele and Franseen, 2001; Wiele and Franseen, in review), as well as the bar deposition response measured at many sites following the 1983 high flow (Schmidt and Graf, 1990).

Recently, cooperating scientists have reported recommendations for how dam operations might be altered to improve the potential of achieving sediment objectives within the context of MLFF; including BHBFs. These alternatives are intended to increase the effectiveness of sediment conservation measures below the dam by either: 1) enhancing channel-stored sediment supplies immediately prior to a BHBF, or 2) immediately re-depositing new sediment by implementing BHBFs after sediment enters the ecosystem. Rubin et al (2000), suggest that long-term sustainability of sand resources may turn out to be impossible - owing to limited sediment supply - even if their first two recommended alternatives are implemented; this situation, they claim, might only be mitigated through sediment augmentation. Owing to this possibility, the GCMRC believes the testing of the first two of the Rubin et al. (2000), recommended alternatives should be pursued at the earliest time that basin hydrology and reservoir storage conditions permit. Forecasted runoff predictions into Powell reservoir for Water Years 2002 and 2003, may allow for testing of both alternatives 1 and 2. Other alternatives for <u>temporarily</u> increasing sand storage within eddies (so called, HMF or Load Following) following August – December sediment inputs, are currently under consideration by the Technical Work Group. The GCMRC recommends conducting such alternative tests only after testing of Alternatives #1 and #2 (Rubin et al., 2000) are clearly demonstrated to achieve long-term sustainability of sand resources. Such alternative tests should also be undertaken during future periods when Alternative #2, is not possible owing to wet basin hydrology (years above the 8.23 maf release level). Previous study results from 1997, indicate that the WAPA alternatives, contained in an attachment hereto, are likely provide little to no new information, or resource advantage, except under conditions when lower eddy accommodation space is enlarged because of high-flow operations – a situation known to occur immediately following high, sustained clearwater releases, such as occurred immediately following the 1996 controlled flood test.

Comparison of Trend Data with AMWG Goals/MOs – Goal 8 (and associated MO's) of the Glen Canyon Dam Adaptive Management Program's Strategic Plan, intends to achieve conservation of fine-sediment within the main channel so as to support achievement of other ecosystem goals and objectives – maintenance of physical habitats associated with the terrestrial and aquatic components of the ecosystem. If new sediment inputs from tributaries are not managed effectively so as to enrich the ecosystem's supplies, then implementation of BHBF operations cannot effectively support other resource goals, such as mitigation of erosion of cultural materials within existing sand bars, restoration of recreational camping beaches, maintenance of terrestrial substrates that support riparian vegetation, or rejuvenation of near-shore habitats of benefit to native fishes. Recent trends in sediment monitoring data support the early conclusions of Laursen et al. (1976), and suggest that goals that depend on retention of fine sediment will not be achieved unless future BHBF's are strategically timed to take advantage of tributary sediment inputs that temporarily enrich the ecosystem's sand and silt supply.

- <u>Data and trends on Humpback chub</u>

GCMRC has established an effective monitoring program, which allows detection of change in both recruitment and abundance of HBC in the LCR population in the Grand Canyon. Other populations (aggregations) are in such low abundance that effective and quantitative techniques for estimating their abundance remain elusive. The LCR population is comprised of individuals that move back and forth between the LCR proper and the mainstem river in approximately a 5-mile reach upstream and downstream of the LCR confluence. Most if not all reproduction is believed to occur in the LCR where adult fish migrate to spawn. Subsequent survival and recruitment of young HBC is believed to be influenced by a combination of factors in the LCR and the mainstem.

A stock assessment approach (Hilborn, 1990) is being used to monitor status and trends of the LCR population. This approach uses closed population estimation techniques involving mark and recapture procedures to estimate abundance of individuals >150mm. Recruitment is estimated using a population model known as Supertag developed by Carl Walters of the University of British Columbia. This model uses capture histories of marked individuals in the population to estimate recruitment by brood year (year when fish hatched from eggs). This model has allowed a reconstruction of recruitment trends going back to the early 1990's.

Comparison of Trend Data with AMWG Goals/MO's and EIS Table II-7. The most recent data available (based on sampling through 2001) suggest declines in overall abundance and recruitment of HBC in the LCR population since the early 1990's when first experimental and subsequently ROD flows were implemented. These data, presented in Figures 1 & 2 suggest that both the status and trends related to the HBC population are inconsistent with predictions of table II-7 from the EIS, as well as the adopted Goals and

Management Objectives of the AMP. Table II-7 suggests stable to moderate improvement in HBC populations under ROD flows. Goal 2 of the AMP and most of its associated MO's call for maintaining and enhancing the population(s) of HBC with removal of jeopardy for the species as primary driving force. Figure 3 extrapolates recent and current recruitment trends into estimates of future abundance for the LCR HBC population. Clearly this trend is in opposition to the AMP goals.

- <u>Data and trends on Lees Ferry Trout and Non-native fish (salmonids) throughout the CRE</u>

The Lees Ferry rainbow trout fishery has been maintained by a combination of stocking and natural reproduction since the late 1960's. This fishery has been widely regarded as one of the best "tailwater" trout fisheries in the western U.S. The fishery has been predominately maintained by natural reproduction in recent years. This fishery has long been regarded as a blue-ribbon fishery although its characteristics have changed over the years. Since the mid 1990's RBT have increased their abundance tremendously in both the Lees Ferry reach and throughout much of the Marble Canyon and Upper Grand Canyon reaches. The abundance of RBT in the CRE below Lees Ferry has increased dramatically with current estimated abundance totaling nearly 1 million adult fish. Figures 4 & 5 show .catch per unit effort for trout in the LCR reach where the HBC population exists. Similarly brown trout (BRT) have also increased in abundance. It is unkown how much of these increases are due to local natural reproduction versus recruitment from other spawning area such as Lees Ferry for RBT and Bright Angel Creek for BT.

The increase in abundance at Lees Ferry has been accompanied by an increased catch rate for anglers along with a decline in the average size of fish caught. The potential of fluctuating flows to reduce spawning and recruitment success for this population may reduce overall numbers in the population and reduce catch rate somewhat. 1-2 years of suppression of spawning and recruitment at a modest level (somewhere between 10-50%) should produce trout averaging 17 inches in this fishery after a few years compared to the current average size of 13-14 inches.

- <u>Data and Trends on Cultural and Recreational Resources</u>

Data from on going archaeological and tribal monitoring, indicate that erosion continues at archaeological sites under ROD operations. Monitoring of these resources indicates BHBF flows appear to benefit resources through the deposition of sediments in erosion features such as gullies. Modeled data with high sediment loads and at high flow stages (i.e., 100,000 cfs) suggests that portions of gullies at selected sites would be buried, temporarily arresting erosion through the sites. Monitoring of traditional resources indicates that higher flows appear to benefit traditional plant resources through the deposition of nutrient rich sediments and clays.

The preferred alternative (modified low fluctuating flows) was developed to reduce daily flow fluctuations below the no action levels and to provide special high steady releases of short duration. Relative to cultural resources the EIS (preferred alternative) predicted that impacts to archaeological resources would be moderate with impacts to less than 157 sites, there would be moderate impacts to Traditional Cultural Properties and there would be increased protection to traditional cultural resources. A comparison of these predictions and the results of data collection indicate that cultural resources (archaeological and traditional) appear to benefit from higher flows of short duration that replenish sediments and mimic unregulated spring river conditions.

Conservation and redistribution of sediment is best understood relative to a beneficial purpose to other resources. Accumulation of sediments is most beneficial for the conservation of archaeological resources that are finite and irreplaceable. Unlike endangered species that may be encouraged to increase in abundance, a decrease in archaeological site number is irreversible. While Grand and Glen Canyons are erosional features, management actions can assist in prolonging the existence of these resources in keeping with AMWG management objectives.

III. RATIONALE FOR AN ECOSYSTEM VS. A SINGLE RESOURCE EXPERIMENT

GCMRC interpreted the AMWG motion as a sediment conservation experiment within the framework of benefiting native fish. The AMP is intended to use an ecosystem-science approach in testing the effects of dam operations. It also recognizes that the Endangered Species Act mandates that the Department of the Interior take action to protect endangered species. At the January AMWG meeting, GCMRC presented data that indicated sediment resources and HBC are not responding to the ROD as anticipated in the EIS. As indicated above both sediment resources and HBC are in decline. Given this information, GCMRC believes it would be irresponsible to make a recommendation to the AMWG for an experimental flow that does not take an ecosystem science approach and that does not address the resources of concern.

The Experimental Flow Scenarios proposed in this document call for ramping rates and daily fluctuations that are outside the preferred alternative. However, it is our contention that the Experimental Flow Scenarios described here are within that portion of the ROD that allows for experimentation, if ROD flows are not achieving the intended benefits. GCMRC also believes that after the AOP process considers the experimental flow request and determines WY 2003 monthly volumes, the proposed flows are in compliance with the current interpretation of the Law of the River as all of the flow elements that are proposed for testing could be implemented, following appropriate compliance, within the current interpretation of the Law of the River. Given the provision in the ROD that calls for experiments if the resources are not responding as expected to the ROD flows, no elements of the proposed flows are thought to be outside the ROD.

Although, there is considerable uncertainty regarding the causal mechanism for the decline in adult HBC abundance, the predation / competition hypothesis has a higher likelihood than other mechanisms (disease/parasitism, hydrology, food-limitations, habitat degradation, etc.) for explaining the decline. In addition, this is a testable hypothesis using management flow prescriptions. Finally, it is plausible that the predation / competition hypothesis could overwhelm any benefits derived from management flow prescriptions intended to provide beneficial habitat conditions.

GCMRC believes the benefits to native fish will accrue indirectly through a reduction in predation/competition by non-native fish, primarily salmonids in the LCR reach. The model developed by Dave Speas and Carl Walters provides support for load-following to negatively impact RBT by interfering with and disrupting spawning activity as well as reducing the recruitment of young fish.

The winter load following component of the experiment is not intended to benefit the sediment resource. However, there may be some advantage derived from the winter load-following with respect to modifying the newly formed bar morphologies.

Finally, consistent with sound principles of Adaptive Management, any experiment that is implemented should be well-designed and have the power to actually have the potential affect that one is trying to test. And, the monitoring and research program must be designed so as to measure the intended effect. In addition, as noted by Walters and Korman (unpublished manuscript) any experimental flow alternative should be "implemented and monitored with 'replicated' years of operation under each alternative." That is one may need to repeat one of the Experimental Flow Scenarios to see the biological affect given the lag time before the ultimate affects are measurable. The decision to repeat such a flow can be based on the measurement of intermediate parameters.

IV. WORKING HYPOTHESES

Sediment- Monitoring data indicate that tributary inputs of sand do not accumulate within the river channel over multi-year periods as predicted by the final EIS, and that such inputs are transported out of the Colorado River Ecosystem within less than one year under most ROD operations. On the basis of results from the summer 2000 flow experiment, as well as historical sediment-transport data, new inputs of sand should be retained more effectively within main channel storage sites during extended periods of dam releases at or below about 10,000 cfs (Rubin et al., 2000; Topping et al., 2000a; 2000b). If such operations promote retention of sand (and finer sediment as well), then implementation of a Beach/Habitat-Building Flow following such periods should greatly increase the effectiveness of such controlled floods in restoring and maintaining terrestrial sand bars and related resources. More efficient retention of fine sediment and silt prior to controlled floods is hypothesized to result in more rapid rates of sand bar deposition, as well as sand bars with finer grain-size distributions. Finer-textured sand bars may be less prone to rapid erosion following bar building, as well as retain a higher level of nutrients contributed to the main channel by tributaries. Enhanced conservation of tributary sediment inputs in the channel should result in elevated suspended-sediment concentrations during BHBF's, leading to rapid depositional rates during sand-bar building. Elevated rates of sand-bar deposition should reduce the required duration for BHBF's, and hence will limit spill volumes. If sand bar deposition is significantly enhanced by implementing BHBFs when the ecosystem's sediment supply is greatly enriched (resulting in sustainability of finer, more stable bars), then perhaps the frequency for making such releases is simply linked to timing of tributary inputs.

Native and Non-native Fish-The LCR population of HBC has not demonstrated a positive response to the mainstem flow regimes under ROD operations. While the population of rainbow trout in Lees Ferry and the populations of rainbow and brown trout in the mainstem below the Paria River appear to have shown a positive response as reflected in increased abundance. Within the ROD, there is a need to implement experimental flows, which may improve survival and recruitment of HBC. The LCR population of HBC is comprised of fish resident in the LCR and in the mainstem near the LCR confluence. Therefore flows, which affect changes in HBC status in the mainstem, may positively influence the overall LCR/HBC population.

Initial flow experiments to modify habitat have not shown a strong response in increased HBC abundance. This could be due to a number of factors including both the power of the experiment, the ability of monitoring programs to detect a change, and the short time since the most recent experiment (LSSF) has been conducted. Another possibility is that non-native and native fish interactions (i.e., predation and competition) are over-riding any potential positive effects from flows that improve habitat conditions. The experimental flows described here are intended to test this possibility and produce a measurable affect on non-native fish and hence on non-native and native fish interactions. The hope is that this will result in a positive effect on HBC and lead to the designing of experimental flows or other management actions that also can improve habitat for native fish, including HBC that will address Goal 2 of the AMP strategic plan.

V. EXPERIMENTAL FLOW SCENARIOS

WY 2002 – 2003 Hydrology Assumption

These experimental flow recommendations assume that WY 2002 and perhaps WY 2003 will be relatively low runoff years with low antecedent reservoir storage in Lake Powell. Thus **these recommendations are based on an 8.23 maf water year scenario**. As noted above, GCMRC together with the experimental flows ad hoc group, is also developing a longer term set of experimental flow recommendations. These recommendations will address the need for repeated and long term experimentation as part of adaptive management and in recognition that basin hydrology over the long term will be variable.

Scenarios

We assume the antecedent and contemporary conditions for experiments conducted in WY 2002-2003 will be so called 8.23maf or at best average inflow years, thus allowing GCD operations to achieve constant low-flows in fall 2002 or load following flows below 10,000 cfs, and perhaps in subsequent seasons. GCMRC is recommending three versions (I.A, I.B, and I.C) of experimental flow scenarios when significant sediment inputs occur in the summer/fall or winter of WY 2002. Each of these scenarios is further divided into two (1 and 2) possible post BHBF water releases. GCMRC is recommending one scenario of experimental releases if no sediment inputs occur in the summer/fall and winter of WY 2002. This scenario is also further subdivided into two April – September 2003 release scenarios. Each is described briefly below and a figure depicting a hydrograph for the particular flow is provided in the Tables and Figures section of this document. While these hydrographs show specific daily flow levels, they are intended to be **conceptual hydrographs** whose precise nature (specific floors and ceilings, up-ramp and down-ram rates, and durations) will need to be determined.

Scenario I.A.1 (Figure 6).
This scenario provides for experimental flows aimed at **both** conserving sediment and benefiting native fishes. From October 2001 through June 2002 the dam follows normal ROD operations. Following **significant**[3] sediment inputs in the July - December 2002 period the dam is operated at a constant 8,000 cfs following sediment inputs (or perhaps a low level, e.g. 5-9,000 cfs ROD flow) until January 2003. In January 2003 a BHBF[4] of limited duration is conducted. This is followed by high experimental fluctuating flows for the main portion of the non-native spawning and emergent/juvenile season (January through March). From April – September 2003 operations would follow monthly volumes under the ROD. This hydrograph could be repeated in WY2003-04.

Scenario I.A.2 (Figure 7).
This hydrograph is the same as that described above under scenario I.A.1., except that no high experimental fluctuating flows for the main portion of the non-native spawning and emergent/juvenile season (January through March) are conducted. Essentially, this experiment is focused only on sediment conservation.

Scenario I.B.1 (Figure 8)
This scenario provides for experimental flows aimed at **both** conserving sediment and benefiting native fishes. From October 2001 through June 2002 the dam follows normal ROD operations. Whenever **significant** sediment inputs in the July - October 2002 period occurs, a habitat maintenance flow (HMF) is immediately triggered. This is followed by ROD operations until January 2003. In January 2003 a BHBF of limited duration is conducted. This is followed by high experimental fluctuating flows for the main portion of the non-native spawning and emergent/juvenile season (January through March). From April – September 2003 operations would follow monthly volumes under the ROD. This hydrograph could be repeated in WY2003-2004.

Scenario I.B.2. (Figure 9)
This hydrograph is the same as that described above under scenario I.B.1., except that no high experimental fluctuating flows for the main portion of the non-native spawning and

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[3] A year with significant sediment inputs would be defined as an instantaneous discharge of 2,000 cfs or greater from the Paria River or an instantaneous discharge of 10,000 cfs or greater from the LCR during the period August 1-October 31.
[4] In every scenario where a BHBF is proposed to be released in January 2003, the BHBF should have a magnitude of at least 10,000 cfs above peak powerplant discharge, or higher depending on lake elevation.

emergent/juvenile season (January through March) are conducted. Essentially, this experiment is focused only on sediment conservation.

Scenario I.C.1. (Figure 10)
This scenario represents a year when there are no significant monsoonal sediment inputs but there are significant **sediment inflows in winter.** It also includes flows intended to benefit native fishes. If there are No significant sediment inputs in the July through December period the dam would be operated under normal ROD operations until December 2002. Beginning in January 2003 high experimental fluctuating flows for the main portion of the non-native spawning and emergent/juvenile season (January through March) would be implemented. From April – September 2003 operations would follow monthly volumes under the ROD. In this scenario, a BHBF would occur if significant sand inputs occurred during the January through July period. The BHBF would be released as soon as possible and in the same month that the sediment input(s) occur. The BHBF would have a magnitude of at least 10,000 cfs above peak powerplant discharge, or higher depending on lake elevation.

Scenario I.C.2. (Figure 11)
This hydrograph is the same as that described above under scenario I.C.1., except that no high experimental fluctuating flows for the main portion of the non-native spawning and emergent/juvenile season (January through March) are conducted. Essentially, this experiment is focused only on sediment conservation.

Scenario II. (Figure 12)
In this scenario, no significant sediment inputs occur in the summer/fall or the winter input period. The dam is operated under normal ROD operations until December 2002. Beginning in January 2003 high experimental fluctuating flows for the main portion of the non-native spawning and emergent/juvenile season (January through March) would be implemented. From April – September 2003 operations would follow monthly volumes under the ROD. No BHBFs or HMFs would be implemented. This experiment is essentially focused on negatively affecting non-native fish populations by disrupting the non-native fish spawning and emergent/juvenile season.

Evaluation of the Proposed Experimental Flow Scenarios

Scenarios I.A. 1 and I.A.2:

Initial Response of Dam operations less than 10,000 cfs until January BHBF – This option follows the recommendation of the sediment researchers, outlined as Alternative #2 (Rubin et al., 2000). This design builds on previous results from the summer 2000, Low-Summer-Steady-Flow test, historical synthesis of flow and sediment-transport data analyses, and the November 1997, test of peak power-plant release following tributary sediment inputs from the Paria River (intended to increase conservation of sand through enhanced eddy storage). This approach ensures greatest likelihood for enrichment of channel-stored sediment supply prior to implementation of BHBF (January). As the adaptive management program approaches only its second test of the BHBF concept, the strategy for learning is to drastically change the antecedent sediment supply conditions of the ecosystem (compared with March 1996), while keeping the magnitude of the controlled flood at the limit designated in the ROD. Research findings suggest that the BHBF response under enhanced sediment supply conditions, should result in faster depositional rates for sand bars, as well as potentially larger sand bars that fill both the lower and higher portions of eddies and channel margins, as well as finer grain-size distributions. The only difference between these alternatives is whether or not experimental fluctuating flows are implemented following the recessional limb of the January 2003, BHBF (see associated null hypotheses, below).

The null hypotheses to be tested within this experimental design include:

Flows below 10,000 cfs prior to BHBF – Ho_1 – Constrained operations between time of sediment input and BHBF result in the same level of sediment storage as that estimated prior to the 1996 controlled flood test.
Flows below 10,000 cfs prior to BHBF – Ho_2 – Constrained operations between time of sediment input and BHBF result in the same level of sediment storage as that associated with the 1997 peak power-plant flow release test.

BHBF - Ho_1 - The sand-bar depositional response to this second BHBF will be identical to the 1996 response in terms of depositional rates, total volume and grain-size characteristics, and,
BHBF – Ho_2 – Sand bars with finer grain-size distributions than those measured in 1996, are no more stable (erode just as rapidly) that those monitored after April 1996.

Recessional Limb – Ho_1 – A stepped recessional component of the hydrograph following the BHBF, results in the same steep-faced beach morphology as measured following the 1996 BHBF.
Recessional Limb – Ho_2 – A stepped recessional component of the hydrograph following the BHBF, results in the same rate of reworking (erosion) of newly formed sand bars as measured following the 1996 BHBF.

With Experimental Fluctuating Flows – Ho_1 – Large-magnitude fluctuations following the BHBF through March, result in the same steep-faced beach morphology as measured following the 1996 BHBF.
With Experimental Fluctuating Flows – Ho_2 – Large-magnitude fluctuations following the BHBF through March, result in the same rate of reworking (erosion) of newly formed sand bars as measured following the 1996 BHBF.

Without Experimental Fluctuating Flows – Ho_1 – Fluctuations associated with normal MLFF operations following the January 2003, BHBF, result in less steep beach-face morphology than measured following the 1996 BHBF.
Without Experimental Fluctuating Flows – Ho_2 – Fluctuations associated with normal MLFF operations following the January 2003, BHBF, result in a slower rate of reworking (erosion) of newly formed sand bars than measured following the 1996 BHBF.

Scenarios I.B.1 and I.B.2 (Includes WAPA's Alternatives):

Initial Response of Dam operations includes *either* steady 31,500 cfs or experimental fluctuating flows following one or more sediment inputs from the Paria River, followed by normal ROD operations until January BHBF – Either of these two options represent an alternative to testing the recommendations of the sediment researchers, outlined as Alternative #1 and #2 (Rubin et al., 2000). Results of the November 1997, peak power-plant test suggest that testing either of these designs will provide little in the way of new information, will likely provide little benefit to enhancing sand storage, and is relatively more risky (elevated levels of sediment export with little to no increase in eddy storage) than merely following normal ROD operations during the 8.23 maf year from August through September. If these alternatives are to be tested at all, then the GCMRC recommends testing them during wetter years, when such actions may be the only viable alternative to summer and fall months with large volumes and related operations. Trading off sediment storage throughout the entire channel bed, for relatively little to no potential storage volumes within eddies (as is the premise for doing these alternative tests) is deemed by the GCMRC as an extremely inferior tradeoff during periods when new sediment is likely to be better conserved by either low constant flows, or even merely releasing fluctuating flows associated with the ROD operations associated with an 8.23 maf year. See attachment for suite of null hypotheses associated with these test flow alternatives proposed by Western Area Power Administration. The study design for such tests must include both intensive suspended-sediment transport measurements, as well as multiple topographic measurements within eddies and the main channel (before and following sediment inputs and power-plant spike flows and/or experimental fluctuations. Owing to the need for this additional information, the science costs for conducting these alternative tests is estimated to be significantly greater than costs associated with testing of the Rubin et al. (2000), operating alternatives.

Scenario I.C.1 and I.C.2:

Dam operations above power-plant capacity (45,000 cfs BHBF) as soon as possible following enrichment of the main channel's sediment supply. This option is designed to test hypotheses associated with the recommendation of the sediment researchers, outlined as Alternative #1 (Rubin et al., 2000). The main hypotheses for this experimental design are the same as shown above within I.A.1 and I.A.2, scenarios, plus two additional null hypotheses:

BHBF Immediately Following Sediment Inputs from Paria River – Ho_1 – The sand-bar depositional response to this second BHBF is identical to the 1996 response in terms of depositional rates, total volume and grain-size characteristics,
and,

BHBF Immediately Following Sediment Inputs from Paria River – Ho_2 – The sand-bar depositional response to this BHBF is not significantly different than the response, in terms of depositional rates, total volume and grain-size characteristics, measured for an Alternative #2 BHBF scenario(Rubin et al., 2000).

All Scenarios:

High Experimental Fluctuating Flows – are mainly intended to disadvantage non-native fish recruitment in the main channel, thereby achieving the most effective long-term control on predation/competition through reduced population size. This reduction in population size in non-native fish would result from a combination of spawning disruption and creating unfavorable conditions for survival of young non-native fish. Fluctuating flows, similar to operations that occurred under "No-Action" era would provide the greatest disadvantage to non-native fish, and might be most effective at reducing the non-native fish populations by causing lower recruitment over several years of implementation. This may actually improve the quality of the Lees Ferry trout fishery. Over the course of multiple years, reduction of RBT and BNT abundance is intended to result in increased HBC recruitment.

- **Hypotheses to be tested include:** **H1**: Winter load following does not reduce recruitment of RBT and BNT in Grand Canyon. **H2**: Winter fluctuating flows as described with a 5,000cfs lower limit, does not increase export of ecosystem sand. **H3**: Winter fluctuating flows does not produce eddy-bar morphologies that are more conducive to recreational and other ecosystem uses. **H4**: Winter fluctuating flows will not adversely impact food base resources. Only the lower limit of the diurnal range would be constrained for purpose of limiting detrimental impact to phyto-benthos resources. **H5**: HBC recruitment is not limited by RBT or BNT predation.

Costs and Benefits to Hydropower of the Implementation of Each Scenario

[Information to be provided by WAPA]

Potential Risks or Unintended Consequences of Each Scenario

[To Be Added]

VI. Recommendation

- GCMRC recommends that Experimental Flow Scenario I.A.1. be implemented if there are significant sediment inputs in the August through December period.

- GCMRC recommends that Experimental Flow Scenario I.C.1. be implemented if there are significant sediment inputs in the January through July period.

- GCMRC recommends that Experimental Flow Scenario II. be implemented if there are NO significant sediment inputs.

VII. Tables and Figures

VIII. LITERATURE CITED

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IX. ATTACHMENTS

ATTACHMENT 1. IMPLEMENTATION PLAN

ATTACHMENT 2. FREQUENTLY ASKED QUESTIONS AND ANSWERS

ATTACHMENT 3. WAPA ALTERNATIVE EXPERIMENTAL FLOW REGIMES