

7000 4/9/98

**DRAFT RESEARCH AND MONITORING PLAN FOR
EXPERIMENTAL 45,000 cfs BEACH/HABITAT BUILDING FLOW(S)
FROM GLEN CANYON DAM, APRIL TO JULY 1998**

INTRODUCTION

Beach/habitat building flow(s) (BHBF) of 45,000 cfs from Glen Canyon Dam may be considered by the Adaptive Management Work Group for April-July 1998. This experiment would be used to confirm and test existing and new hypotheses surrounding the use of dam releases to manage sediment distribution and ecosystem resources in Glen and Grand canyons. This draft document outlines the research, monitoring, and flow-related synthesis activities planned before, during and after the BHBF event, and the budget associated with those activities.

The duration, magnitude and ramping of the BHBF hydrograph is subject to discussion by the Technical Work Group (TWG) and the Adaptive Management Work Group (AMWG). Based upon information developed from the 1996 BHBF, 2 to 4 days of high flows are expected to be sufficient to balance benefits to sediment, biological and cultural resources (Figure 1). Prior and subsequent constant flows are recommended for aerial photographic purposes, at the lowest normally-achieved level of pre-event fluctuating flows. Field studies are planned prior to, after and six months following this BHBF.

The duration of the BHBF should be established by a combination of resource and research needs.

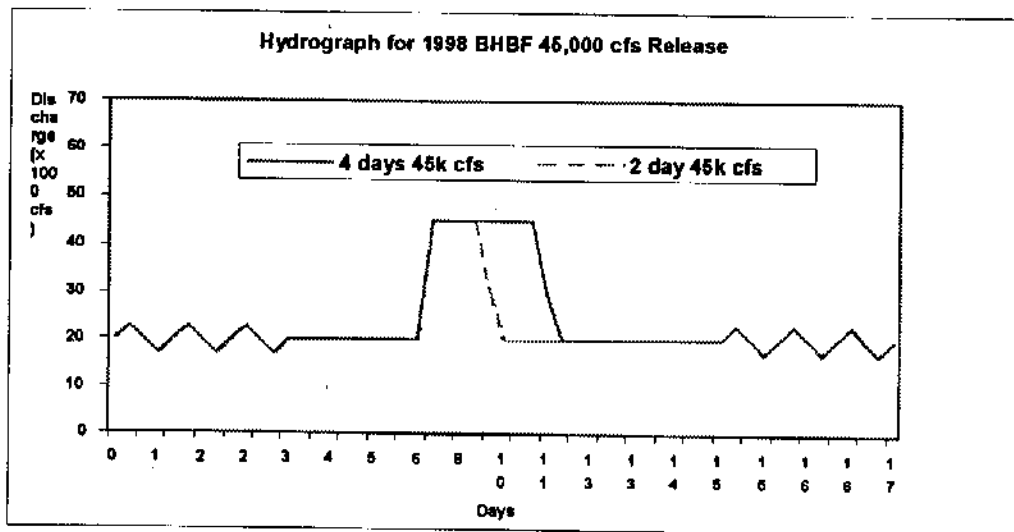


Figure 1: Potential hydrograph for an experimental 45,000 cfs BHBF from Glen Canyon Dam.

On-going monitoring efforts will be incorporated to minimize the research costs associated with the 1998 BHBF(s). Research and monitoring activities will be coordinated and logistically supported by GCMRC¹, pending discussions by the TWG and AMWG, and approval of proposals. Given the short time frame surrounding planning and implementation of research activities for BHBF (s) defined by the flow triggering criteria, GCMRC will not pursue a competitive funding approach to accomplish research and monitoring tasks, but will use a variety of mechanisms, including modification of existing contracts and in-house expertise.

OBJECTIVES

Results of the monitoring and research activities conducted in 1996 are the primary basis for the development of the 1998 BHBF program. The overall monitoring and research objectives of the 1998 BHBF research program are to advance scientific understanding on the best use of planned flows for river ecosystem resource enhancement and mitigation, both upstream and downstream from Glen Canyon Dam. Specific objectives include:

1. Verify the conclusions of the 1996 BHBF program, particularly those related to BHBF hydrograph shape and duration.
 - a. Determine the extent to which altered antecedent resource conditions influence the outcome of a BHBF.
 - b. Determine and verify the rate and mechanisms of bar development during high flows.
 - c. Determine the threshold flow level for development of "secondary circulation" patterns.
 - d. Determine threshold velocities for return current channel activation.
2. Monitor BHBF impacts on selected biological resources.

The monitoring and research activities presented in this document will ensure sufficient information to assess the effects of this hydrograph, and advance scientific understanding of the potential for resource mitigation or enhancement by 45,000 cfs flow(s). Each monitoring studies should address the question, "What is the status of the resource, how does this status compare to objectives for that resource?" Each research project should address the question, "Will the results of this research enable predictions to be made about future resource responses to alternative flows?" In other words, how will the research results be used to help design future flows?

In addition, each project undertaken here will include a review and analysis of flow impacts (high or low, constant or fluctuating) on each resource category. Collectively, this information will be

used in a review of flow impacts on resources, and used to plan subsequent research on flow impacts.

The studies proposed here involve both monitoring and research activities. Stakeholder objectives have been revised and are presently in draft form, but may provide guidance in determining whether resource conditions, as well as flow criteria, indicate the need or potential benefit of one or more BHBFs.

1998 BHBF MONITORING AND RESEARCH

The following monitoring and research studies are suggested as appropriate for this event, pending discussions by the TWG and AMWG.

1. Event Documentation: Determine BHBF impacts on the river ecosystem.

a) *Photography*: Fixed-wing black and white aerial photography will be conducted before and after the BHBF(s) at a 1:4800 scale, according to the standard flight lines and protocols used in past photographic studies. Color photographs will be taken of selected sites for vegetation analysis. Analysis of these photographs will provide a permanent, system-wide documentation of stage level, alteration of rapids, sandbar distribution, and backwater habitat distribution, and riparian vegetation, and will allow assessment of the extent to which 1998 BHBF(s) were similar to the 1996 BHBF.

Fixed wing photography will be conducted at a constant flow level to be decided upon by the TWG. It is preferable from a scientific standpoint to have aerial imagery of the river corridor at a constant flow of 20,000 cfs, as this stage has been proposed for future high flow year photography and is a stage for which high quality imagery does not presently exist. Furthermore, a 20,000 cfs constant flow would provide the opportunity for calibration of 8,000 cfs flows photography, which has been the standard up to this time. Alternatively, the TWG may opt for a constant flow stage slightly above the lowest stage regularly achieved during the month prior to the BHBF. Although scientifically inferior to a constant 20,000 cfs flow, such a flow may conserve more water. A constant flow of 15,000 cfs might be a reasonable flow stage given that it is approximately the mean post-dam discharge stage.

In addition to the fixed wing photography, a helicopter-mounted videography run of the river corridor will be conducted near the conclusion of the BHBF, following previous protocols and flight lines. This videography will provide documentation of the peak flow stage through the river corridor, as well as additional information on shoreline and backwater conditions.

Pending additional funding, a comparison of the traditional Reclamation fixed wing photography, videography, and multi-spectral videography may be conducted prior to the BHBF. This effort, and the associated analyses of the photographic data, will permit evaluation of existing data and

potential new remote sensing approaches. The cost of a detailed comparison of the two methodologies is approximately \$100,000 for data acquisition and testing.

b) *Streamflow Gauging*: Flow will be monitored at the mainstream gauging stations, as described in the existing monitoring program, with data collection at 15 minute intervals at the mainstream cableways at Lees Ferry, above the Little Colorado River, at Phantom Ranch, at Diamond Creek, and pending TWG approval, at a temporary site near Mile 40, as well as at the Paria and Little Colorado river stream gauge stations.

2. Do BHBFB's affect seasonal limnological development of Lake Powell reservoir and downstream Colorado River water quality?

a) *Limnology*: The limnology of Lake Powell reservoir was substantially altered by the 1996 BHBFB, and impacts on the structure of the reservoir were detected as much as 100 km uplake. Limnological changes in the reservoir may affect the seasonal development of the lake, as well as the downriver aquatic food chain. Changes in the limnological structure of Lake Powell are being assessed on a quarterly basis, and additional measurements are recommended before, during and after the event(s). Temperature, dissolved oxygen concentration, pH, specific conductance, and plankton will be measured in Lake Powell before and after the event(s). A chain of Datasondes will be established to measure water quality at 5 depths at least 2 weeks before the event, and maintained until stratification resumes a normal profile. Additional security will be required at the forebay buoy using a chain rather than a rope. Full limnological profiles of the forebay uplake to Bullfrog are recommended to augment seasonal sampling; however, seasonal monitoring may be employed if the timing of the BHBFB(s) is appropriate.

Water quality recorders will be maintained in a jet tube port (if possible), at the draft tube monitoring station at the foot of the dam, 1.2 km downstream, and at Lees Ferry. Additional funding may be requested for upgrading monitoring hardware.

3. Physical Resources/Processes: The following studies are designed to build on the foundation of existing high-flow scientific data on sediment storage, transport and sandbar distribution.

a) Pre-BHBFB Flow and Sediment Research

1) **Suspended sediment concentration** will be monitored twice daily at the mainstream cableways, with more frequent sampling during the rising limb. Daily suspended sediment sampling at the tributary gauges (Paria and Little Colorado rivers). In addition, depth-integrated sediment sampling from a crane mounted on a sport boat will be made along a temporary tag line in the vicinity of Mile 40.

2) **Channel storage and movement** will be monitoring at established mainstream cross-

sections from the dam to -10, -3 to 2 mile, 0-8 mile cross-sections (USGS) and below the LCR confluence. A baseline trip will be conducted for mainstream channel-bed volumes and grain size using standard tagline/monumented cross sections, as well as new (pipe dredge) protocols.

3) Topography and bathymetry will be surveyed at a selected subset of the 34 monitoring sites before the BHBF, using the existing monitoring schedule as much as possible. In addition, stratigraphy and daily oblique photography will be conducted at selected sites.

4) Bar Evolution Rates: Eddy deposits were shown to change to change dramatically during the 1996 BHBF. Baseline Superhydro measurements of eddy complexes will be conducted prior to the BHBF(s), particularly at Eminence (Mile 45). This work may be conducted in association with the sand bar surveys (3.a.3).

b) During-BHBF Flow and Sediment Research

1) Suspended sediment concentration will be monitored twice daily at the mainstream cableways, with more frequent sampling during the rising limb of the high flow. Daily suspended sediment sampling at the tributary gauges (Paria and Little Colorado rivers). In addition, depth-integrated sediment sampling may be conducted from a crane mounted on a sport boat along a temporary tag lines in the vicinity of Mile 40.

2) Bed grain-size sampling is recommended using pipe dredges or a rotating side-scan sonar system in the cableway reaches, and daily repeated measurement of monumented cross sections is recommended at the monitoring sites near the confluences of the Paria and Little Colorado rivers.

3) Bar Evolution Rates: The 1996 BHBF resulted in punctuated (rapid) aggradation patterns at the numerous sites downstream from the LCR, where sediment is abundant. However, the Eminence (45 Mile) site showed a pattern of gradual aggradation. The working hypothesis that shorter duration high flows may accomplish sand bar rejuvenation may required further modification if sediment limited sites aggrade slowly. Daily Superhydro and land survey measurements are recommended at a suite of major eddy complexes in Marble Canyon, including Eminence (Mile 44R), Saddle Canyon (Mile 47R), "Dino" (Mile 50R) and Mile 51.5L. Measurement of these sites can be accomplished with one crew, and twice-daily measurements may be conducted at Eminence if time and funding permits. In addition, a rotating side-scan sonar system may be used to detect bar slumping.

4) Secondary Circulation: One of the most important sedimentological discoveries during the 1996 BHBF was a "secondary circulation" pattern, which involves cross-channel transport of sediment during high flows. Determination of the threshold at which this secondary circulation pattern is initiated is best accomplished using an acoustic dopler during the rising limb of the BHBF at one or more sites. This research may be accomplished in the straight channel segment downstream from the Paria River confluence and presently monitored for cross section

measurements. Alternatively, or in addition, the use of an acoustic dopler at the sites described in 3.b.3 (above) would enhance understanding of the velocity field in eddy and channel sections at daily monitored study sites, particularly the Eminence site.

5) Return Current Channel (Backwater) Rejuvenation: Use of an acoustic dopler at that site would also permit analysis of velocity and grain size interactions that result in return current channel (primary backwater) reactivation.

c) Post-BHBF Flow and Sediment Research

1) Suspended sediment concentration will be monitored daily at the mainstream cableways for 2-3 d after the recession of the BHBF. Daily suspended sediment sampling will continue to be conducted at the tributary gauges on the Paria and Little Colorado rivers during this interval. In addition, depth-integrated sediment sampling from a crane mounted on a sport boat will be made along a temporary tag line in the vicinity of Mile 40.

2) Bed grain-size sampling is recommended using pipe dredges in the cableway reaches, and post-BHBF monitoring of monumented cross sections is recommended at the monitoring sites near the confluences of the Paria and Little Colorado rivers.

3) Channel and bar topography will be surveyed at a selected subset of the 34 monitoring sites immediately after, and six months after, the BHBF, using the existing monitoring schedule as much as possible. In addition, stratigraphy and daily oblique photography will be conducted at selected sites.

4) Bathymetry: For 2-3 d following recession of the BHBF high flow, daily Superhydro measurements are recommended at the major eddy complexes in Marble Canyon, including Eminence (Mile 44R), Saddle Canyon (Mile 47R), "Dino" (Mile 50R) and Mile 51.5L.

5) Alteration of Rapids: Analysis of aerial photography may be used to detect alteration of rapids following a BHBF.

4. Aquatic Biological Resources

a) Aquatic Foodbase: Aquatic foodbase monitoring will be conducted pre-BHBF and post-BHBF, according to present protocols at 6 sites: Glen Canyon Dam, Lees Ferry, just below the Paria River confluence, above and below the LCR confluence, and near Diamond Creek. Drift will be monitored twice daily for 3 d prior to the BHBF, twice daily during the BHBF, 3 d following the BHBF, and 6 months after the BHBF. Drift will be sampled at the base of Glen Canyon Dam and at four mainstream cableways. Bulk ash-free dry mass of aquatic and terrestrial components will be sampled, without fine sorting, and subsamples will be preserved for potential future detailed analyses. If the major tributaries are flowing above base level, limited collection of

drift data from the Paria and Little Colorado rivers is recommended.

b) Native Fish: Based partially on the results of the 1996 BHBF, and depending on the timing of 1998 BHBF(s), high flow impacts on native fish, particularly endangered humpback chub, may include impacts on larval and young individuals. In contrast, high flow impacts on subadult and adult individuals are probably undetectable.

1) Ponding: Larval HBC and other native fish may be ponded during a high flow, and the rate of accumulation in tributary mouth pool areas, and different size classes may be lost from the mouth pools as high flows subside. This process should be documented at the Paria and Little Colorado river confluences.

2) Displacement: Young HBC and native fish may be swept out of backwaters as flow levels increase, and that process should be documented in the lower (left) channel of the LCR, and in backwaters in the vicinity of the LCR. Such an analysis, coupled with on-going monitoring, will also permit verification of recovery times for non-native fish.

3) Habitat Changes: An analysis of backwater and near-shore habitat changes associated with a BHBF will be coordinated with on-going syntheses of backwater habitat availability using aerial photography.

c) Trout:

1) Population: Trout population changes will be determined by electroshocking before and after the BHBF(s), as well as creel censuses, incorporating existing monitoring schedules and protocols to the greatest extent possible.

2) Redd Distribution: Depending on BHBF timing of the BHBF(s), active redd distribution will be monitored before and after the BHBF(s).

3) Trout Diet: Trout diet analyses are recommended to determine linkage between alteration of the foodbase and fish foraging success.

5. Terrestrial Biological Resources

a) Endangered Kanab Ambersnail:

1) KAS Monitoring and Mitigation: Kanab ambersnail (KAS) habitat and population monitoring and mitigation is required, pending discussion with Reclamation and FWS. The KAS habitat and population will be monitored before and after the BHBF(s). Moving KAS that exist in the flood zone to higher stage elevations is recommended to mitigate BHBF impacts on the population. This movement of KAS will be overseen by the FWS. Habitat and population recovery will continue to be monitored in accord with the existing monitoring schedule.

2) **Support KAS Recovery Activities:** The Arizona Game and Fish Department is engaged in establishment of a Phoenix Zoo captive KAS population, and some KAS and habitat in the flood zone may be salvaged for that activity. Depending on the timing of the BHBF(s), Stevens and Price are permitted to remove 250 KAS for laboratory and field experiments at Northern Arizona University, and those collections may take place prior to the BHBF if it is conducted in June. Pending approval of recovery activities involving establishment of second populations in Grand Canyon, additional KAS may be collected for transport to selected second population release sites.

b) **Endangered Southwestern Willow Flycatcher:** Depending on the timing of the BHBF(s), southwestern willow flycatcher (SWWF) habitat and population monitoring is likely to be required, pending discussion with Reclamation and FWS. Historical nesting areas will be monitored using aerial photography and site mapping. If the BHBF's occur during the breeding season (late May through July), observers will be placed on site one week before the event(s) to document BHBF impacts on distribution and behavior before, during and after the BHBF(s).

c) **Riparian Vegetation:** Riparian vegetation monitoring may be necessary to verify patterns detected during the 1996 BHBF, and for monitoring cultural resources (below). In particular, a BHBF in May-July may result in germination of tamarisk and other non-native plant species. Monitoring will detect the extent of this process.

d) **Riparian Fauna:** The 1996 BHBF occurred prior to the growing season and this limited assessment of impacts on non-avian terrestrial fauna, including invertebrates, herpetofauna and mammals. Advance notice of planned high flows may permit assessment of flood impacts on these taxa, and would enhance understanding of the extent of terrestrial drift. These data can be related to existing data on terrestrial fauna.

6. Cultural and Socioeconomic Impacts

a) **Arroyo Channel Sedimentation:** Arroyo channel mouth sedimentation occurred under the 1996 BHBF; however, a shorter duration BHBF and different antecedent sediment storage may result in different arroyo mouth sedimentation patterns during 1998 BHBF(s). Understanding these dynamics will contribute to understanding the role of dam management in the protection of riverside archeological sites. Some of this work can be undertaken using existing monitoring schedules, but detailed information should be collected before and after, and 6 months after the BHBF(s).

b) **Traditional Cultural Properties:** Monitoring of traditional cultural resources and sites will be undertaken by the cooperating Native American tribes.

c) **Archeological sites** are being monitored using existing monitoring projects. No additional information should be collected for some terrace deposits in the Glen Canyon Reach as wselected archeological sites in other reaches. Supplemental work may include photographs, and possible

terrace mapping.

d) Recreational Impacts: Recreational safety analyses may be desired, particularly if the BHBF(s) take place during the high visitation season (May through September). Interviews of river runners and observation of accidents at major rapids before, during and after the BHBF(s) may be conducted to test the hypothesis that high flows represent no danger to the visiting public.

In addition, assessment of impacts to the commercial trout fishing industry may be determined for the Glen Canyon reach.

7. Flow Impacts Review: Each participant in this BHBF program will be required to provide a review of flow (high, low, constant and fluctuating) impacts on the resources with which that individual has expertise. Guidelines will be developed by GCMRC and the TWG to focus this review process. Results of the reviews will be compiled by GCMRC for each research category, and presented as an integrated assessment.

8. Logistics

Pending finalization of projects, workplans and schedules, a comprehensive logistics plan will be developed. The permitting and scheduling challenges associated with a short planning horizon are numerous. The logistics budget and schedule presented in Table 1 will require refinement following authorization to conduct the BHBF and proceed with research planning.

Table 1. Draft field research and monitoring activities budget¹ for a single 45,000 cfs BHBF in April-July 1998.

Scientific Activities	Est'd. Total Cost (x \$1000)
Event Monitoring:	\$260
Aerial Photography and Analyses	(\$150)
2 fixed wing flights, pre and post-event	
1 video flight during the event	
Streamgauge analyses and cross-sections	(\$110)
Mainstream flow and sediment at LF, LCR,	
PR, DC, new gage; and the Paria R and LCR	
Lake Powell	\$40
Sediment:	\$130
Sandbar erosion and stratigraphy	
Bathymetry, velocity and channel storage	
Steroview oblique analyses, daily photography	
Aquatic Biology	\$150
Drift, benthos and nutrient dynamics	
Native fish (distribution, flow experiments)	
Native fish habitat	
Trout (population, redd distribution, diet)	
Terrestrial Biology	\$70
Kanab ambersnail	
Southwestern willow flycatcher	
Riparian vegetation and biota	
Cultural/Socioeconomic:	\$140
Sedimentation in arroyo channels	
Archeological sites	
Traditional cultural properties	
Recreational safety	
Logistics ¹	\$300
Pre-BHBF (5 trips)	
During BHBF (2 trips)	
Post-BHBF (5 trips)	
TOTAL	² \$1090

¹ GCMRC will reprogram \$60,000 of its FY98 budget for this program.

² Many GCMRC services are included in the above budget.