United States Department of the Interior

U. S. GEOLOGICAL SURVEY

Memorandum

To: John Hamill, Chief, Grand Canyon Monitoring and Research Center

From: Dave Rubin, David Topping, Scott Wright

Subject: Status of sand mass balance in the Colorado River ecosystem below Glen Canyon Dam

Date: October 19, 2006

Summary

Recent floods on the Paria River and Little Colorado River have supplied large quantities of sand to the mainstem Colorado River downstream from Glen Canyon Dam. Sand deliveries of such large magnitude occur on average only every five years, and the October 6, 2006, flood was the largest on the Paria River since 1998. Resource managers now have the relatively rare opportunity of exploiting this large quantity of sand for both habitat restoration and additional scientific learning.

Background

The most important science question identified by sediment scientists and managers at the 2005 Knowledge Assessment Workshop (KAW) was:

Is there a "flow-only" operation that will restore and maintain sandbar habitats over decadal timescales?

One significant outcome of the 2005 Knowledge Assessment conducted by the GCMRC was that, despite the great deal of learning that has occurred regarding sediment transport, sand bars, and dam operations in this system, the information and models are not yet capable of answering this question. The question can only be answered through a program that utilizes rigorous experimental floods whenever triggered by the specified amounts of new sand. The rationale for conducting experimental floods under sediment-enriched conditions has been documented in several peer-reviewed outlets, including Webb and others (1999), Topping and others (2000), Rubin and Topping (2001), Rubin and others (2002), Schmidt and others (2004), Wright and others (2005), Hazel and others (2006), Topping and others (2006), and by Randall and others (written

communication). The flow chart below was developed at the KAW to guide experimentation toward answering the sediment science question:

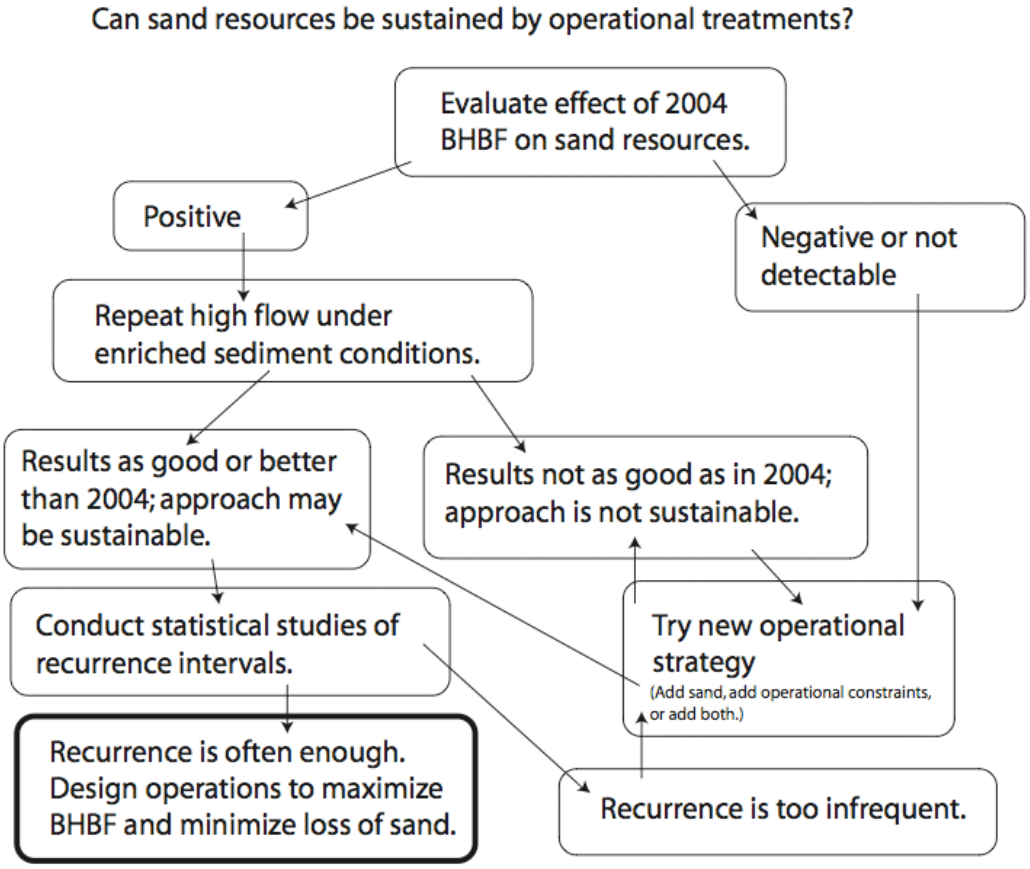

Figure 1. Flow chart for experiments testing the ability of operational treatments to restore sand resources.

Recent sand inputs to the Colorado River ecosystem from tributaries below Glen Canyon Dam provide an ideal opportunity to replicate the 2004 experimental flood—a key step in the flow chart—and address this strategic science question.

Sediment scientists at the U.S. Geological Survey recently produced the following estimates made on the basis of a combination of modeling and measurements over the last two years, with the following updated information included through October 18, 2006:

Sand Supply in the Main Channel of the Colorado River

Since July 1, 2006, the Paria has supplied between 1.32 and 1.98 million metric tons of sand, and the LCR has supplied between 260,000 and 380,000 metric tons of sand. The lesser tributaries in upper Marble Canyon are estimated to have supplied at least 170,000 metric tons of sand during this same period and perhaps much more.

Considering the uncertainties associated with the sand mass balance methods, the lower bound of the amount sand that accumulated in Marble Canyon since the 2004 experimental flood is 1.39 million metric tons, and the lower bound of sand that accumulated in upper Grand Canyon (below the Little Colorado River) is 300,000 metric tons. Following the scheme proposed by Science Planning Group and weighting the upper Grand Canyon sand at 50% (150,000 metric tons) and adding this reduced amount to the Marble Canyon sand gives a lower bound of 1.54 million metric tons. This exceeds the trigger by at least 540,000 metric tons.

Compared to sand status leading to the November 2004 flood, we now have almost 2 times that amount in upper Marble Canyon and about 3 times that amount in upper Grand Canyon. The recent Paria flood is the largest since 1998, and it is relatively rare to get large inputs from both the Paria River and LCR during the same year. Given the recent history of inputs from the Paria, Little Colorado, and lesser tributaries, the current opportunity to conduct an experimental flood with the amount of sediment now in the system should be considered rare, even if no additional sand is supplied. This large amount of sand recently supplied from the Paria, LCR, and lesser tributaries occurs only once in every 5-10 years. Furthermore, continued tributary flooding could result in additional new sand. This is perhaps the best opportunity managers will have in this decade to build on the results of 2004.

Upper Colorado River Basin Hydrology and Annual Glen Canyon Dam Releases

The same weather patterns that contributed to supply of sand to the Colorado River have apparently also supplied a significant volume of runoff to the Upper Colorado River Basin, and these inputs have come very early in the 2007 Water Year. It is anticipated that such early inflows to Lake Powell might result in Glen Canyon Dam releases later in the year (presumably, summer months with high daily peak discharges) exceeding the minimum release volume of 8.23 million acre feet. The known influence of any significantly increased monthly volume releases from the dam will be faster export (loss) of these new sand inputs. Sand-transport data collected during late-1999 and early-2000 indicate that if higher than 8.23 million acre-foot dam releases occur prior to conducting the next experimental flood, the recent large sand inputs will be exported from the canyon within 2007, and additional erosion of older sand in storage is likely. Such an increase in annual releases from the dam constrains the time available for exploiting the recent sand inputs.

Sediment Scientists' Recommendation for Restoration Experiment

Timing

Sand supplied by tributaries to the mainstem Colorado River is exported downstream relatively quickly, which constrains the time available for the new sand to be utilized for restoration (Rubin and others, 2002). The rate at which new sand is exported depends on water discharge and the availability of the new sediment (which in turn depends on the quantity and distribution of new sediment). The majority of sand in a moderate input is predicted to be lost within days (at discharges of >35,000 cfs) weeks (at discharges of ~25,000 cfs) or months (at discharges of ~15,000 cfs); at discharges of 10,000 cfs and lower, sand is retained for periods of months to years. As discussed previously (Rubin and others, 2002), the new sand will only be available for restoration if a flood is implemented promptly or if releases are constrained; as noted above, basin hydrology may prohibit low releases.

The goal of an experimental flood is three-fold: (1) to transfer inputs of tributary-supplied sand from the channel of the Colorado River to where it is needed (on the parts of the bars that will be emergent at typical dam releases) and where it will persist for longer timescales than on the channel bed, (2) to temporarily (over timescales of months) reduce the subsequent transport/export of sand by coarsening the sand on the surface of the channel bed and lower parts of bars, and (3) to maintain the increased bar size and sand resources until a subsequent experimental flood can be released from the dam. Preliminary analysis of data following the 2004 flood suggest that goals (1) and (2) were met, and that (3) can still be met if the next experimental flood is implemented in a timely manner.

Experimental plan

1) Use a combination of suspended-sediment measurements and the USGS's sand-routing model (Wiele and others, in press) to observe and predict downstream redistribution of new sand as a means of identifying optimal timing of an experimental flood (presumably in winter or spring 2007).

2) Repeat 2004 experimental flood hydrograph (in a month to be determined by 1 above, and by managers), thereby using the flood experiment as a monitoring tool. Differences in bar size between successive experiments will provide information about success or failure of a sediment-management program based purely on dam operations (see above diagram).

3) Use experience gained from the 1996 and 2004 science programs to design a smaller, lower-cost, surveying and change detection program. For example, instead of conducting both pre- and post-flood surveys, researchers could survey bars only after the flood.

In addition to addressing the strategic science question identified in the flow chart, this experimental plan has the potential to increase the ecosystem's sand resources. There is no guarantee that flow-only restoration is possible, but we know of no better flow-only option than an experiment to retain these large recent inputs.

Reporting of Future Inputs and Exports

Tributaries are continuing to supply additional sand to the Colorado River. We will provide undated reports of the mass balance by email. In the meantime, please feel free to contact me with any additional questions that you or the stakeholder group might have regarding this updated information on the sand mass balance and associated scientific recommendations. I can be reached at (831) 427-4736.

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