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Sand deposition in the Colorado River in the Grand Canyon from flooding of the Little Colorado River

S. M. Wiele
Water Resources Division, U.S. Geological Survey, Boulder, Colorado

J. B. Graf
Water Resources Division, U.S. Geological Survey, Tucson, Arizona

J. D. Smith
Water Resources Division, U.S. Geological Survey, Boulder, Colorado

Abstract. Methods for computing the volume of sand deposited in the Colorado River in Grand Canyon National Park by floods in major tributaries and for determining redistribution of that sand by main-channel flows are required for successful management of sand-dependent riparian resources. We have derived flow, sediment transport, and bed evolution models based on a gridded topography developed from measured channel topography and used these models to compute deposition in a short reach of the river just downstream from the Little Colorado River, the largest tributary in the park. Model computations of deposition from a Little Colorado River flood in January 1993 were compared to bed changes measured at 15 cross sections. The total difference between changes in cross-sectional area due to deposition computed by the model and the measured changes was 6%. A wide reach with large areas of recirculating flow and large depressions in the main channel accumulated the most sand, whereas a reach with similar planimetric area but a long, narrow shape and relatively small areas of recirculating flow and small depressions in the main channel accumulated only about a seventh as much sand. About 32% of the total deposition was in recirculation zones, 65% was in the main channel, and 3% was deposited along the channel margin away from the recirculation zone. Overall, about 15% of the total input of sand from this Little Colorado River flood was deposited in the first 3 km below the confluence, suggesting that deposition of the flood-derived material extended for only several tens of kilometers downstream from the confluence.

Introduction

Closure of Glen Canyon Dam in 1963 turned a once abundant sand supply in the Colorado River through the Grand Canyon into a precious resource. Understanding the fate of sand added to the Grand Canyon segment of the Colorado River from its two main sources, the Paria and Little Colorado Rivers, is crucial if the limited influxes of sand are to be managed to support a precarious riparian environment. Effective management of the river corridor for environmental purposes requires accurate methods to estimate (1) the volume and distribution of sand contributed by the two major tributaries and (2) the rates and patterns of redistribution of that sand by dam-regulated main stem flows.

Flooding on the Little Colorado River in January 1993 significantly replenished sand in the Colorado River downstream from the confluence. Much of that sand restored deposits near the water surface along the channel edges. The remainder was deposited within the channel, where it became a source of sand for enhanced downstream transport or a sand supply that could potentially be redistributed to the channel edges by manipulation of dam releases. Proposals to scour sediment from channel storage and deposit it along the margins using carefully designed periods of high steady discharge from Glen Canyon Dam [*Bureau of Reclamation* (*BOR*), 1994] have recently received increased interest. Effective redistribution of sand to the channel edges, however, requires keeping careful track of where the ever-moving sand mass is in the system. This investigation was initiated to track the fate of the sand contributed by the Little Colorado River flood and to evaluate models we have developed to predict its distribution.

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Background

By the early 1980s, agencies charged with management of the Colorado River in the Grand Canyon, white-water rafters, and anglers had become concerned that the normal hydroelectric peak-power production operations of Glen Canyon Dam were eroding sand bars used as campsites and which are critical to the riparian ecology of Grand Canyon National Park. This concern prompted BOR to initiate an investigation of the sand resources in the river between Lake Powell and Lake Mead, and since 1983, the BOR has coordinated a comprehensive program of investigations, the Glen Canyon Environmental Studies (GCES), to determine the effects of releases from Glen Canyon Dam on the riparian and aquatic resources in the park. As part of GCES, the U.S. Geological Survey (USGS) began in