8-6-1992

# Channel Restoration Above Elephant Butte Reservoir

Christopher A. Gorbach
*ASCE*

Published in Hydraulic Engineering: Saving a Threatened Resource—In Search of Solutions:
Proceedings of the Hydraulic Engineering sessions at Water Forum '92.
Baltimore, Maryland, August 2–6, 1992. Published by American Society of Civil Engineers.



# CHANNEL RESTORATION ABOVE ELEPHANT BUTTE RESERVOIR

By Christopher A. Gorbach, A.M. ASCE[1]

## Abstract

The Bureau of Reclamation is responsible for maintenance of channel facilities above Elephant Butte Reservoir in New Mexico. These facilities are designed to maximize the efficiency of water delivery into the reservoir pool. The major facilities operated and maintained by Reclamation include a rectified floodway channel and the Low Flow Conveyance Channel. When constructed in the 1950's, a period of prolonged drought and low reservoir levels, these channels extended some 20 (32 km) miles through then dry areas of the reservoir.

Between 1979 and 1987 flows in the Rio Grande were significantly above normal. Elephant Butte Reservoir filled for the first time since 1942 and the lower reaches of the Low Flow Conveyance Channel and rectified floodway were inundated. Great quantities of sediment deposited in the upper reservoir and in the river reach affected by its backwater. Channels were filled by depositing sediment impairing delivery of water into the reservoir.

When the reservoir level began to drop, restoration of efficient channels into the reservoir became a high priority. This paper describes and documents the strategies and methods employed to restore efficient transport of water and sediment into Elephant Butte Reservoir.

## Introduction

The terms of the Rio Grande Compact require the State of New Mexico to deliver water to downstream users from Elephant Butte Reservoir. An international treaty also obligates the United States to deliver Rio Grande water to the Republic of Mexico. Maximizing the flow of water into Elephant Butte Reservoir is essential to meet these obligations. Inability of New Mexico to

[1]Hydraulic Engineer, U.S. Bureau of Reclamation, 505 Marquette Ave. NW, Suite 1313, Albuquerque, NM 87102-2162





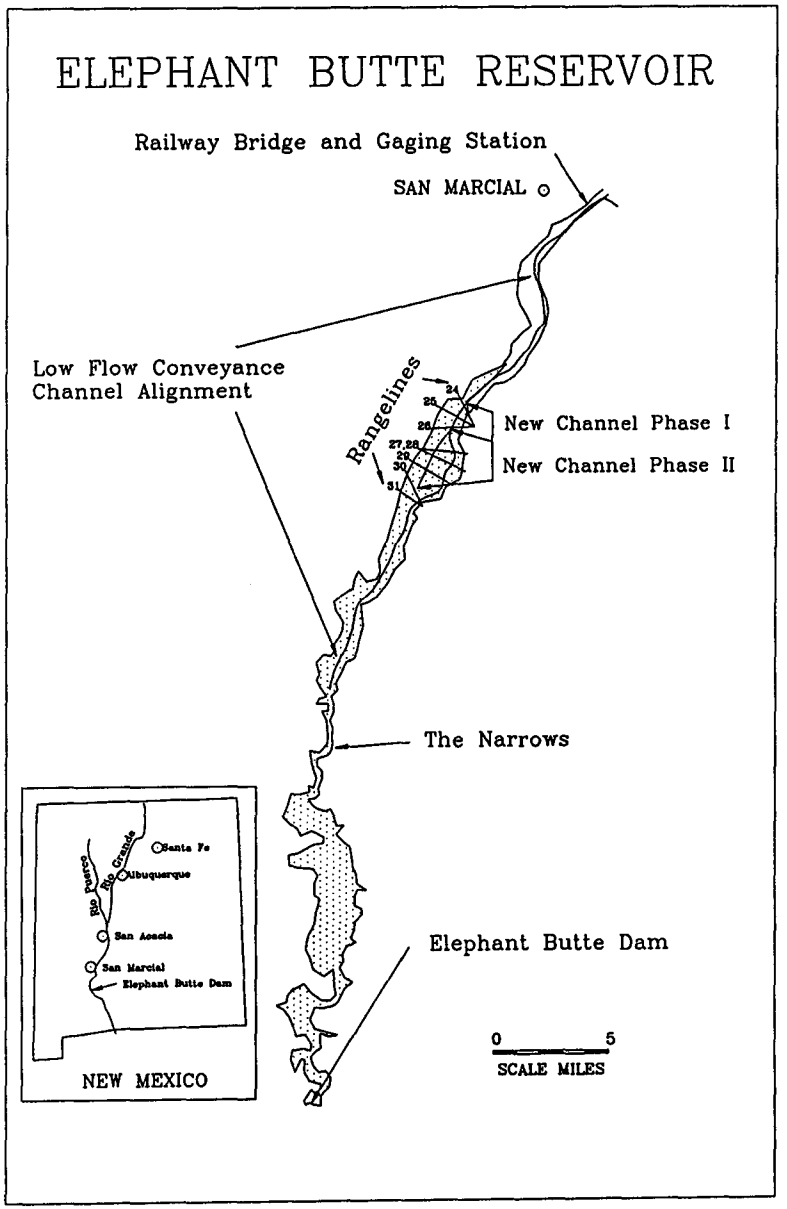


**Figure 1. Location Map**

deliver water to the reservoir to meet international and Rio Grande Compact obligations can result in the curtailment of water use in the state.

Under authority granted by Congress in the Flood Control Acts of 1948 and 1950, the Bureau of Reclamation has constructed, operated, and maintained conveyance facilities in the Middle Rio Grande Valley to provide efficient conveyance of water and sediment through the valley and into the reservoir. In the reach below San Marcial, New Mexico, a floodway channel and the Low Flow Conveyance Channel (Low Flow Channel, Conveyance Channel) are maintained for this purpose. The Low Flow Channel is a man-made channel designed to carry flows up to 2,000 cubic feet per second (cfs) (56 $m^3/s$) from San Acacia, New Mexico to the reservoir. The floodway is essentially the natural river channel managed and maintained for the passage of higher flows.

## Problem Development

Between 1979 and 1987 flow of the Rio Grande was significantly above normal in eight of the nine years. Elephant Butte Reservoir filled to capacity in the spring of 1985 and remained essentially full through 1988. The reservoir last filled in the early 1940's. Sediment deposition during the filling of the reservoir caused complete destruction of conveyance system facilities within the upper reservoir and aggradation of the river channel for a considerable distance upstream. Since March 1985 aggraded channel conditions have prevented operation of the Low Flow Conveyance Channel because of diminished sediment transport capacity. This important conveyance and water salvage facility is essential to New Mexico's ability to fulfill Rio Grande Compact obligations, especially in dry years.

Spring runoff volume was below normal in 1988, 1989, and 1990. By September 1990, the reservoir pool had dropped 27 (8m) feet below the spillway crest and the headwaters had receded about 5 miles (8km). Because all conveyance facilities below rangeline 24 had been lost, the means for efficient delivery of water into Elephant Butte Reservoir no longer existed. Above rangeline 24, the decrease in channel capacity caused by aggradation of the river threatened further destruction of the Low Flow Channel and its protecting levee. Floodway capacity in most of the 10 mile (16 km) reach upstream of rangeline 24 was less than the estimated 2 year return frequency flood peak of 7,000 cfs (196 $m^3/s$). Breaching or overtopping of the levee would cause severe damage to the Low Flow Conveyance Channel. Estimated replacement cost of the Low Flow Channel is $1,400,000 per mile ($880,000/km).

## Channel Restoration Concepts

The Bureau of Reclamation's maintenance program in the Elephant Butte Reservoir headwater area has two objectives. First, effective conveyance for water and sediment to the main pool of the reservoir must be established and



maintained. Second, the river channel bed must be lowered to increase discharge capacity and provide protection for the Low Flow Conveyance Channel and other facilities in the area. Channel degradation must also be accomplished to enable returning the Low Flow Conveyance Channel to operation at the earliest possible time. The two objectives are related to the extent that efficient sediment transport will promote channel degradation. The initial channel restoration project was done in two distinct phases. Phase I exploited the river's natural ability to cut a new channel by headcutting and scour. In Phase II it was necessary to excavate a new channel mechanically.

Restoring a channel in the old alignment below rangeline 24 presented certain difficulties. For almost 40 years the river had been confined to the eastern side of the dry reservoir by the Conveyance Channel levee. Consequently, during the reservoir rise, deposition of sediments was generally greater on the eastern side of the reservoir leaving the terrain sloping down from east to west. A large delta deposit completely buried the Floodway, Low Flow Conveyance Channel, and even the levee in the vicinity of rangelines 27 and 28.

A new alignment toward the west side of the reservoir had several advantages. Assuming reservoir contents at 1,200,000 acre feet (1.48EE9 $m^3$), a channel in the new alignment was 55 percent shorter than one following the old channel route. The shorter distance not only decreased excavation quantity but also allowed for a steeper slope that provided higher sediment transport capacity. Depth of necessary cuts was also be decreased. Following the old alignment would have required some cuts up to 10 feet deep; in the new alignment, cuts were only about 4 to 5 feet (1.2 to 1.5 m). In addition, remains of the abandoned "B-line" drain, which had been cut in the early 1950's between rangelines 27 and 30, still existed in a location nearly ideal for incorporation into the new channel alignment. Altogether the required excavation in the new alignment was about 65 percent less than that which would have been required in the old alignment.

While offering some definite advantages, the new channel alignment to the west posed some daunting construction problems. Much of the work area was flooded, and even in drier areas the ground was so soft that conventional equipment could not be used.

## Channel Restoration Project -- Phase I

When the reservoir was full, the river flowed east of the levee to a point just above rangeline 24. It then flowed through a breach in the levee and out over a delta through several distributary channels. One of the main distributary channels followed the old Conveyance Channel to a point just above rangeline 26, but no defined channels existed below that point.

The plan adopted for the first phase of the channel restoration involved closing

off distributary channels and forcing the river to flow down the old Low Flow Channel as far as rangeline 26. This action maximized the potential of the river to cut its own channel in the sands that had been deposited in the Low Flow Channel.

A berm was built parallel to and 500 feet (150m) west of the old levee. The berm is about 5 feet (1.5m) high and runs 7,500 feet (2,250m) from just above rangeline 24 to rangeline 26. Borrow material came from west of the berm leaving a vegetated fringe between the new berm and the channel to protect against erosion. Where possible the berm was built by dozers making a wide, shallow cut allowing root structures to remain as an aid to revegetation. Work with dozers became impractical because of soft ground about 3,500 feet (1,050m) below rangeline 24. Below that point the berm was built by a dragline working on timber mats.

Rip rap bank protection was provided at the sharp bend making the transition into the Phase I reach at its upstream end. Otherwise, only the brush fringe was used for erosion control and bank protection.

### Channel Restoration Project -- Phase II

Below rangeline 26 the new channel was routed toward the west side of the reservoir to avoid the large delta that buried the Low Flow Channel at the east end of rangelines 27 and 28. The new alignment diverged from the Low Flow Channel at rangeline 26 and linked with the old "B-Line" Drain at rangeline 27. The "B-Line" drain was cleared, enlarged, and incorporated into the new channel. The Phase II channel is 120 feet (36m) wide and averages about 4 feet (1.2m) deep. Spoil berms on either side of the channel increase its capacity. Total conveyance capacity was further increased by moving the west side spoil bank approximately 100 feet (30m) to provide some overbank flow capacity while retaining a narrower main channel for efficiency of sediment transport at lower discharges.

Conditions in the Phase II reach were very different from those in the Phase I area. The strategy employed in the Phase I reach, forcing the river to scour its own channel, was impractical because the deposited sediments were predominantly clay. Establishing a channel required mechanical excavation of 265,000 cubic yards (200,000$m^3$)in very soft, saturated terrain. Conventional ground based equipment was unsuited for the job. After evaluating several alternatives, special amphibious excavators, designed for work in the Mississippi Delta, were selected for the job.

### Amphibious Excavators

The amphibious excavators are conventional hydraulic excavators with the undercarriages replaced by pontoons that have walking tracks driven from the



machines' hydraulic system. These machines are mobile in water, soft mud, or on dry land, and they are capable of working in water up to 5 feet (1.5m) deep. Conventional undercarriages are supplied so that the excavators can be easily converted for full time operation on land.

Reclamation acquired two amphibious excavators for the initial excavation of the Phase II reach. The amphibious excavators proved so successful that a third machine was eventually purchased. These machines provided a means of constructing the second phase of the channel restoration project simply and economically. Amphibious equipment was a key factor in the success of the project, being ideally suited to the difficult site conditions and the scale and scope of the project. Excavation of the Phase II channel was done between September 1990 and June 1991. Unit cost for the excavation was approximately $3.00 per cubic yard ($3.93/$m^3$).

Moreover, the versatility and mobility of the machines has allowed them to do other tasks associated with the channel development work. Notably, the amphibious excavators have been used to remove sediment plugs that have developed in the river channel upstream of the new channel reach. Removal of the plugs enables headcutting and channel degradation trends to proceed upstream beyond these obstructions. In the generally prevailing trend of channel degradation, it was sufficient to make small pilot cuts through the plugs to initiate scouring by the river. The river then removed the bulk of the plugs by erosion and sediment transport.

### Effectiveness of the Channel Restoration Project

The new river channel performed successfully during the 1991 spring runoff and through the summer thunderstorm season, accommodating flows up to 5,000 cfs (140$m^3$/s). Channel restoration in the Phase I reach was almost completely accomplished by the river's own scouring and headcutting action. Significant scouring of the river channel upstream of the channel restoration area is also apparent. Above rangeline 24, channel capacity was increased from 2,000 cfs to 6,000 cfs (56 to 168 $m^3$/s) due to headcutting and channel degradation. Near rangeline 24 the river channel degraded about 9 feet (2.7m) permitting drainage and groundwater flow from the Low Flow Conveyance Channel to be discharged into the river for the first time since 1985. Channel scouring at the San Marcial Railway Bridge, some 8 miles (13km) upstream, was very apparent, and a rating shift of more than 3 feet (.9m) at the San Marcial Gage was recorded in October 1991.

The projects described in this report were intended as short term, emergency remedies for critical conditions of immediate concern. Work to promote channel development in the Elephant Butte Reservoir headwater area continues, and more detailed and exhaustive study is underway to determine longer term strategies for management.