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SEDIMENTATION EFFECTS ON WATER QUALITY AT ELEPHANT BUTTE RESERVOIR

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INTRODUCTION

The Rio Grande has always been a heavily silt-laden stream with turbidity levels that rivals the Colorado River. With the construction of Abiquiu, Cochiti, Galisteo, and Jemez reservoirs, the Rio Grande's sediment load has been decreased. This leaves the Rio Puerco as the last remaining major sediment-contributing tributary. The average annual sediment load of the Rio Puerco and its tributaries is over 7,000 acre-feet of sediment per year. Rio Puerco sediment, due to its physical and chemical characteristics, requires annual maintenance and repair to the Rio Grande river channel and the low flow conveyance channel, and damages fish and wildlife habitat.

Along with continued soil conservation, construction of a proposed flood and sediment control dam on the Rio Puerco and incorporation of watershed treatment practices by the U.S. Forest Service, will enhance greatly the long-term productivity of the middle Rio Grande valley. These activities also will curtail possible contamination to the water supply at Elephant Butte Reservoir. This interagency effort will improve grazing and agricultural potentials throughout the tributary area. By reducing the turbidity at the headwaters of Elephant Butte, the fish spawn will be increased.

POTENTIAL FLOOD DAMAGE

The Army Corps of Engineers has significantly reduced the flood threat to the Middle Rio Grande floodway by constructing Abiquiu, Cochiti, Galisteo, and Jemez Canyon dams. A potential for vast flood damage exists when a summer or fall transition storm system centers on the western portion of New Mexico or specifically over the Rio Puerco and Rio Salado watersheds. Historically these tributary river basins have caused major damage to the Rio Grande floodway when moist air from the Gulf of California or the Gulf of Mexico has moved north as a result of tropical storms.

The storm of September 20-23, 1929, might be considered typical of a major summer-to-fall transition over the Rio Grande basin. The following is quoted directly from the Meteorological Summary, U.S. Weather Bureau, dated August 1, 1946.

> "The source of moist air for this storm was the Pacific Ocean off the coast of Mexico where three tropical disturbances were tracked between September 10 to the 27th. During the period of the tropical storms a polar air mass was moving south into New Mexico. The pressure gradient between a stationary high pressure centered over the east coast and the low pressure of the polar air mass produced a sustained flow of tropical air into the Colorado Plateau. The heavy showers

that resulted dumped 4.81 inches of rain on Santa Fe, New Mexico within a 60 hour period. A secondary rainfall center was observed in the San Juan and Chama River basins."

Another storm with tropical air beginnings occurred in October 1911, when a tropical cyclone moved into eastern Arizona, western New Mexico, and southwestern Colorado. Recorded runoff at San Marcial gage measured in excess of 203,000 acre-feet on October 6-16.

Storms of similar origin in the fall of 1929 and again in 1933 deposited large amounts of sediment in the Rio Grande floodway below the mouths of the Rio Puerco and Rio Salado and led to the abandonment of the town of San Marcial, which was located at the headwaters of Elephant Butte Reservoir.

SEDIMENTATION DAMAGES

The extent of damage caused by sedimentation to the Rio Grande Valley is severe. Sedimentation results in increased maintenance costs to the floodway, irrigation water distribution systems, and the low flow conveyance channel. Sediment-laden waters that enter the Rio Grande from the Rio Puerco and Rio Salado watersheds have a detrimental effect on crop production and in some instances, crops have been killed when the sediment-laden waters have been used for irrigation. The flood of September 1929 destroyed the town of San Marcial when sediment deposits of over nine feet covered the floodway. The results of a similar flood event today would be devastating. In addition to sediment deposition problems in the floodway, storage efficiency in Elephant Butte Reservoir is curtailed by the increasing amount of lake surface exposed to evaporation. In 1916 the capacity of Elephant Butte Reservoir was 2,634,800 acre-feet at the spillway elevation. A 1988 sedimentation survey conducted by the Bureau of Reclamation showed a capacity of 2,065,010 acre-feet. This difference indicates a capacity loss of 569,700 acre-feet during the 73-year period between the dam's completion and the sedimentation survey.

Currently, the Bureau of Reclamation is engaged in an effort to remove numerous sediment plugs deposited as a result of sediment transport into the reservoir. In calendar year 1991 the Bureau removed over 265,000 cubic yards of silt and sediment from the Rio Grande channel in the San Marcial reach at a cost of approximately $1 million.

Average annual flow into Elephant Butte for the 25-year period, 1961 to 1985, is 725,000 acre-feet. Between 1978 and 1989 inflows into the reservoir were significantly above normal in seven of the twelve years. Average annual inflow for the twelve years is 896,027 acre-feet. These large inflows transported great quantities of sediment and have deposited the sediment in the reservoir's upper reaches. For the twelve-year survey period the average annual computed sediment loads at San Marcial were:

Silt and clay loads	2,405,975 tons/year
Bed material load	2,133,124 tons/year
Total load	4,539,099 tons/year

An analysis of the sediment-producing area above Elephant Butte (25,923 square miles) shows that sediment is trapped in the upstream reservoirs constructed by the Army Corps of Engineers.

Table 1. Dams upstream from Elephant Butte Reservoir containing trapped sediment.

Site	Year Completed	Square Miles
Jemez Canyon Dam	1953	1,034
Galisteo Dam	1970	596
Cochiti Dam	1973	11,960
Total		13,590

Subtracting the total square miles of these three dams from the 25,923 square miles above Elephant Butte, results in 12,333 square miles of watershed area unprotected from flood and sediment damage. The Rio Puerco and Rio Salado basins make up the majority of this unprotected area.

The Rio Puerco and Rio Salado watersheds contain 7,340 and 1,350 square miles, respectively. The watersheds' total area, 8,690 square miles, is 70 percent of the sediment-contributing areas to Elephant Butte Reservoir. A soil analysis of the Rio Grande floodway between San Acacia and Elephant Butte shows that the soils have been formed from the highly colloidal materials deposited by the Rio Puerco and are generally of a heavy texture according to a 1977 study by the U.S. Bureau of Reclamation.

ENVIRONMENTAL DAMAGE

A far more serious effect is the potential from heavy metal contaminated sediment from the Grants mining area, which is drained by the Rio San Jose tributary to the Rio Puerco. Materials derived from uranium mine tailings piles or waste ponds can be especially significant to the Rio Puerco due to its high sediment load. In 1981 there were 42 active mines and five processing mills in this area. The Rio Puerco has been estimated to contribute only 16 percent of the water to the Rio Grande but over 60 percent of the sediment load. Above the mouth of the Rio Puerco at Bernardo, the Rio Grande (before flows from the Rio Puerco) has been estimated to have an average annual sediment load of 1,600 acre-feet per year. The Rio Puerco at Bernardo before it discharges into the Rio Grande basin is estimated to have an average annual estimated sediment load of 5,584 acre-feet.

Of particular concern are the waste materials accumulated in ponds from mine dewatering or from ion exchange plants. Water in ion-exchange plants generally pass through settling/evaporation basins, and then are either discharged or used as makeup water. As mining progresses, the uranium content of the mine water increases due to oxidation. Ion-exchange plants lower the uranium content to approximately 0.5 ppm. The water is then discharged into the Rio Puerco watershed. Since upstream water is diverted for agricultural, municipal, and industrial use, the Rio San Jose is normally dry. Radionuclides and heavy metals are commonly absorbed by clay soils. Most soils in the Rio Puerco and Rio San Jose watersheds are of a clay origin. The possibility then exists that uranium and other heavy metals are being transported downstream by sediment movement. During flash floods or heavy runoff, water remobilizes and transports absorbed or precipitated heavy metals. Studies conducted during the 1980s by Dr. Carl Popp and Dr. Donald Brandvold of the New Mexico Institute of Mining indicate that heavy metal contaminated sediment is being transported to the mainstem of the Rio Grande and into Elephant Butte Reservoir.

In April 1990, Dr. Donald Brandvold and Lynn Brandvold of the New Mexico Bureau of Mines and Mineral Resources presented a compilation of data obtained from different studies that sampled the waters of the Rio Grande basin at approximately 43 sites (New Mexico Water Resources Research Institute Miscellaneous Report No. M22). These sampling sites began at the Colorado/New Mexico state line and ended at the Texas/New Mexico state line. Studies were done for dissolved metals as well as metals in suspended, bottom, and bank sediment. The report summarizes the findings of four M.S. theses, an Interstate Stream Commission report, a study done for the EPA, and a report for the Office of Surface Mining. Only two elements, mercury and selenium, exceeded the New Mexico Environment Department criteria for Public Drinking Water Standards.

SUMMARY

This paper's purpose is to bring attention to the possibility of serious environmental, flood, and sediment damage to the Rio Grande floodway and Elephant Butte Reservoir. In 1915 when Elephant Butte Reservoir was completed, it had a storage capacity of 2,534,800 acre-feet. In 1988 as a result of a sedimentation survey conducted by the Bureau of Reclamation, the reservoir's capacity was 2,065,000 acre-feet for a loss of 569,700 acre-feet during the 73-year period. This loss threatens the water supply for agricultural and municipal purposes below Elephant Butte. The sediment deposited at the upper regions of the Elephant Butte Reservoir has destroyed an enormous amount of wildlife habitat. About 50 percent of the cottonwood trees, and even salt cedars, have been killed because of this sediment. This results in a loss of fish and wildlife habitat, and jeopardizes the municipal, agricultural, and industrial water supply for the people below Elephant Butte Reservoir.

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