Paper W 8

MONITORING OF STREAMFLOW IN THE VERDE RIVER BY ERTS-1 DATA COLLECTION SYSTEM (DCS)

Herbert H. Schumann, *U. S. Geological Survey, Water Resources Division, Phoenix, Arizona*

ABSTRACT

The Verde River watershed in central Arizona furnishes municipal, industrial, and agricultural water to the Salt River Valley —an area that contains more than half of Arizona's population and about one-fourth of the State's irrigated land. Water management decisions related to the operation of large multiple-use reservoirs require accurate and continuous monitoring of moisture conditions over large remote areas.

The U.S. Geological Survey in cooperation with the Salt River Valley Water Users' Association installed a specially designed gaging station on the Verde River near the town of Camp Verde to evaluate near-real time streamflow data furnished by the ERTS-1 Data Collection System (DCS). On Nov. 3, 1972, the installation was equipped with a Stevens digital water-level recorder, modified for telemetry, and an ERTS-1 data collection platform operating in the digital-parallel mode. During the 43-day period between Nov. 3 and Dec. 15, 1972, the DCS relayed 552 transmissions during 193 data passes. The DCS system transmitted stream-stage information 4.5 times per day on the average. The amount of data received far exceeded the expected single high quality transmission rate of once per 12-hour period from the DCS system.

The digital-parallel ERTS-1 Data Collection System has furnished data sufficient to accurately compute daily mean gage heights. These, in turn, are used to compute the average daily streamflow rates during stable or slowly changing flow conditions. The digital-parallel DCS data has also furnished useful information during peak-flow periods. However, the serial-digital DCS capability, currently under development for transmitting streamflow data, should provide data of greater utility for determining times of flood peaks.

INTRODUCTION

The Salt and Verde Rivers drain approximately 13,000 square miles of central Arizona. Runoff from these rivers is stored and regulated by a series of reservoirs operated by the Salt River Valley Water Users' Association (fig. 1). These reservoirs are utilized to furnish hydroelectric power, municipal, industrial, and agricultural water to the Salt River Valley in Maricopa County, Arizona. The Salt River Valley contains more than half of Arizona's population (Phoenix metropolitan area), about one-fourth of the State's irrigated land, and is the third most important agricultural area in the United States.

The inability to accurately measure or monitor moisture conditions over large remote areas of central Arizona presents serious land and water management problems. The lack of timely information about rainfall, snow-water content, and streamflow conditions present vexing water management problems related to multiple-use reservoir operations that can and have resulted in the loss of water resources, extensive property damage, and even the loss of life.

The U.S. Geological Survey (USGS) ERTS-1 Data Collection System (DCS) experiment in Arizona includes the use of six (6) data collection platforms to relay hydrologic and meteorologic data. Data from these platforms will be used to test and evaluate the application of near real-time satellite telemetry systems to assist in the management of Arizona's land and water resources. However, because of limited time available, this presentation will be restricted to the application of the DCS to monitoring of streamflow in the Verde River.

RESERVOIRS AND STREAMFLOW

Streamflow in the Verde River is regulated by Bartlett and Horseshoe reservoirs, located northeast of Phoenix (fig. 1). These reservoirs have a combined storage capacity of 317,700 acre-feet (one acre-foot is equal to the quantity of water required to cover one acre to a depth of one foot and is equivalent to 43,560 cubic feet or 325,851 gallons). The streamflow rate in the Verde River above Horseshoe Dam has ranged from a minimum of 48 cfs (cubic feet per second) to a maximum of 81,600 cfs and has averaged 450 cfs during

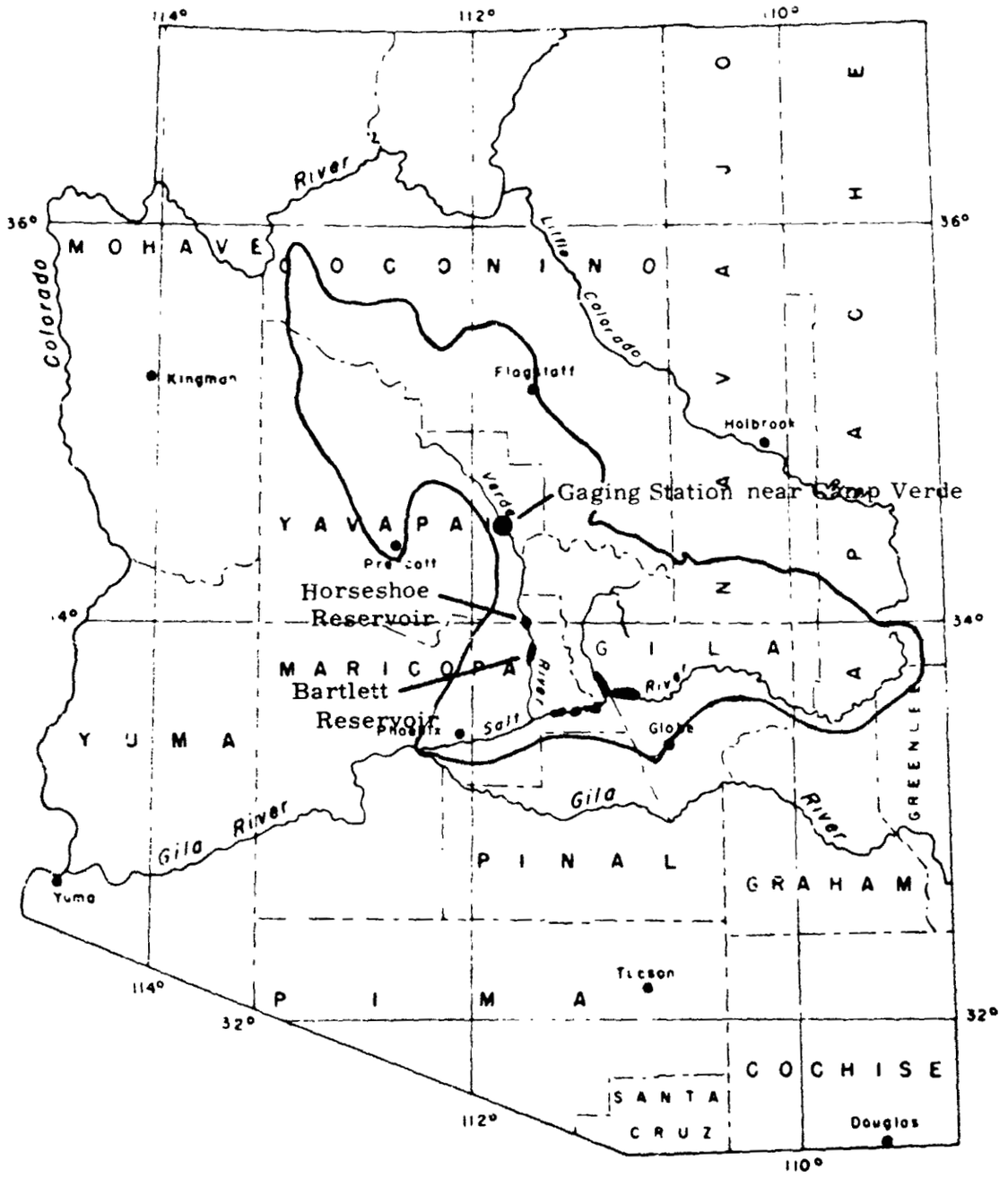

FIGURE 1. — SALT AND VERDE RIVER WATERSHEDS, ARIZONA

the 1945-1970 period of record. The U.S. Geological Survey, in cooperation with the Salt River Valley Water Users' Association, installed a specially designed gaging station on the Verde River near the town of Camp Verde to evaluate near-real time streamflow data furnished by the ERTS-1 Data Collection System (DCS) and to provide early warning of large flood flows.

STREAMFLOW INFORMATION FURNISHED BY ERTS-1 DATA COLLECTION SYSTEM

On Nov. 3, 1972, the U.S. Geological Survey gaging station near Camp Verde was equipped with a Stevens digital water-level recorder, modified for telemetry, and a ERTS-1 data collection platform operating in the digital-parallel mode. During the 43-day period between Nov. 3, and Dec. 15, 1972, the DCS relayed 552 transmissions from this installation during 193 data passes. The DCS transmitted stream stage information 4.5 times per day on the average. Stream stage or gage height is the water surface elevation referred to some arbitrary gage datum. The amount of data received from this station far exceeded the expected single high-quality transmission rate of once per 12-hour period from the DCS. This DCS data received during November and December 1972 is shown on figure 2.

The data received from the Verde River gage with the DCS system operating in digital-parallel mode furnished information sufficient to accurately compute daily mean gage heights. These data, in turn, are used to compute the daily mean streamflow rate during stable or slowly changing flow conditions. Daily mean gage heights were computed from both the digital recorder and from the DCS data. During slowly changing flow conditions daily mean gage heights determined graphically from the DCS data were within ±0.10 feet of daily mean gage heights computed from 96 readings per day supplied by the digital water-level recorder.

To obtain a preliminary estimate of the accuracy of streamflow rates as computed from the DCS data, daily mean streamflow rates were computed from both the DCS data and the digital recorder data for the period Nov. 3 through Dec. 30, 1972. The daily mean streamflow rate as determined from both data sources were compared and the differences, expressed as a percent of the flow rate computed from the digital recorder data, are shown on figure 3. During periods

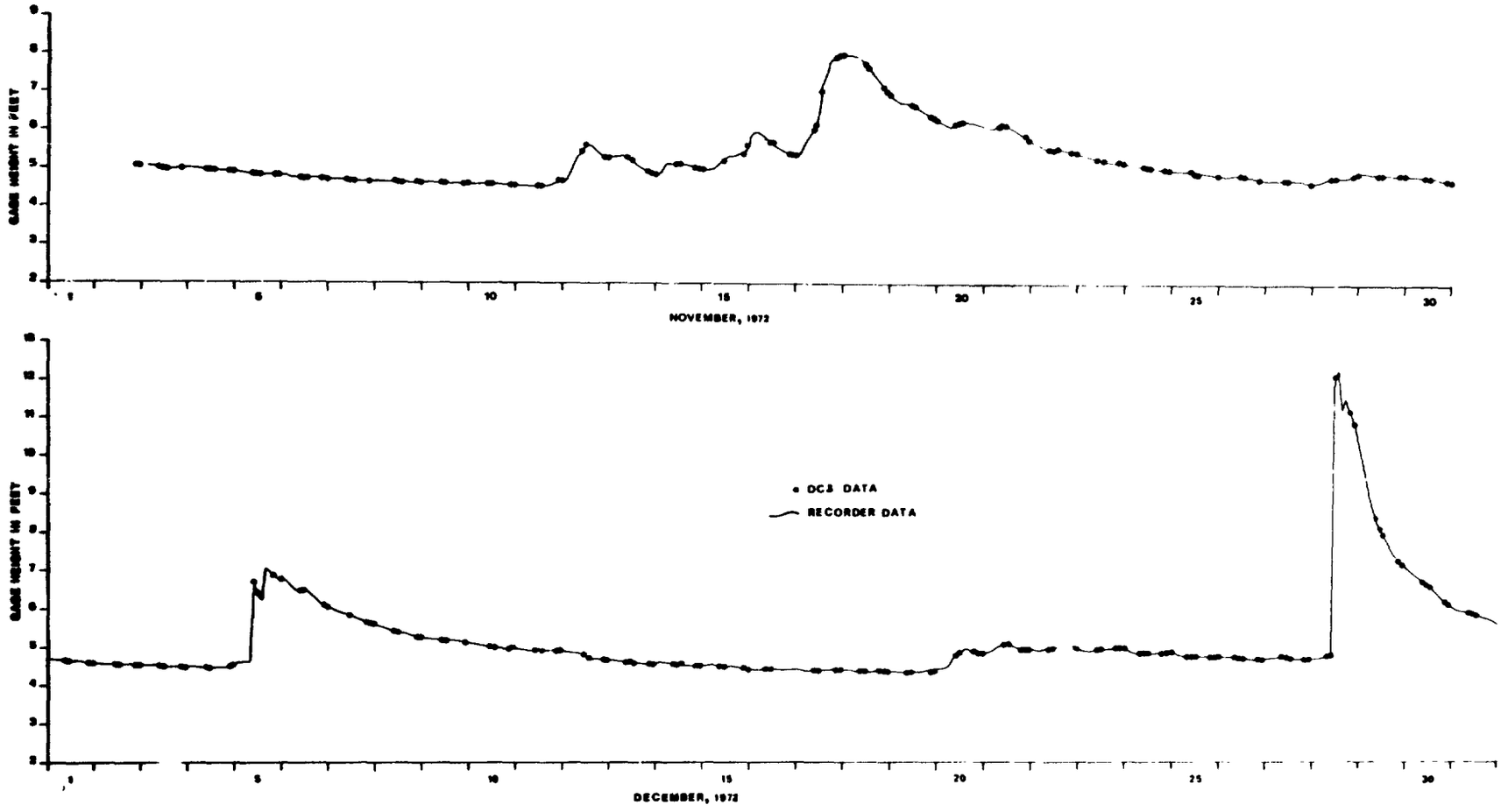

FIGURE 2.—STREAMFLOW GAGE HEIGHTS AT THE VERDE RIVER GAGE, NEAR CAMP VERDE, ARIZONA

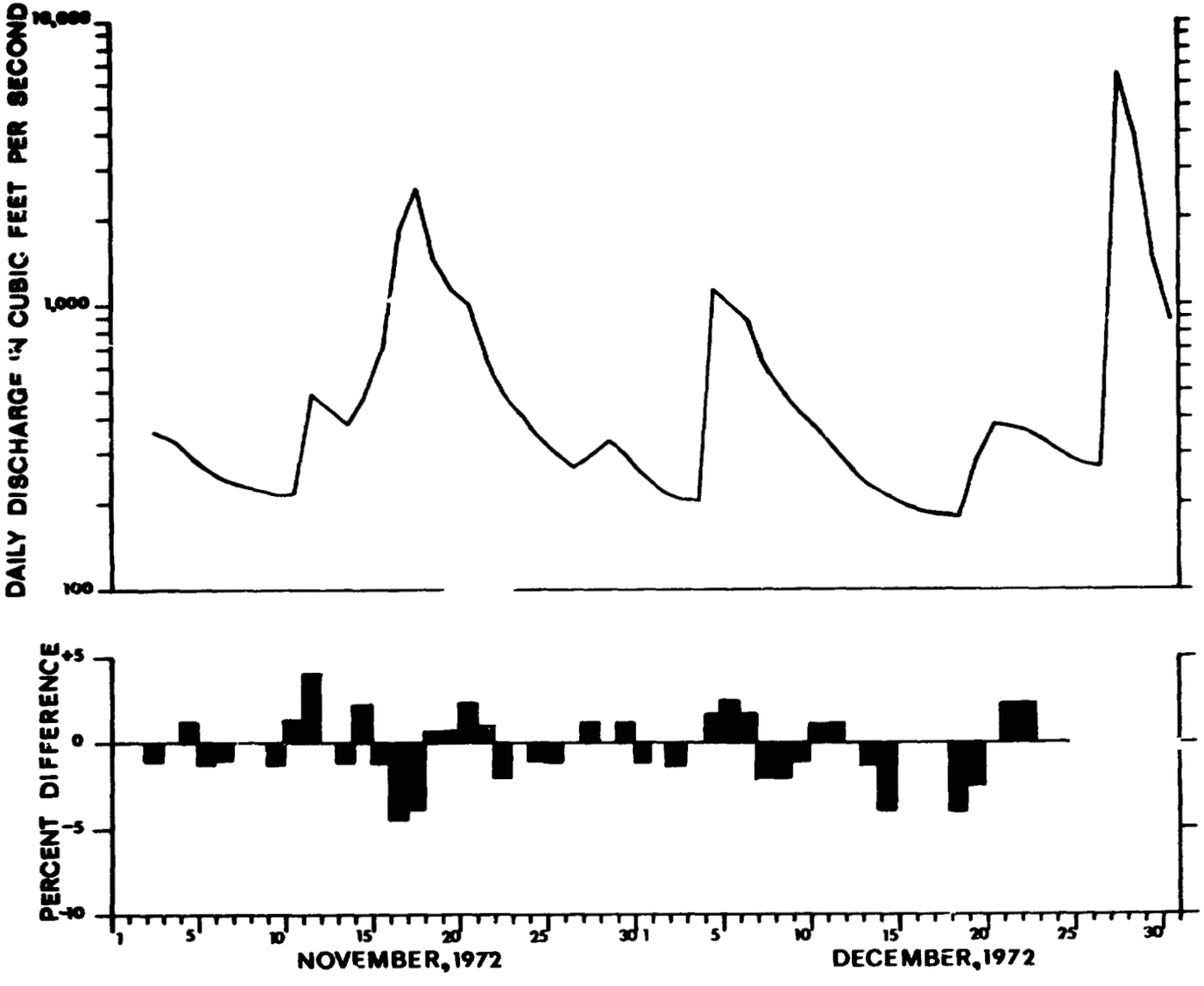

FIGURE 3.—MEAN DAILY DISCHARGE IN VERDE RIVER NEAR CAMP VERDE, ARIZONA

of stable or slowly changing flow conditions, daily mean flow rates computed from the DCS data agreed within ±5 percent of those computed from the digital recorder data. During the period of high flow in late December 1972, daily mean flow rates computed from the DCS data agreed with those computed from the digital recorder data within ±10 percent. This preliminary comparison indicates the DCS system furnished data sufficient to accurately compute daily mean streamflow rates during the first two-month period of operation at this site. However, a longer period of record is necessary to adequately evaluate the capability of the system to furnish accurate streamflow data.

The digital-parallel DCS data has furnished useful information during peak-flow conditions. Late in the afternoon of Feb. 21, 1973, the USGS was requested by the Salt River Valley Water Users' Association to furnish streamflow information on the Verde River near Camp Verde on an emergency basis. Water stored in the Verde River reservoirs had reached about 95 percent of capacity (20,000 acre-feet of available storage) as a result of runoff from a general rain over most of the watershed during the previous 24-hour period and it had become necessary to release water. The immediate problem was to determine the amount of runoff that was coming from the upper snow covered portion of the watershed in order to determine the minimum rate of release from the reservoirs that would maintain the minimum available storage capacity considered essential to provide some protection from major flood damage downstream.

The latest reading from the DCS equipped gage on the Verde River near Camp Verde was requested from the Goddard Space Flight Center (GSFC) by telephone at 1630 hours MST (Mountain Standard Time) and it indicated the flow had been approximately 400 cfs at 1227 hours MST. The next available data from this station was requested on a high priority basis by the USCS. At 2219 hours MST the next readings from the station were received by GSFC and were provided to the USGS at 2240 hours MST by telephone. These data indicated the approximate streamflow rate had increased to only about 500 cfs and this information was furnished to the Salt River Valley Water Users' Association at 2245 hours MST. The DCS had in fact furnished near-real time information - 26 minutes receipt by the satellite to delivery to the user - that indicated the snowpack was not melting at a rapid rate and releases from the reservoir could be made accordingly. DCS data received the following morning confirmed this interpretation. Although some road crossings in the Phoenix area were closed by the released water, the data

furnished the USGS by the DCS provided key information that helped water management minimize the amount of inconvenience caused by the necessary release of water while still maintaining a minimum safe margin of available reservoir storage to protect against major flooding. The serial-digital DCS capability, currently under development for transmitting streamflow data, should provide data of greater utility for determining times of flood peaks and the rate of change of streamflow.

SUMMARY AND CONCLUSIONS

The digital-parallel gage height data received from the USGS Verde River gage near Camp Verde, Arizona furnished information sufficient to accurately compute daily mean streamflow rates during the first two months of operation. However a longer period of record is necessary to adequately evaluate the capability of the DCS to furnish accurate streamflow data.

The DCS is capable of furnishing near real-time information on streamflow. On Feb. 21, 1973, the USGS was able to furnish streamflow information to aid in the operation of multiple-use reservoirs on the Verde River, within 26 minutes from the time of transmission, by means of the ERTS-1 DCS. The serial-digital capability for transmitting streamflow data by the DCS is currently under development, and should provide near real-time data of greater utility for determining time of flood peaks and rates of change of streamflow.