THE LABOR DAY STORM OF 1970 IN ARIZONA

551-72

By

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Introduction

The 1970 Labor Day Storm caused more loss of human life than any other storm in Arizona's recent history. In addition, many dwellings, roads, bridges, and other structures were damaged by record flooding. Consequently, the meteorological and hydrological features of this event, and the resulting damage to human, cultural, and natural resources have been documented and analyzed. Such analyses contribute to improved estimates of the magnitude and frequency of future storm and flood events, and assist engineers and planners in the design and location of new communities, drainage systems, bridges, dams, and other cultural features.

Meteorological Event

The meteorological events involved in the Storm began on September 2nd, when moist air, associated with tropical storm Norma, flowed into Arizona from the Pacific Ocean and the Gulf of California (National Oceanic and Atmospheric Administration 1970). This air mass extended over the State during the next two days, and reached sufficient depth to allow the formation of thunderstorms over southeastern Arizona on the 3rd. Thunderstorms spread northwestward into the Phoenix area by evening, and continued to spread northwestward over the State at night.

A convergent flow of air in the lower atmosphere over southern Arizona on the 4th caused heavy rainfall to occur on the east side of the Baboquivari Mountains and northward to Tucson and the Avra Valley. This rainfall ended late on the 4th.

On the morning of the 5th, a cold front had extended from southwestern Utah into southern Nevada, and an associated deep upper trough was located over Nevada and southern California. Simultaneously, in advance of the cold front, a surface trough was oriented from Las Vegas, Nevada to Palm Springs, California. Strong, southerly winds developed in the lowest 10,000 feet of the atmosphere early on the 5th. Orographically induced rainfall increased sharply over the mountains of central Arizona as the troughs approached from the west. In addition, a combination of the eastward advancing trough and normal daytime heating generated lines of thunderstorms in the desert valleys of western Arizona by midafternoon. These thunderstorms progressed eastward and intensified, resulting in heavy rainfall by late afternoon in the Salt River Valley. Most of the activity associated with the lines of thunderstorms had weakened by late evening, and precipitation ended over the central mountains and the northeastern plateau. However, the eastward movement of the surface trough had slowed during the day, causing renewed storm activity throughout the evening in the desert valleys eastward of the Buckeye area.

The original cold front dissipated by the evening of the 5th, and the surface trough, now located east of Phoenix, acquired the characteristics of a cold front. This newer and weaker cold front progressed southward to a position between Tucson and Douglas on the morning of the 6th. Strong, southerly winds continued south of the front, and there was more orographic rainfall over the mountains of southeastern Arizona. Late on the 6th, all atmospheric disturbances had weakened and most of the precipitation ceased, bringing the Storm to an end.

An isohyetal map of total storm precipitation shows that orographic effects were prominent (Figure 1). Higher rainfall totals (six inches or more) were mainly associated with the Sierra Ancha, Mazatzal, Bradshaw, Black Hills, Santa Catalina, and Baboquivari mountain ranges. Heavy rainfall also occurred along the Mogollon Rim northeast of Payson and on the high country south of Flagstaff.

New precipitation records for a 24-hour observational day were established at many National Weather Service stations in Arizona (Thorud and Ffolliott 1971). The most spectacular record was established at Workman Creek, located in the Sierra Ancha Mountains; here,

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a rain gage recorded 11.4 inches of precipitation during one 24-hour period, establishing a new record for Arizona. The previous official National Weather Service 24-hour record for an observational day was only six inches, recorded at Crown King on December 19, 1967.

Rainfall intensities greater than three inches in four hours were reported for several stations during the Storm (Roeske 1971). Also, stations in the Sierra Ancha and Mazatzal Mountains and on the plateau southeast of Flagstaff had maximum 15-minute intensities exceeding two inches per hour. Intensities of this magnitude could exceed infiltration rates on some watersheds, particularly those with shallow storage over bedrock, and thereby lead to surface runoff and high peak streamflows. Infiltration rates are even more likely to be exceeded by high rainfall intensities when total storm precipitation is high, as was observed at many locations during this storm.

Analysis of the Workman Creek rainfall record suggests that the total rainfall of 11.4 inches recorded during 24 hours at this station may occur only once in 500 years, on the average (Kangieser 1972). This does not necessarily mean that such a storm occurs at 500-year intervals; the same event could occur two years in a row at the same location, but such a sequence is unlikely.

The Workman Creek frequency analysis represents only a small area. More general analyses suggest that the Storm may have been a 100-year event in other areas. According to a frequency map prepared by the U. S. Weather Bureau (1967), a 24-hour rainfall total of five-to-six inches is a 100-year event at many locations in central Arizona. This amount was equalled or exceeded at several of these locations during the Storm.

Hydrological Event

Arizona experienced high peak streamflows and subsequent flooding as a result of the Storm. The peak discharge of several streams possibly exceeded that of the 50-year flood (Roeske 1971). As expected, much of the flooding was associated with areas receiving high rainfall amounts and high rainfall intensities (Figure 2).

The most serious flooding was in central Arizona, where large, sudden flows occurred on Tonto, Sycamore, Dry Beaver, Wet Beaver, and Oak Creeks, and in the East Verde and Hassayampa Rivers (Roeske 1971). New River and the Agua Fria River also had high peak streamflows. Flooding occurred in Altar and Brawley Washes in southern Arizona, primarily due to heavy rainfall near the border town of Sasabe; also, Sabino Creek near Tucson experienced a record peak streamflow. Flood flows occurred in the Little Colorado River, partly as the result of inflows from the Puerco River and Chevelon and East Clear Creeks.

Flood stages and peak discharges recorded at selected stations during the Storm indicate new records for many locations (Roeske 1971). In the Gila River Basin, at least 30 of the 50 U. S. Geological Survey streamflow gaging stations had record peak flows.

In central Arizona, recreation areas near Kohl's Ranch on Tonto Creek were severely damaged by flooding (U. S. Forest Service 1971). At Kohl's Ranch, an estimated peak streamflow of 18,400 cfs occurred on the 5th. This flow, combined with high flows from two tributary streams, Christopher and Haigler Creeks, caused a peak flow of 46,300 cfs at Tonto Creek near Gisela on the 5th. The peak streamflow of Tonto Creek near Gisela may have exceeded the 50-year flood by a ratio of 1.2 (Roeske 1971).

The estimated peak streamflow in Christopher Creek near Kohl's Ranch was 11,900 cfs. Rye Creek, another tributary of Tonto Creek, had a peak flow of 44,400 cfs; fortunately, the peak flows on these two streams occurred about two hours apart. The peak streamflow on Rye Creek was estimated to be twice as large as the 50-year flood. The highest discharge in Tonto Creek above Gun Creek was 53,000 cfs, which may be a 30-year flood.

Flows on Tonto Creek and some of its tributaries were particularly destructive as a result of debris produced during the flood. The debris, which consisted of rock materials, trees and parts of trees, formed dams in the channels (U. S. Forest Service 1971). In some cases, the dams caused channel diversion as a head of water built up; in other cases, they breached, sending a surge of destructive water, rock materials and timber downstream to the next restriction point where the process might be repeated.

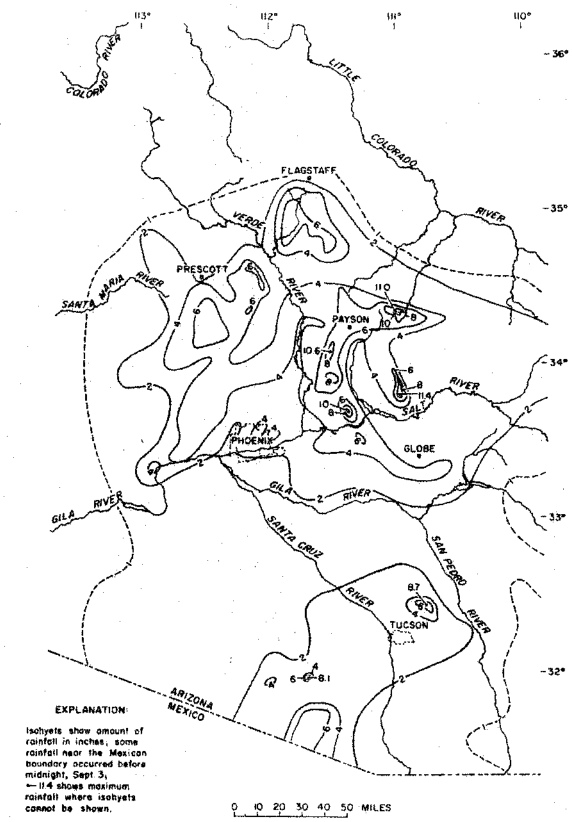

FIGURE 1. RAINFALL, SEPTEMBER 4-6, 1970 IN SOUTHERN AND CENTRAL ARIZONA (adapted from Roeske 1971).

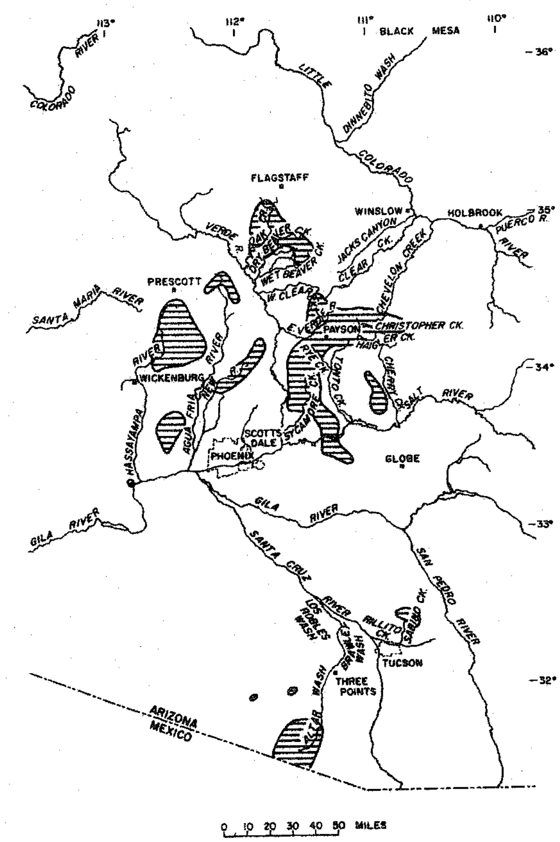

FIGURE 2. RIVER SYSTEM AND AREAS THAT RECEIVED A TOTAL RAINFALL OF FIVE INCHES OR MORE DURING THE LABOR DAY STORM OF 1970 IN ARIZONA. THE RAINFALL ZONES ARE CROSSHATCHED (adapted from Roeske 1971).

Sycamore, Dry Beaver and Oak Creeks and the East Verde River had peak streamflows ranging from 23,500 to 26,600 cfs. These flows exceeded the 50-year flood on all but the East Verde. West Clear Creek did not experience serious flooding, and the peak streamflow in Wet Beaver Creek only slightly exceeded the previous record. The flows from tributary streams contributed to the highest peak flow in the Verde River above Horseshoe Dam (67,000 cfs) since a flooding event in August 1951. The 1970 flood on the Verde River was about a once in 15-year event, however, and would not necessarily be considered a rare occurrence.

The Hassayampa River at the Box damsite experienced a peak streamflow of 58,000 cfs, estimated to be at least twice the 50-year flood. New River near Rock Springs and the Agua Fria River near Mayer had peak streamflows estimated to be 50- and 20-year floods, respectively.

Flood flows of 22,000 and 13,200 cfs were observed in Altar and Brawley Washes, respectively, near Three Points. A record peak streamflow of 7,550 cfs occurred in Sabino Creek, which drains from the Santa Catalina Mountains. This flow occurred two days after the flooding in Altar and Brawley Washes, and was at least a 100-year event.

The Little Colorado River at Holbrook had a peak streamflow of 20,000 cfs, which was estimated to be a 20-year flood. Downstream from Holbrook, Chevelon and East Clear Creeks added to the volume of the Little Colorado River, which caused flooding in Winslow on the 6th. Peak streamflows in Chevelon and East Clear Creeks near Winslow were 8,010 and 15,300 cfs, respectively.

Rainfall in northeastern Arizona was believed to be only one to two inches during the Storm, but reliable data are scarce (Roeske 1971). Some runoff values were large enough to suggest greater rainfall than this at higher elevations. For example, Dinnebito Wash, which drains from Black Mesa, had a peak streamflow of 28,900 cfs on the 5th. The previous known maximum flow was 5,890 cfs, although the period of record is short.

Losses and Damages

The heavy rainfall associated with the Storm brought flooding throughout central and northeastern Arizona, southeastern Utah and southwestern Colorado (Roeske 1971). This flooding caused widespread and unprecedented losses and damages to human, cultural, and natural resources.

Tragically, 23 lives were reported lost in central Arizona. The greatest loss of life occurred in the Kohl's Ranch area on Tonto Creek, where 14 lives were lost. The total number of people injured or hospitalized as a direct result of the Storm is unknown, but presumed many.

Damage to sewage collection and treatment facilities occurred in the immediate aftermath of the Storm in Phoenix, Scottsdale, Holbrook, and Wickenburg. Flood waters caused damage to public water supply systems in Buckeye, Tempe, and Phoenix, and to ten small water systems in the outlying area around but not including Payson; fortunately, all systems were quickly restored to an adequate operating condition.

Seasonal and permanent residences, farming and ranching operations, business establishments, and recreational facilities were damaged or destroyed in many areas that experienced record flood stages and peak discharges. Damage to highways, including interstate, primary, secondary, and private systems, was widespread throughout central and northeastern Arizona. The use of power transmission lines and telephone systems was interrupted in some areas, although, in most instances, service was quickly restored.

Flood waters rolled over fields planted to sugar beets, grains, and other crops in central Arizona, and extensive inundation of cotton crops occurred. Structural failures of irrigation and erosion control systems, diversion dams, dikes, and ponds compounded the losses and damages to croplands in this area. While the rainfall furnished short-term additional livestock water, the accumulation of sediments and other debris reduced the capacities of many permanent livestock water impoundments. Extensive damages to allotment fences and livestock driveways occurred across many rangelands, although the extent of these damages is difficult to ascertain.

Sediments and debris were deposited in several reservoir systems, particularly along the Mogollon Rim. Since urban developments are situated in the flood plains below some of these reservoirs, an even greater disaster was possible if additional rainfall and flooding had occurred.

High flood stages and peak discharges drastically altered the character of many stream channels throughout the Storm-affected area. Trees growing along channels were uprooted and piled downstream, preventing free movement of water in the channel. The scouring action of flood waters also caused many stream improvements and diversion channels to be lost or severely damaged.

On September 22nd, at the request of Governor Jack Williams, President Nixon declared the flood-damaged areas of Arizona a major disaster. This action paved the way for political jurisdictions and private parties to be reimbursed by the Federal Government for eligible expenditures made as a result of the Storm. Financial assistance approved by the Office of Emergency Preparedness, as of March 10, 1971, was $621,521. It is necessary to add financial assistance and expenditures provided through media other than the above-mentioned to obtain a monetary estimate representing the total loss and damage picture for the Storm. For example, a state and its political jurisdictions must expend, within a 12-month period immediately preceding a request for a Presidential declaration of a major disaster, a certain amount before a request to the President will be honored. Arizona's obligation of $750,000 was satisfied. Also, a record of expenditures by federal agencies operating within Arizona must be considered. A preliminary accounting of expenditures by federal agencies indicates expenditures in excess of $4,000,000.

Discussion

In terms of safety hazards to human well-being, the most important flooding during an event such as the Storm may be on small, remote streams utilized for recreation. The unwary camper or cabin dweller may not appreciate the vulnerability of his location should a rapid rise in water level occur. These streams can respond quickly to a precipitation event with little advance warning, especially if breached debris dams release surges of water downstream.

Although no amount of benefit can compensate for the loss of life, the Storm did cause increased storage in surface water reservoirs. Preliminary evaluation suggests that the gain to reservoirs on the Salt and Verde River basins was in excess of 160,000 acre-feet. This water gain may have been particularly significant since below normal precipitation and runoff characterized the following months (Enz 1971).

This tropical storm was not the first to be associated with flooding and damage in Arizona. Other examples include tropical storms Claudia (September, 1962) and Tillie (September, 1964). Conditions seem to be right for such storms to produce floods perhaps once every four or five years in Arizona (Sellers 1960). Possibly, an analysis of the meteorological and associated hydrological characteristics of these storms should be undertaken. A comprehensive study involving meteorology, hydrology, and engineering skills may yield useful design and safety information. This information could be particularly important for central and southern Arizona, where settlement and construction continue at a rapid pace, and where storms of tropical origin seem to have great impact.

Acknowledgements

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