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Storm Runoff at Los Alamos National Laboratory in 2002

Los Alamos
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ABSTRACT

This report describes precipitation and fire-related storm runoff events that occurred during 2002 at the Los Alamos National Laboratory (LANL) two years after the Cerro Grande Fire. Storm runoff events are described from data obtained from stream gaging stations where runoff occurred during the 2002 runoff season. The report incorporates available information pertaining to the location of significant precipitation events, precipitation amounts, and resulting storm runoff rates and volumes. The report is intended to provide the background information necessary to assist in the understanding of the runoff characteristics at LANL and the water quality data obtained from the storm runoff samples.

No snowmelt occurred in the spring of 2002. There were fewer storm runoff events at LANL in 2002 and most were considerably less intense than in 2000 and 2001, due to below-normal amounts of precipitation during the summer monsoon season. Significant runoff events occurred on June 21, August 28, and September 10, 2002. Abnormally little precipitation and runoff occurred during July 2002.

The largest storm runoff event at LANL in 2002 occurred on the night of June 21-22 when a short-duration relatively high-intensity thunderstorm occurred over the western part of the Pajarito Plateau. This event created runoff in all the major drainages at LANL that totaled 120 ac-ft, about 48% of all runoff in 2002, and caused a flood in Pueblo Canyon that totaled about 80 ac-ft.

The total downstream runoff at LANL in 2002 was 248 ac-ft, about 2.3 times higher than the prefire average annual runoff (106 ac-ft), although the seasonal precipitation in 2002 (8.5 in.) was about 70% of the prefire average seasonal precipitation (12.4 in.). The higher than prefire average runoff at LANL in 2002 indicates effects from the Cerro Grande Fire were still present. Lower runoff volumes in 2002, compared with 2000 and 2001, were partially the result of lower precipitation amounts, but significantly lower peak flows and runoff yields may reflect a partial recovery of the fire-impacted areas of watersheds since the Cerro Grande Fire.

1.0 Introduction

Los Alamos National Laboratory (LANL) is located on 40 mi^2 of the Pajarito Plateau on the east flank of the Jemez Mountains (the Sierra de los Valles) of north-central New Mexico (Figure 1-1). Bandelier National Monument is located south of LANL, and the Santa Fe National Forest is located on the slopes of the Sierra de los Valles west and north of LANL.

The Pajarito Plateau slopes to the east-southeast and varies in elevation from west to east from about 7600 ft to about 6300 ft, for a total change in elevation of about 1300 ft; canyons and mesas extend along the entire slope of the plateau. Significant larger-scale topographic features exist in the vicinity of the plateau, such as the broad north-south-trending Rio Grande Valley to the east and the Sierra de los Valles to the west, which extend to over 10,000 ft, up to 3000 ft above the plateau. The local and regional topographical features contribute to the meteorological complexity of the site and significantly influence the local meteorology and runoff characteristics of the plateau (Baars et al. 1998).

This report describes precipitation events and storm runoff events that occurred during 2002 at LANL and provides a summary of the fire-related runoff characteristics for the three storm runoff seasons since the Cerro Grande Fire of May 2000 (for a description of the Cerro Grande Fire see Webb and Carpenter, 2001). Storm runoff events are described for stream gaging stations where runoff samples were collected during the 2002 runoff season and where significant runoff events occurred (Appendix A). The report incorporates available information pertaining to the location of significant precipitation events, precipitation amounts, and storm water flow rates and flow volumes that occurred in major drainages at LANL in 2002. Due to below normal snowpack in the Sierra de los Valles in the spring of 2002, snowmelt runoff did not occur at LANL in 2002. Surface water data at LANL for 2002 are reported by Shaull et al. (2003). Runoff after the Cerro Grande Fire in 2000 and 2001 was previously described by Koch et al. (2001; 2002).

This report is primarily intended to provide the background information necessary to assist in the understanding of the runoff and water quality characteristics associated with runoff from LANL and fire-related areas around LANL. Descriptions of storm runoff not associated with flow in main-canyon stream channels and therefore not fire-related runoff, such as storm runoff samples routinely collected from mesa-top sites such as Technical Area (TA) 54, Material Disposal Area (MDA) G, TA-55, and other mesa-top sites, are not included in this report.

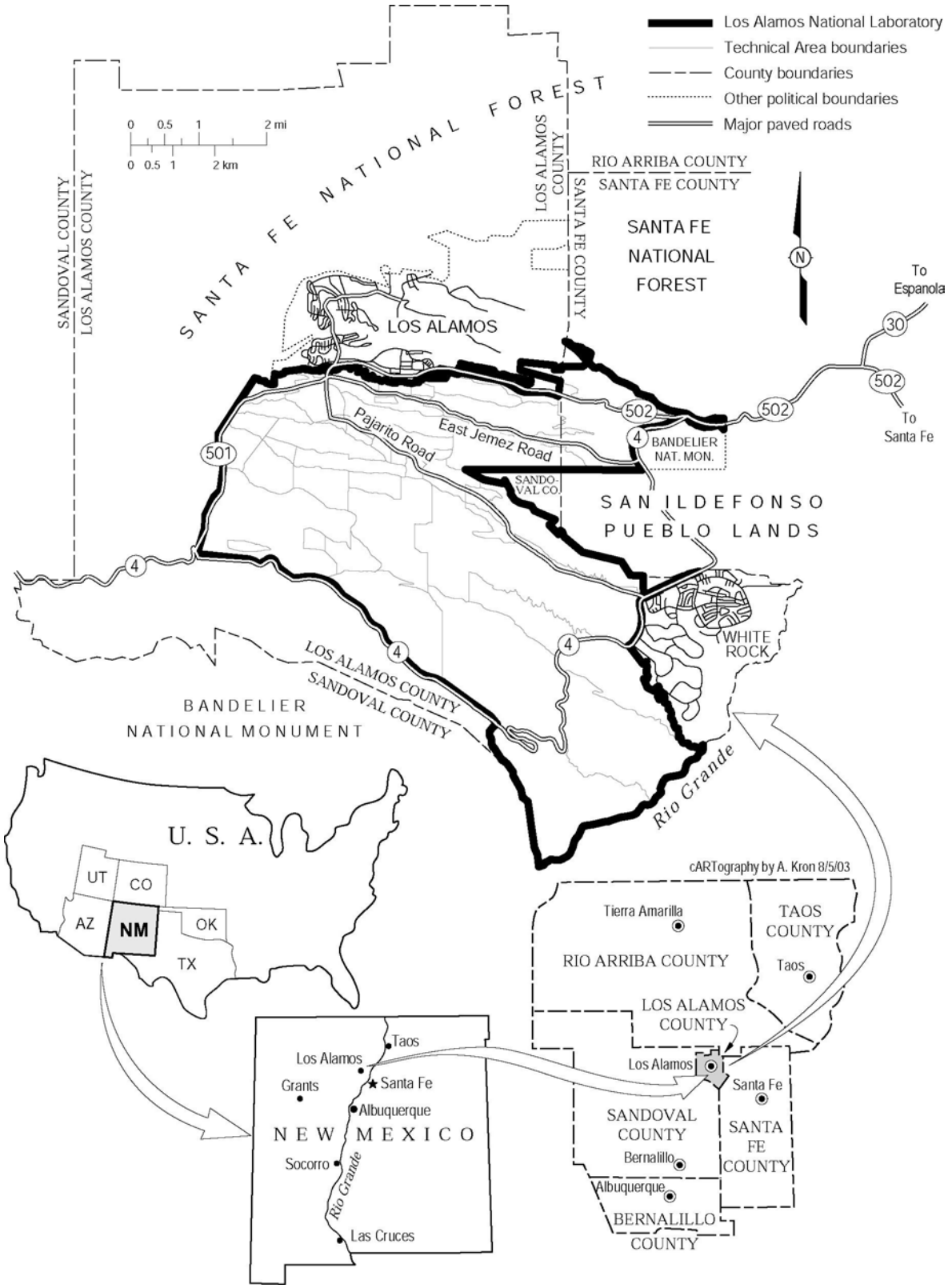


Figure 1-1. Regional location of Los Alamos National Laboratory.

2.0 Brief Climatology of the Pajarito Plateau

The Pajarito Plateau has a temperate, semiarid mountain climate that is largely influenced by elevation. Large temperature and precipitation differences are observed across the Laboratory because of the 1000-ft elevation change across the Pajarito Plateau. General information about the climate of the Laboratory area is provided in the annual environmental surveillance reports (e.g., Environmental Surveillance Program [2002]). Bowen (1990) provides detailed data compilations and extensive statistical summaries, including projected probabilities for climate. Much of the following summary of climate is from the LANL Weather Machine on the following Laboratory web site: http://weather.lanl.gov/. General weather conditions for Los Alamos and the Laboratory are reported from data collected at the meteorological tower located at TA-6 (see Figures in Appendix B for locations of meteorological stations).

Four distinct seasons occur on the Pajarito Plateau. Spring is usually windy and dry. Summer begins with warm, usually dry conditions in June, followed by a two-month rainy season in July and August when afternoon convection thunderstorms containing hail and lightning are common. Autumn is the end of the rainy season when the climate returns to drier, cooler, and calmer weather. Winters are generally mild with occasional winter storms that contain large snows and cause frigid temperatures. Mid-latitude winter storms drop far enough to the south to keep the ground covered with snow for about two months each winter.

Meteorological variables at LANL are measured at five towers located on the Pajarito Plateau. Four of the towers are located on mesas and one tower is located in Los Alamos Canyon, which is one of the larger canyons on the plateau. The meteorological observation stations and information about the stations are listed in Table 2-1. A sixth tower was recently installed on Pajarito Mountain to help predict wind shifts across the plateau below.

Table 2-1. Meteorological Observation Stations at Los Alamos National Laboratory.

Station Name	Location	Elevation (ft)	Period of Record	Comment
Meteorological Towers				
TA-6	South of TA-3, upper Pajarito Plateau	7424	2/90 to present	Official meteorological station for LANL and Los Alamos
TA-41	Los Alamos Canyon south of town site	6914	11/93 to present	Provides information about meteorology in the canyons
TA-49	Frijoles Mesa	7045	6/87 to present	Provides information for Bandelier National Monument
TA-53	Los Alamos Neutron Science Center	6990	2/92 to present	
TA-54	MDA-G, White Rock	6548	1/92 to present	MDA-G observation station, previous station record at MDA-G from 1979 to 1992
Pajarito Mt.	Pajarito Mountain	10,360	8/97 to present	Installed in 1994, reconfigured in 1997
SODAR	TA-6	7414	2/90 to present	Sound detection and ranging
Precipitation-Only Stations				
TA-16	S-Site	7635	1/77 to present	Precipitation measurement
TA-74	State Road (SR) 4/ SR 501 Intersection	6370	7/81 to present	Near Test Well 1 in Pueblo Canyon
North Community	Los Alamos town site	7420	1/86 to present	Northwest side of Los Alamos

Adapted from Baars et al. (1998) p. 7-8.

Data collected at the observation stations include wind, temperature, pressure, relative humidity and dew point, and solar and terrestrial radiation. Wind variables are measured at different heights above ground levels on the meteorological towers, including 37.5 ft, 75 ft, and 150 ft, and at the TA-6 tower at 300 ft. The atmospheric state variables, precipitation, and radiative energy fluxes are measured at 5 ft above the ground surface. The data are obtained through direct measurement or calculation from most sites every 15 minutes, and some variables such as precipitation are totaled for each 24-hr period (Baars et al. 1998).

In addition to the period of record available for the active stations listed in Table 2-1, 2002 precipitation data are available from a meteorological station located at Bandelier National Monument. Data from the Frijolito meteorological station, located near the park headquarters in the eastern part of the monument, was used in the construction of precipitation pattern figures in Appendix B. The Cerro Grande station that was installed on Cerro Grande in 2000 after the fire was not functional during the 2002 runoff season. After the Cerro Grande Fire in May 2000, nine remote automated weather stations (RAWS) were installed in the Sierra de los Valles north and west of Los Alamos. RAWS locations are shown in figures in Appendix B. Data from these weather stations were also used in construction of figures in this document and are available at http://www.wrcc.dri.edu/losalamos/.

During the summer of 2002, additional rain gages were installed at several stream gaging stations at LANL. Rain gages were installed at stream gages located in upper Pajarito Canyon, upper Water Canyon, middle DP Canyon, and lower Water Canyon. Available precipitation data from these rain gages are shown on some Figures in Appendix B. Rainfall data from a privately owned and maintained meteorological station located in the Pajarito Acres subdivision of White Rock, called the OooWoo Kennel (available at http://www.ooowoo.com/WEATHER/Current_Vantage_Pro_Plus.htm), were also used in construction of some precipitation pattern maps in Appendix B.

Table 2-2 lists the average daily climate variables for each of the active meteorological stations at the Laboratory. The highest average daily wind speed is recorded at TA-49, and the lowest average wind speed is at TA-41 in Los Alamos Canyon. The highest average daily maximum temperature is recorded at TA-54, and the lowest minimum temperature is recorded at TA-41. The highest average annual precipitation is at TA-6, and the lowest average annual precipitation is at TA-54.

Table 2-2. Average Daily Climate Variables at LANL Meteorological Stations.

	Units	TA-6	TA-41	TA-49	TA-53	TA-54
Atmospheric Variables						
Average Wind Speed	m/s	2.49	1.66	3.16	2.90	2.74
Maximum Temperature	Degree-C	15.03	15.61	16.18	16.58	17.58
Minimum Temperature	Degree-C	1.77	0.66	3.44	4.36	0.99
Average Relative Humidity	%	50.83		47.30	49.02	52.01
Average Dew Point	Degree-C	-2.80			-2.05	-2.15
Average Precipitation	In./yr	19.69		18.68	15.97	14.57
Radiative Energy Variables						
Short Wave Irradiance (incoming)	mJ/m^2	18.87	14.49	19.14	18.94	19.23
Net Radiation	mJ/m^2	7.04				5.72
Sensible Heat Energy	mJ/m^2	3.23				5.45
Latent Heat Energy	mJ/m^2	2.32				0.99
Subsurface/Ground Variables						
Average Soil Moisture – 3 in.	%	25.65				12.32
Average Soil Moisture – 6 in.	%	29.84				31.02
Ground Heat Flux	mJ/m^2	0.85				0.15

Source: LANL Weather Machine

Several factors influence the temperature of the Pajarito Plateau, however, elevation is the primary influence; and at elevations of the mesas that are generally over 7000 ft, the plateau is cooler in the summer than nearby locations that are at lower elevation. The changes in elevation of the plateau are reflected in the sloping nature of the plateau and the configuration of the mesas and canyons, which combine to cause daily temperature changes. In the evening and at night, cooled air drains off the plateau and flows down the canyons; thus, nighttime temperatures on the mesas are often warmer than in the canyons and at lower elevations.

Another factor affecting the temperature is the lack of moisture in the atmosphere. With less moisture, there is less cloud cover, which allows a significant amount of solar heating during the daytime and radiative cooling during the nighttime. This heating and cooling often cause a wide range of daily temperatures, which averages 56°F. July is the warmest month of the year with an average daily high of 81°F. January is the coldest month when the temperatures range from an average daily high of 40°F to a low of 17°F.

Relative humidity varies considerably over daily periods, but monthly average values vary little during the year. Relative humidity ranges from a low of 39% in June to a high of 56% in December and averages 51% over the entire year. Absolute humidity ranges from a low of 2.4 g of water/m^3 of air in January to a high of 8.7 g/m^3 in July and August, when moist subtropical air invades the region during the rainy season. Fog in the Pajarito Plateau area is very rare, occurring less than five times a year on average.

The average annual precipitation from rainfall and the water-equivalent from frozen precipitation at Los Alamos is 18.7 in. However, the annual total fluctuates considerably from year to year, with the standard deviation of the fluctuation being 4.8 in. The lowest recorded annual precipitation is 6.8 in., and the highest is 30.3 in. The maximum precipitation recorded for a 24-h period is 3.5 in., and the maximum 15-minute precipitation in the period of record is 0.9 in. Because of the eastward slope of the Pajarito Plateau terrain, there is a large east-to-west gradient in precipitation across the plateau. White Rock often receives 5.1 in. less annual precipitation than does the official observing station at TA-6, and the eastern flanks of the Sierra de los Valles often receive an equivalent amount of additional precipitation.

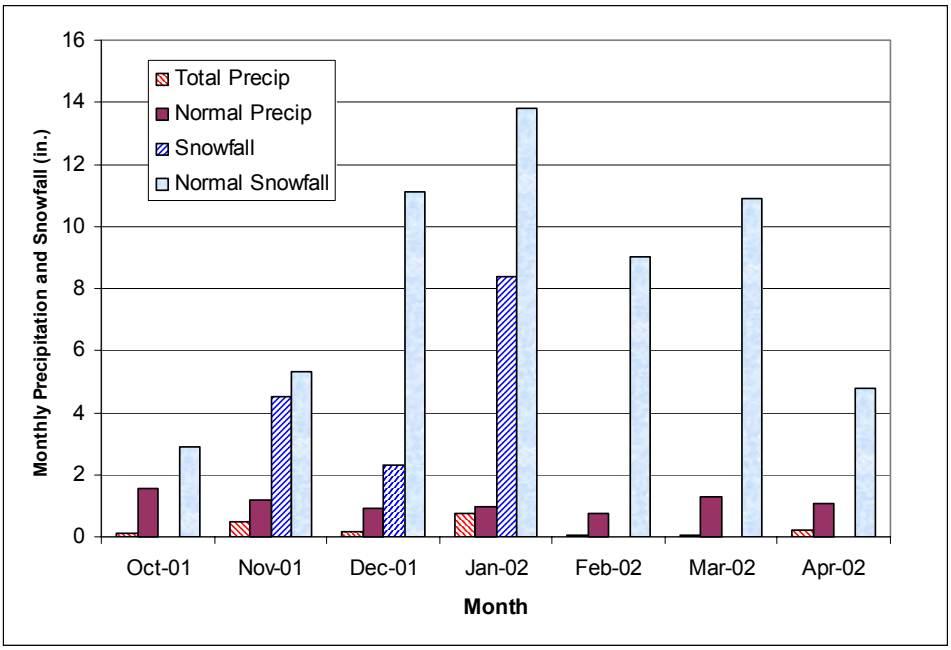
About 36% of the annual precipitation is received during the July and August rainy season. The Pajarito Plateau experiences on average 61 thunderstorm days each year, about twice the national average. Lightning and hail frequently accompany the thunderstorms. Hailstones 0.25 in. in diameter are common, and stones as large as 1 in. have been reported. Hail has caused significant damage to property and vegetation and localized accumulations of 3 in. have been observed.

Winter precipitation occurs mostly as snow. The snow is generally dry with, on average, 20 units of snow equivalent to one unit of water. The annual snowfall averages 59 in., but, from year to year, the amount of snow is quite variable. The standard deviation of annual snowfall is 28 in. The highest recorded snowfall for one season is 153 in., and the highest recorded snowfall for a 24-h period is 22 in. In a typical winter season there are 14 days containing snowfall exceeding 1 in. and 4 days of snowfall exceeding 4 in. The extreme single-storm snowfall on record is 48 in.

Wind conditions on the Pajarito Plateau are generally light, having an average annual wind speed of 5.5 mph. However, the windy period from mid-March to early June sustains wind speeds exceeding 8.8 mph 20% of the time during the daytime, and the daily maximum wind gust exceeds 31 mph about 20% of the time. The highest wind gust on record is 77 mph. High winds are associated with the passage of weather fronts, thunderstorms, and mid-latitude storm systems. Tornadoes have not touched the ground in the Pajarito Plateau area, however, funnel clouds have been observed in Los Alamos and Santa Fe Counties.

2.1 Precipitation in the Winter of 2001–2002

Drought conditions returned to northern New Mexico, as well as much of the southwestern US in the winter of 2001-2002 with one of the driest winters on record. Figure 2-1 shows the total monthly precipitation and snowfall recorded at the TA-6 meteorological station during the winter of 2001–2002. Normal monthly snowfall and precipitation are also shown for comparison.



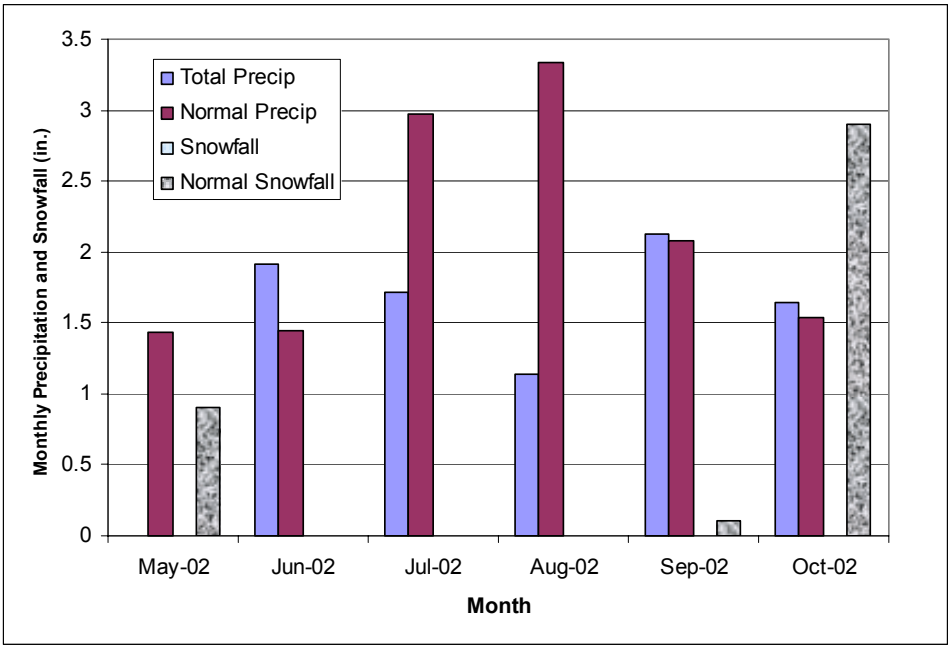
Source: http://Weather.lanl.gov

Figure 2-1. Total monthly precipitation and snowfall recorded at TA-6, October 2001 through April 2002.

Meteorological stations at LANL received below-normal precipitation each month from October 2001 through April 2002. During this period, the seasonal precipitation received at the TA-6 meteorological station was 1.7 in., which was 23% of normal. The snowpack during the 2001–2002 winter season was much below normal; the local Pajarito Mountain Ski Area was open only 4 days during the 2001–2002 winter season. The snowpack in the Jemez Mountains ranged from 62% of normal in November 2001 to 0% of normal in April 2002 and averaged 33% of normal for the winter season (USFS 2002). The Palmer Drought Severity Index for early May 2002 indicated that north-central New Mexico was in “Extreme Drought” (Palmer Index –4.0 or less) (NWS 2002).

2.2 Precipitation in the 2002 Runoff Season

Figure 2-2 shows the total monthly precipitation and snowfall recorded at the official LANL TA-6 meteorological station from May through October 2002. Normal monthly precipitation and snowfall amounts are also shown for comparison. No precipitation was recorded at the TA-6 meteorological station during May and only trace amounts of 0.05 in. or less were received at other LANL meteorological stations during May. The lack of precipitation in northern New Mexico extended the drought conditions in the “Extreme Drought” category (NWS 2002).



Source: **http://Weather.lanl.gov**

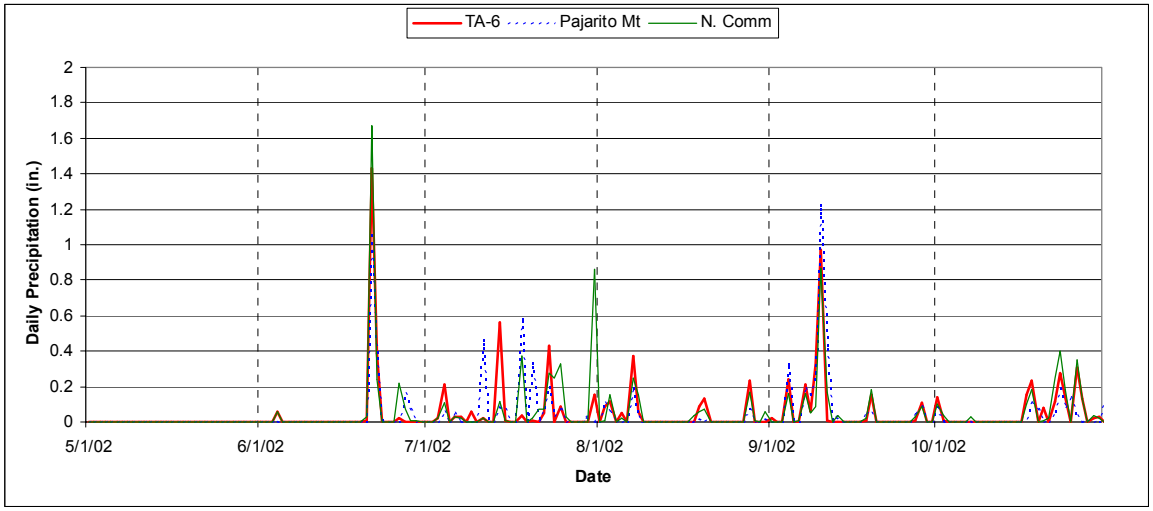
Figure 2-2. Total monthly precipitation recorded at TA-6, May through October 2002.

One relatively large rain event during the night of June 21 and 22 was sufficient for June rainfall (1.91 in.) to be above (133%) normal. Precipitation in July (1.71 in.) was 58% of normal, and in August (1.14 in.) was 34% of normal. Precipitation in September and October was approximately normal. For the period May through October 2002, the seasonal precipitation was 8.52 in., which was 67% of normal. The Palmer Drought Index for northern New Mexico continued in the "Extreme Drought" category throughout the summer of 2002 until the middle of September when normal rainfall conditions prompted lowering the drought index to "Severe Drought" (NWS 2002).

Precipitation recorded at individual LANL meteorological stations from May 1 through October 30, 2002 is shown in Figure 2-3 (a, b, c). These figures show the total daily precipitation recorded at stations north and west of LANL (Figure 2-3a: North Community, TA-6, and Pajarito Mountain stations), stations in the southern and central portions of LANL (Figure 2-3b: TA-16, TA-49, and TA-53), and stations in the eastern part of LANL (Figure 2-3c: TA-54 and TA-74). Precipitation isopleth maps in Appendix B show the pattern of precipitation received on the Pajarito Plateau on specific days when significant precipitation was received. Further descriptions of individual precipitation events are in Section 3.

The general pattern of precipitation received on the Pajarito Plateau during the summer of 2002 can be interpreted from Figure 2-3. Only three significant precipitation events of over 1 in. of rainfall occurred in 2002; one on the night of June 21 and 22, another on September 9, and one on August 28 that was mainly located over the eastern Pajarito Plateau. All other precipitation events were less than 1 in. and most were less than 0.5 in.

Most precipitation events in 2002 appear to have been thunderstorms that were relatively localized and brief. These events are represented on Figure 2-3 by highly variable amounts of precipitation at different meteorological stations on a given day. During June, July, and August, thunderstorms likely occurred in response to diurnal heating of the ground causing localized thunderstorms to form, usually over higher terrain. Some precipitation events, such as those in late October, appear to have uniformly impacted meteorological stations on the Pajarito Plateau, which indicates a larger-scale precipitation event rather than a localized thunderstorm event.



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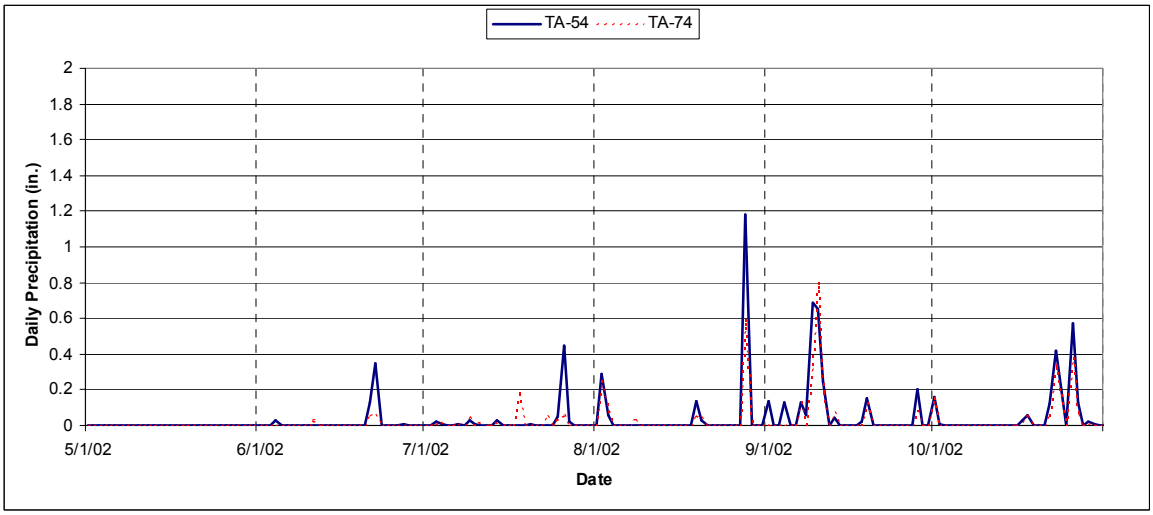

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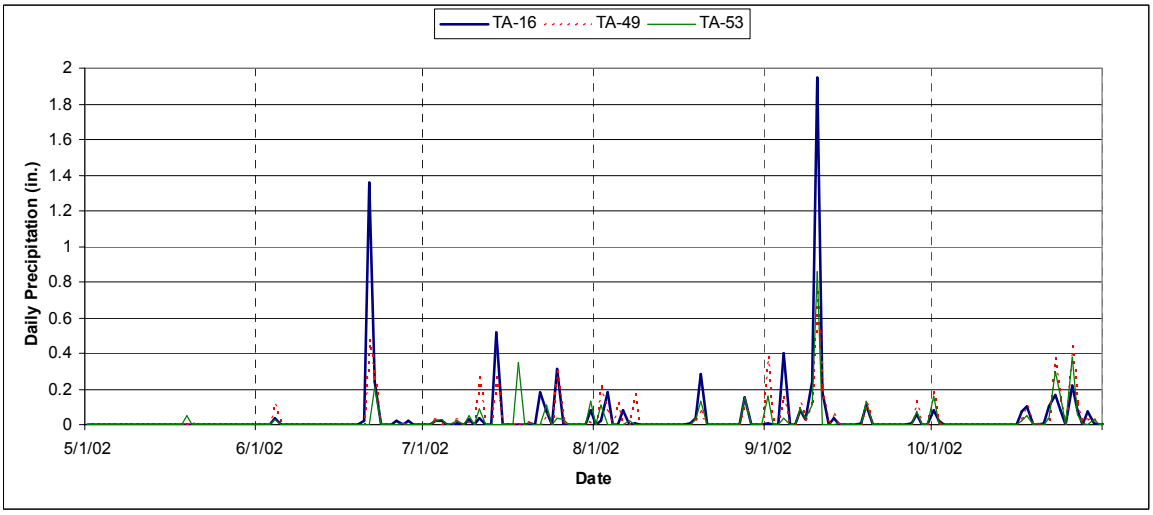


2.3c

Figure 2-3. Precipitation at LANL meteorological stations, May 1 to November 30, 2002.

One of the largest precipitation events of the 2002 summer season occurred on the night of June 21 and 22 when the overnight total precipitation at the North Community meteorological station was 1.82 in. Rainfall occurred over a 5-hr period and overnight totals at other stations included 1.63 in. at TA-6, 1.48 in. at TA-16, and 1.49 in. at the Pueblo Canyon RAWS. This precipitation event caused the largest runoff event of 2002 in Pueblo Canyon. The largest rainfall recorded in July at Los Alamos was 0.86 in. at the North Community meteorological station, on July 31. The most precipitation recorded in August was 1.18 in. at TA-54 on August 28, which was from a relatively localized thunderstorm over the eastern Pajarito Plateau. The largest daily precipitation received in 2002 was 1.95 in. at TA-16 on September 10, when maximum daily precipitation was also recorded at the TA-49, TA-53, TA-74, and Pajarito Mountain meteorological stations.

In July of each year, the summer monsoon rains begin as tropical moisture moves northward into New Mexico from Mexico. Precipitation events in July and August are typically more numerous compared with those in June, September, and October, and normal precipitation amounts are usually greatest in August (see Figure 2-2); however, in 2002, more precipitation was received in the months of June and September than in July and August. In 2002, monsoon rains were fewer and usually less intense than the two previous seasons since the Cerro Grande Fire (Koch et al. 2001; 2002). Monsoon rains continued until about September 10 (Figure 2-3), after which only a few occasional light showers occurred in latter September and early October. Several days of light, steady rains during the last week of October into the first part of November provided much needed precipitation for the Pajarito Plateau and enabled near-normal precipitation for the months of October and November.

Lower-elevation meteorological stations at TA-54 and TA-74 recorded more precipitation than higher-elevation stations on several days in 2002, notably on July 26, August 2, August 28, September 11, September 28, October 23, October 24, and October 26. Precipitation pattern maps (see Appendix B) show the different patterns of precipitation that occurred over the Pajarito Plateau in the summer of 2002.

3.0 Runoff Monitoring at Los Alamos National Laboratory

In 1991, LANL began regularly monitoring runoff from storm events on Laboratory property in Pueblo and Los Alamos Canyons. The number of monitoring locations (stream gages) was augmented from 1995 to 2002 and most of the stream gages were equipped with automated runoff samplers. By 2002, the sampling network comprised more than 70 sampling stations. Figure 3-1 shows the locations of the runoff sampling stations in major drainages on the Pajarito Plateau. Runoff sampling at LANL is routinely performed to provide compliance with environmental permits and approvals (e.g., Environmental Surveillance Program 2000).

Refer to Table 3-1 for location names.

Figure 3-1. Watercourse runoff sampling stations on the Pajarito Plateau in 2002.

In 2000, LANL conducted an extensive environmental monitoring and sampling program to evaluate the effects of the Cerro Grande Fire at LANL and especially to evaluate if the Laboratory may have impacted public and worker health and the environment as a result of the fire (Gallaher et al. 2002). These monitoring and sampling activities continued through 2001 and 2002 to evaluate the extended impacts from the fire and to monitor impacts to storm water from LANL operations. Snowmelt and storm runoff sampling activities are conducted according to the Institutional Monitoring and Sampling Plan for Evaluating Impacts of the Cerro Grande Fire (LANL 2000) and according to the procedure for Operation of Stream Gaging Stations and Collection of Storm Water Runoff Samples (LANL 2001).

Using the automated flow monitoring stations and visual inspections of runoff conditions, LANL personnel collect runoff samples at the following sites:

- In major watercourses upstream of LANL operational areas as storm runoff moves onto LANL property from the Sierra de los Valles,
- In major and minor watercourses on LANL property at
    - specific mesa-top sites where LANL operations occur, and
    - primary and selected secondary watercourses as storm runoff originates and flows through LANL,
- In major watercourses near the downstream boundary of LANL, and
- In Rendija Canyon and Guaje Canyon north of LANL.

At times, runoff samples are also collected manually at specific locations where stream gages and automatic samplers are not located. These samples are designated as manual, or grab, runoff samples.

A list of the stream gage sampling stations and manual collection sites that were active during the 2002 runoff season is in Table 3-1. This table shows the canyon where the sample collection sites are located, the common name of the collection site, and whether automated or manual runoff samples were collected at each site.

Table 3-1. Storm Runoff Collection Sites at LANL in 2002.

Gage/ Site	Canyon	Location	Type	Collection Method
E026	Los Alamos	Los Alamos Canyon below ice rink	Watercourse	Automated
E030	Los Alamos	Los Alamos Canyon above DP Canyon	Watercourse	Automated
E038	DP	DP Canyon above TA-21	Watercourse	Automated
E039	DP	DP Canyon below meadow at TA-21	Watercourse	Automated
E040	DP	DP Canyon above Los Alamos Canyon	Watercourse	Automated
E042	Los Alamos	Los Alamos Canyon above SR 4	Watercourse	Automated
E049	Los Alamos	Los Alamos Canyon Weir	Watercourse	Manual
E050	Los Alamos	Los Alamos Canyon below LA Weir	Watercourse	Automated
E055	Pueblo	Pueblo Canyon above Acid Canyon	Watercourse	Automated
E056	Acid	Acid Canyon above Pueblo Canyon (Acid Weir)	Watercourse	Automated
E060	Pueblo	Pueblo Canyon above SR 502	Watercourse	Automated
E070	Bayo	Bayo Canyon below TA-10	Watercourse	Automated
E089	Guaje	Guaje Canyon above Rendija Canyon	Watercourse	Automated
E090	Rendija	Rendija Canyon above Guaje Canyon	Watercourse	Automated
E099	Guaje	Guaje Canyon below SR 502	Watercourse	Automated
E110	Los Alamos	Los Alamos Canyon above Rio Grande	Watercourse	Automated
E121	Sandia	Sandia right fork at Power Plant	Watercourse	Automated
E122	Sandia	Sandia left fork at Asphalt Plant	Watercourse	Automated
E122.2	Sandia	Sandia Canyon tributary at Sigma Building	Mesa-Top	Automated
E122.3	Sandia	Sandia Canyon tributary below Sigma Building	Mesa-Top	Automated
E122.4	Sandia	Sandia Canyon tributary at Motor Pool	Mesa-Top	Automated
E122.5	Sandia	Sandia Canyon tributary at Salvage Yard	Mesa-Top	Automated
E123	Sandia	Sandia Canyon below Wetlands	Watercourse	Automated
E124	Sandia	Sandia Canyon above Firing Range	Watercourse	Automated
E125	Sandia	Sandia Canyon above SR 4	Watercourse	Automated
E196	Mortandad	Mortandad Canyon tributary at TA-55	Mesa-Top	Automated

Table 3-1. cont.

Gage/ Site	Canyon	Location	Type	Collection Method
E200	Mortandad	Mortandad Canyon below Effluent Canyon	Watercourse	Automated
E201.1	Ten Site	Ten Site Canyon at TA-50	Mesa-Top	Automated
E201.3	Ten Site	Ten Site Canyon below MDA-C	Mesa-Top	Automated
E201.5	Ten Site	Ten Site Canyon above Mortandad Canyon	Watercourse	Automated
E218	Cañada del Buey	Cañada del Buey at TA-46	Watercourse	Automated
E220	Cañada del Buey	TA-54 RANT	Mesa-Top	Automated
E221	Cañada del Buey	TA-54 MDA-J	Mesa-Top	Automated
E223	Cañada del Buey	TA-54 below MDA-L	Mesa-Top	Automated
E225	Cañada del Buey	Cañada del Buey near MDA-G	Watercourse	Automated
E227	Cañada del Buey	TA-54 MDA-G-13 (former MDA G-6)	Mesa-Top	Automated
E230	Cañada del Buey	Cañada del Buey above SR 4	Watercourse	Automated
E240	Pajarito	Pajarito Canyon below SR 501	Watercourse	Automated
E241	Pajarito	Pajarito Canyon above Starmers	Watercourse	Automated
E242	Starmers/Pajarito	Starmers above Pajarito Canyon	Watercourse	Automated
E242.5	La Delfe/Pajarito	La Delf above Pajarito Canyon	Watercourse	Automated
E243	Pajarito	Pajarito Canyon above Twomile Canyon	Watercourse	Automated
E243.5	Twomile	Twomile tributary at TA-3	Mesa-Top	Automated
E245	Pajarito	Pajarito Canyon above TA-18	Watercourse	Automated
E245.5	Pajarito	Pajarito Canyon above Threemile Canyon	Watercourse	Automated
E246	Threemile	Threemile Canyon at TA-18	Watercourse	Automated
E247	Pajarito	TA-54 MDA G-1	Mesa-Top	Automated
E248	Pajarito	TA-54 MDA G-2	Mesa-Top	Automated
E248.5	Pajarito	TA-54 MDA G-6U (former MDA-G-3)	Mesa-Top	Automated
E249	Pajarito	TA-54 MDA G-4	Mesa-Top	Automated
E249.5	Pajarito	TA-54 MDA G-7 (former MDA-G-4)	Mesa-Top	Automated
E250	Pajarito	Pajarito Canyon above SR 4	Watercourse	Automated
E252	Water	Water Canyon above SR 501	Watercourse	Automated
E253	Cañon de Valle	Cañon de Valle above SR 501	Watercourse	Automated
E256	Cañon de Valle	Cañon de Valle below MDA-P	Watercourse	Automated
E257	Cañon de Valle	Cañon de Valle tributary at Burn Grounds	Watercourse	Automated
E260	Water	Water Canyon above S Site Canyon	Watercourse	Automated
E261	Water	S-Site Canyon above Water Canyon	Watercourse	Automated
E262	Cañon de Valle	Cañon de Valle above Water Canyon	Watercourse	Automated
E262.5	Water	Water Canyon below MDA-AB	Watercourse	Automated
E263	Water	Water Canyon above SR 4	Watercourse	Automated
E264	Water	Indio Canyon at SR 4	Watercourse	Automated
E265	Water	Water Canyon below SR 4	Watercourse	Automated
E265.5	Water	Water Canyon tributary Study Area	Mesa-Top	Automated
E267	Potrillo	Potrillo Canyon above SR 4	Watercourse	Automated
E267.2	Potrillo	Potrillo Canyon tributary Study Area below SR 4	Mesa-Top	Automated
E273	Ancho	Ancho Canyon above SR 4	Watercourse	Automated
E274	Ancho	Ancho north fork below SR 4	Watercourse	Automated
E275	Ancho	Ancho Canyon below SR 4	Watercourse	Automated
E338	Chaquehui	Chaquehui at TA-33	Watercourse	Automated
E340	Chaquehui	Chaquehui tributary at TA-33	Mesa-Top	Automated

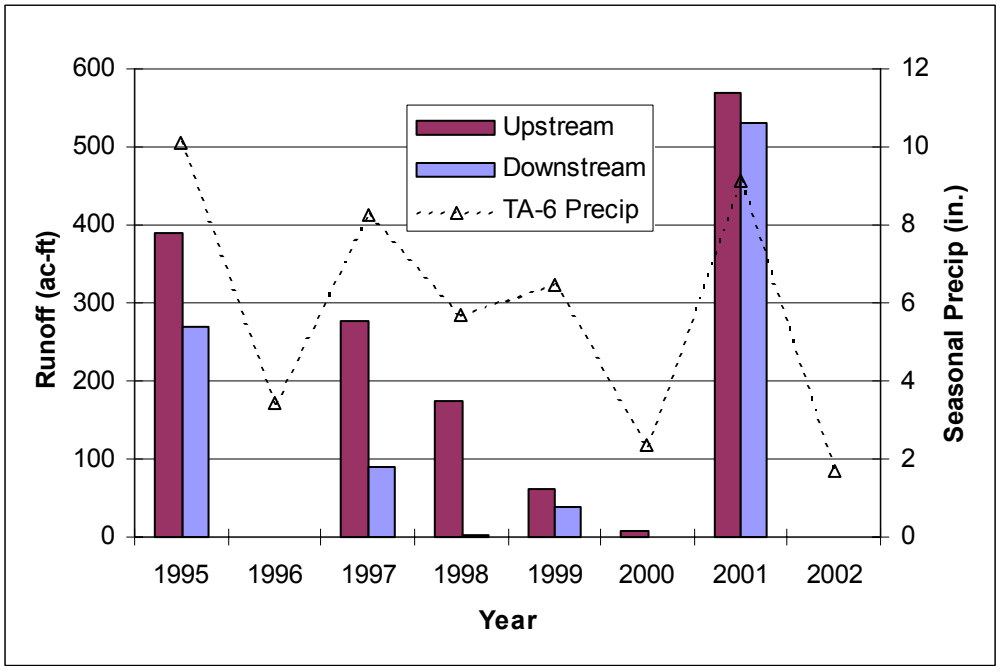
3.1 Snowmelt Runoff

Snowpack in the Jemez Mountains was below normal throughout the winter of 2001-2002. Snowfall equivalent precipitation from November 2001 through April 2002 at the TA-6 LANL meteorological station was 1.68 in., which was 27% of normal (see Section 2.1). By the middle of March, the snowpack in the Jemez Mountains was virtually nonexistent, compared with a normal year when the snowpack is present until about mid May (USFS 2002).

Above-normal temperatures at times during the end of February and in March contributed to the early demise of the snowpack and caused measurable snowmelt runoff at only two gaging stations at LANL in 2002. None of the primary upstream or downstream gages at LANL measured significant snowmelt runoff

in 2002. Measurable snowmelt runoff was recorded at gage E089 in Guaje Canyon on February 23 and at gage E218 in upper Cañada del Buey on March 22. Small amounts of snowmelt runoff may have occurred at other gaging stations, but flow was typically too small to be measured.

Figure 3.1-1 shows the total annual snowmelt runoff at upstream and downstream gages at LANL (excluding gage E060 in lower Pueblo Canyon) and the November through May seasonal precipitation for each year. The snowmelt runoff in 2002 was virtually nonexistent, primarily due to the lowest seasonal precipitation for the eight-year period from 1995 through 2002. Snowmelt runoff at upstream and downstream stations in 2002 was 0 ac-ft. Previously, snowmelt did not occur at LANL in 1994 when the seasonal precipitation was 3.5 in., which was about double the seasonal winter precipitation in 2002 (1.7 in.).



Data from Shaull et al. 1996a, 1996b, 1998, 1999, 2000, 2001, 2002, and 2003.

Figure 3.1-1. Seasonal precipitation at TA-6 and annual snowmelt runoff at upstream and downstream LANL gages.

The prefire high snowmelt runoff was in 1995 when runoff totaled 390 ac-ft at upstream gages and 269 ac-ft at downstream gages. The runoff in 2001 after the fire was about 1.5 times higher than previously observed at upstream gages and about two times higher than previously observed at downstream gages, although the seasonal precipitation in 2001 (9.1 in.) was about 10% less than that received in 1995 (10.1 in.). The increased snowmelt runoff in 2001 was likely due in part to the effects of the Cerro Grande Fire.

3.2 Storm Runoff

One of the notable effects of the Cerro Grande Fire was increased runoff from precipitation events during the summers of 2000, 2001, and 2002. When thunderstorms occurred over the higher elevations of the Sierra de los Valles, runoff from burned slopes was significantly higher in canyons downstream of the precipitation than before the fire. Storm runoff in 2000 after the Cerro Grande Fire was described by Shaull et al. (2001), Koch et al. (2001), and Gallaher et al. (2002) and storm runoff in 2001 was described by Shaull et al. (2002) and Koch et al. (2002).

For the 2002 runoff season, stream gages were added in Guaje Canyon above SR 502 (E099) and in a tributary to Twomile Canyon near TA-3 (E243.5). Additionally, runoff gage height data became available for the stream gages in upper Pueblo Canyon above Acid Canyon (E055) and in Acid Canyon above Pueblo Canyon (E056). In 2002, storm runoff was monitored at approximately 70 stream gage stations at LANL and storm runoff samples were collected from 40 automated samplers. Figure 3-1 shows the locations of the stream gage stations and Table 3-1 lists the gage stations operable in 2002. For the summary purposes and discussion in this report, the storm runoff season is considered to be from June through October of each year.

3.2.1 Storm Runoff in 2002

Figure 3.2-1 shows the daily mean runoff at downstream gages at LANL during the storm runoff season in 2002 (June through October). Baseflow in lower Pueblo Canyon at gage E060 is from discharge from the Los Alamos County Sewage Treatment Plant; baseflow does not occur at other downstream gages at LANL, where flow is usually associated with storm runoff events.

Storm runoff in 2002 was primarily the result of monsoonal thunderstorms from late June to early September. Generally, there were fewer storm runoff events at LANL in 2002 and most were considerably less intense than in 2000 and 2001, mainly due to below-normal amounts of precipitation during the summer monsoon season. Significant runoff events occurred on June 21, August 28, and September 10. Abnormally little precipitation and runoff occurred in July 2002.

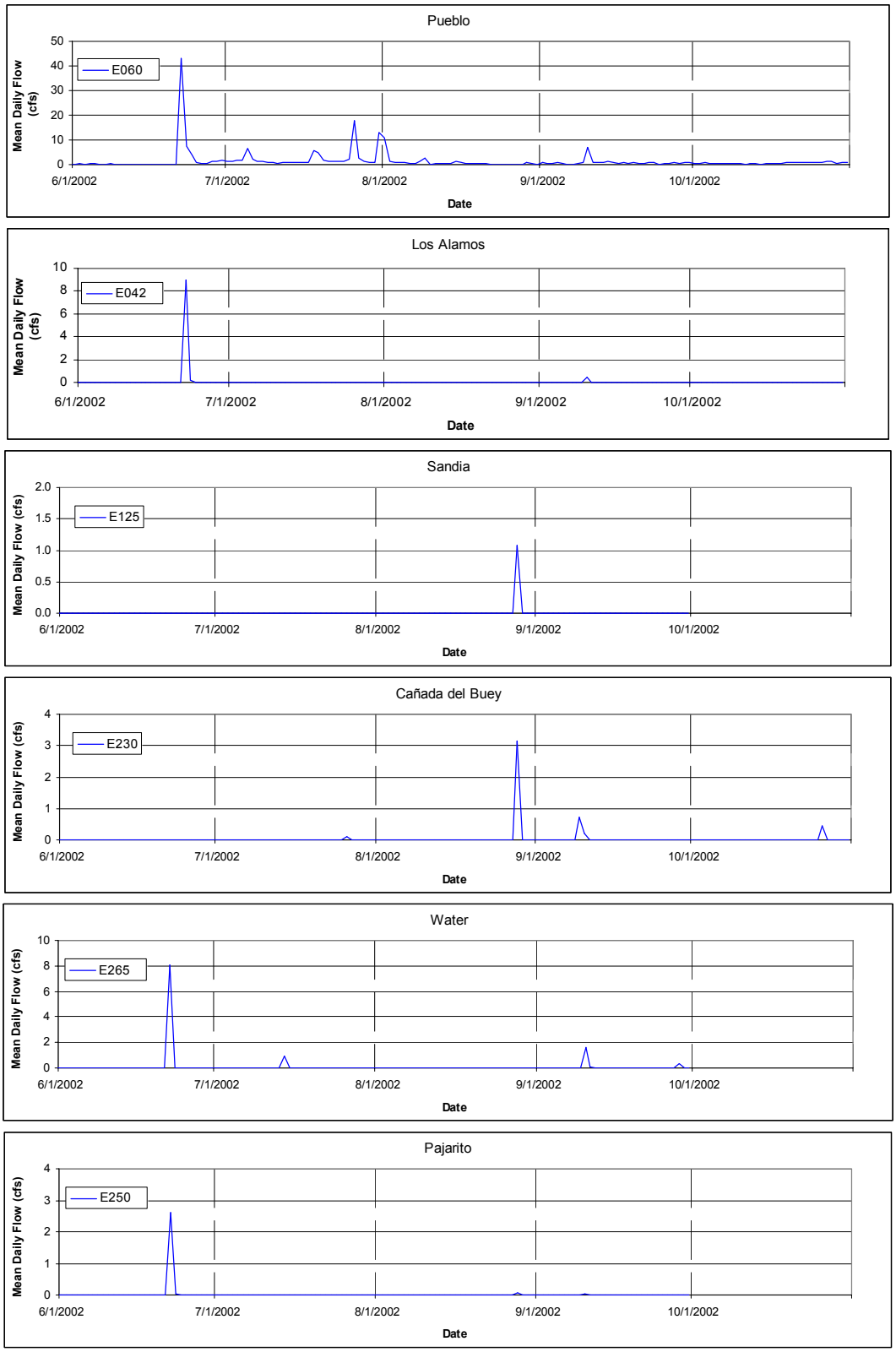
The major storm runoff event of 2002 occurred in Pueblo Canyon on the night of June 21-22 when a flood event totaling about 80 ac-ft rushed through the canyon and runoff occurred in the major LANL drainages. The total runoff at all downstream LANL gages from this event was about 120 ac-ft, accounting for approximately 48% of all runoff in 2002. This runoff event resulted from a thunderstorm that occurred on the western part of the Pajarito Plateau on the night of July 21-22.

Table 3-2 summarizes the annual storm runoff at LANL stream gages in 2002 from June through October and historical runoff data for these months from previous years. Figure 3.2-2 shows the volumes of storm runoff at upstream (where present) and downstream gages in each canyon at LANL in 2002. The highest seasonal flow volume at any gage in 2002 was 427 ac-ft at gage E060 in lower Pueblo Canyon. However, most of this flow was baseflow from discharge from the Los Alamos County Sewage Treatment Plant rather than from storm runoff, which in 2002 is estimated to be approximately 190 ac-ft or about 44% of the total flow in lower Pueblo Canyon.

Total runoff at the downstream gage in Los Alamos Canyon (E042) in 2002 was about 19 ac-ft, compared with 2.1 ac-ft in Sandia Canyon, 9.2 ac-ft in Cañada del Buey, 5.4 ac-ft in Pajarito Canyon, 0.6 ac-ft in Potrillo Canyon, and 21.9 ac-ft in Water Canyon, for a total volume of downstream runoff from LANL (excluding Pueblo Canyon) of about 58 ac-ft. The total storm runoff from LANL, including Pueblo Canyon, was about 248 ac-ft. The runoff in lower Rendija Canyon was 96 ac-ft, and in Guaje Canyon above Rendija Canyon, the runoff was about 23 ac-ft, for a total runoff of at least 119 ac-ft from the Guaje Canyon watershed. Storm runoff did not occur in significant volumes in Ancho Canyon (gage E275) and Mortandad Canyon (gage E204) in 2002 (Shaull et al. 2002).

Flow volumes from the upstream gage (E055) in Pueblo Canyon are not available. In Los Alamos Canyon about 6.8 ac-ft of runoff occurred at the upstream gage (E026) and an additional 6.2 ac-ft of runoff came from DP Canyon at gage E040. The upstream gage in Pajarito Canyon (E240) was relocated downstream of SR 501 after the large flood event in June 2000 destroyed the gage. In 2002, gage E240 recorded 48 ac-ft of storm runoff, mostly from the June 21 runoff event.

Baseflow from springs and storm runoff in upper Water Canyon (gage E252) totaled 10.1 ac-ft, of which approximately 8.4 ac-ft was storm runoff (interrupted base flow was approximately 0.1 cfs for a total of approximately 4.2 ac-ft). Runoff in upper Cañon de Valle (gage E253) was 0.9 ac-ft; thus, the total storm runoff at upstream Water Canyon/Cañon de Valle gages was 9.3 ac-ft.



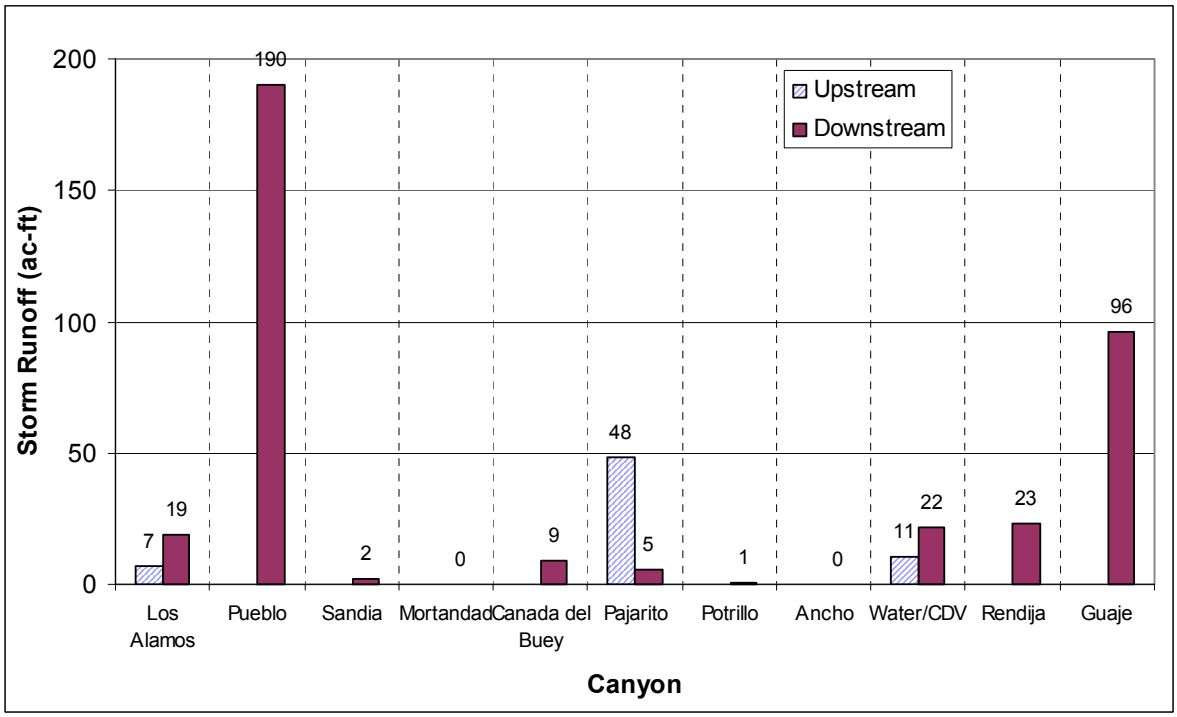
Note scale change on charts.

Figure 3.2-1. Mean daily flow at downstream gaging stations at LANL in 2002.

Table 3-2. Summary of Storm Runoff (June through October) at LANL in 2002.

Canyon	Gage	1995–1999 Average Annual Runoff (ac-ft)	2000 Runoff Volume (ac-ft)	2001 Runoff Volume (ac-ft)	2002 Runoff Volume (ac-ft)
Pueblo Canyon	E060	51.0	71.8	250.0	189.9
Guaje Canyon	E089	ND*	ND	74.3	22.8
Rendija Canyon	E090	ND	ND	93.9	96.0
Los Alamos Canyon	E025/E026	48.0	137.0	83.6	6.8
	E030	35.0	56.0	46.9	9.0
	E042	40.0	51.7	105.1	19.2
Sandia Canyon	E125	0.0	0.0	0.0	2.1
Cañada del Buey	E230	12.0	4.7	0.1	9.2
Pajarito Canyon	E240	40.0	65.8	12.8	48.3
	E245	39.0	55.0	28.1	29.7
	E250	3.2	11.9	11.2	5.4
Potrillo Canyon	E267	2.1	5.5	0.0	0.6
Water Canyon/Cañon de Valle	E252	2.4	68.8	62.7	9.6
	E253	0.0	59.3	3.4	0.9
	E265	0.4	90.8	22.1	22.0
Ancho Canyon	E275	6.0	12.0	0.0	0.0

* ND = No Data. Note: The total seasonal flow at gage E060 in lower Pueblo Canyon in 2002 was 427 ac-ft, of which approximately 190 ac-ft or 44% is estimated to be storm runoff. Baseflow at gage E060 is from the Los Alamos County Sewage Treatment Plant. Flow at other downstream gages at LANL is predominantly storm runoff.



Note: The total seasonal flow at gage E060 in lower Pueblo Canyon in 2002 was 427 ac-ft, of which approximately 190 ac-ft or 44% is estimated to be storm runoff. Baseflow at gage E060 is from the Los Alamos County Sewage Treatment Plant. Flow at other downstream gages at LANL is predominantly storm runoff. CDV = Cañon de Valle

Figure 3.2-2. Storm runoff at upstream and downstream gages at LANL in 2002.

For the canyons with upstream and downstream runoff data (which does not include Pueblo Canyon), about 66 ac-ft of storm runoff occurred at upstream gages and about 58 ac-ft occurred at downstream gages in 2002. The runoff data indicate that in 2002 slightly more runoff flowed onto LANL at upstream gages than flowed off LANL at downstream gages; at least 8 ac-ft of storm runoff was apparently lost to infiltration or evapotranspiration in major drainages at LANL in 2002.

The seasonal runoff and baseflow in Sandia Canyon at gage E123 (below wetlands) in 2002 was about 158 ac-ft, of which about 24 ac-ft (15%) was storm runoff. Runoff from a local precipitation event occurred in lower Sandia Canyon at gage E125 on August 28, 2002, when about 2.1 ac-ft passed the gage. Runoff in upper Cañada del Buey at gage E218 in 2002 was about 2.6 ac-ft, and runoff in lower Cañada del Buey at gage E230 totaled 9.2 ac-ft. The total seasonal flow in Mortandad Canyon at gage E200 (below Effluent Canyon) in 2002 was about 12 ac-ft, of which about 2.3 ac-ft was from storm runoff. Storm runoff did not occur at the LANL boundary in Mortandad Canyon in 2002.

A listing of all storm runoff events at LANL in 2002 is in Appendix Table C-1. The date and time of the beginning of the runoff event, the instantaneous peak flow in cfs, the time of the peak flow, the date and time of the end of the runoff event, the runoff volume, and the runoff yield are summarized for each significant runoff event.

Table 3-3 summarizes the runoff events at LANL in 2002. The median time of a runoff event was 4.4 hours and the median flow volume was 0.4 ac-ft. The median time between the beginning of runoff and the peak runoff was 0.2 hrs. The longest runoff event in 2002 was 71.4 hours and the largest runoff event was 80.6 ac-ft, which occurred in Pueblo Canyon on June 22. The peak flow recorded was 583 cfs, also in Pueblo Canyon on June 22.

Table 3-3. Summary of Runoff Events at LANL in 2002.

	Average	Median	Maximum
Event Time (hr)	8.8	4.4	71.4
Time to Peak (hr)	0.9	0.2	18.7
Peak Flow (cfs)	35.0	6.0	583
Flow Volume (ac-ft)	4.0	0.4	80.6

3.2.2 Impact of Cerro Grande Fire on Storm Runoff

3.2.2.1 Historical Runoff

Figure 3.2-3 shows the annual upstream and downstream storm runoff for 2000, 2001, 2002, and the prefire and postfire average values. Because upstream runoff data are not available for Pueblo Canyon, the downstream runoff for this canyon is shown separately. After the fire, upstream runoff at LANL was 331 ac-ft in 2000, 3.7 times higher than the prefire average; about 163 ac-ft in 2001, 1.8 times higher than the prefire average; and 66 ac-ft in 2002, 70% of the prefire average (partially due to below-average precipitation). The downstream runoff at LANL gages was 177 ac-ft in 2000, 2.8 times higher than the prefire average; 139 ac-ft in 2001, 2.2 times the prefire average; and 58 ac-ft in 2002, 90% of the prefire average.

Storm runoff in Pueblo Canyon was 72 ac-ft in 2000, slightly higher than the prefire Pueblo Canyon average, but was 250 ac-ft in 2001, about 5 times higher than the prefire average; and 190 ac-ft in 2002, 3.7 times the prefire average. Decreasing runoff at upstream and downstream locations since 2000 likely reflects partial recovery of the fire-impacted portions of the watersheds.

Figure 3.2-4 shows the seasonal storm runoff measured at all downstream gages at LANL (including Pueblo Canyon) for the period 1995 through 2002 and the prefire and postfire averages. The seasonal storm runoff for each year is the sum of runoff at each downstream gage from June 1 through October 31 of each year. Also shown on Figure 3.2-4 is the seasonal precipitation received at the TA-6 meteorological station each year from June 1 through October 31. Because flow at gage E060 in lower

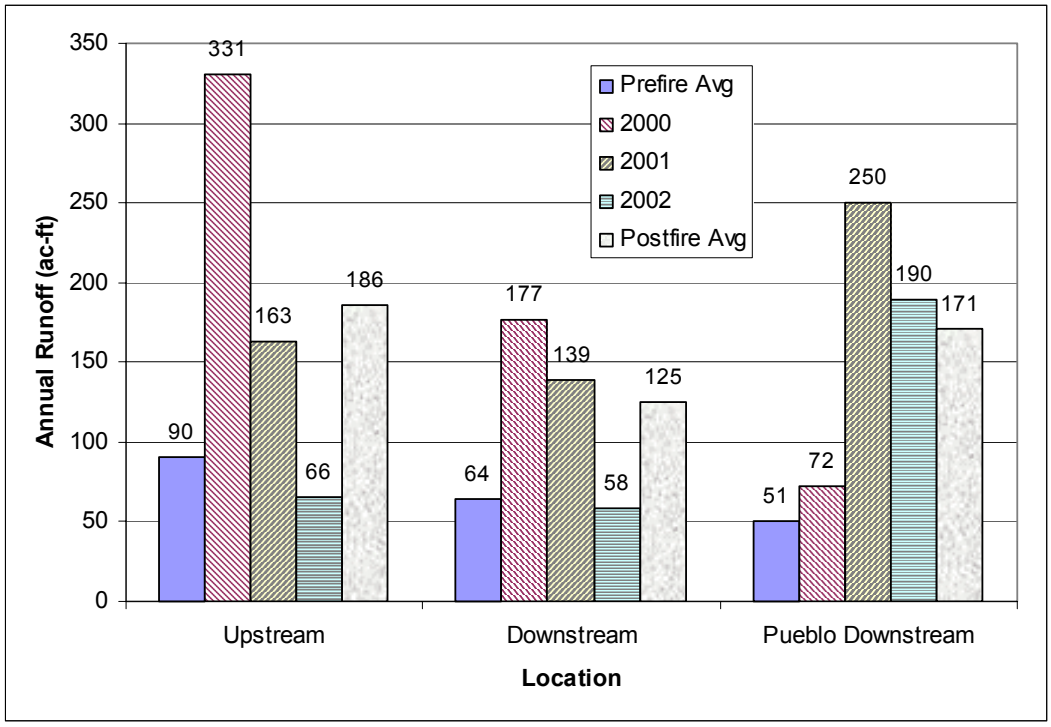
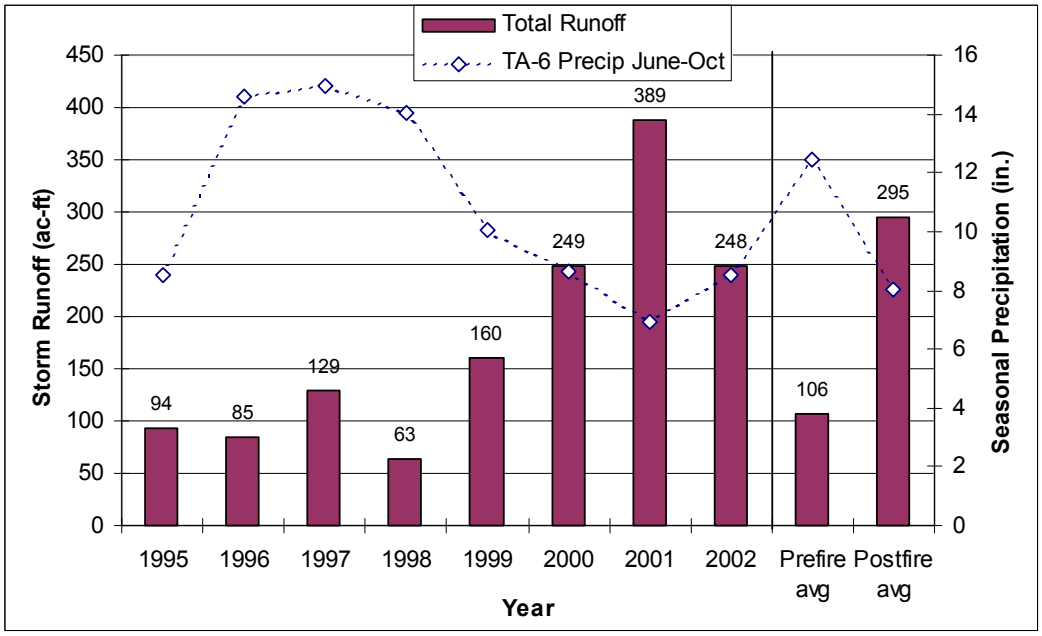


Figure 3.2-3. Annual storm runoff at upstream and downstream locations, prefire and postfire.



Note: Downstream gages include E060, E042, E125, E230, E250, E265, E267, and E275.

Figure 3.2-4. Annual seasonal precipitation and storm runoff at downstream gages at LANL.

Pueblo Canyon is primarily discharge from the Los Alamos County Sewage Treatment Plant, storm runoff at this gage was calculated using daily flow records that exceeded the usual sewage treatment plant discharges.

The total downstream runoff at LANL in 2002 was 248 ac-ft, similar to the total runoff in 2000. About 120 ac-ft of the downstream runoff at LANL in 2002 (48%) occurred as a result of a single storm event that occurred on June 21-22.

Storm runoff at downstream gages in 2002 (and 2000) was about 2.3 times higher than the prefire average (106 ac-ft). The total downstream runoff in 2001 was 1.5 times higher than the runoff in 2002 and about 3.6 times higher than the prefire average annual runoff, even though the seasonal precipitation in 2001 (6.94 in.) was less than received in 2000 and 2002 and significantly less than the prefire average seasonal precipitation (12.4 in.). The higher runoff in 2000, 2001, and 2002 results from the effects of the Cerro Grande Fire in the upper reaches of the watersheds at Los Alamos.

The largest runoff event in 2000 after the Cerro Grande Fire occurred after a thunderstorm event on June 28, 2000, that primarily occurred in the upper reaches of Pajarito Canyon and Water Canyon. Due to the location of this storm event and the configuration of the affected canyons, downstream runoff from this storm event was less than experienced in subsequent years when the major runoff events occurred in Pueblo Canyon. After the June 28, 2000, storm, runoff was only 2.75 ac-ft in lower Pajarito Canyon (compared with an estimated 50 ac-ft at the upstream gage) and 21.8 ac-ft in lower Water Canyon (compared with an estimated 107 ac-ft at upstream Water Canyon and Cañon de Valle gages) (Koch et al. 2001; Shaull et al. 2001). Since 2000, the major precipitation and runoff events have occurred in the Pueblo Canyon drainage, where downstream flows have been as high as 90 ac-ft from individual runoff events. Had a significant precipitation event occurred in the upper Pueblo Canyon drainage in 2000, total downstream runoff for 2000 would have likely been much higher than what was observed in 2001.

Figure 3.2-5 shows the result of normalizing downstream runoff with seasonal precipitation. The normalization is performed by dividing the total annual downstream runoff (ac-ft) by the seasonal TA-6 precipitation (in.). Precipitation data from the TA-6 meteorological tower were used for the normalization of the runoff data because this site serves as the official meteorological record for Los Alamos. The TA-6

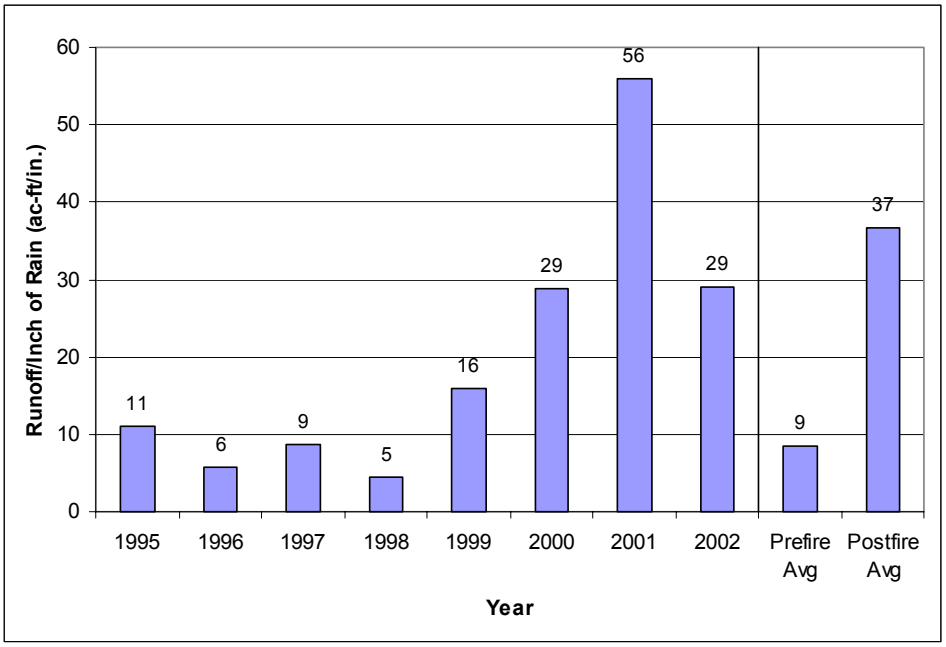


Figure 3.2-5. Downstream storm runoff normalized with seasonal precipitation.

tower is located in the western-central part of LANL, south of Los Alamos Canyon and north of Pajarito Canyon (see figures in Appendix B), and may not be as representative of precipitation received in the Pueblo Canyon drainage as the North Community rain gage site. However, for the years after the Cerro Grande Fire, seasonal precipitation at TA-6 and the North Community rain gage (see Section 2.0 and Appendix B figures) have not been significantly different to appreciably impact the normalization of the runoff.

Because precipitation and runoff were similar in 2000 and 2002, the normalized runoff for both of these years was 29 ac-ft/in. However, in 2001, the normalized runoff was about 56 ac-ft/in., largely due to higher runoff in Pueblo Canyon. The prefire normalized runoff was 9 ac-ft/in., whereas the postfire normalized runoff was 37 ac-ft/in., about four times higher after the Cerro Grande Fire.

3.2.2.2 Peak Flows

Table 3-4 shows the peak flow data for the prefire period of record and the postfire years 2000, 2001, and 2002. Runoff data are shown for 19 stream gages, of which peak flows at 2 gages were higher in 2002 than previously recorded. Record peak flows in 2002 were recorded at gage E125 in lower Sandia Canyon and gage E250 in lower Pajarito Canyon.

Table 3-4. Peak Flows at LANL, Prefire, and Postfire Years of 2000, 2001, and 2002.

			Pre-Fire		2000		2001		2002		Ratio	
Canyon	Gage	Period of Record Start	Date of Peak Flow	Peak Flow (cfs)	Date of Peak Flow	Peak Flow (cfs)	Date of Peak Flow	Peak Flow (cfs)	Date of Peak Flow	Peak Flow (cfs)	Post-Fire peak/ Pre-fire peak	Comment
Los Alamos	E026	10/1/1993	05/04/95	10	7/18	**60**	8/9	**185**	6/21	43	18.5	E025 data before 2/26/01
	E030	7/1/1994	07/31/68	**329**	6/2	13	8/9	60	6/22	125	0.4	
	E042	10/1/1991	08/22/97	**171**	6/2	17	8/9	146	6/22	160	0.9	
Pueblo	E060	1/1/1992	07/09/99	11	10/24	**139**	7/2	**1440**	6/22	582	130.9	
Guaje	E089	6/14/2001					8/11	**644**	7/4	263		Gage installed in 2001
Rendija	E090	6/19/2001					8/11	**2120**	7/31	486		Gage installed in 2001
	E200 M	5/1/1995		38	8/19	11			6/22	14	0.4	
	E202 M	10/1/1997		6.4	7/29	1.9					0.3	
	E218 C	10/1/1999		10	7/29	129					12.9	
Sandia	E125	10/1/1994	09/08/95	13	N/A	0	N/A	0	8/28	**18**	1.4	2002 record peak flow
CDB	E230	10/1/1991	06/17/99	**210**	8/9	33	8/4	5.8	8/28	168	0.8	
Pajarito	E240	10/1/1993	06/21/64	2.4	6/28	**1020**	8/9	155	6/21	173	425.0	
	E241	3/1/1999	09/16/99	0.21	6/28	**300**	8/9	109	6/21	207	1428.6	
	E242	10/1/1999	05/04/99	10	6/28	**180**	6/27	137	6/21	8	18.0	
	E245	11/1/1993	08/17/97	30	6/28	**517**	6/27	141	6/21	140	17.2	
	E250	11/1/1993	06/17/99	20	6/28	14	8/16	**22**	6/22	**26**	1.3	2002 record peak flow
Water/CDV	E252	10/1/1994	03/23/97	0.29	6/28	**840**	7/22	242	6/21	114	2896.6	
	E253	10/1/1994		0	6/28	**740**	8/9	19	8/13	12		No flow before fire
	E263	10/1/1998		20	6/28	**306**			6/22	149	15.3	
	E265	10/1/1993	08/29/95	21	6/28	**274**	8/3	92	9/28	105	13.0	
Potrillo	E267	10/1/1993	08/29/95	**63**	8/9	7	N/A	0	8/28	15	0.2	
Ancho	E275	10/1/1993	06/29/95	**520**	8/6	348	8/12	0.05	N/A	0	0.7	

Source: Shaull et al. (2001, 2002, 2003). Bold numbers are record peak flows. CDB is Cañada del Buey; CDV is Cañon de Valle.

The record peak flow of 18 cfs in lower Sandia Canyon at gage E125 occurred on August 28, 2002. The previous peak flow at this gage was 13 cfs on October 1, 1994. Gage E125 in lower Sandia Canyon is usually dry and did not flow in 2000 or 2001. The record peak flow of 26 cfs in lower Pajarito Canyon occurred on June 22, 2002. The previous peak flow at gage E250 was 20 cfs on June 17, 1999. The record peak flows established in 2000 and 2001 (Table 3-4) were related to high-volume runoff from burned areas associated with the Cerro Grande Fire, however, the peak flows in 2002 were more related to local precipitation and runoff from the Pajarito Plateau and not necessarily to any residual effects from

the Cerro Grande Fire. This likely suggests partial recovery of the fire-effected areas in the upper parts of the watersheds at Los Alamos.

Prefire peak flow records are still in effect at four downstream gages, including E042 in lower Los Alamos Canyon, E230 in lower Cañada del Buey, E267 in lower Potrillo Canyon, and E275 in lower Ancho Canyon. Potrillo Canyon and Ancho Canyon were not significantly affected by the Cerro Grande Fire. The upper reaches of Cañada del Buey were affected by fire, but due to the relatively small watershed area (and possibly due to a lack of precipitation), an increase in the runoff to the lower part of the canyon was not evident after the fire. The Los Alamos Canyon reservoir in upper Los Alamos Canyon buffered the impact of runoff from burned areas in upper Los Alamos Canyon to the lower parts of Los Alamos Canyon and gage E042.

Figure 3.2-6 shows the instantaneous peak flows observed at selected stream gages in 2000, 2001, and 2002, compared with prefire peak flow rates. In 2000, nine stream gages experienced peak of record runoff, and in 2001, three gages (E026, E060, and E250) experienced peak of record runoff. The highest peak runoff observed in 2000 after the Cerro Grande Fire was 1020 cfs at gage E240 in upper Pajarito Canyon while other peak flows in 2000 ranged from 274 to 840 cfs. In 2001, peak flows at LANL were usually less than 200 cfs, except at gage E252 in upper Water Canyon, where the peak flow was 242 cfs, and at gage E060 in Pueblo Canyon, where the peak flow was 1440 cfs. Peak flows in 2001 at newly installed gages E089 in Guaje Canyon and E090 in Rendija Canyon was 644 cfs and 2120 cfs, respectively.

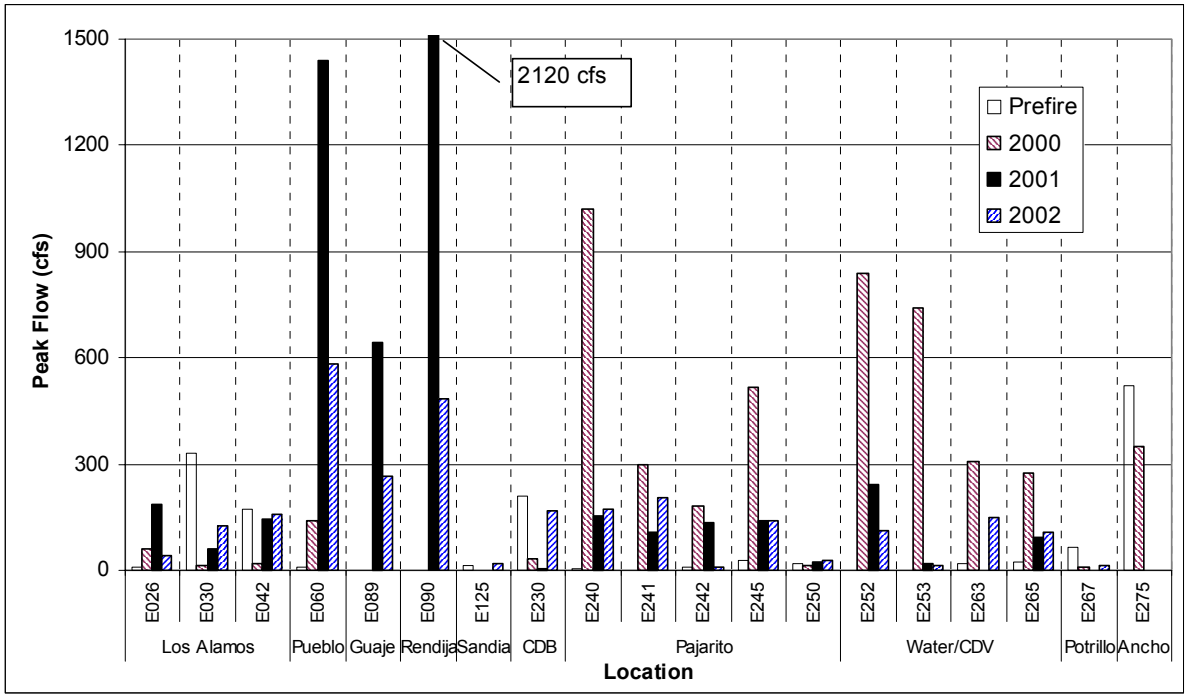


Figure 3.2-6. Peak runoff recorded in 2000, 2001, and 2002, compared with prefire peak flows.

In 2002, peak flows at most gages in fire-related drainages were significantly less than in 2000 and 2001, especially at upstream sites. The peak flows in Guaje and Rendija Canyons in 2002 (263 cfs and 486 cfs, respectively) are 41% and 23% of the 2001 peak flows, respectively. Peak flows in upper Pajarito Canyon at gage E240 in 2002 were 17% of the 2000 peak. Similarly, 2002 peak flows in upper Water Canyon (gage E252) and upper Cañon de Valle (gage E253) were 14% and 2%, of the 2000 peak flows, respectively. Peak flows reflect local storm intensity and are not necessarily comparable from year to

year; however, the seasonal precipitation amounts in 2000 and 2002 were similar (see Figure 3.2-4). Thus, the significantly lower peak flows in 2002 may indicate, to some degree, a partial recovery of the fire-impacted areas of watersheds since the Cerro Grande Fire.

3.2.2.3 Runoff Yield

The average annual storm runoff yield for each gaging station is calculated by dividing the annual runoff in ac-ft by the drainage area in mi^2. Table 3-5 summarizes the annual runoff yield for some gaging stations at LANL for prefire and postfire years, and Figure 3.2-7 shows the trends in annual runoff yield. Runoff yields for most gaging stations were higher in 2000 after the Cerro Grande Fire, and some gaging stations were higher again in 2001.

Table 3-5. Summary of Annual Runoff Yield at LANL, Prefire and Postfire.

Canyon	Gage	Drainage Area (mi^2)	Prefire Average Runoff Yield (ac-ft/mi^2)	2000 Storm Runoff Yield (ac-ft/mi^2)	2001 Storm Runoff Yield (ac-ft/mi^2)	2002 Storm Runoff Yield (ac-ft/mi^2)
Pueblo	E060	6.9	7.3	10.3	36.0	27.4
Guaje	E089	14.6	ND*	ND	5.1	1.6
Rendija	E090	9.6	ND	ND	9.8	10.0
	E025/E026	7.1	6.7	19.2	11.7	1.0
	E030	8.6	4.1	6.5	5.5	1.1
Los Alamos	E042	9.1	4.4	5.7	11.6	2.1
CDB	E230	2.1	5.6	2.2	0.1	4.3
	E240	1.9	21.1	34.6	6.7	25.4
Pajarito	E245	7.8	5.0	7.0	3.6	3.8
	E250	10.9	0.3	1.1	1.0	0.5
Potrillo	E267	2.3	0.9	2.4	0.0	0.3
	E252	3.4	0.7	20.3	18.5	2.8
	E253	2.5	0.0	24.1	1.4	0.4
Water/CDV	E265	13.0	0.0	7.0	1.7	1.7
Ancho	E275	4.6	1.3	2.6	0.0	0.0

High runoff events in Pueblo Canyon in 2001 and 2002 caused unusually high yield values for these years, resulting from the affects of the Cerro Grande Fire in the upper part of the drainage. The higher yield in upper Pajarito Canyon in 2002 primarily resulted from one runoff event in June. Other upstream gaging stations in Los Alamos Canyon, Cañon de Valle, Water Canyon, and Guaje Canyon have significantly lower runoff yields in 2002 compared with 2000 and 2001, which suggests partial recovery of these drainages since the Cerro Grande Fire.

3.3 Summary of Runoff in 2002

Storm runoff in 2002 was primarily the result of monsoonal thunderstorms from late June to early September. Generally, there were fewer storm runoff events at LANL in 2002 than in 2000 and 2001 and most were considerably less intense, mainly due to below-normal amounts of precipitation during the summer monsoon season. Significant runoff events occurred on June 21, August 28, and September 10. Abnormally little precipitation and runoff occurred in July 2002.

The total downstream storm runoff at LANL in 2002 was 248 ac-ft, which was similar to the total runoff in 2000 after the Cerro Grande Fire, but about 140 ac-ft less than in 2001. The total downstream runoff in 2002 was about 2.3 times higher than the prefire average annual runoff (106 ac-ft), even though the seasonal precipitation in 2002 (8.5 in.) was significantly less than the prefire average seasonal precipitation (12.4 in.).

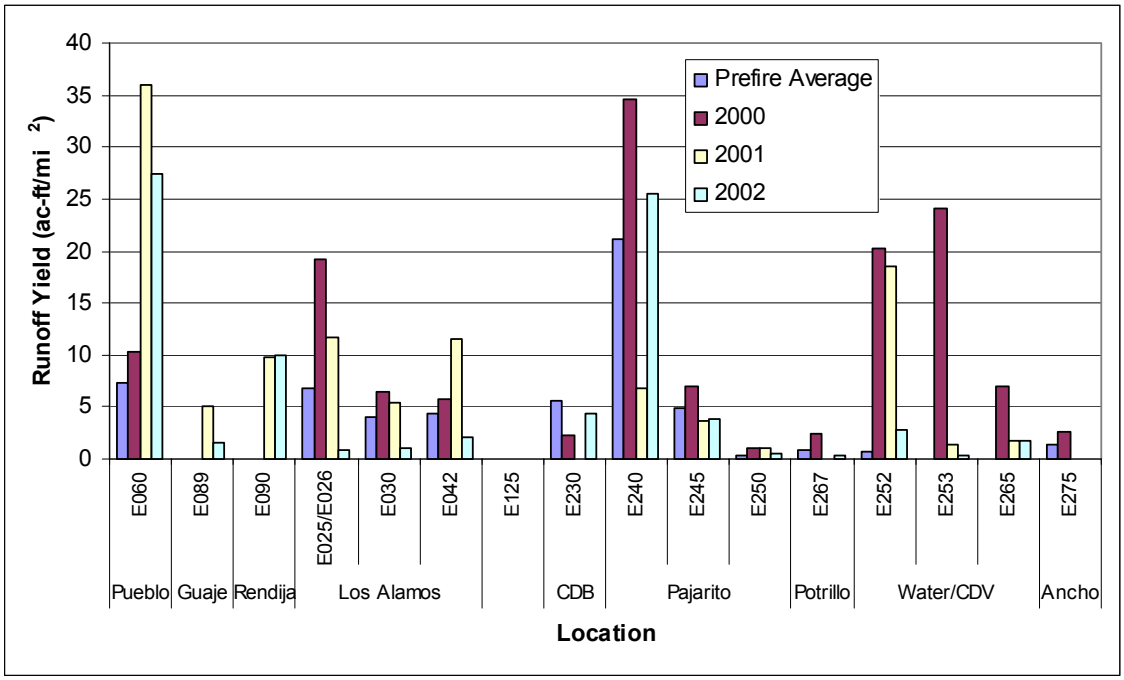


Figure 3.2-7. Summary of annual runoff yield at LANL, prefire and postfire.

The largest storm runoff event at LANL in 2002 occurred on the night of June 21-22 when a thunderstorm occurred over the western part of the Pajarito Plateau. This event created runoff in all the major drainages at LANL that totaled 120 ac-ft, which comprised about 48% of all runoff in 2002. The June 21-22 event caused a flood in Pueblo Canyon that totaled about 80 ac-ft.

For the canyons with upstream and downstream runoff data at LANL, about 66 ac-ft of storm runoff occurred at upstream gages and about 58 ac-ft occurred at downstream gages in 2002. The runoff data indicate that at least 8 ac-ft of storm runoff was lost to infiltration or evapotranspiration in the major drainages at LANL in 2002.

Record peak flows were established at 2 gages in 2002; gage E125 in lower Sandia Canyon and gage E250 in lower Pajarito Canyon. The record peak flows in 2002 were related to local precipitation and runoff and not necessarily to any residual effects from the Cerro Grande Fire. The runoff yields at four of five of the fire-impacted upstream gaging stations were lower in 2002 than in 2000 and 2001, which suggests partial recovery of these drainages since the Cerro Grande fire.

Downstream runoff at LANL in 2002 was over 2 times the prefire average, indicating that the effects of the Cerro Grande Fire were still present. Lower runoff volumes in 2002, compared with 2000 and 2001, were partially the result of lower precipitation, but significantly lower peak flows and runoff yields may reflect a partial recovery of the fire-impacted areas of watersheds since the Cerro Grande fire.

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5.0 References

Baars, J., Holt, D., and Stone, G., 1998. "Meteorological Monitoring at Los Alamos," Los Alamos National Laboratory report LA-UR-98-2148, Los Alamos, New Mexico.

Bowen, B.M., 1990. "Los Alamos Climatology," Los Alamos National Laboratory report LA-11735-MS, Los Alamos, New Mexico.

Environmental Surveillance Program (ESP), 2000. "Environmental Surveillance at Los Alamos during 1999," Los Alamos National Laboratory report LA-13775-ENV, Los Alamos, New Mexico.

Environmental Surveillance Program (ESP), 2001. "Environmental Surveillance at Los Alamos during 2000," Los Alamos National Laboratory report LA-13861-ENV, Los Alamos, New Mexico.

Environmental Surveillance Program (ESP), 2002. "Environmental Surveillance at Los Alamos during 2001," Los Alamos National Laboratory report LA-13979-ENV, Los Alamos, New Mexico.

Gallaher, B., Koch, R., and Mullen, K., 2002. "Quality of Storm Water Runoff at Los Alamos National Laboratory in 2000 with emphasis on Impacts from the Cerro Grande Fire," Los Alamos National Laboratory report LA-13926, Los Alamos, New Mexico.

Koch, R., Shaull, D., Gallaher, B., and Alexander, M., 2001. "Precipitation Events and Storm Water Runoff Events at Los Alamos National Laboratory after the Cerro Grande Fire," Los Alamos National Laboratory report LA-13849-MS, Los Alamos, New Mexico.

Koch, R., Gallaher, B., and Shaull, D., 2002, "Snowmelt and Storm Water Runoff at Los Alamos National Laboratory in 2001," Los Alamos National Laboratory report LA-13947-MS, Los Alamos, New Mexico.

LANL (Los Alamos National Laboratory), 2000. "Institutional Monitoring and Sampling Plan for Evaluating Impacts of the Cerro Grande Fire," Los Alamos National Laboratory report, Available at http://www.lanl.gov/worldview/news/fire/ert/

LANL (Los Alamos National Laboratory), 2001. "Operation of Stream Gaging Stations and Collection of Storm Water Runoff Samples," Los Alamos National Laboratory, Water Quality and Hydrology Group Procedure ESH-18-HCP-009.0, Los Alamos, New Mexico.
Available at http://www.esh.lanl.gov/~esh18/SWP/documents/ESH-18-HCP-009.0.pdf

National Weather Service (NWS), 2002. "U.S. Drought Assessment, Drought Data for 2002," National Weather Service Climate Prediction Center, Data accessed November 22, 2002, at http://www.cpc.ncep.noaa.gov/products/expert_assessment/drought_assessment.html

Shaull, D.A., Alexander, M.R., and Reynolds, R.P., 1996a. "Surface Water at Los Alamos National Laboratory: 1995 Water Year," Los Alamos National Laboratory report LA-13177-PR, Los Alamos, New Mexico.

Shaull, D.A., Alexander, M.R., Reynolds, R.P., and McLean, C.T., 1996b. "Surface Water at Los Alamos National Laboratory: 1996 Water Year," Los Alamos National Laboratory report LA-13234-PR, Los Alamos, New Mexico.

Shaull, D.A., Alexander, M.R., Reynolds, R.P., and McLean, C.T., 1998. "Surface Water at Los Alamos National Laboratory: 1997 Water Year," Los Alamos National Laboratory report LA-13403-PR, Los Alamos, New Mexico.

Shaull, D.A., Alexander, M.R., Reynolds, R.P., and McLean, C.T., 1999. "Surface Water at Los Alamos National Laboratory: 1998 Water Year," Los Alamos National Laboratory report LA-13551-PR, Los Alamos, New Mexico.

Shaull, D.A., Alexander, M.R., Reynolds, R.P., McLean, C.T., and Romero, R.P., 2000. "Surface Water Data at Los Alamos National Laboratory: 1999 Water Year," Los Alamos National Laboratory report LA-13706-PR, Los Alamos, New Mexico.

Shaull, D.A., Alexander, M.R., Reynolds, R.P., McLean, C.T., Romero, R.P., Riebsomer, E.T., and McLean, C.T., 2001. "Surface Water Data at Los Alamos National Laboratory: 2000 Water Year," Los Alamos National Laboratory report LA-13814-PR, Los Alamos, New Mexico.

Shaull, D.A., Ortiz, D., Alexander, M.R., Romero, R.P., and Riebsomer, E.T., 2002. "Surface Water Data at Los Alamos National Laboratory: 2001 Water Year," Los Alamos National Laboratory progress report LA-13905-PR, Los Alamos, New Mexico.

Shaull, D.A., Ortiz, D., Alexander, M.R., and Romero, R.P., 2003, "Surface Water Data at Los Alamos National Laboratory: 2002 Water Year," Los Alamos National Laboratory report LA-14019-PR, Los Alamos, New Mexico.

US Forest Service, 2002, "Southwest Area Precipitation Monitoring Page – Jemez Mountains (Western Santa Fe National Forest)," US Forest Service Fire Weather Precipitation Monitoring Page updated November 18, 2002, accessed November 21, 2002, at http://www.fs.fed.us/r3/fire.htm.

Webb, M.D., and Carpenter, K., 2001. "The Cerro Grande Fire, Los Alamos, New Mexico," Los Alamos National Laboratory report LA-UR-01-1630, Los Alamos, New Mexico. Report available online at http://lib-www.lanl.gov/cgi-bin/getfile?00818575.pdf.

Appendix A. Description of Storm Runoff Events in 2002

The descriptions of runoff events that are provided in following sections are primarily focused on providing details for runoff events that occurred in main watercourses. Descriptions of runoff events at mesa-top sites, such as at TA-54 storm runoff gages, are not included.

A.1 June 21-22, 2002

The first significant runoff event in 2002 occurred on the night of June 21 and 22. Precipitation began around 21:00 on the evening of June 21 and continued until about 03:00 on the morning of June 22. During this time, the highest precipitation received was 1.82 in. at the North Community gage, while 1.62 in. was received at TA-6 and 1.29 in. was received at Pajarito Mountain. Figure B-1 shows the pattern of precipitation received on the night of June 21-22, 2002. The runoff characteristics in drainages at LANL are discussed in the following sections.

A.1.1 Guaje and Rendija Canyons

Precipitation at North Community and at the Guaje RAWS site and runoff in Guaje and Rendija Canyons on the night of June 21 and 22 are shown in Figure A.1-1. Runoff began at gage E089 in Guaje Canyon above Rendija Canyon at 24:00 (midnight) on the morning of June 22; the peak flow was 155 cfs at 00:05 and flow decreased to about 4 cfs at 02:00, when in response to additional precipitation, flow increased to 31 cfs at 02:15. Runoff continued at gage E089 until 10:40 on the morning of June 22; the total runoff was about 9.7 ac-ft.

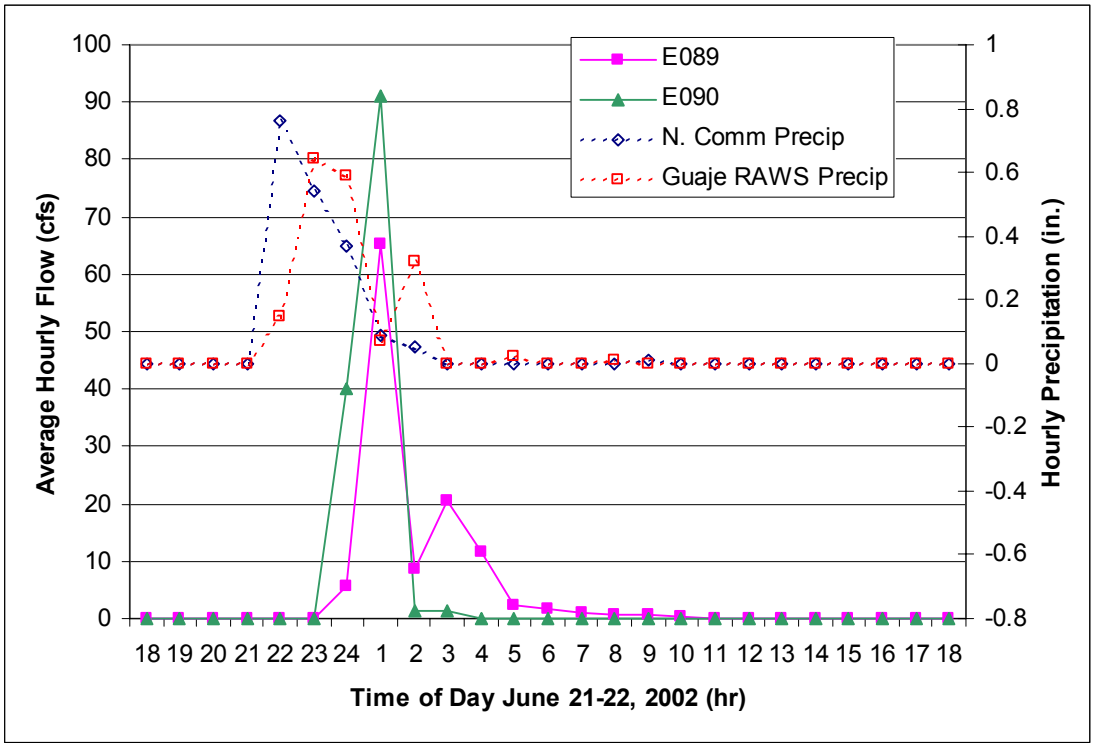

Figure A.1-1. Precipitation and runoff in Guaje and Rendija Canyons on June 21 and 22, 2002.

At gage E090 in lower Rendija Canyon, three relatively short episodes of runoff were recorded on the night of June 21 and 22. The initial runoff event began at 23:10 with a peak flow of 421 cfs, after which flow lasted for 15 minutes. The second runoff episode began at 00:10 on the morning of June 22; peak flow was 225 cfs at 00:20 and flow ended at 01:35. The third episode of runoff began at 02:45 with a peak flow of 9 cfs and runoff continued until about 03:15. The total flow in lower Rendija Canyon at gage E090 on the night of June 21 and 22 was about 11 ac-ft.

A.1.2 Pueblo Canyon

Precipitation at North Community and runoff in Pueblo Canyon at gage E060 are shown in Figure A.1-2. Runoff at gage E055 in upper Pueblo Canyon began at 21:30 on the night of June 21; peak flow occurred at 23:35 and runoff continued until about 02:00 on the morning of June 22. Runoff at gage E056 in Acid Canyon began at 21:55 on the night of June 21; the peak flow occurred at 22:05, and runoff continued at gage E056 until about 02:30 on the morning of June 22.

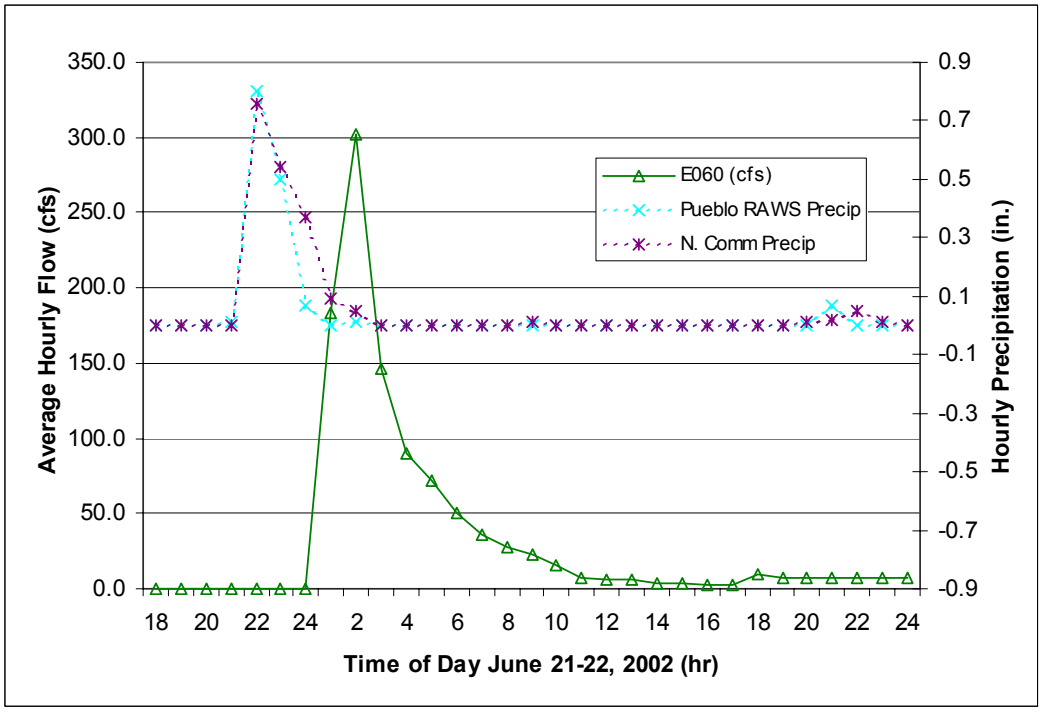

Figure A.1-2. Precipitation and runoff in Pueblo Canyon on June 21 and 22, 2002.

Runoff at gage E060 in lower Pueblo Canyon began at 00:40 on the morning of June 22; the peak runoff was 582 cfs at 01:00. Runoff continued at E060 until about 16:00 on the afternoon of June 22 and the total amount of flow was about 80.6 ac-ft.

A.1.3 Los Alamos Canyon and DP Canyon

The hourly precipitation at TA-53 and the average hourly runoff in DP Canyon at gage E040 and in Los Alamos Canyon at gages E026, E030, and E042 are shown in Figure A.1-3. Runoff began at gage E040 in lower DP Canyon at 22:45; the peak flow was 90 cfs at 24:00 (midnight) on the morning of June 22. Runoff at gage E040 continued until 11:00 on the morning of June 22 and the total runoff from DP Canyon was about 3.75 ac-ft.

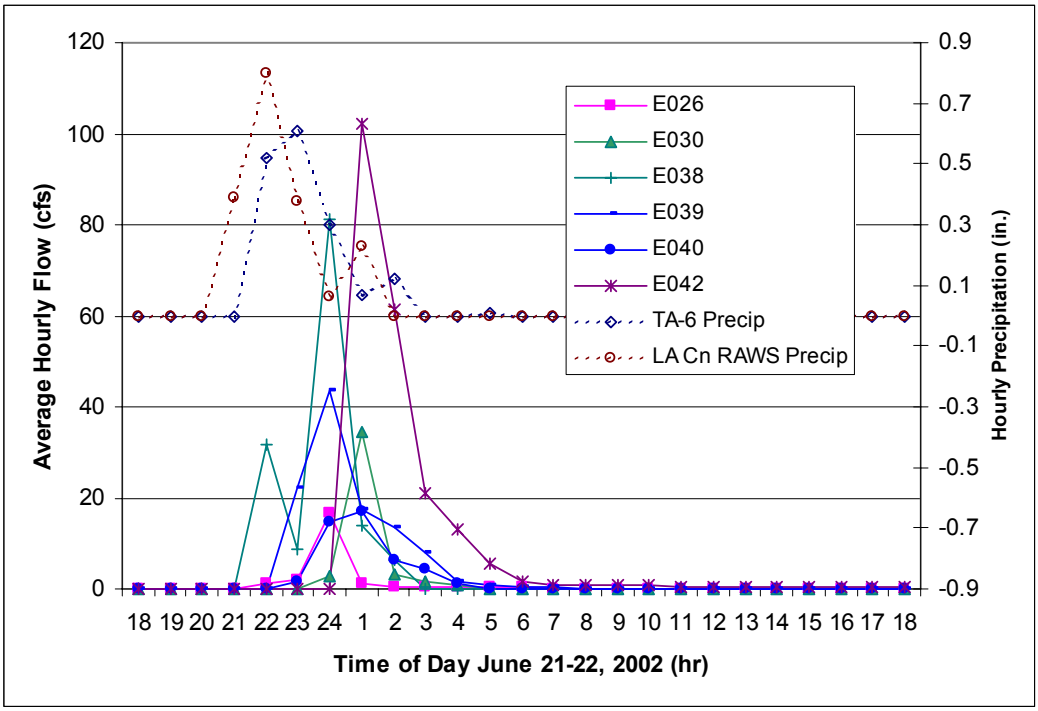

Figure A.1-3. Precipitation and runoff in DP and Los Alamos Canyons on June 21 and 22, 2002.

Locally derived runoff began in Los Alamos Canyon at gage E026 at 21:35 on the night of June 21 with a peak flow of 11.7 cfs at 22:05. Runoff derived from upper Los Alamos Canyon began at gage E026 at 23:05 with a peak flow of 43 cfs at 23:30 on June 21. Runoff, supported by low volumes of spring flow, continued at gage E026 until 23:15 on the night of June 22; the total amount of flow at gage E026 was about 2 ac-ft. Flow at gage E030 began at 23:20 on the night of June 21; the peak flow was 124.5 cfs at 00:25 on the morning of June 22. Runoff continued at gage E030 until 04:40 on the morning of June 22 and the total runoff at gage E030 was about 3.5 ac-ft.

Locally derived runoff began in DP Canyon at gage E038 at 21:50 on the night of June 21 with a locally derived peak flow of 184 cfs. A larger runoff event began at 23:10 and the peak flow was 211.6 cfs at 23:15. Runoff continued at gage E038 until 02:00 on the morning of June 22; the total runoff was about 11.7 ac-ft. Locally derived runoff began at gage E039 in middle DP Canyon at 22:05 on the night of June 21 with a peak flow of 56 cfs. A larger runoff event began at 23:25 and the peak flow was 105 cfs at 23:30. Runoff continued at gage E039 until 15:35 on the afternoon of June 22 and the total runoff was about 8.9 ac-ft.

Locally derived runoff began at gage E040 in lower DP Canyon at 22:45 on the night of June 21; the locally derived peak flow was 7.9 cfs at 22:50. A larger runoff event began at gage E040 at 23:50 and the peak flow was 90 cfs at 24:00 (midnight) on the morning of June 22. Runoff at gage E040 continued until 11:00 on the morning of June 22 and the total runoff was about 3.75 ac-ft. The runoff data from DP Canyon indicate that about 8 ac-ft was lost to infiltration between gages E038 and E040, a distance of about 1.4 mi.

Runoff at gage E042 in lower Los Alamos Canyon began at 00:15 on the morning of June 22; the peak flow was 160 cfs at 00:45. Runoff was less than 1 cfs by 06:10 on the morning of June 22, but runoff continued in small volumes at gage E042 until 15:55 on the afternoon of June 23. The total runoff at gage E042 was about 18 ac-ft.

A.1.4 Cañada del Buey

A small amount of runoff occurred in upper Cañada del Buey at gage E218 near TA-46 on the night of June 21. Runoff began at 23:05 when the peak flow was 0.66 cfs. Runoff continued for 25 minutes and the total runoff was about 0.01 ac-ft. Runoff was not recorded at gage E230 in lower Cañada del Buey on the night of June 21 and 22.

A.1.5 Pajarito Canyon

Precipitation at the Pajarito RAWS and TA-6 and runoff in Pajarito Canyon on June 21 and 22 are shown in Figure A.1-4. Runoff in upper Pajarito Canyon at gage E240 began at 21:40 on the night of June 21; the peak flow was 173 cfs at 21:50. Runoff continued at gage E240 until 15:45 on June 23 and the total volume of runoff was about 45.7 ac-ft. Runoff at gage E241 began at 21:55 and the peak flow was 207 cfs at 22:00. Runoff continued at gage E241 until about 01:00 on the morning of June 23 and the total volume of runoff was about 74 ac-ft. After the runoff event, a small volume of spring-supported flow continued at gage E241 until July 1. Spring supported baseflow was not recorded at gage E241 before June 21 but sporadic baseflow occurred after the June 21-22 runoff event.

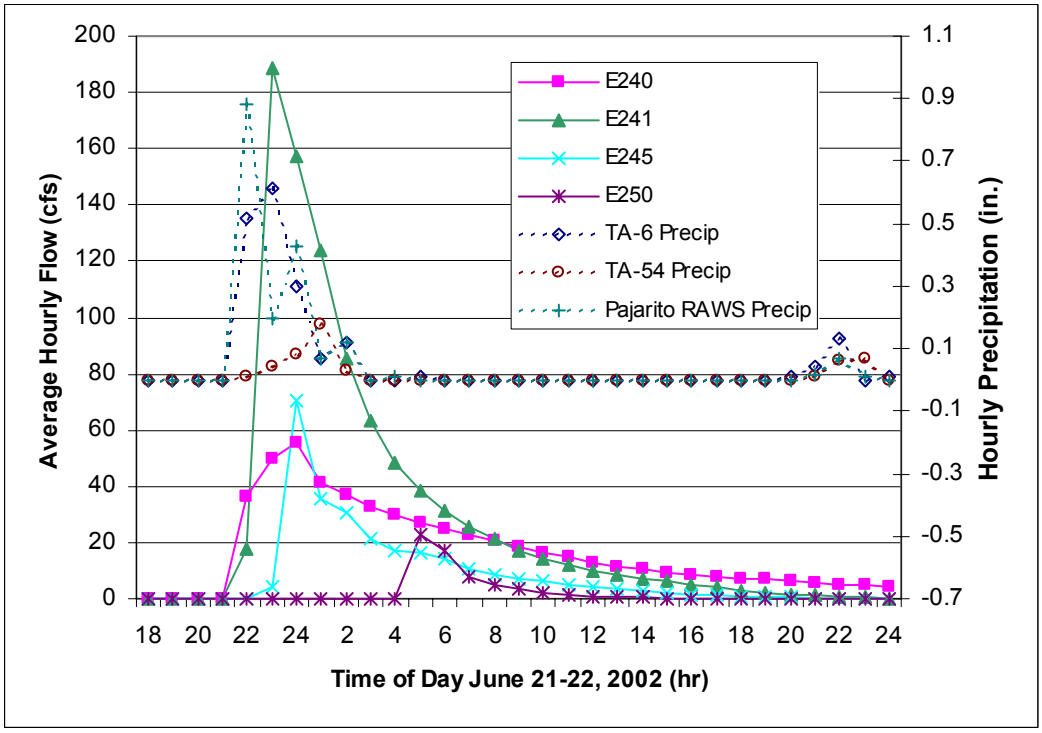

Figure A.1-4. Precipitation and runoff in Pajarito Canyon on June 21 and 22, 2002.

Runoff in middle Pajarito Canyon at gage E245 began at 23:00 on the night of June 21; the peak flow was 140 cfs at 23:20. Runoff continued at gage E245 until 02:00 on the morning of June 23 and the total runoff was about 22 ac-ft. Runoff in lower Pajarito Canyon at gage E250 began at 04:05 on the morning of June 22; the peak flow was 25.7 cfs at 04:35. Runoff continued in small volumes until 16:10 on the afternoon of June 23 and the total runoff was about 5.2 ac-ft. The runoff data indicate that about 70 ac-ft of runoff infiltrated or evapotranspirated in Pajarito Canyon between gages E241 and E250 from June 21 to June 23.

A.1.6 Water Canyon

Precipitation at the Water Canyon RAWS and at TA-49 and runoff in Water Canyon are shown in Figure A.1-5. Baseflow from the Water Canyon Gallery spring in upper Water Canyon at gage E252 on June 21 was about 0.04 cfs. Runoff at gage E252 began at 21:50 on the night of June 21; peak flow was 114 cfs at 23:15. Runoff continued at gage E252 until about 00:30 on the morning of June 22 and the total runoff was about 4.7 ac-ft. Gage E253 in upper Cañon de Valle did not record the runoff event on the night of June 21 and 22 but estimates from the high water mark indicate that the mean daily flow was 0.25 cfs with a total runoff of about 0.25 ac-ft.

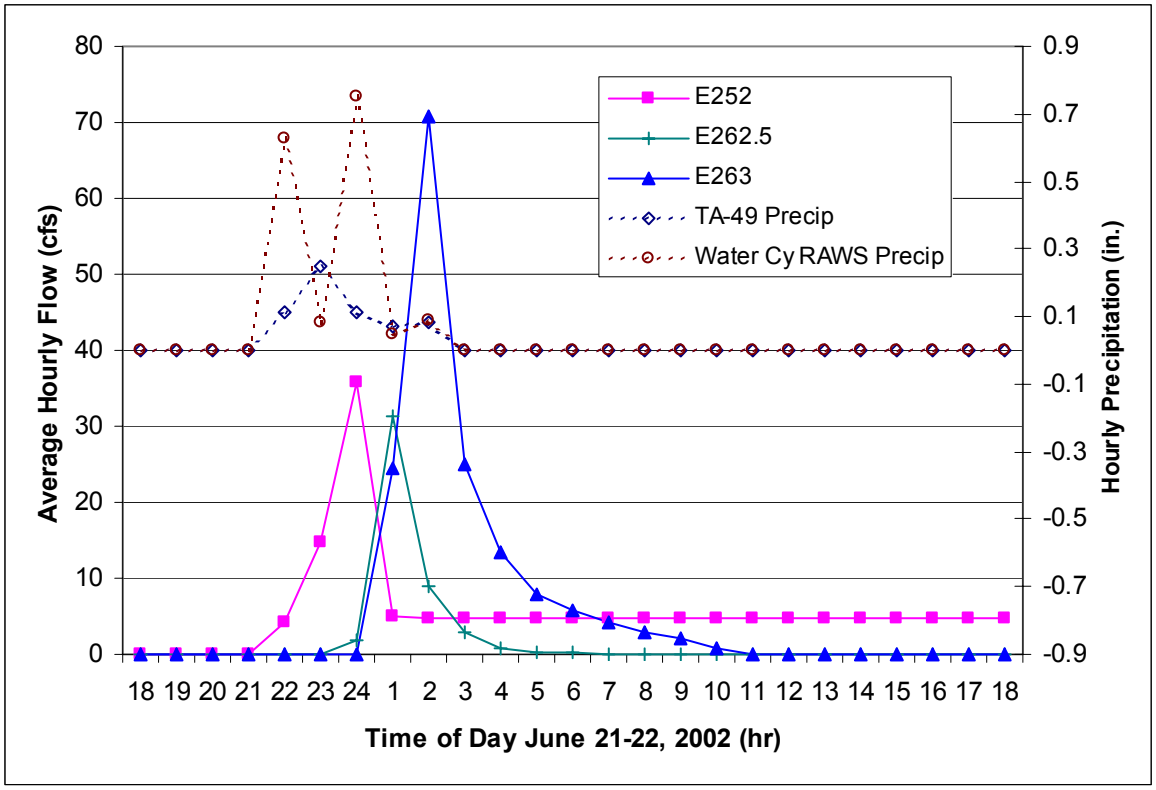

Figure A.1-5. Precipitation and runoff in Water Canyon on June 21 and 22, 2002.

Runoff began in middle Water Canyon at gage E262.5 at 23:55 on the night of June 21; the peak flow was 53 cfs at 00:10 on the morning of June 22. Runoff continued at gage E262.5 until about 09:45 on the morning of June 22 and the total flow was about 3.8 ac-ft. Runoff began in lower Water Canyon at gage E263 at 00:55 on the morning of June 22 with a peak flow of 149 ac-ft. Runoff continued at gage E263 until 11:20 on the morning of June 22 and the total flow was about 13 ac-ft. The runoff event was not recorded at gage E265 in lower Water Canyon, however runoff estimates from the high water mark (2.34 ft) indicate that peak flow was 105 cfs and the estimated total runoff at gage E265 was about 16 ac-ft (Shaull et al. 2003, p. 76)

A.2 July 4, 2002

A midday thunderstorm occurred mainly over the northern part of the Pajarito Plateau on July 4, 2002. The largest precipitation was received at the Garcia Canyon RAWS site where 1.25 in. of rain fell between 11:00 and 13:00. The TA-6 meteorological station received 0.21 in., the North Community

station received 0.11 in., and the Pajarito RAWS received 0.34 in. Other locations on the Pajarito Plateau generally received less than 0.1 in. The pattern of precipitation received on the Pajarito Plateau on July 4 is shown in Figure B-2.

A.2.1 Guaje and Rendija Canyons

Precipitation at the Guaje and Garcia Canyons RAWS and runoff in Guaje Canyon on July 4 are shown in Figure A.2-1. Runoff began in Guaje Canyon at gage E089 at 12:35 on the afternoon of July 4; the peak flow was 263 cfs at 12:40. Runoff continued in Guaje Canyon in small volumes until 11:40 on the morning of July 6 and the total runoff was about 19.3 ac-ft. A small amount of runoff occurred in lower Rendija Canyon at gage E090 as the result of precipitation on July 4. Runoff began at 15:10 on the afternoon of July 4 with a peak flow of 0.05 cfs. Runoff lasted only about 10 minutes and the total volume of flow was about 0.001 ac-ft. The lack of significant flow in Rendija Canyon compared with the peak flow of 263 cfs in Guaje Canyon demonstrates the local nature of the precipitation in the northern part of the Pajarito Plateau on July 4.

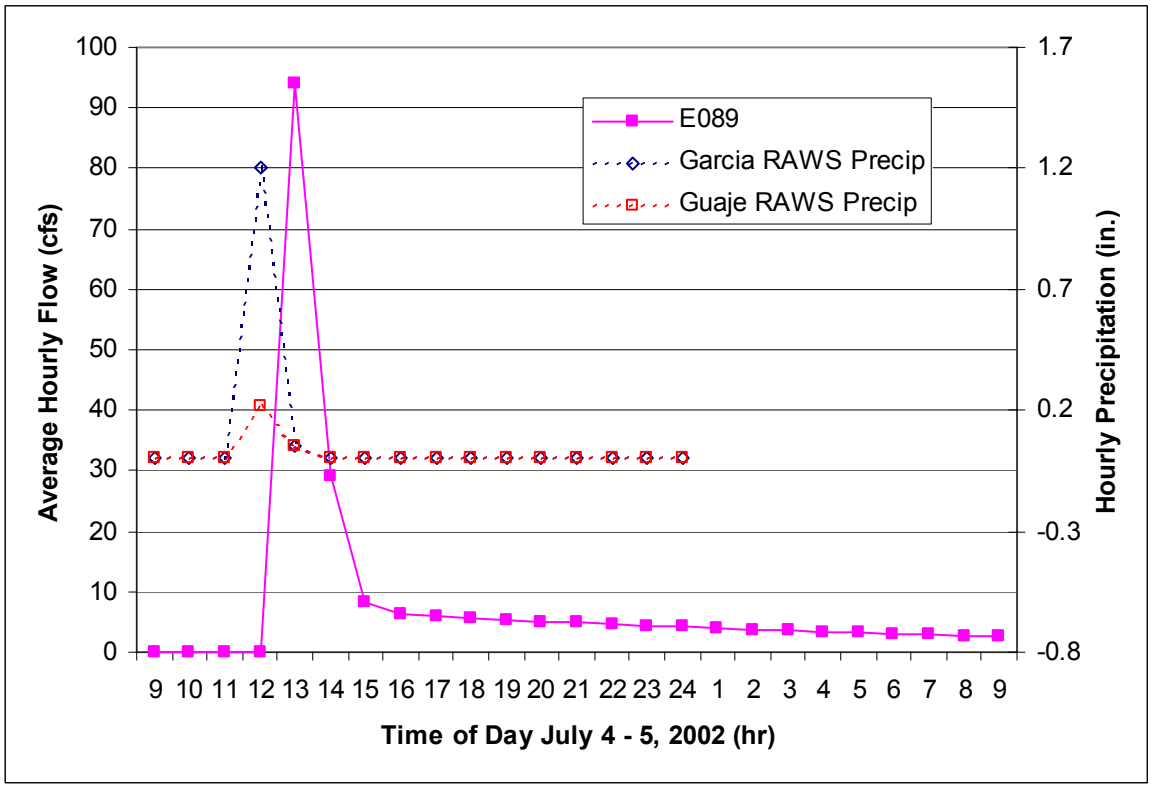

Figure A.2-1. Precipitation and runoff in Guaje Canyon on July 4, 2002.

A.2.2 Los Alamos Canyon

Precipitation at TA-6 and the Los Alamos Canyon RAWS site and flow in Los Alamos and DP Canyons on July 4, 2002, are shown in Figure A.2-2. A small volume of baseflow of 0.02 to 0.04 cfs was present in upper Los Alamos Canyon at gage E026 in the morning of July 4. Runoff in upper Los Alamos Canyon at gage E026 began at 11:50 on the morning of July 4 with a peak flow of 1.29 cfs. Runoff, supported by spring-fed baseflow, continued at gage E026 until about 20:35 on the evening of July 4, and the total volume of flow was about 0.16 ac-ft. Runoff began in middle Los Alamos Canyon at gage E030 at 13:55

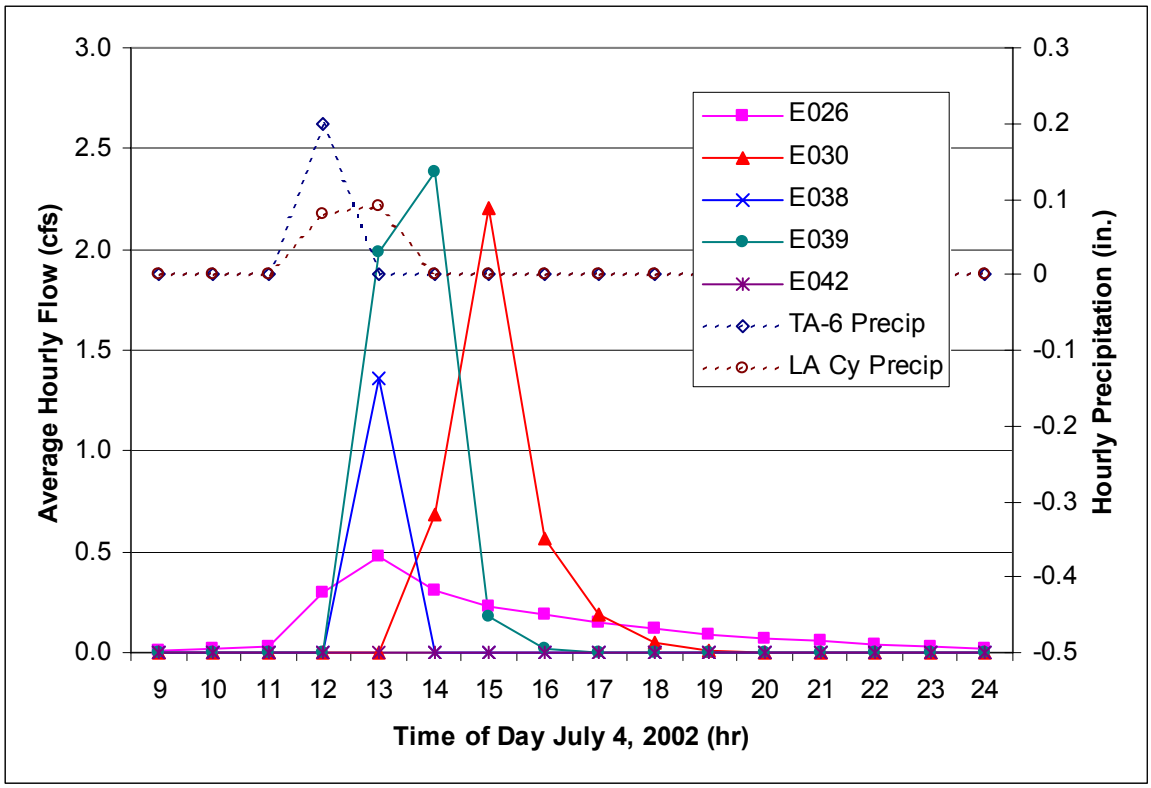

Figure A.2-2. Precipitation and runoff in Los Alamos and DP Canyons on July 4, 2002.

on the afternoon of July 4 with a peak flow of 4.37 cfs. Runoff continued at gage E030 until 18:40 on the evening of July 4 and the total flow was about 0.3 ac-ft. Runoff did not extend to gage E042 in lower Los Alamos Canyon on July 4.

A small amount of runoff occurred in DP Canyon on July 4. Runoff in upper DP Canyon at gage E038 began at 12:10; the peak flow was 6.3 cfs at 12:15. Runoff continued at gage E038 for about 30 minutes and the total flow was about 0.1 ac-ft. Runoff began at gage E039 in middle DP Canyon at 12:50 on the afternoon of July 4 with a peak flow of 8.4 cfs. Runoff continued at gage E039 until 15:40 on the afternoon of July 4, and the total flow was about 0.4 ac-ft. Flow data are not available for gage E040 in lower DP Canyon.

Baseflow in lower Pueblo Canyon midday on July 4, 2002, at gage E060 was about 0.5 cfs. Significant volumes of runoff did not occur in lower Pueblo Canyon on July 4.

Runoff in upper Pajarito Canyon at gage E241 began at 12:05 on July 4; the peak flow was 0.9 cfs at 12:20. Runoff, supported by spring-fed baseflow, continued at gage E241 until about 15:05 on the afternoon of July 4, and the total flow was about 0.4 ac-ft. Runoff was not recorded at other gages in Pajarito Canyon on July 4. Runoff did not occur in Water Canyon, Cañon de Valle, or Ancho Canyon on July 4, 2002.

A.3 July 14, 2002

A thunderstorm occurred over the western Pajarito Plateau on July 14, 2002. The largest amount of precipitation was 0.96 in. at the S002 spring gage. The Water Canyon RAWS received 0.77 in., and TA-16 received 0.52 in. Precipitation occurred from noon to about 14:00 on the afternoon of July 14. The

pattern of precipitation on July 14 is shown in Figure B-3. Due to the pattern of precipitation on July 14, runoff did not occur in Guaje, Rendija, Pueblo, and Los Alamos Canyons and in Cañada del Buey.

A.3.1 DP Canyon and Sandia Canyon

Precipitation at TA-6 and runoff in DP Canyon and Sandia Canyon are shown on Figure A.3-1. Runoff in upper DP Canyon at gage E038 began at 13:20 when the peak flow was 34 cfs. Flow continued for about 15 minutes until 13:35 and the total runoff was about 0.4 ac-ft. Runoff began in middle DP Canyon at gage E039 at 13:55 with a peak flow of 9.6 cfs. Runoff continued until 17:05 and the total flow was about 0.4 ac-ft. Runoff did not occur at gage E040 in lower DP Canyon on July 14.

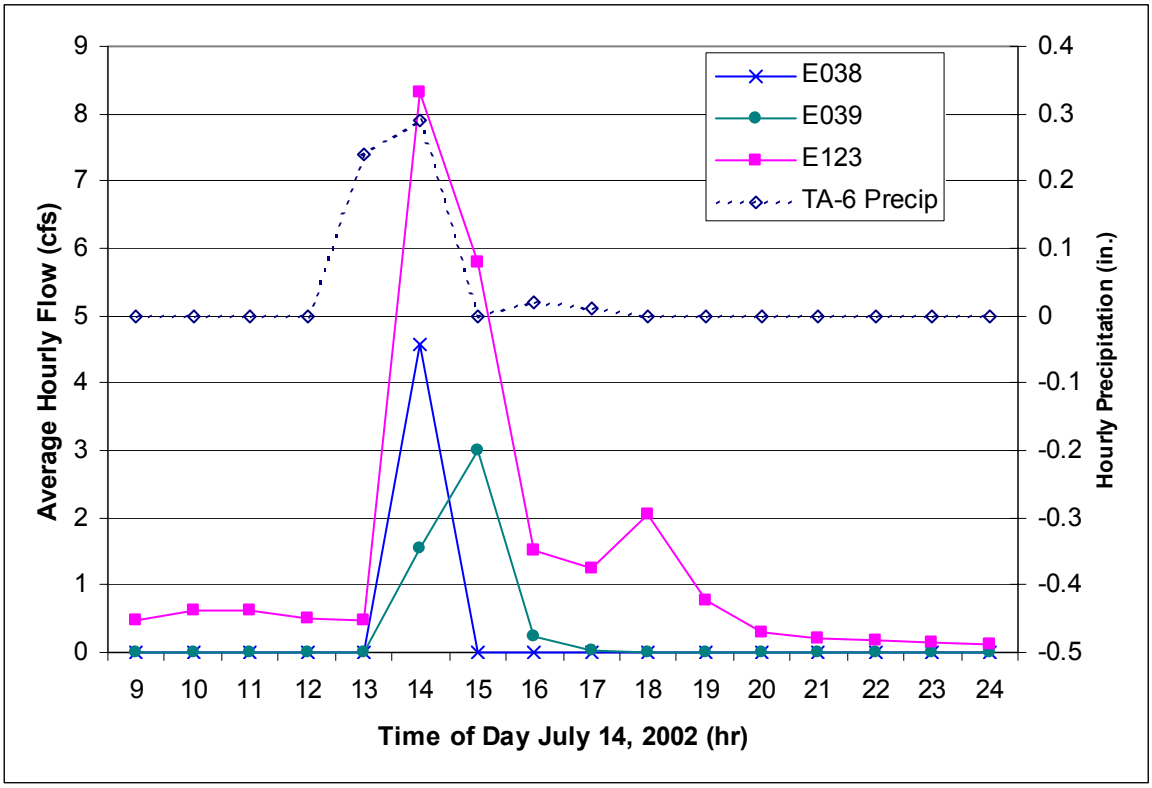

Figure A.3-1. Precipitation and runoff in DP and Sandia Canyons on July 14, 2002.

Baseflow in Sandia Canyon below the wetlands at gage E123 originates from discharge of sanitary effluent; on July 14, baseflow at this gage was 0.5 to 0.8 cfs. Runoff at gage E123 in Sandia Canyon below the wetlands began at 13:35 and the peak flow was 22 cfs at 13:45. Runoff continued until about 20:00 and the total runoff was about 1.6 ac-ft. Runoff did not occur in lower Sandia Canyon at gage E125 on July 14.

A.3.2 Mortandad Canyon

Precipitation at TA-6 and runoff in Mortandad Canyon on July 14 are shown on Figure A.3-2. Baseflow from effluent discharges to Mortandad Canyon at gage E200 below Effluent Canyon midday on July 14 was about 0.01 cfs. Runoff began at gage E200 at 13:20 and the peak flow was 5.2 cfs at 13:25. Runoff continued in Mortandad Canyon until about 19:00 and the total runoff was about 0.15 ac-ft.

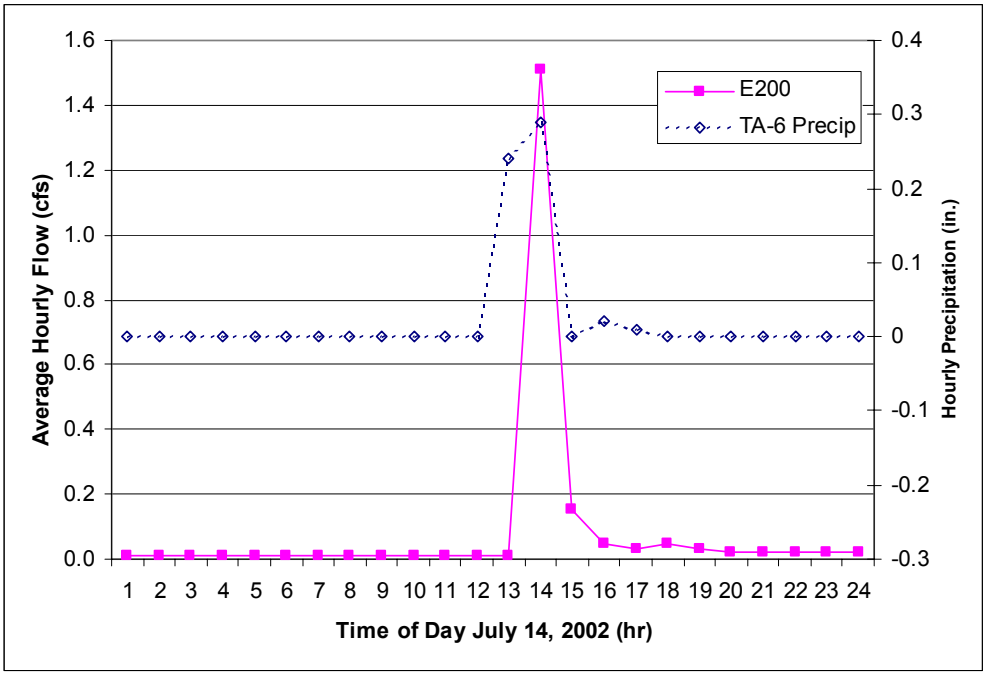

Figure A.3-2. Precipitation and runoff in Mortandad Canyon on July 14, 2002.

A.3.3 Pajarito Canyon

Precipitation at TA-6 and the Pajarito Canyon RAWS and runoff in Pajarito Canyon on July 14 are shown in Figure A.3-3. Runoff began in middle Pajarito Canyon at gage E245 at 14:40 and the peak flow was 20 cfs at 14:45. Runoff supported by spring discharges continued until 23:45 on the night of July 14 and the total flow at gage E245 was about 2.5 ac-ft. Runoff data at gages E240 and E241 are not available for July 14.

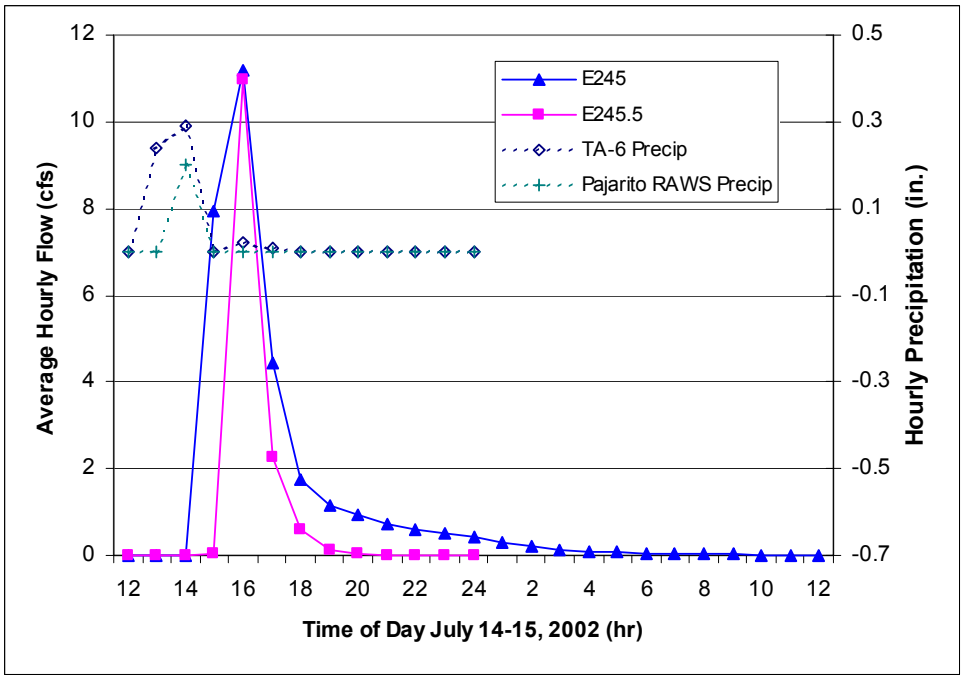

Figure A.3-3. Precipitation and runoff in Pajarito Canyon on July 14, 2002.

Runoff in Pajarito Canyon above Threemile Canyon at gage E245.5 began at 15:00 and the peak flow was 19 cfs at 15:05. Runoff continued until 20:40 on the evening of July 14 and the total runoff was about 1.2 ac-ft. The runoff data indicated that about 1.3 ac-ft of runoff infiltrated or evapotranspirated in middle Pajarito Canyon between gages E245 and E245.5 on July 14. Runoff did not extend downstream in Pajarito Canyon as far as gage E250 on July 14.

A.3.4 Water Canyon and Cañon de Valle

Precipitation at TA-16 and the Water Canyon RAWS and runoff in Water Canyon and Cañon de Valle on July 14 are shown on Figure A.3-4. Runoff in upper Cañon de Valle at gage E253 began at 13:00 and peak flow was 1.4 cfs at 13:20. Runoff continued until 15:55 on the afternoon of July 14 and the total flow was about 0.06 cfs. Runoff data for upper Water Canyon at gage E252 are not available for July 14.

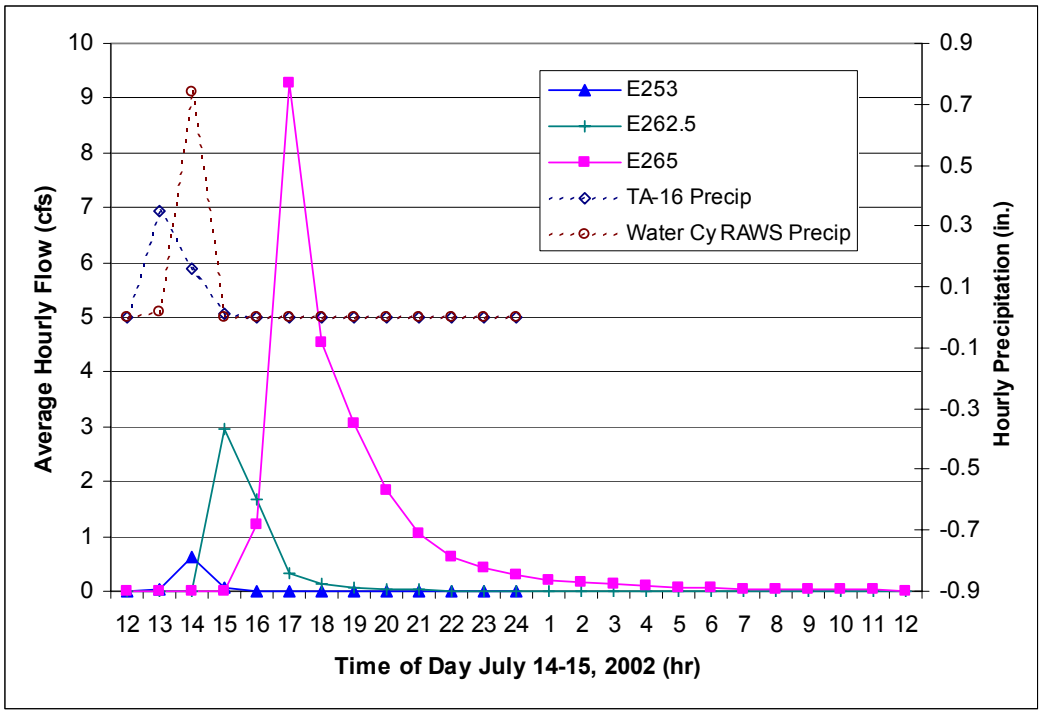

Figure A.3-4. Precipitation and runoff in Cañon de Valle and Water Canyon on July 14, 2002.

Runoff in middle Water Canyon at gage E262.5 began at 14:35 with a peak flow of 11 cfs. Runoff continued until 00:20 on the morning of July 15 and the total flow was about 0.4 ac-ft. Runoff in lower Water Canyon at gage E265 began at 16:00 with a peak flow of 14.4 cfs. Runoff in lower Water Canyon continued until 11:55 on July 15 and the total runoff was about 1.9 ac-ft.

A.4 July 18, 2002

A thundershower occurred west of the Los Alamos town site on the afternoon of July 18, 2002. The upper Los Alamos Canyon RAWS received 1.15 in., the Pueblo Canyon RAWS received 0.25 in., and the North Community rain gage received 0.37 in. The pattern of precipitation received on the Pajarito Plateau on July 18 is shown in Figure B-4. Runoff did not occur in Guaje Canyon at gage E089 and lower Rendija Canyon at gage E090 on July 18.

Runoff began in upper Pueblo Canyon at gage E055 at 16:00 on the afternoon of July 18; the maximum gage height was 0.65 ft at 16:05. Runoff continued at gage E055 until about 16:45. Runoff began in lower Acid Canyon at gage E056 at 16:00; the maximum gage height was about 0.4 ft higher than before the runoff event occurred, however runoff volumes are not available for gages E055 and E056.

After the thunderstorm on July 18, runoff occurred in lower Pueblo Canyon at gage E060. Estimated mean daily flow values were derived from the high water mark after the runoff event (Shaull et al. 2003). The calculated mean daily flow was 5.6 cfs on July 18 and 4.6 cfs on July 19. Accounting for baseflow, the mean daily flow rates indicate that about 14 ac-ft of runoff occurred at gage E060 in lower Pueblo Canyon on July 18 and 19, 2002.

Although relatively heavy precipitation occurred in upper Los Alamos Canyon on July 18, no runoff occurred at gages E026, E030, or E042 on July 18, probably due to the localized nature of the precipitation event and to retention of runoff in Los Alamos reservoir in the upper part of the canyon.

Precipitation and runoff in Sandia Canyon on July 18, 2002, are shown in Figure A.4-1. Runoff began in Sandia Canyon below the wetlands at gage E123 at about 16:25 on the afternoon of July 18; the peak flow was 4.2 cfs at 16:50. Runoff, supported by sanitary effluent baseflow, continued until about 21:30 on the evening of July 18 and the total runoff at gage E123 was about 0.5 ac-ft. Runoff did not occur in lower Sandia Canyon at gage E125 on July 18.

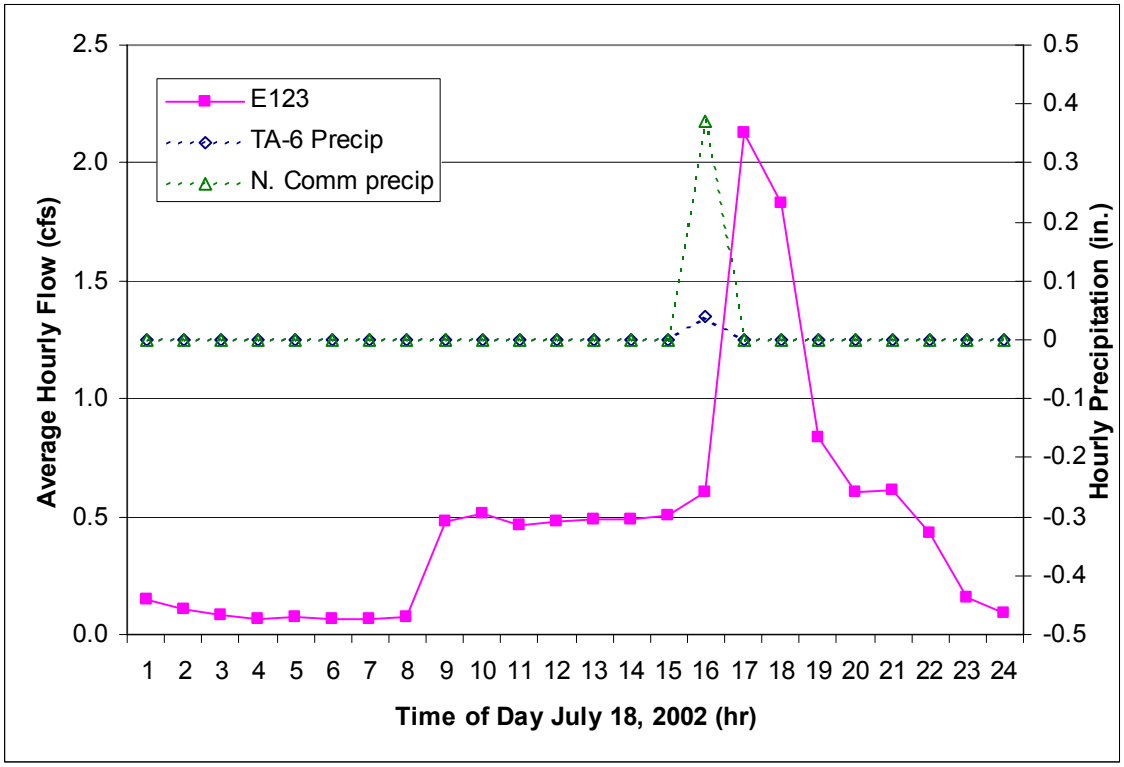

Figure A.4-1. Precipitation and runoff in Sandia Canyon on July 18, 2002.

Precipitation and runoff in Pajarito Canyon on July 18, 2002, are shown on Figure A.4-2. Runoff began in upper Pajarito Canyon at gage E241 at 16:55 with a peak flow of 3.6 cfs. Runoff continued until about 21:15 on the evening of July 18 and the total runoff was about 0.25 ac-ft. Spring-supported baseflow continued at gage E241 until 08:20 on the morning of July 19. Runoff did not extend to middle Pajarito Canyon at gage E245 on July 18.

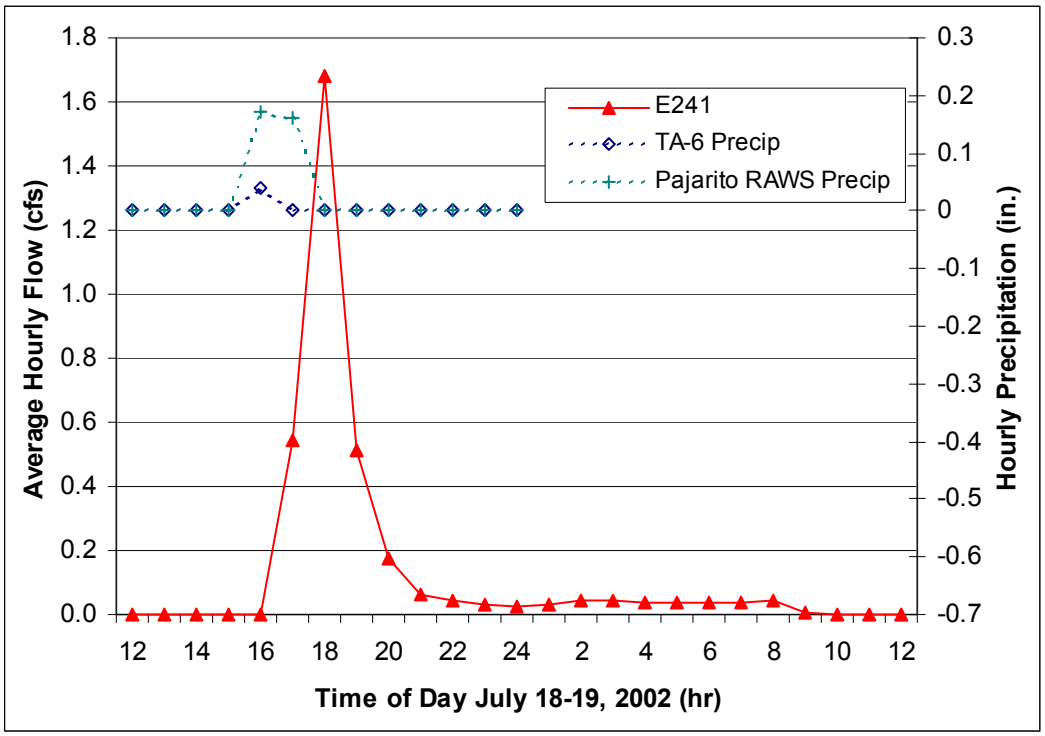

Figure A.4-2. Precipitation and runoff in Pajarito Canyon on July 18, 2002.

A.5 July 22, 2002

A localized precipitation event occurred over the western Pajarito Plateau on the morning of July 22, 2002. Precipitation at the E241 stream gage in upper Pajarito Canyon was 0.34 in. TA-6 received 0.05 in., and TA-16 received 0.18 in. The pattern of precipitation received on the Pajarito Plateau on July 22 is shown in Figure B-5. Runoff did not occur in Guaje Canyon, Rendija Canyon, Pueblo Canyon, Water Canyon, or Cañon de Valle on July 22, 2002.

Runoff in upper Los Alamos Canyon at gage E026 began at 05:45; the peak flow was 0.13 cfs at 06:15. Runoff continued at gage E026 until about 06:35 and the total runoff was about 0.005 ac-ft. Runoff did not extend into middle Los Alamos Canyon to gage E030 and runoff did not occur in DP Canyon.

Precipitation at TA-6 and runoff in Sandia Canyon at gage E123 are shown in Figure A.5-1. Runoff began at gage E123 at 06:20 on the morning of July 22; the peak flow was 10.8 cfs at 06:30. Runoff, continued until about 09:45 on the morning of July 22 and the total runoff was about 0.9 ac-ft. Runoff did not occur in lower Sandia Canyon at gage E125 on July 22, 2002.

Precipitation and runoff in Pajarito Canyon on July 22, 2002, are shown in Figure A.5-2. Runoff began in upper Pajarito Canyon at gage E241 at 05:25; peak flow was 0.03 cfs at 06:10. Runoff continued until about 07:35 and the total runoff was about 0.003 ac-ft. Runoff did not extend down Pajarito Canyon to gage E245 on July 22.

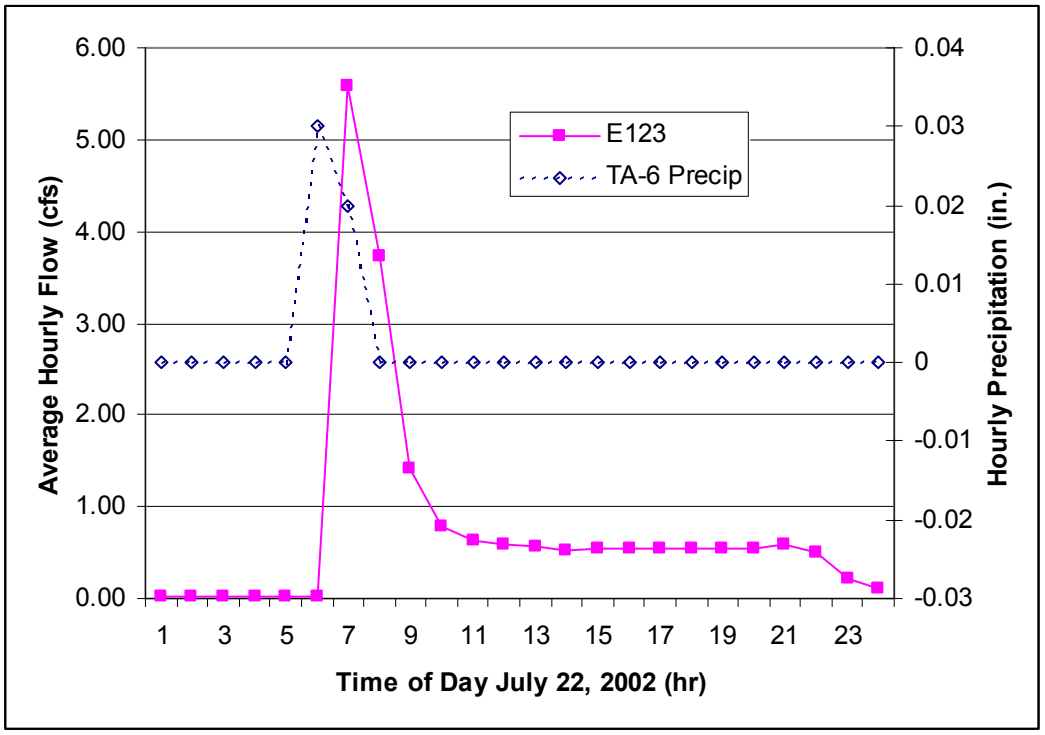

Figure A.5-1. Precipitation and runoff in Sandia Canyon on July 22, 2002.

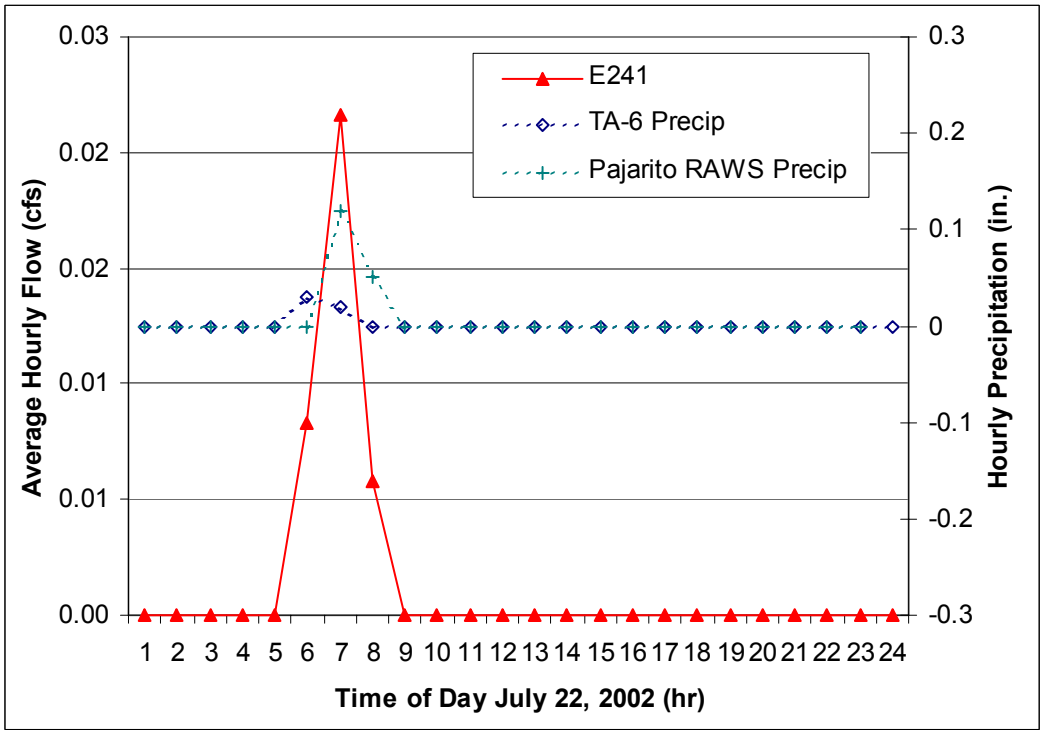

Figure A.5-2. Precipitation and runoff in Pajarito Canyon on July 22, 2002.

A.6 July 23, 2002

An afternoon precipitation event occurred over the western Pajarito Plateau on the afternoon of July 23, 2002. TA-6 received 0.43 in., the Pajarito RAWS received 0.41 in., and the Pueblo RAWS received 0.32 in. of precipitation. The pattern of precipitation received on the Pajarito Plateau on the afternoon of July 23 is shown in Figure B-6. Runoff did not occur in Guaje Canyon or Rendija Canyon on July 23.

Runoff in upper Pueblo Canyon at gage E055 began at 13:25 on the afternoon of July 23; the peak gage height was 0.11 ft at 13:30. Runoff continued at gage E055 until about 14:10 on the afternoon of July 23. Runoff began in lower Acid Canyon at gage E056 at 13:25; the peak gage height was about 0.5 ft and runoff continued until about 16:15 on the afternoon of July 23. Flow volumes are not available for gages E055 and E056. Runoff did not occur in lower Pajarito Canyon at gage E060 on July 23.

A.6.1 Los Alamos Canyon

Precipitation and runoff in Los Alamos and DP Canyons on July 23, 2002, are shown in Figure A.6-1. Runoff in upper Los Alamos Canyon at gage E026 began at 12:55 on the afternoon of July 23; peak flow was 0.8 cfs at 13:10. Runoff continued at gage E026 until 16:55 on the afternoon of July 23 and the total runoff was about 0.04 ac-ft. Runoff began in middle Los Alamos Canyon at gage E030 at 14:45 on the afternoon of July 23 when the peak flow was 7.6 cfs. Runoff continued at gage E030 until 18:50 and the total runoff was about 0.6 ac-ft.

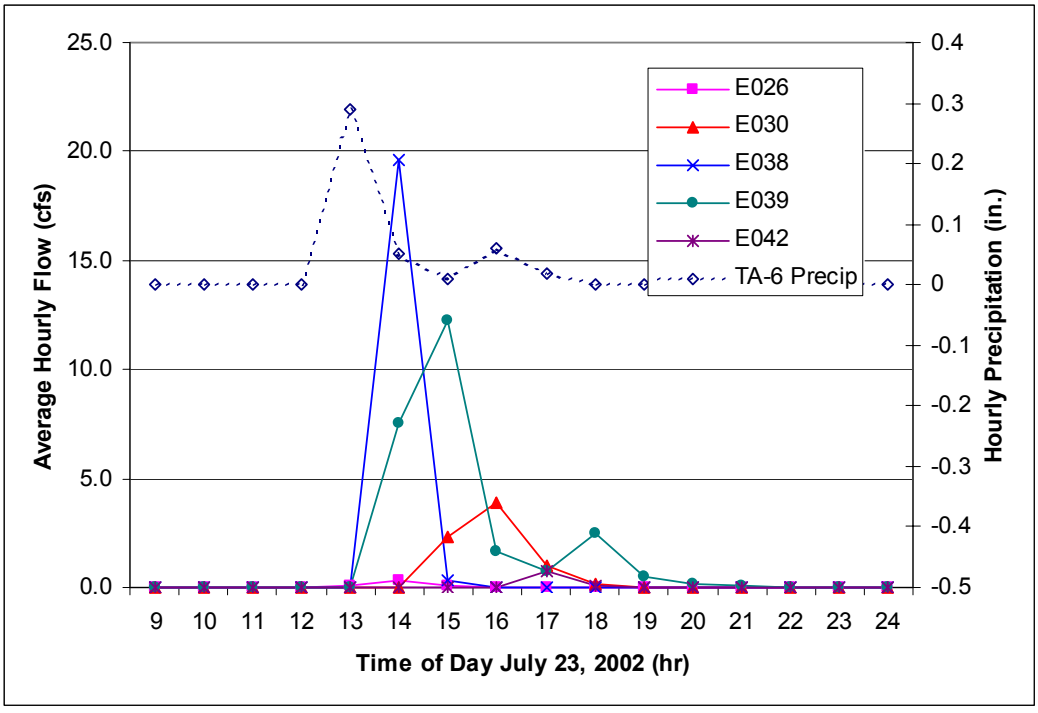

Figure A.6-1. Precipitation and runoff in Los Alamos and DP Canyons on July 23, 2002.

Runoff in upper DP Canyon at gage E038 began at 13:25 on the afternoon of July 23 when the peak flow was 43 cfs. Runoff continued at gage E038 until 14:15 and the total runoff was about 1.6 ac-ft. Runoff in middle DP Canyon at gage E039 began at 13:50; peak flow was 33.4 cfs at 13:55. Runoff continued at gage E039 until 23:00 on the night of July 23 and the total runoff was about 2.1 ac-ft. Runoff in lower DP

Canyon at gage E040 began at 14:40 on the afternoon of July 23 with a peak flow of 6.6 cfs. Runoff continued at gage E040 until 20:50 on the night of July 23 and the total runoff was about 0.2 ac-ft.

Runoff in lower Los Alamos Canyon at gage E042 began at 16:10 on the afternoon of July 23 with a peak flow of 2.4 cfs. Runoff continued at gage E042 until 17:45 on July 23 and the total runoff in lower Los Alamos Canyon was about 0.07 ac-ft.

A.6.2 Sandia Canyon and Mortandad Canyon

Precipitation and runoff in Sandia Canyon and Mortandad Canyon on July 23, 2002, are shown in Figure A.6-2. Baseflow in Sandia Canyon before the runoff event on July 23 was about 0.7 cfs. Runoff began in Sandia Canyon below the wetlands at gage E123 at 12:55 on the afternoon of July 23; the peak flow was 22 cfs at 13:35. Runoff continued until 19:30 on the evening of July 23 and the total runoff was about 2.2 ac-ft.

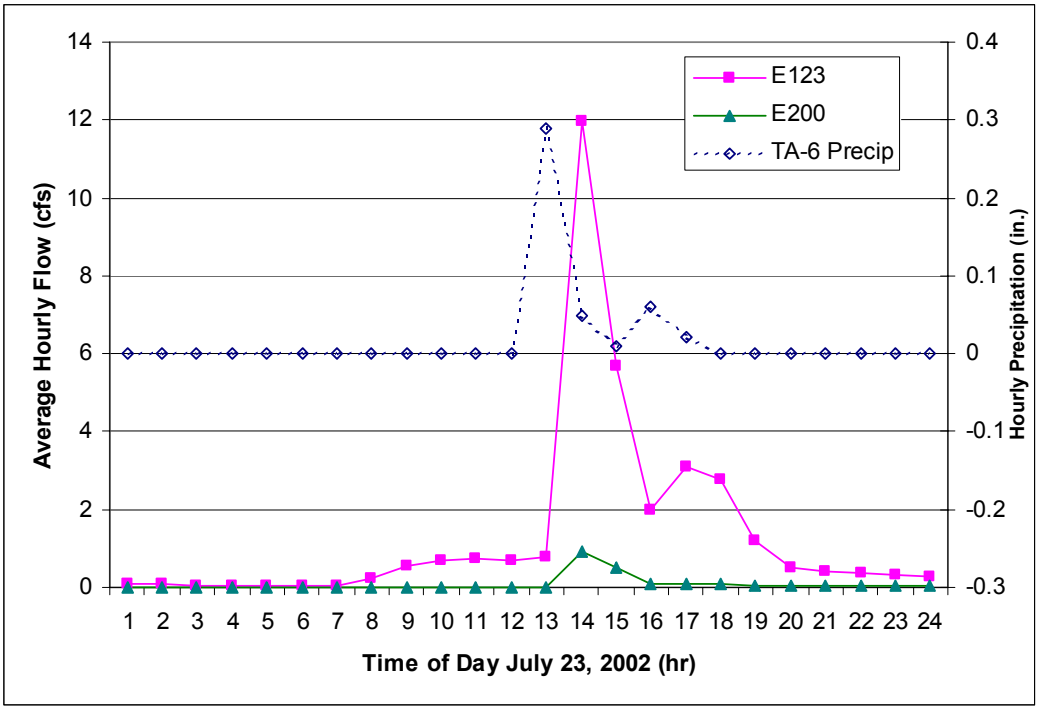

Figure A.6-2. Precipitation and runoff in Sandia Canyon and Mortandad Canyon on July 23, 2002.

Runoff in Mortandad Canyon below Effluent Canyon at gage E200 began at 13:35 on the afternoon of July 23 with a peak flow of 2.2 cfs. Runoff, supported by baseflow, continued until about 19:00 on the evening of July 23 and the total runoff was about 0.15 ac-ft.

A.6.3 Pajarito Canyon

Precipitation and runoff in Pajarito Canyon on July 23, 2002, are shown in Figure A.6-3. Runoff began in upper Pajarito Canyon at gage E241 at 12:35 on the afternoon of July 23; peak flow was 0.2 cfs at 12:55. Runoff continued at gage E241 until 16:55 on the afternoon of July 23 and the total runoff was 0.01 ac-ft. Runoff began in middle Pajarito Canyon at gage E245 at 14:55 on the afternoon of July 23; peak flow was 6.1 cfs at 15:00. Runoff from draining of the Pajarito retention pond continued at gage E245 until 20:20 on the night of July 25 and the total runoff was about 1.5 ac-ft.

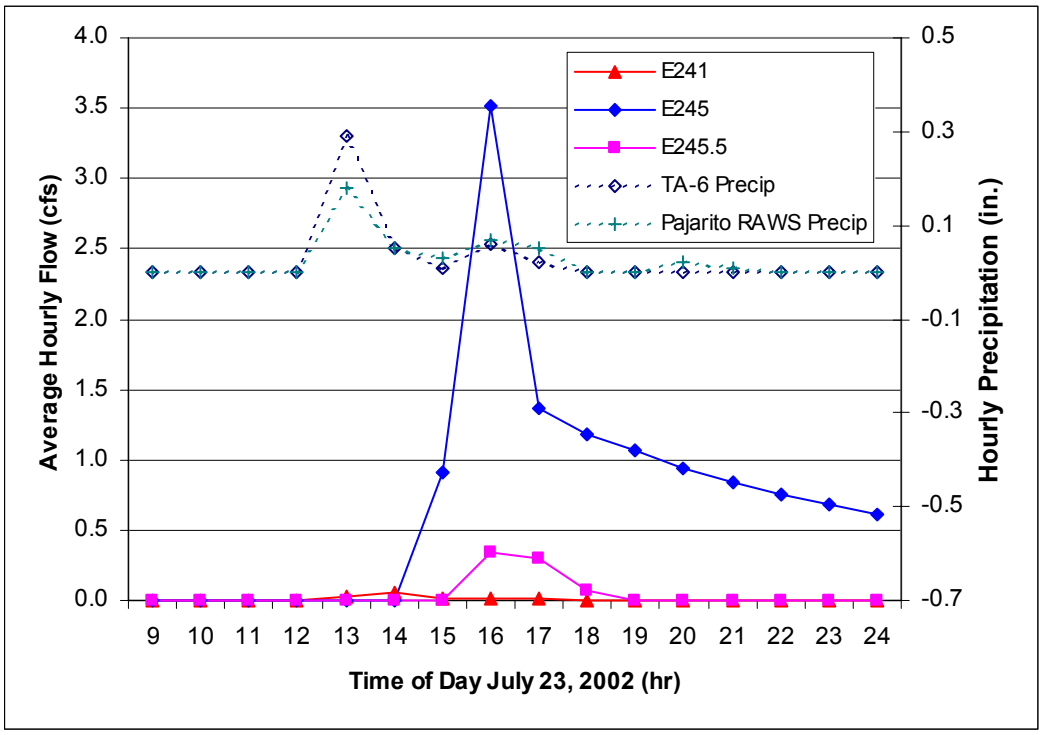

Figure A.6-3. Precipitation and runoff in Pajarito Canyon on July 23, 2002.

Runoff began in middle Pajarito Canyon above TA-18 at gage E245.5 at 15:40 on the afternoon of July 23; peak flow was 1.1 cfs at 15:45. Runoff continued until 18:15 on the evening of July 23 and the total runoff was about 0.06 ac-ft. Runoff did not occur in lower Pajarito Canyon at gage E250 on July 23 or July 24, 2002. Significant runoff did not occur in Water Canyon on July 23, 2002.

A.7 July 25, 2002

Two precipitation events occurred on July 25, 2002; one occurred in the afternoon between 12:00 to 16:00 and another occurred in the evening between 20:00 to 24:00. The afternoon precipitation event was located primarily south and southwest of LANL, the Water Canyon RAWS received 0.52 in. during the afternoon and TA-16 received 0.29 in. The evening precipitation event was centered west of LANL and the Los Alamos town site, where the Pajarito RAWS received 0.54 in. and the Pueblo RAWS received 0.52 in. The pattern of precipitation received on the afternoon of July 25 is shown in Figure B-7a and the pattern of precipitation received on the night of July 25 is shown in Figure B-7b. Runoff did not occur in Guaje and Rendija Canyons on July 25.

A.7.1 Pueblo Canyon

Runoff began in upper Pueblo Canyon at gage E055 at 20:30 in response to the evening precipitation event. The peak gage height was 1 ft and the runoff event continued until about 02:45 on the morning of July 26. Flow in Acid Canyon at gage E056 also began at 20:30; the peak gage height was 1.1 ft above no-flow conditions. Runoff continued at gage E056 until about 22:40 on the night of July 25. Measured gage height data for gage E060 in lower Pueblo Canyon show that maximum flow was about 80 cfs at 01:30 on the morning of July 26 and the total runoff was about 34 ac-ft (Shaull et al. 2003).

A.7.2 Los Alamos and DP Canyons

Precipitation and runoff in Los Alamos Canyon on July 25 and 26 are shown in Figure A.7-1. Spring-supported baseflow/runoff in upper Los Alamos Canyon at gage E026 began at 12:00 on the afternoon of July 25; the peak flow was 1.1 cfs at 12:55. Baseflow/runoff continued at gage E026 through the afternoon at about 0.5 to 0.8 cfs. Runoff associated with the evening precipitation event began at gage E026 at 20:00 on the evening of July 25; the peak flow was 1.7 cfs at 20:45. Runoff continued at gage E026 until 00:45 on the morning of July 26 and the total baseflow/runoff was about 0.76 ac-ft. Runoff in middle Los Alamos Canyon at gage E030 began at 22:00 with a peak flow of 6.5 cfs. Runoff continued at gage E030 until 05:10 on the morning of July 26 and the total runoff was about 0.8 ac-ft.

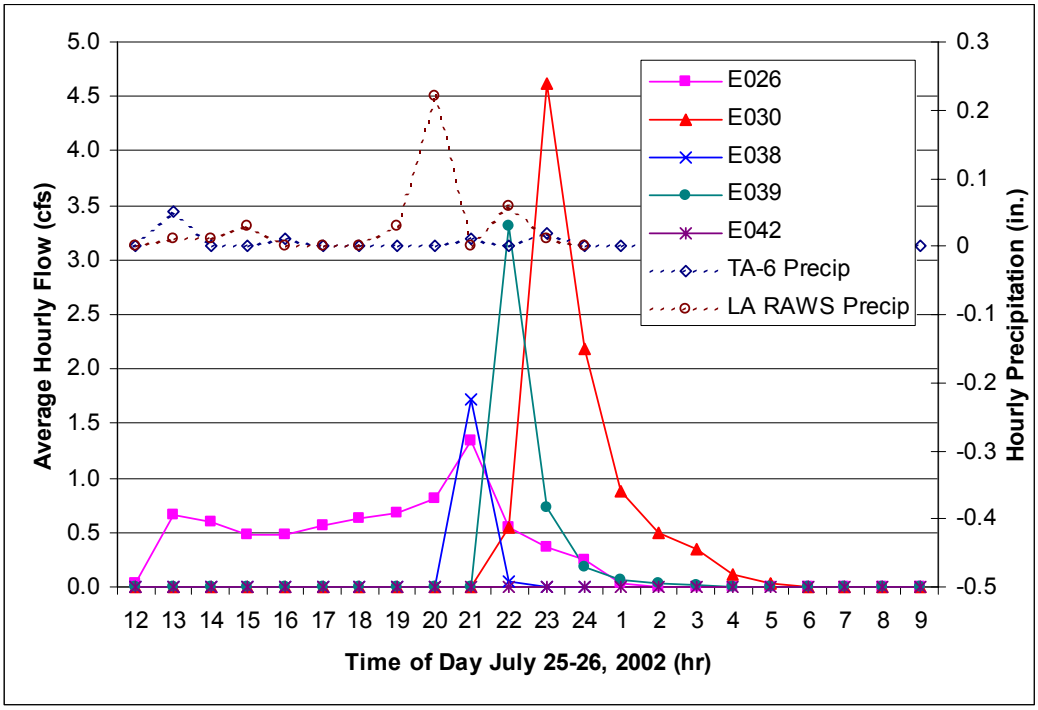

Figure A.7-1. Precipitation and runoff in Los Alamos and DP Canyons on July 25 and 26, 2002.

Runoff began in upper DP Canyon at gage E038 at 20:35 on the evening of July 25; the peak flow was 8 cfs at 20:40. Runoff continued at gage E038 until 21:15 on the evening of July 25 and the total runoff was about 0.15 ac-ft. Runoff began at gage E039 in middle DP Canyon at 21:15 with a peak flow of 6.6 cfs. Runoff continued at gage E039 until 02:40 on the morning of July 26 and the total runoff was about 0.4 ac-ft. Runoff did not occur in lower DP Canyon at gage E040 on the evening of July 25.

Runoff began in lower Los Alamos Canyon at gage E042 at 00:45 on the morning of July 26 with a peak flow of 0.03 cfs. Runoff continued for about 15 minutes and the total runoff was about 18 cubic ft.

A.7.3 Sandia Canyon and Mortandad Canyon

Precipitation at TA-6 and runoff in Sandia Canyon and Mortandad Canyon on July 25 and 26 are shown in Figure A.7-2. Two small runoff events occurred in Sandia Canyon in response to the precipitation events on July 26. Baseflow in Sandia Canyon at midday was about 0.6 cfs. Runoff from the first precipitation event began in Sandia Canyon at gage E123 at 13:35; the peak flow was 9.7 cfs at 13:45. Runoff continued until about 16:45 and the total runoff from the first precipitation event was about

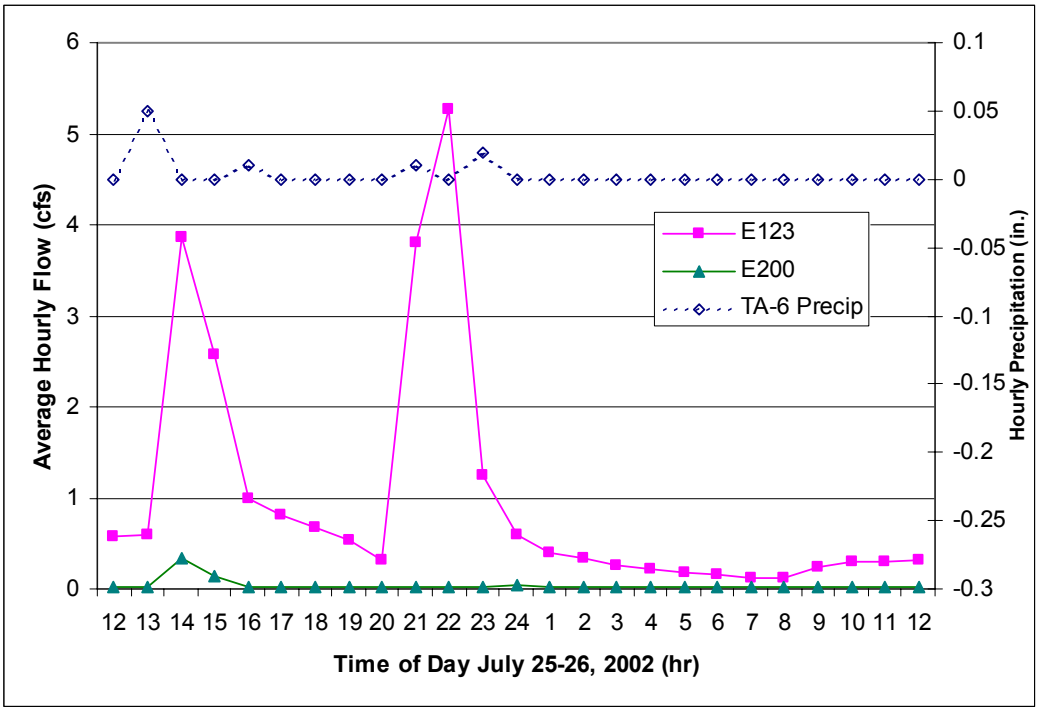

Figure A.7-2. Precipitation and runoff in Sandia Canyon and Mortandad Canyon on July 25 and 26, 2002.

0.6 ac-ft. Runoff resulting from the second precipitation event began in Sandia Canyon at gage E123 at 20:45 on the evening of July 25; peak flow was 15.3 cfs at 20:55. Runoff supported by baseflow continued until about 04:00 on the morning of July 26 and the total runoff/baseflow on the night of July 25 and 26 was about 1 ac-ft. The total runoff at gage E123 on July 25 and 26 was about 1.6 ac-ft.

Baseflow in Mortandad Canyon at gage E200 below Effluent Canyon on July 25 was 0.01 cfs. Runoff began at gage E200 at 13:35; peak flow was 0.75 cfs at 13:55. Runoff continued at gage E200 until about 17:00 on the afternoon of July 25 and the total runoff was about 0.04 ac-ft.

Precipitation and runoff in Pajarito Canyon on July 25, 2002, are shown in Figure A.7-3. A small amount of runoff occurred in upper Pajarito Canyon at gage E241 in response to the afternoon precipitation event. Runoff at gage E241 began at 12:30; the peak flow was 0.02 cfs at 12:35. Runoff continued in trace amounts until 13:15 and the total runoff was about 39 cubic ft. Runoff associated with the evening precipitation event began at 20:40 on the evening of July 25; peak flow was 5.5 cfs at 20:45. Runoff, supported by a small amount of spring-supported baseflow, continued until about 11:00 on the morning of July 26 and the total runoff was 0.25 ac-ft. This precipitation event may have been similar to the one that occurred on June 28, 2000, when over 1000 cfs of runoff occurred in upper Pajarito Canyon after the Cerro Grande Fire.

Runoff in middle Pajarito Canyon was temporarily contained in the Pajarito retention structure upstream of gage E245. Runoff at gage E245 began at 00:45 on the morning of July 26 with a peak flow of 1.7 cfs. Runoff drained from the retention structure until midnight on the night of July 28 and 29 and the total runoff was about 1.2 ac-ft. Runoff began at gage E245.5 above TA-18 at 02:20 on the morning of July 26 with a peak flow of 0.1 cfs. Runoff continued until 08:10 on the morning of July 26 and the total runoff was about 0.02 ac-ft. Runoff did not occur in lower Pajarito Canyon at gage E250 on July 25 or 26.

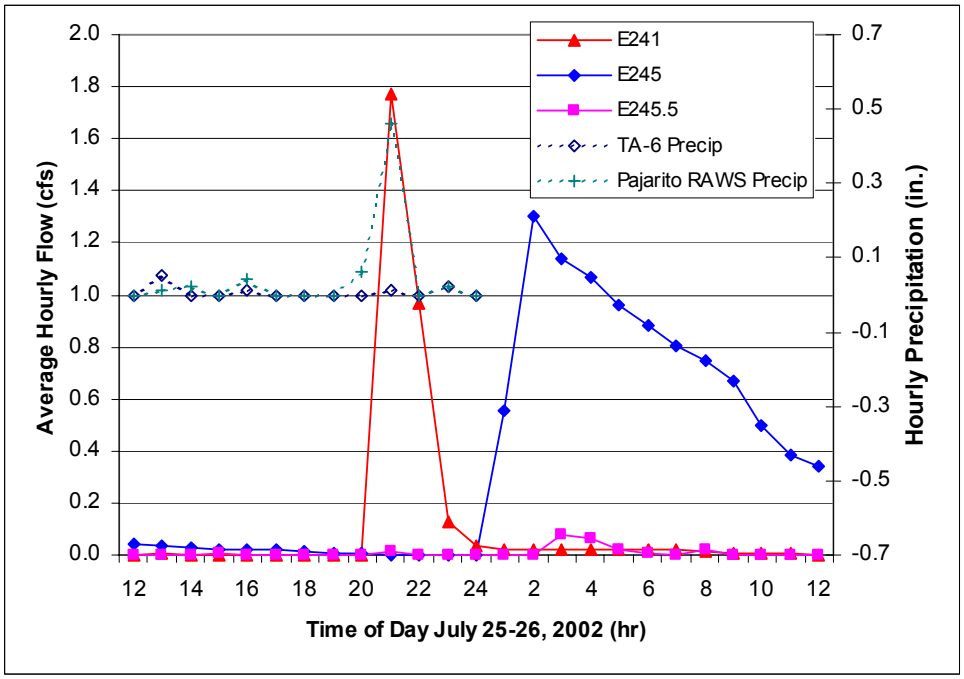

Figure A.7-3. Precipitation and runoff in Pajarito Canyon on July 25 and 26, 2002.

A.7.4 Water Canyon

Precipitation and runoff in Water Canyon and Cañon de Valle on July 25 are shown in Figure A.7-4. Although about 0.5 in. of precipitation was received at the Water Canyon RAWS site in the early afternoon of July 25 (see Figure B-7a), no significant runoff occurred in Water Canyon, probably due to the extreme drought conditions in the area. Spring-supported baseflow in upper Water Canyon at gage E252 was about 0.05 cfs on the morning of July 25, which increased throughout the afternoon to a maximum of 0.14 cfs around midnight July 25-26, probably in response to the precipitation event.

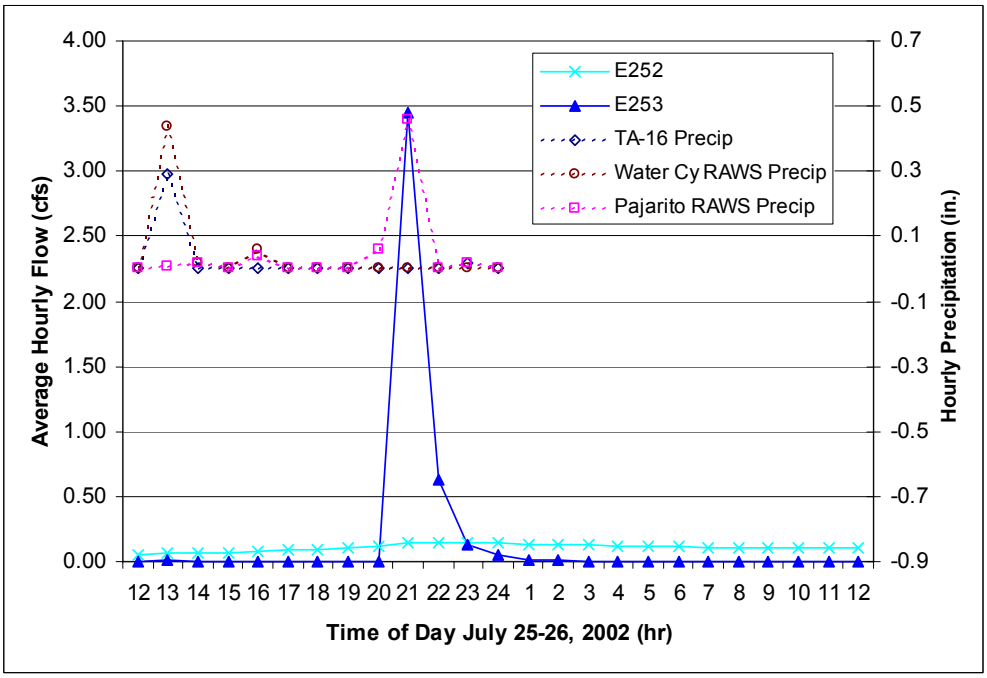

Figure A.7-4. Precipitation and runoff in Water Canyon and Cañon de Valle on July 25 and 26, 2002.

Runoff in upper Cañon de Valle at gage E253 occurred in response to both precipitation events on July 25. Runoff associated with the first precipitation event began at gage E253 at 12:30; the peak flow was 0.1 cfs at 12:35. Runoff continued until 13:15 and the total runoff was about 75 cubic ft. Runoff associated with the second precipitation event began at gage E253 at 20:20 on the evening of July 25 with a peak flow of 7.7 cfs. Runoff continued until 01:40 on the morning of July 26 and the total runoff was about 0.35 ac-ft. Runoff did not occur at downstream stations E262.5 and E265 on July 25 and 26.

A.8 July 26, 2002

A precipitation event occurred over the eastern Pajarito Plateau on July 26, 2002. TA-54 received 0.45 in. and Bandelier National Monument at Frijolito received 0.13 in. The precipitation event occurred between 13:00 and 14:00 on the afternoon of July 26. The pattern of precipitation on July 26 is shown in Figure B-8. Runoff did not occur in Guaje, Rendija, Pueblo, Los Alamos, Sandia, Mortandad, Pajarito, Water, and Ancho Canyons on July 26.

Precipitation at TA-54 and runoff in Cañada del Buey on July 26, 2002, are shown in Figure A.8-1. Runoff in lower Cañada del Buey at gage E230 began at 13:05 on the afternoon of July 26; peak flow was 2.9 cfs at 13:15. Runoff continued until 16:20 on the afternoon of July 26 and the total runoff was about 0.2 ac-ft. Runoff did not occur in upper Cañada del Buey at gage E218 on July 26.

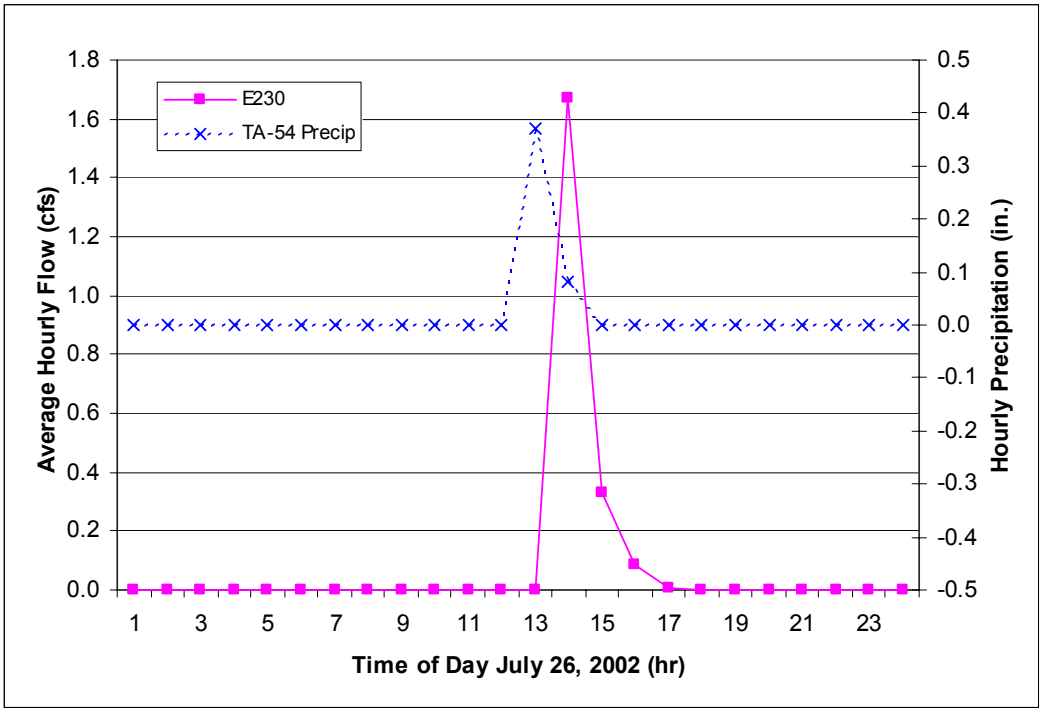

Figure A.8-1. Precipitation and runoff in Cañada del Buey on July 26, 2002.

A.9 July 31, 2002

A localized thunderstorm precipitation event occurred over the western Los Alamos town site on the afternoon of July 31, 2002. TA-6 received 0.15 in., the North Community rain gage received 0.86 in., and

the Guaje RAWS site received 0.72 in. The precipitation occurred between 16:00 to 18:00 on the afternoon of July 31. The pattern of precipitation received on July 31 is shown in Figure B-9.

Runoff did not occur in Mortandad Canyon, Cañada del Buey, Pajarito Canyon, Cañon de Valle, or Water Canyon on July 31.

A.9.1 Guaje and Rendija Canyons

Precipitation and runoff in Guaje and Rendija Canyons are shown in Figure A.9-1. Runoff began in Guaje Canyon at gage E089 at 17:40 on the afternoon of July 31; peak flow was 10.4 cfs at 18:50. Runoff continued in Guaje Canyon until 02:15 on the morning of August 1 and the total runoff was about 1.8 ac-ft.

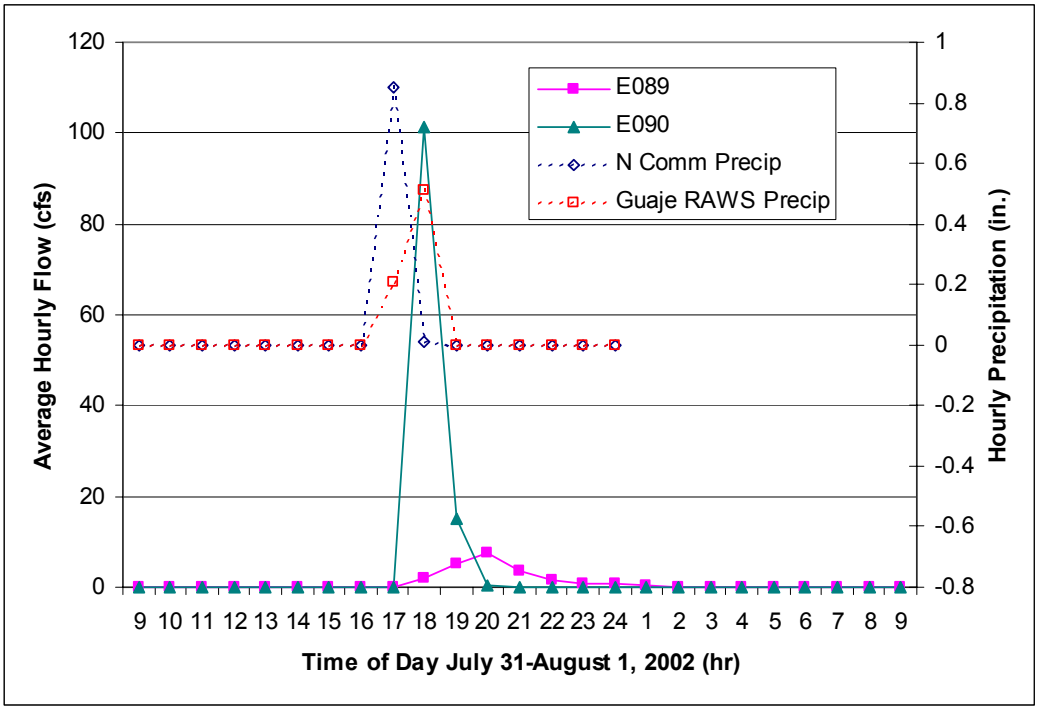

Figure A.9-1. Precipitation and runoff in Guaje and Rendija Canyons on July 31, 2002.

Runoff also began in lower Rendija Canyon at gage E090 at 17:40 on July 31 with a peak flow of 486 cfs. Runoff continued in lower Rendija Canyon until 20:05 on the evening of July 31 and the total runoff in Rendija Canyon was about 9.7 ac-ft.

A.9.2 Pueblo Canyon

Runoff in Acid Canyon at gage E056 began at 16:50 on the afternoon of July 31; the peak gage height was 1.4 ft above the no flow datum. Runoff continued in Acid Canyon until about 19:40 on the evening of July 31. Runoff hydrographic data for gage E055 in upper Pueblo Canyon are not available for July 31.

After the thunderstorm on July 31, runoff occurred in lower Pueblo Canyon at gage E060. Estimated mean daily flow values were derived from the high water mark after the runoff event (Shaull et al. 2003). The calculated mean daily flow was 13 cfs on July 31 and 11 cfs on August 1, with peak flow of about 90 cfs occurring at 21:45 on the night of July 31. Accounting for about 1.5 cfs baseflow, the mean daily flow rates indicate that about 42 ac-ft of runoff occurred at gage E060 in lower Pueblo Canyon on July 31 and August 1, 2002.

A.9.3 Los Alamos and DP Canyons

Precipitation and runoff in Los Alamos and DP Canyons on July 31 are shown in Figure A.9-2. Runoff began in upper Los Alamos Canyon at gage E026 at 14:55 on the afternoon of July 31; peak flow was 2.2 cfs at 16:45. Runoff, supported by spring flow, continued until about 01:30 on the morning of August 1 and the total runoff was about 0.24 ac-ft. Runoff in middle Los Alamos Canyon at gage E030 began at 19:00 on the evening of July 31 when the peak flow was 4.2 cfs. Runoff continued until 23:25 on the night of July 31 and the total runoff was about 0.3 ac-ft.

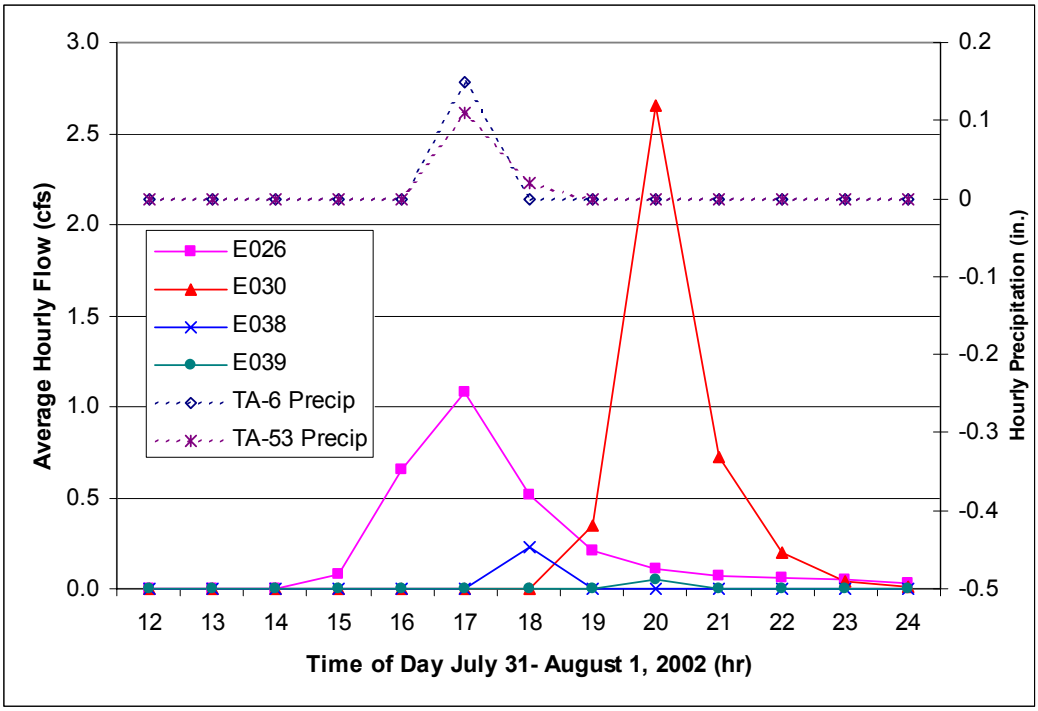

Figure A.9-2. Precipitation and runoff in Los Alamos and DP Canyons on July 31, 2002.

Runoff in upper DP Canyon at gage E038 began at 17:30 on the afternoon of July 31 when the peak flow was 1.0 cfs. Runoff continued at gage E038 for about 30 minutes and the total runoff was about 800 cubic ft. Runoff in middle DP Canyon at gage E039 began at 19:10 on the evening of July 31; the peak flow was 0.1 cfs at 19:15. Runoff continued at gage E039 until 20:10 on the evening of July 31 and the total runoff was about 200 cubic ft. Runoff did not occur in lower DP Canyon at gage E040 and in lower Los Alamos Canyon at gage E042 on July 31.

A.9.4 Sandia Canyon

Precipitation and runoff in Sandia Canyon on July 31, 2002, are shown in Figure A.9-3. Runoff began at gage E123 at 17:30 on the afternoon of July 31; peak flow was 11 cfs at 17:45. Runoff, supported by baseflow, continued until 19:00 and the total runoff was about 0.7 ac-ft.

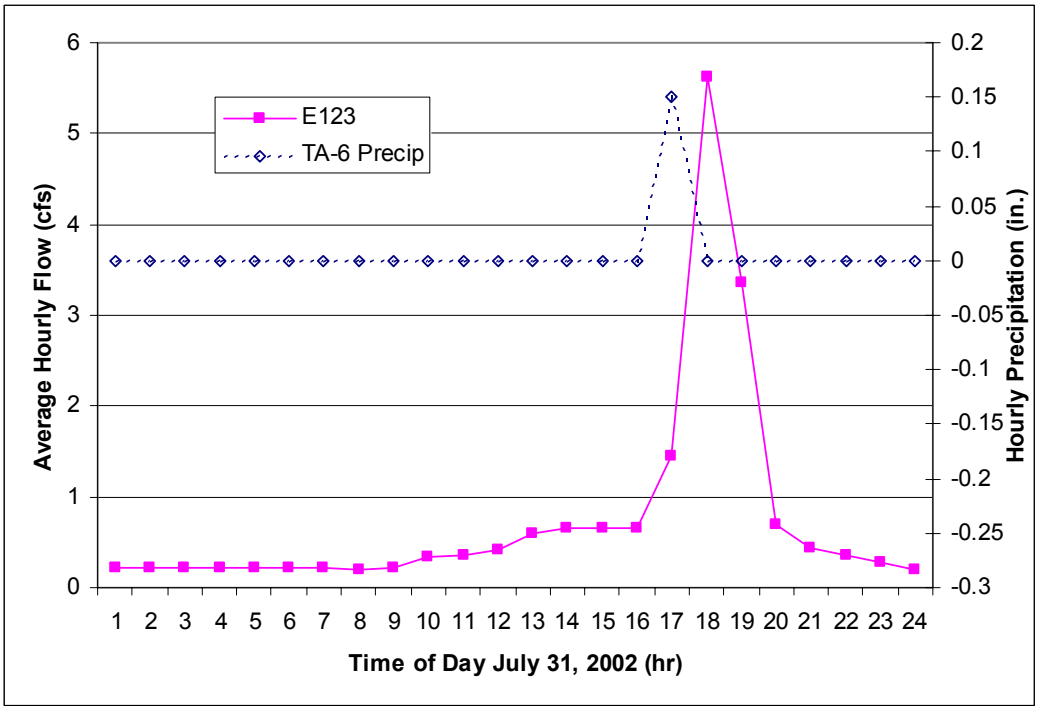

Figure A.9-3. Precipitation and runoff in Sandia Canyon on July 31, 2002.

A.10 August 7, 2002

A local thunderstorm occurred over the western Pajarito Plateau on the early afternoon of August 7, 2002. Precipitation at TA-6 was 0.37 in., at North Community gage was 0.25 in., at the Pueblo RAWS site was 0.53 in., and at the Pajarito RAWS site was 0.72 in. The pattern of precipitation on the Pajarito Plateau on August 7 is shown in Figure B-10. Runoff occurred in Pueblo, Los Alamos, Sandia, and Pajarito Canyons on August 7 after the thunderstorm. Runoff did not occur in Water Canyon or Cañon de Valle on August 7.

A.10.1 Pueblo Canyon

Precipitation and runoff in lower Pueblo Canyon at gage E060 on August 7 are shown in Figure A.10-1. Runoff at gage E056 in Acid Canyon began at 13:05 on the afternoon of August 7; peak gage height was 0.25 ft above pre-runoff conditions. Runoff continued at gage E056 until about 15:20 on the afternoon of August 7. Flow data for gages E055 and E056 are not available for August 7.

Runoff (possibly supported by baseflow) in lower Pueblo Canyon at gage E060 began at 16:00; peak flow was 4.4 cfs at 20:15. Runoff continued in lower Pueblo Canyon until 05:40 on August 8 and the total runoff was about 1.5 ac-ft.

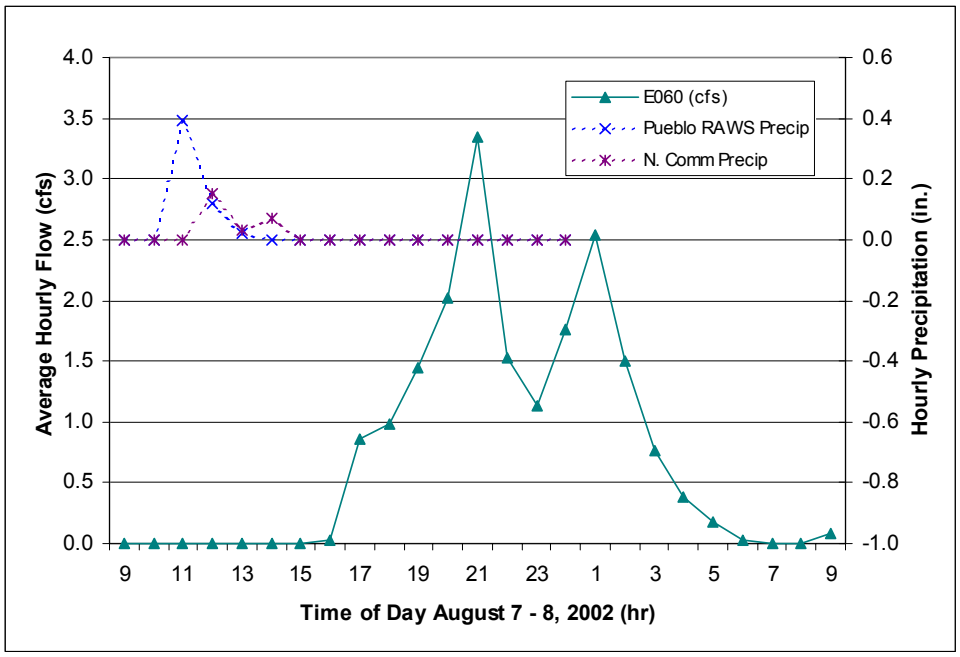

Figure A.10-1. Precipitation and runoff in Pueblo Canyon on August 7, 2002.

A.10.2 Los Alamos and DP Canyons

Precipitation and runoff in Los Alamos Canyon and DP Canyon on August 7, 2002, are shown in Figure A.10-2. Runoff began in upper Los Alamos Canyon at gage E026 at 11:50 on the morning of August 7; peak flow was 3.5 cfs at 12:00. Runoff continued at gage E026 until 14:45 on the afternoon of August 7 and the total runoff was about 0.15 ac-ft. Runoff in middle Los Alamos Canyon at gage E030 began at 14:45 when the peak flow was 8.3 cfs. Runoff at gage E030 continued until 19:30 on the evening of August 7 and the total runoff was about 0.7 ac-ft.

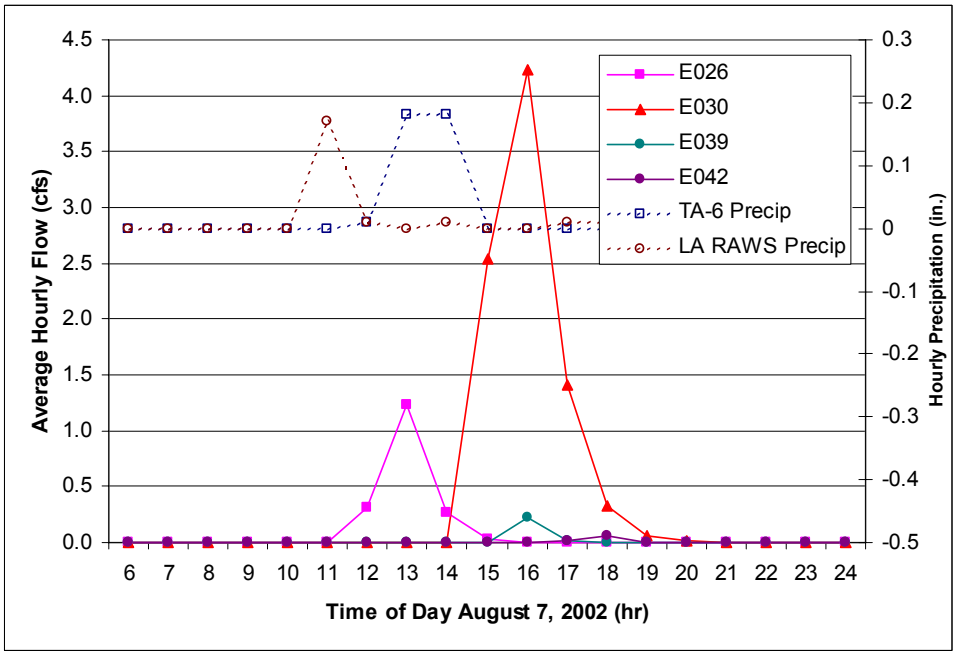

Figure A.10-2. Precipitation and runoff in Los Alamos and DP Canyons on August 7, 2002.

Runoff in middle DP Canyon at gage E039 began at 15:10 on the afternoon of August 7 with a peak flow of 0.4 cfs. Runoff continued until 16:35 and the total runoff was about 0.02 ac-ft. Runoff did not occur in lower DP Canyon at gage E040 on August 7 and runoff data for gage E038 in upper DP Canyon are not available for August 7.

Runoff in lower Los Alamos Canyon at gage E042 began at 17:00 on the afternoon of August 7 with a peak flow of 0.15 cfs. Runoff continued until 17:50 and the total runoff was about 240 cubic ft.

A.10.3 Sandia and Mortandad Canyons

Precipitation and runoff in Sandia Canyon are shown in Figure A.10-3. Baseflow in Sandia Canyon midday August 7 was about 0.7 cfs. Runoff in Sandia Canyon at gage E123 began at 12:50; peak flow was 5.2 cfs at 13:00. Baseflow-supported runoff continued until about 18:30 on the evening of August 7 and the total runoff was about 2.2 ac-ft.

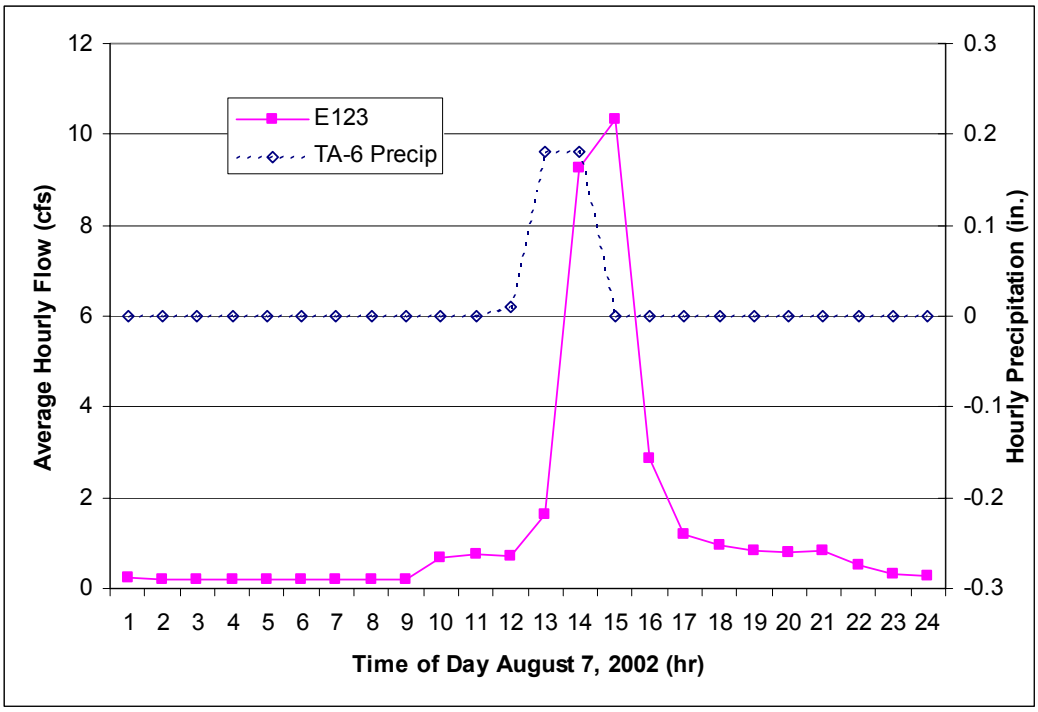

Figure A.10-3. Precipitation and runoff in Sandia Canyon on August 7, 2002.

Baseflow in Mortandad Canyon at gage E200 was 0.01 cfs on August 7. Runoff at gage E200 began at 13:35; peak flow was 0.2 cfs at 13:40. Baseflow-supported runoff continued until about 19:15 on the evening of August 7 and the total runoff was about 700 cubic ft.

A.10.4 Pajarito Canyon

Precipitation and runoff in Pajarito Canyon on August 7, 2002, are shown in Figure A.10-4. Runoff in upper Pajarito Canyon at gage E241 began at 12:45 on the afternoon of August 7; peak flow was 0.06 cfs at 12:55. Runoff continued until 13:25 and the total runoff at gage E241 was about 60 cubic ft. Runoff in middle Pajarito Canyon at gage E245 began at 14:50 when the peak flow was 7.9 cfs. Runoff and baseflow from draining of the Pajarito retention pond continued at gage E245 until about midnight on August 8 and 9 and the total runoff, including runoff on August 8, was about 1.2 ac-ft.

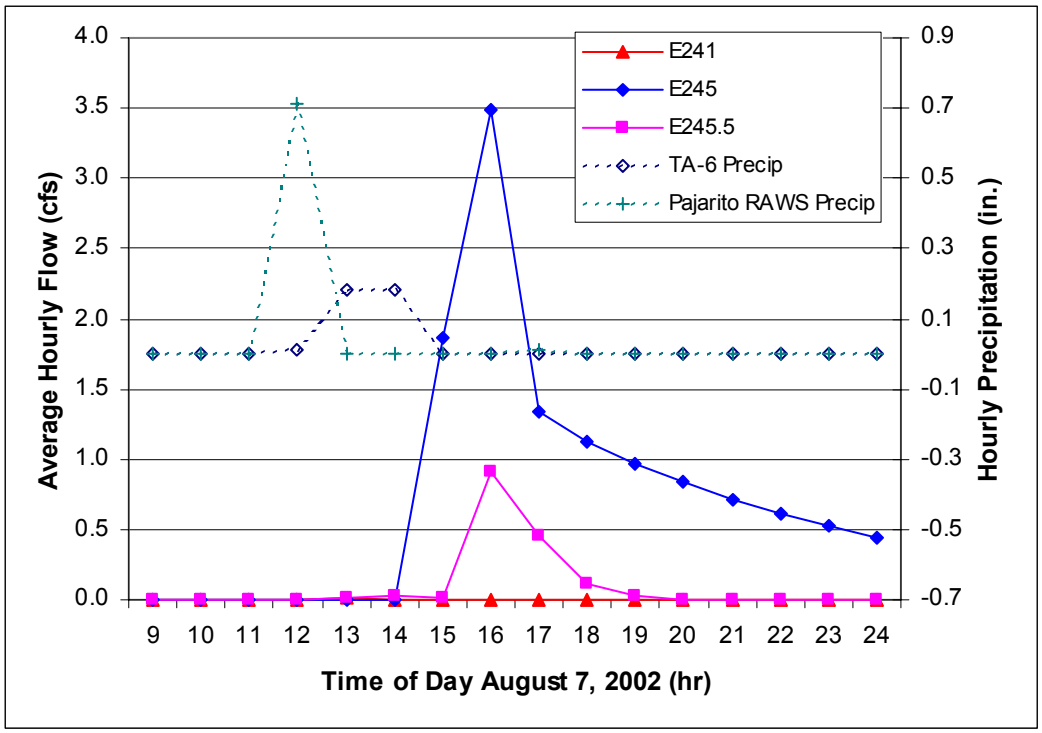

Figure A.10-4. Precipitation and runoff in Pajarito Canyon on August 7, 2002.

Runoff in middle Pajarito Canyon at gage E245.5 began at 15:25 on the afternoon of August 7 with a peak flow of 1.8 cfs. Runoff continued at gage E245.5 until 19:05 on the evening of August 7 and the total runoff was about 0.1 ac-ft. Runoff did not occur in lower Pajarito Canyon at gage E250 on August 7 or 8.

A.11 August 8, 2002

A localized thunderstorm occurred over the western Pajarito Plateau during the early afternoon of August 8, 2002. The Pajarito RAWS site received 0.48 in., North Community received 0.25 in., and TA-6 received 0.06 in. The pattern of precipitation received on the Pajarito Plateau on August 8 is shown in Figure B-11.

A.11.1 Pueblo Canyon

Runoff in Acid Canyon at gage E056 began at 13:25 on the afternoon of August 8; peak flow was about 0.4 ft higher than pre-runoff conditions. The runoff continued until about 17:25 on the afternoon of August 8. Runoff volumes are not available for gage E056.

A.11.2 Los Alamos Canyon

Precipitation and runoff in Los Alamos and DP Canyons are shown in Figure A.11-1. Runoff did not occur in upper Los Alamos Canyon at gages E026 and E030 on August 8. Runoff in middle DP Canyon at gage E039 began at 12:55 on the afternoon of August 8; the peak flow was 36 cfs at 13:00. Runoff continued in middle DP Canyon until 23:40 on the night of August 8 and the total runoff was about 1.9 ac-ft. Runoff in lower DP Canyon at gage E040 began at 13:45 on when the peak flow was 5.9 cfs. Runoff continued at gage E040 until 19:00 on the evening of August 8 and the total runoff in lower DP Canyon was about 0.2 ac-ft.

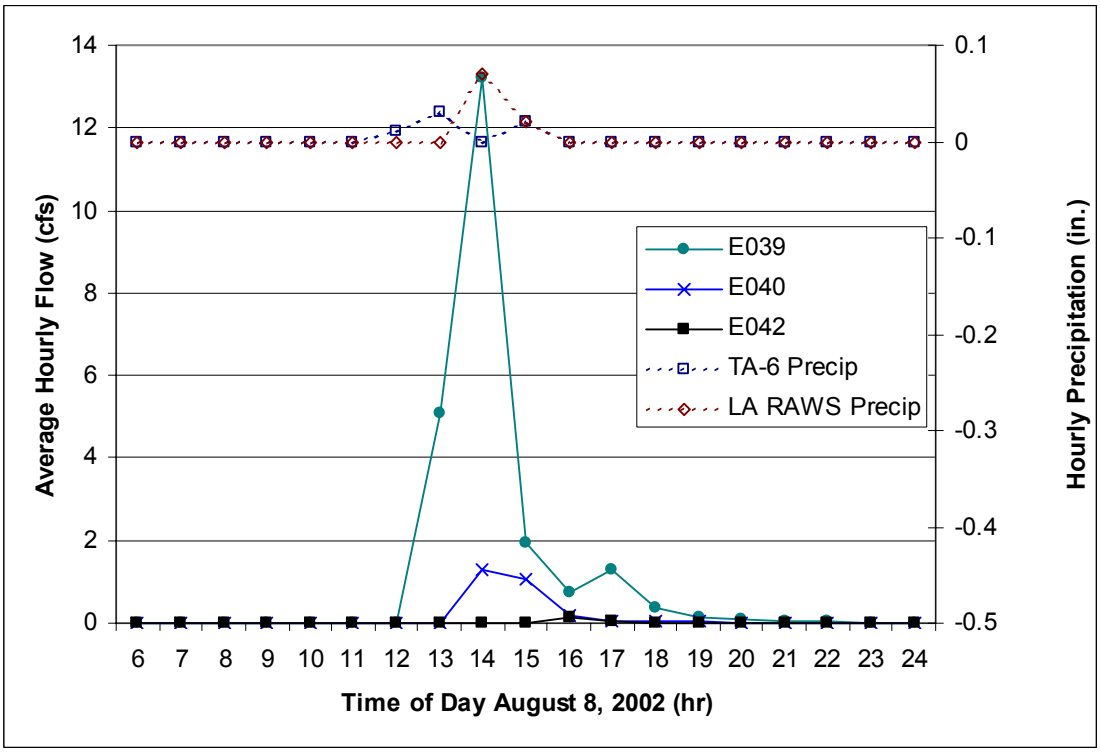

Figure A.11-1. Precipitation and runoff in DP and Los Alamos Canyons on August 8, 2002.

Runoff began in lower Los Alamos Canyon at gage E042 at 15:35 when the peak flow was 0.4 ac-ft. Runoff continued at gage E042 until 1635 on the afternoon of August 8 and the total runoff in lower Los Alamos Canyon was about 0.01 ac-ft.

A.11.3 Sandia Canyon

Precipitation and runoff in Sandia Canyon on August 8, 2002, are shown in Figure A.11-2. Baseflow in Sandia Canyon was about 0.85 cfs in the early afternoon of August 8. Runoff began in Sandia Canyon at gage E123 at 15:35; peak flow was 4.6 cfs at 14:50. Runoff supported by baseflow continued until about 17:40 on the afternoon of August 8 and the total runoff at gage E123 was about 0.4 ac-ft. No significant volume of runoff occurred in Mortandad Canyon on August 8, 2002.

Precipitation and runoff in Pajarito Canyon on August 8, 2002, are shown in Figure A.11-3. Runoff in upper Pajarito Canyon at gage E240 began at 14:55 on the afternoon of August 8 when the peak flow was 3.8 cfs. Flow continued at gage E240 until 15:20 and the total runoff was 0.06 ac-ft. Runoff began at gage E241 at 15:25 on the afternoon of August 8 when the peak flow was 5.7 ac-ft. Runoff continued at gage E241 until 18:30 on the evening of August 8 and the total runoff was about 0.2 ac-ft.

Significant volumes of runoff did not occur in middle Pajarito Canyon at gage E245.5, and runoff did not occur in lower Pajarito Canyon at gage E250 on August 8. Runoff data for gage E245 are not available for August 8, 2002.

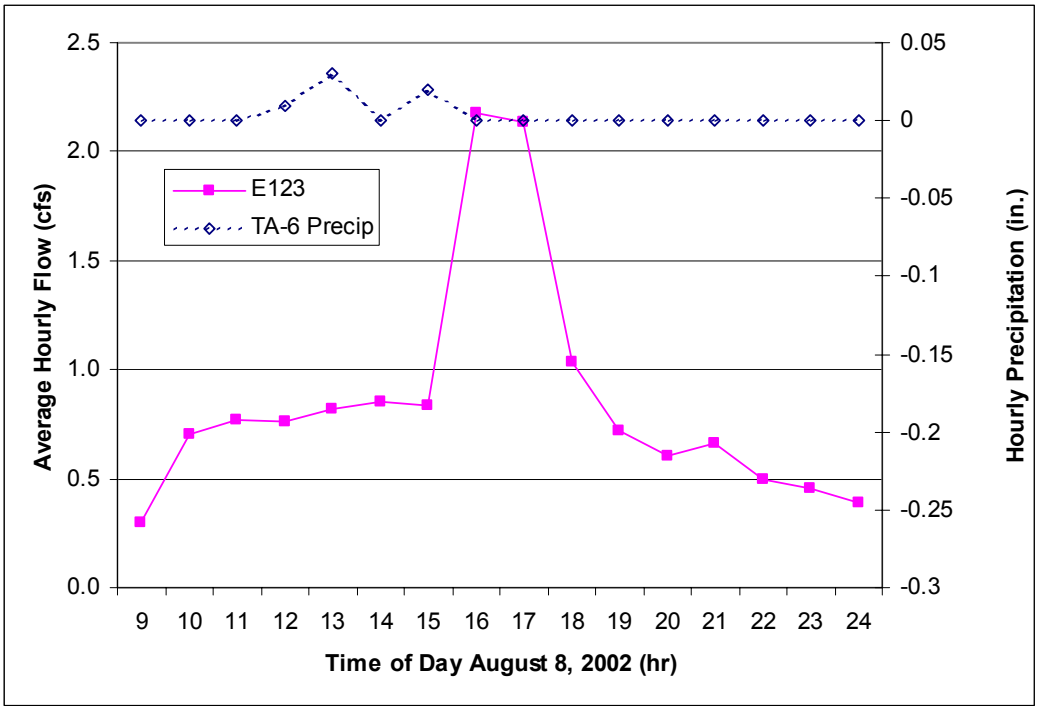

Figure A.11-2. Precipitation and runoff in Sandia Canyon on August 8, 2002.

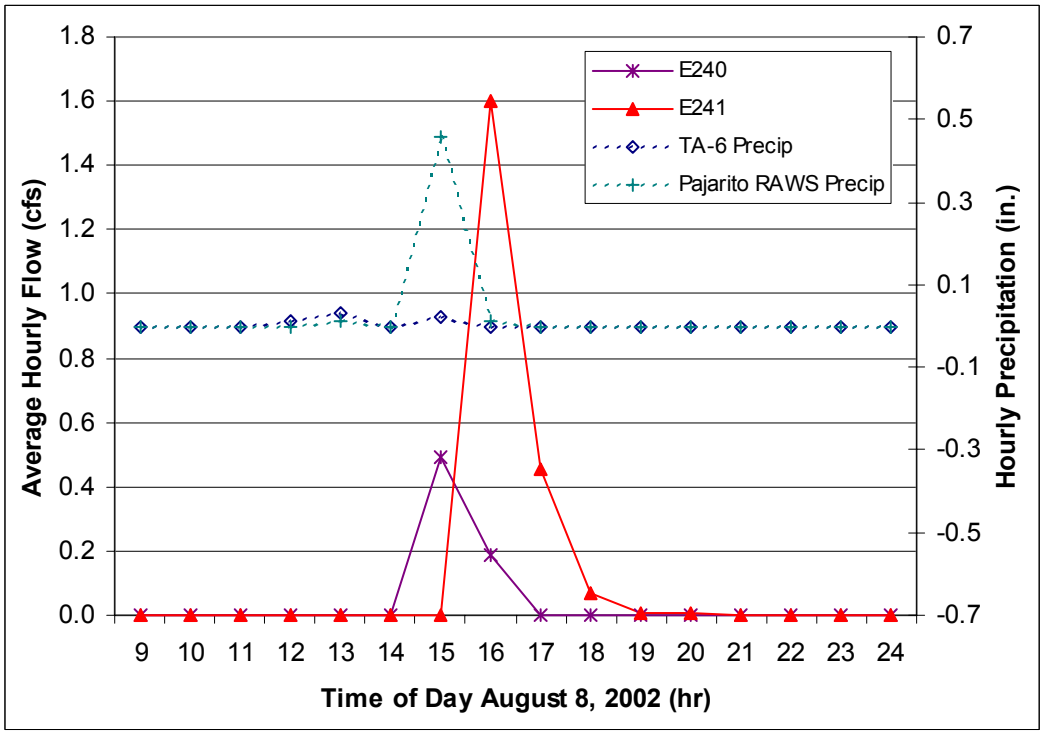

Figure A.11-3. Precipitation and runoff in Pajarito Canyon on August 8, 2002.

A.12 August 28, 2002

A large thunderstorm event occurred over the eastern Pajarito Plateau on the afternoon of August 28, 2002. TA-54 received 1.18 in., mostly between 13:00 and 14:00; TA-74 received 0.39 in., and TA-6 received 0.22 in. Another thunderstorm occurred over the northern Pajarito Plateau in the Santa Clara Canyon area between 11:00 and 13:00 on August 28; the upper Santa Clara Canyon RAWS site received 0.76 in. The pattern of precipitation received on the Pajarito Plateau on August 28 is shown in Figure B-12.

Significant volumes of runoff did not occur in Guaje, Rendija, Pueblo, Water, and Ancho Canyons on August 28, 2002. Due to the precipitation pattern on August 28, runoff did not occur at upstream locations at LANL. However, locally derived runoff occurred in lower Los Alamos, Sandia, Pajarito, and Potrillo Canyons and Cañada del Buey.

A.12.1 Los Alamos and DP Canyons

Precipitation and runoff in Los Alamos and DP Canyons on August 28, 2002, are shown in Figure A.12-1. Runoff did not occur in upper and middle Los Alamos Canyon at gages E026 and E030 on August 28. Runoff in lower Los Alamos Canyon at gage E042 occurred at 14:10 on the afternoon of August 28; flow lasted for less than five minutes. The peak flow at gage E042 was about 0.3 cfs and the total runoff in response to the local precipitation event was about 100 cubic ft.

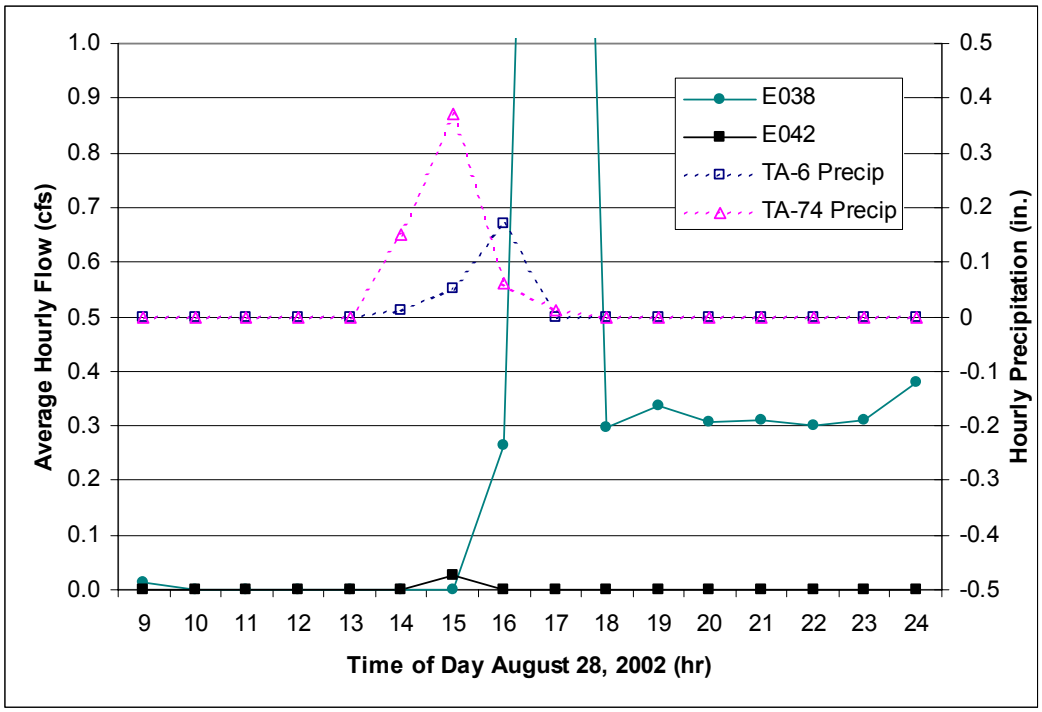

Figure A.12-1. Precipitation and runoff in Los Alamos and DP Canyons on August 28, 2002.

Runoff in upper DP Canyon at gage E038 began at 16:00; the peak flow was 16 cfs at 16:05. Runoff continued at gage E038 until about 17:00 and the total runoff was about 0.3 ac-ft. Runoff did not occur in middle DP Canyon at gage E039 or in lower DP Canyon at gage E040 on August 28.

The runoff data indicate that runoff in upper DP Canyon did not extend into Los Alamos Canyon and that the small amount of runoff in lower Los Alamos Canyon at gage E042 was locally derived.

A.12.2 Sandia Canyon and Mortandad Canyon

Precipitation and runoff in Sandia Canyon on August 28, 2002, are shown in Figure A.12-2. The precipitation event occurred earlier on the eastern part of the Pajarito Plateau than on the western part of the plateau, therefore, runoff in lower Sandia Canyon at gage E125 began before runoff in the upper part of the canyon at gage E123. Runoff in lower Sandia Canyon at gage E125 began at 14:05 on the afternoon of August 28; the peak flow was 18 cfs at 14:10. Runoff continued until 01:10 on the morning of August 29 and the total runoff at gage E125 in lower Sandia Canyon was about 2.1 ac-ft.

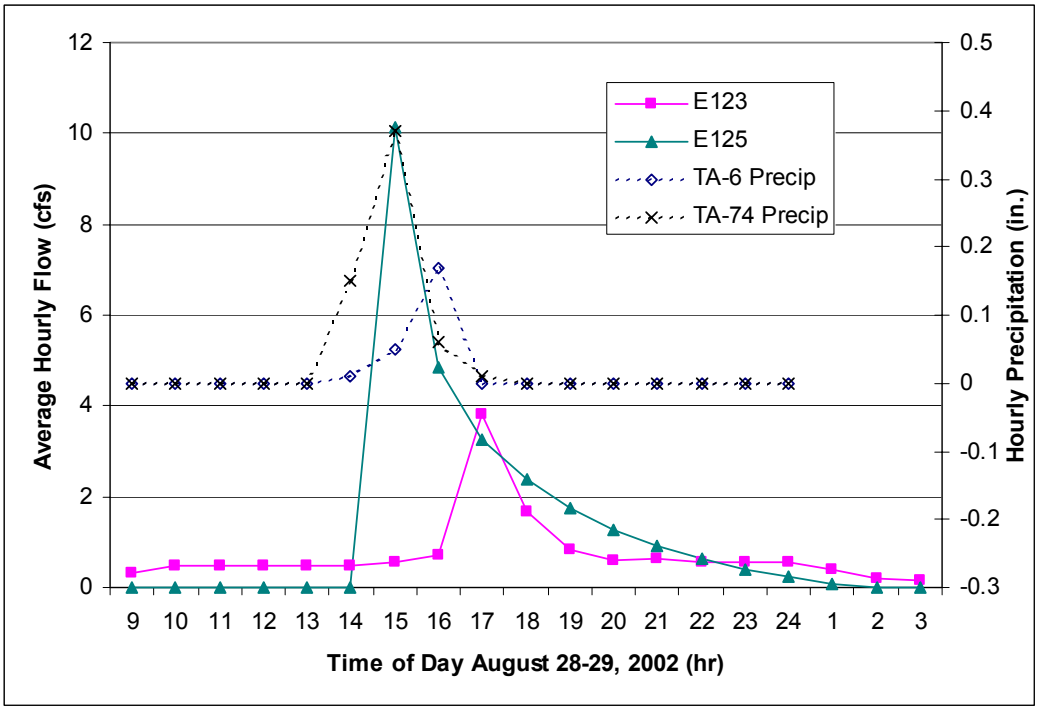

Figure A.12-2. Precipitation and runoff in Sandia Canyon on August 28, 2002.

Runoff began in upper Sandia Canyon at gage E123 at 16:20 on the afternoon of August 28; the peak flow was 6.7 cfs at 16:35. Runoff supported by baseflow continued until about 18:05 and the total runoff was about 0.4 ac-ft. The runoff data indicate that runoff in the upper part of the canyon did not extend downstream to the eastern LANL boundary at gage E125, but that the runoff in lower Sandia Canyon at gage E125 was locally derived.

A small amount of runoff occurred in Mortandad Canyon at gage E200 on the afternoon of August 28. Runoff began at 16:25 when the peak flow was 0.12 cfs. Runoff, supported by a small amount of baseflow, continued until about 17:20 and the total runoff at gage E200 was about 200 cubic ft.

A.12.3 Cañada del Buey

Precipitation and runoff in Cañada del Buey on August 28, 2002, are shown in Figure A.12-3. Due to the pattern of precipitation on August 28 (Figure B-12), runoff did not occur in upper Cañada del Buey at gage E218 on August 28. Runoff in lower Cañada del Buey at gage E230 began at 14:00 on the afternoon of August 28; the peak runoff was 168 cfs at 14:10. Runoff continued at gage E230 until 20:20 on the evening of August 28 and the total runoff was about 6.3 ac-ft.

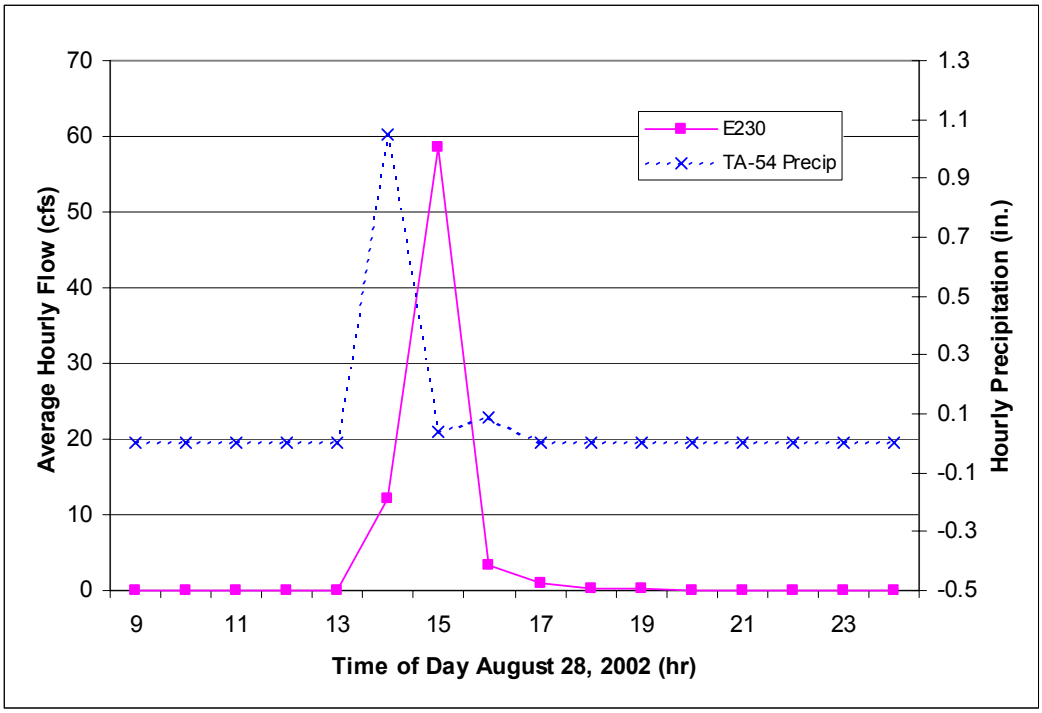

Figure A.12-3. Precipitation and runoff in Cañada del Buey on August 28, 2002.

A.12.4 Pajarito Canyon and Potrillo Canyon

Precipitation and runoff in Pajarito Canyon and Potrillo Canyon on August 28, 2002, are shown in Figure A.12-4. Due to the pattern of precipitation on August 28, runoff did not occur in upper and middle Pajarito Canyon at gages E240, E241, E245, and E245.5. Runoff in lower Pajarito Canyon at gage E250 began at 14:10 on the afternoon of August 28; the peak flow was 1.8 cfs at 14:20. Runoff continued at gage E250 until 20:55 on the evening of August 28 and the total runoff was about 0.1 ac-ft. The data indicate that the runoff in lower Pajarito Canyon on August 28 were locally derived.

Runoff in lower Potrillo Canyon at gage E267 began at 13:50 on the afternoon of August 28; peak flow was 15.2 cfs at 14:05. Runoff continued in lower Potrillo Canyon until 14:30 and the total runoff was about 0.6 ac-ft.

A.13 September 4, 2002

A thundershower occurred over the western Pajarito Plateau midday on September 4, 2002. Precipitation at the Water Canyon RAWS site was 0.69 in. and at the Pajarito Canyon RAWS site was 0.48 in. TA-6 received 0.24 in. and TA-16 received 0.4 in. The pattern of precipitation on September 4 is shown in Figure B-13. Significant volumes of runoff did not occur in Guaje Canyon, Rendija Canyon, Pueblo Canyon, Water Canyon, and Cañada del Buey on September 4.

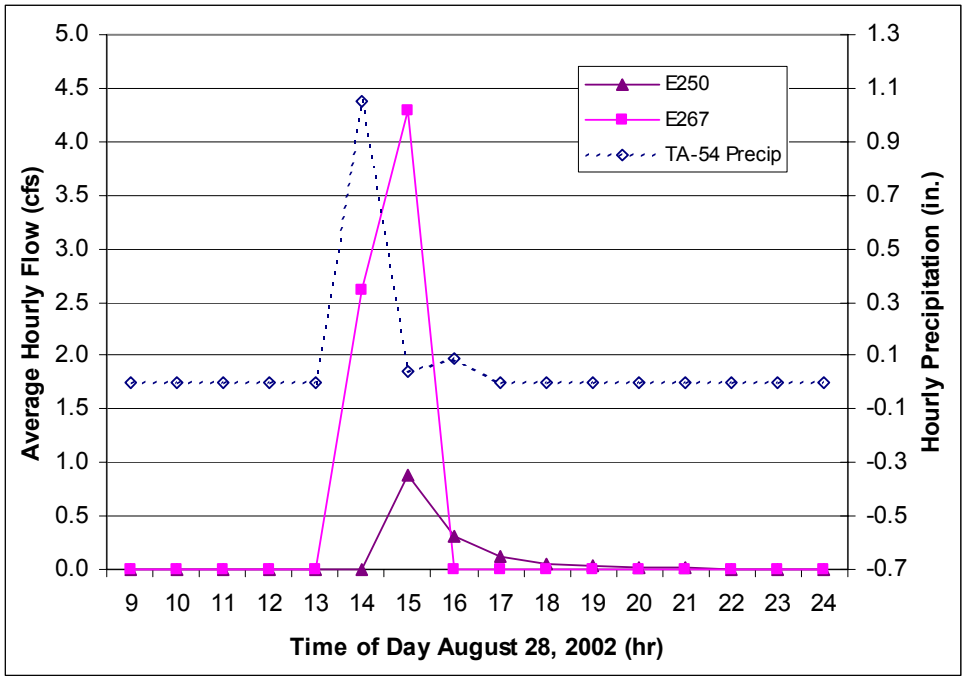

Figure A.12-4. Precipitation and runoff in Pajarito and Potrillo Canyons on August 28, 2002.

A.13.1 Los Alamos Canyon and DP Canyon

Precipitation and runoff in Los Alamos and DP Canyons on September 4, 2002, are shown in Figure A.13-1. Runoff in upper Los Alamos Canyon at gage E026 began at 11:35 on the morning of September 4; peak flow was 9.9 cfs at 12:15. Runoff continued until 15:20 on the afternoon of September 4, and the total runoff was about 0.8 ac-ft. Runoff did not occur in middle Los Alamos Canyon at gage E030 or in lower Los Alamos Canyon at gage E042 on September 4.

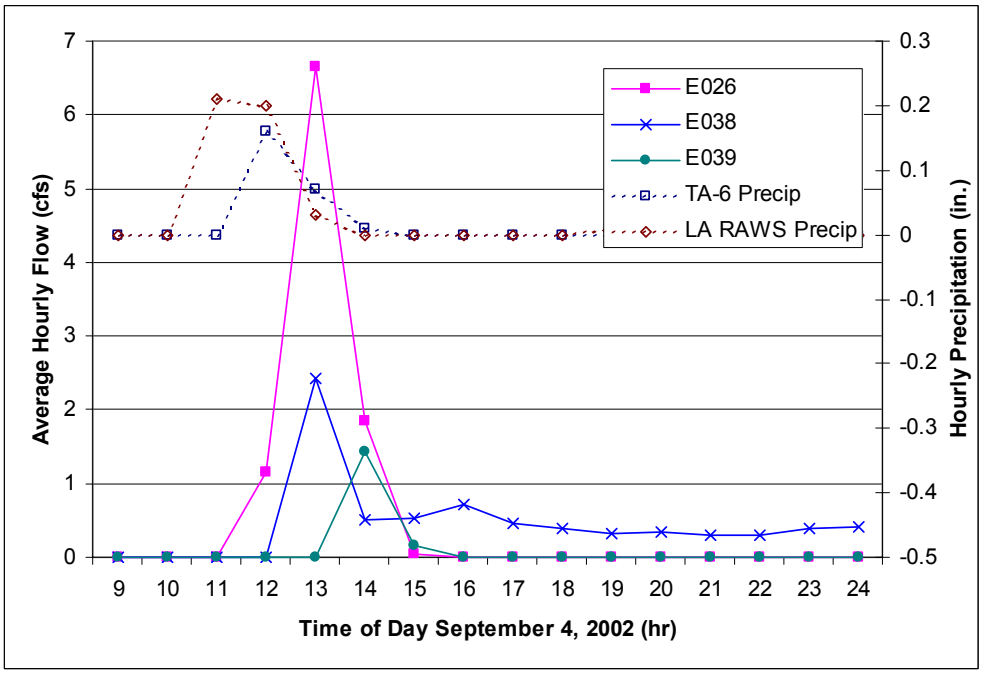

Figure A.13-1. Precipitation and runoff in Los Alamos and DP Canyons on September 4, 2002.

Runoff began in upper DP Canyon at gage E038 at 12:05 when the peak flow was 5.5 cfs. Runoff continued at gage E038 until about 14:30 on the afternoon of September 4 and the total flow was about 0.26 ac-ft. Runoff in middle DP Canyon at gage E039 began at 13:10; peak flow was 2.4 cfs at 13:15. Runoff at gage E039 continued until 15:20 and the total runoff was about 0.13 ac-ft. Runoff did not occur in lower DP Canyon at gage E042 on September 4.

A.13.2 Sandia Canyon and Mortandad Canyon

Precipitation and runoff in Sandia Canyon and Mortandad Canyon on September 4, 2002, are shown in Figure A.13-2. Baseflow in Sandia Canyon on the morning of September 4 was about 0.5 cfs. Runoff in Sandia Canyon at gage E123 began at 12:15; the peak flow was 8.7 cfs at 13:00. Runoff, supported by baseflow, continued at gage E123 until about 17:00 on the afternoon of September 9 and the total runoff was about 1.1 ac-ft.

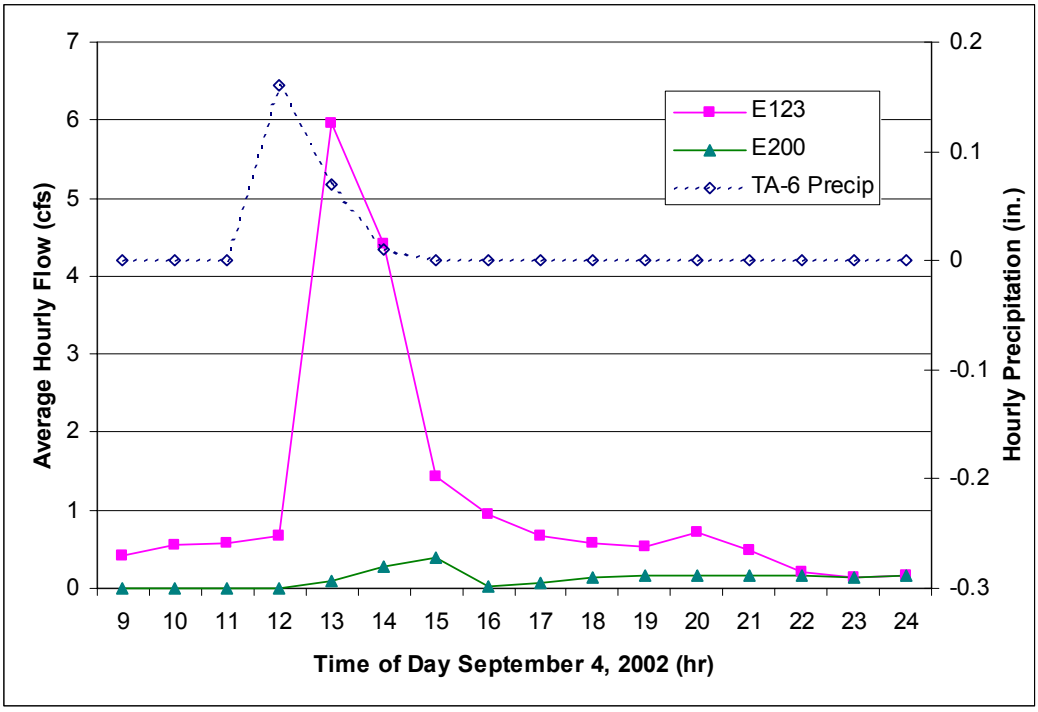

Figure A.13-2. Precipitation and runoff in Sandia Canyon and Mortandad Canyon on September 4, 2002.

Baseflow in Mortandad Canyon on the morning of September 4 was about 0.1 cfs. Runoff in Mortandad Canyon at gage E200 began at 12:30; peak flow was 0.8 cfs at 13:55. Runoff continued at gage E200 until about 15:10 and the total runoff from upper Mortandad Canyon was about 2800 cubic ft.

A.13.3 Water Canyon

Precipitation and runoff in Water Canyon and Cañon de Valle on September 4, 2002, are shown in Figure A.13-3. Runoff in upper Water Canyon at gage E252 began at 12:05 on the afternoon of September 4; peak flow was 0.13 cfs at 12:50. Runoff continued until about 14:00 and the total runoff was about 250 cubic ft.

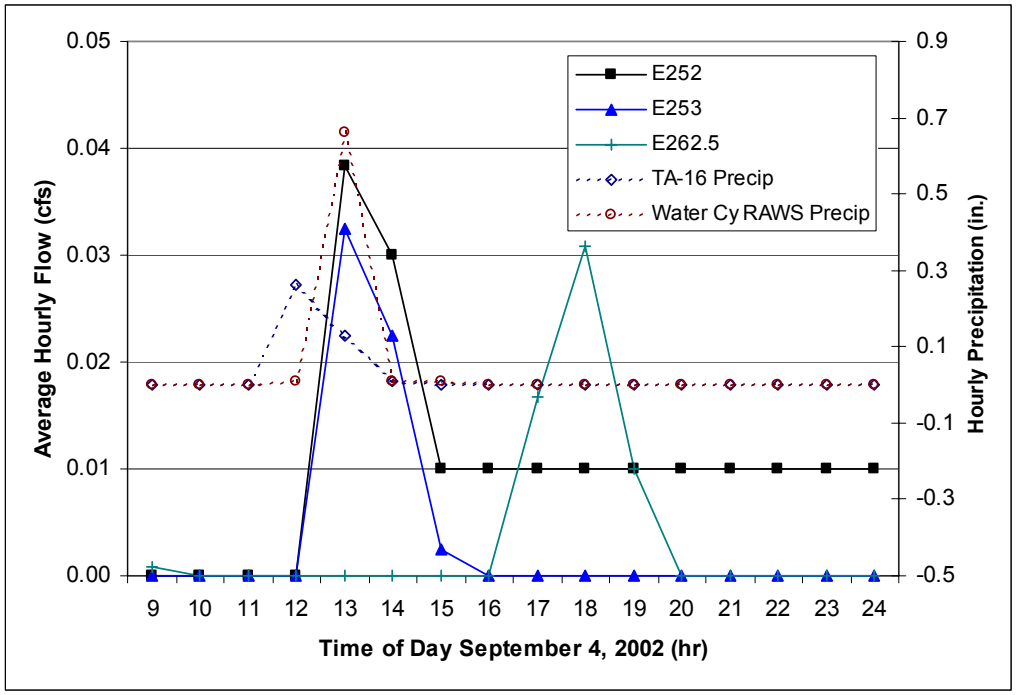

Figure A.13-3. Precipitation and runoff in Water Canyon and Cañon de Valle on September 4, 2002.

Runoff in upper Cañon de Valle at gage E253 began at 12:05 when the peak flow was 0.08 cfs. Runoff continued until 14:15 on the afternoon of September 4 and the total runoff was about 200 cubic ft.

Flow in middle Water Canyon at gage E262.5 began at 16:40 on the afternoon of September 4 when the peak flow was 0.04 cfs. Flow continued until 18:50 on the evening of September 4, and the total flow was about 200 cubic ft. The flow at gage E262 does not appear to be continuous runoff from upper Water Canyon and Cañon de Valle, but may be associated spring flow induced by infiltration of runoff from the upper part of the canyon.

A.14 September 9, 2002

Two precipitation events occurred on the afternoon of September 9, 2002. Precipitation occurred over the western Pajarito Plateau where TA-6 received 0.33 in. and the upper Los Alamos Canyon RAWS site received 0.61 in. Another precipitation event occurred over the eastern Pajarito Plateau, where TA-54 received 0.69 in. and TA-74 received 0.34 in. Most of the Los Alamos town site and the central part of LANL received about 0.1 in. or less. The pattern of precipitation received on September 9, 2002, is shown in Figure B-14.

Significant volumes of runoff did not occur in Guaje, Rendija, Pueblo, Los Alamos, and Water Canyons and Cañon de Valle on September 9, 2002.

A.14.1 Sandia Canyon and Mortandad Canyon

Precipitation and runoff in Sandia and Mortandad Canyons on September 9, 2002, are shown in Figure A.14-1. Baseflow in Sandia Canyon was about 0.6 cfs on September 9. Runoff in Sandia Canyon at gage E123 began at 15:05; the peak flow was 3.6 cfs at 15:30. Runoff supported by baseflow continued until about 17:30 and the total runoff was about 0.37 ac-ft. Runoff did not occur in lower Sandia Canyon at gage E125 on September 9.

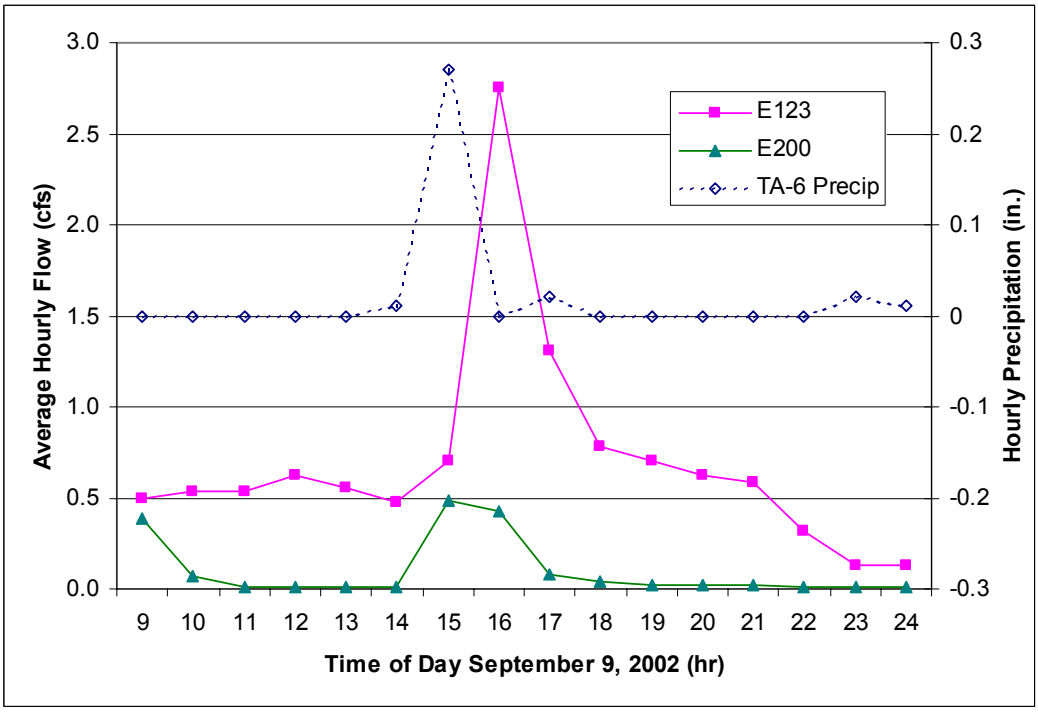

Figure A.14-1. Precipitation and runoff in Sandia Canyon and Mortandad Canyon on September 9, 2002.

Baseflow in Mortandad Canyon at gage E200 was about 0.01 cfs on September 9. Runoff in Mortandad Canyon at gage E200 began at 14:50; the peak flow was 2.2 cfs at 14:55. Runoff supported by baseflow continued until about 18:30 on the evening of September 9 and the total runoff from upper Mortandad Canyon was about 0.1 ac-ft.

A.14.2 Cañada del Buey

Precipitation and runoff in Cañada del Buey on September 9 are shown in Figure A.14-2. Runoff did not occur in upper Cañada del Buey at gage E218, but due to local precipitation in the lower Cañada del Buey area, runoff occurred at gage E230. Runoff at gage E230 began at 14:40 on the afternoon of September 9; peak flow was 42 cfs at 15:55. Runoff continued until 17:40 on the afternoon of September 9 and the total runoff from the afternoon precipitation event was about 1.4 ac-ft.

A.14.3 Pajarito Canyon and Potrillo Canyon

Precipitation and runoff in upper and middle Pajarito Canyon on September 9, 2002, are shown in Figure A.14-3. Runoff in upper Pajarito Canyon at gage E240 began at 14:35 on the afternoon of September 9 when the peak flow was 1.1 cfs. Runoff continued until 15:05 and the total runoff was about 0.03 ac-ft. Runoff at gage E241 began at 15:10; the peak flow was 2.5 cfs at 15:15. Runoff continued at gage E241 until 18:25 on the evening of September 9 and the total runoff was about 0.15 ac-ft. Runoff did not occur in middle Pajarito Canyon at gages E245 and E245.5 on September 9.

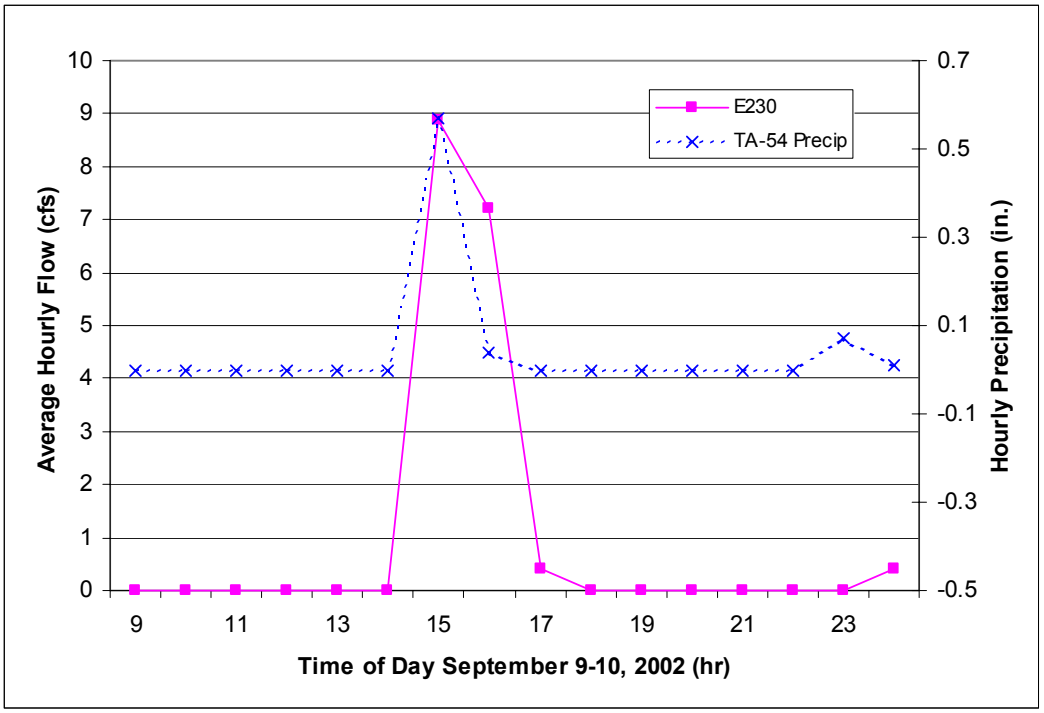

Figure A.14-2. Precipitation and runoff in Cañada del Buey on September 9, 2002.

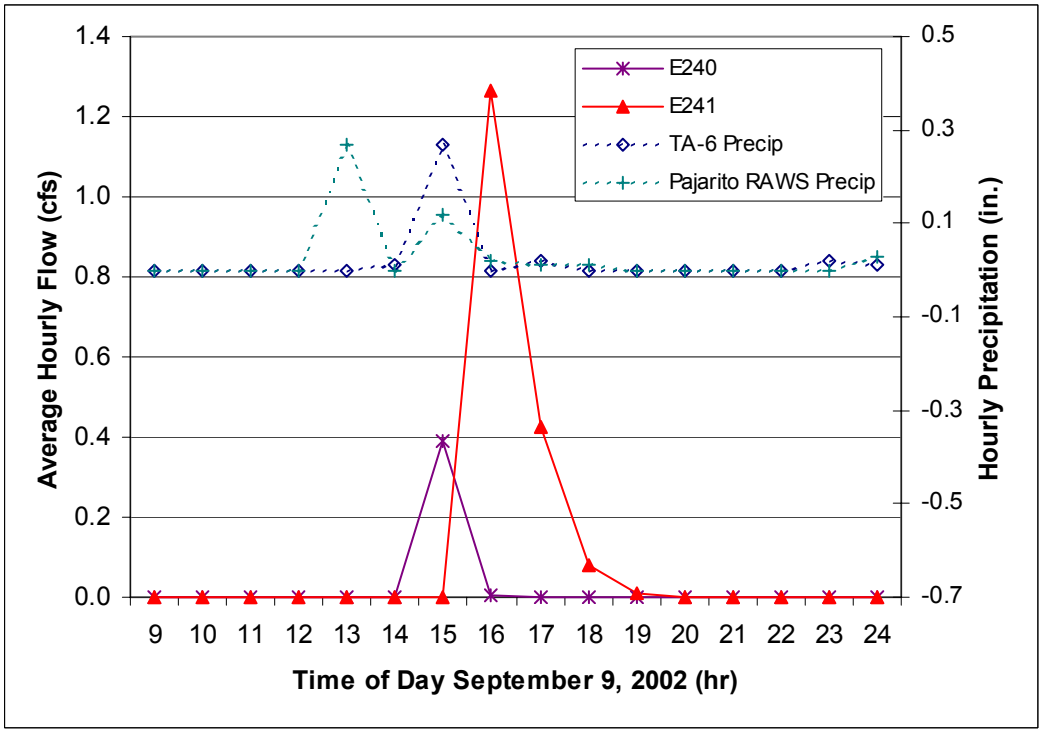

Figure A.14-3. Precipitation and runoff in upper Pajarito Canyon on September 9, 2002.

Runoff occurred in lower Pajarito Canyon at gage E250 in response to local precipitation on September 9. Precipitation at TA-54 and runoff in lower Pajarito Canyon at gage E250 and lower Potrillo Canyon at gage E267 on September 9 are shown in Figure A.14-4. Runoff at gage E250 began at 16:15; peak flow was 0.06 cfs at 16:50. Runoff continued at gage E250 until 21:15 on the evening of September 9, and the total runoff was about 570 cubic ft (0.01 ac-ft). The runoff in lower Pajarito Canyon on September 9 resulted from local precipitation and did not derive from runoff from the upper part of the canyon.

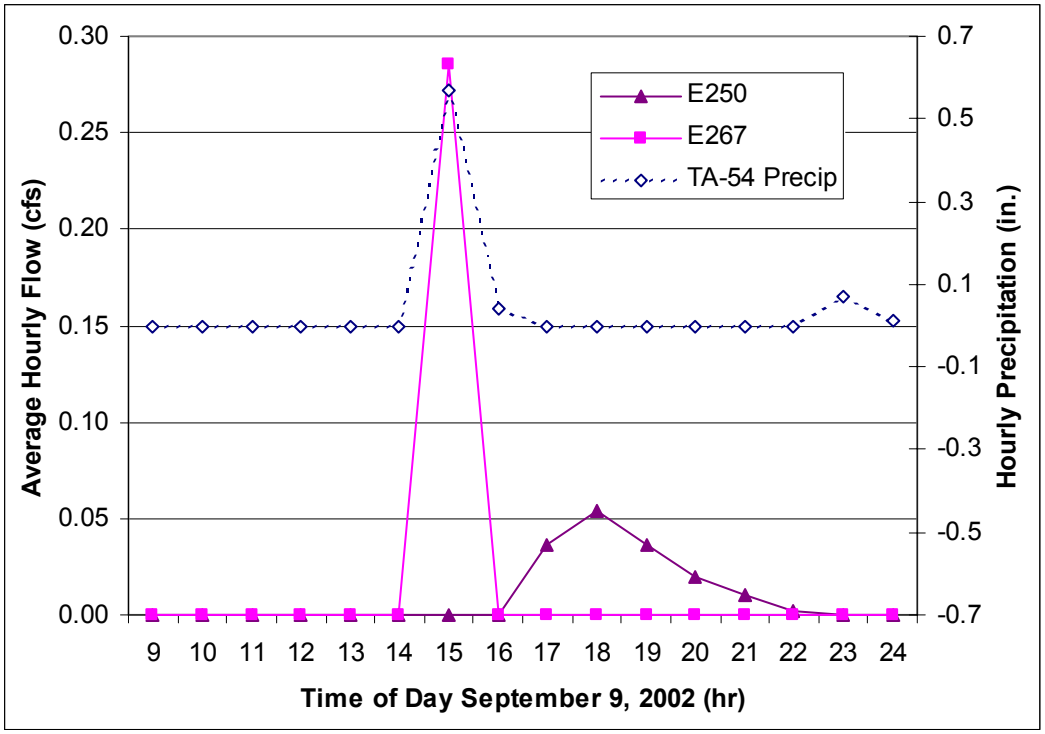

Figure A.14-4. Precipitation and runoff in lower Pajarito and Potrillo Canyons on September 9, 2002.

Runoff in lower Potrillo Canyon at gage E267 began at 14:50 on the afternoon of September 9, 2002; the peak flow was 2 cfs at 14:55. Runoff continued at gage E267 for less than 20 minutes and the total runoff was about 0.02 ac-ft.

A.15 September 10, 2002

A steady, soaking precipitation event occurred on the Pajarito Plateau on September 10, 2002. Precipitation began about 23:00 on the night of September 9 and continued sporadically until about 16:00 on the afternoon of September 10. Rainfall amounts included 0.97 in. at TA-6, 1.95 in. at TA-16, 1.22 in. at Pajarito Mountain, 0.86 in. at TA-53, and 0.65 in. at TA-54. The pattern of precipitation received on the Pajarito Plateau on September 10 is shown in Figure B-15.

A.15.1 Guaje Canyon and Rendija Canyon

The precipitation and runoff in Guaje Canyon and Rendija Canyon on September 19 are shown in Figure A.15-1. Runoff in Guaje Canyon at gage E089 began at 04:05 on the morning of September 10; the peak flow was 218 cfs at 04:35. Runoff continued until at least 08:25 on the morning of September 10, after which data are not available, runoff at gage E089 was at least 26 ac-ft.

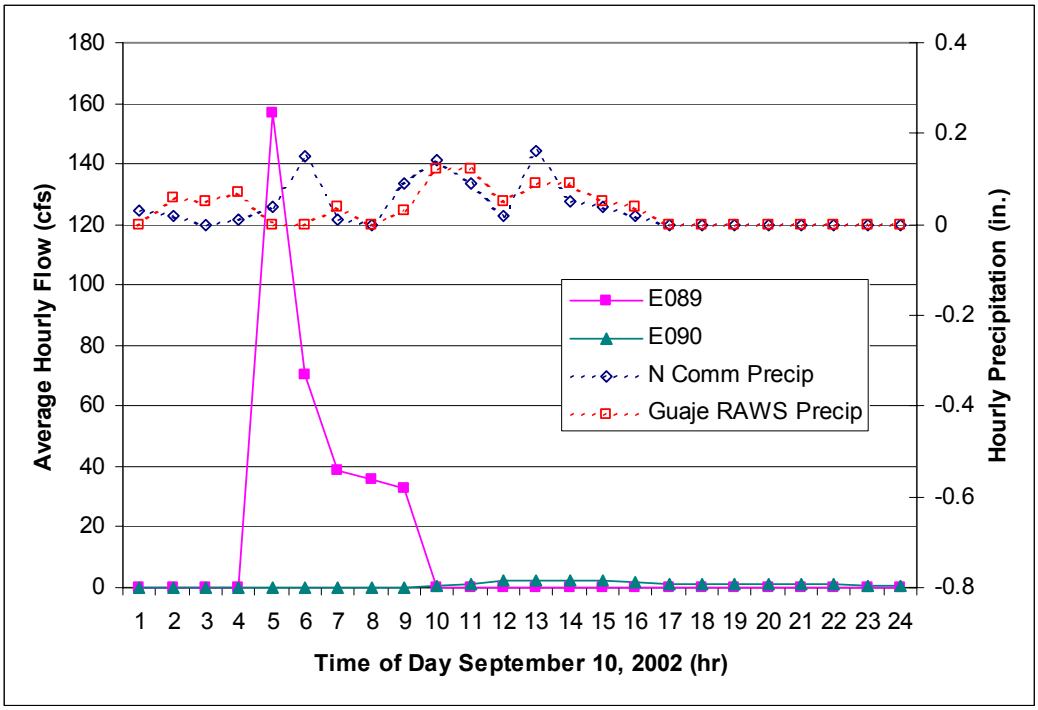

Figure A.15-1. Precipitation and runoff in Guaje and Rendija Canyons on September 10, 2002.

Runoff in lower Rendija Canyon at gage E090 began at 04:45; the peak runoff was 3 cfs at 12:00 on September 10. Runoff continued in small volumes until 07:00 on the morning of September 12, and the total runoff from Rendija Canyon was about 2.1 ac-ft.

A.15.2 Pueblo Canyon

Precipitation and runoff in Pueblo Canyon on September 10, 2002, are shown in Figure A.15-2. Baseflow in lower Pueblo Canyon at gage E060 on the morning of September 10 was about 1 cfs. Runoff at gage E060 began at 10:45 on the morning of September 10; the peak flow was 28 cfs at 17:45 on the afternoon of September 10. Runoff continued in lower Pueblo Canyon until about 23:00 on the night of September 10 and the total runoff was about 12 ac-ft.

A.15.3 DP Canyon

Precipitation and runoff in DP Canyon on September 10, 2002, are shown in Figure A.15-3. Runoff in middle DP Canyon at gage E039 began at 01:50 on the morning of September 10 and peak flows were 22 cfs at 06:20, 20 cfs at 11:25, and 19 cfs at 13:15. Runoff continued at gage E039 until about 20:45 on the evening of September 10 and the total runoff was about 7.25 ac-ft.

Runoff in lower DP Canyon at gage E040 began at 06:50 with a peak flow of 8.4 cfs, other peak flows included 8.7 cfs at 11:55 and 8.2 cfs at 13:50. Runoff continued at gage E040 until 21:45 on the evening of September 10 and the total runoff in lower DP Canyon was about 2 ac-ft.

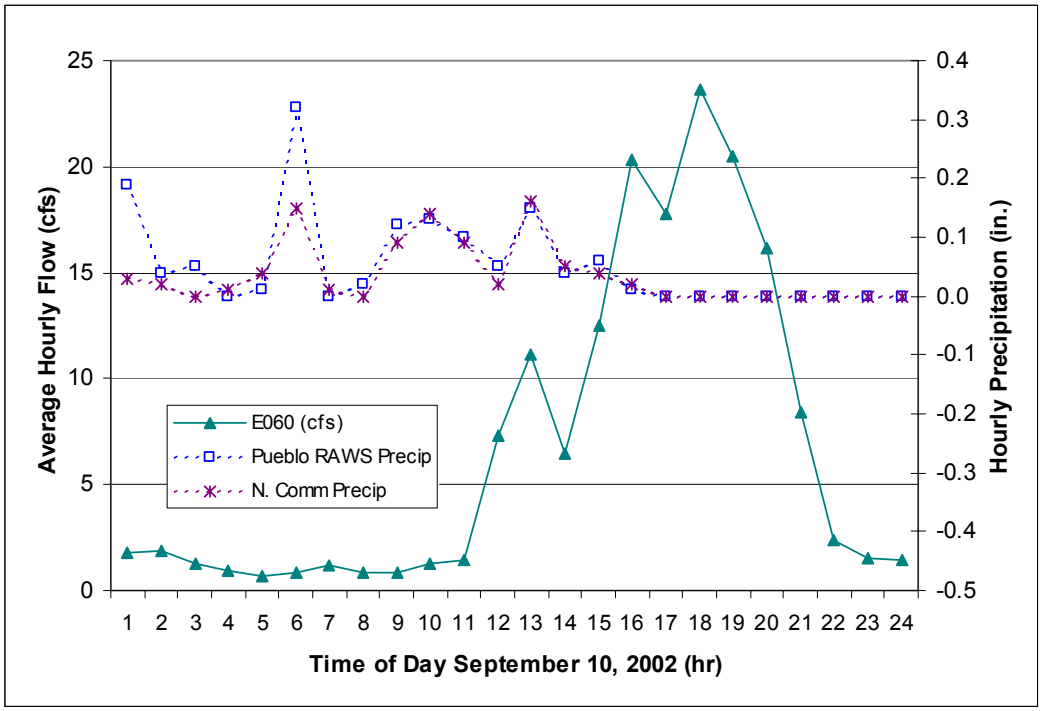

Figure A.15-2. Precipitation and runoff in Pueblo Canyon on September 10, 2002.

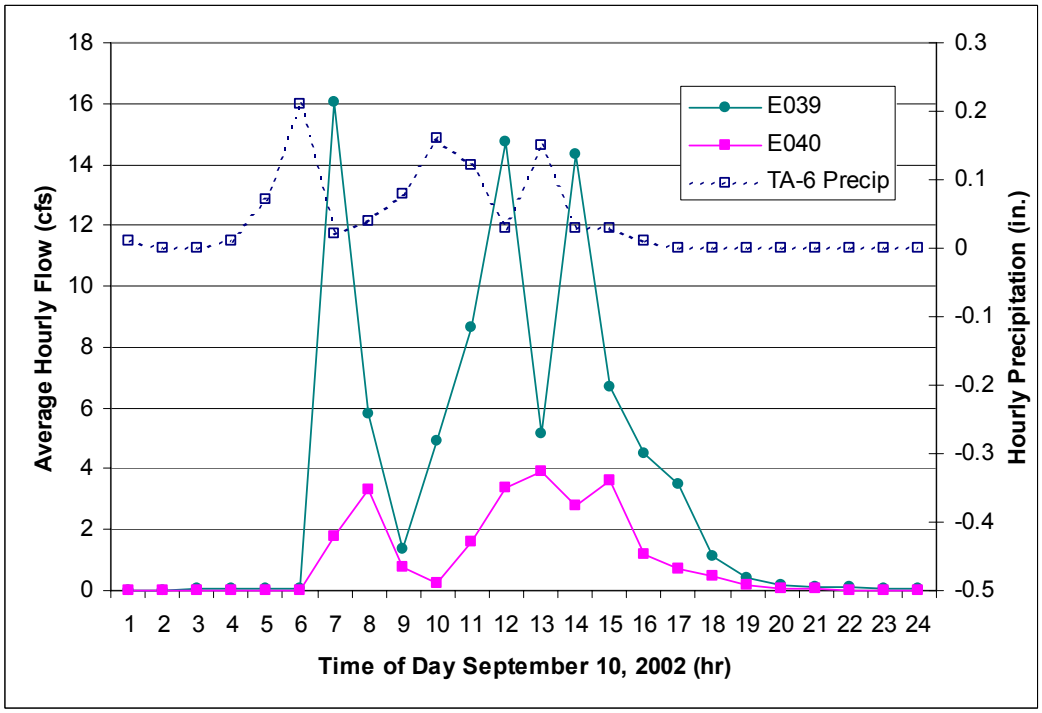

Figure A.15-3. Precipitation and runoff in DP Canyon on September 10, 2002.

A.15.4 Los Alamos Canyon

Precipitation and runoff in Los Alamos Canyon on September 10, 2002, are shown in Figure A.15-4. Three periods of precipitation occurred in upper Los Alamos Canyon from midnight until about noon. Runoff in upper Los Alamos Canyon at gage E026 began at 05:55; the peak flow of three runoff pulses was 2.4 cfs at 07:05. Runoff continued at gage E026 until 17:40 on the afternoon of September 10 and the total runoff was about 0.35 ac-ft.

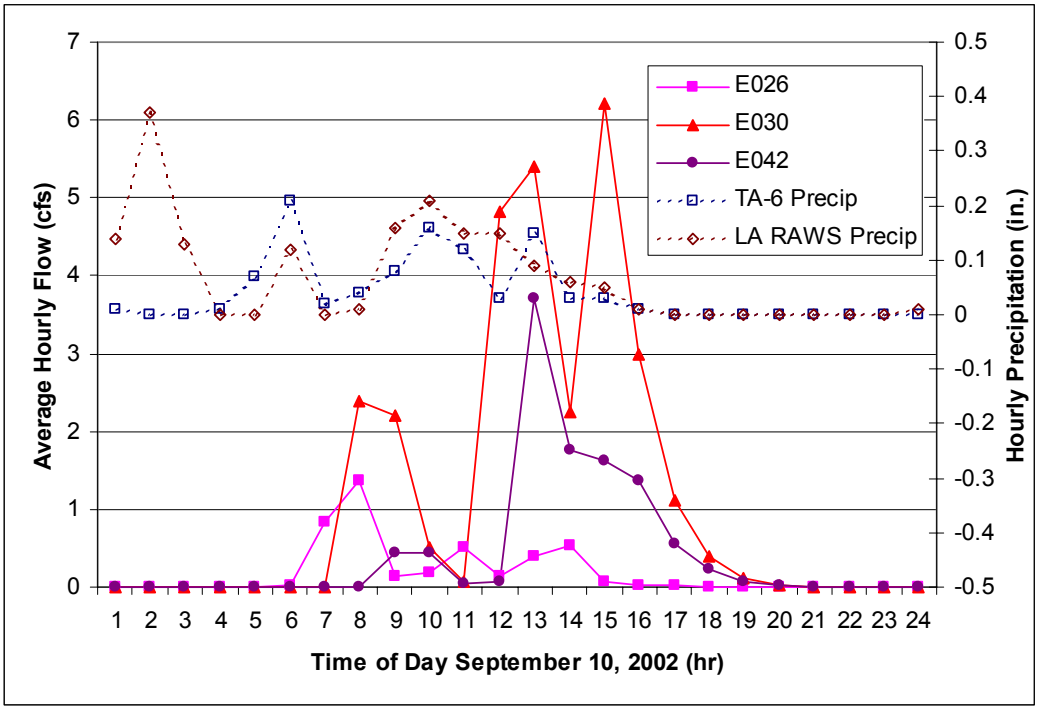

Figure A.15-4. Precipitation and runoff in Los Alamos Canyon on September 10, 2002.

Runoff in middle Los Alamos Canyon at gage E030 began at 07:35; peak flows in response to precipitation events were 5.6 cfs at 07:35, 6.5 cfs at 12:20, and 8.1 cfs at 14:10. Runoff continued at gage E030 until 19:40 on the evening of September 10 and the total runoff was about 2.35 ac-ft.

Two episodes of runoff occurred in lower Los Alamos Canyon at gage E042 on September 10. The first episode of runoff at gage E042 began at 08:35 with a peak flow of 1.3 cfs at 08:40. The first runoff episode continued until 10:45. The second episode of runoff at gage E042 began at 11:55; peak flow was 7.6 cfs at 12:35. Runoff continued at gage E042 until 19:45 on the evening of September 10 and the total runoff in lower Los Alamos Canyon was 0.85 ac-ft.

A.15.5 Sandia Canyon and Mortandad Canyon

Precipitation and runoff in Sandia Canyon and Mortandad Canyon on September 10, 2002, are shown in Figure A.15-5. Baseflow in Sandia Canyon at gage E123 was about 0.25 cfs on the morning of September 10. Runoff at gage E123 began at 05:45, with peak flows of 14 cfs at 06:15, 10.5 cfs at 10:40, and 12.2 cfs at 13:20. Runoff supported by baseflow continued at gage E123 until about 18:30 and the total runoff was about 5.1 ac-ft.

Baseflow in Mortandad Canyon at gage E200 was about 0.01 cfs on the morning of September 10. Runoff in Mortandad Canyon at gage E200 began at 04:50 with peak flows of 2 cfs at 06:15, 2.6 cfs at

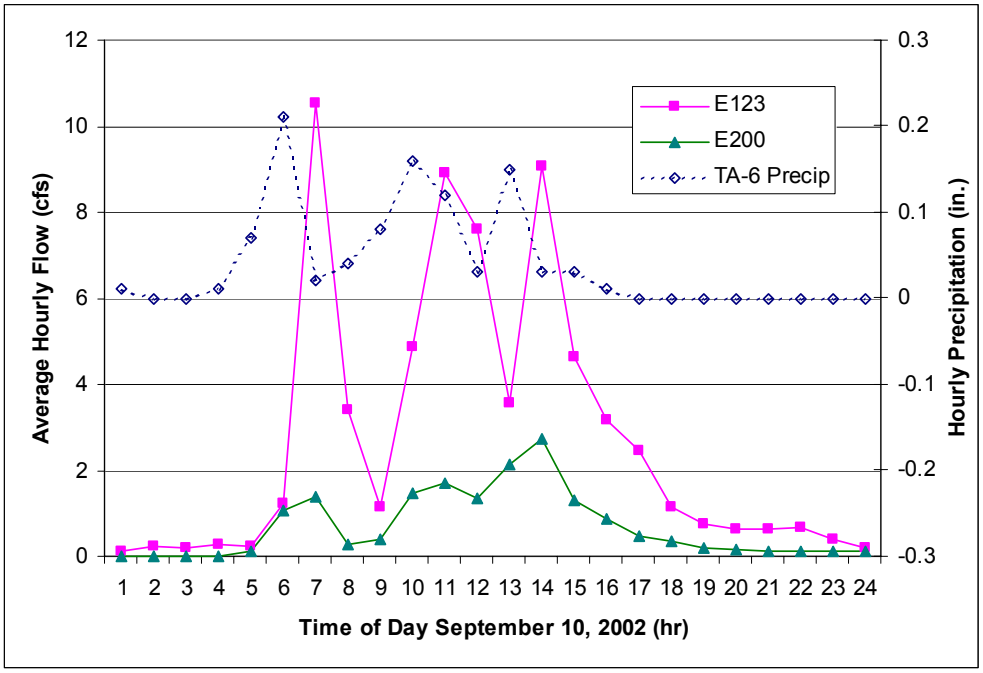

Figure A.15-5. Precipitation and runoff in Sandia Canyon and Mortandad Canyon on September 10, 2002.

11:05, and 4.5 cfs at 12:50. Runoff supported by baseflow continued at gage E200 until about 19:00 on the evening of September 10 and the total runoff in upper Mortandad Canyon was about 1.3 ac-ft.

A.15.6 Cañada del Buey

Precipitation and runoff in Cañada del Buey on September 10, 2002, are shown in Figure A.15-6. Runoff did not occur in upper Cañada del Buey at gage E218 on September 10. Runoff from local precipitation on the night of September 9-10 occurred in lower Cañada del Buey at gage E230. Runoff at gage E230 began at 23:05 on the night of September 9 with peak flows of 1.1 cfs at 23:25 on September 9 and 7 cfs at 01:25 on the morning of September 10. Runoff continued at gage E230 until 10:20 on the morning of September 10 and the total runoff in lower Cañada del Buey was about 0.4 ac-ft.

A.15.7 Pajarito Canyon

Precipitation and runoff in upper and middle Pajarito Canyon on September 10, 2002, are shown in Figure A.15-7. Runoff in upper Pajarito Canyon at gage E240 occurred at 05:10 for about five minutes and again at 06:10 for about 10 minutes. The peak flow at gage E240 was 0.1 cfs and the total runoff was about 60 cubic ft. The first episode of runoff at gage E241 began at 01:50 on the morning of September 10 and continued for two hours; the peak flow during this time was 0.5 cfs at 01:55. Runoff began again at gage E241 at 04:55 and, supported by baseflow, continued until about 16:00 on the afternoon of September 10. The peak flow was 3.1 cfs at 05:35 and the total flow was about 0.3 ac-ft.

Runoff in middle Pajarito Canyon at gage E245 began at 09:05 on the morning of September 10; the peak flow was 8.2 cfs at 11:25. Runoff continued at gage E245 until about 12:20 on the afternoon of September 10 and the total runoff was about 0.75 ac-ft. Runoff in middle Pajarito Canyon at gage E245.5 began at 10:00 on the morning of September 10; peak flow in response to precipitation events was 2.5 cfs at 12:10 and 6.2 cfs at 14:40. Runoff continued at gage E245.5 until 21:55 on the evening of September 10 and the total runoff was about 1 ac-ft.

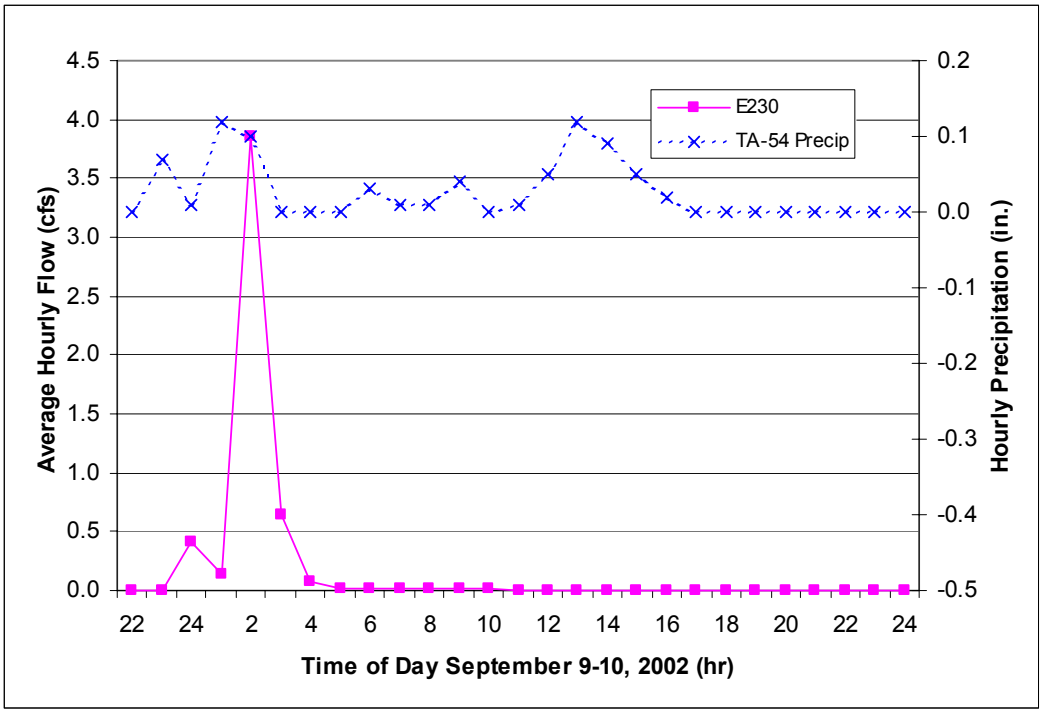

Figure A.15-6. Precipitation and runoff in Cañada del Buey on September 10, 2002.

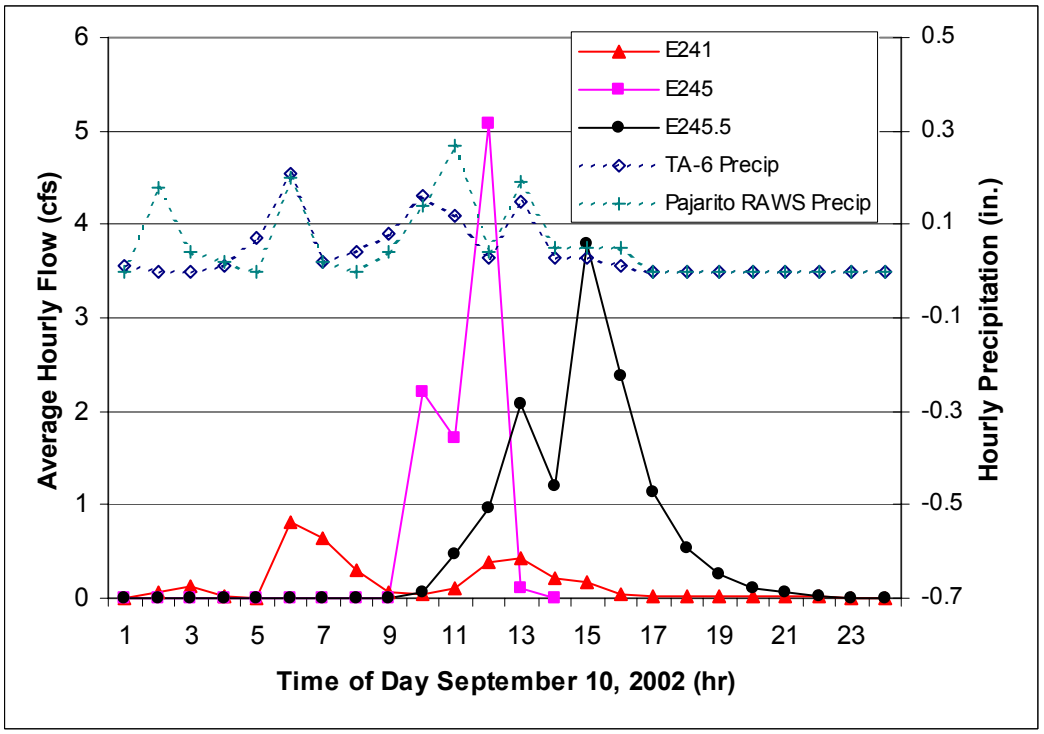

Figure A.15-7. Precipitation and runoff in upper and middle Pajarito Canyon on September 10, 2002.

Precipitation at TA-54 and runoff in lower Pajarito Canyon at gage E250 are shown in Figure A.15-8. Runoff at gage E250 began at 01:55 on the morning of September 10 in response to local precipitation. The peak flows in response to precipitation events throughout the day were 0.08 cfs at 03:10 and 0.03 cfs at 14:20 to 17:50. Runoff continued until 00:50 on the morning of September 11; the total runoff at gage E250 was about 21 cubic ft (0.05 ac-ft). The runoff in lower Pajarito Canyon on September 10 resulted from local precipitation and did not derive from runoff from the upper part of the canyon.

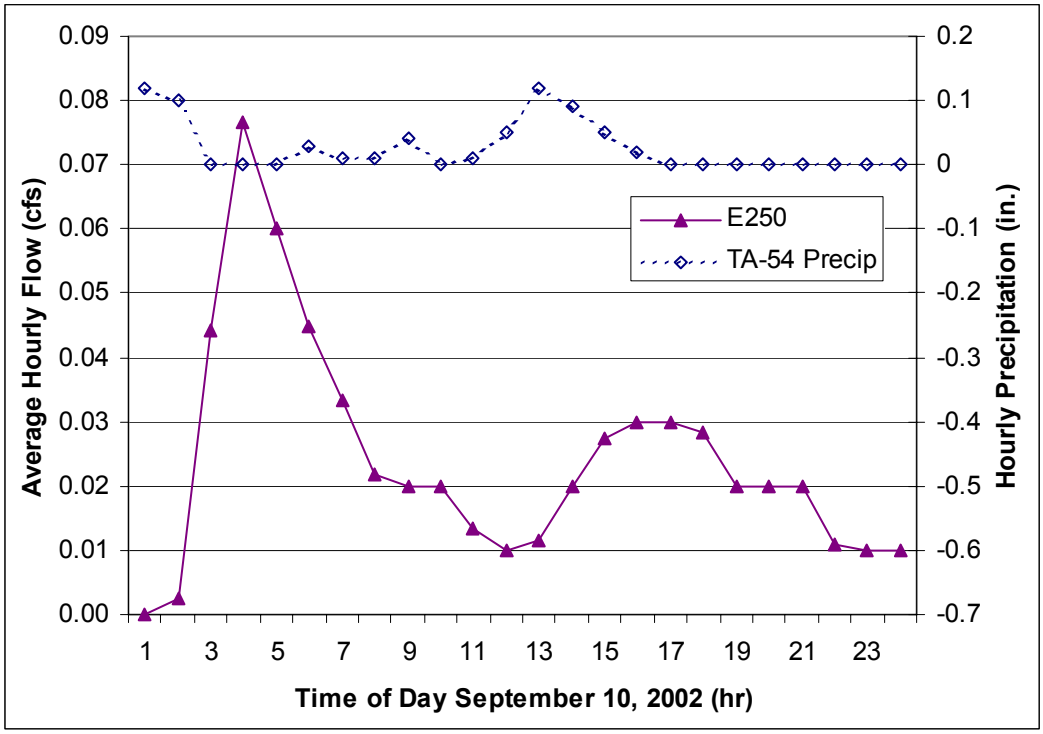

Figure A.15-8. Precipitation and runoff in lower Pajarito Canyon on September 10, 2002.

A.15.8 Water Canyon and Cañon de Valle

Precipitation and runoff in Water Canyon and Cañon de Valle on September 10, 2002, are shown in Figure A.15-9. Baseflow in upper Water Canyon at gage E252 on the morning of September 10 was 0.01 cfs. Runoff at gage E252 began at 04:50; the peak flow was 14 cfs at 05:40. Runoff at gage E252 continued until 16:15 on the afternoon of September 10 and the total runoff was about 0.35 ac-ft. Runoff in upper Cañon de Valle at gage E253 began at 04:40; the peak flow was 0.26 cfs at 06:00. Runoff continued at gage E253 until 13:20 on the afternoon of September 10 and the total runoff was about 700 cubic ft (0.02 ac-ft).

Runoff in middle Water Canyon at gage E262.5 began at 06:50 when the peak flow was 14.3 cfs. Runoff continued at gage E262.5 until 22:45 on the night of September 10 and the total runoff was about 0.87 ac-ft. Runoff in lower Water Canyon at gage E263 began at 07:50; the peak flow was 40 cfs at 08:00. Runoff continued at gage E263 until 21:50 on the night of September 10 and the total runoff was about 4.8 ac-ft. Runoff at gage E265 in lower Water Canyon began at 07:55; the peak flow was 15.6 cfs at 08:00. Runoff continued at gage E265 until 11:30 on the morning of September 11 and the total runoff was about 3.3 ac-ft.

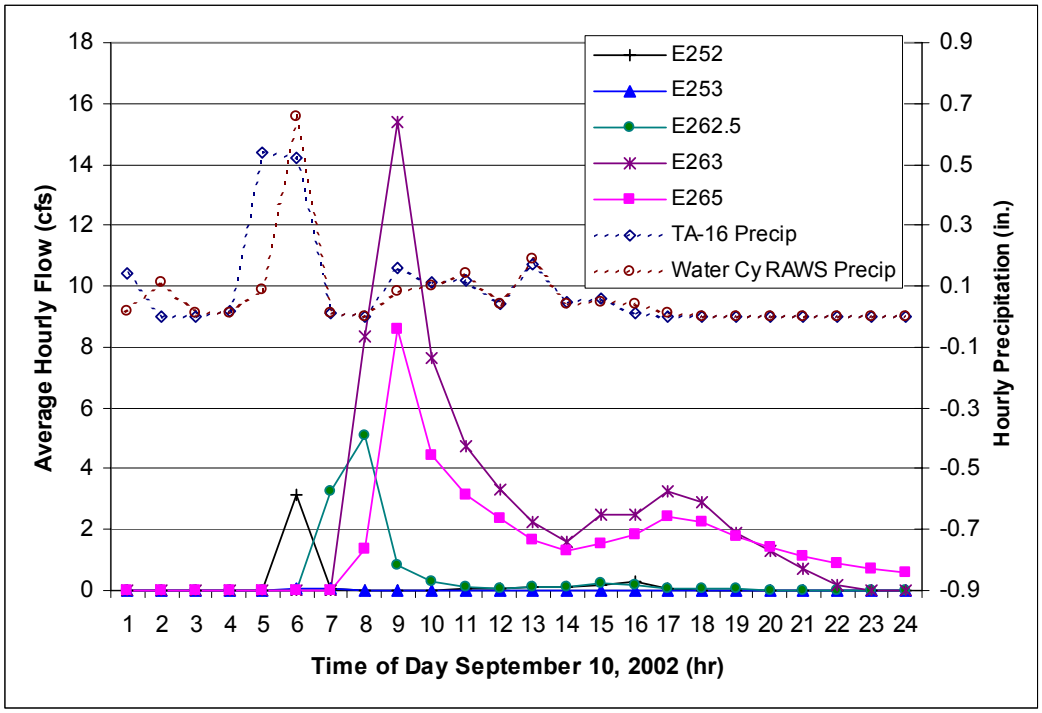

Figure A.15-9. Precipitation and runoff in Water Canyon and Cañon de Valle on September 10, 2002.

A.16 September 28, 2002

An afternoon thunderstorm occurred over the eastern part of the Pajarito Plateau on August 28, 2002. TA-49 received 0.13 in. TA-54 received 0.2 in., and TA-6 received 0.11 in. Other locations received generally less than 0.1 in. The pattern of precipitation received on the Pajarito Plateau on September 28 is shown in Figure B-16. Runoff did not occur in Guaje, Rendija, Pueblo, Los Alamos, Sandia, or Pajarito Canyons or in Cañada del Buey on September 28.

Runoff in lower Potrillo Canyon and lower Water Canyon occurred on September 28 after the thunderstorm. Precipitation and runoff in lower Water Canyon at gage E265 are shown in Figure A.16-1. Runoff at gage E265 began at 15:35 on the afternoon of September 28; the peak flow was 29.4 cfs at 15:50. Runoff continued until 17:00 on the afternoon of September 28 and the total runoff in lower Water Canyon was about 0.5 ac-ft. Runoff did not occur at gage E263 in lower Water Canyon, thus the runoff was from local precipitation.

A.17 October 23 and 24, 2002

Light rain showers occurred throughout the day on October 23 and during the morning of October 24, 2002. On October 23, precipitation was heaviest in the upper Los Alamos Canyon/Quemazon Canyon area where the upper Los Alamos Canyon RAWS site received 0.61 in. and the Quemazon RAWS site received 0.5 in.; and in the southern and eastern parts of the Pajarito Plateau, where the Frijolito station received 0.64 in. and TA-54 received 0.28 in. The TA-6 meteorological station received 0.28 in. The pattern of precipitation received on the Pajarito Plateau on October 23, 2002, is shown in Figure B-17.

A similar pattern of precipitation occurred on October 24, 2002. The highest precipitation (0.31 in.) was received at the Bandelier Frijolito station. Precipitation over most of LANL was about 0.1 to 0.17 in. on October 24. The pattern of precipitation received on October 24 is shown in Figure B-18. Significant volumes of runoff did not occur in Pajarito Canyon or Water Canyon and Cañon de Valle on October 23 and 24.

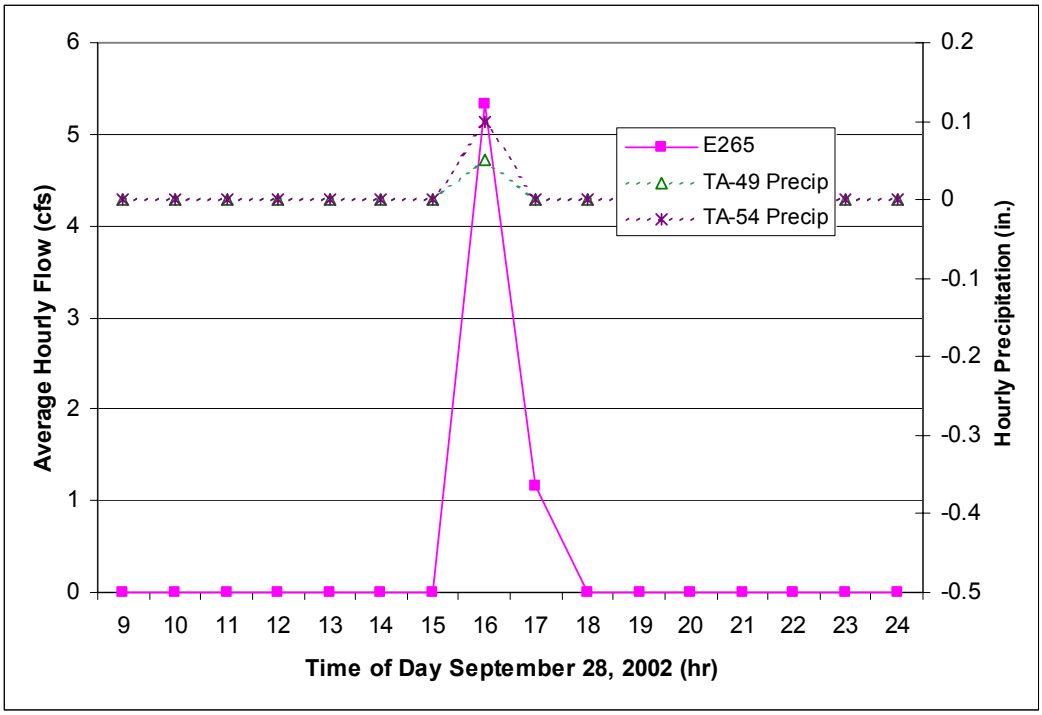

Figure A.16-1. Precipitation and runoff in Water Canyon on September 28, 2002.

A.17.1 Guaje Canyon

Precipitation and runoff in Guaje Canyon on October 23 and 24, 2002, are shown in Figure A.17-1. Four episodes of runoff occurred in response to precipitation activity over these two days. Runoff began in Guaje Canyon at gage E089 at 01:30 on the morning of October 23; the peak flow of the first runoff event was 18.7 cfs at 01:35. The second runoff event began at 16:35 with a peak flow of 12.1 cfs. The third runoff event began at 02:20 on the morning of October 24; the peak flow was 20.6 cfs at 02:40. The fourth runoff event began at 13:05 on the afternoon of October 24; the peak flow was 4.33 cfs at 17:00 during the afternoon, and runoff continued until 02:35 on the morning of October 25. The total runoff in Guaje Canyon at gage E089 on October 23 and 24 was about 9.5 ac-ft. Runoff did not occur in lower Rendija Canyon at gage E090 on October 23 or 24.

A.17.2 Los Alamos and DP Canyons

Precipitation and runoff in Los Alamos Canyon are shown in Figure A.17-2. Runoff in upper Los Alamos Canyon at gage E026 was intermittent throughout the day on October 23 and the morning on October 24. Runoff began at gage E026 at 12:35 on the afternoon of October 23 and continued intermittently until 06:50 on the morning of October 24. The peak flow was 0.1 cfs at 01:00 on the morning of October 24 and the total runoff was about 0.02 ac-ft.

Runoff in middle Los Alamos Canyon at gage E030 began at 14:10 on the afternoon of October 24 when the peak flow was 4.4 cfs. Runoff continued at gage E030 until 15:10 on the afternoon of October 24 and the total runoff was about 0.08 ac-ft. Runoff did not occur in lower Los Alamos Canyon at gage E042 on October 23 or 24.

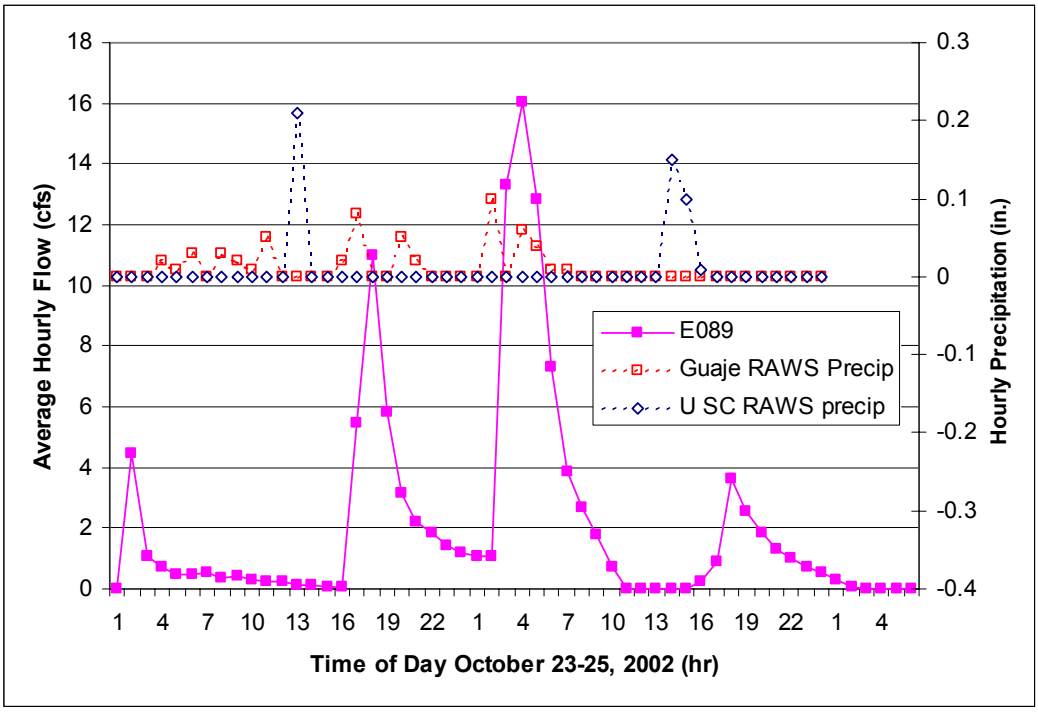

Figure A.17-1. Precipitation and runoff in Guaje Canyon on October 23 through 25, 2002.

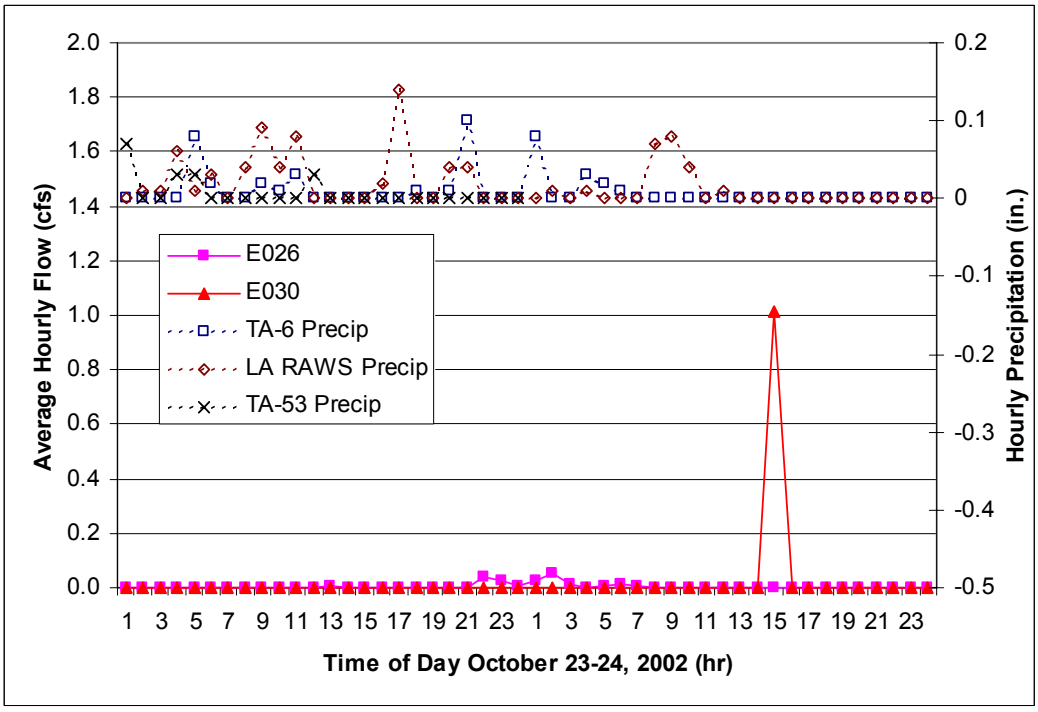

Figure A.17-2. Precipitation and runoff in Los Alamos Canyon on October 23 and 24, 2002.

Precipitation and runoff in DP Canyon on October 23 and 24, 2002, are shown in Figure A.17-3. Runoff in upper DP Canyon at gage E038 responded intermittently to intervals of precipitation and began at 04:40 on the morning of October 23 with a peak flow of 5.5 cfs. Another runoff event began at 21:10 and continued for about 15 minutes with a peak flow of 1.2 cfs. Another runoff event began at 00:35 on the morning of October 24 when the peak flow was 35 cfs. Runoff continued until 00:50 and the total runoff at gage E038 on October 23 and 24 was about 0.45 ac-ft.

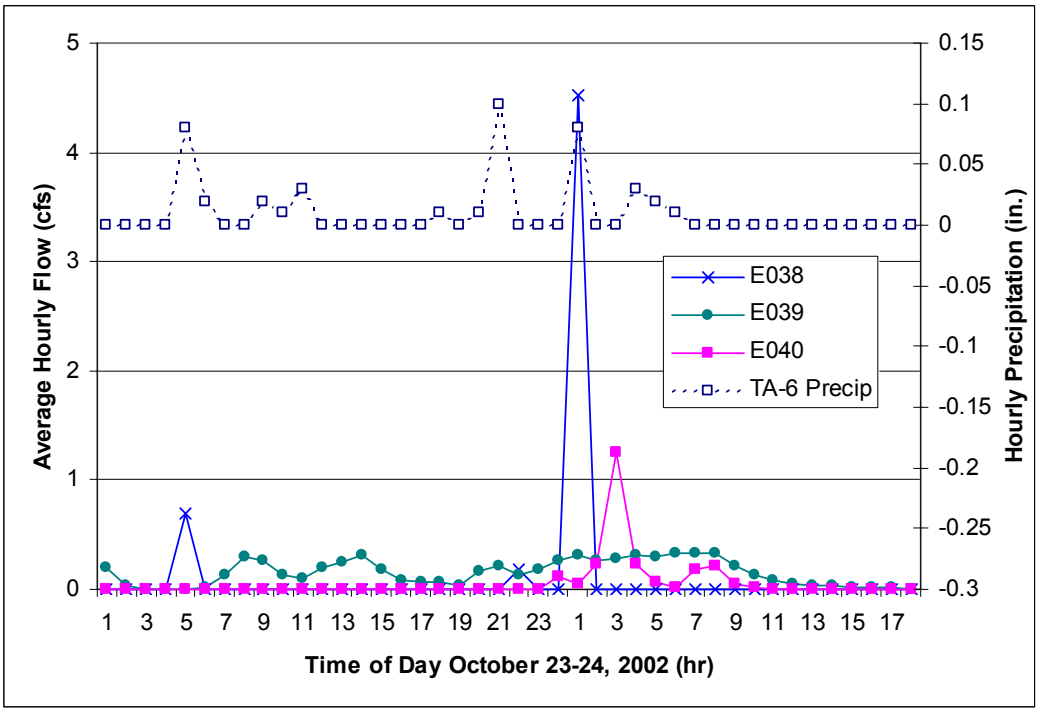

Figure 4.17-3. Precipitation and runoff in DP Canyon on October 23 and 24, 2002.

Runoff in middle DP Canyon at gage E039 began at 05:30 on the morning of October 23; peak flow was 0.33 cfs, which occurred several times throughout October 23 and 24. The runoff at gage E039 continued until 18:05 on the evening of October 24 and the total runoff was about 0.5 ac-ft.

Runoff in lower DP Canyon at gage E040 began at 23:20 on the night of October 23; peak flow was 2.7 cfs at 02:00 on the morning of October 24. Runoff continued at gage E040 until 09:55 on the morning of October 24 and the total runoff was about 0.2 ac-ft.

A.17.3 Mortandad Canyon

Precipitation and runoff in Mortandad Canyon at gage E200 are shown in Figure A.17-4. Baseflow in middle Mortandad Canyon was about 0.05 cfs on the morning of October 23. Runoff occurred in seven episodes in response to precipitation on October 23 and 24. Runoff at gage E200 began at 04:55 on the morning of October 23; the peak flow was 1 cfs at 08:45. Runoff continued in episodes until about 09:45 on the morning of October 24 and the total runoff and baseflow was about 0.5 ac-ft.

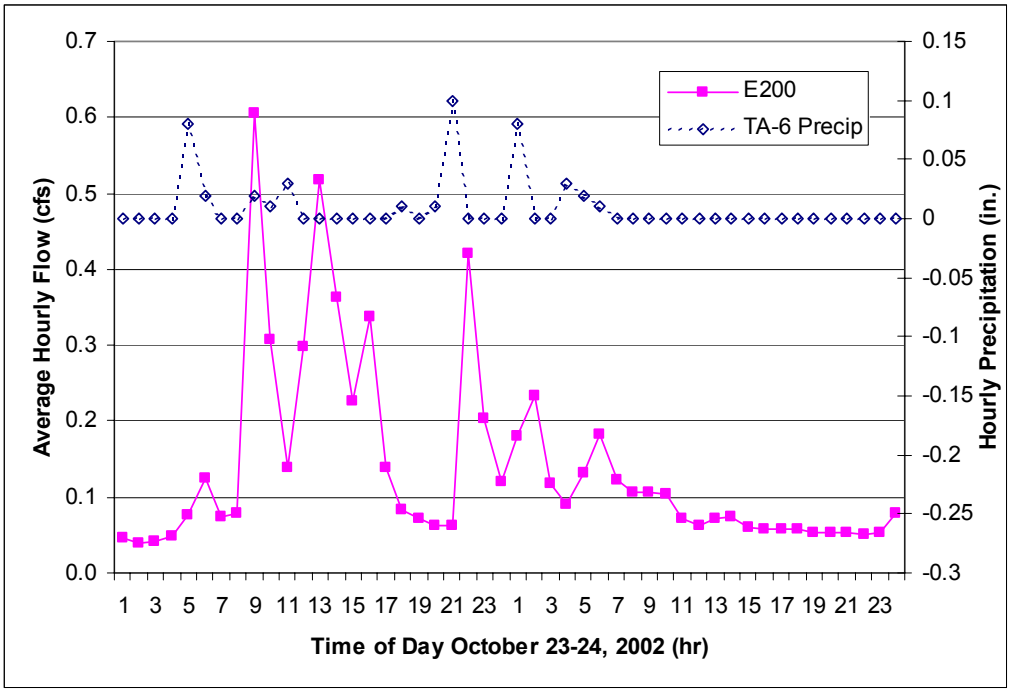

Figure A.17-4. Precipitation and runoff in Mortandad Canyon on October 23 and 24, 2002.

A.17.4 Cañada del Buey

Precipitation and runoff in Cañada del Buey on October 23, 2002, are shown in Figure A.17-5. Runoff in lower Cañada del Buey at gage E230 began at 17:55 on the afternoon of October 23; the peak flow was 0.15 cfs at 18:20. Runoff continued until 18:55 and the total runoff was about 0.01 ac-ft. Runoff did not occur in upper Cañada del Buey at gage E218 on October 23 and 24.

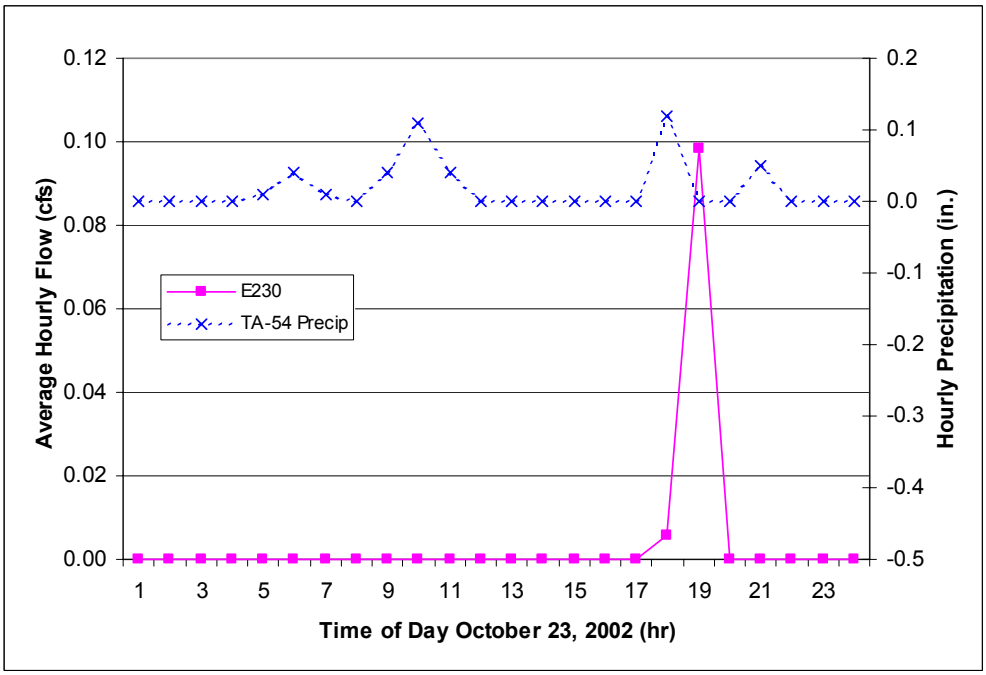

Figure A.17-5. Precipitation and runoff in Cañada del Buey on October 23, 2002.

Appendix B. Figures Showing the Pattern of Precipitation in 2002 on Days of Significant Runoff

Daily precipitation data used to create the following precipitation isopleth maps were obtained from the following sources.

- The Laboratory Meteorology and Air Quality Group (RRES-MAQ) maintains precipitation data for several Los Alamos National Laboratory area meteorological stations at their web page located at www.weather.lanl.gov

- The Desert Research Institutes (DRI) Remote Area Weather Stations (RAWS) are provided through interagency cooperation of the Bureau of Land Management, National Interagency Fire Center, and the Western Region Climate Center. The data are available at the DRI web site at http://www.wrcc.dri.edu/losalamos/

- The Bandelier National Monument provided precipitation data for one station, called Frijolito, located at the main monument headquarters. Thanks to Kay Beeley of the National Park Service for providing these data.

- Rainfall data from a privately owned and maintained meteorological station located in the Pajarito Acres subdivision of White Rock, called the OooWoo Kennel, were also used in construction of some of the precipitation pattern maps. Thanks to Stephen Lee who is the owner and operator of this meteorological station. Meteorological data for the OooWoo Kennel are available at the following web sites: http://www.ooowoo.com/WEATHER/Current_Vantage_Pro_Plus.htm and http://www.wunderground.com/weatherstation/WXDailyHistory.asp?ID=KNMLOSAL1.

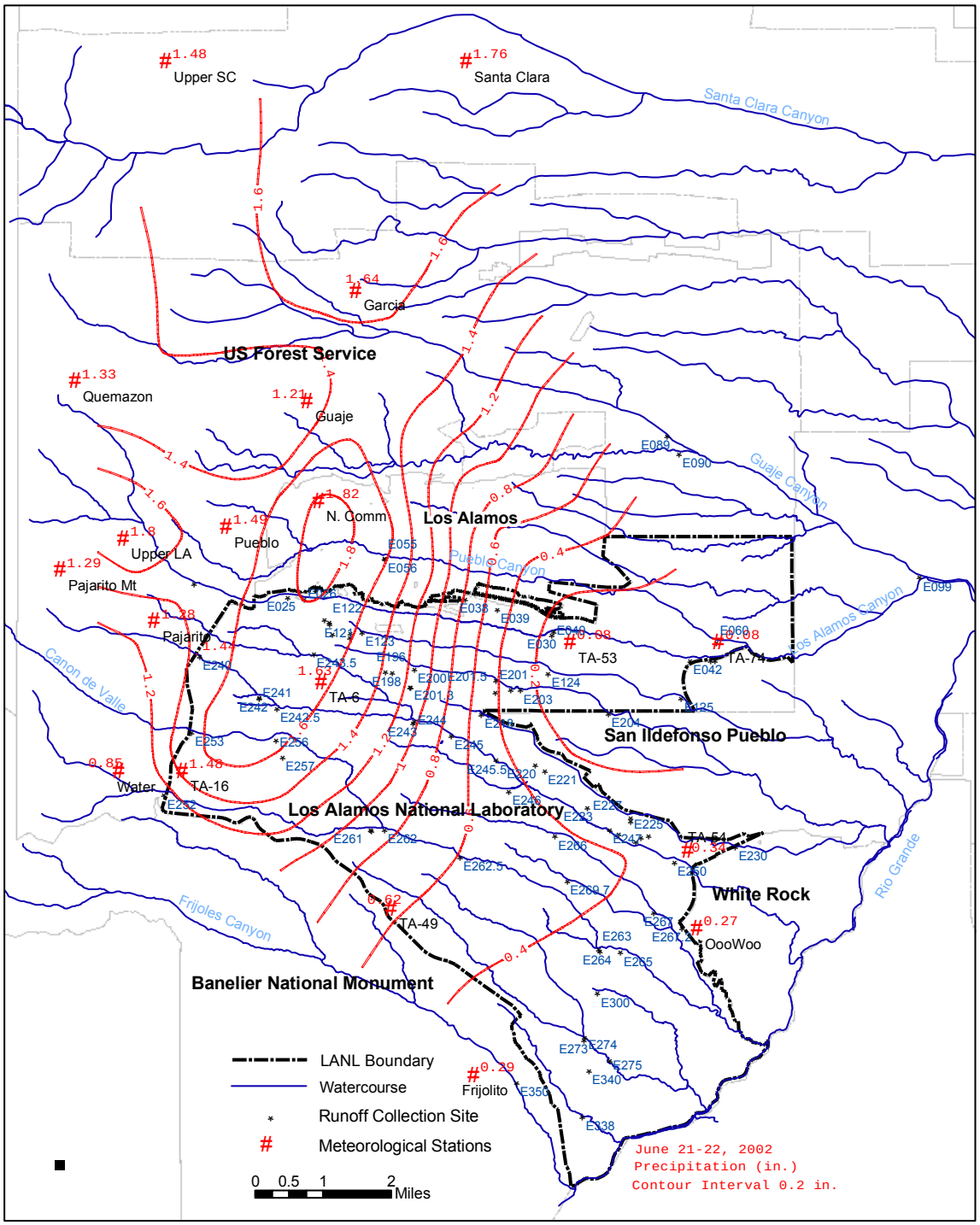

Figure B-1. Pattern of precipitation recorded on the Pajarito Plateau on the night of June 21 and 22, 2002.

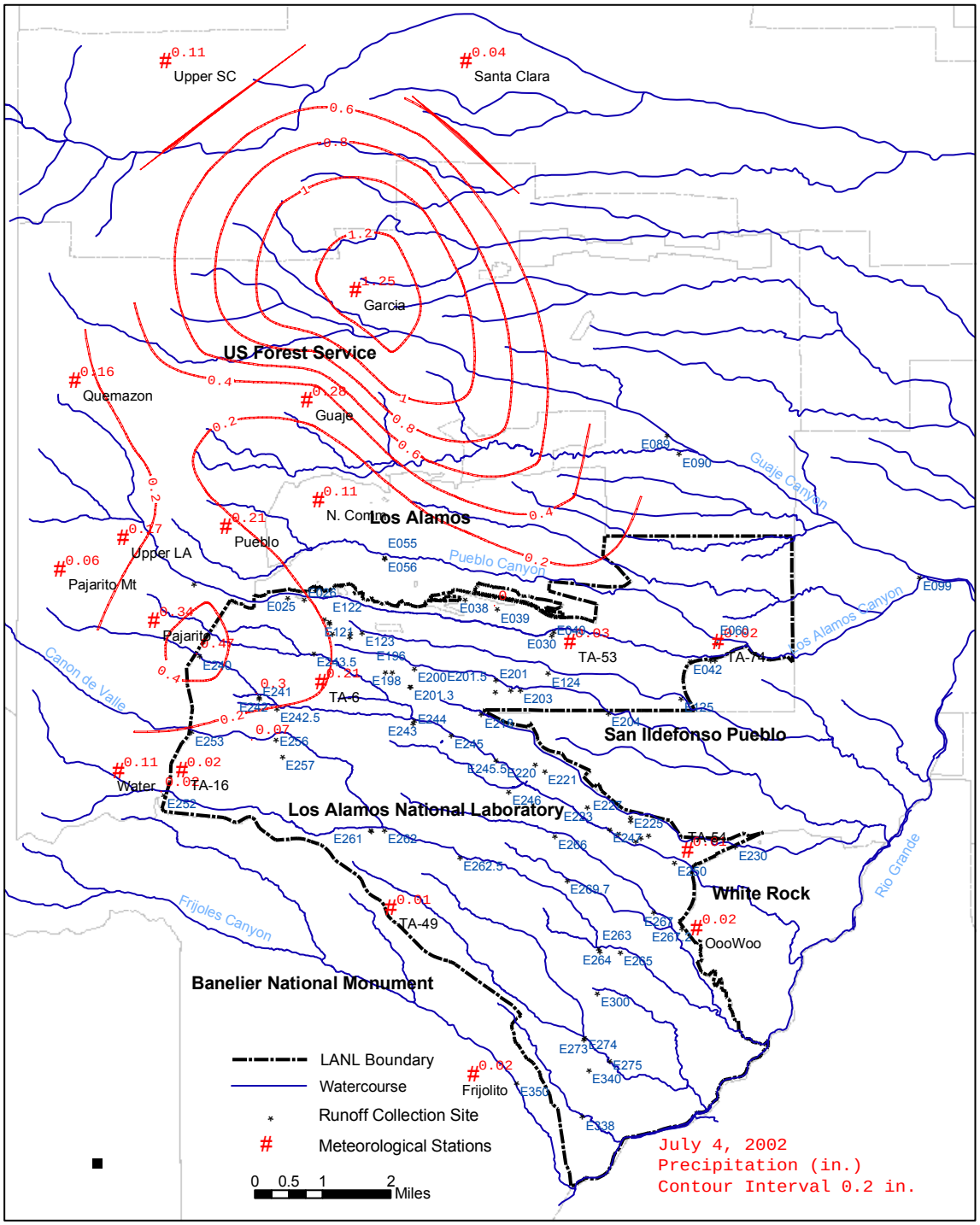

Figure B-2. Pattern of precipitation recorded on the Pajarito Plateau on July 4, 2002.

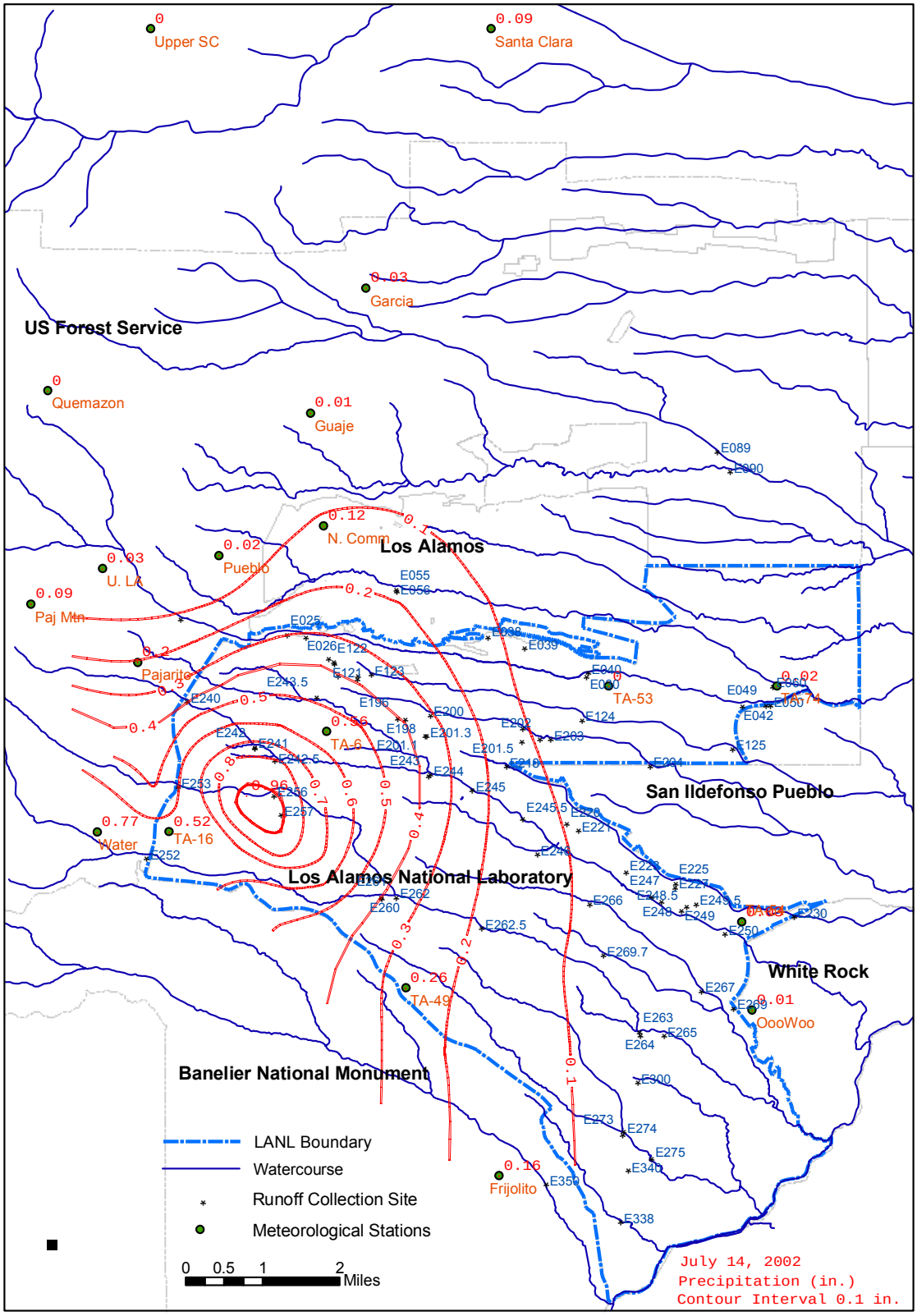

Figure B-3. Pattern of precipitation recorded on the Pajarito Plateau on July 14, 2002.

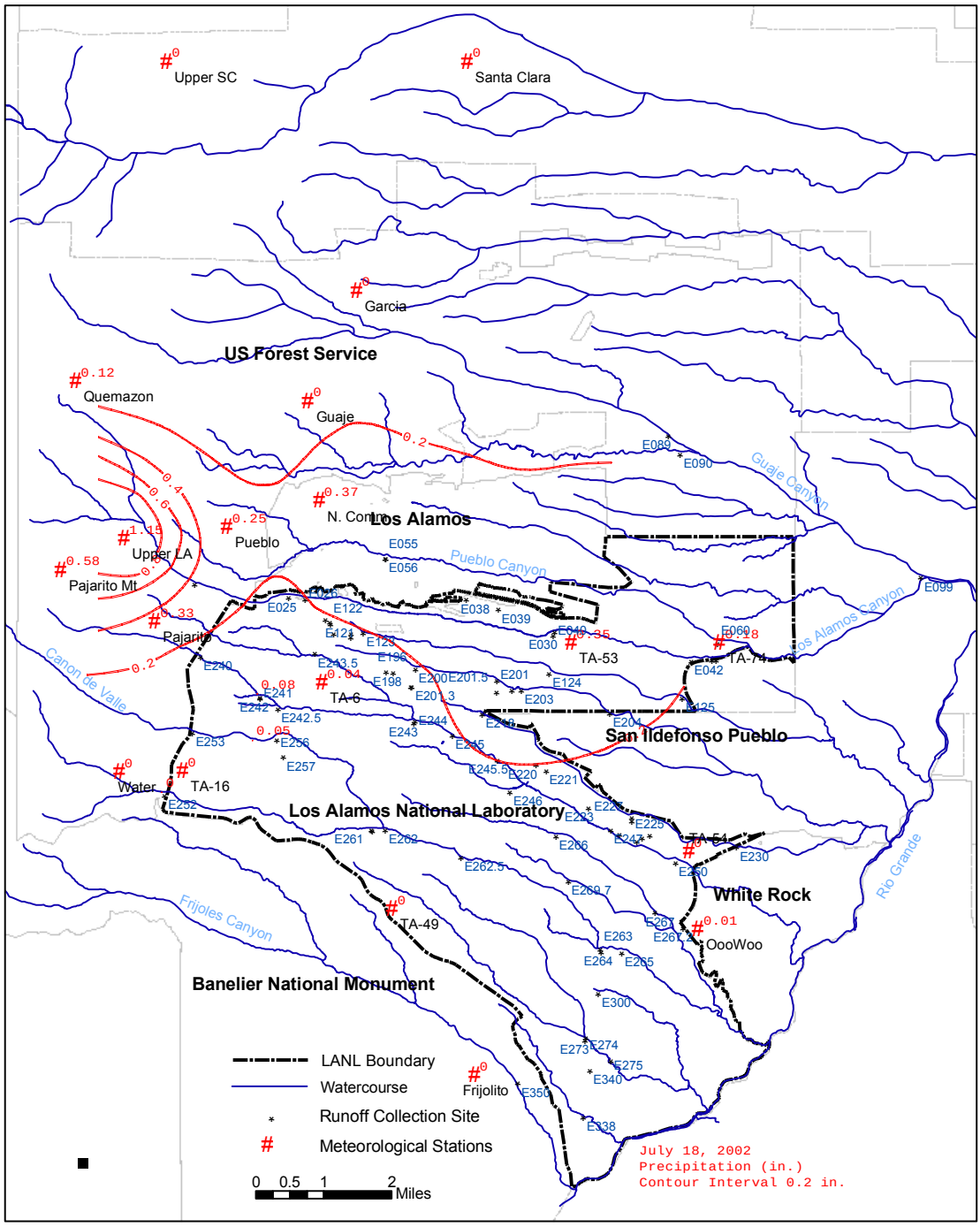

Figure B-4. Pattern of precipitation recorded on the Pajarito Plateau on July 18, 2002.

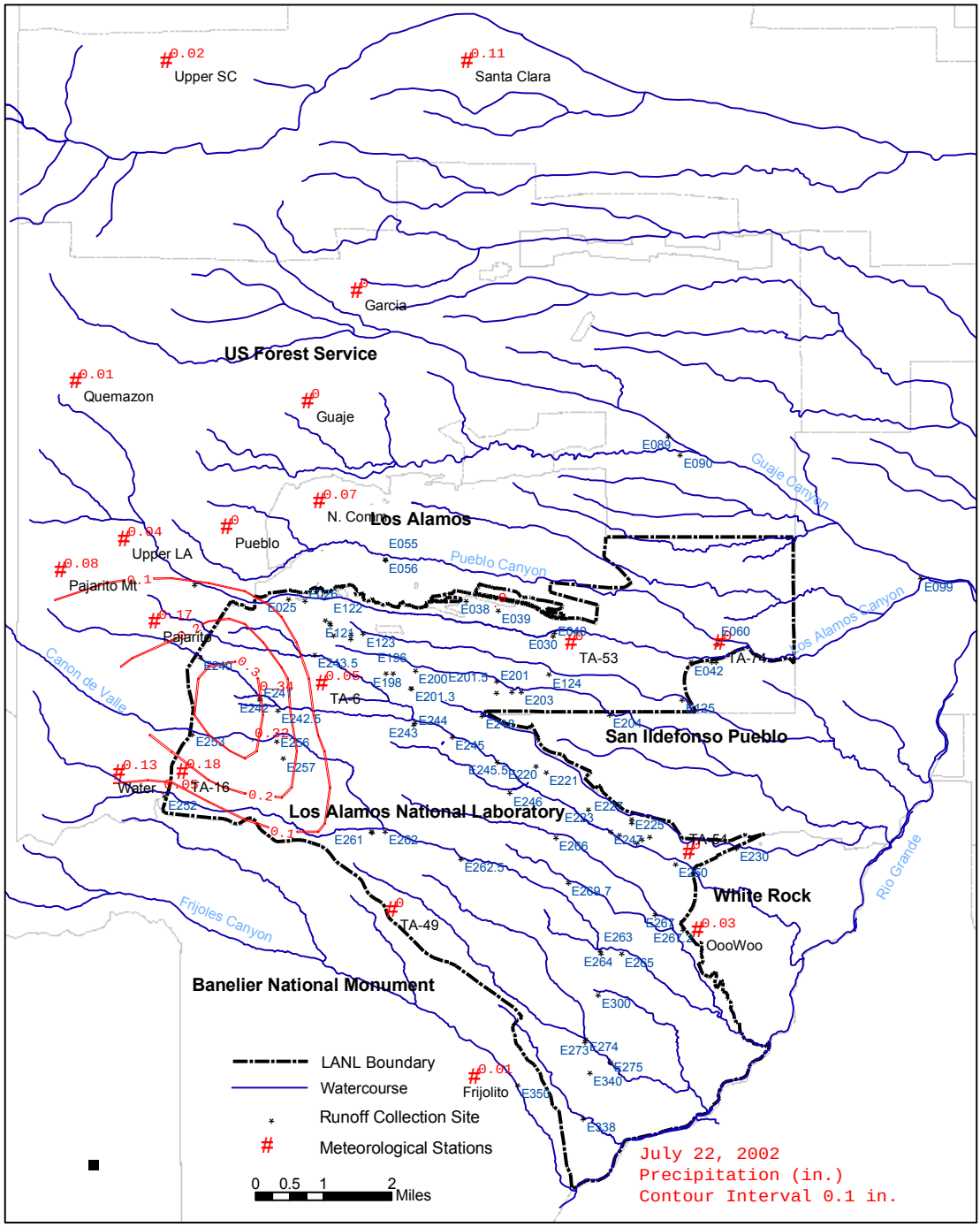

Figure B-5. Pattern of precipitation recorded on the Pajarito Plateau on July 22, 2002.

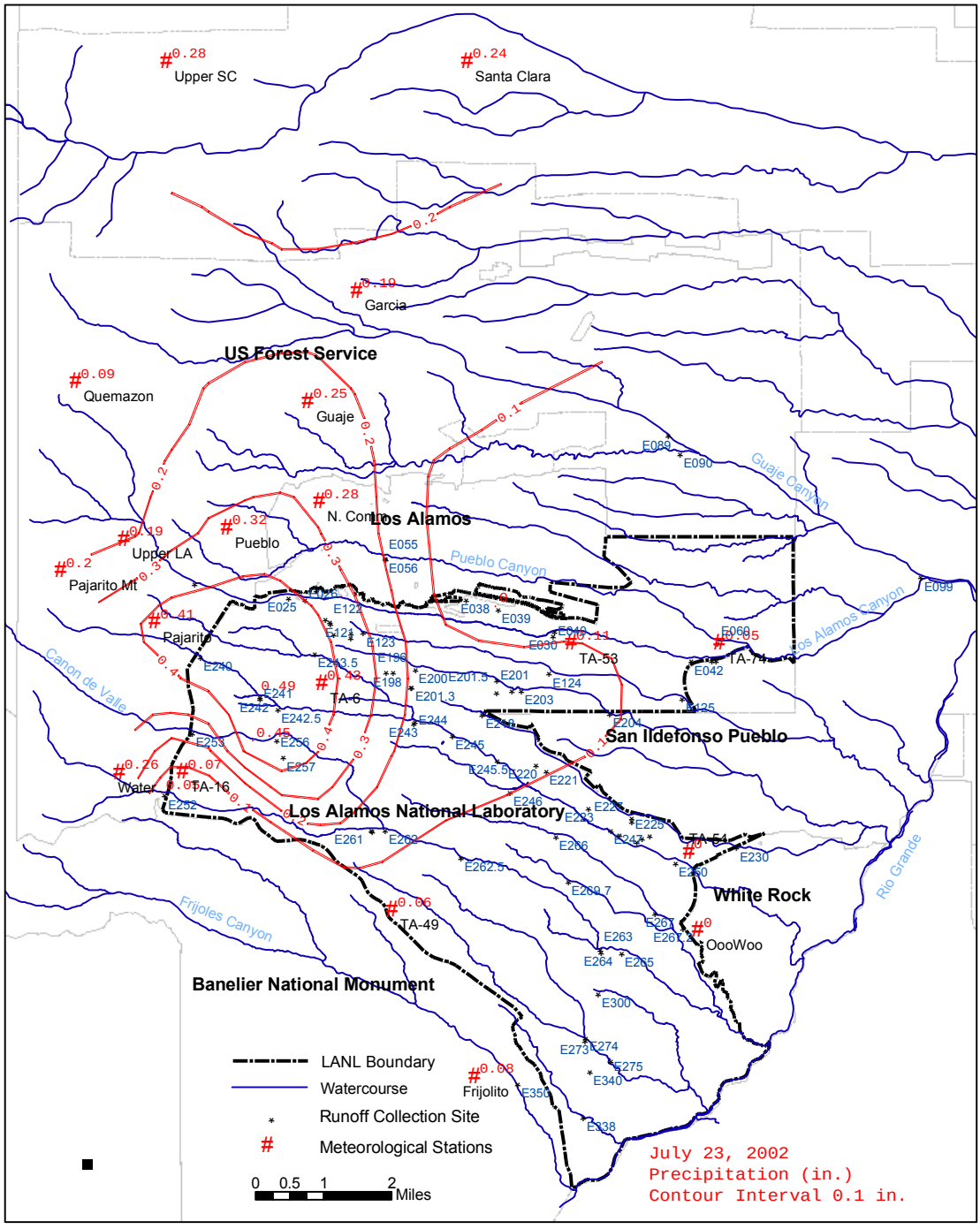

Figure B-6. Pattern of precipitation recorded on the Pajarito Plateau on July 23, 2002.

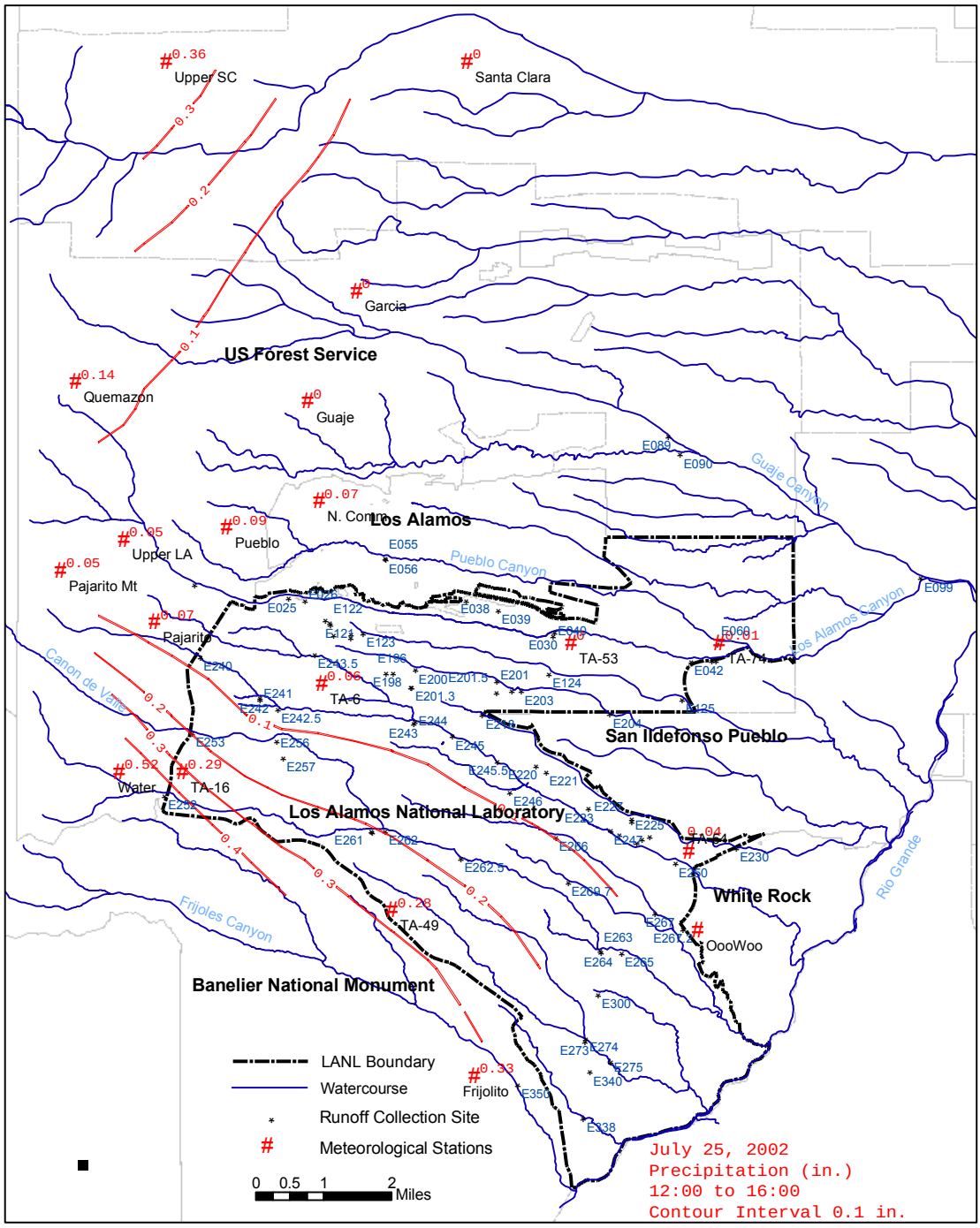

Figure B-7a. Pattern of precipitation recorded on the Pajarito Plateau on the afternoon of July 25, 2002, 12:00 to 16:00.

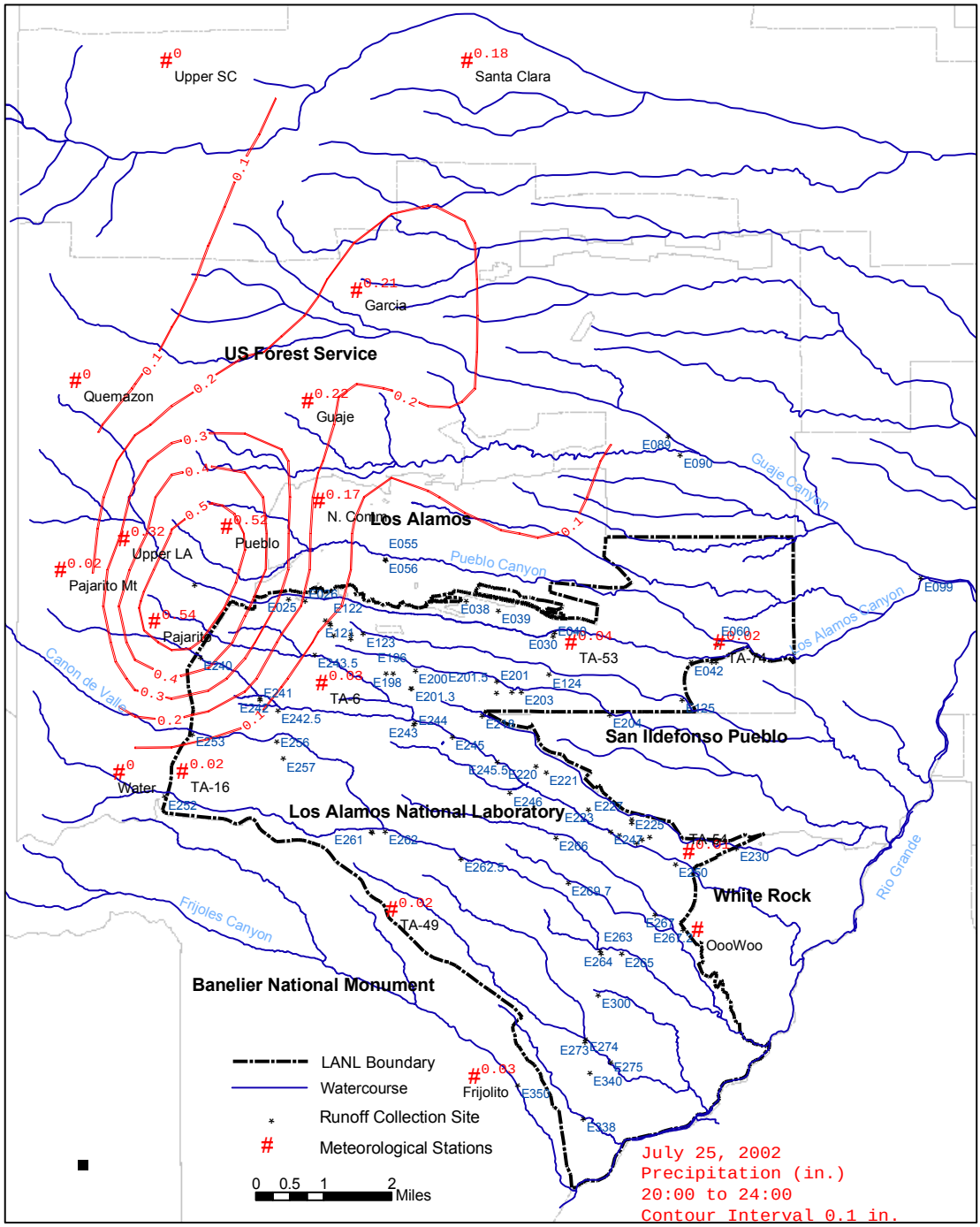

Figure B-7b. Pattern of precipitation recorded on the Pajarito Plateau on the night of July 25, 2002, 20:00 to 24:00.

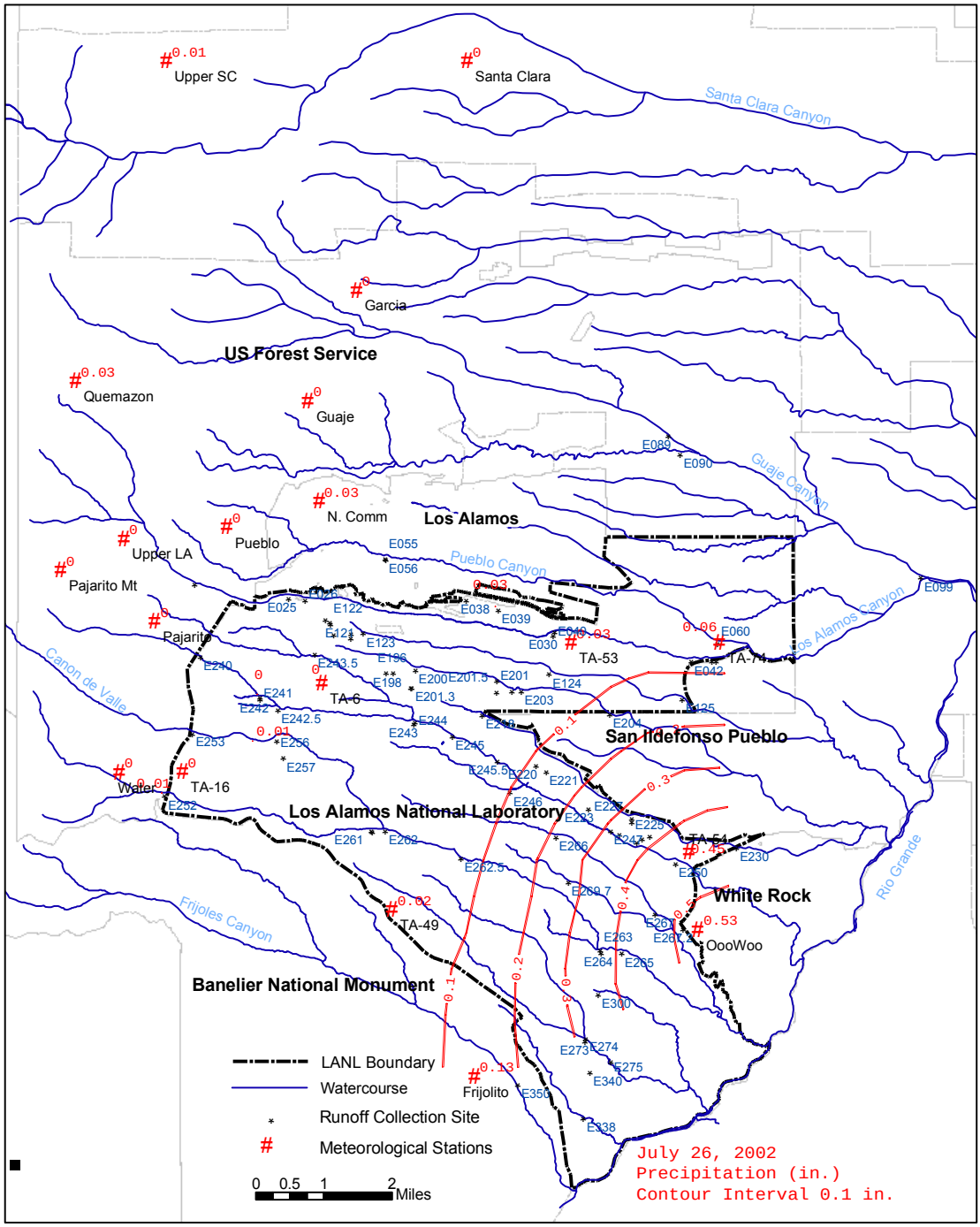

Figure B-8. Pattern of precipitation recorded on the Pajarito Plateau on July 26, 2002.

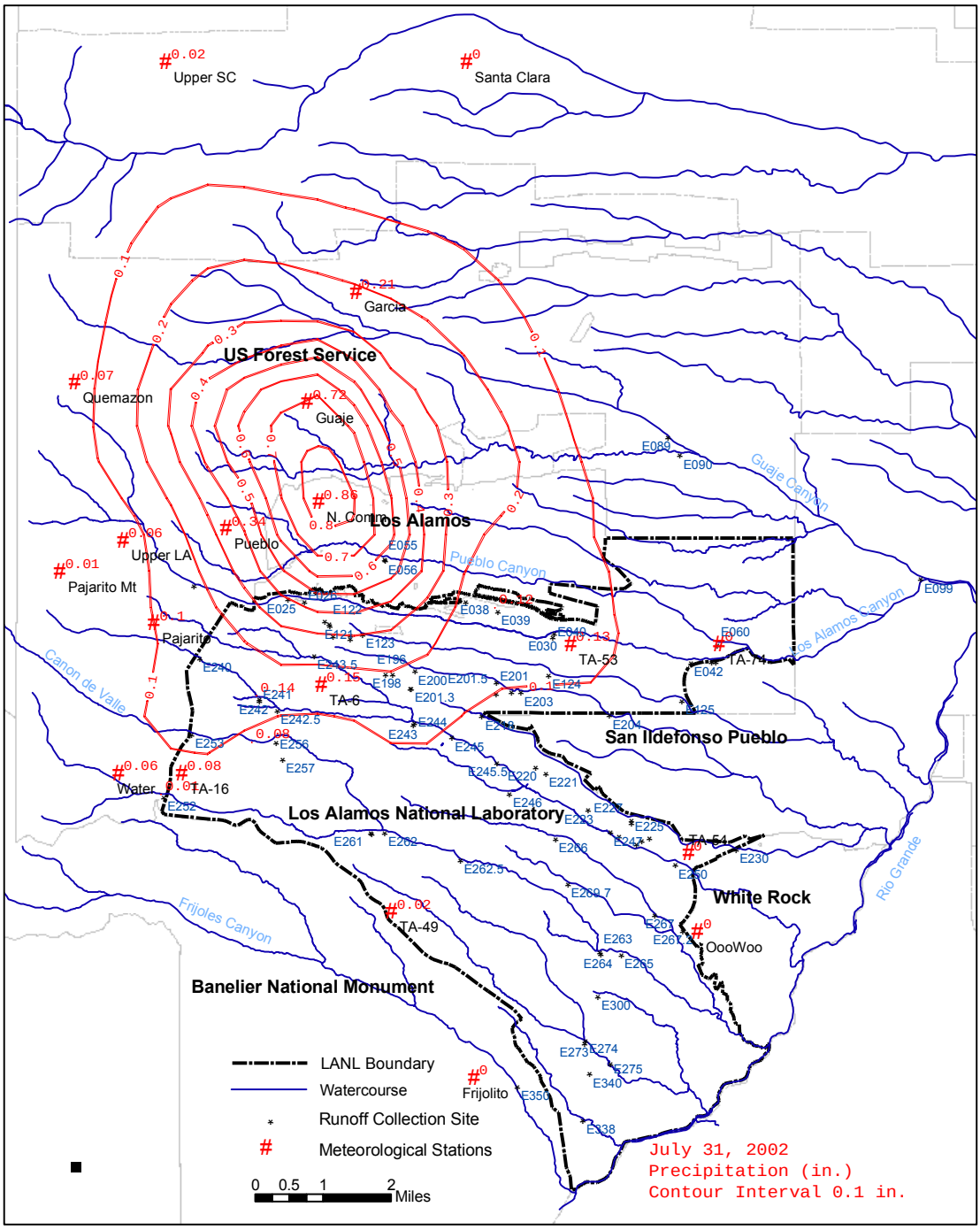

Figure B-9. Pattern of precipitation recorded on the Pajarito Plateau on July 31, 2002.

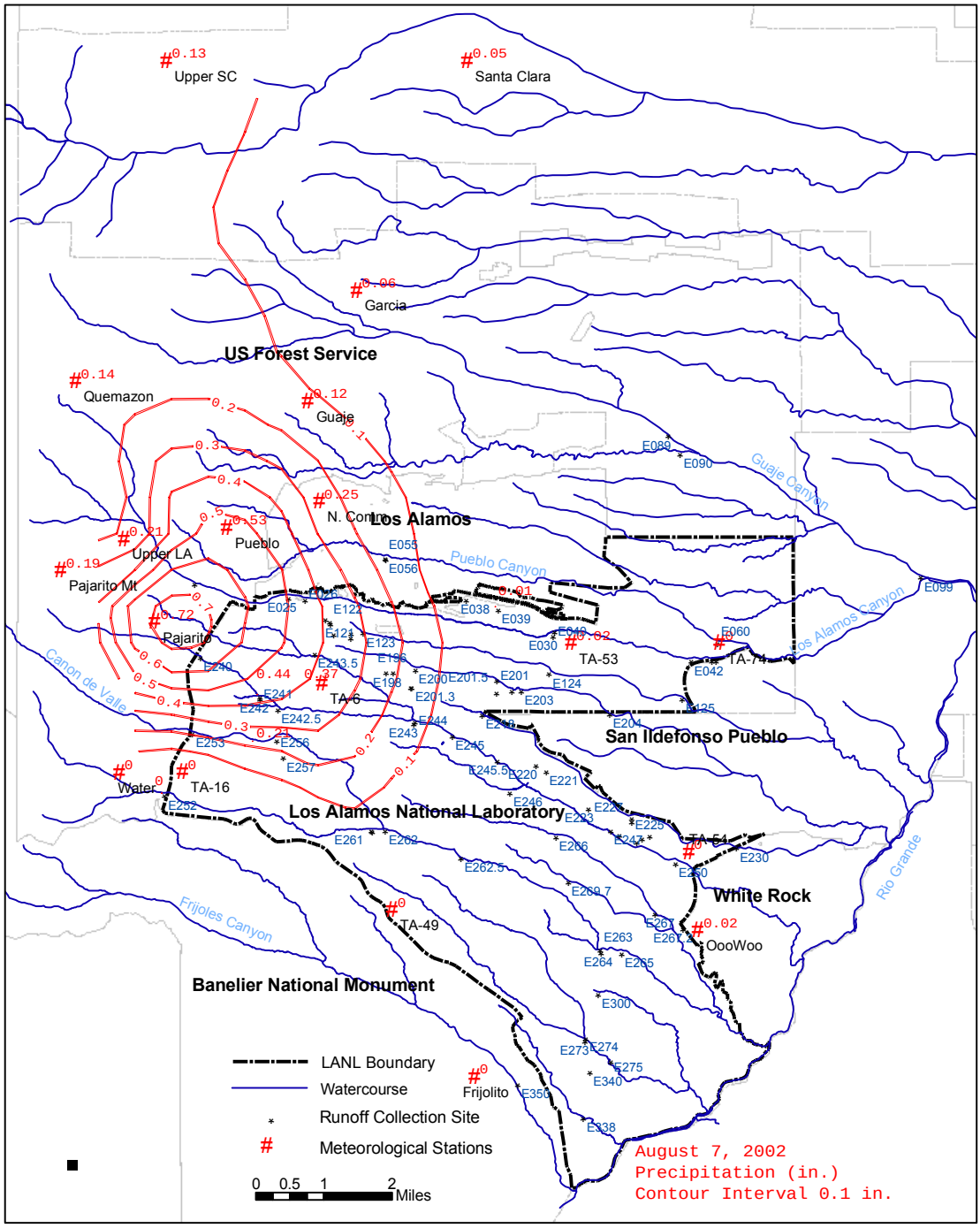

Figure B-10. Pattern of precipitation recorded on the Pajarito Plateau on August 7, 2002.

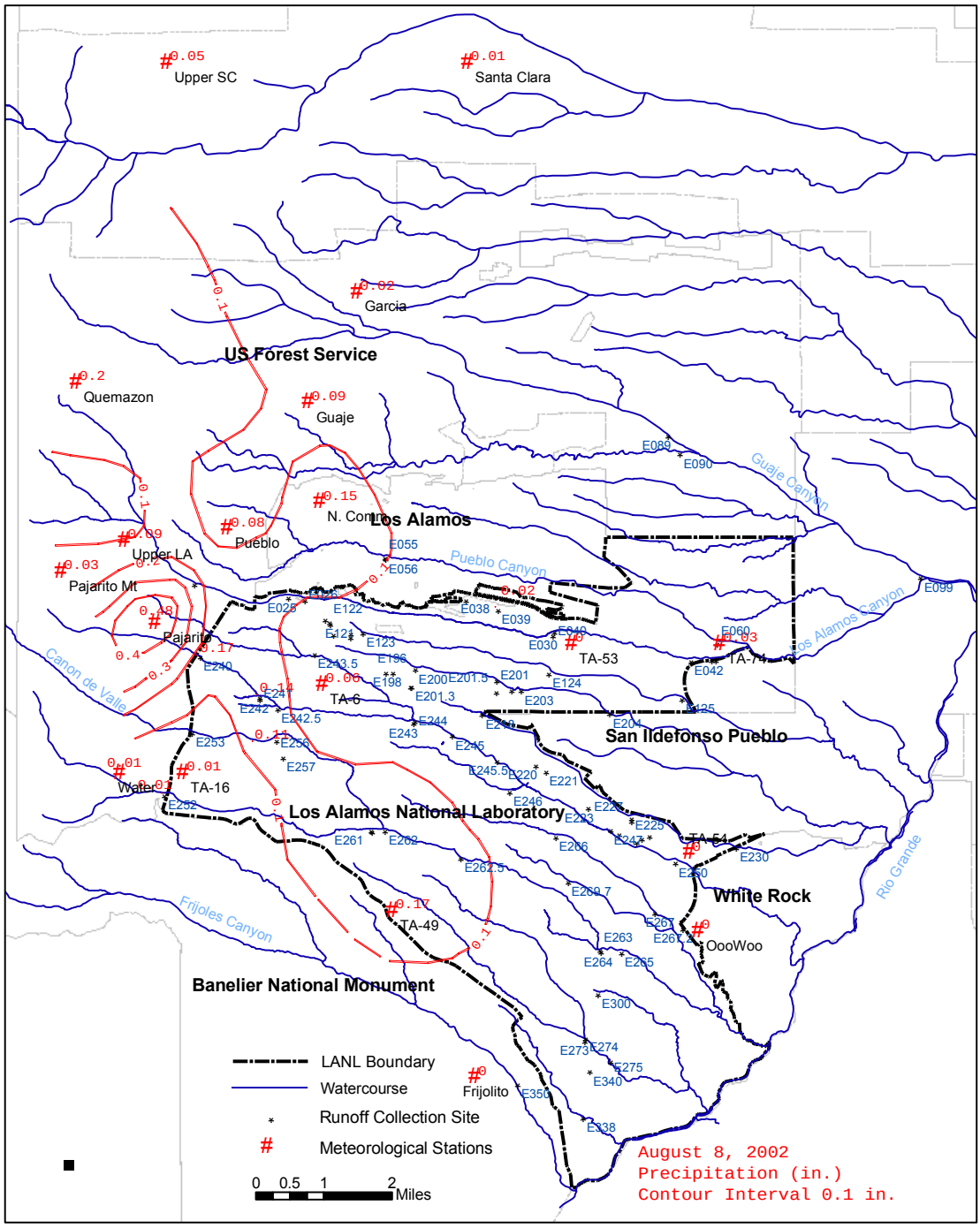

Figure B-11. Pattern of precipitation recorded on the Pajarito Plateau on August 8, 2002.

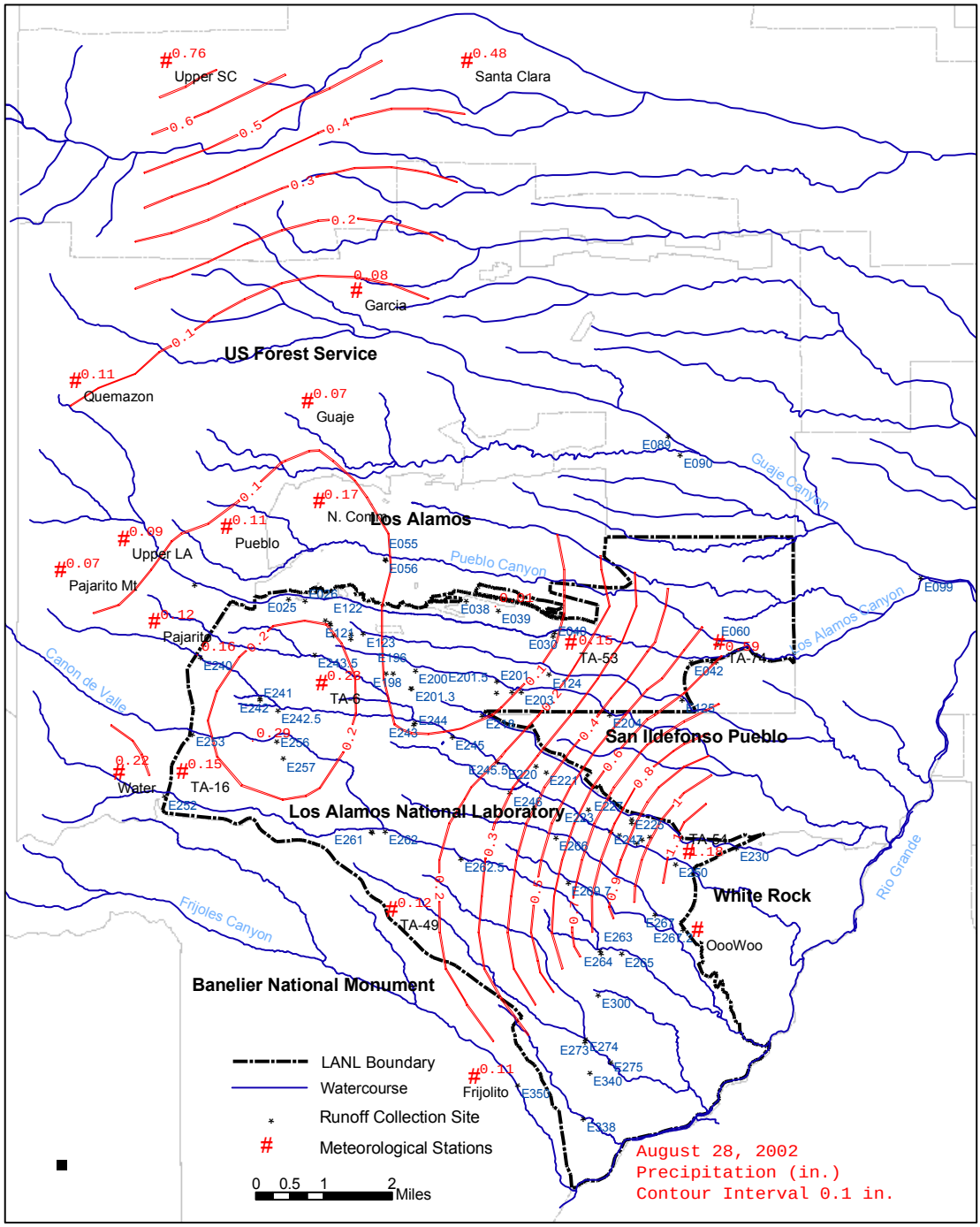

Figure B-12. Pattern of precipitation recorded on the Pajarito Plateau on August 28, 2002.

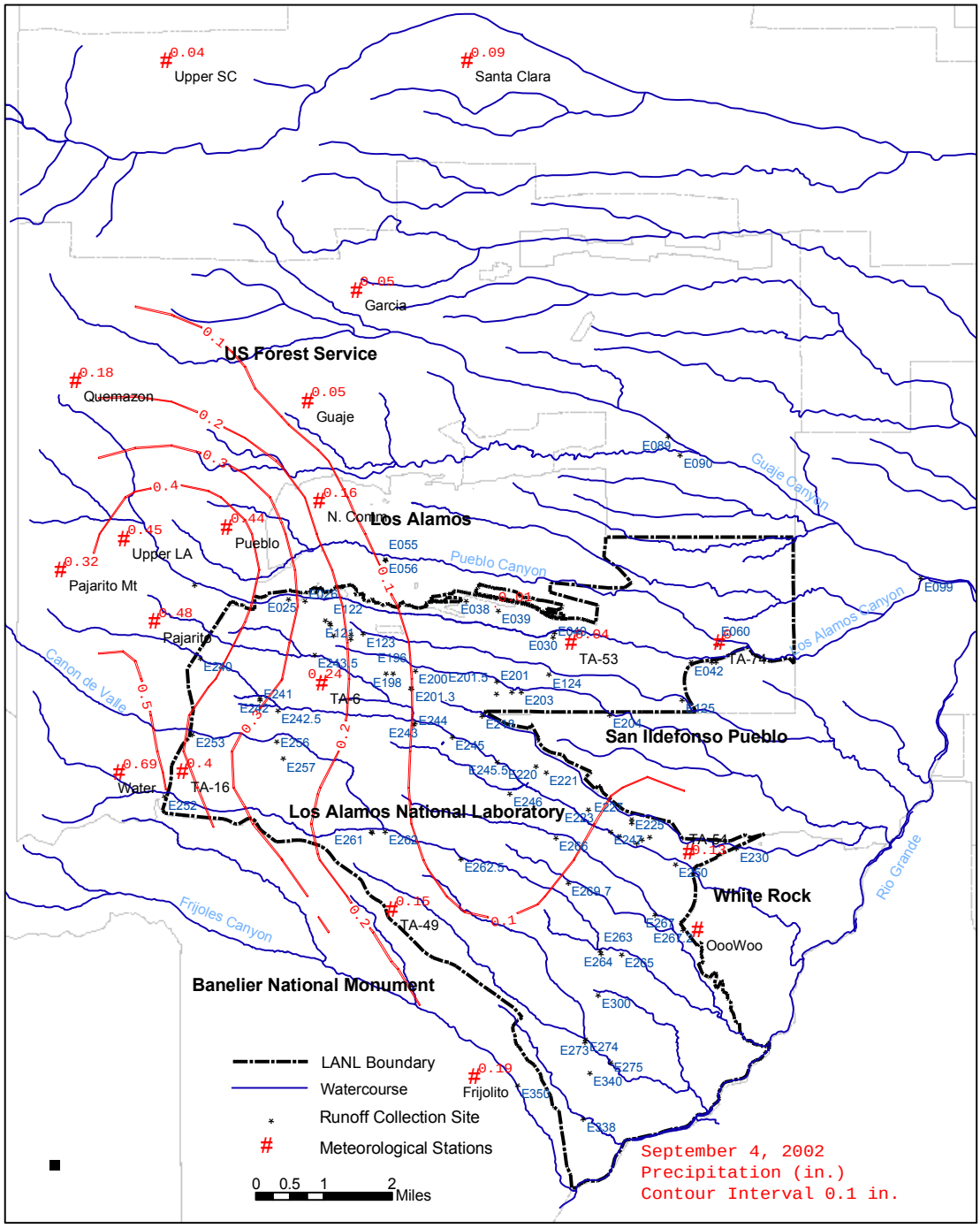

Figure B-13. Pattern of precipitation recorded on the Pajarito Plateau on September 4, 2002.

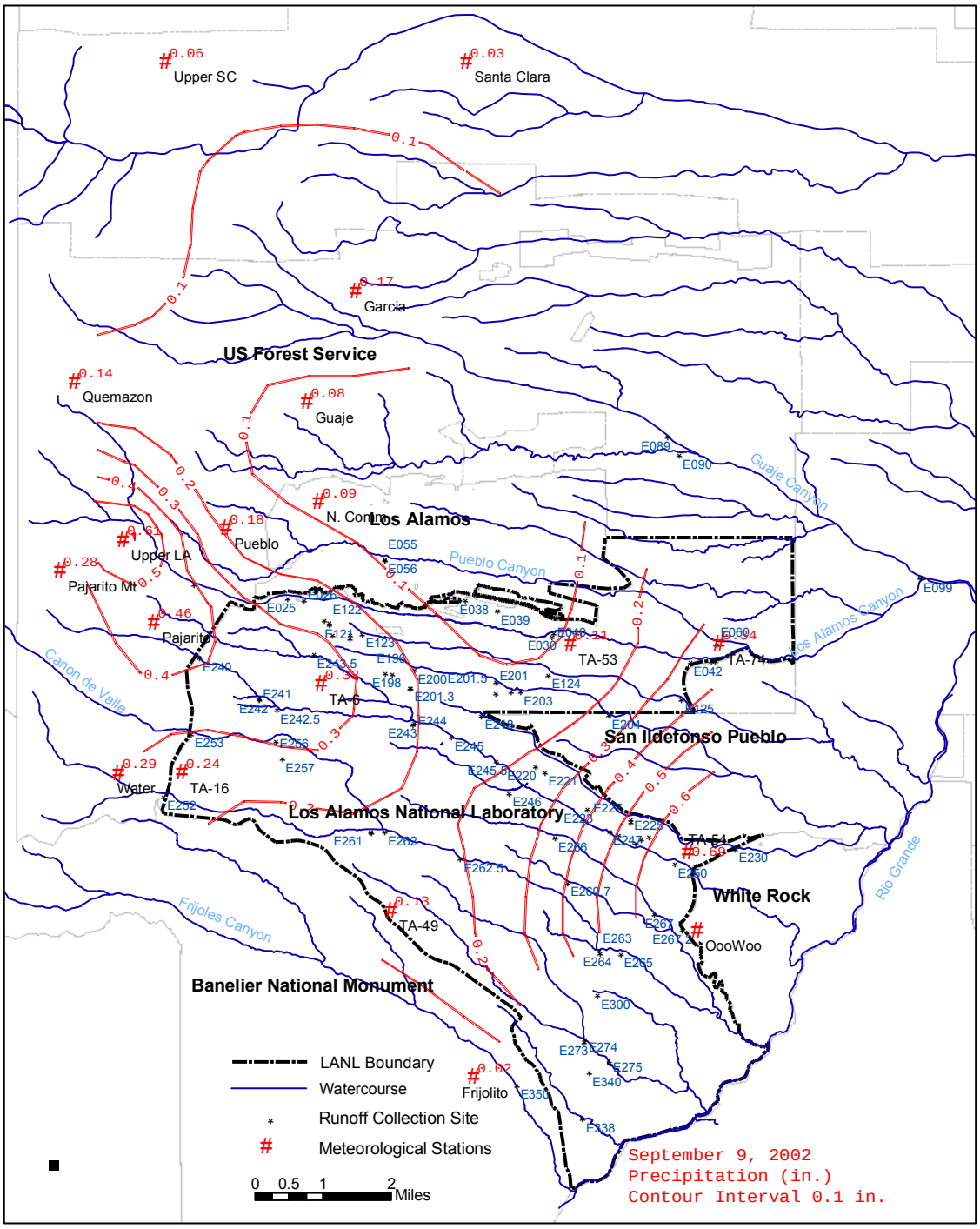

Figure B-14. Pattern of precipitation recorded on the Pajarito Plateau on September 9, 2002.

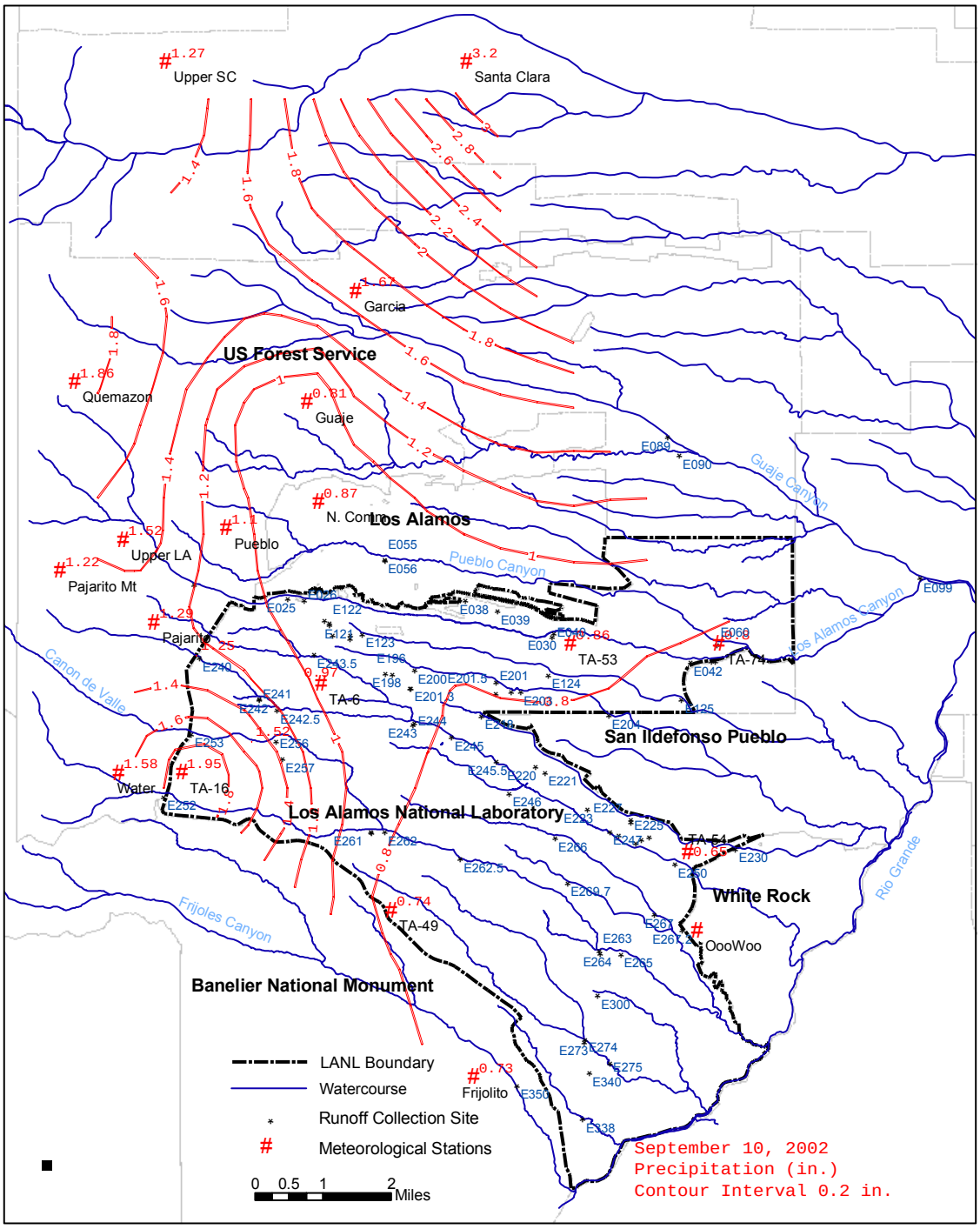

Figure B-15. Pattern of precipitation recorded on the Pajarito Plateau on September 10, 2002.

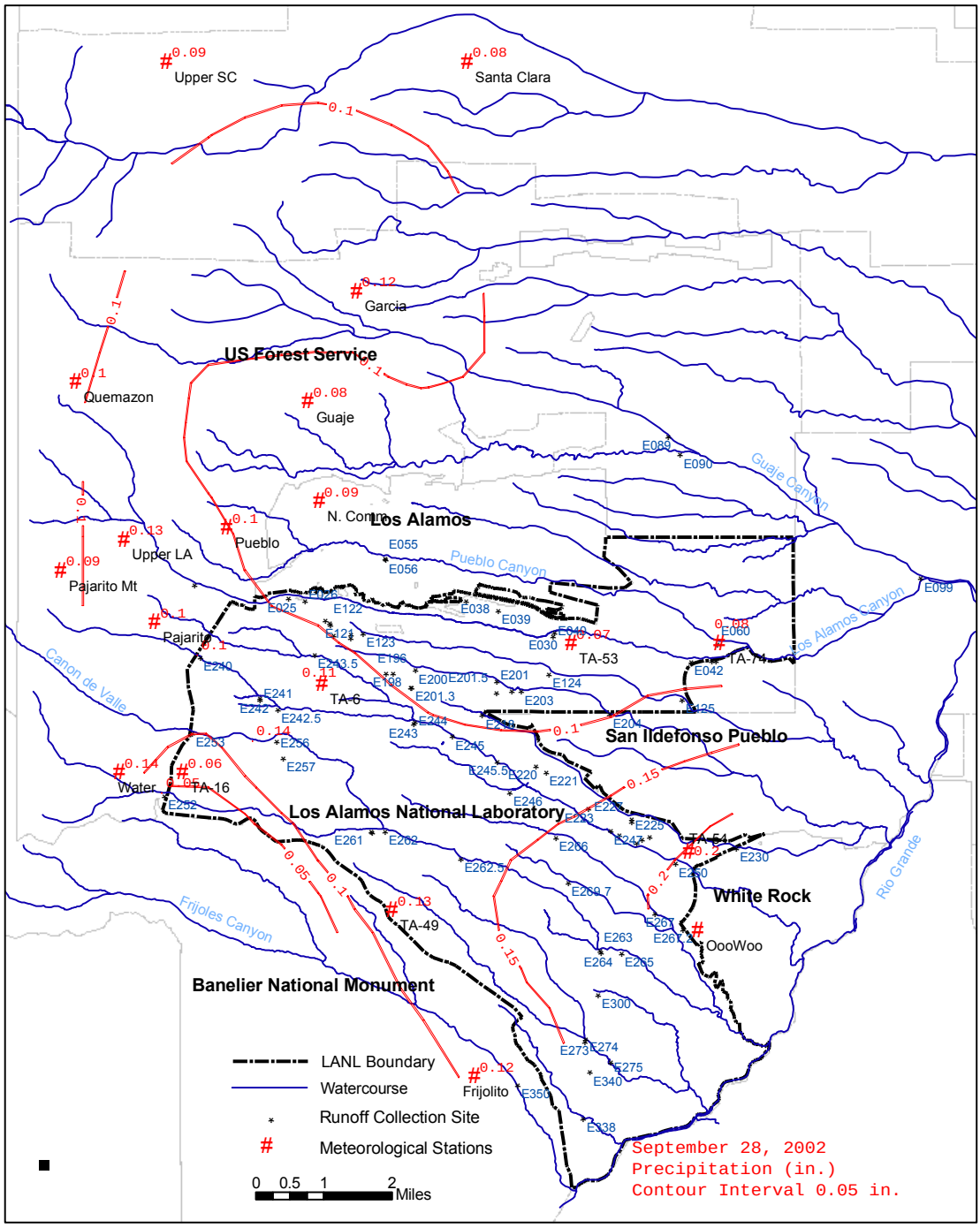

Figure B-16. Pattern of precipitation recorded on the Pajarito Plateau on September 28, 2002.

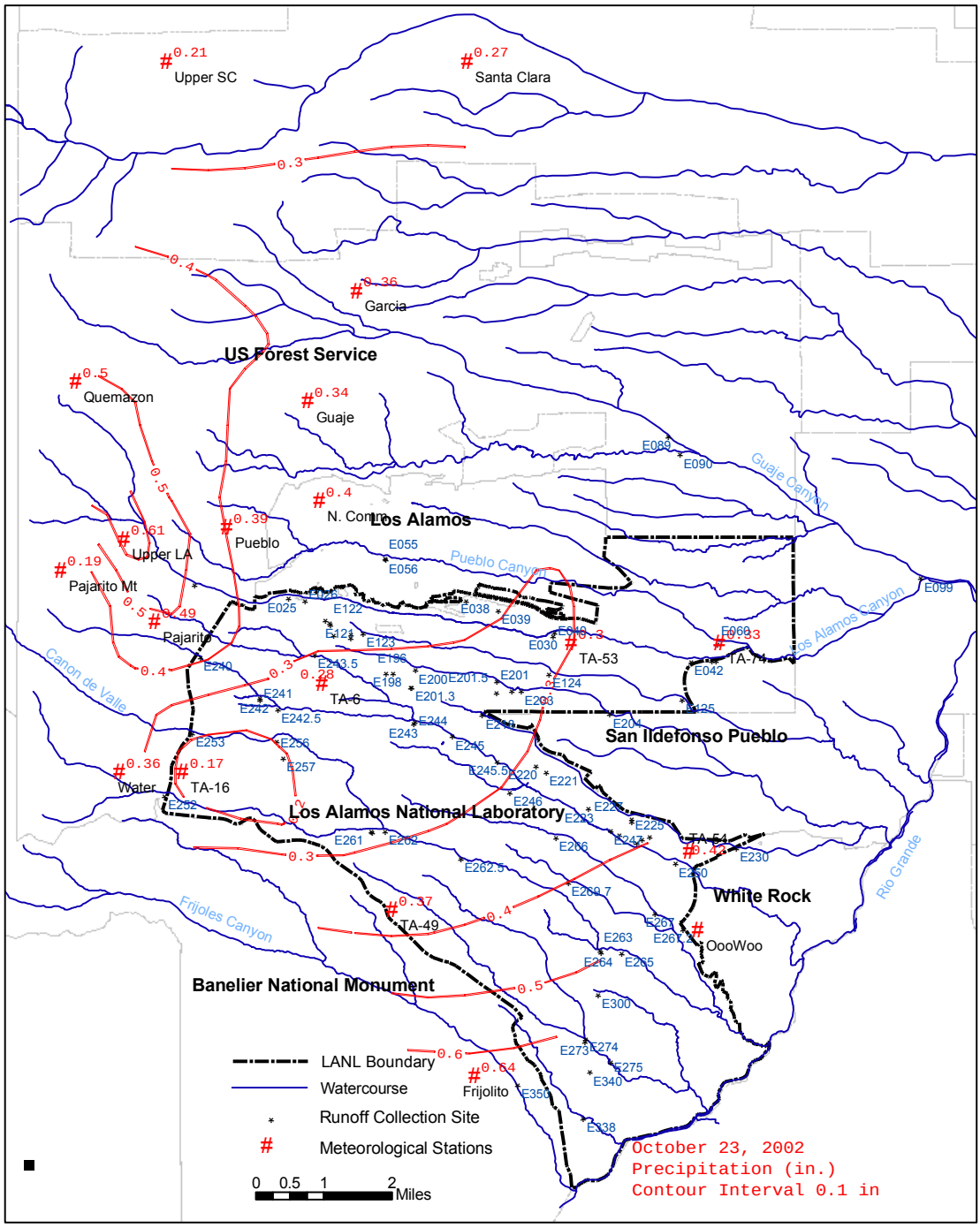

Figure B-17. Pattern of precipitation recorded on the Pajarito Plateau on October 23, 2002.

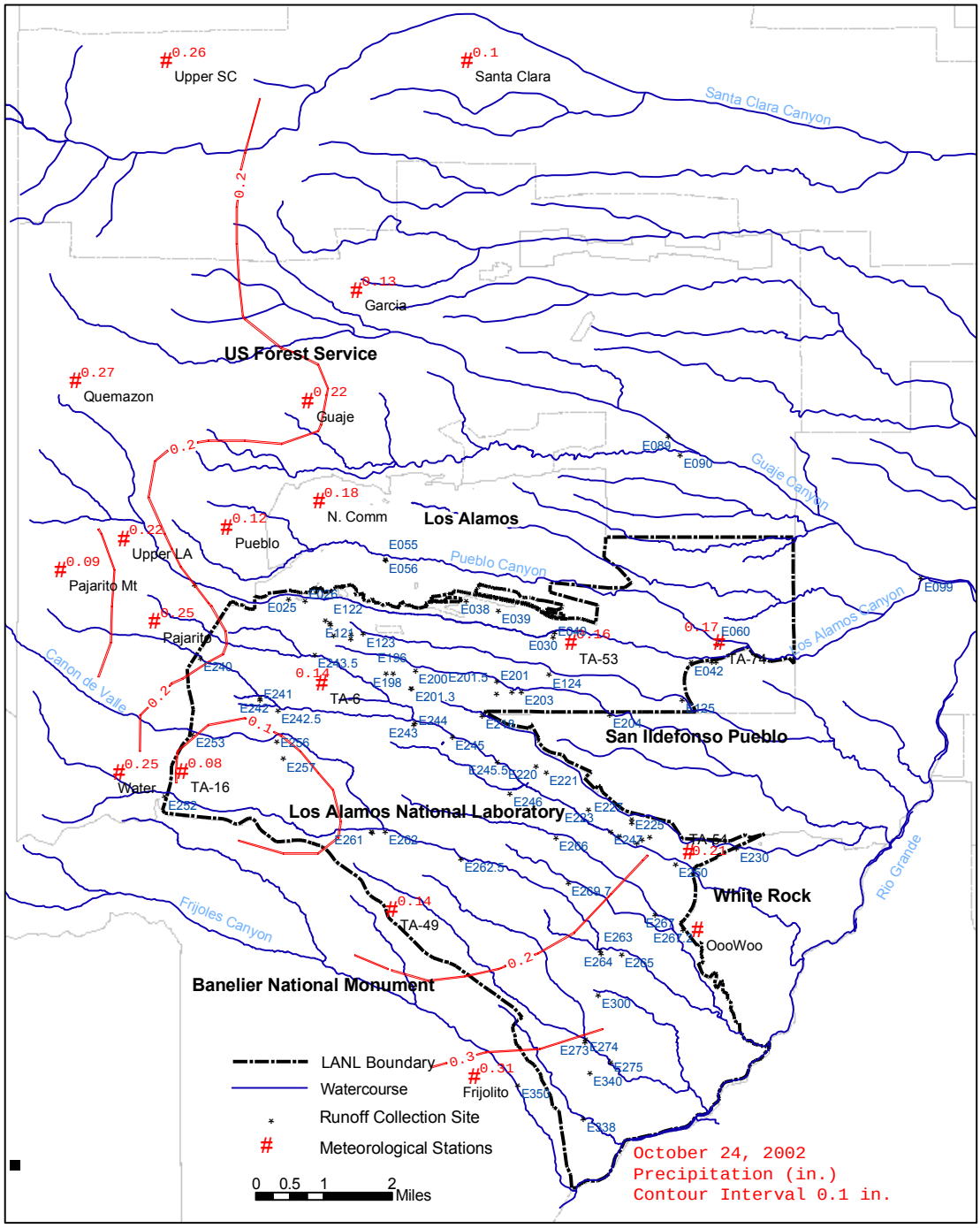

Figure B-18. Pattern of precipitation recorded on the Pajarito Plateau on October 24, 2002.

Appendix C. Summary of Storm Runoff Events at LANL in 2002

Table C-1. Storm Water Runoff Events at LANL in 2002

Gage	Date Time Start	Instant Peak Flow (cfs)	Time Peak Flow	Date Time End	Flow Volume (ac-ft)	Drainage Area (mi^2)	Runoff Yield (ac-ft/mi^2)	Comment
E026	6/21/02 21:35	43	6/21/02 23:30	6/22/02 23:15	1.98	7.12	0.28	
E030	6/21/02 23:20	124.5	6/22/02 00:25	6/22/02 00:40	3.50	8.58	0.41	
E038	6/21/02 21:50	211.6	6/21/02 23:15	6/22/02 02:00	11.70	0.21	55.71	
E039	6/21/02 22:05	105	6/21/02 23:30	6/22/02 15:35	8.94	0.32	28.38	
E040	6/21/02 22:45	89.9	6/22/02 24:00	6/22/02 11:00	3.75	0.57	6.58	
E042	6/22/02 00:15	160.3	6/22/02 00:45	6/23/02 15:55	17.90	9.08	1.97	
E055	6/21/02 21:30	NA	6/21/02 23:35	NA	NA	NA	NA	
E056	6/21/02 21:55	NA	6/21/02 22:05	NA	NA	NA	NA	
E060	6/22/02 00:40	583	6/22/02 01:00	6/22/02 16:00	80.60	6.94	11.61	
E089	6/22/02 24:00	155	6/22/02 00:05	6/22/02 10:40	9.70	14.60	0.66	
E090	6/21/02 23:10	421	6/21/02 23:10	6/22/02 03:15	11.00	9.58	1.15	
E218	6/21/02 23:05	0.66	6/21/02 23:05	6/21/02 23:25	0.01	0.31	0.03	
E240	6/21/02 21:40	173	6/21/02 21:50	6/23/02 15:45	45.7	1.90	24.05	2002 Peak Flow
E241	6/21/02 21:55	206.8	6/21/02 22:00	6/23/02 01:05	73.97	3.97	18.63	
E245	6/21/02 23:00	140	6/21/02 23:20	6/23/02 02:00	21.87	7.84	2.79	
E250	6/22/02 04:05	25.7	6/22/02 04:35	6/23/02 16:10	5.18	10.90	0.48	
E252	6/21/02 21:50	114.01	6/21/02 23:15	6/22/02 00:30	4.73	3.39	1.40	
E253	6/22/02 24:00	12	NA	NA	0.50	2.46	0.20	Calculated flow
E262.5	6/21/02 23:55	53.26	6/22/02 00:10	6/22/02 09:45	3.84	11.30	0.34	
E263	6/22/02 00:55	148.94	6/22/02 00:55	6/22/02 11:20	12.98	12.30	1.06	
E265	6/22/02	105	NA	NA	16.07	13.00	1.24	Calculated flow
E026	7/4/02 11:50	1.29	7/4/02 11:50	7/4/02 20:35	0.16	7.12	0.02	
E030	7/4/02 13:55	4.37	7/4/02 13:55	7/4/02 18:40	0.31	8.58	0.04	
E038	7/4/02 12:10	6.26	7/4/02 12:15	7/4/02 12:35	0.11	0.21	0.52	
E039	7/4/02 12:50	8.42	7/4/02 12:50	7/4/02 15:40	0.38	0.32	1.19	
E089	7/4/02 12:35	263.3	7/4/02 12:40	7/6/02 11:40	19.30	14.60	1.32	
E090	7/4/02 15:10	0.05	7/4/02 15:10	7/4/02 15:15	0.00	9.58	0.00	
E218	7/4/02 12:30	1.71	7/4/02 12:30	7/4/02 12:40	0.01	0.31	0.03	
E241	7/4/02 12:05	0.93	7/4/02 12:20	7/4/02 15:05	0.04	3.97	0.01	
E038	7/14/02 13:20	33.9	7/14/02 13:20	7/14/02 16:35	0.38	0.21	1.81	
E039	7/14/02 13:55	9.6	7/14/02 13:55	7/14/02 17:05	0.40	0.32	1.25	
E123	7/14/02 13:35	21.7	7/14/02 13:45	7/14/02 20:00	1.60	0.45	3.56	
E200	7/14/02 13:20	5.2	7/14/02 13:25	7/14/02 19:00	0.15	0.49	0.31	
E245	7/14/02 14:40	20.4	7/14/02 14:45	7/15/02 23:45	2.55	7.84	0.33	
E245.5	7/14/02 15:00	19.2	7/14/02 15:05	7/14/02 20:40	1.16	7.44	0.16	
E253	7/14/02 13:00	1.42	7/14/02 13:20	7/14/02 15:55	0.06	2.46	0.02	
E262.5	7/14/02 14:35	11.12	7/14/02 14:35	7/15/02 00:20	0.43	11.30	0.04	
E265	7/14/02 16:00	14.1	7/14/02 16:00	7/15/02 11:55	1.92	13.00	0.15	
E055	7/18/02 16:00	NA	7/18/02 16:05	7/18/02 16:45	NA	NA	NA	
E056	7/18/02 16:00	NA	7/18/02 17:15	NA	NA	NA	NA	
E060	7/18/02 18:05	30	7/18/02 22:00	07/19/02	15.3	6.94	2.20	HWM measurement
E123	7/18/02 16:25	4.25	7/18/02 16:50	7/18/02 21:30	0.50	0.45	1.11	
E241	7/18/02 16:55	3.8	7/18/02 16:55	7/18/02 21:15	0.25	3.97	0.06	
E026	7/22/02 05:45	0.13	7/22/02 06:15	7/22/02 06:35	0.01	7.12	0.00	
E123	7/22/02 06:20	10.8	7/22/02 06:30	7/22/02 09:45	0.94	0.45	2.09	

Gage	Date Time Start	Instant Peak Flow (cfs)	Time Peak Flow	Date Time End	Flow Volume (ac-ft)	Drainage Area (mi^2)	Runoff Yield (ac-ft/mi^2)	Comment
E241	7/22/02 05:25	0.03	7/22/02 06:10	7/22/02 07:35	0.00	3.97	0.00	
E055	7/23/02 13:25	NA	7/23/02 13:40	7/23/02 14:10	NA	NA	NA	
E056	7/23/02 13:25	NA	7/23/02 13:35	7/23/02 16:15	NA	NA	NA	
E026	7/23/02 12:55	0.8	7/23/02 13:10	7/23/02 16:55	0.04	7.12	0.01	
E030	7/23/02 14:45	7.6	7/23/02 14:45	7/23/02 18:50	0.61	8.58	0.07	
E038	7/23/02 13:25	43	7/23/02 13:25	7/23/02 14:15	1.65	0.21	7.86	
E038	7/23/02 16:25	0.2	7/23/02 16:30	7/23/02 16:35	0.00	0.21	0.00	
E039	7/23/02 13:50	33.4	7/23/02 16:55	7/23/02 23:00	2.11	0.32	6.59	
E040	7/23/02 14:40	6.57	7/23/02 14:40	7/23/02 20:50	0.23	0.57	0.40	
E042	7/23/02 16:10	2.42	7/23/02 16:10	7/23/02 17:45	0.07	9.08	0.01	
E123	7/23/02 12:55	21.9	7/23/02 13:35	7/23/02 19:30	2.24	0.45	4.98	
E200	7/23/02 13:35	2.19	7/23/02 13:35	7/23/02 19:00	0.15	0.49	0.31	
E241	7/23/02 12:35	0.19	7/23/02 12:55	7/23/02 16:55	0.01	3.97	0.00	
E245	7/23/02 14:55	6.1	7/23/02 15:00	7/25/02 20:20	1.53	7.84	0.20	
E245.5	7/23/02 15:40	1.1	7/23/02 15:45	7/23/02 18:15	0.06	7.44	0.01	
E055	7/25/02 20:30	NA	7/25/02 20:45	7/26/02 02:45	NA	NA	NA	
E056	7/25/02 20:30	NA	7/25/02 20:30	7/25/02 22:40	NA	NA	NA	
E026	7/25/02 20:00	1.7	7/25/02 20:45	7/26/02 00:45	0.62	7.12	0.09	
E030	7/25/02 22:00	6.54	7/25/02 22:00	7/26/02 05:10	0.76	8.58	0.09	
E038	7/25/02 20:35	8.1	7/25/02 20:40	7/25/02 21:15	0.15	0.21	0.71	
E039	7/25/02 21:15	6.57	7/25/02 21:15	7/26/02 02:40	0.36	0.32	1.13	
E042	7/26/02 00:45	0.03	7/26/02 00:45	7/26/02 00:55	0.00	9.08	0.00	
E060	7/25/02	80	7/26/02 01:30	NA	34.31	6.94	4.94	HWM measurement
E123	7/25/02 20:45	15.3	7/25/02 20:55	7/26/02 04:00	0.99	0.45	2.20	
E200	7/25/02 13:35	0.75	7/25/02 13:55	7/25/02 17:00	0.04	0.49	0.08	
E241	7/25/02 12:30	0.02	7/25/02 12:35	7/25/02 13:15	0.00	3.97	0.00	
E241	7/25/02 20:40	5.47	7/25/02 20:45	7/26/02 11:00	0.25	3.97	0.06	
E245	7/26/02 00:45	0.11	7/26/02 00:45	7/29/02 00:10	1.21	7.84	0.15	
E245.5	7/26/02 02:20	0.11	7/26/02 02:20	7/26/02 08:10	0.02	7.44	0.00	
E253	7/25/02 12:30	0.1	7/25/02 12:35	7/25/02 13:15	0.00	2.46	0.00	
E253	7/25/02 20:20	7.74	7/25/02 20:20	7/26/02 01:40	0.35	2.46	0.14	
E230	7/26/02 13:05	2.88	7/26/02 13:15	7/26/02 16:20	0.17	2.14	0.08	
E026	7/31/02 14:55	2.16	7/31/02 16:45	8/1/02 01:30	0.24	7.12	0.03	
E030	7/31/02 19:00	4.21	7/31/02 19:00	7/31/02 23:25	0.33	8.58	0.04	
E038	7/31/02 17:30	1.03	7/31/02 17:30	7/31/02 17:55	0.02	0.21	0.10	
E039	7/31/02 19:10	0.11	7/31/02 19:15	7/31/02 20:10	0.00	0.32	0.00	
E056	7/31/02 16:50	NA	7/31/02 17:10	7/31/02 19:40	NA	NA	NA	
E060	07/31/02	90	7/31/02 21:45	08/01/02	42	6.94	6.00	HWM measurement
E089	7/31/02 17:40	10.38	7/31/02 18:50	8/1/02 02:15	1.80	14.90	0.12	
E090	7/31/02 17:40	486	7/31/02 17:40	7/31/02 20:05	9.70	9.58	1.01	
E123	7/31/02 17:30	11	7/31/02 17:45	7/31/02 19:00	0.68	0.45	1.51	
E026	8/7/02 11:50	3.5	8/7/02 12:00	8/7/02 14:45	0.15	7.12	0.02	
E030	8/7/02 14:45	8.3	8/7/02 14:45	8/7/02 19:30	0.71	8.58	0.08	
E039	8/7/02 15:10	0.44	8/7/02 15:10	8/7/02 16:35	0.02	0.32	0.06	
E042	8/7/02 17:00	0.15	8/7/02 17:00	8/7/02 17:50	0.01	9.08	0.00	
E056	8/7/02 13:05	NA	8/7/02 13:45	8/7/02 15:20	NA	NA	NA	
E060	8/7/02 16:00	4.4	8/7/02 20:15	8/8/02 05:40	1.50	6.94	0.22	
E123	8/7/02 12:50	5.2	8/7/02 13:00	8/7/02 18:30	2.16	0.45	4.80	
E200	8/7/02 13:35	0.2	8/7/02 13:40	8/7/02 19:15	0.02	0.49	0.04	

Gage	Date Time Start	Instant Peak Flow (cfs)	Time Peak Flow	Date Time End	Flow Volume (ac-ft)	Drainage Area (mi^2)	Runoff Yield (ac-ft/mi^2)	Comment
E241	8/7/02 12:45	0.06	8/7/02 12:55	8/7/02 13:25	0.00	3.97	0.00	
E245	8/7/02 14:50	7.9	8/7/02 14:50	8/9/02 24:00	1.20	7.84	0.15	
E245.5	8/7/02 15:25	1.8	8/7/02 15:25	8/7/02 19:05	0.12	7.44	0.02	
E039	8/8/02 12:55	35.9	8/8/02 13:00	8/8/02 23:40	1.90	0.32	6.03	
E040	8/8/02 13:45	5.87	8/8/02 13:45	8/8/02 19:00	0.22	0.57	0.39	
E042	8/8/02 15:35	0.41	8/8/02 15:35	8/8/02 16:35	0.01	9.08	0.00	
E123	8/8/02 15:35	4.66	8/8/02 15:50	8/8/02 17:40	0.38	0.45	0.84	
E240	8/8/02 14:55	3.8	8/8/02 14:55	8/8/02 15:20	0.06	1.90	0.03	
E241	8/8/02 15:25	5.7	8/8/02 15:25	8/8/02 18:30	0.18	3.97	0.05	
E038	8/28/02 16:00	16.3	8/28/02 16:05	8/28/02 17:00	0.31	0.21	1.50	
E123	8/28/02 16:20	6.7	8/28/02 16:35	8/28/02 18:05	0.44	0.45	0.98	
E125	8/28/02 14:05	17.7	8/28/02 14:10	8/29/02 01:10	2.14	2.52	0.85	Local Runoff
E200	8/28/02 16:25	0.12	8/28/02 16:25	8/28/02 17:20	0.00	0.49	0.01	
E230	8/28/02 14:00	167.6	8/28/02 14:10	8/28/02 20:20	6.26	2.14	2.93	Local Runoff
E250	8/28/02 14:10	1.84	8/28/02 14:20	8/28/02 20:55	0.12	10.90	0.01	Local Runoff
E267	8/28/02 13:50	15.2	8/28/02 14:05	8/28/02 14:30	0.57	2.25	0.25	
E026	9/4/02 11:35	9.9	9/4/02 12:15	9/4/02 15:20	0.80	7.12	0.11	
E038	9/4/02 12:05	5.47	9/4/02 12:05	9/4/02 14:30	0.26	0.21	1.26	
E039	9/4/02 13:10	2.37	9/4/02 13:15	9/4/02 15:20	0.13	0.32	0.41	
E123	9/4/02 12:15	8.67	9/4/02 13:00	9/4/02 17:00	1.10	0.45	2.44	
E200	9/4/02 12:30	0.83	9/4/02 13:55	9/4/02 15:10	0.06	0.49	0.13	
E252	9/4/02 12:05	0.13	9/4/02 12:50	9/4/02 14:00	0.01	3.39	0.00	
E253	9/4/02 12:05	0.08	9/4/02 12:05	9/4/02 14:15	0.01	2.46	0.00	
E262.5	9/4/02 16:40	0.04	9/4/02 16:40	9/4/02 18:50	0.00	11.30	0.00	
E123	9/9/02 15:05	3.62	9/9/02 15:30	9/9/02 17:30	0.37	0.45	0.82	
E200	9/9/02 14:50	2.23	9/9/02 14:55	9/9/02 18:30	0.09	0.49	0.17	
E230	9/9/02 14:40	42.15	9/9/02 14:55	9/9/02 17:40	1.37	2.14	0.64	Local Runoff
E240	9/9/02 14:35	1.14	9/9/02 14:35	9/9/02 15:05	0.03	1.90	0.02	
E241	9/9/02 15:10	2.52	9/9/02 15:15	9/9/02 18:25	0.15	3.97	0.04	
E250	9/9/02 16:15	0.06	9/9/02 16:50	9/9/02 21:15	0.01	10.90	0.00	Local Runoff
E267	9/9/02 14:50	1.95	9/9/02 15:55	9/9/02 15:00	0.02	2.25	0.01	
E026	9/10/02 05:55	2.39	9/10/02 07:05	9/10/02 17:40	0.35	7.12	0.05	
E030	9/10/02 07:35	8.1	9/10/02 14:10	9/10/02 19:40	2.35	8.58	0.27	
E039	9/10/02 01:50	22	9/10/02 06:20	9/10/02 20:45	7.25	0.32	23.02	
E040	9/10/02 06:50	8.73	9/10/02 11:55	9/10/02 21:45	1.99	0.57	3.49	
E042	9/10/02 11:55	7.61	9/10/02 12:35	9/10/02 19:45	0.85	9.08	0.09	
E060	9/10/02 10:45	28.48	9/10/02 17:45	9/10/02 23:00	12.30	6.94	1.77	
E089	9/10/02 04:05	217.76	9/10/02 04:35	NA	35.00	14.60	2.40	
E090	9/10/02 04:45	3.07	9/10/02 12:00	9/12/02 07:00	2.10	9.58	0.22	
E123	9/10/02 05:45	13.97	9/10/02 06:15	9/10/02 18:30	5.12	0.45	11.38	
E200	9/10/02 04:50	4.5	9/10/02 12:50	9/10/02 19:00	1.31	0.49	2.67	
E230	9/9/02 23:05	6.97	9/10/02 01:25	9/10/02 10:20	0.43	2.14	0.20	Local Runoff
E241	9/10/02 04:55	3.13	9/10/02 05:35	9/10/02 16:00	0.29	3.97	0.07	
E245	9/10/02 09:05	8.2	9/10/02 11:25	9/10/02 12:20	0.75	7.84	0.10	
E245.5	9/10/02 10:00	6.18	9/10/02 14:40	9/10/02 21:55	1.08	7.44	0.15	
E250	9/10/02 01:55	0.08	9/10/02 03:10	9/11/02 00:50	0.05	10.90	0.00	Local Runoff
E252	9/10/02 04:50	14	9/10/02 05:40	9/10/02 16:15	0.35	3.39	0.10	
E253	9/10/02 04:40	0.26	9/10/02 06:00	9/10/02 13:20	0.02	2.46	0.01	
E262.5	9/10/02 07:55	15.6	9/10/02 08:00	9/10/02 22:45	0.87	11.30	0.08	
E263	9/10/02 07:50	40.1	9/10/02 08:00	9/10/02 21:50	4.83	12.30	0.39	

Gage	Date Time Start	Instant Peak Flow (cfs)	Time Peak Flow	Date Time End	Flow Volume (ac-ft)	Drainage Area (mi^2)	Runoff Yield (ac-ft/mi^2)	Comment
E265	9/10/02 07:55	15.6	9/10/02 08:00	9/11/02 11:30	3.25	13.00	0.25	
E265	9/28/02 15:35	29.42	9/28/02 15:50	9/28/02 17:00	0.54	13.00	0.04	
E230	10/22/02 18:20	0.19	10/22/02 18:25	10/22/02 18:35	0.00	2.14	0.00	Local Runoff
E026	10/23/02 12:35	0.1	10/24/02 01:00	10/24/02 06:50	0.02	7.12	0.00	Multiple events
E030	10/24/02 14:10	4.37	10/24/02 14:10	10/24/02 15:10	0.08	8.58	0.01	
E038	10/23/02 04:40	5.47	10/23/02 04:40	10/23/02 04:50	0.06	0.21	0.29	
E038	10/23/02 21:10	1.24	10/23/02 21:15	10/23/02 21:20	0.02	0.21	0.10	
E038	10/24/02 00:35	34.9	10/24/02 00:35	10/24/02 00:50	0.37	0.21	1.79	
E039	10/23/02 05:30	0.33	10/24/02 00:10	10/24/02 18:05	0.51	0.32	1.62	
E040	10/23/02 23:20	2.7	10/24/02 02:00	10/24/02 09:55	0.20	0.57	0.35	
E200	10/23/02 04:55	1.05	10/23/02 08:45	10/24/02 09:45	0.46	0.49	0.94	Multiple events
E230	10/23/02 17:55	0.15	10/23/02 18:20	10/23/02 18:55	0.01	2.14	0.00	

Note: NA = Not Available; HWM = high water mark

Los Alamos NM 87545