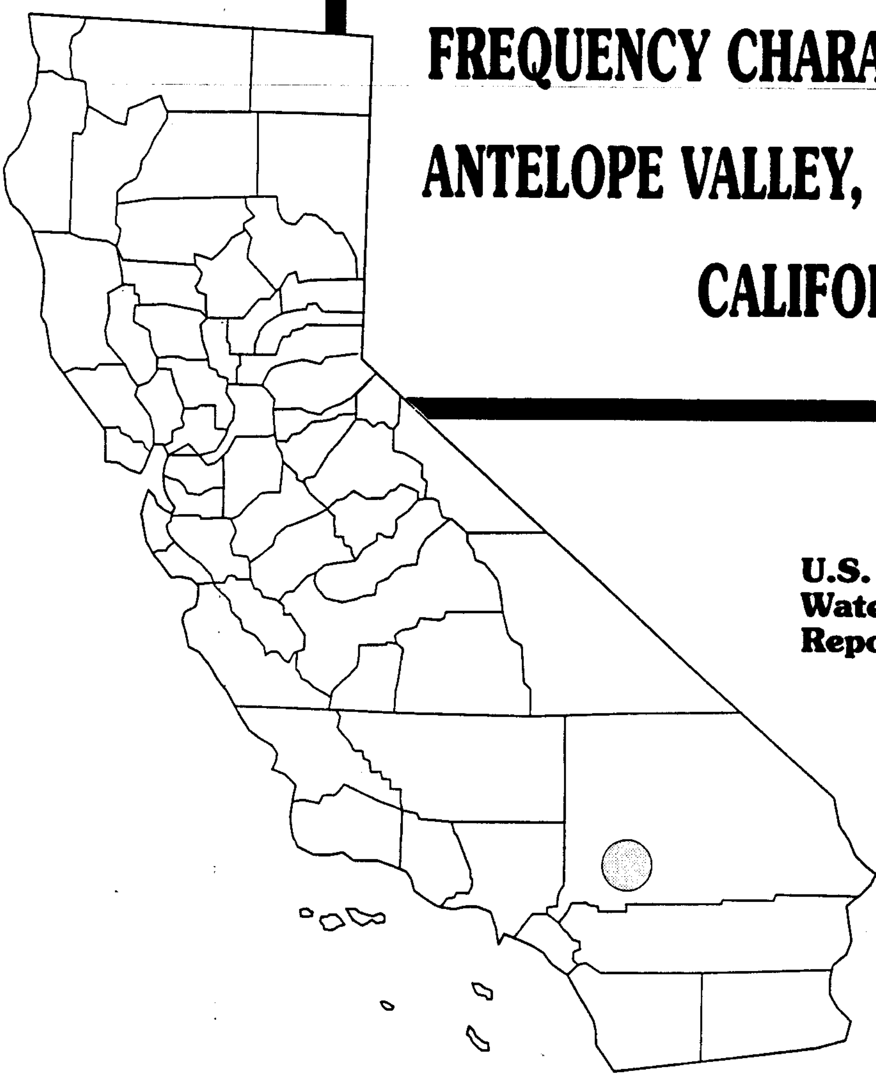
PRECIPITATION DEPTH-DURATION AND FREQUENCY CHARACTERISTICS FOR ANTELOPE VALLEY, MOJAVE DESERT, CALIFORNIA



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CONTENTS

FIGURES

Precipitation Depth-Duration and Frequency Characteristics for Antelope Valley, Mojave Desert, California

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Abstract

Methods to evaluate changes in the volume of storm runoff from drainage basins that are likely to be urbanized are needed by land-use planning agencies to establish criteria for the design of flood-control systems. To document the changes in runoff volume of basins that may be urbanized, nine small basins that are considered representative of varying hydrologic conditions in Antelope Valley, California, were selected for detailed study. Precipitation and stream-gaging stations were established and data were collected for the period 1990-93. The data collected at these U.S. Geological Survey stations were supplemented by data collected at 35 long-term precipitation stations operated by the National Oceanic and Atmospheric Administration and the Los Angeles County Department of Public Works. These data will be used to calibrate and verify rainfall-runoff models for the nine basins. Results of the model runs will then be used as a guide for estimating basin runoff characteristics throughout Antelope Valley.

Annual precipitation in Antelope Valley ranges from more than 20 inches in the mountains to less than 4 inches on the valley floor. Most precipitation in the valley falls during the months of December through March, but cyclonic storms in the fall and convectional storms in the summer sometimes occur. The duration of most storms ranges from 1 to 8 days, but most of the precipitation usually occurs within the first 2 days. Many parts of the valley have been affected by storms with precipitation depths that equal or exceed 0.60 inch per hour. The storms of January 1943 and March 1983 were the most intense storms of record, with recurrence intervals greater than 100 years in some parts of the valley.

Depth-duration ratios were calculated by disaggregating daily total precipitation data for intervals of 1, 2, 3, 4, 6, 12, and 18 hours for storms that occurred during 1990-93. The hourly total precipitation data were then disaggregated at 5-minute intervals. A comparison of the depth-duration data collected during 1990-93 at the Geological Survey stations with the data collected at the other stations indicated that the 1990-93 data are not representative of historical storms. Therefore, depth-duration ratios developed using these data should be considered preliminary for use in disaggregating the historical hourly data for Antelope Valley.

Annual maximum 24-hour precipitation records were used to calculate precipitation depth-frequency relations for 23 stations in the valley using the log Pearson type III distribution. These calculations indicate that the storms of January 1943 and March 1983 were the most intense of record in the valley with recurrence intervals greater than 100 years.

INTRODUCTION

Changes in peak magnitude and volume of storm runoff in drainage basins undergoing urbanization are a major environmental concern. Runoff volumes from newly urbanized drainage basins are

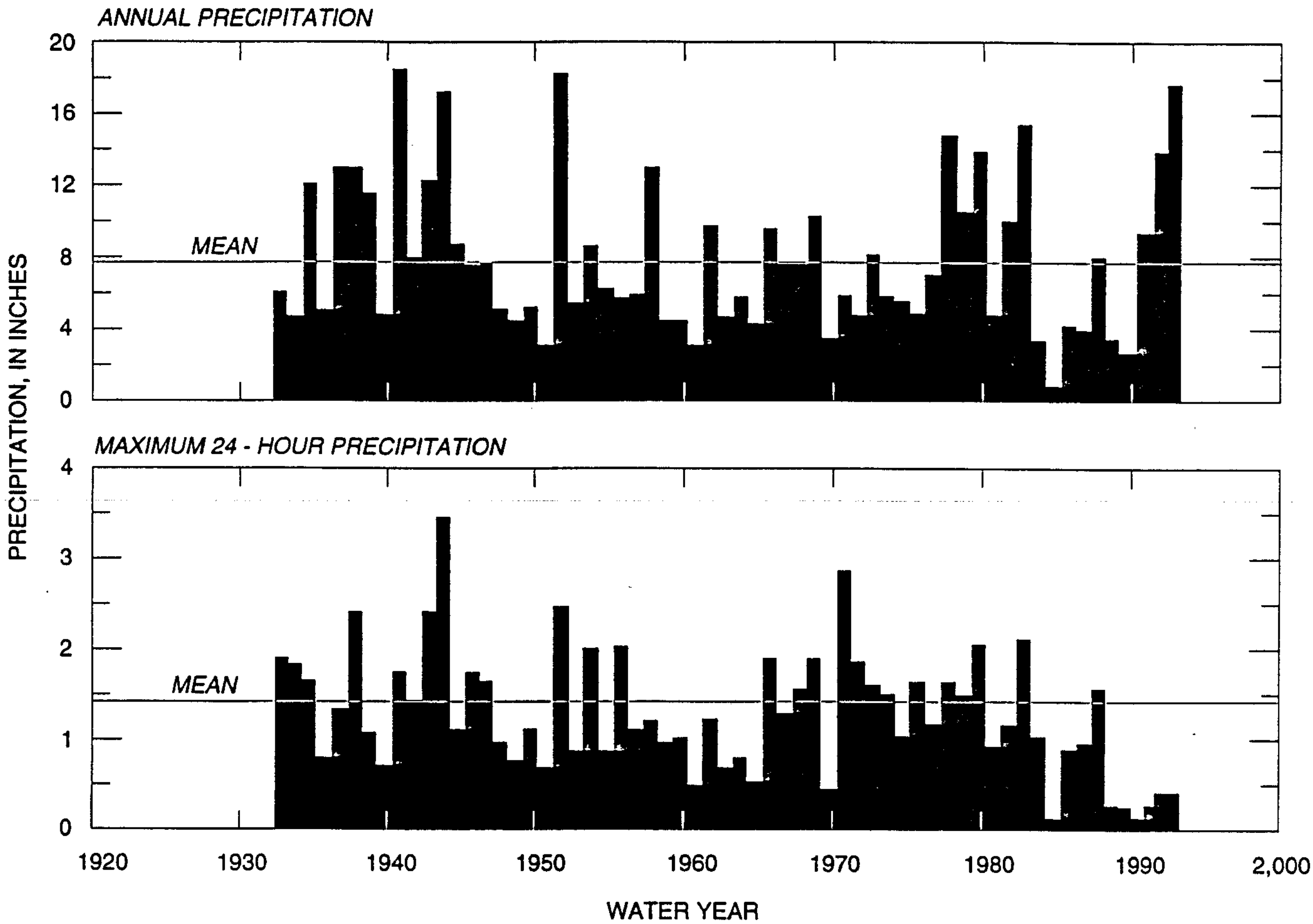

Figure 2. Annual total and maximum 24-hour precipitation depths at Palmdale, California, 1933-93.

then be used to provide guidelines for estimating basin runoff characteristics throughout Antelope Valley.

Description of Study Area

Antelope Valley, California, is about 50 mi north of the City of Los Angeles in the northwestern Mojave Desert. The valley is a closed, inland drainage basin that covers about a 2,400-mi^2 area. The Tehachapi Mountains, with elevations as high as 8,000 ft, form the northern and western borders of the valley, and the San Gabriel Mountains, with elevations to 10,000 ft, form the southern border (fig. 1). The eastern border of the valley, near the Los Angeles-San Bernardino County line, is formed by low ridges with elevations to about 4,000 ft. The average elevation of the valley floor is about 2,500 ft.

Areas in the western and southern part of Antelope Valley, particularly along the foothills and on the alluvial fans, are being urbanized. These new urbanized areas generally are located higher on these fans and on the foothills above the older subdivisions.

The present flood-drainage system occupies alluvial fans in Antelope Valley and consists of channels subject to flooding depending on the intensity and areal diversity of storms over the valley. Much of Antelope Valley is subject to inundation by floodflows. These floodflows follow small defined drainage channels in the upper parts of the basin, but occupy channels with unpredictable paths across the valley floor toward Rosamond, Buckhorn, and Rogers Lakes (fig. 1). Extensive flooding of urban areas in the cities of Palmdale and Lancaster occurred in February 1992, and the largest flood of record in the valley occurred in March 1938.

Annual precipitation in the valley ranges from about 20 in. in the mountains to less than 4 in. on the valley floor. The maximum 24-hour total precipitation

Table 1. Precipitation stations in Antelope Valley, California, and vicinity--*Continued*

Station No.	Station name	Elevation (feet)	Latitude/ longitude	Mean annual precipitation (inches)	Period of record analyzed	Type of data	Agency
979	Boron	2,455	350000/ 1173900	4.79	1960-93	daily/hourly	NOAA
1063	Soledad Pass	3,520	342935/ 1180528	10.23	1953-93	daily	LACDPW
1212	Lancaster FSS	2,340	344400/ 1181300	6.78	1973-93	daily	NOAA
2771	El Mirage Field	2,910	343600/ 1173600	6.32	1970-93	daily	NOAA
5756	Mojave[2]	2,735	350300/ 1181000	5.62	1937-93	daily/hourly	NOAA
6624	Palmdale	2,596	343500/ 1180600	7.38	1931-93	daily/hourly	NOAA
6773	Pearblossom	3,049	343000/ 1175300	6.95	1984-93	daily	NOAA
7253	Randsburg	3,570	352200/ 1173900	5.48	1937-93	daily	NOAA
7735	Sandberg WSMO	4,517	344500/ 1184400	11.97	1932-93	daily	NOAA
8014	Saugus PWR PL 1	2,105	343500/ 1182700	17.52	1932-93	daily	NOAA
8826	Tehachapi	4,017	350800/ 1182700	10.40	1895-1993	daily/hourly	NOAA
9325	Victorville P.P.	2,858	343200/ 117---	5.00	1936-93	daily/hourly	NOAA
9999	EAFB	2,317	345448/ 1175402	4.84	1948-93	daily	USAF
10263675	Big Rock Creek at Highway 138	3,160	343134/ 1175958	--	1990-93	daily/5-minute	USGS
10264502	Peach Tree Creek	2,850	343734/ 1175958	--	1990-93	daily/5-minute	USGS
10264508	Somerset Creek	2,640	343407/ 1180506	--	1990-93	daily/5-minute	USGS
10264510	Inn Creek	2,700	343451/ 1180805	--	1990-93	daily/5-minute	USGS
10264530	Pine Creek	3,010	343609/ 1181448	--	1990-93	daily/5-minute	USGS
10264550	City Ranch Creek	2,760	343500/ 1181036	--	1990-93	daily/5-minute	USGS
10264555	Estates Creek	2,700	343819/ 1181452	--	1990-93	daily/5-minute	USGS
10264605	Joshua Creek	3,820	350045/ 1182040	--	1990-93	daily/5-minute	USGS
10264675	Rogers Lake Tributary	2,340	345806/ 1175329	--	1990-93	daily/5-minute	USGS

[1]Prior to July 1948, station named Llano, 7 miles southeast, afterwards known as Llano, Eberle Ranch, Llano Shawnee Hills Ranch. After January 5, 1966, station operated by Los Angeles County Department of Public Works.

[2]Prior to 1948, data for Backus Ranch (1937-48) (latitude 345500, longitude 1181100, elevation 2,620 feet) used to supplement record.

that can affect precipitation catchment and to minimize problems of vandalism. A shielded, two-conductor cable connects the tipping bucket to a CR-10 data logger inside the gage house. The tipping-bucket assembly tips and activates a magnetic reed switch to provide incremental rainfall measurements in hundredths of an inch. These gages were installed during the winter months of 1989-90 and have operated to date with few performance problems.

To provide a check on the amount of precipitation recorded by the tipping-bucket rain gages, two types of nonrecording rain gages also were installed at the USGS. Plastic rain gages with a 4-in.-diameter orifice were installed at all stations. These gages can measure up to 11 in. of precipitation and are graduated in hundredths of an inch. The gages were mounted on fence posts or other support structures near the other precipitation gages.

At two stations, forestry-type, nonrecording rain gages were installed (fig. 5) to provide an additional check on catchment amounts obtained by the tipping-bucket and plastic rain gages. The forestry-type gage has a 7.6-in.-diameter orifice and a capacity of 7 in. of precipitation. The gage is supported by a post and is

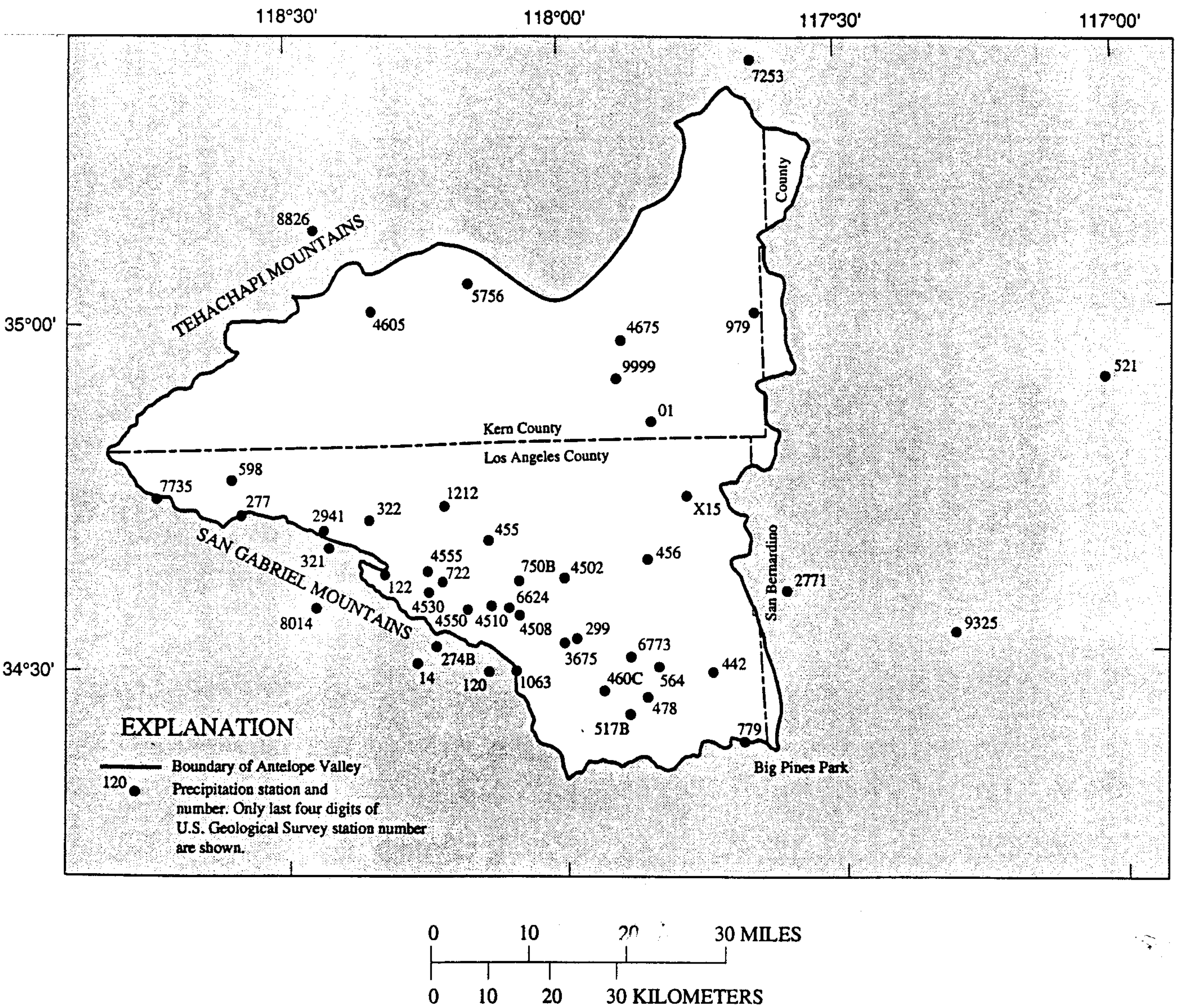

Figure 3. Precipitation stations in Antelope Valley, California, and vicinity.

Table 2. Catchment for various types of rain gages at U.S. Geological Survey stream-gaging and precipitation stations in Antelope Valley, California

[do, ditto; --, no data]

Station No.	Station name	Number of observations	Type of rain gage		
			Tipping-bucket continuous recorder	Plastic storage	Forestry storage
10264605	Joshua Creek	33	1.00	0.92	--
10264675	Rogers Lake Tributary	17	do	.74	1.03
10264508	Somerset Creek	30	do	.95	--
10263675	Big Rock Creek at Highway 138	32	do	.92	--
10264555	Estates Creek	30	do	1.03	--
10264530	Pine Creek	29	do	.93	--
10264550	City Ranch Creek	26	do	.98	.98
10264510	Inn Creek	17	do	.82	--
10264502	Peach Tree Creek	28	do	1.04	--
01	Rogers Lake fissure	9	1.00	.93	--
	Average		1.00	.93	1.01

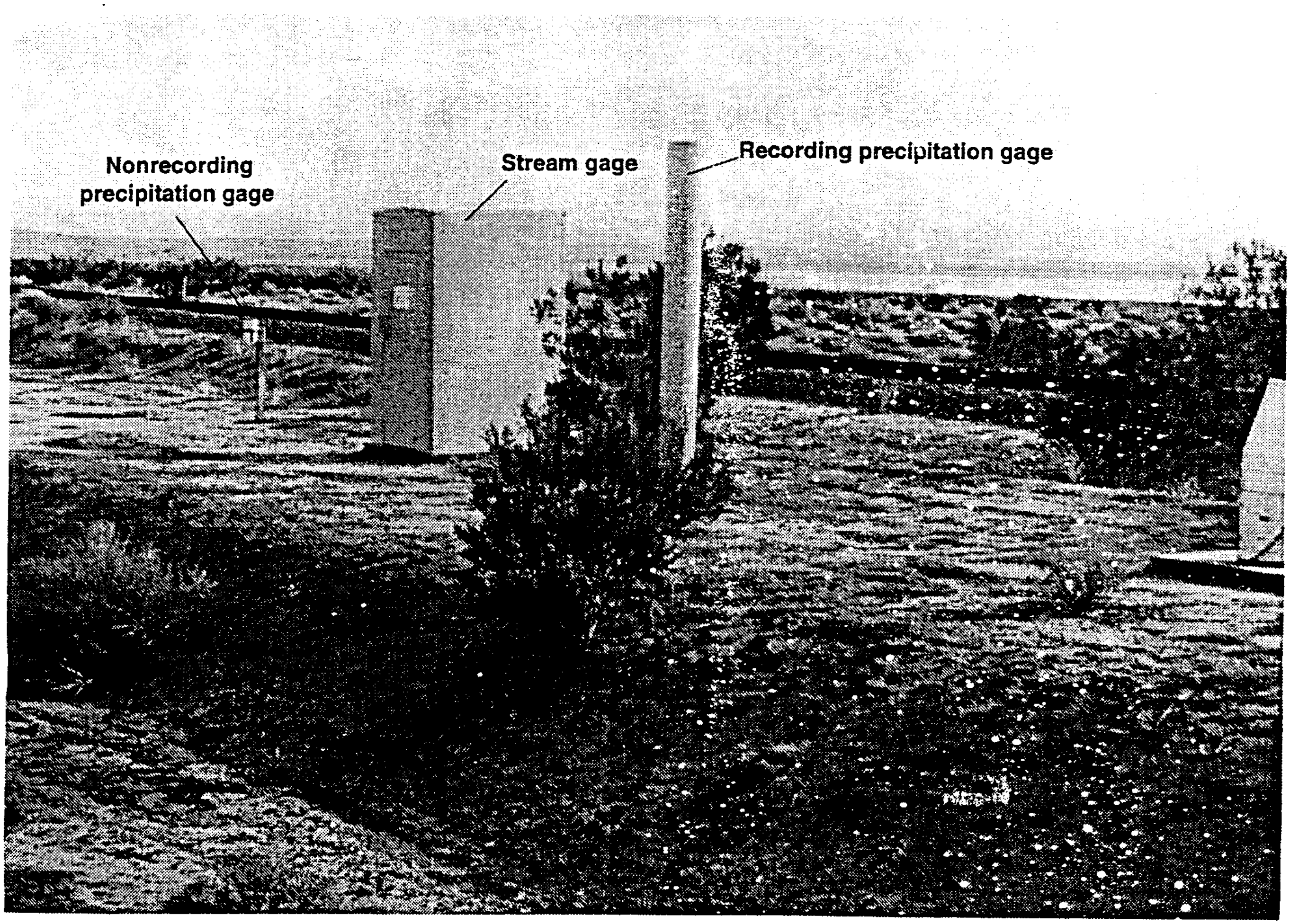

Figure 5. Precipitation stations at Rogers Lake Tributary, Edwards Air Force Base, California.

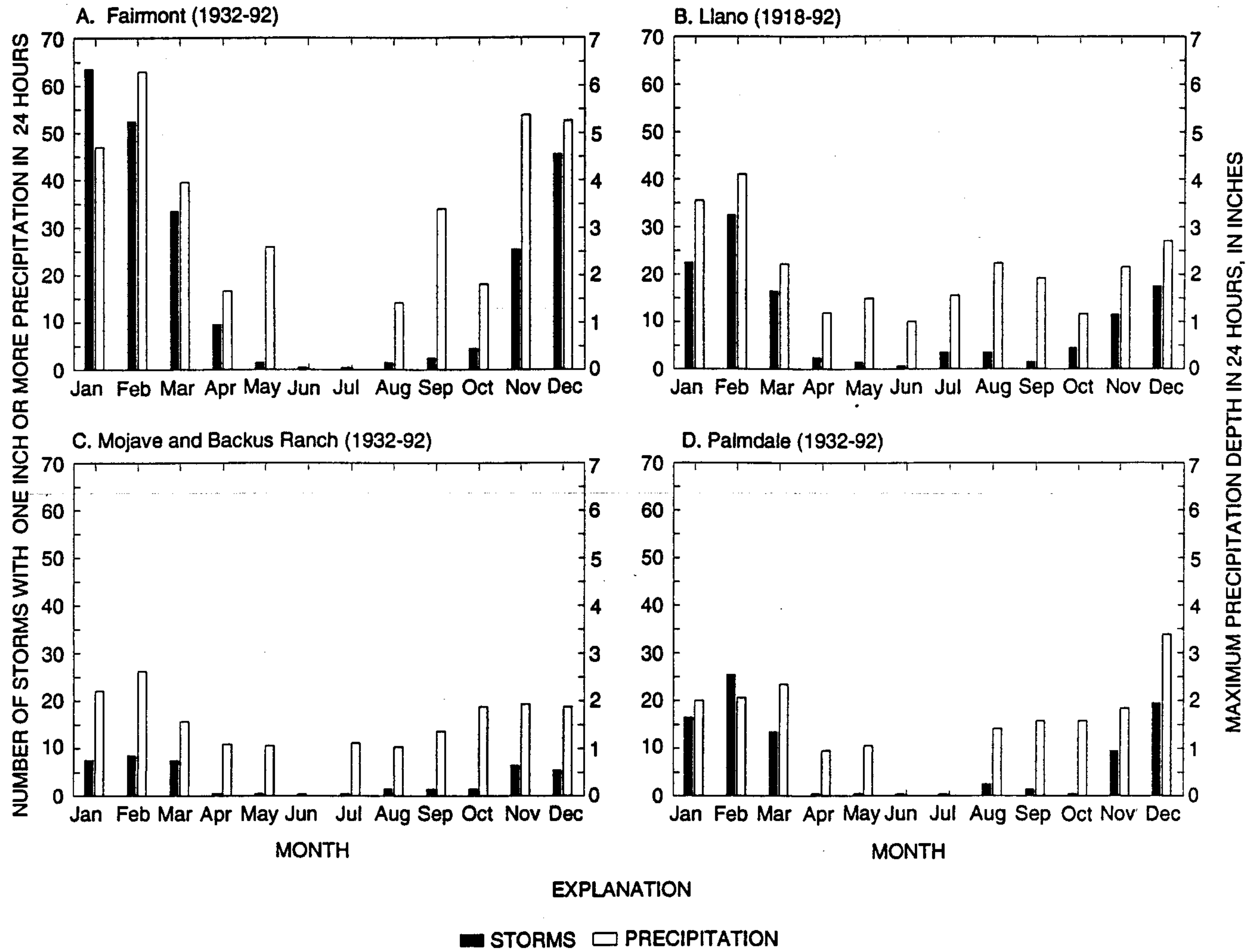

Figure 6. Seasonal distribution of storms at selected stations in Antelope Valley, California, 1918-92.

cantly and can reflect the orographic influence of the Tehachapi and San Gabriel Mountains. The area of lowest mean annual precipitation is near the center of the valley and southwest of EAFB (fig. 7). Variation in mean annual precipitation at other locations in the State has been associated with the areal variation in storm intensity and duration (Rantz, 1971). The duration of most storms in the valley is about 6 days or less. Precipitation depth-duration relations for four stations in the valley (fig. 8) were prepared for 12 selected large storms that occurred during the period 1938-93. Precipitation data for all stations were analyzed for the same storms, and the mean precipitation depth of the 12 storms for each daily increment was used in the plot. About 50 percent of the total 6-day precipitation was recorded within the first 2 days of a storm. Storms of high intensity do not necessarily have long durations.

Disaggregation of Daily Total Precipitation Data

Rainfall-runoff models are used to calculate floodflows, which are then used in the design of drainage facilities for those areas on alluvial fans and in the foothills that are subject to flooding. For smaller basins, the accuracy of the model depends, in part, on the availability of precipitation data that were collected at intervals between 5 and 60 minutes. However, most of the historical precipitation data are available only as daily totals. In Antelope Valley and vicinity, only seven NOAA stations (table 1) collect depth was 2.12 in. Both values are less than the maximum of record at the Palmdale station. In terms of maximum precipitation for any selected duration of less than 24 hours, the storms of February 9-10, 1978, February 16-17, 1980, March 1, 1983, and February 10, 1992 (table 3), are the largest of record.

A longer duration storm of a given intensity will produce more runoff than a storm of shorter duration. In general, a storm with heavy precipitation during the initial hours will cause a rapid rise in runoff. For the Rogers Lake Tributary station during the storm of March 26-27, 1991, the rainfall hydrograph (fig. 9)

Table 3. Maximum precipitation depths for durations of 24 hours or less for selected storms and stations in Antelope Valley, California.

[USGS, U.S. Geological Survey; NOAA, National Oceanic and Atmospheric Administration; --, no data]

Station no.	Station name	Years	Date of maximum 24 hour precipitation	Maximum precipitation depth (inches) for indicated duration (hours)[1]							
				1	2	3	4	6	12	18	24
			USGS stations								
10263675	Big Rock Creek at Highway 138	1990-93	2-10-92	0.36	0.36	0.51	0.64	0.79	1.30	1.73	1.75
10264502	Peach Tree Creek	1990-93	2-10-92	.29	.34	.47	.67	.88	1.13	1.43	1.48
10264508	Somerset Creek	1990-93	2-10-92	.38	.48	.66	.88	1.26	1.73	1.98	2.12
10264510	Inn Creek	1990-93	2-12-92	.38	.46	.64	.88	1.00	1.91	2.16	2.28
10264530	Pine Creek	1990-93	2-12-92	.37	.58	.83	1.08	1.51	2.76	3.33	3.49
10264550	City Ranch Creek	1990-93	2-10-92	.36	.54	.75	.93	1.33	2.18	2.63	2.66
10264555	Estates Creek	1990-93	2-10-92	.44	.53	.76	.94	1.39	2.19	2.70	2.82
10264605	Joshua Creek	1990-93	2-27-91	.39	.39	.57	.74	1.04	1.79	2.16	2.34
10264675	Rogers Lake Tributary	1990-93	2-12-92	.30	.55	.72	.81	.93	1.02	1.02	1.33
01	Rogers Lake fissure	1992-93	1-12-93	.29	.50	.66	.74	.78	.90	.92	1.38
			NOAA stations								
14	Acton-Escondido FC261[2]	1978-93	2-18-93	0.60	0.80	1.00	1.20	1.50	2.30	2.80	3.40
6624	Palmdale	1952-93	2-10-92	.30	.50	.80	1.00	1.30	1.90	2.20	2.50
			3-1-83	.44	.79	1.08	1.32	1.73	2.26	2.40	2.69
			2-16-80	.33	.61	.71	.88	1.19	2.42	2.57	2.57
			2-9-78	.50	.66	.77	.84	.91	1.16	1.44	1.60
5756	Mojave	1969-93	2-12-92	.40	.70	.90	1.10	1.30	1.40	1.40	2.10
			2-16-80	--	--	--	--	--	--	--	
			2-9-78	.33	.64	.89	1.05	1.18	1.72	2.44	2.53
779	Big Pines Park F683B	1956-93	2-11-92	.40	.50	.50	.60	.70	1.80	2.80	3.30
			3-1-83	.5	.9	1.2	1.6	2.2	3.4	4.3	4.8
			2-16-80	--	--	--	--	--	--	--	--
			2-10-78	.6	1.1	1.3	1.8	2.2	3.70	5.50	7.3
979	Boron	1960-93	2-12-92	.34	.56	.71	.80	.92	.93	.93	.93
			3-1-83	.59	.83	1.24	1.68	2.52	3.10	3.27	3.34
			2-16-80	.29	.55	.76	.91	1.18	1.53	1.53	1.53
			2-10-78	.39	.64	.70	.75	.76	.81	1.17	1.33
9325	Victorville Pumping Plant	1952-93	2-12-92	.30	.50	.70	.90	1.10	1.20	1.20	1.50
			3-1-83	.5	1.0	1.3	1.7	2.3	2.5	2.6	2.7
			2-16-80	.3	.6	.8	.9	1.0	1.3	1.3	1.3
			2-10-78	.24	.43	.54	.71	.86	1.43	1.61	1.85

[1]Duration is the true time intervals used to calculate 24-hour totals.
[2]No data are available for February 1992 and March 1983 storms.

Table 4. Maximum precipitation depths for storm of January 5, 1992, at selected time intervals for the Somerset Creek station, California

[The maximum hourly precipitation total (0.17 inch, hour 6) is listed as calculated maximum for hour 1. The maximum adjacent measured precipitation is 0.13 inch, hour 5, giving a 2-hour total maximum of 0.30 inch. The procedure was expanded to include 24 hours or duration of the storm]

Method of determining precipitation depth	Hours from beginning of storm duration									
	1	2	3	4	5	6	7	8	9	10
Measured precipitation depth, inches	0.01	0.01	0.09	0.15	0.13	0.17	0.04	0.03	0.01	0.01
Calculated maximum precipitation depth for indicated duration, inches	.17	.30	.45	.54	.58	.61	.62	.72	.73	.74

6, 12, and 18 hours for the storms that occurred during 1990-93. The hourly total precipitation data were then disaggregated at 5-minute intervals.

Maximum precipitation depth-duration relations (fig. 10) for the NOAA Palmdale station and for 10 USGS hourly stations were developed using data (table 3) for the period of record, 1952-93. To compare the depth-duration intensities recorded at USGS stations for the various storms during 1990-93 with those recorded at long-term NOAA stations, the maximum precipitation depths for each time interval were expressed as a ratio of the total precipitation for the 24-hour interval by the equation:

$$hn = \frac{h_t}{h_{24}}$$

where

hn is the depth-duration ratio;

h_t is maximum precipitation, in inches, recorded during a storm for a selected time interval; and

h_{24} is total precipitation depth, in inches, for the 24-hour duration that includes the interval h_t.

The depth-duration curves on figure 10 represent the maximum ratios of recorded precipitation for the indicated durations. About 70 percent of the total daily precipitation occurs during the first 12 hours of most storms. During some major storms, such as the storm of February 10, 1978, at Big Pines Park, only 0.6 in. of precipitation occurred during the first hours, but, by hour 12, about half of the 24-hour precipitation total of 7.3 in. had occurred. The storm of February 10-12, 1992, was the most intense storm recorded at most of the USGS stations during 1990-93 (table 3). This storm, when compared with 24-hour totals of significant historical storms at Palmdale, was slightly less intense than the storm of March 1983 at all hourly intervals.

The depth-duration relation for the NOAA Palmdale station in Antelope Valley indicates that more than 70 percent of the total precipitation in 24 hours occurred by hour 6 (curve A, fig. 10), similar to precipitation recorded by hour 6 at the USGS stations (curve B, fig. 10). The difference in the depth-duration relations for durations greater than 4 hours is attributed to the smaller number of storms recorded at the USGS stations than were recorded at the NOAA stations. The depth-duration relation based on precipitation depths for a 100-year recurrence interval (curve C) represents an average of data for 200 stations (Hersfield, 1961). This relation indicates that the frequency analysis using procedures of Miller and others (1973) may result in depths of precipitation not representative of storms in Antelope Valley.

In some cases, 24-hour storm totals for the USGS precipitation stations that were used to calculate the hourly depth-duration relations were less than the historical maximums observed at the NOAA stations (table 3). Application of the maximum depth-duration ratio curves, defined by the USGS data on figure 10, to storms with 24-hour precipitation totals larger than those recorded during 1990-93 can result in questionable estimates of precipitation depths for storms of short (less than about 7 hours) duration.

Disaggregation of Hourly Total Precipitation Data

Hourly precipitation data have been collected at six NOAA stations in Antelope Valley since 1952. Maximum hourly depths for a storm can vary throughout the valley and nearby mountains. In general, maximum hourly precipitation depths of as much as 0.70 in. occurred at stations in the mountains (Big Pines Park and Acton-Escondido), but maximum hourly

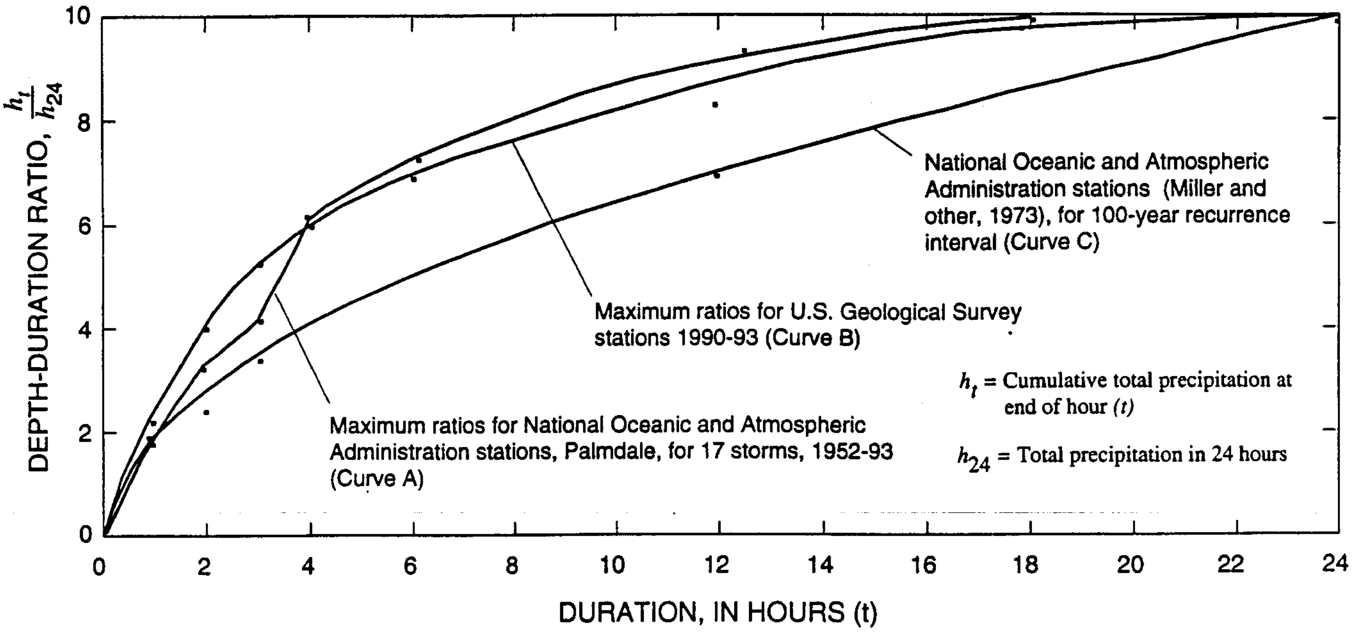

Figure 10. Depth-duration ratios for maximum recorded hourly precipitation depths in Antelope Valley, California.

depths of 0.59 and 0.60 in. were recorded at Boron and Palmdale on the valley floor during the storms of March 1983 and February 1993 (table 5). These data indicate that most parts of the valley can receive precipitation intensities that equal or exceed 0.60 in/h.

A description of precipitation depth and areal variation in the valley for subhourly time intervals was based on data collected at 10 continuous recording stream-gaging and precipitation stations established by the USGS in 1989-90. Data were collected at 5-minute intervals and were used in an evaluation of disaggregated hourly precipitation totals. During 1990-93, precipitation data for as many as 23 storms, depending on station location, were recorded at the USGS stations (table 6). Maximum precipitation depths recorded during the storm of January 5, 1992, at the Estates Creek near Quartz Hill station ranged from 0.08 in. for a 5-minute duration to 0.44 in. for a 60-minute duration (table 6, fig. 11). The maximum depth recorded during this storm at the NOAA Palmdale station (4.5 mi east of Estates Creek gage) was 0.10 in. in 60 minutes (National Oceanic and Atmospheric Administration, 1992), indicating the large areal variability in precipitation depths for this storm. For comparison, curve C on figure 11 indicates precipation depths for intervals less than 60 minutes using procedures given in a report by Miller and others (1973) and a 60-minute total of 0.44 in. The maximum 60-minute depth recorded at Palmdale was 0.60 in. during the storm of February 18-19, 1993 (table 5). The maximum depth-duration ratio curve (B) is higher than the curve (A) for the storm of January 5, 1992, at Estates Creek (fig. 11). The difference between curves A and B indicates the large amount of areal variability of storm intensity and duration recorded during 1990-93 throughout the valley. A depth-duration curve (C) based on adjustment factors developed by Miller and others (1973) for intervals of less than 60 minutes and an assumed 24-hour precipitation total of 0.44 in. at Palmdale also is shown on figure 11. Curve C precipitation depths at the 5-minute duration are about 1.6 times that of curve B. Precipitation data for the cyclonic storm Octave in October 1983 at Tucson, Ariz., for intervals of 5, 10, 15, 20, 30, 45, and 60 minutes also are shown on figure 11 and indicate the intensity of a significant historical storm that caused precipitation in much of the southwest, including Antelope Valley.

Depth-duration ratio curves based on 5-minute interval precipitation data collected at the 10 USGS stations for selected periods of less than 60 minutes are shown on figure 12. Curve A shows the average depth-duration relation for ratios based on data collected at USGS stations. Curve B shows the relation for the maximum ratios at the USGS stations that were calculated for storms that occurred during 1990-93. Because the intensity of storms varied throughout the valley (table 5), disaggregation of hourly precipitation data was analyzed to provide maximum rather than average ratios.

The curve for maximum ratios calculated for USGS stations (fig. 12, curve B) is about 19 percent greater than the curve calculated for 200 NOAA stations (fig. 12, curve C) (Hersfield, 1961; Miller and others, 1973). Ferro (1993) presents a similar relation of depth-duration ratios for intervals of less than 60 minutes for the United States (fig. 12) that closely approximates the data for Antelope Valley for durations of less than 10 minutes.

A precipitation depth-duration relation based on the ratios for the cyclonic storm "Octave" in October 1983 at Tucson, Ariz., is shown on figure 12 to indicate the relative significance of a cyclonic storm with documented short-interval data. The precipitation depth-duration relation for this storm also can be used as an indicator of ratios that might have occurred in Antelope Valley during large historical storms, such as December 21, 1943 (table 6), for which no subhourly precipitation data are available.

During the storm of February 9-12, 1992, a 60-minute total precipitation of 0.50 in. was recorded at the NOAA Palmdale station (table 5). Precipitation data for duration intervals of 5, 10, 15, 30, 50, and 60 minutes for selected USGS stations in the vicinity of the NOAA Palmdale station for this storm are given in table 7. By using ratios from curve A on figure 12, precipitation depths for the selected duration intervals were estimated. These estimates closely approximate the measured precipitation depths for the nearby USGS stations, but were somewhat higher at durations of 50 and 60 minutes. The estimated maximum precipitation depths, such as 0.29 in. for a 10-minute duration, also were derived using curve B on figure 12. The estimated precipitation depths presented in table 7 indicate the maximum depths that would occur at Palmdale on the basis of data collected during 1990-93. For comparison, depth-duration relations developed from data presented in reports by Miller and others (1973) and Ferro (1993) are slightly lower than those based on the 1990-93 data.

Miller and others (1973) reported that the adjustment factors used to obtain *n*-minute estimates for intervals of time (t) less than 60 minutes are independent of the recurrence interval. As such, the maximum depth-duration relation (fig. 12, curve B) provides a preliminary means to disaggregate hourly

precipitation stations, Antelope Valley, California, 1990-93

Maximum precipitation depths, in inches[1]--*Continued*							
2 hours	3 hours	4 hours	6 hours	8 hours	12 hours	16 hours	24 hours
0.59	0.72	0.86	1.02	1.09	1.30	1.64	1.75
.53	.67	.78	.95	.99	1.13	1.29	1.48
.54	.69	.88	1.26	1.43	1.63	1.83	2.12
.60	.79	.91	1.20	1.50	1.91	2.16	2.28
.61	.89	1.06	1.23	1.34	1.47	1.49	3.49
.61	.86	1.09	1.47	1.66	2.03	2.34	2.66
.67	.78	.94	1.30	1.63	2.01	2.44	2.82
.61	.92	1.18	1.48	1.67	1.74	1.81	2.34
.55	.72	.81	.93	1.02	1.02	1.03	1.33
.53	.69	.78	.89	.91	.91	.91	1.38
.67	.92	1.18	1.48	1.67	2.03	2.44	3.49
.58	.77	.93	1.17	1.32	1.52	1.69	2.16
26.9	35.6	43.1	54.2	61.1	70.4	78.2	100

Table 7. Total measured and estimated precipitation for selected durations for the storm of February 9-12, 1992, at Palmdale, California, and vicinity

Station name	Total precipitation, in inches, for indicated duration, in minutes					
	5	10	15	30	50	60
Measured						
Palmdale	--	--	--	--	--	0.50
Peach Tree Creek	0.06	0.10	0.13	0.17	0.26	.29
City Ranch Creek	.06	.11	.17	.26	.34	.36
Somerset Creek	.04	.08	.12	.22	.32	.38
Inn Creek	.05	.10	.13	.24	.34	.38
Estates Creek	.04	.07	.10	.18	.27	.31
Estimated						
Palmdale (using mean, curve A, figure 12)	.06	.10	.14	.27	.44	.50
Palmdale (using maximum, curve B, figure 12)	.22	.29	.34	.42	.48	.50
Palmdale (using procedures presented by Miller and others, 1973, for 100-year recurrence interval)	.27	.42	.54	..74	.88	.94

precipitation data and is considered independent of the recurrence interval.

REGIONAL CHARACTERISTICS OF SELECTED STORMS

The areal variation of precipitation in Antelope Valley is influenced by the Tehachapi and San Gabriel Mountains. These mountain ranges cause west-to-east variations in precipitation and a rain-shadow effect. Mean annual precipitation ranges from about 20 in. in the mountains to less than 4 in. near the eastern border of the valley (frontispiece). The close and irregular spacing of the precipitation lines near the foothills and mountains (fig. 7) indicates that runoff magnitude can vary by large amounts between basins that are in close proximity, especially near Palmdale and Fairmont (fig. 1).

Flow records for Big Rock Creek near Valyermo for 1923-93 indicate seven storms caused floods that exceeded the 10-year recurrence interval (1,500 ft^3/s) (fig. 4). Maximum 24-hour precipitation data for the various stations throughout the valley were compiled for these seven storms to identify their magnitude and areal variability. The magnitude and areal variability of maximum 24-hour precipitation for 16 additional major storms that occurred between 1938 and 1993 also are given in table 8.

Nine storms that occurred during water years 1991-93 were selected for analysis. Precipitation data for these storms were recorded at the short-term USGS precipitation stations (table 8), as well as at the long-term NOAA and LACDPW stations. Maximum precipitation depths for these storms were less than the historical maximums recorded at the long-term stations. Therefore, application of rainfall-runoff models using data collected at short-term stations will be based on precipitation depths that are less than historical maximums.

In general, maximum 24-hour precipitation during the 23 selected major storms in Antelope Valley averaged 70 percent of the precipitation depths recorded at the NOAA Palmdale station (fig. 13) in the eastern part of the valley and 220 percent in the western part. For the storm of February 18-20, 1993, 27 long-term stations and 9 short-term stations throughout the valley (table 8) were used to define the areal variability of precipitation. For this storm, the maximum precipitation depth for a 24-hour duration at Palmdale was 1.60 in. and at Big Pines Park was 4.40 in. This storm was much less intense than the storm of December 10-11, 1943, which had a 24-hour maximum precipitation of 3.43 in. at Palmdale, 3.58 in. at Fairmont, and 5.00 in. at Lewis Ranch (table 8).

Maximum 24-hour precipitation depths for selected storms were used to indicate the variation in intensity of individual storms throughout the valley. Precipitation data for 35 long-term stations (1952-93) were selected for analysis (table 8). Some precipitation data for stations outside the valley also were used to define the characteristics of storms at the valley boundary. So that the relative magnitude and areal did not record all 23 storms were calculated on the basis of the mean for seven stations—Fairmont, Palmdale, Llano, Edwards Air Force Base; P.P., pumping plant; WSMO, Weather Service Meteorlogical Observatory; PWR PL1, power

1980 2/14-19	1983 3/1-2	1983 10/1	1991 2/27-3/1	1991 3/19-20	1991 3/26-27	1992 2/10-13	1993 1/7-8	1993 1/12-13	1993 2/7-8	1993 2/18-20	1993 2/26-27	Adjusted mean
1.96	2.30	0.49	1.4	0.9	1.4	--	2.40	1.70	1.30	2.70	0.10	2.16
2.32	--	--	--	--	--	--	--	--	--	--	--	1.76
2.81	2.25	1.05	3.62	1.3	1.62	3.51	2.11	1.64	1.92	3.94	.39	3.24
--	2.88	.21	1.23	.53	.95	2.25	.98	.84	1.03	1.14	.75	1.46
2.75	2.93	.17	1.29	.68	.79	2.14	1.33	1.60	1.04	2.30	0	1.53
1.46	2.11	.31	1.03	.72	1.08	1.51	1.58	1.10	1.29	1.60	.45	1.56
--	--	.42	1.17	.54	.84	1.26	.86	.47	.87	1.18	0	1.10
1.37	3.38	.20	.81	.41	1.36	1.21	.86	.84	.40	.28	.30	1.10
1.53	3.28	.09	1.13	.2	.37	.93	.97	.53	.40	.37	--	1.09
1.69	2.92	.74	1.32	.86	1.43	1.47	.55	.35	1.20	1.52	.22	1.55
3.7	4.48	2.05	3.10	1.3	1.80	2.00	4.70	4.90	3.00	4.40	.20	4.28
--	5.00	0	1.46	.33	1.33	1.42	.77	.59	.87	--	--	1.48
2.45	2.01	.46	.52	.23	1.4	1.07	1.07	.43	.45	1.07	.28	1.14
2.2	2.68	.65	1.35	.28	1.66	1.44	.64	.85	1.02	1.12	.09	1.22
.83	1.52	.35	--	--	--	.96	.63	.20	.95	.77	.38	.66
2.21	.79	1.05	2.26	1.55	.69	2.46	.42	1.55	4.20	3.10	3.10	2.18
--	3.40	.55	1.60	.5	.5	1.88	1.90	.50	1.57	1.20	.15	1.41
1.56	2.70	.37	1.18	.8	1.52	1.18	1.01	.68	1.29	1.27	.68	1.49
1.84	3.12	.65	2.0	1.35	1.85	1.89	--	--	--	--	2.85	2.27
1.59	3.15	.12	1.15	1.33	1.45	1.33	1.08	.98	1.46	2.80	.17	1.73
2.52	1.93	.21	1.98	.74	1.51	1.59	--	2.04	--	2.68	.32	2.04
2.68	4.82	1.01	--	--	--	4.6	--	--	1.6	3.5	3.62	3.50
4.62	3.00	.40	2.60	.97	1.38	3.60	1.80	2.00	1.60	3.96	.39	2.52
1.85	4.20	.68	1.33	.59	1.77	1.90	1.31	--	.98	2.30	.11	1.53
2.77	4.39est	1.88	--	--	--	--	--	--	--	--	4.31	3.38
2.57	2.00	1.28	3.0	2.15	4.0	5.00	--	--	--	--	3.11	3.04
1.4	1.38	.04	1.09	.72	1.25	2.66	1.60	1.50	1.06	2.20	.75	1.34
2.63	3.05	.20	1.55	.78	1.45	2.08	1.43	1.30	1.35	1.46	.28	1.81
4.46	7.20	2.00	4.97	2.80	1.97	4.29	2.48	2.40	3.95	3.25	.68	3.95
1.2	2.50	.15	--	--	--	--	--	--	--	--	--	.83
1.17	2.12	--	--	--	--	--	--	--	--	--	1.48	1.05
1.35	3.50	.30	1.28	1.4	1.73	1.76	1.52	.93	1.64	2.67	.24	2.04
--	--	--	--	--	--	--	--	--	--	--	--	2.62
--	--	0	6.32	2.55	.26	2.13	1.02	1.14	1.25	1.98	.53	2.11
4.35	4.60	1.24	3.62	1.61	2.4	3.35	1.83	2.45	2.21	2.62	.35	3.11
--	--	--	.85	.38	.75	1.18	.43	.23	.31	--	--	.88
--	--	--	.67	.59	.69	1.21	.54	.34	.27	.52	.29	.77
--	--	--	.92	.50	1.04	1.93	.82	.38	.5 est	.64	.14	1.03
--	--	--	.85	.52	1.44	1.93	.61	.37	.31	.63	.13	1.02
--	--	--	1.63	.67	1.82	2.09	.89	.50	.38	.71	.13	1.33
--	--	--	1.71	.82	1.64	2.76	.91	.56	.39	1.12	.18	1.52
--	--	--	1.71	.55	1.33	2.32	.73	.72	.29	1.20	.16	1.36
--	--	--	2.34	.98	.52	1.81	.37	.45	.40	.51	.18	1.14
--	--	--	.58	.38	.80	1.03	.37	.38	.23	.24	.24	.64
--	--	--	--	--	--	.91	.77	1.39	.22	.57	1.44	.99
2.60	3.33	0.71	2.27	1.25	1.49	2.41	1.52	1.31	1.82	2.62	0.43	--

Maximum 24-hour precipitation depths of record occurred prior to 1991 at the 35 stations. However, none of the 24-hour precipitation depths recorded throughout the valley (table 8) during the March 2, 1938, storm were a maximum of record. The extreme flooding that occurred during the March 1938 storm was attributed to a combination of precipitation and snowmelt in the San Gabriel and Tehachapi Mountains. For those stations with a complete record for the selected storms of 1938-93, the maximum 24-hour precipitation depths occurred during 1943-83. For storms that occurred during 1991-93, maximum 24-hour precipitation depths averaged 50 percent less than the maximum of record during 1938-93.

Methods used to determine precipitation depth-duration frequency relations at ungaged sites generally assume that a relation exists between the mean annual precipitation at a site and the depth of precipitation for a given duration and recurrence interval (Rantz, 1971). Isolines of maximum 24-hour precipitation depths, such as those shown on figure 7, can be used to estimate the magnitude of precipitation for a selected duration at ungaged locations relative to sites with measured depths. However, this procedure may not be valid if the intensity of significant storms does not follow the precipitation pattern described by the isolines developed on the basis of mean annual precipitation.

To compare precipitation depth-duration characteristics of historic storms in the valley with mean annual precipitation patterns, the areal variation in storm intensity, based on the adjusted mean 24-hour maximum precipitation depths for 23 storms (table 8) is shown on figure 13. The lines of equal precipitation are based on the adjusted means for six stations that have complete records and 39 stations that have incomplete records of these storms. These precipitation depths represent precipitation patterns in the valley as a result of various types of storms and the effect of the San Gabriel and Tehachapi Mountains.

The areal variation in precipitation depths based on individual historical storm systems provides the additional detail needed to define flood-related precipitation depth-duration characteristics in the valley. These data provide more accurate definition of the isolines of maximum precipitation than could have been obtained using variations described by isolines of mean annual precipitation.

A comparison of the isolines defined by historic storm patterns and those defined by mean annual precipitation (figs. 7 and 13) indicate dissimilarities of the two methods. For example, isolines of mean annual precipitation (fig. 7) depict an area of depression north of Palmdale. However, the 24-hour storm precipitation depth isolines for the same area (fig. 13) indicate a gradual decline from west to east. Also, the isolines based on storm patterns (fig. 13) depict a different arrangement and steeper gradients in the area south and west of Palmdale than do those based on mean annual precipitation (fig. 7). These differences are attributed to the larger network of stations used in defining the isolines on figure 13 and to variations in the storm patterns that produced much of the precipitation associated with flood conditions in the valley.

MAXIMUM 24-HOUR TOTAL PRECIPITATION AND FREQUENCY

Precipitation depth-duration and frequency relations were calculated for selected recurrence intervals of between 2 and 100 years for stations in Antelope Valley using annual maximum 24-hour recorded totals at eight selected stations in the valley (fig. 14). Data for 24-hour total precipitation depth-duration and frequency analysis were obtained from records published by NOAA, LACDPW, and EAFB (table1). For a given station, 24-hour annual maximum precipitation depths were estimated for 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals from isopluvials and by using procedures described by Miller and others (1973). Frequency relations for 2- to 100-year recurrence intervals were then developed (fig. 14). The stations were selected to provide an indication of the areal diversity of depth-duration and frequency relations throughout the valley and vicinity, and each station had from 20 to 50 years of record prior to 1973 (table 9). Precipitation stations in Antelope Valley and nearby surrounding areas were included in the study so that areas near the valley borders also could be analyzed, especially the foothill areas of the Tehachapi and San Gabriel Mountains. Precipitation depths for a 100-year recurrence interval varied from 2.9 in. at EAFB (fig. 14*H*) to 18 in. at Big Pines Park (fig. 14*D*).

Using the additional data collected since publication of the report by Miller and others (1973) and using a log Pearson type III distribution, frequency relations of annual maximum 24-hour precipitation depths were calculated for the eight selected stations (table 9). Generalized skew coefficients were used to calculate the frequency distribution of these data using

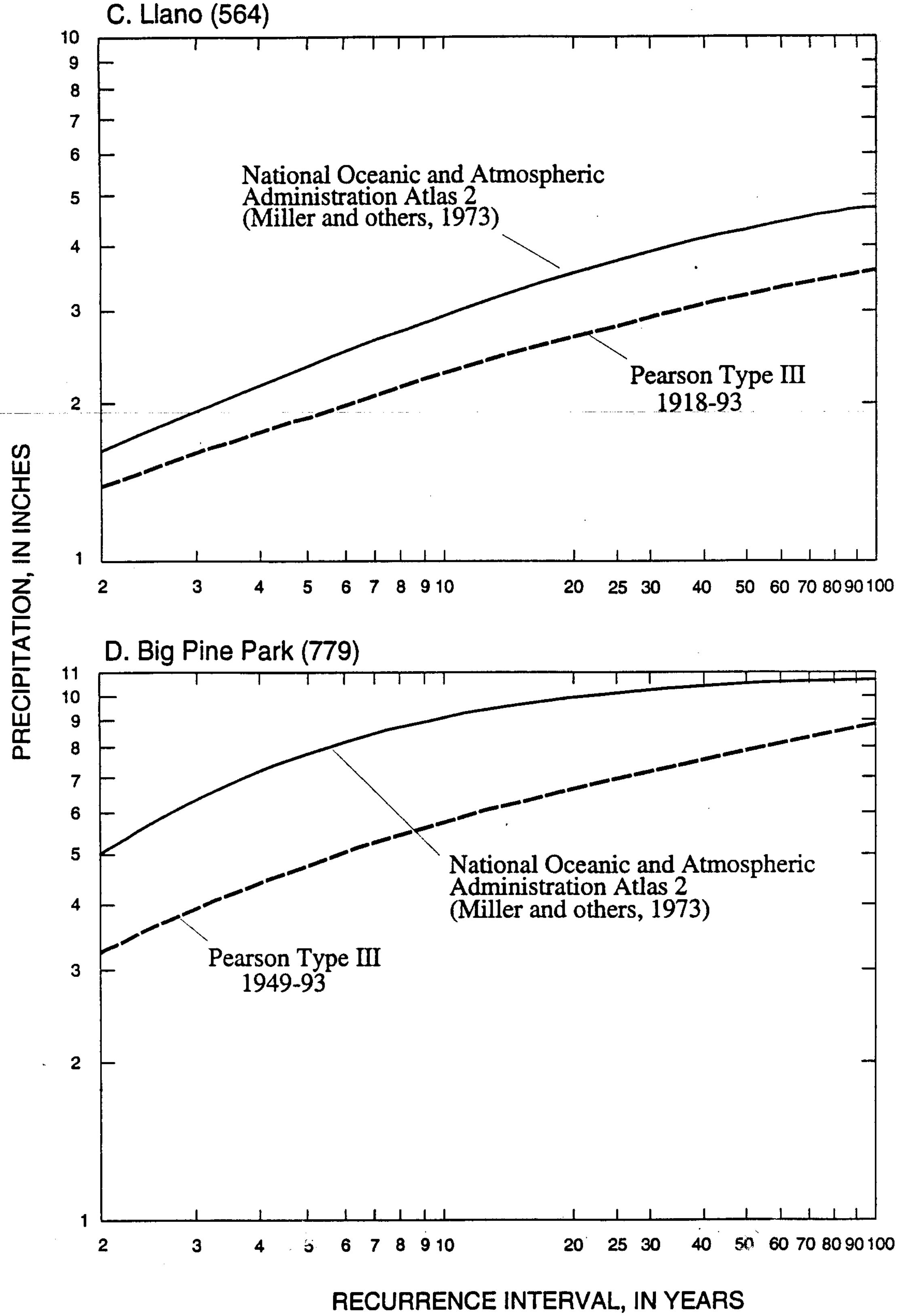

Figure 14.--*Continued*

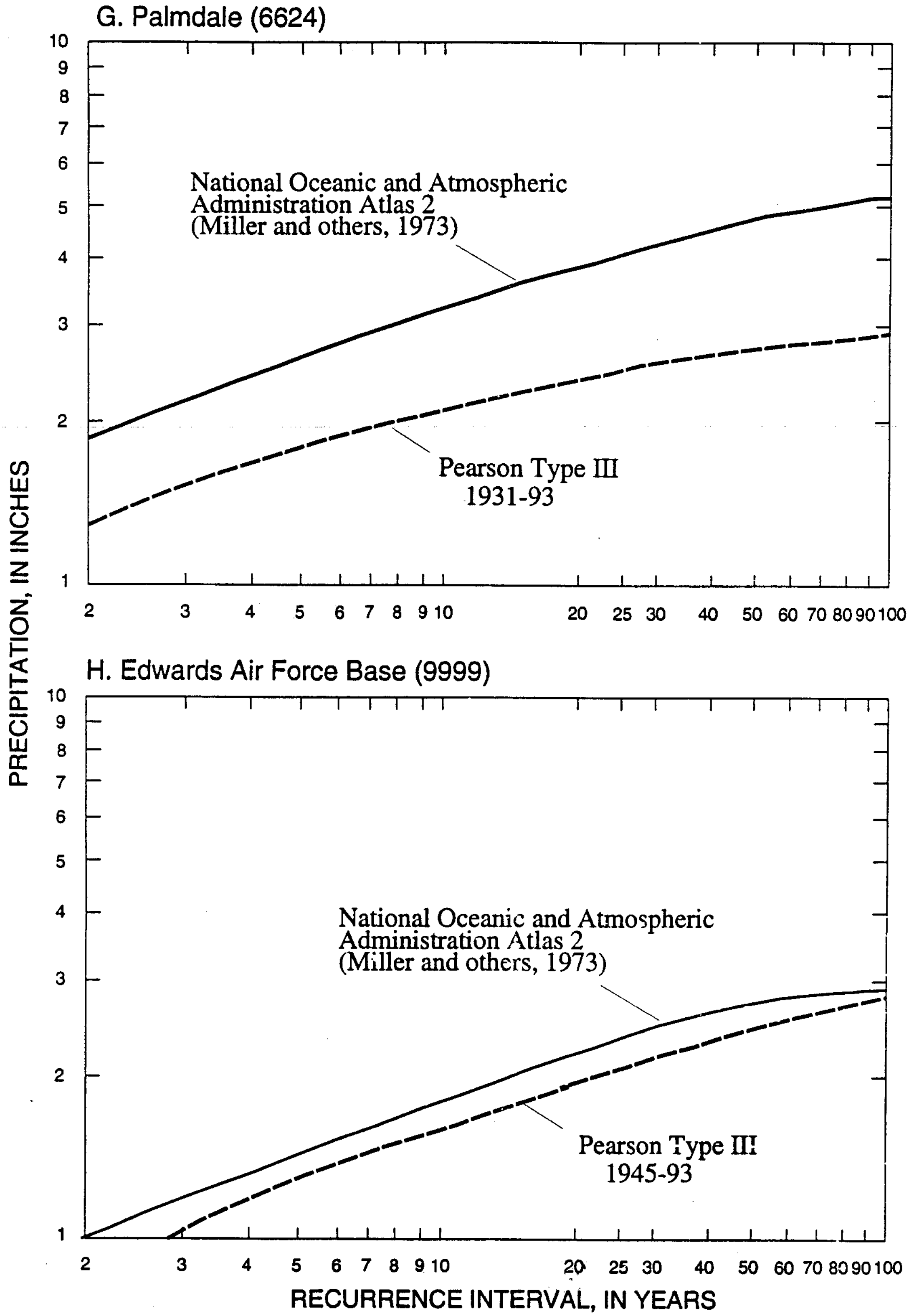

Figure 14.--*Continued*

Table 10. Precipitation depth-duration and frequencies at selected stations for selected storms in Antelope Valley, California

[Recurrence intervals calculated using the log Pearson type III distribution with weighted generalized skew as described by Lumb and others (1990). P, precipitation, in inches; RI, recurrence interval, in years; >, greater than; <, less than]

Date storm began	Storm duration: 1 day		2 days		3 days		4 days		7 days	
	P	RI	P	RI	P	RI	P	RI	P	RI
Palmdale, 1932-93										
3/2/38	2.39	22	3.15	16	4.02	17	5.43	38	5.57	23
1/22/43	2.40	22	4.41	>100	4.93	42	4.93	26	5.48	19
2/10/78	1.30	2	2.46	5	2.48	4	2.52	3	2.86	3
3/1/83	2.11	10	3.84	43	4.20	23	4.26	15	5.02	15
2/28/91	1.03	<2	1.98	3	2.05	3	2.05	2	2.08	2
2/10/92	1.51	3	2.93	11	4.12	20	4.33	17	4.68	12
2/26/93	1.60	3	2.37	5	2.37	3	2.46	3	2.68	3
Llano, 1918-93										
3/2/38	1.75	4	2.33	4	2.78	5	2.82	4	2.82	3
1/23/43	3.60	>100	6.45	>100	6.45	>100	6.45	>90	7.25	>76
2/10/78	2.43	13	3.70	20	3.70	12	3.92	11	4.77	14
3/2/83	2.92	30	4.68	50	5.71	73	6.01	>63	6.04	34
2/28/91	1.43	2	1.65	2	1.95	2	1.95	<2	1.96	<2
2/11/92	1.47	2	2.69	6	3.51	10	3.73	9	4.01	7
2/26/93	.22	<2	.27	<2	.27	<2	.27	<2	.27	<2
Neenach-Erstad, 1944-93										
2/10/78	3.58	23	5.58	32	5.60	15	5.73	14	9.26	46
3/00/83	5.00	>100	8.00	>100	8.45	>100	8.47	>100	8.57	32
2/28/91	2.26	4	2.86	4	3.26	3	3.26	3	3.64	3
2/10/92	2.52	6	3.00	4	5.46	14	6.43	22	6.85	14
2/26/93	3.10	12	4.42	12	4.42	7	4.42	6	5.35	6
Edwards Air Force Base, 1945-93										
2/9/78	1.33	5	2.51	23	2.92	23	2.06	5	2.92	9
3/1/83	3.38	>100	4.34	>100	4.87	>100	5.83	>100	6.32	>100
3/1/91	1.36	6	1.54	4	1.56	4	1.58	3	1.58	3
2/10/92	1.21	4	1.74	6	2.81	19	3.18	20	3.74	20
2/26/93	.30	<2	.49	<2	.52	<2	.53	<2	.61	<2

current analysis, and application of different frequency distributions.

The greatest source of error in precipitation depth-duration and frequency analyses for the valley is the difficulty in defining homogeneous hydrologic regions for which values of generalized skew coefficients can be estimated. Generally, a minimum of 40 years of record should be available to define generalized skew coefficients. This availability of record will reduce the mean square error of station skew to a reasonable (50 percent) range when estimating precipitation depths for a 100-year recurrence interval.

Precipitation depth and duration analyses for durations of 1, 2, 3, 4, and 7 days were made at four stations (table 10). These data indicate that the intensity of the storm of February 10-11, 1992, was low (recurrence interval less than 11 years) for 1- and 2-day durations, but was more intense (recurrence interval up to 22 years) at durations of 4 to 7 days. The storms of January 1943 and March 1983, with total 24-hour precipitation depths of 3.60 and 2.92 in., respectively, at Llano, were the most intense storms of record in the valley with recurrence intervals of up to about 100 years.

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