HYDROMETEOROLOGICAL REPORT NO. 58
(SUPERCEDES HYDROMETEOROLOGICAL REPORT NO. 36)

PROBABLE MAXIMUM PRECIPITATION FOR CALIFORNIA –
CALCULATION PROCEDURES

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

Silver Spring, MD
October 1998

HYDROMETEOROLOGICAL REPORTS

No 1 Maximum possible precipitation over the Ompompanoosuc Basin above Union Village, Vt 1943
No 2 Maximum possible precipitation over the Ohio River Basin above Pittsburgh, Pa 1942
No 3. Maximum possible precipitation over the Sacramento Basin of California. 1943
No. 4 Maximum possible precipitation over the Panama Canal Basin. 1943.
No. 5 Thunderstorm rainfall. 1947.
No 6 A preliminary report on the probable occurrence of excessive precipitation over Fort Supply Basin, Okla 1938
No 7 Worst probable meteorological condition on Mill Creek, Butler and Hamilton Counties, Ohio 1937 (Unpublished) Supplement, 1938
No 8 A hydrometeorological analysis of possible maximum precipitation over St Francis River Basin above Wappapello Mo. 1938
No 9 A report on the possible occurrence of maximum precipitation over White River Basin above Mud Mountain Dam site, Wash 1939
No 10 Maximum possible rainfall over the Arkansas River Basin above Caddoa, Colo 1939 Supplement, 1939
No 11 A preliminary report on the maximum possible precipitation over the Dorena, Cottage Grove, and Fern Ridge Basins in the Willamette Basin, Oregon. 1939
No 12 Maximum possible precipitation over the Red River Basin above Denison, Tex. 1939.
No 13. A report on the maximum possible precipitation over Cherry Creek Basin in Colorado 1940
No 14. The frequency of flood-producing rainfall over the Pajaro River Basin in California. 1940.
No 15 A report on depth-frequency relations of thunderstorm rainfall on the Sevier Basin, Utah 1941
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No 17 Maximum possible precipitation over the Pecos Basin of New Mexico. 1944. (Unpublished)
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No 19 Preliminary report on depth-duration-frequency characteristics of precipitation over the Muskingum Basin for 1- to 9-week periods 1945.
No 20 An estimate of maximum possible flood-producing meteorological conditions in the Missouri River Basin above Garrison Dam site 1945.
No. 21 A hydrometeorological study of the Los Angeles area. 1939.
No 21A Preliminary report on maximum possible precipitation, Los Angeles area, California 1944.
No 21B Revised report on maximum possible precipitation, Los Angeles area, California. 1945.
No 22 An estimate of maximum possible flood-producing meteorological conditions in the Missouri River Basin between Garrison and Fort Randall 1946.
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No. 24 Maximum possible precipitation over the San Joaquin Basin, California. 1947.
No. 25 Representative 12-hour dewpoints in major United States storms east of the Continental Divide 1947
No 25A Representative 12-hour dewpoints in major United States storms east of the Continental Divide 2d edition. 1949
No 26 Analysis of winds over Lake Okeechobee during tropical storm of August 26-27, 1949. 1951
No 27 Estimate of maximum possible precipitation, Rio Grande Basin, Fort Quitman to Zapata. 1951
No 28 Generalized estimate of maximum possible precipitation over New England and New York. 1952.
No. 29 Seasonal variation of the standard project storm for areas of 200 and 1.000 square miles east of 105th meridian 1953
No 30 Meteorology of floods at St Louis. 1953. (Unpublished.)
No 31. Analysis and synthesis of hurricane wind patterns over Lake Okeechobee, Florida. 1954.
No. 32 Characteristics of United States hurricanes pertinent to levee design for Lake Okeechobee, Florida. 1954
No. 33 Seasonal variation of the probable maximum precipitation east of the 105th meridian for areas from 10 to 1,000 square miles and durations of 6, 12, 24, and 48 hours 1956.
No 34 Meteorology of flood-producing storms in the Mississippi River Basin. 1956
No 35 Meteorology of hypothetical flood sequences in the Mississippi River Basin. 1959.
No 36 Interim report–probable maximum precipitation in California. 1961 Also available is a supplement, dated October 1969
No 37 Meteorology of hydrologically critical storms in California 1962
No 38. Meteorology of flood-producing storms in the Ohio River Basin 1961
No 39. Probable maximum precipitation in the Hawaiian Islands. 1963.
No 40. Probable maximum precipitation, Susquehanna River drainage above Harrisburg, Pa. 1965
No 41. Probable maximum and TVA precipitation over the Tennessee River Basin above Chattanooga. 1965
No 42. Meteorological conditions for the probable maximum flood on the Yukon River above Rampart, Alaska. 1966.
No 43. Probable maximum precipitation, northwest states 1966
No 44 Probable maximum precipitation over South Platte River, Colorado, and Minnesota River, Minnesota. 1969
No 45. Probable maximum and TVA precipitation for Tennessee River Basins up to 3,000 square miles in area and durations to 72 hours 1969
No 46 Probable maximum precipitation, Mekong River Basin 1970.
No 47 Meteorological criteria for extreme floods for four basins in the Tennessee and Cumberland River Watersheds 1973
No 48 Probable maximum precipitation and snowmelt criteria for Red River of the North above Pembina, and Souris River above Minot, North Dakota 1973.

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HYDROMETEOROLOGICAL REPORT NO. 58

(SUPERCEDES HYDROMETEOROLOGICAL REPORT NO. 36)

PROBABLE MAXIMUM PRECIPITATION FOR CALIFORNIA – CALCULATION PROCEDURES

Prepared By

P. Corrigan, D.D. Fenn, D. R. Kluck, and J.L. Vogel
Hydrometeorological Design Studies Center
Office of Hydrology
National Weather Service

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Incorrect entries have been discovered in two tables in HMR 58. The corrections are as follows:

1. Table 2.3 (page 22).

Portions of Table 2.3 (page 22) are garbled. Only the *Midcoastal* and *Central Valley* segments of these tables are involved. Replace the *Midcoastal* and *Central Valley* sections with the following:

Table 2.3. All-season depth-area relations for California by region.

Midcoastal						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	100.00	100.00	100.00	100.00	100.00	100.00
50	87.50	88.75	90.00	91.00	92.00	93.00
100	81.75	83.75	85.50	87.00	88.50	90.00
200	75.75	78.25	80.50	82.50	84.50	86.25
500	67.50	71.00	73.50	76.00	78.50	80.50
1000	60.75	65.50	68.00	70.50	73.00	75.50
2000	53.00	58.50	61.50	64.00	67.00	70.00
5000	38.00	44.50	48.50	52.00	55.00	59.00
10000	25.00	34.00	38.00	42.00	45.00	49.00
Central Valley						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	100.00	100.00	100.00	100.00	100.00	100.00
50	84.50	87.25	89.50	91.50	92.75	94.00
100	77.25	81.00	84.00	86.50	88.50	90.50
200	70.00	74.50	78.00	81.00	83.00	85.00
500	59.75	64.75	68.75	72.00	74.50	77.00
1000	51.00	56.50	61.00	64.50	67.00	69.50
2000	41.00	47.50	52.00	55.50	58.50	61.50
5000	27.00	33.75	38.50	42.00	45.25	48.50
10000	14.00	21.00	26.00	30.00	33.00	36.50

2. Table 2.5 (page 27).

Table 2.5 defines seasonally adjusted areal reduction factors for the *Midcoastal* region. The incorrect entries there are for all area sizes BUT ONLY for the 5-month offset segment and ONLY at the 72-hour duration (right-most column of the segment).

The following segment should replace that portion of Table 2.5 (page 27) dealing with the 5-month offset:

Table 2.5. Seasonally adjusted areal reduction factors for the Midcoastal region.

Offset 5 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.842	0.879	0.897	0.915	0.936	0.955
100	0.757	0.809	0.832	0.855	0.872	0.888
200	0.664	0.730	0.765	0.787	0.808	0.824
500	0.539	0.614	0.650	0.679	0.705	0.722
1000	0.434	0.526	0.556	0.587	0.615	0.643
2000	0.331	0.427	0.461	0.493	0.526	0.557
5000	0.196	0.289	0.325	0.364	0.396	0.431
10000	0.110	0.194	0.228	0.267	0.299	0.333

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PROBABLE MAXIMUM PRECIPITATION FOR CALIFORNIA– CALCULATION PROCEDURES

P. Corrigan, D.D. Fenn, D. R. Kluck, and J. L. Vogel
Hydrometeorological Design Studies Center
Office of Hydrology
National Weather Service

ABSTRACT

This study provides estimates of general-storm probable maximum precipitation (PMP) for drainages in California for durations of 1 to 72 hours, for areas of 10 to 10,000 mi^2, and during any month of the year. The report also provides local-storm PMP for durations of 15 minutes to 6 hours in drainages of 1 to 500 mi^2. Step-by-step procedures are given along with example calculations. For the first time, the plates accompanying the report and all of the figures are digital products.

1. INTRODUCTION

1.1 Background

Generalized estimates of probable maximum precipitation (PMP) for Pacific Ocean drainages of California were first published by the National Weather Service (NWS) as Technical Paper No. 38 in 1960, and followed in 1961 by Hydrometeorological Report No. 36 (U. S. Weather Bureau 1961), and a revised report in October 1969 (U. S. Weather Bureau 1969). PMP estimates were provided for general storms from October through April. General-storm estimates of PMP for southeast California (mostly desert) were presented in Hydrometeorological Report No. 49 (Hansen et al. 1977). Hydrometeorological Report No. 49, which examined the Colorado River and Great Basin Drainages, also provided estimates of local-storm PMP for all of California. None of the reports provided general-storm PMP estimates for most of northeast California. In this report, publications in the Hydrometeorological Report series, such as Hydrometeorological Reports No. 36 and 49, will be abbreviated as HMR 36 and HMR 49.

HMR 36 used a mass-conservation model as a primary tool to develop estimates of general-storm PMP in topographic regions, but was unable to account for local convergence, convection, and synergistic effects caused by natural upper-level seeding of low-level clouds in orographic regions (Browning 1980, Hobbs 1989). This last effect is sometimes called the "seeder-feeder" effect. It is caused by convergence of moisture and upward vertical motion on the windward side of a mountain, with precipitation from the upper levels seeding and feeding (enhancing) the lower levels, resulting in increased precipitation on the ground. Presently, no numerical model of atmospheric processes can completely replicate orographic precipitation, especially quantitative amounts, in a reliable manner, especially for extreme general storms (Cotton and Anthes 1989, Katzfey 1995).

HMR 57, a recent PMP study for the Pacific Northwest (Hansen et al. 1994), showed some major differences between general-storm PMP estimates at the California-Oregon border, and local-storm values, especially in the western half of California. In addition, some intense storms that occurred since the publication of HMR 36 had many precipitation amounts that approached, and in a few instances surpassed the PMP estimates given in

HMR 36. As a result, it was decided that PMP estimates for California needed to be examined using new storm data and new techniques for an orographic region, which uses storms as the basis for establishing PMP.

1.2 Authorization

The authorization to develop new PMP estimates for California was given by the United States Army Corps of Engineers Office of Civil Works. Funding for this work was received from the United States Army Corps of Engineers and the Corps of Engineers Los Angeles District Office, South Pacific Division. Appropriations supporting the National Weather Service (NWS) effort were provided through a continuing Memorandum of Understanding between the NWS and the Corps of Engineers (COE). The Bureau of Reclamation (BOR), through its Flood Hydrology Group in Denver, provided insight, ideas, and reviewed the work throughout the study, giving many helpful suggestions and comparisons.

Many review meetings were held from 1992 to 1997 to share the progress being made in the development of California PMP estimates. Regular attendees, known as the Federal Interagency Team, were representatives of the COE (Office of the Chief Engineer, South Pacific Division, and the Los Angeles and Sacramento Districts of the South Pacific Division), BOR, Federal Energy Regulatory Commission, and the NWS. Many comments and suggestions made by this group improved the final estimates presented in this report.

1.3 PMP Definition and Philosophy

The PMP definition used for this report was given in HMR 55A (Hansen et al. 1988) as "theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given storm area at a particular geographical location at a certain time of the year." This is slightly different from the previous definition (American Meteorological Society 1959), which was used in HMR 36. The HMR 36 definition stressed that the estimate was for a particular drainage area. The current definition is more generalized, and emphasizes the control the atmosphere has over a broad geographic region. At the same time, the techniques from this report provide estimates of PMP for specific basins.

2. COMPUTATIONAL PROCEDURE

2.1 Introduction

The steps to calculate probable maximum precipitation (PMP) for general and local storms in California are provided in this Hydrometeorological (HMR) Report. All tables, figures, and plates are included here. As in the procedures recommended in HMR 55A and HMR 57, these steps produce storm-centered, average depths of PMP applicable to a specific drainage.

General-storm PMP may be determined for durations from 1 to 72 hours over areas from 10 to 10,000 mi^2, and local-storm PMP may be determined for durations from 15 minutes to 6 hours over areas between 1 and 500 mi^2. When making PMP estimates for basins less than 500 mi^2, it is recommended that both general and local-storm PMP be calculated. The larger of these estimates represents the basin PMP. The decision as to which of these results is most critical for the basin involves hydrological considerations related to flooding, and are beyond the scope of this report. The final selection of PMP, local- or general-storm value, is a choice for the user. Seasonal variation of general-storm PMP has been included to aid the user when other hydrologic factors have a bearing on water management decisions. The seasonal information is shown in Figures 2.1 - 2.10.

We have attempted to keep the computational procedure in this report simple and straightforward. The Index PMP map was drawn for the general storm at 1:1,000,000 scale for northern and southern sections of California, with an overlap of at least one degree of latitude. The maps contain latitude and longitude markings, county boundaries, and selected cities or towns. In addition, each index map contains regional boundaries for use with DAD relations. These maps accompany this report, Plates 1 and 2. See Endnote[1] for map supplement requests.

If calculations are being made for a drainage which encompasses more than one DAD region (Figure 2.11, and also outlined on Plates 1 and 2), use proportionally-weighted

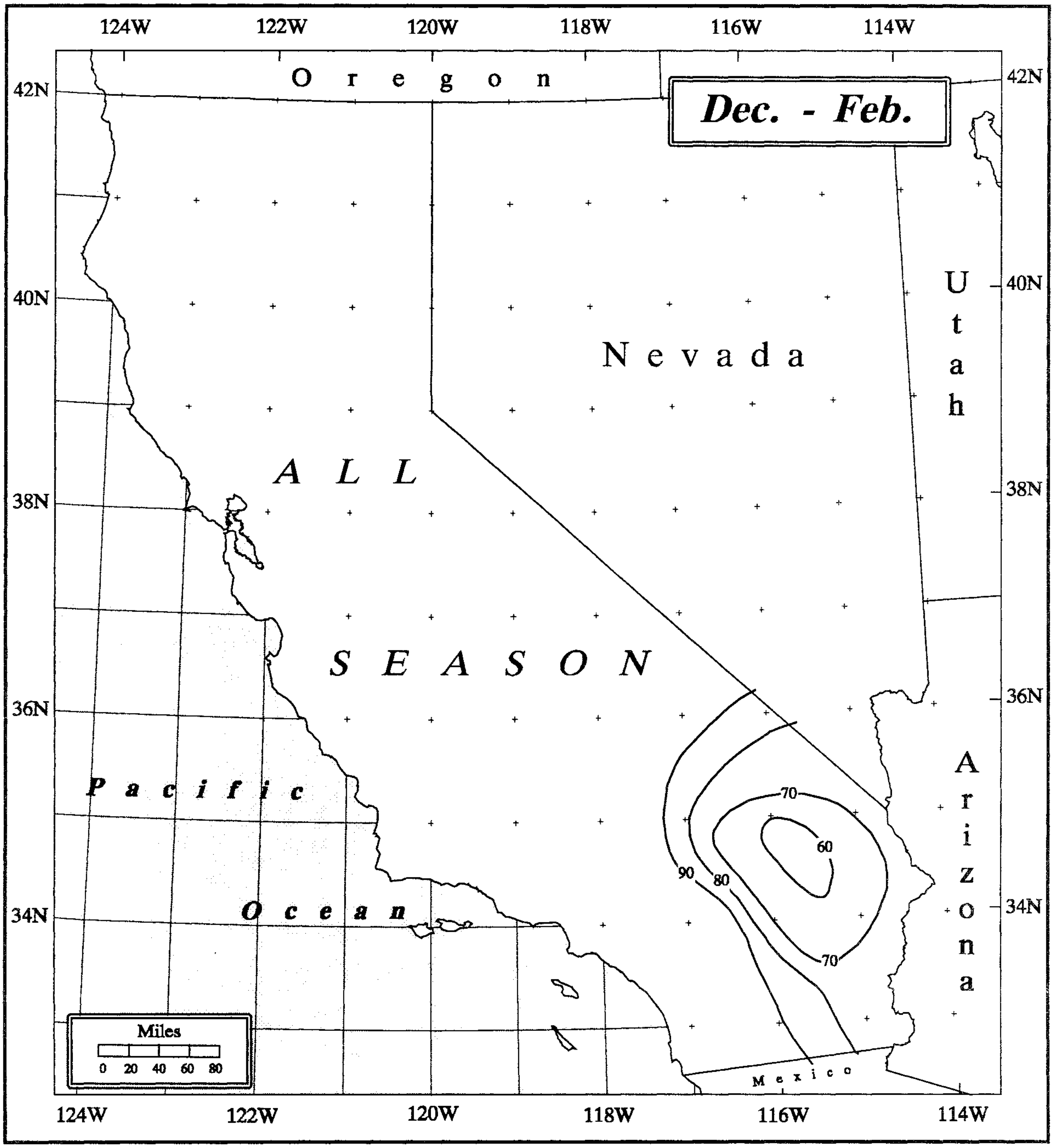


Figure 2.1. *10-mi² 24-hour general-storm PMP for December through February in California as a percent of all-season PMP (Plates 1 and 2).*

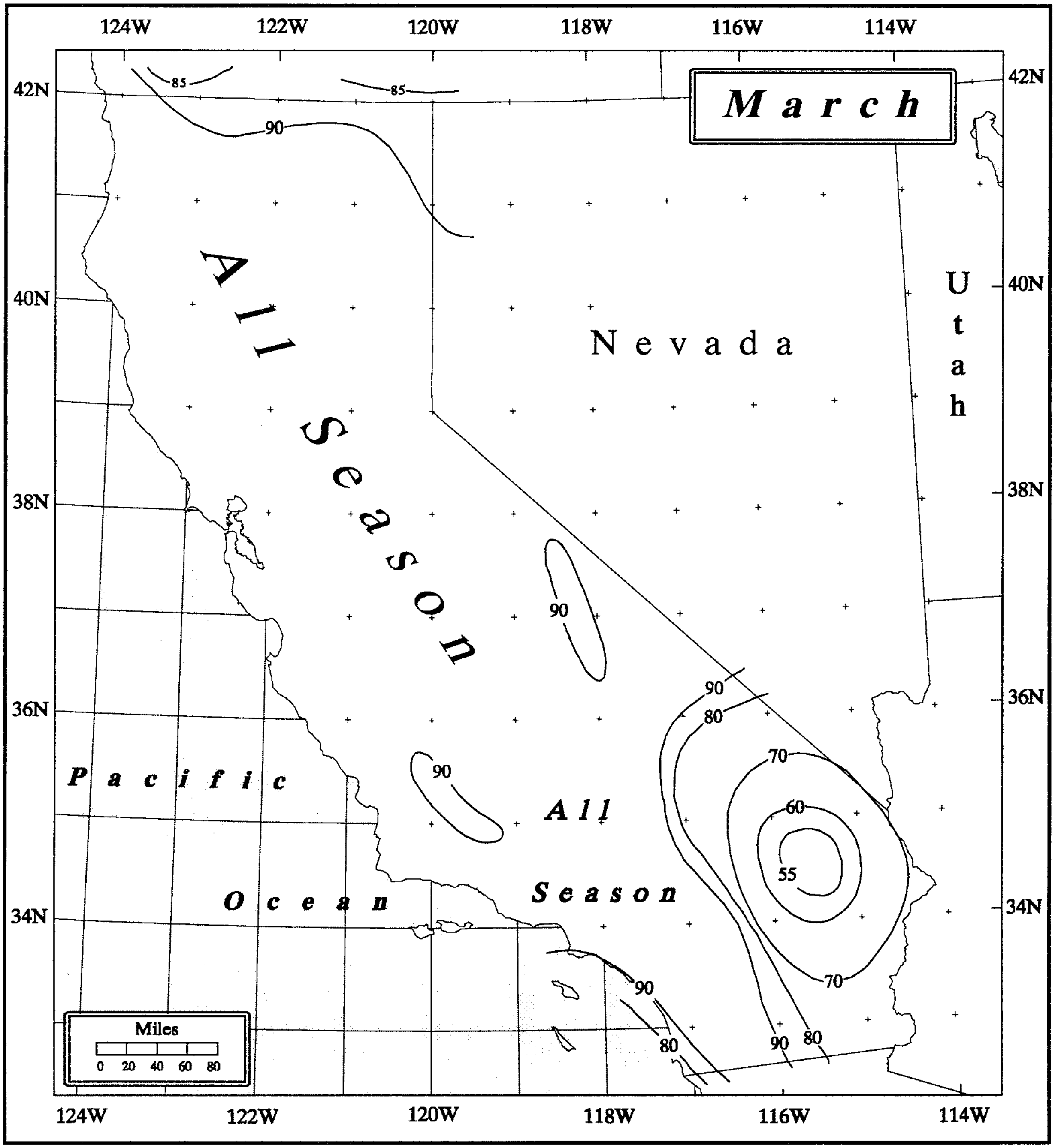


Figure 2.2. *10-mi² 24-hour general-storm PMP for March in California as a percent of all-season PMP (Plates 1 and 2).*

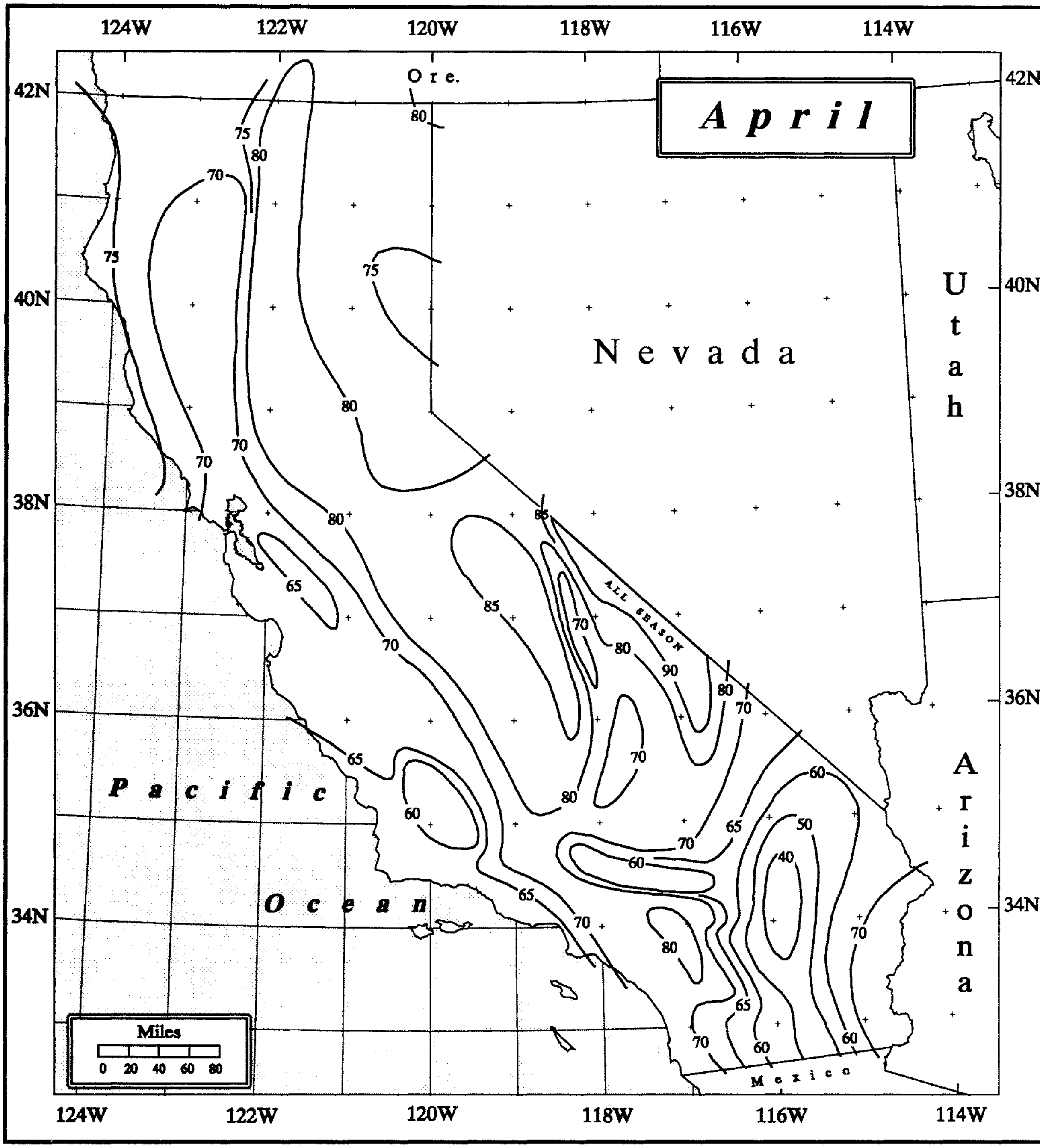


Figure 2.3. *10-mi² 24-hour general-storm PMP for April in California as a percent of all-season PMP (Plates 1 and 2).*

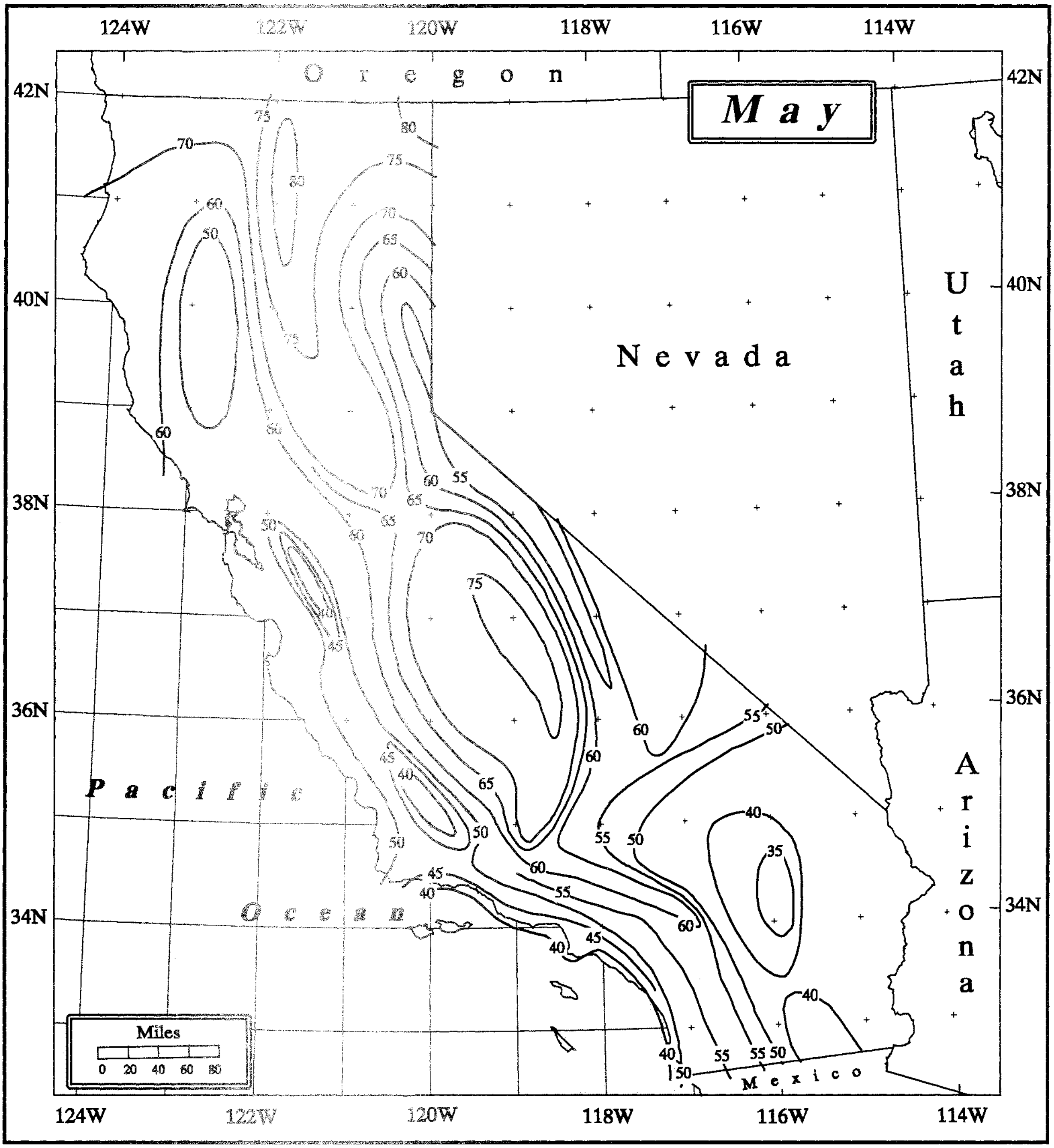


Figure 2.4. *10-mi² 24-hour general-storm PMP for May in California as a percent of all-season PMP (Plates 1 and 2).*

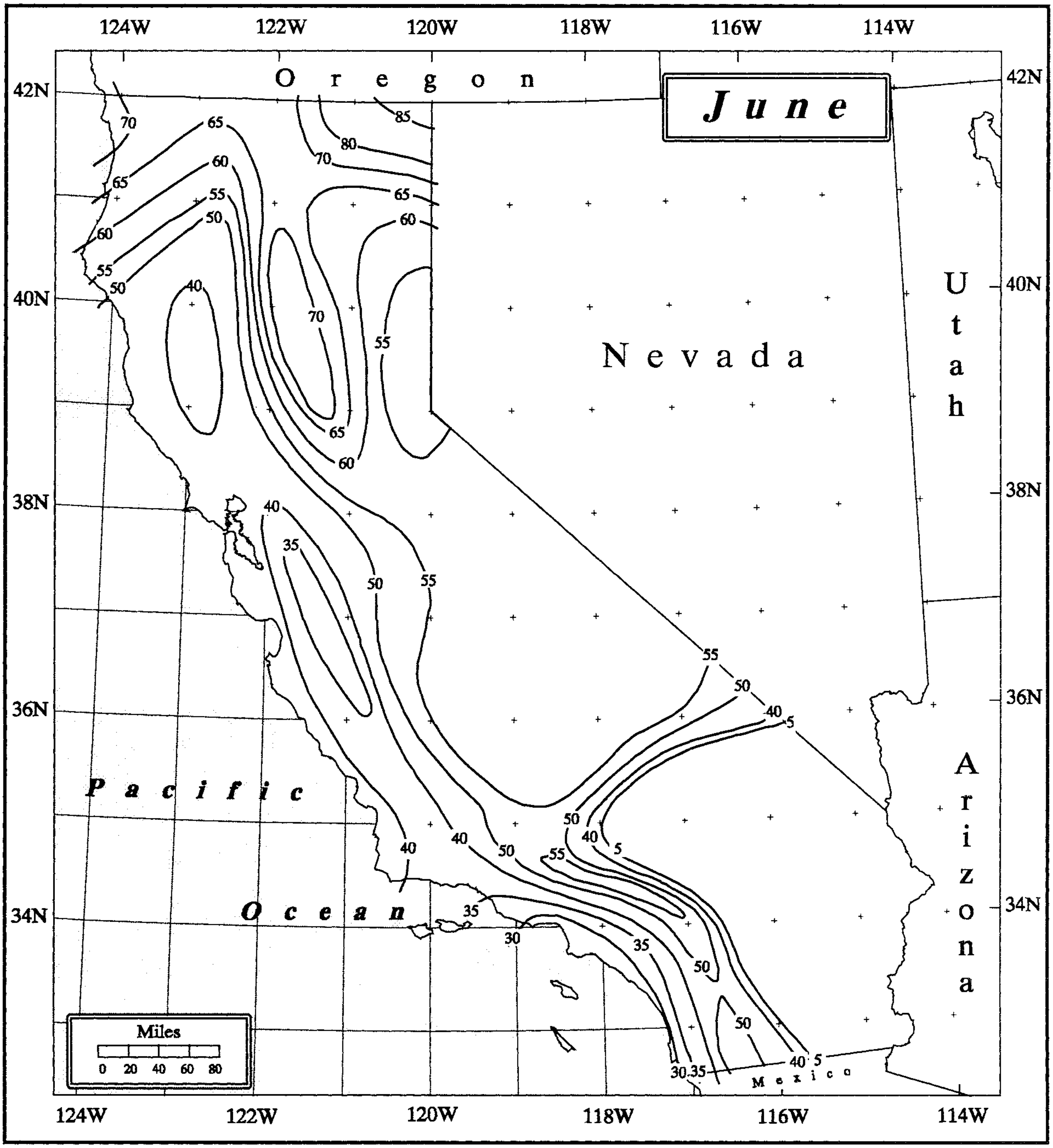


Figure 2.5. *10-mi² 24-hour general-storm PMP for June in California as a percent of all-season PMP (Plates 1 and 2).*

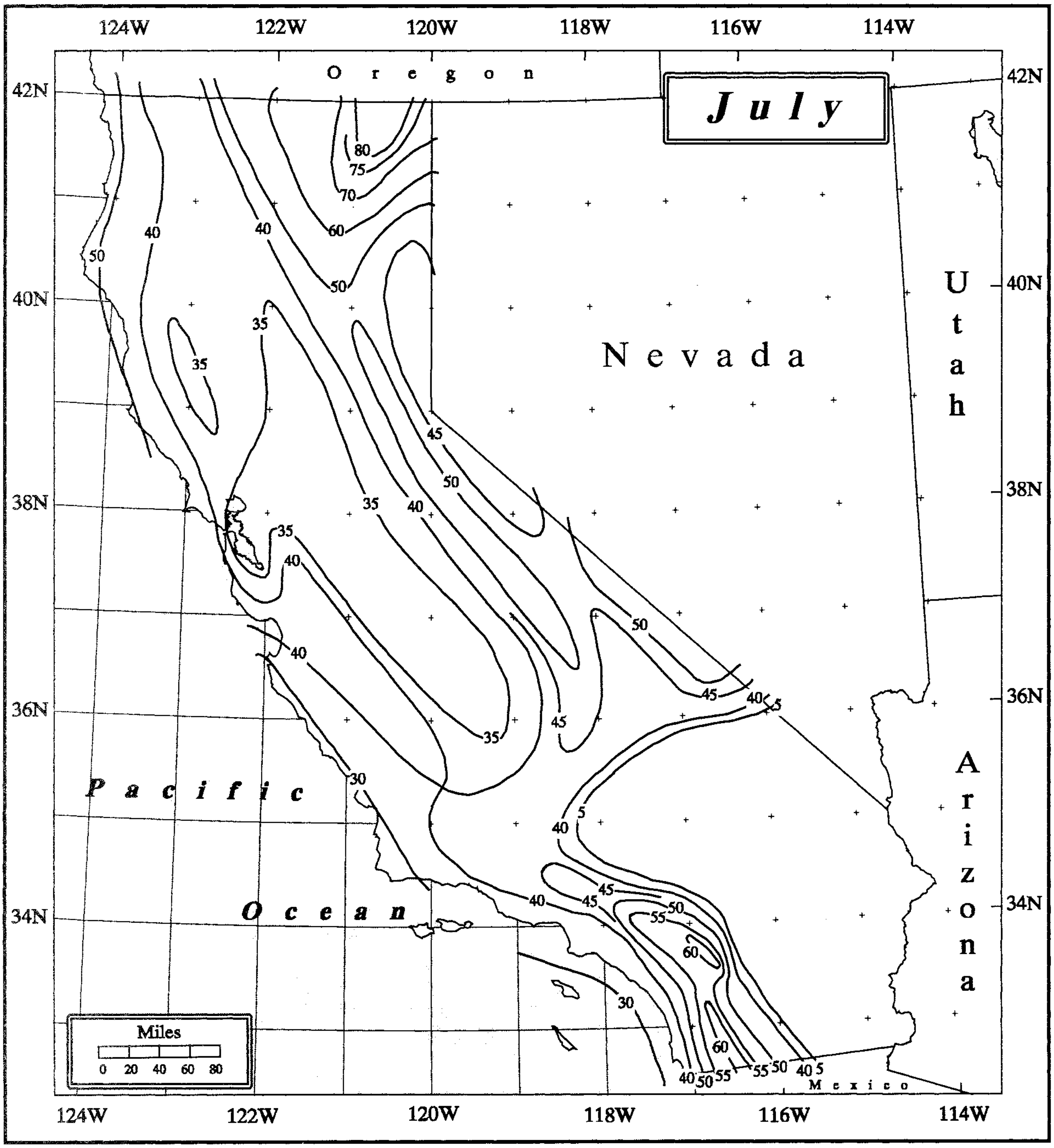


Figure 2.6. *10-mi² 24-hour general-storm PMP for July in California as a percent of all-season PMP (Plates 1 and 2).*

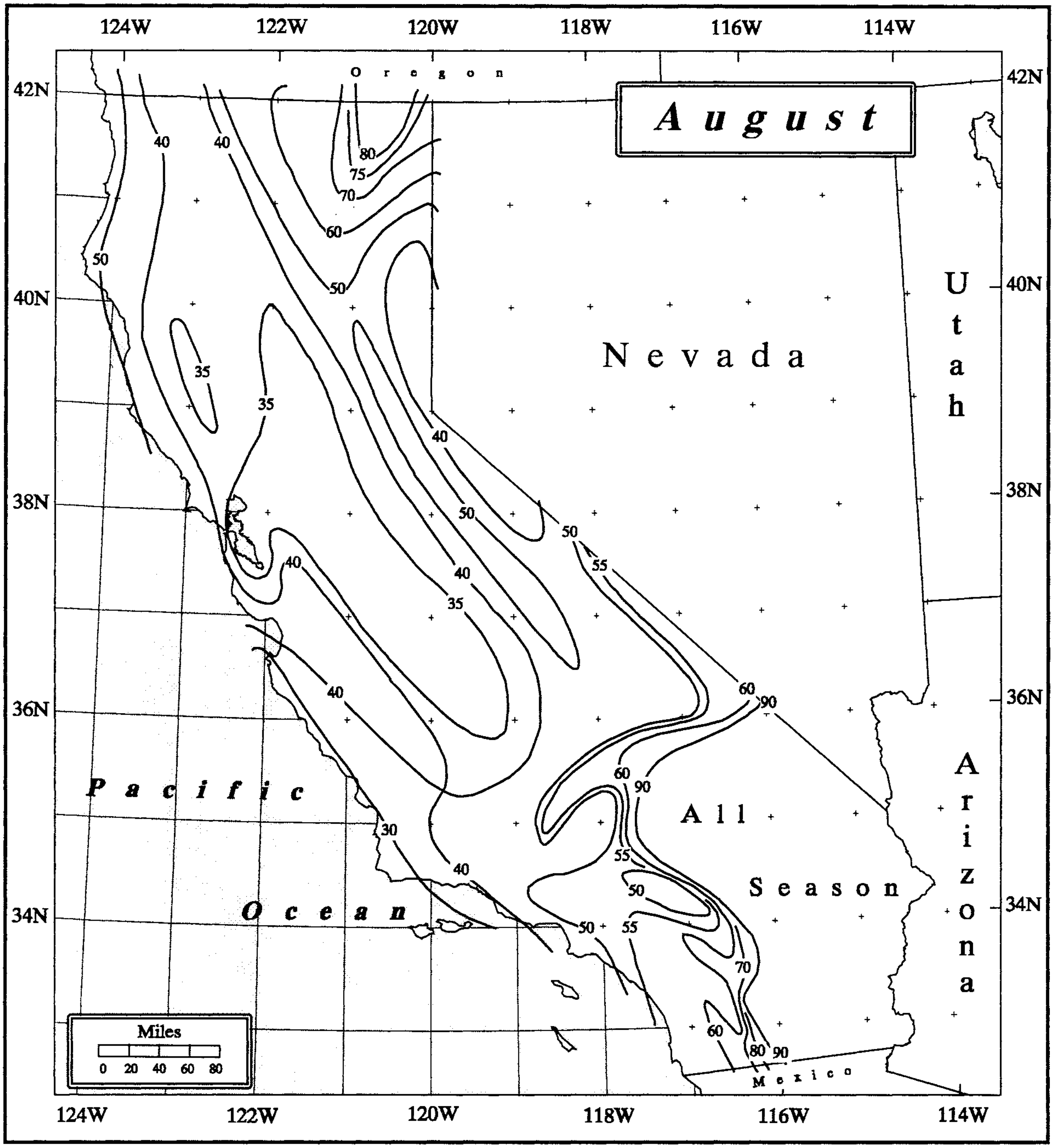


Figure 2.7. *10-mi² 24-hour general-storm PMP for August in California as a percent of all-season PMP (Plates 1 and 2).*

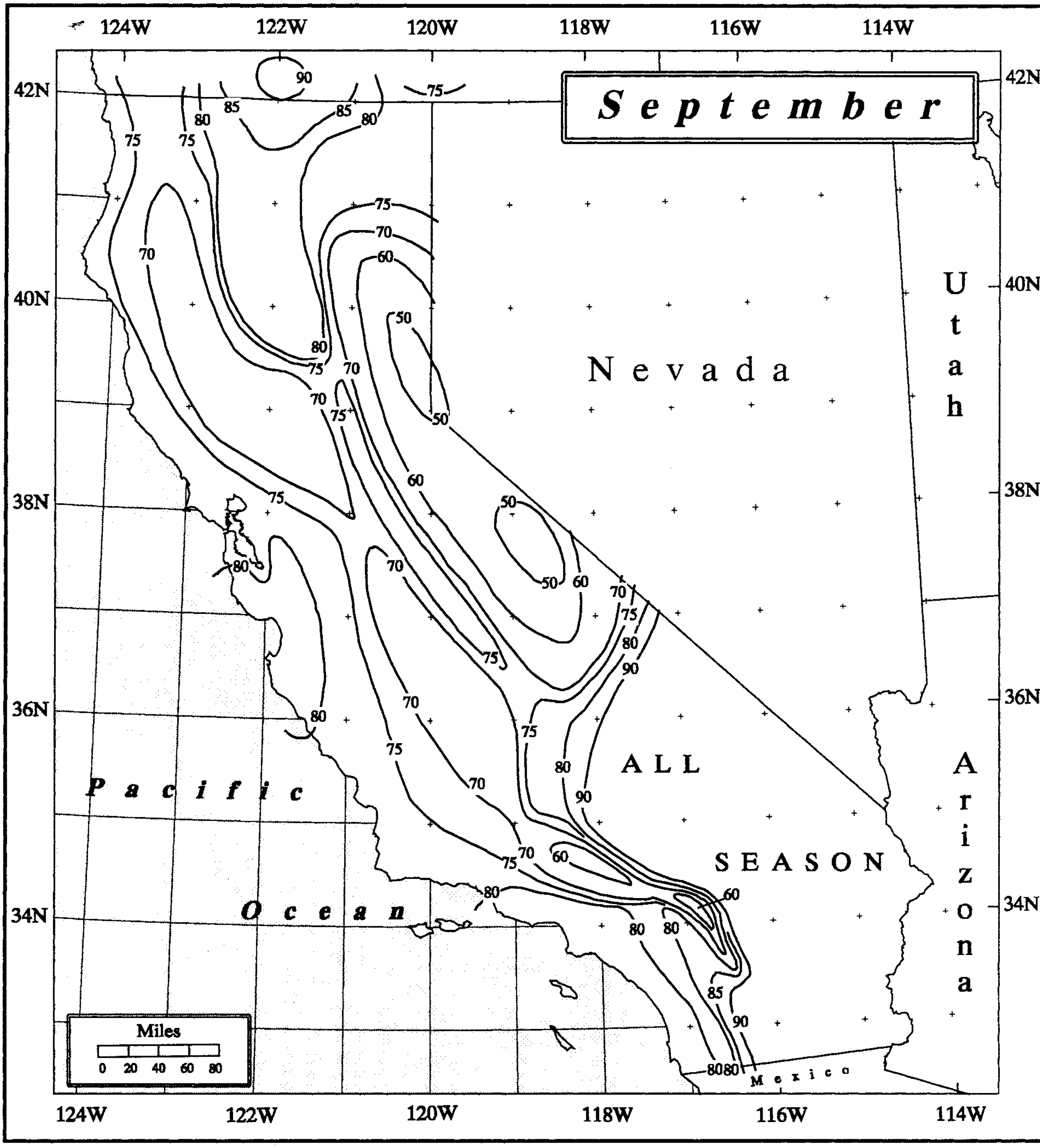


Figure 2.8. *10-mi² 24-hour general-storm PMP for September in California as a percent of all-season PMP (Plates 1 and 2).*

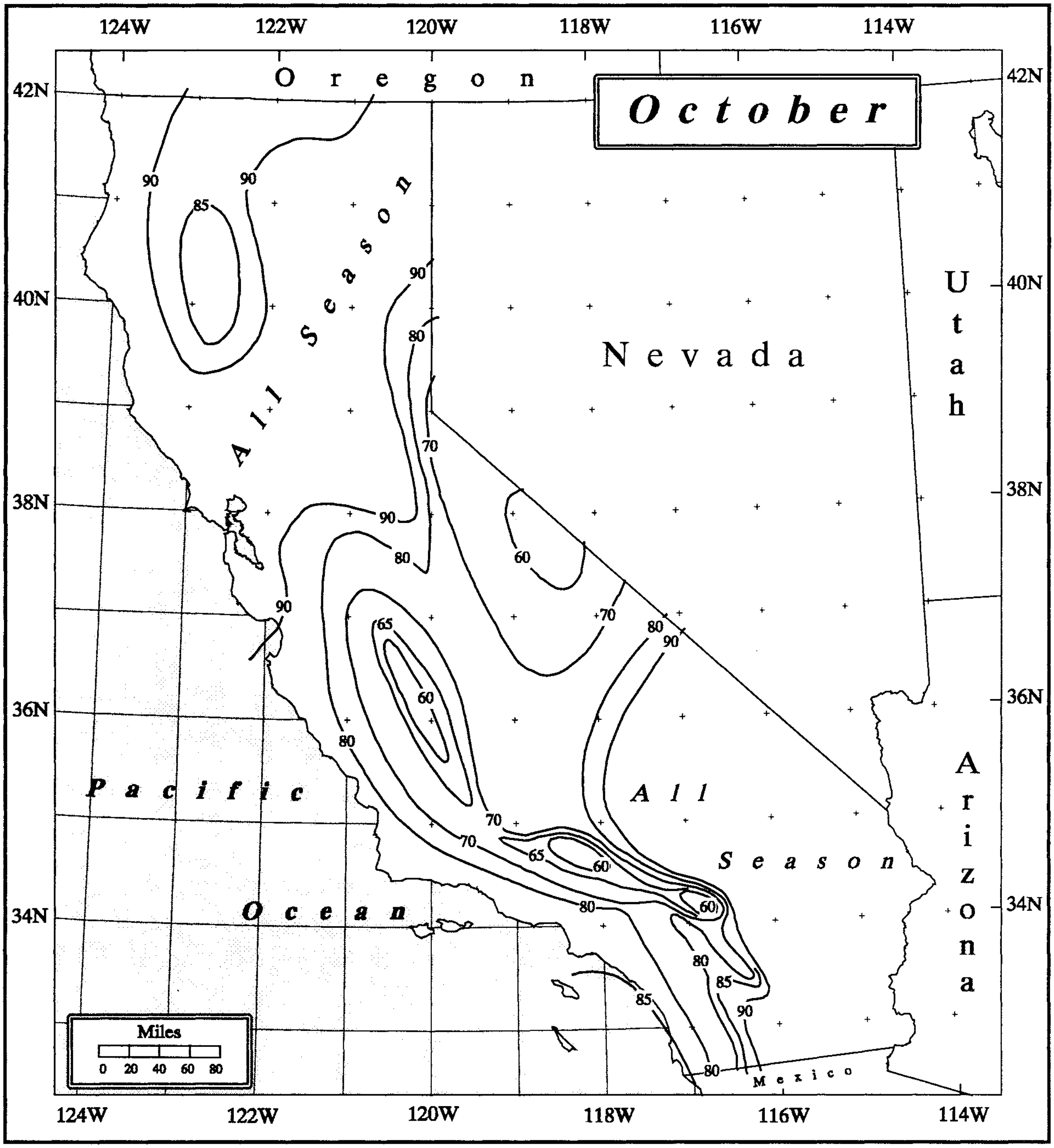


Figure 2.9. *10-mi² 24-hour general-storm PMP for October in California as a percent of all-season PMP (Plates 1 and 2).*

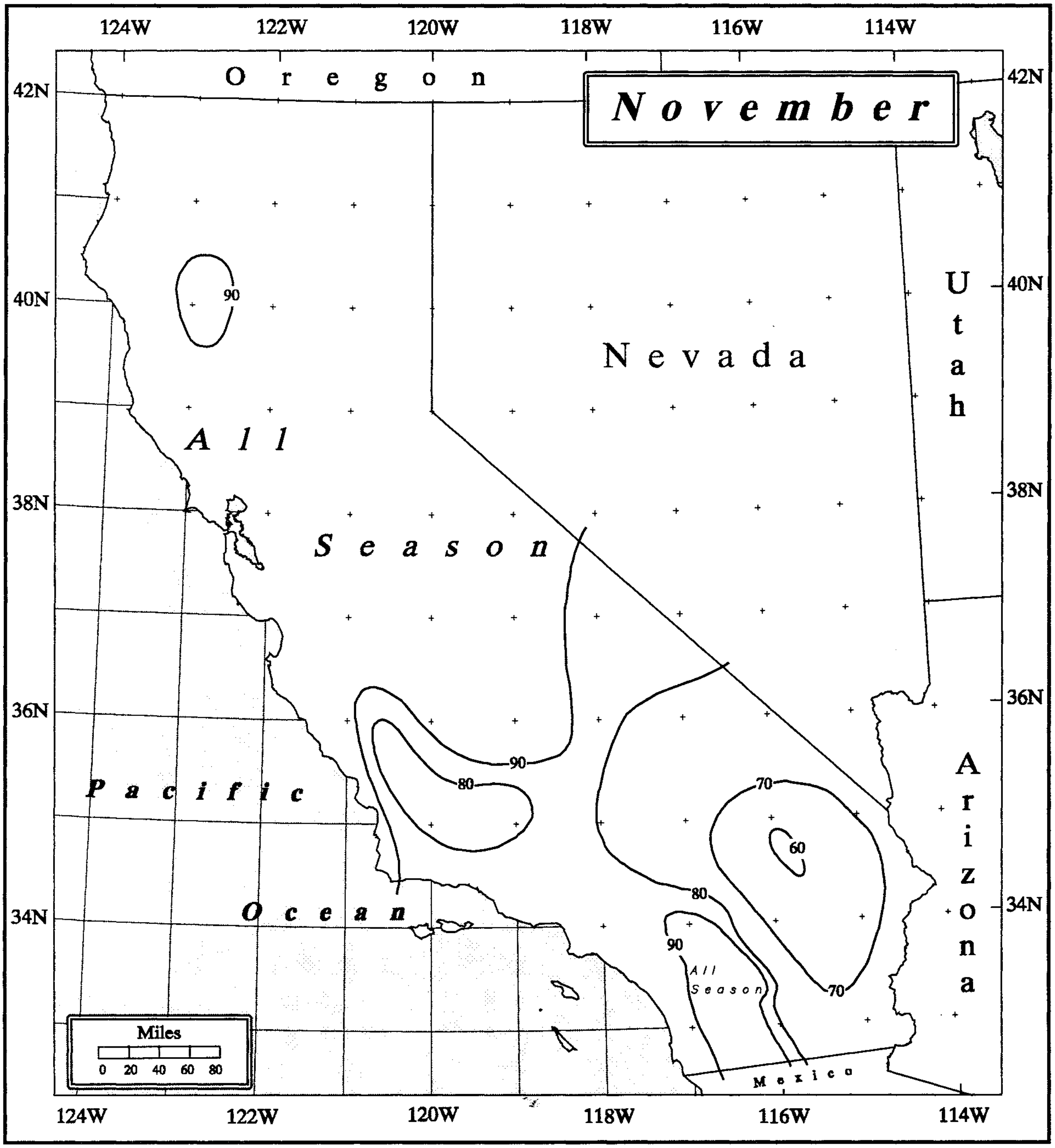


Figure 2.10. *10-mi² 24-hour general-storm PMP for November in California as a percent of all-season PMP (Plates 1 and 2).*

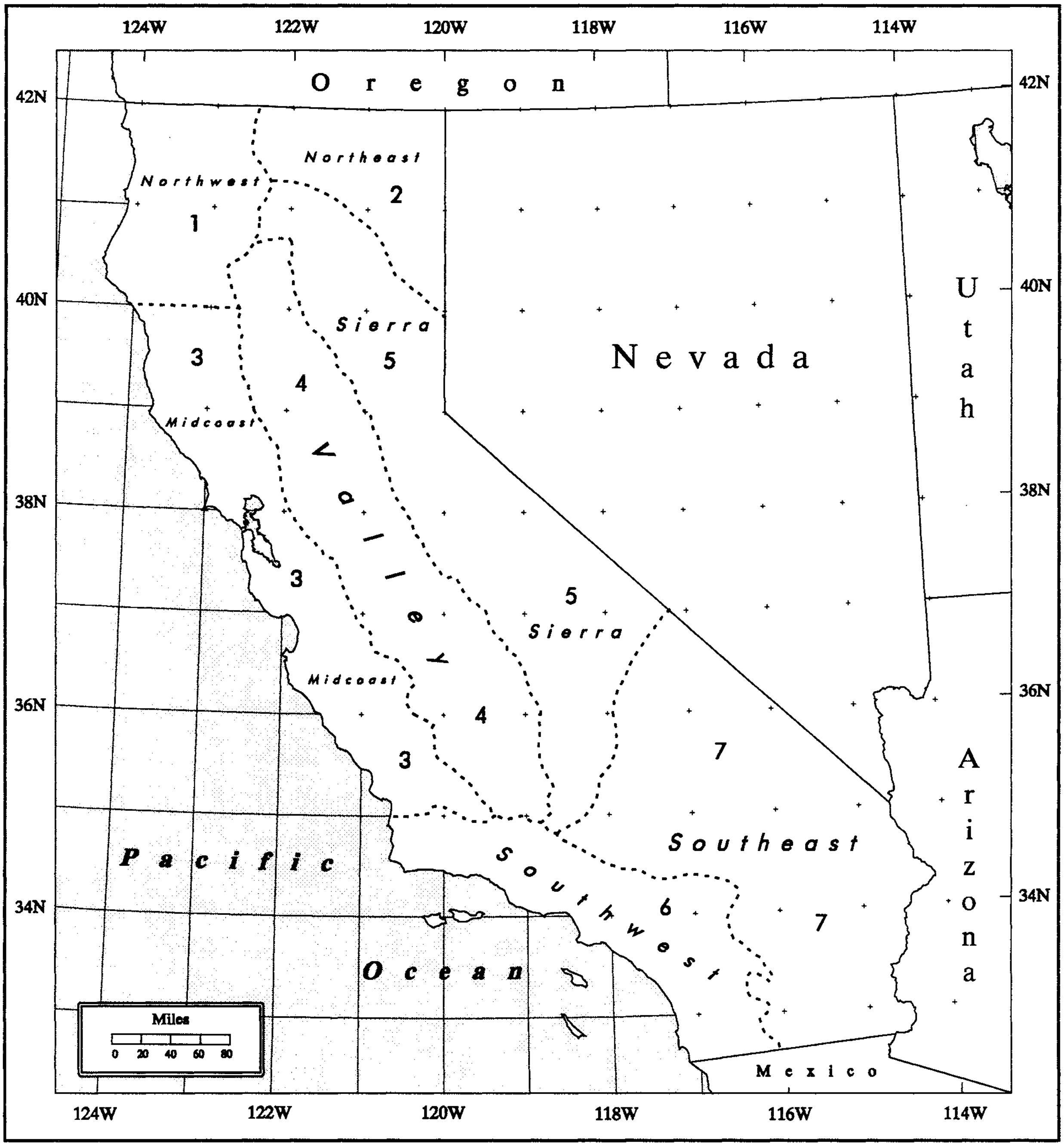


Figure 2.11. *Regional boundaries for development of depth-area-duration relations.*

results; i.e., calculate results for each subregion separately and then combine the PMP values in a manner proportional to the area of each subregion. For example, for a drainage of 100 area units which encompasses three subregions each having areas of 70, 20, 10 units respectively, the resulting average value for the drainage, R, is:

$$R = ((R_1)\ 70 + (R_2)20 + (R_3)10)/100$$

where R_1, R_2, and R_3 are the average PMP values within each of the subregions within the drainage.

The following sections present the detailed steps needed to specify PMP either for all-season, i.e., an annual maximum, or for any individual month of the year. These steps are comprehensive, in the sense that they are applicable for any and every drainage in California. The procedures outlined here, along with the general-storm Index map, have been peer-reviewed. If a user finds that these steps, with their supporting maps, figures, or diagrams, do not account for some unique hydrometeorological aspect of a particular drainage, he or she should consult the Hydrometeorological Design Studies Center staff of the National Weather Service to determine the best course of action.

2.2 General Storm Procedure

Step

1. Drainage Outline

   Trace the outline of the perimeter of the drainage of concern (at 1:1,000,000 scale) onto a transparent overlay, or define the basin boundary using a Geographic Information System (GIS).

2. User Decision

   Decide whether an all-season (annual) PMP value is needed or seasonal PMP is required.

3. All-Season Index PMP Estimate

Place the drainage overlay on the appropriate all-season index map and make an uniform grid that covers the drainage. Obtain index map estimates of PMP for each grid point and determine the drainage average index PMP amount. The grid separation size should take into account the gradient of PMP across the drainage, so that reasonably representative results will be obtained. This step can also be done using a GIS or other commercial software. In areas with extreme gradients, such an analysis would be more accurate when using the digital file of Plates 1 or 2, which is available from the Hydrometeorological Design Studies Center.

4. Seasonal Index PMP Estimates

Skip to Step 5 if all-season PMP alone is required. Figures 2.1 to 2.10 are the starting point for seasonal PMP estimates. Determine the average value for each month to the nearest whole percent within the drainage and plot them on graph paper at the midpoint of each month. Draw a smooth curve through the points. In doing this a range of plus or minus 5 percent is allowed for any percentage at or below 85 percent. Select the percentage at any point in the selected month(s) from the smoothed curve. Any month with a selected percentage higher than 90 percent is treated as a month in which the all-season value of PMP applies, i.e., 100 percent applies to such a month. Multiply the all-season, average value of PMP from Step 3 by the percentage from this step.

For each month of interest determine the value of the monthly offset from the all-season envelope (90% or greater) for that month. The offset is determined by "taking the shorter path" or by counting the number of months from the nearest all-season month.

5. Depth-Duration Relations

The depth-duration subregions for California are shown on Figure 2.11. These subregions are also delineated on Plates 1 and 2. For the subregion containing the drainage of interest, read the corresponding depth-duration ratios from Table 2.1

(all-season) or Table 2.2 (seasonally adjusted) and multiply each by the 24-hour result obtained from Step 3 (all-season) or Step 4 (seasonally-adjusted). Use proportionally-weighted results if more than one subregion is subtended by a drainage boundary.

Table 2.1. *All-season depth-duration ratios for California regions.*

	Duration					
Region	**1**	**6**	**12**	**24**	**48**	**72**
Northwest	0.10	0.40	0.73	1.00	1.49	1.77
Northeast	0.16	0.52	0.69	1.00	1.40	1.55
Midcoastal	0.13	0.45	0.74	1.00	1.45	1.70
C. Valley	0.13	0.42	0.65	1.00	1.48	1.75
Sierra	0.14	0.42	0.65	1.00	1.56	1.76
Southwest	0.14	0.48	0.76	1.00	1.41	1.59
Southeast	0.30	0.60	0.86	1.00	1.17	1.28

6. Areal Reduction Factors

Obtain the all-season reduction factors from either Table 2.3, or from Figures 2.12 - 2.17, as appropriate. For a specific month, however, use Tables 2.4 - 2.9 (interpolate to the required drainage area size) using the monthly offset for seasonal PMPs selected in step 4. Multiply the applicable reduction factors by the corresponding 10-mi^2 amounts from Step 5. If the drainage includes more than one subregion, again use proportionately-weighted results.

7. Incremental Estimates

If incremental values for the various durations are needed, plot the results from Step 6 on graph paper and draw a smooth curve to obtain intermediate

Table 2.2. *Seasonally adjusted 10-mi^2 depth-duration ratios (monthly offsets).*						
Northwest						
Offset	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
1	0.102	0.404	0.734	1.000	1.445	1.682
2	0.106	0.416	0.745	1.000	1.386	1.558
3	0.112	0.428	0.759	1.000	1.341	1.469
4	0.121	0.448	0.774	1.000	1.296	1.416
5	0.127	0.464	0.788	1.000	1.267	1.381
Northeast						
Offset	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
1	0.163	0.525	0.693	1.000	1.358	1.473
2	0.170	0.541	0.704	1.000	1.302	1.364
3	0.179	0.556	0.718	1.000	1.260	1.287
4	0.194	0.582	0.731	1.000	1.218	1.240
5	0.203	0.603	0.745	1.000	1.190	1.209
Midcoastal						
Offset	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
1	0.133	0.455	0.744	1.000	1.407	1.615
2	0.138	0.468	0.755	1.000	1.349	1.496
3	0.146	0.482	0.770	1.000	1.305	1.411
4	0.157	0.504	0.784	1.000	1.262	1.360
5	0.165	0.522	0.799	1.000	1.233	1.326
Central Valley						
Offset	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
1	0.133	0.424	0.653	1.000	1.436	1.663
2	0.138	0.437	0.663	1.000	1.376	1.540
3	0.146	0.449	0.676	1.000	1.332	1.453
4	0.157	0.470	0.689	1.000	1.288	1.400
5	0.165	0.487	0.702	1.000	1.258	1.365

Table 2.2. (cont.) *Seasonally adjusted 10-mi² depth-duration ratios (monthly offsets).*						
			Sierra			
Offset	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
1	0.143	0.424	0.653	1.000	1.513	1.672
2	0.148	0.437	0.663	1.000	1.451	1.549
3	0.157	0.449	0.676	1.000	1.404	1.461
4	0.169	0.470	0.689	1.000	1.357	1.408
5	0.178	0.487	0.702	1.000	1.326	1.373
			Southwest			
Offset	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
1	0.143	0.485	0.764	1.000	1.368	1.511
2	0.148	0.499	0.775	1.000	1.311	1.399
3	0.157	0.514	0.790	1.000	1.269	1.320
4	0.169	0.538	0.806	1.000	1.227	1.272
5	0.178	0.557	0.821	1.000	1.199	1.240
			Southeast			
Offset	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
1	0.294	0.594	0.856	1.000	1.206	1.347
2	0.283	0.577	0.843	1.000	1.258	1.455
3	0.268	0.561	0.827	1.000	1.300	1.542
4	0.248	0.536	0.811	1.000	1.345	1.600
5	0.236	0.517	0.796	1.000	1.376	1.641

Table 2.3. *All-season depth-area relations for California by region.*

Northwest / Northeast						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	100.00	100.00	100.00	100.00	100.00	100.00
50	87.50	88.50	90.00	91.50	93.00	94.00
100	82.00	84.00	86.00	88.00	89.50	91.00
200	77.00	79.50	82.00	84.00	86.00	87.75
500	69.50	73.00	76.25	78.25	81.00	83.00
1000	63.00	67.50	71.00	73.50	76.50	79.00
2000	55.50	60.50	64.00	67.00	69.50	72.00
5000	42.50	49.50	52.50	56.00	59.00	62.00
10000	32.00	40.00	43.50	47.00	51.00	54.00
Midcoastal						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	100.00	100.00	100.00	100.00	100.00	100.00
50	87.50	88.75	90.00	91.00	92.00	93.00
100	81.75	83.75	85.50	87.00	88.50	90.00
200	75.75	78.25	80.50	82.50	84.50	86.25
500	67.50	71.00	73.50	76.00	78.50	80.50
1000	60.75	65.50	68.00	70.50	73.00	75.50
2000	53.00	58.50	61.50	64.00	67.00	70.00
5000	38.00	44.50	48.50	52.00	55.00	59.00
Central Valley						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	100.00	100.00	100.00	100.00	100.00	100.00
50	84.50	87.25	89.50	91.50	92.75	94.00
100	77.25	81.00	84.00	86.50	88.50	90.50
200	70.00	74.50	78.00	81.00	83.00	85.00
500	59.75	64.75	68.75	72.00	74.50	77.00
1000	51.00	56.50	61.00	64.50	67.00	69.50
2000	41.00	47.50	52.00	55.50	58.50	61.50
5000	27.00	33.75	38.50	42.00	45.25	48.50
10000	14.00	21.00	26.00	30.00	33.00	36.50
10000	25.00	34.00	38.00	42.00	45.00	49.00

Table 2.3 (cont.) *All-season depth-area relations for California by region.*						
			Sierra			
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	100.00	100.00	100.00	100.00	100.00	100.00
50	88.00	89.00	90.00	91.00	92.50	94.00
100	82.50	84.00	85.50	87.00	89.25	91.25
200	76.75	78.75	80.75	82.75	85.50	88.25
500	69.25	71.75	74.25	77.00	80.50	83.50
1000	63.25	66.25	69.25	72.25	76.25	79.75
2000	57.00	60.00	63.50	67.00	71.25	75.25
5000	47.50	51.00	55.00	59.00	63.50	68.00
10000	40.00	44.00	48.00	52.50	57.50	62.00
			Southwest			
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	100.00	100.00	100.00	100.00	100.00	100.00
50	87.75	88.50	89.50	90.50	91.75	92.75
100	81.75	83.25	84.75	86.25	87.75	89.25
200	75.75	78.00	79.75	81.50	83.75	85.75
500	67.50	70.50	72.50	75.00	77.50	80.00
1000	60.00	63.50	66.00	69.00	71.75	74.75
2000	51.00	56.00	59.00	62.00	65.00	68.00
5000	35.00	41.00	46.00	50.00	52.50	56.00
10000	22.00	30.00	34.00	38.00	42.00	46.00
			Southeast			
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	100.00	100.00	100.00	100.00	100.00	100.00
50	89.00	90.50	91.75	93.00	94.50	96.00
100	83.50	85.25	87.25	89.00	90.75	92.50
200	76.50	79.75	82.00	84.00	86.00	88.00
500	66.00	70.75	74.00	76.50	78.75	81.00
1000	56.50	63.25	67.00	70.00	72.50	75.00
2000	46.00	54.75	59.00	62.00	64.75	67.50
5000	31.25	41.50	47.00	50.00	52.50	55.50
10000	19.00	30.00	36.00	39.50	42.50	45.00

Table 2.4.	*Seasonally adjusted areal reduction factors for the Northeast and Northwest regions.*					
			Offset 1 Month			
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.913	0.930	0.948	0.960	0.967	0.975
100	0.861	0.883	0.905	0.928	0.945	0.960
200	0.785	0.818	0.847	0.871	0.900	0.919
500	0.677	0.725	0.769	0.798	0.835	0.859
1000	0.582	0.644	0.690	0.730	0.762	0.790
2000	0.480	0.559	0.608	0.650	0.680	0.709
5000	0.340	0.436	0.478	0.524	0.561	0.595
10000	0.240	0.338	0.372	0.418	0.467	0.502
			Offset 2 Months			
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.894	0.921	0.939	0.952	0.959	0.965
100	0.831	0.868	0.892	0.916	0.929	0.941
200	0.753	0.802	0.834	0.858	0.880	0.892
500	0.641	0.702	0.746	0.778	0.806	0.825
1000	0.544	0.617	0.658	0.697	0.728	0.751
2000	0.447	0.528	0.570	0.610	0.639	0.666
5000	0.313	0.401	0.436	0.484	0.519	0.552
10000	0.218	0.302	0.335	0.381	0.428	0.459
			Offset 3 Months			
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.883	0.916	0.933	0.944	0.950	0.955
100	0.809	0.859	0.882	0.904	0.916	0.926
200	0.729	0.789	0.821	0.844	0.867	0.878
500	0.619	0.687	0.726	0.757	0.785	0.803
1000	0.522	0.596	0.636	0.671	0.697	0.719
2000	0.425	0.500	0.541	0.576	0.605	0.634
5000	0.294	0.374	0.412	0.451	0.481	0.512
10000	0.205	0.284	0.320	0.355	0.393	0.424

Table 2.4. (cont.) *Seasonally adjusted areal reduction factors for the Northeast and Northwest regions.*						
Offset 4 Months						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.865	0.902	0.926	0.940	0.946	0.952
100	0.787	0.837	0.869	0.890	0.901	0.913
200	0.696	0.760	0.800	0.821	0.842	0.853
500	0.576	0.649	0.695	0.721	0.747	0.765
1000	0.474	0.555	0.601	0.633	0.658	0.679
2000	0.375	0.464	0.502	0.536	0.563	0.590
5000	0.244	0.337	0.375	0.412	0.435	0.459
10000	0.162	0.248	0.283	0.317	0.354	0.383
Offset 5 Months						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.851	0.893	0.917	0.931	0.946	0.955
100	0.770	0.823	0.851	0.874	0.886	0.898
200	0.672	0.743	0.778	0.801	0.822	0.833
500	0.551	0.627	0.667	0.697	0.722	0.740
1000	0.448	0.538	0.572	0.607	0.635	0.660
2000	0.347	0.445	0.480	0.516	0.546	0.572
5000	0.216	0.322	0.352	0.392	0.425	0.453
10000	0.141	0.228	0.261	0.298	0.339	0.367

Table 2.5. *Seasonally adjusted areal reduction factors for the Midcoastal region.*

Offset 1 Month						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.903	0.915	0.928	0.943	0.957	0.975
100	0.846	0.868	0.886	0.908	0.930	0.949
200	0.775	0.804	0.832	0.856	0.885	0.909
500	0.663	0.710	0.750	0.778	0.815	0.838
1000	0.564	0.630	0.671	0.706	0.738	0.770
2000	0.458	0.536	0.584	0.621	0.655	0.690
5000	0.308	0.392	0.441	0.486	0.523	0.566
10000	0.188	0.287	0.325	0.374	0.412	0.456
Offset 2 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.885	0.906	0.919	0.935	0.949	0.965
100	0.817	0.853	0.872	0.896	0.914	0.931
200	0.743	0.787	0.820	0.843	0.866	0.882
500	0.627	0.688	0.727	0.758	0.786	0.805
1000	0.527	0.603	0.639	0.673	0.704	0.732
2000	0.427	0.506	0.547	0.582	0.616	0.648
5000	0.283	0.360	0.403	0.450	0.484	0.525
10000	0.170	0.257	0.293	0.340	0.378	0.417
Offset 3 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.874	0.902	0.913	0.927	0.940	0.955
100	0.795	0.844	0.862	0.885	0.901	0.917
200	0.719	0.775	0.807	0.830	0.852	0.869
500	0.606	0.673	0.708	0.739	0.766	0.784
1000	0.505	0.583	0.619	0.648	0.674	0.701
2000	0.405	0.480	0.520	0.550	0.583	0.616
5000	0.266	0.336	0.381	0.419	0.448	0.487
10000	0.160	0.241	0.279	0.317	0.347	0.385

Table 2.5. (cont.)	*Seasonally adjusted areal reduction factors for the Midcoastal region.*					
Offset 4 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.855	0.888	0.907	0.923	0.936	0.952
100	0.774	0.823	0.850	0.871	0.887	0.903
200	0.688	0.746	0.786	0.807	0.827	0.843
500	0.564	0.636	0.677	0.703	0.729	0.747
1000	0.459	0.543	0.584	0.612	0.637	0.662
2000	0.358	0.445	0.483	0.512	0.543	0.574
5000	0.220	0.303	0.347	0.382	0.406	0.437
10000	0.126	0.211	0.247	0.284	0.313	0.348
Offset 5 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	0.000
50	0.842	0.879	0.897	0.915	0.936	0.000
100	0.757	0.809	0.832	0.855	0.872	0.000
200	0.664	0.730	0.765	0.787	0.808	48.000
500	0.539	0.614	0.650	0.679	0.705	1.016
1000	0.434	0.526	0.556	0.587	0.615	0.919
2000	0.331	0.427	0.461	0.493	0.526	0.875
5000	0.196	0.289	0.325	0.364	0.396	0.834
10000	0.110	0.194	0.228	0.267	0.299	0.749

Table 2.6. *Seasonally adjusted areal reduction factors for the Central Valley region.*

Offset 1 Month						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.828	0.886	0.918	0.940	0.952	0.970
100	0.752	0.823	0.866	0.893	0.915	0.934
200	0.663	0.750	0.798	0.832	0.860	0.889
500	0.536	0.638	0.701	0.739	0.775	0.803
1000	0.437	0.541	0.608	0.652	0.683	0.715
2000	0.333	0.440	0.504	0.548	0.582	0.616
5000	0.207	0.295	0.350	0.393	0.432	0.466
10000	0.113	0.182	0.222	0.267	0.302	0.339
Offset 2 Months						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.812	0.877	0.909	0.932	0.944	0.960
100	0.726	0.809	0.853	0.882	0.899	0.916
200	0.636	0.734	0.786	0.819	0.841	0.862
500	0.507	0.618	0.679	0.720	0.748	0.771
1000	0.408	0.518	0.580	0.622	0.652	0.679
2000	0.310	0.415	0.472	0.514	0.547	0.578
5000	0.190	0.271	0.320	0.363	0.400	0.432
10000	0.102	0.162	0.200	0.243	0.277	0.310
Offset 3 Months						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.802	0.872	0.903	0.924	0.935	0.951
100	0.707	0.801	0.843	0.870	0.886	0.902
200	0.615	0.723	0.774	0.806	0.828	0.849
500	0.490	0.605	0.661	0.701	0.729	0.751
1000	0.391	0.500	0.561	0.599	0.624	0.651
2000	0.295	0.394	0.448	0.486	0.518	0.550
5000	0.179	0.253	0.302	0.338	0.371	0.400
10000	0.096	0.153	0.191	0.227	0.254	0.287

Table 2.6. (cont.) *Seasonally adjusted areal reduction factors for the Central Valley region.*						
Offset 4 Months						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.785	0.859	0.897	0.920	0.931	0.947
100	0.688	0.780	0.831	0.857	0.873	0.889
200	0.588	0.696	0.753	0.784	0.804	0.825
500	0.456	0.572	0.633	0.668	0.694	0.716
1000	0.355	0.466	0.529	0.565	0.590	0.615
2000	0.260	0.365	0.416	0.452	0.482	0.513
5000	0.148	0.228	0.275	0.309	0.336	0.359
10000	0.076	0.133	0.169	0.203	0.229	0.259
Offset 5 Months						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.772	0.850	0.888	0.912	0.931	0.951
100	0.673	0.768	0.813	0.841	0.858	0.874
200	0.568	0.681	0.733	0.764	0.785	0.805
500	0.436	0.552	0.608	0.645	0.670	0.692
1000	0.336	0.451	0.504	0.542	0.569	0.597
2000	0.241	0.350	0.398	0.435	0.467	0.497
5000	0.131	0.218	0.258	0.294	0.328	0.354
10000	0.066	0.123	0.156	0.191	0.219	0.248

Table 2.7. *Seasonally adjusted areal reduction factors for the Sierra region.*						
Offset 1 Month						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.908	0.920	0.933	0.950	0.962	0.985
100	0.851	0.868	0.886	0.908	0.930	0.960
200	0.775	0.799	0.822	0.851	0.880	0.919
500	0.667	0.706	0.745	0.778	0.820	0.859
1000	0.582	0.630	0.676	0.715	0.762	0.810
2000	0.493	0.550	0.603	0.650	0.699	0.749
5000	0.385	0.449	0.501	0.552	0.608	0.653
10000	0.300	0.372	0.410	0.472	0.531	0.577
Offset 2 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.889	0.911	0.924	0.942	0.954	0.975
100	0.821	0.853	0.872	0.896	0.914	0.941
200	0.743	0.782	0.810	0.839	0.861	0.892
500	0.632	0.684	0.722	0.758	0.791	0.825
1000	0.544	0.603	0.644	0.683	0.728	0.770
2000	0.459	0.519	0.565	0.610	0.658	0.703
5000	0.354	0.413	0.457	0.510	0.563	0.605
10000	0.272	0.332	0.370	0.429	0.487	0.527
Offset 3 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.878	0.907	0.918	0.934	0.945	0.965
100	0.800	0.844	0.862	0.885	0.901	0.926
200	0.719	0.770	0.797	0.825	0.847	0.878
500	0.611	0.669	0.703	0.739	0.771	0.803
1000	0.522	0.583	0.623	0.657	0.697	0.737
2000	0.436	0.492	0.537	0.576	0.622	0.669
5000	0.333	0.385	0.432	0.475	0.522	0.561
10000	0.256	0.312	0.353	0.400	0.447	0.487

Table 2.7. (cont.) *Seasonally adjusted areal reduction factors for the Sierra region.*						
Offset 4 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.860	0.893	0.912	0.930	0.941	0.961
100	0.778	0.823	0.850	0.871	0.887	0.913
200	0.688	0.742	0.777	0.802	0.823	0.853
500	0.568	0.632	0.673	0.703	0.734	0.765
1000	0.474	0.543	0.588	0.621	0.658	0.697
2000	0.385	0.456	0.498	0.536	0.579	0.623
5000	0.276	0.347	0.393	0.434	0.472	0.503
10000	0.202	0.273	0.312	0.358	0.403	0.440
Offset 5 Months						
Area (mi^2)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.846	0.883	0.902	0.922	0.941	0.965
100	0.761	0.809	0.832	0.855	0.872	0.898
200	0.664	0.725	0.756	0.783	0.803	0.833
500	0.543	0.610	0.646	0.679	0.709	0.740
1000	0.448	0.526	0.560	0.595	0.635	0.676
2000	0.356	0.438	0.476	0.516	0.561	0.604
5000	0.245	0.332	0.369	0.413	0.461	0.496
10000	0.176	0.251	0.288	0.337	0.386	0.422

Table 2.8. *Seasonally adjusted areal reduction factors for the Southwest region.*						
Offset 1 Month						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.893	0.915	0.928	0.940	0.952	0.965
100	0.837	0.863	0.881	0.898	0.920	0.939
200	0.770	0.799	0.818	0.842	0.870	0.899
500	0.658	0.696	0.730	0.758	0.795	0.828
1000	0.555	0.611	0.647	0.686	0.723	0.760
2000	0.441	0.513	0.561	0.601	0.636	0.670
5000	0.284	0.361	0.419	0.468	0.499	0.538
10000	0.165	0.254	0.291	0.338	0.384	0.428
Offset 2 Months						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.875	0.906	0.919	0.932	0.944	0.955
100	0.807	0.848	0.867	0.887	0.904	0.921
200	0.739	0.782	0.805	0.829	0.851	0.872
500	0.623	0.674	0.708	0.739	0.767	0.795
1000	0.519	0.585	0.616	0.655	0.690	0.722
2000	0.411	0.484	0.525	0.564	0.598	0.629
5000	0.261	0.332	0.382	0.433	0.462	0.498
10000	0.150	0.227	0.262	0.308	0.353	0.391
Offset 3 Months						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.864	0.902	0.913	0.924	0.935	0.946
100	0.786	0.840	0.858	0.875	0.891	0.907
200	0.715	0.770	0.793	0.815	0.838	0.859
500	0.602	0.660	0.689	0.720	0.747	0.775
1000	0.497	0.566	0.596	0.630	0.661	0.692
2000	0.390	0.459	0.499	0.533	0.566	0.598
5000	0.245	0.310	0.361	0.403	0.428	0.462
10000	0.141	0.213	0.250	0.287	0.323	0.361

Table 2.8. (cont.) *Seasonally adjusted areal reduction factors for the Southwest region.*						
Offset 4 Months						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.846	0.888	0.907	0.920	0.931	0.942
100	0.765	0.818	0.845	0.861	0.877	0.894
200	0.683	0.742	0.772	0.793	0.813	0.834
500	0.560	0.624	0.659	0.685	0.712	0.738
1000	0.451	0.527	0.563	0.595	0.624	0.654
2000	0.344	0.426	0.463	0.496	0.527	0.558
5000	0.203	0.279	0.329	0.368	0.387	0.414
10000	0.111	0.186	0.221	0.257	0.292	0.327
Offset 5 Months						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.833	0.879	0.897	0.912	0.931	0.946
100	0.748	0.805	0.827	0.846	0.863	0.879
200	0.660	0.725	0.751	0.774	0.794	0.814
500	0.536	0.602	0.633	0.662	0.688	0.713
1000	0.427	0.510	0.536	0.571	0.602	0.635
2000	0.319	0.409	0.443	0.477	0.510	0.541
5000	0.180	0.267	0.308	0.350	0.378	0.409
10000	0.097	0.171	0.204	0.241	0.279	0.313

Table 2.9. *Seasonally adjusted areal reduction factors for the Southeast region.*

Offset 1 Month						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.902	0.935	0.945	0.952	0.964	0.970
100	0.838	0.877	0.894	0.912	0.920	0.929
200	0.779	0.832	0.848	0.874	0.880	0.891
500	0.713	0.760	0.776	0.807	0.820	0.837
1000	0.643	0.702	0.725	0.745	0.763	0.780
2000	0.561	0.622	0.647	0.655	0.675	0.690
5000	0.389	0.477	0.522	0.535	0.553	0.573
10000	0.253	0.355	0.427	0.444	0.464	0.484
Offset 2 Months						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.921	0.944	0.954	0.960	0.972	0.980
100	0.869	0.892	0.908	0.924	0.936	0.947
200	0.813	0.849	0.861	0.887	0.900	0.918
500	0.753	0.785	0.800	0.828	0.850	0.871
1000	0.688	0.733	0.761	0.781	0.799	0.821
2000	0.602	0.659	0.691	0.698	0.717	0.735
5000	0.423	0.519	0.572	0.578	0.597	0.618
10000	0.279	0.397	0.474	0.488	0.506	0.529
Offset 3 Months						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.932	0.949	0.960	0.968	0.982	0.990
100	0.892	0.902	0.918	0.936	0.950	0.962
200	0.840	0.862	0.874	0.902	0.914	0.933
500	0.779	0.802	0.822	0.850	0.872	0.894
1000	0.718	0.759	0.787	0.811	0.834	0.857
2000	0.634	0.695	0.728	0.738	0.759	0.773
5000	0.450	0.556	0.605	0.621	0.644	0.667
10000	0.297	0.423	0.497	0.523	0.552	0.573

Table 2.9. (cont.) *Seasonally adjusted areal reduction factors for the Southeast region.*

Offset 4 Months						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.952	0.964	0.967	0.972	0.986	0.994
100	0.917	0.926	0.932	0.951	0.965	0.976
200	0.879	0.896	0.898	0.927	0.941	0.961
500	0.838	0.849	0.859	0.893	0.916	0.939
1000	0.791	0.815	0.833	0.859	0.883	0.907
2000	0.719	0.750	0.783	0.794	0.815	0.829
5000	0.543	0.618	0.664	0.680	0.711	0.743
10000	0.376	0.484	0.562	0.585	0.612	0.634
Offset 5 Months						
Area (mi²)	**1 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**72 hr**
10	1.000	1.000	1.000	1.000	1.000	1.000
50	0.968	0.974	0.977	0.981	0.986	0.990
100	0.938	0.941	0.952	0.968	0.981	0.993
200	0.910	0.916	0.923	0.951	0.964	0.984
500	0.876	0.880	0.894	0.924	0.948	0.971
1000	0.836	0.841	0.875	0.896	0.915	0.934
2000	0.776	0.781	0.820	0.825	0.841	0.855
5000	0.612	0.646	0.709	0.714	0.729	0.753
10000	0.432	0.526	0.608	0.622	0.639	0.662

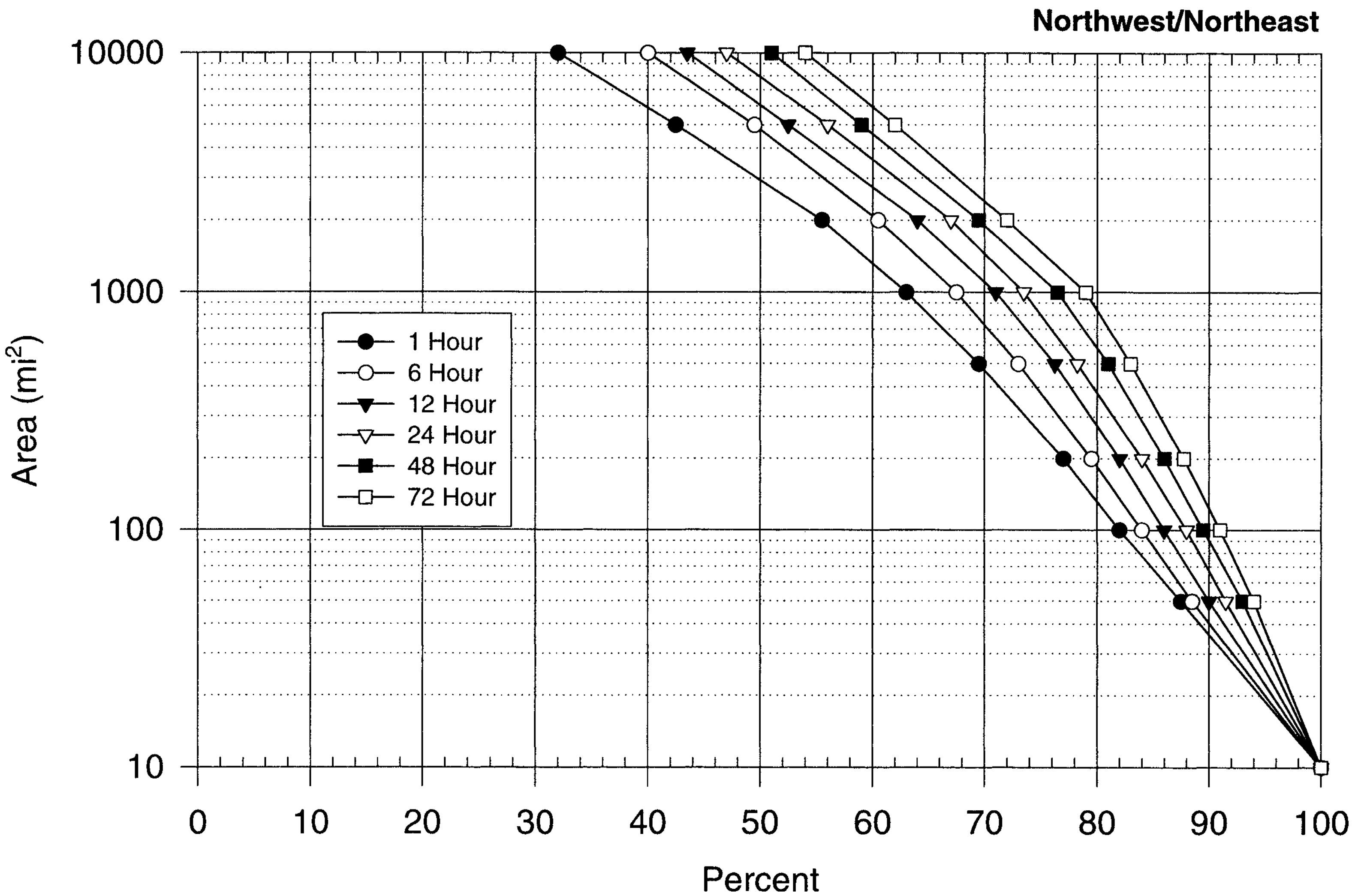


Figure 2.12. *Depth-area relations for the California Northwest/Northeast region for 1 to 72 hour durations.*

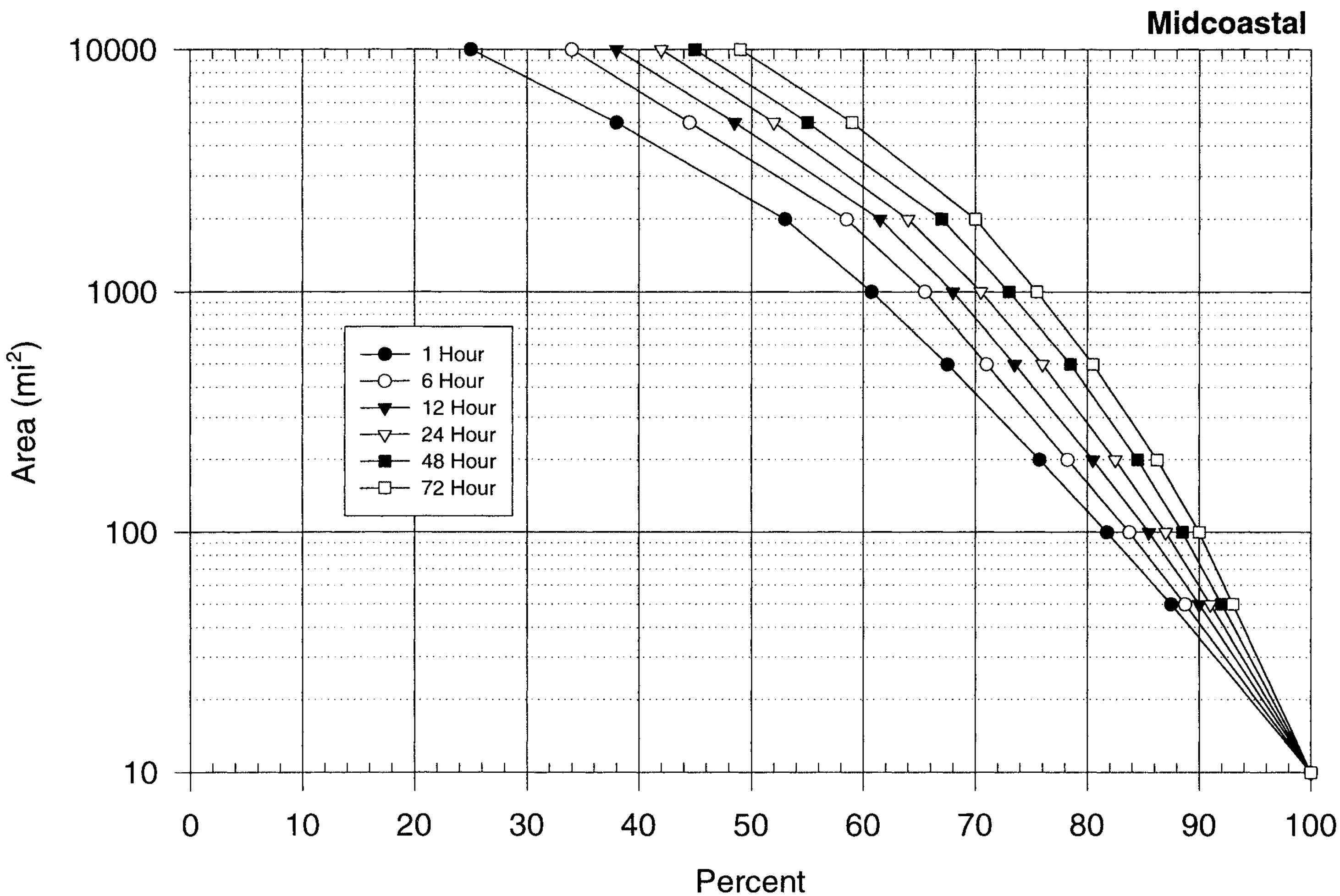


Figure 2.13. *Depth-area relations for the California Midcoastal region for 1 to 72 hour durations.*

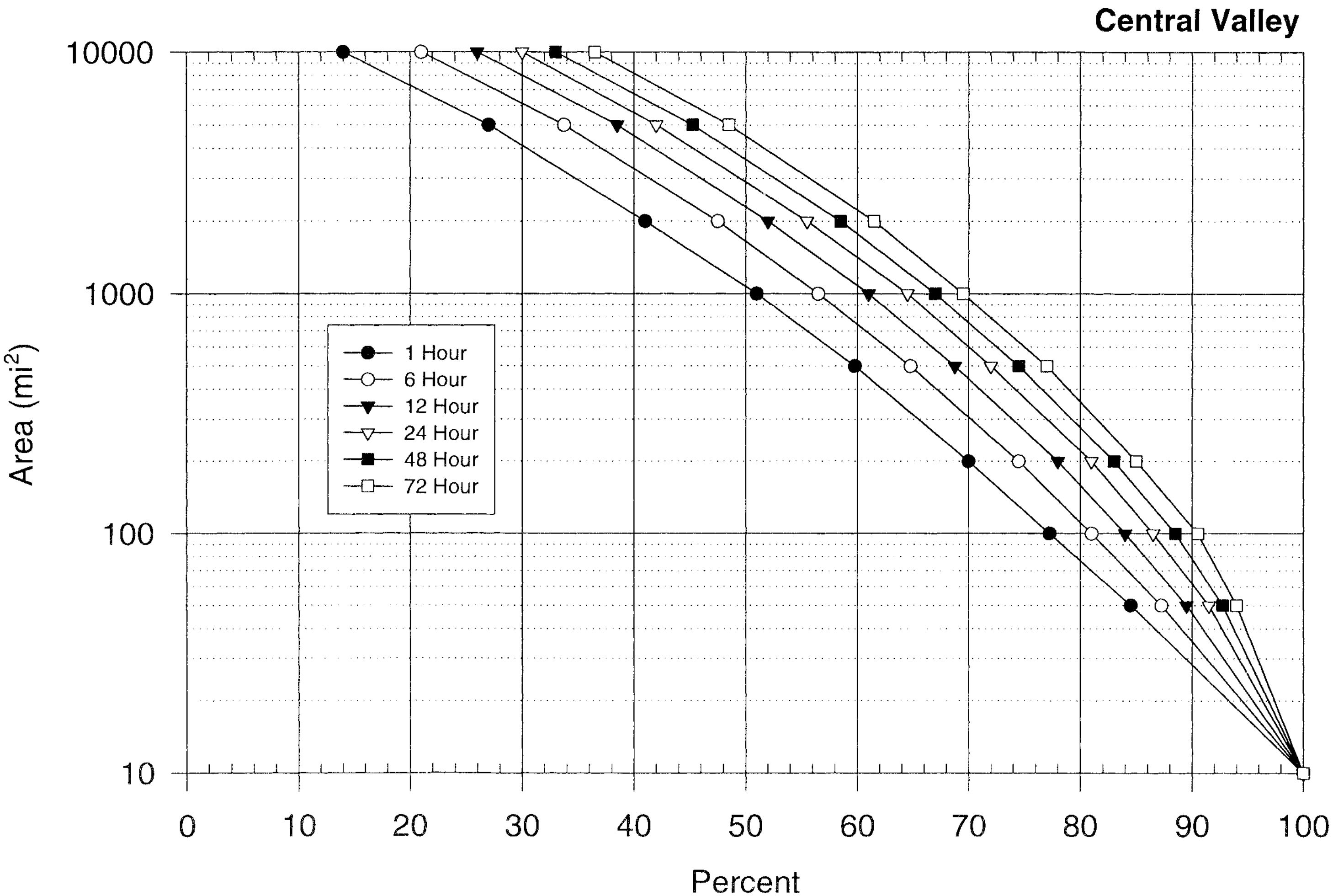


Figure 2.14. *Depth-area relations for the California Central Valley region for 1 to 72 hour durations.*

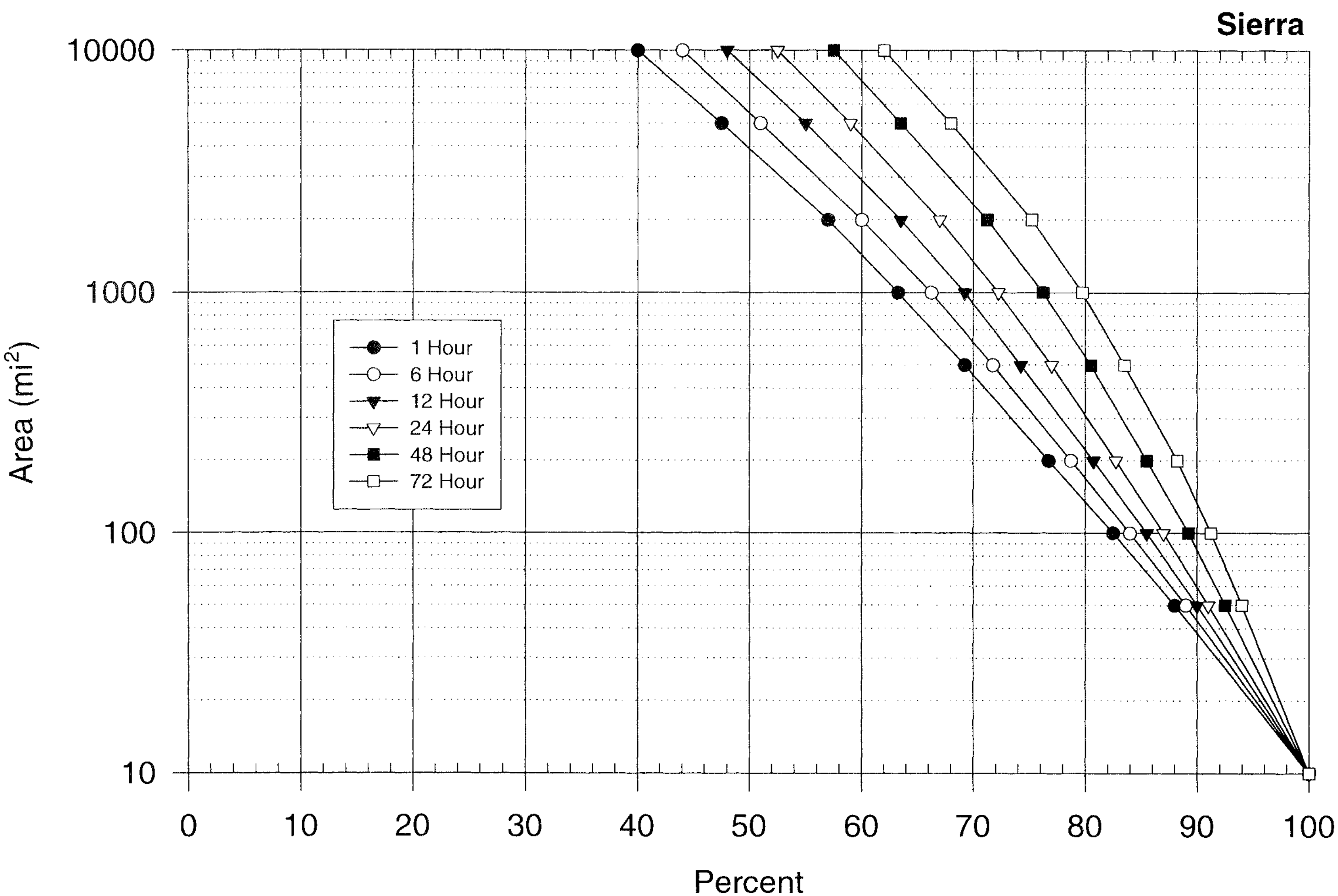


Figure 2.15. *Depth-area relations for the California Sierra region for 1 to 72 hour durations.*

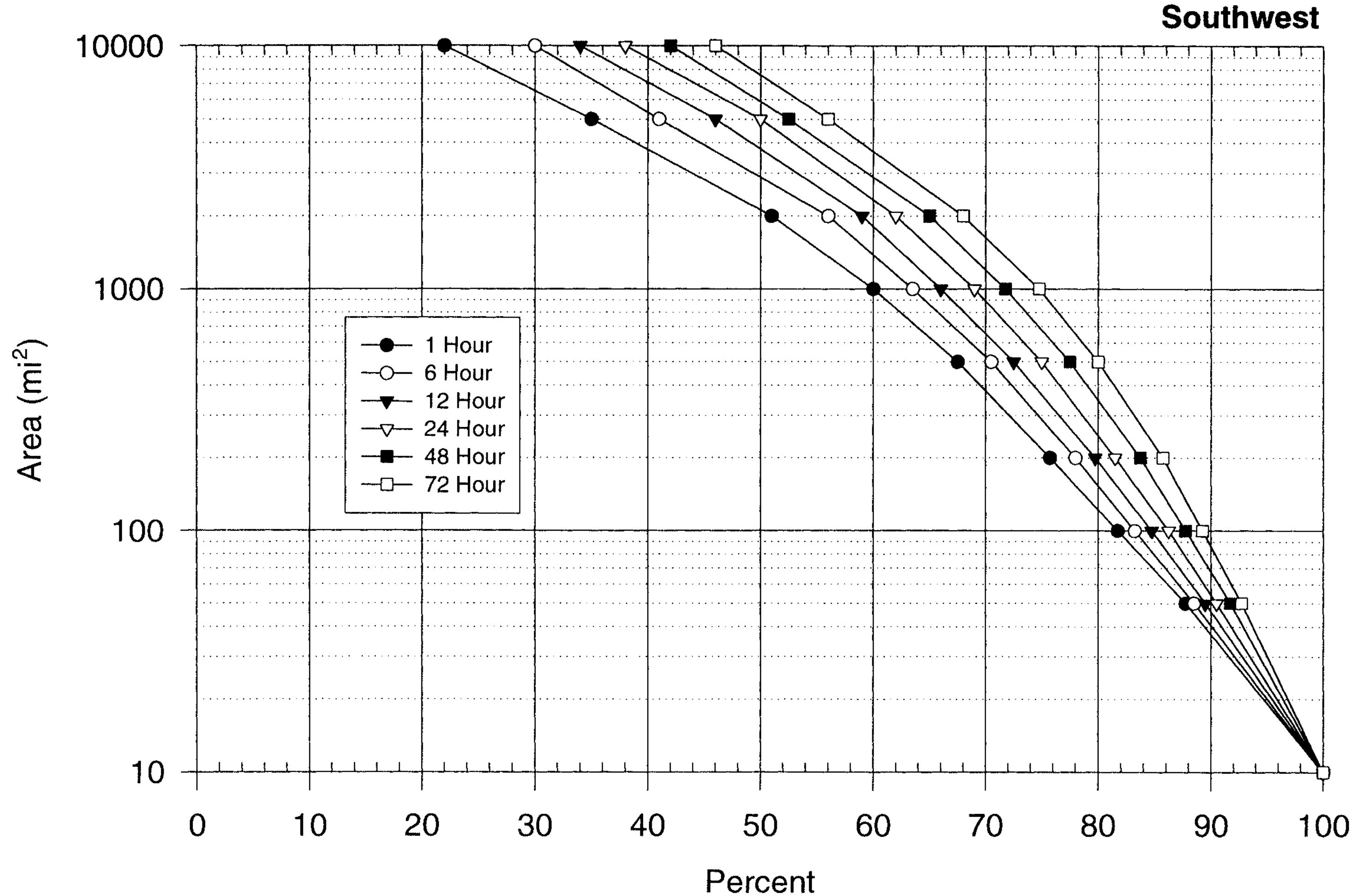


Figure 2.16. *Depth-area relations for the California Southwest region for 1 to 72 hour durations.*

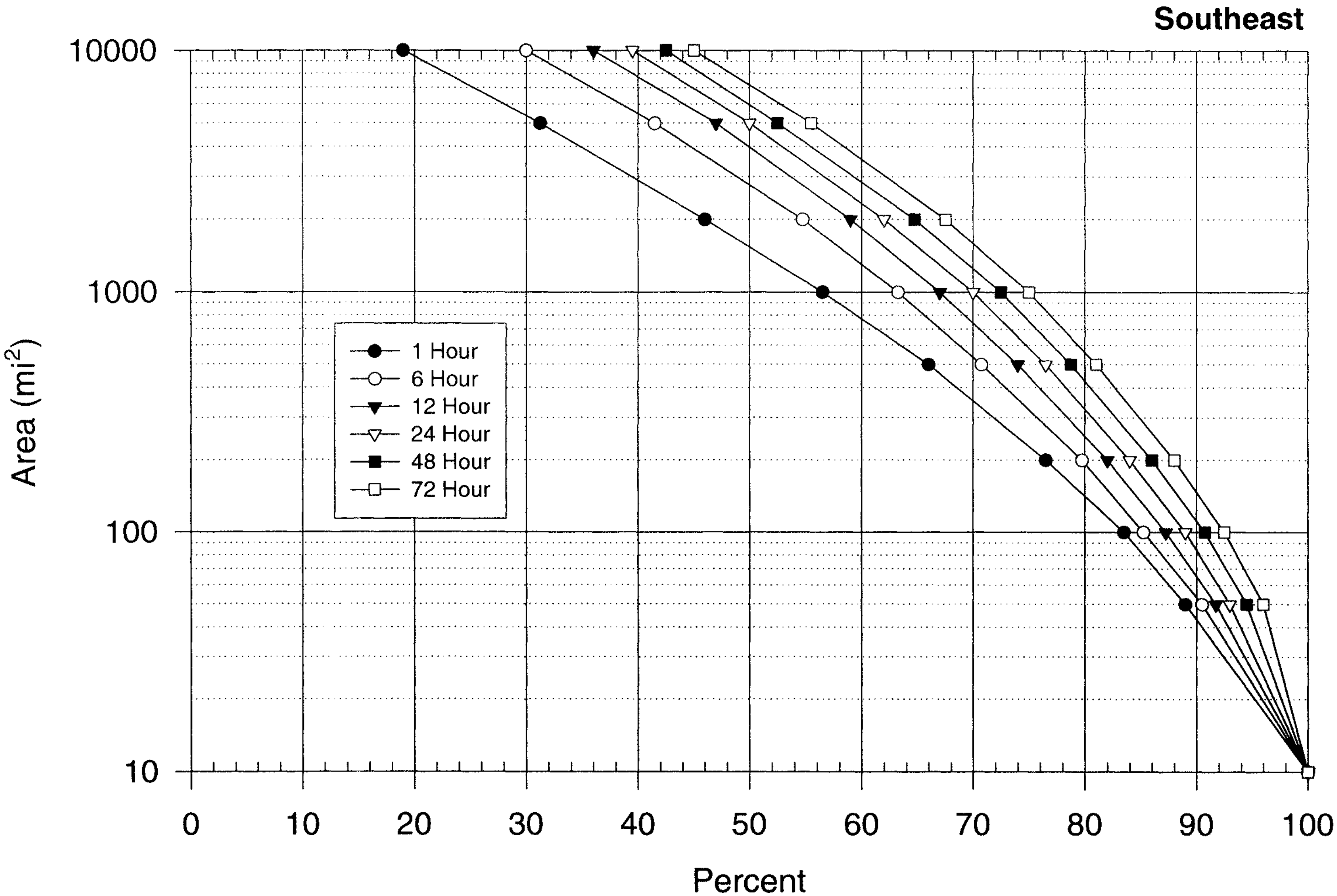


Figure 2.17. *Depth-area relations for the California Southeast region for 1 to 72 hour durations.*

cumulative 6-hour values. A margin of plus or minus 0.5 inch is permissible in drawing this curve due to various roundings in Steps 1 to 6. Subtract each cumulative 6-hour depth from the depth of the next longer cumulative 6-hour duration. Some applications may require hourly increments. If this is the case, the smooth curve is subdivided into 72 cumulative hourly amounts and each cumulative hourly depth is subtracted from the depth at the next cumulative 1-hour longer duration.

8. Snowmelt parameters, temporal, and areal distributions.

During peer review a consensus recommendation was to include some procedures in the report to deal with these items. These items had not been within the scope originally formulated for the study. The snowmelt procedure from HMR 36 is incorporated in this report and found in the Appendix.

Chronological partitioning of the PMP and its areal distribution were not studied in this report We would recommend that the user employ historical storms or divide the 72-hour PMP into 6-hour increments. Then arrange the final storm configuration into a front-, middle-, or end-loaded temporal distribution depending on the water management decisions that are required. One possible way of doing this is as follows:

A. For DAD regions 1-6 (Figure 2.11), group the four heaviest 6-hour values of the 72-hour PMP in a 24-hour sequence.

B. Within the maximum 24-hour period arrange the four 6-hour values as follows. Place the second highest 6-hour values next to the highest, the third highest on either side of the first two 6-hour values, and the fourth highest at either end.

C. The 24-hour largest 6-hour values may be positioned anywhere in the 72-hour storm period. The remaining eight 6-hour amounts may be positioned anywhere else.

A hydrologist may experiment with different temporal sequences to uncover any factors that would make a particular sequence more critical than another for a basin of concern. Selection of a particular sequence for a basin is a decision for the user.

One way of distributing the storm spatially is by developing an isopercental analysis based on the 100-year precipitation frequency maps from NOAA Atlas 2 (Miller et al., 1973). This approximation was used to develop the individual storm analyses for this study, and has been used on other occasions to represent storm distributions.

Another approximation can be made by using a significant storm with a sufficient number of observations to draw a storm pattern over the basin of interest. If such a storm has been observed, then the storm pattern can be used to define an isopercental analysis for the PMP distribution. However, only a few California storms have sufficient detail to define a storm pattern over the complex terrain.

2.3 Example of General-Storm PMP Computation

The 973-mi^2 Auburn drainage above Folsom Lake is used as an example for the general-storm PMP. The Auburn drainage is located in the Sierra subregion or region 5. In this example, we will use the steps of Section 2.2. First, we will calculate the all-season PMP for the drainage, and then the PMP for the "off-season" month of May.

All-Season Calculation

Step

1. Drainage Outline

The Auburn drainage is outlined on a section of the 24-hour, general-storm PMP Index in Figure 2.18, at a scale of 1:1,000,000.

2. User Decision

We will do an all-season PMP calculation.

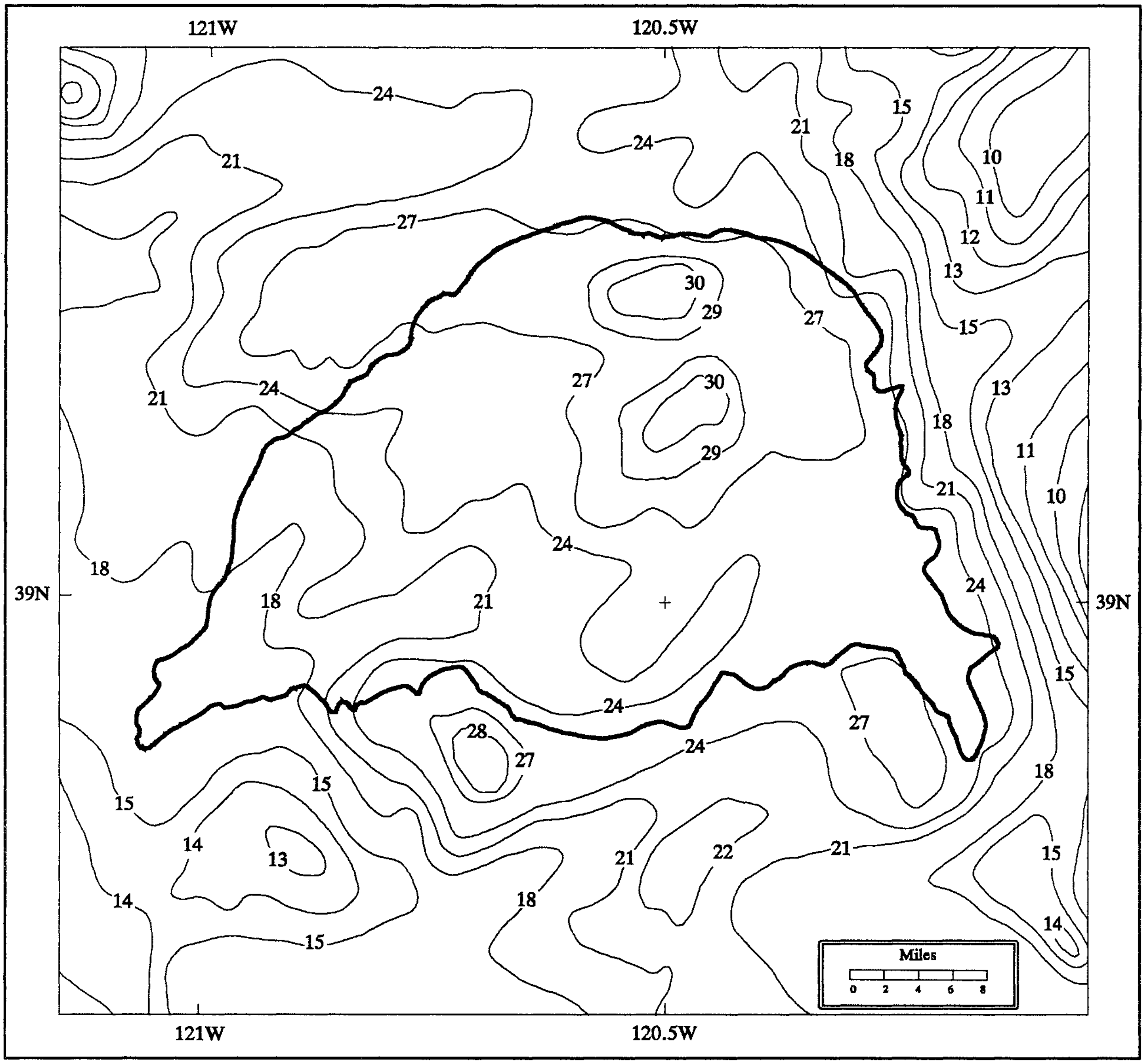


Figure 2.18. *Contours of general-storm index PMP in and around the 973-mi² Auburn drainage (heavy solid line) in California.*

3. All-Season Index PMP Estimate

Figure 2.18 shows the contours of index (10-mi^2, 24-hour) PMP superimposed on the outline of the Auburn drainage. It's average value is 24.6 inches.

4. Seasonal Index PMP Estimates

Skip this step.

5. Depth-Duration Relations

The Auburn drainage is within the Sierra classification (region 5) except for a very small portion near the dam site which may be regarded as inconsequential. Table 2.1 gives the ratios for durations from 1 hour to 72 hours.

Ratios for Auburn drainage						
	Duration (hours)					
	1	6	12	24	48	72
All-Season	.14	.42	.65	1.00	1.56	1.76

Multiply the result from Step 3, the average 10-mi^2, 24-hour PMP of 24.6 inches, by these ratios to produce the following 10-mi^2 depths of all-season PMP for Auburn:

Auburn drainage 10-mi^2 PMP						
	Duration (hours)					
	1	6	12	24	48	72
All-Season Depth (inches)	3.4	10.3	16.0	24.6	38.4	43.3

6. Areal Reduction Factors

Using the Auburn drainage area of 973 mi^2 and Figure 2.15, we get the following reduction ratios:

Reduction factors for Auburn drainage						
	Duration (hours)					
	1	6	12	24	48	72
All-Season	.64	.67	.70	.72	.77	.80

The depths from Step 5 are multiplied by these ratios to obtain the all-season, storm-centered average depths of PMP for the 973-mi^2 area of the Auburn drainage:

Auburn drainage average PMP depths						
	Duration (hours)					
	1	6	12	24	48	72
All-Season Depth (inches)	2.2	6.9	11.2	17.7	29.6	34.6

The results are plotted in Figure 2.19 as a solid line.

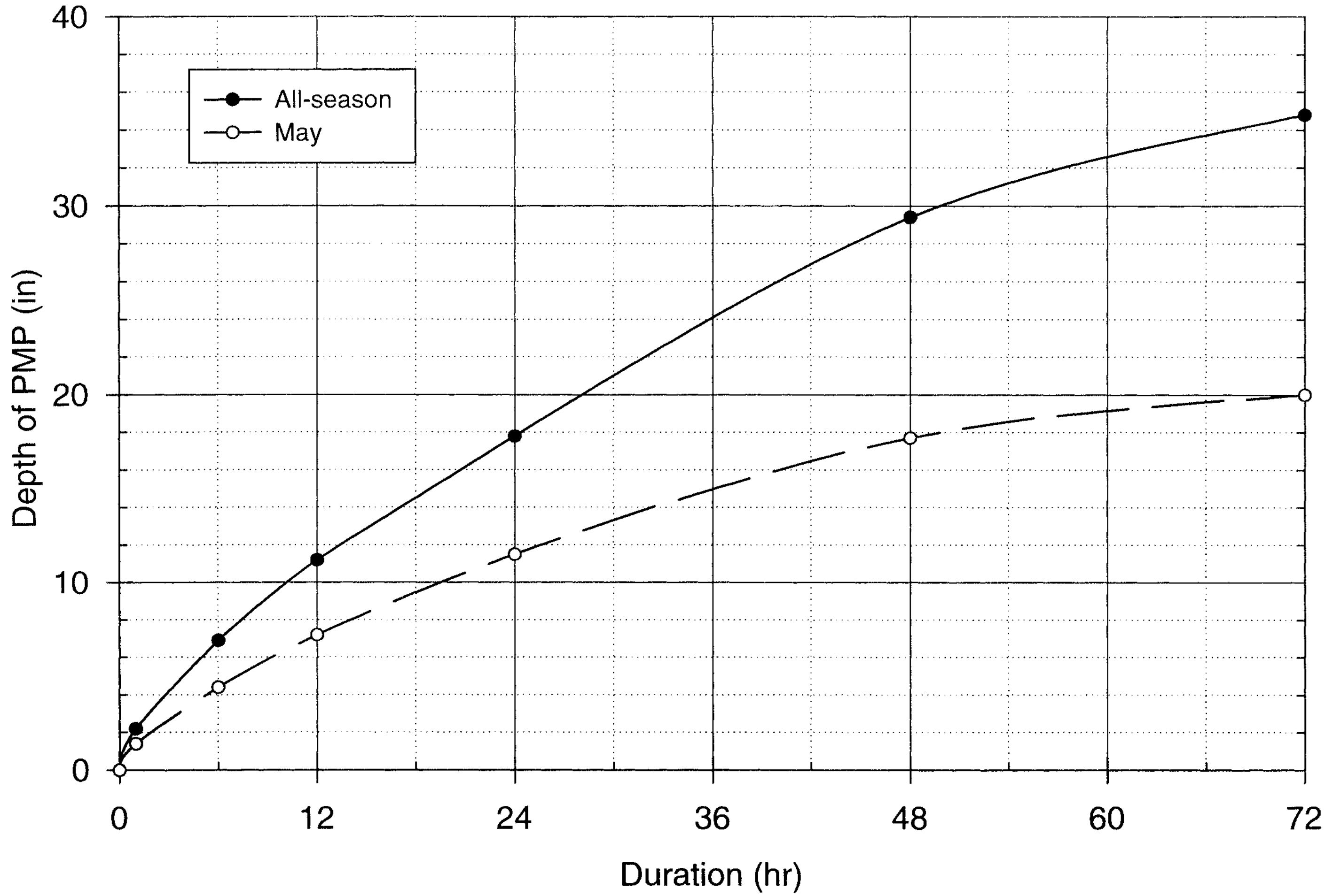


Figure 2.19. *Depth-duration curves for storm-centered, average depth of all-season (solid) and May (dotted) PMP for the 973-mi*^{2} *Auburn drainage in California.*

7. Incremental Estimates

Cumulative depths at 6-hour increments, extracted from the curve of Figure 2.19 are:

6-hour cumulative depths												
Duration (hours)												
	6	12	18	24	30	36	42	48	54	60	66	72
All-Season PMP (inches)	6.9	11.2	14.6	17.7	20.8	23.8	26.7	29.6	31.6	32.7	33.7	34.6

The 6-hour incremental amounts are obtained by subtracting each (cumulative) durational amount from the next larger amount to get:

6-hour incremental depths												
Duration (hours)												
	6	12	18	24	30	36	42	48	54	60	66	72
All-Season PMP Increment (inches)	6.9	4.3	3.4	3.1	3.1	3.0	2.9	2.9	2.0	1.1	1.0	0.9

8. Temporal Distribution, Areal Distribution, and Snowmelt Parameters

Using the rules from Step 8 the twelve 6-hour increments from Step 7 could be distributed as following: 3.1, 3.0, 2.9, 2.9, 3.1, 4.3, 6.9, 3.4, 1.1, 0.9, 2.0, 1.0

The areal distribution can be found by following Step 8 in Section 2.2.

For snowmelt parameters see the Appendix. A completed example for the all-season month of November may be found there.

Seasonal or Monthly PMP Calculation

Step

1. Drainage Outline

   As with the all-season example, the outline of the drainage depicted nominally at a scale of 1:1,000,000 in Figure 2.18 is the of Auburn drainage.

2. User Decision

   We will calculate seasonal PMP for the month of May.

3. All-Season Index PMP Estimate

   Even though we are doing PMP for May which is not an all-season month, we need an all-season index value as a starting point. As with the previous all-season example, Figure 2.18 shows the average depth to be 24.6 inches.

4. Seasonal Index PMP estimates

   Figure 2.4 shows the variation of general-storm PMP for the month of May as a percentage of all-season PMP (Plates 1 and 2). We determined an average value of 68 percent (to the nearest whole percent) for the Auburn drainage. This percentage was multiplied by the average depth from Step 3, and gives an average value of PMP of 16.7 inches for May. The nearest all-season month is March (Figure 2.2), and the monthly offset is 2.

5. Depth-Duration Relations

   As indicated earlier, the Auburn drainage is within the Sierra classification (region 5) except for a very small portion near the dam site which is inconsequential. Table 2.2 shows that the seasonally adjusted 10-mi^2 depth-duration ratios for May or a two-month offset are:

Ratios for Auburn drainage						
	Duration (hours)					
	1	6	12	24	48	72
May	.148	.437	.663	1.00	1.451	1.549

The 10-mi^2 depth of May PMP is obtained by multiplying the average 24-hour, 10-mi^2 PMP for May (16.7 inches) at Auburn by ratios for 1 hour to 72 hours. These are shown below:

Auburn drainage 10-mi^2 PMP						
	Duration (hours)					
	1	6	12	24	48	72
May Depth (inches)	2.5	7.3	11.1	16.7	24.2	25.9

6. Areal Reduction Factors

Interpolating to 973 mi^2 from Table 2.7 (Sierra region, offset of 2), we obtain the following reduction ratios:

Reduction factors for Auburn drainage						
	Duration (hours)					
	1	6	12	24	48	72
May	.548	.607	.648	.687	.731	.773

Multiplying these ratios by the corresponding May PMP depths from Step 5 gives the following storm-centered average depths of PMP across the 973-mi^2 Auburn drainage for May:

Auburn average drainage (973-mi²) PMP depths						
Duration (hours)						
	1	6	12	24	48	72
May Depth (inches)	1.4	4.4	7.2	11.5	17.7	20.0

7. Incremental Estimates

The results from Step 6 are also plotted in Figure 2.19 and a curve (dotted line) is drawn for these results. Cumulative depths at 6-hour increments to the nearest tenth of an inch, extracted from the curves, are as follows:

6-hour cumulative depths												
Duration (hours)												
	6	12	18	24	30	36	42	48	54	60	66	72
May PMP (inches)	4.4	7.2	9.4	11.5	13.3	15.0	16.4	17.7	18.5	19.1	19.6	20.0

To obtain 6-hour PMP values, subtract each (cumulative) amount from the next larger amount to get:

6-hour incremental depths												
Duration (hours)												
	6	12	18	24	30	36	42	48	54	60	66	72
May PMP Increment (inches)	4.4	2.8	2.2	2.1	1.8	1.7	1.4	1.3	0.8	0.6	0 .5	0.4

8. Temporal Distribution, Areal Distribution, and Snowmelt Parameters

A possible temporal precipitation (inches) sequence for the twelve 6-hour increments in May is: 0.6, 0.8, 2.2, 4.4, 2.8, 2.1, 1.8, 1.7, 1.4, 1.3, 0.5, 0.4

This is a possible sequence from the guidelines mentioned is Step 8 of Section 2.2. The areal distribution of isohyets can be obtained using the guidance from Step 8 of Section 2.2. No snowmelt parameters are required for May, since they are only valid for October through April.

2.4 Local Storm Procedures

Two options are available for obtaining the local-storm PMP values. They are:

A. Obtain the average depth of PMP for a drainage without specifying its areal distribution, or

B. Specify the areal distribution of the precipitation from a PMP storm within a drainage.

Option A requires Steps 1-5 below; Option B requires that Steps 1 and 2 are used followed by Step 6. If Option B is selected, a drainage average depth of the isohyetal precipitation pattern for various PMP storm placements must be chosen. There will be as many average depths for the drainage as there are placements for the PMP storm. The average depths of precipitation in a drainage obtained from Option B will be less than the average depth of PMP from Option A unless the drainage has the exact boundary shape shown in Figure 2.20.

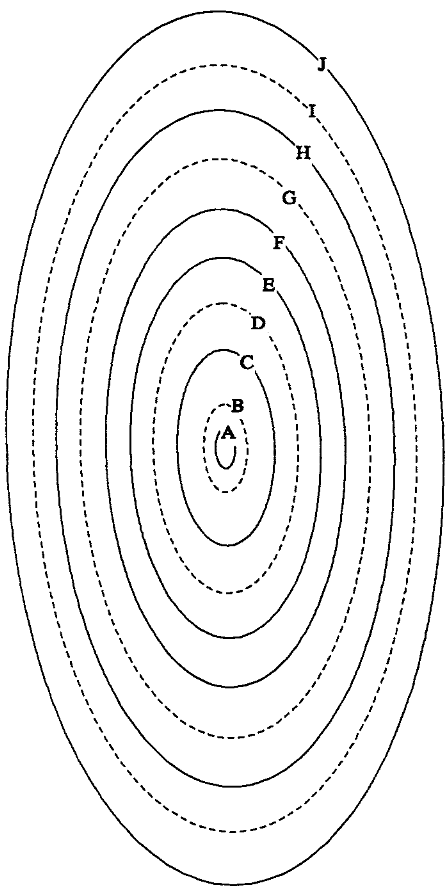
Step

1. One-hour, 1-mi^2 local-storm PMP

Locate the basin on Figure 2.21 and determine the basin-average, 1-hour, 1-mi^2, local-storm index value of PMP. Use linear interpolation.

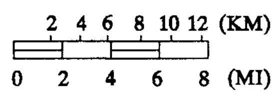
2. Adjustment for Mean Drainage Elevation

Determine the mean elevation of the drainage. No adjustment is necessary for elevations of 6,000 feet or less. If the mean elevation is greater than 6,000 feet,



	ENCLOSED AREA	AREA
ISOHYET	(MI^2)	(KM^2)
A	1	2.6
B	5	13
C	25	65
D	55	142
E	95	246
F	150	388
G	220	570
H	300	777
I	385	997
J	500	1295

DISTANCE SCALE



SCALE
1:500,000

Figure 2.20. *Idealized isohyetal pattern for local-storm PMP areas up to 500 mi².*

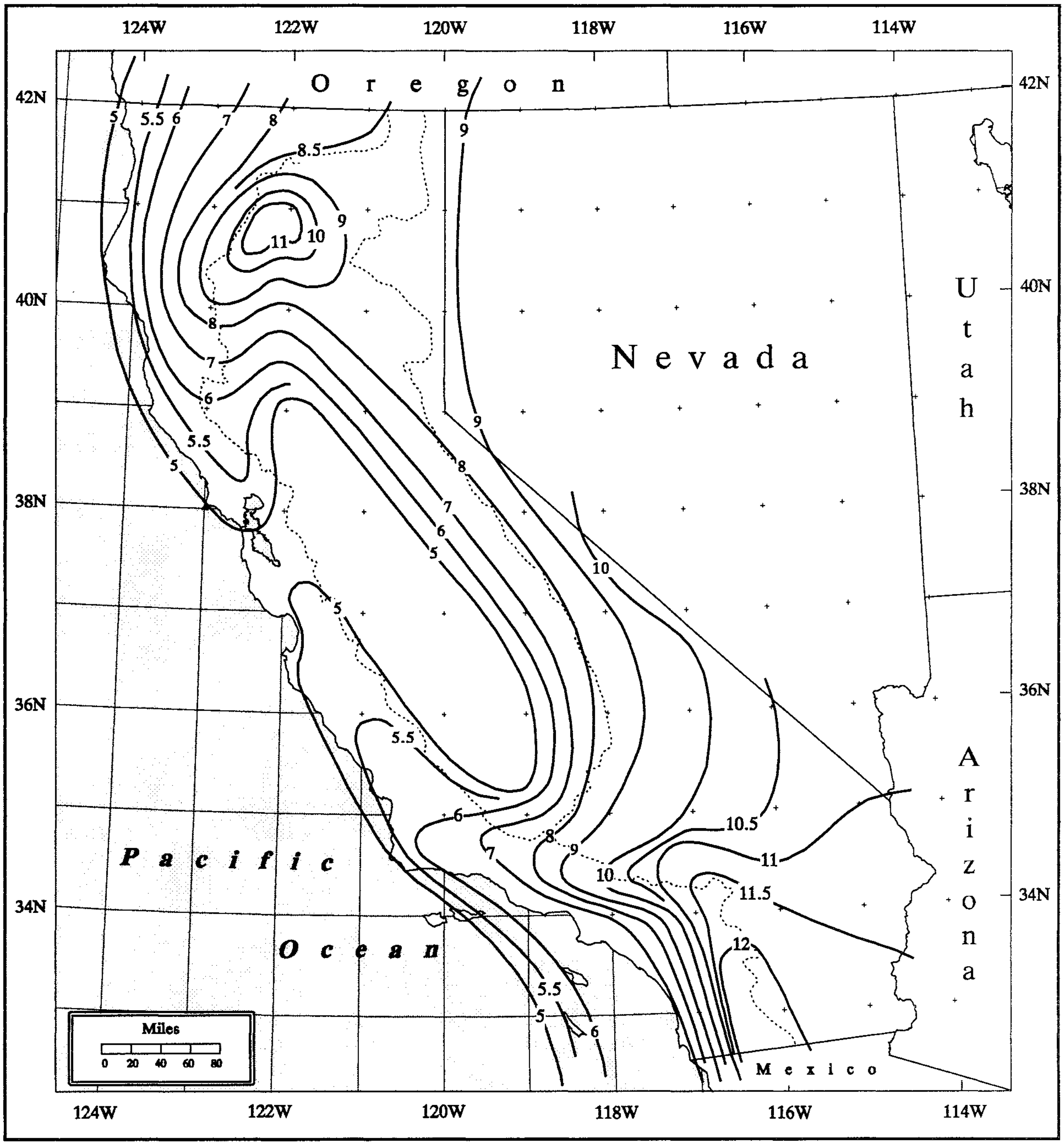


Figure 2.21. *California local-storm PMP precipitation estimates for 1 mi², 1 hour (inches).*

reduce the PMP from Step 1 by 9 percent for every 1,000 feet above the 6,000-foot level. Figure 2.22 can be used to graphically determine this value.

As an example of the elevation adjustment let us assume we have a basin with a mean elevation of 8,700 feet (2,700 feet above 6,000 feet). The reduction factor would be 24.3 percent (2.7 times .09), giving an elevation-adjusted PMP of 76 percent (rounded) of full 1-hour, 10-mi^2 PMP. Had Figure 2.22 been used, a value of about 76 percent is read off the line labeled pseudo-adiabat for an elevation of 8,700 feet.

3. Adjustment for Duration

The 1-mi^2 local-storm PMP estimates for durations less than 1 hour are obtained from Figure 2.23, as a percentage of the 1-hour amount from Step 2. For durations greater than 1 hour, determine the location of the basin on Figure 2.24, which provides a 6-hour to 1-hour ratio of the local-storm PMP. Multiply this ratio by the 1-hour local-storm PMP to obtain the 6-hour local-storm PMP. The four multipliers on Figure 2.24 are defined as A (1.15), B (1.2), C (1.3), and D (1.4) and correspond to the A, B, C, and D of Figure 2.23. Local-storm PMP amounts for durations of 1 to 6 hours can be obtained from Figure 2.23 or Table 2.10 for specific durations.

4. Adjustment for Basin Area

Figures 2.25 to 2.28 give the area reductions to 500 mi^2 depending on the 6-hour depth-duration ratio used in Step 3. The reductions obtained for the selected durations and area of the basin then are multiplied respectively by the results from Step 3, and a smooth curve is drawn on graph paper for the plotted values to get estimates for durations not specified.

5. Temporal Distribution

Review of local-storm temporal distributions for this region show that most local storms have durations less than 6 hours and that the greatest 1-hour amount occurs

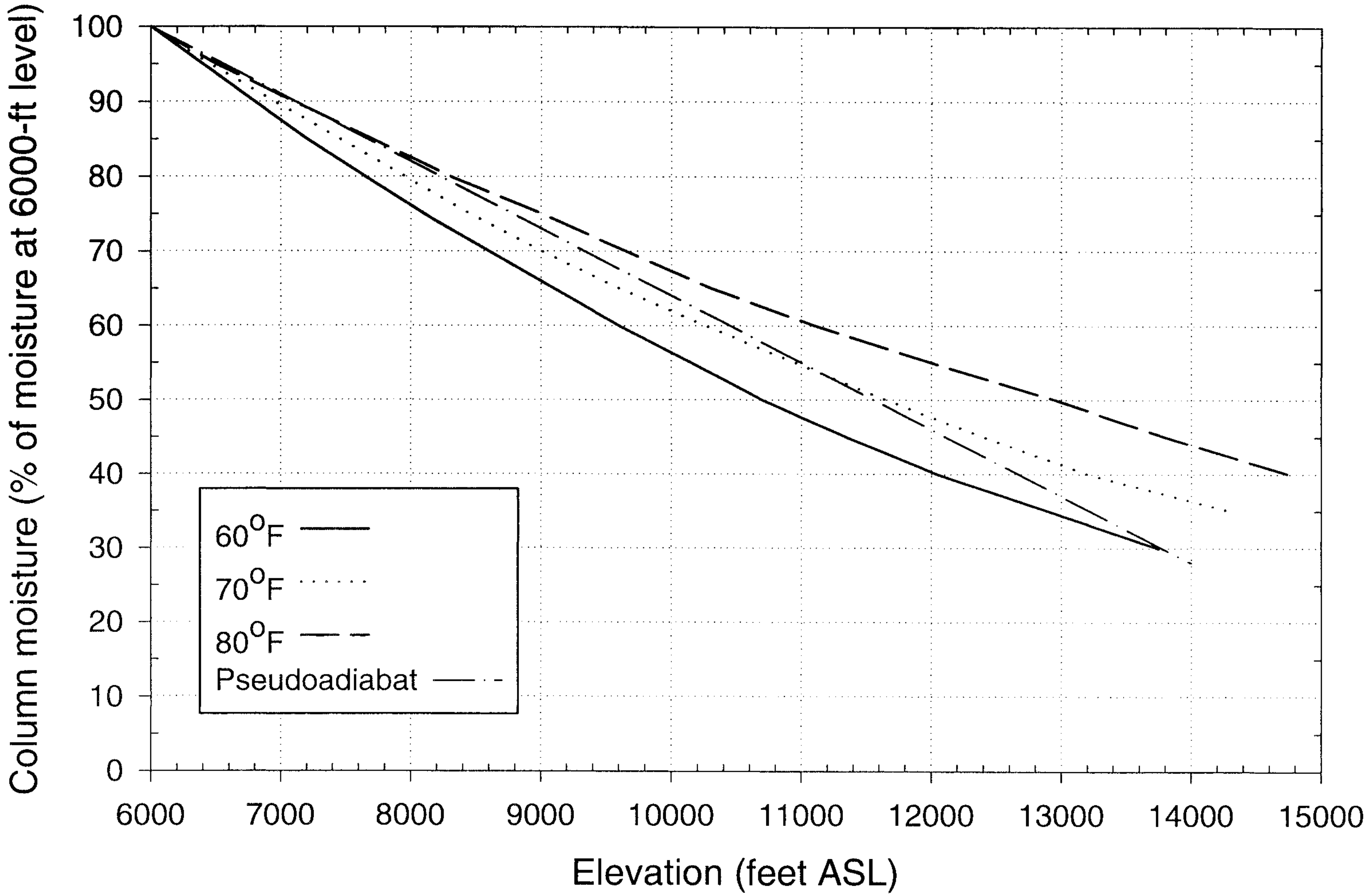


Figure 2.22. *Pseudoadiabatic decrease in column moisture for local-storm basin elevations.*

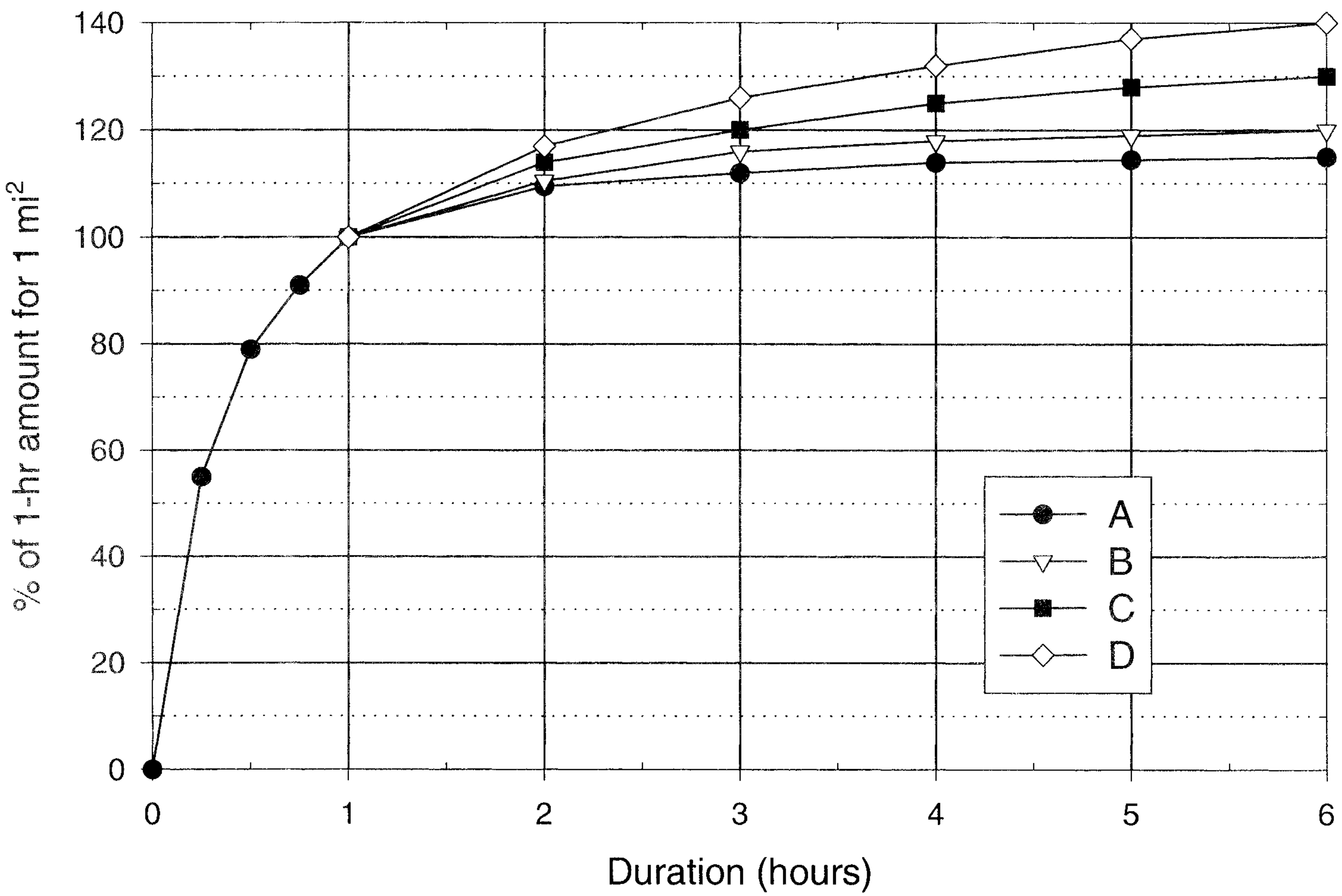


Figure 2.23. *Depth-duration relations for California for 6-hour to 1-hour ratios. The ratios are mapped in Figure 2.24; A = 1.15, B = 1.2, C = 1.3, D = 1.4.*

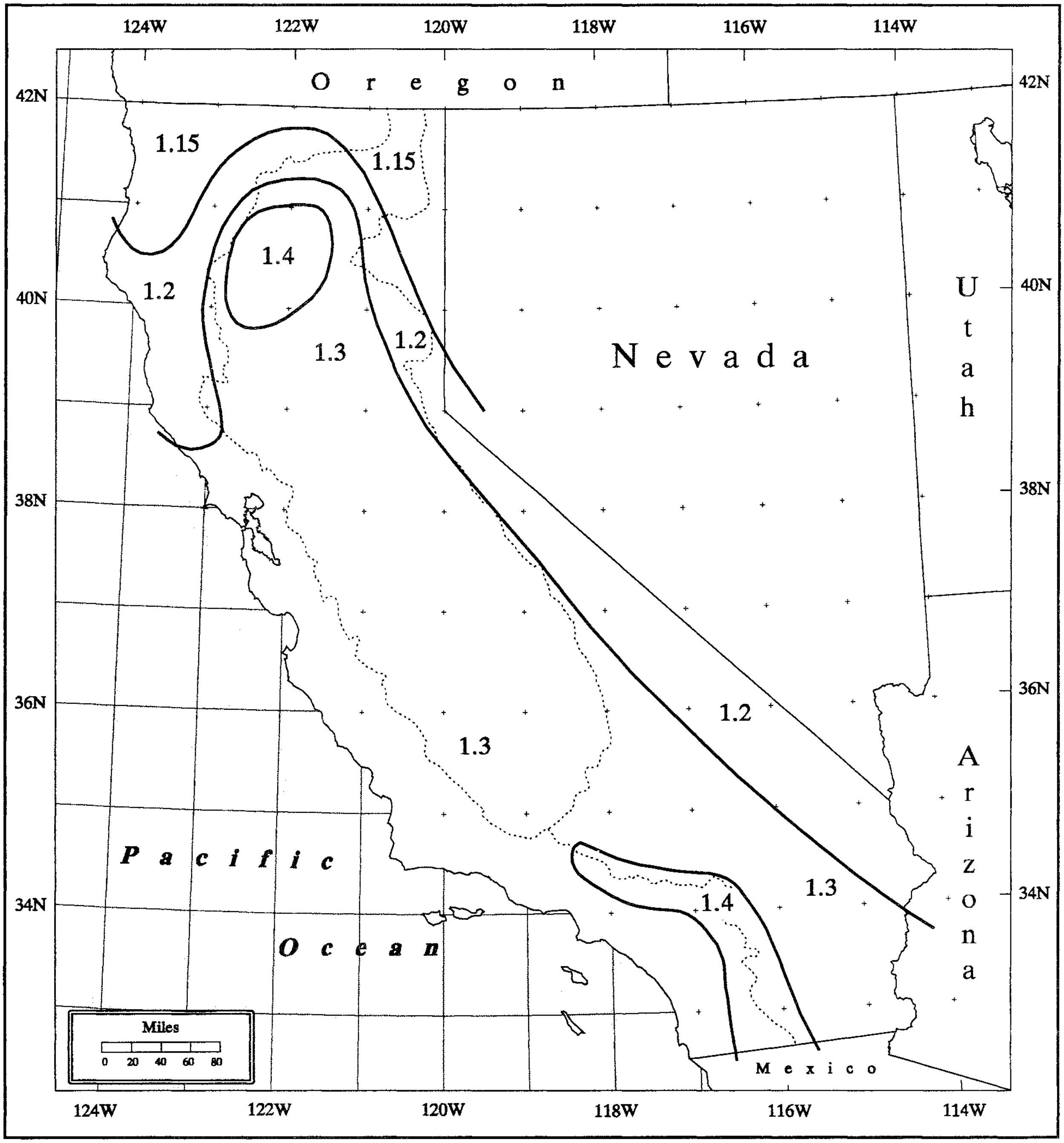


Figure 2.24. *California local-storm PMP 6-hour to 1-hour ratios for 1 mi*^{2}*. For use with Figure 2.23; A = 1.15, B = 1.2, C = 1.3, D = 1.4.*

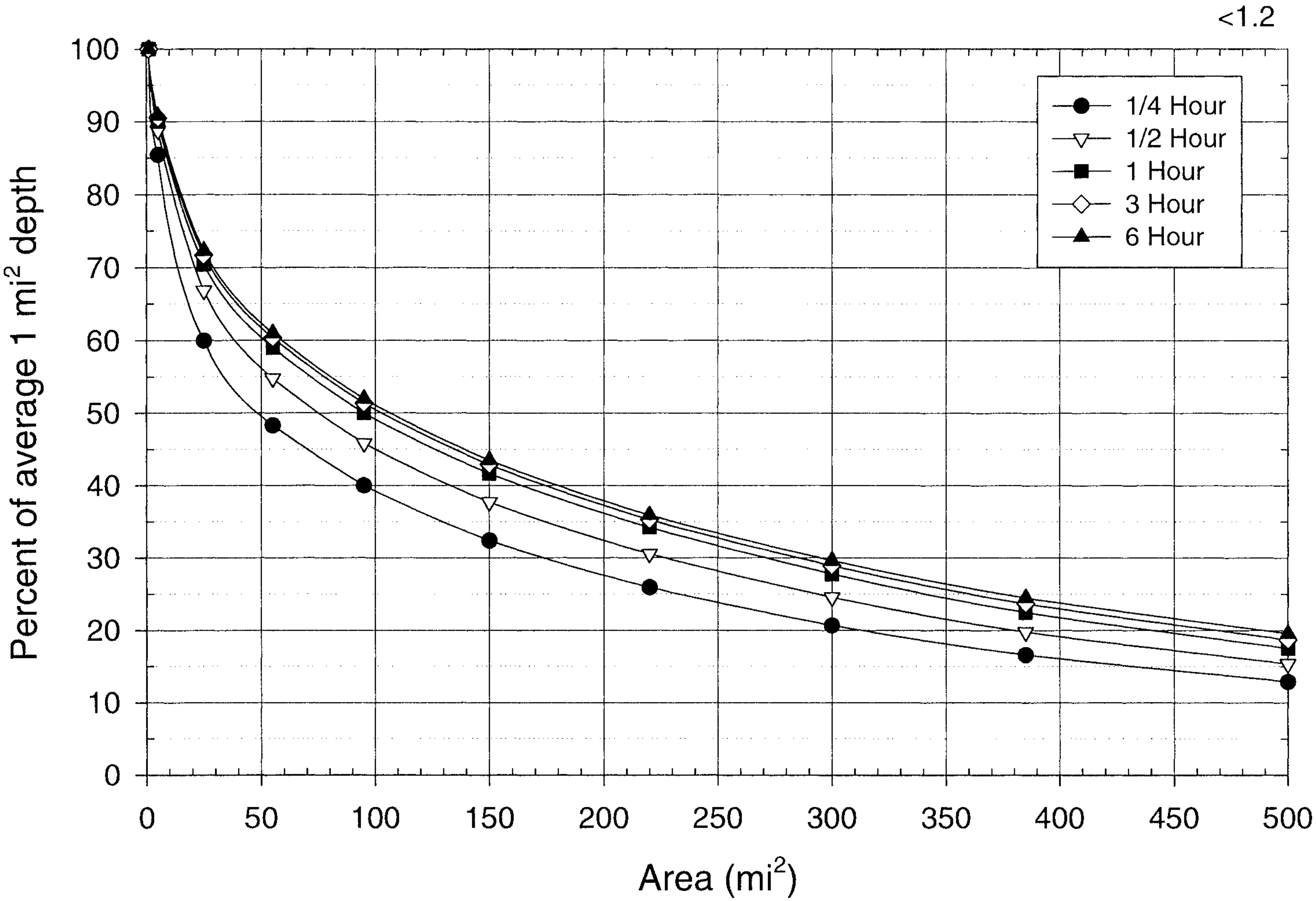


Figure 2.25. *Depth-area relations for California local-storm PMP for a 1-mi², 6-hour to 1-hour depth-duration ratio less than 1.2.*

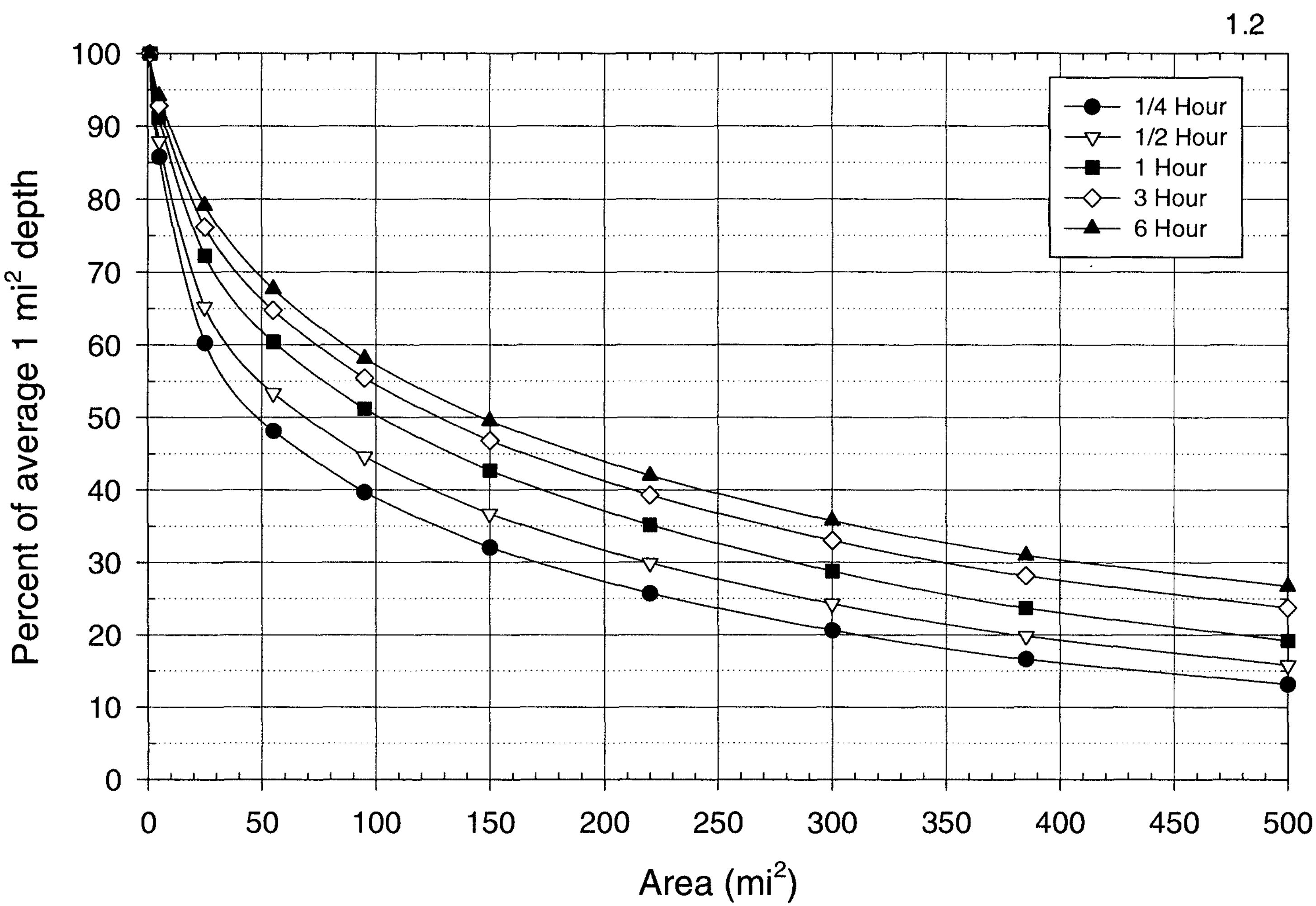


Figure 2.26. *Depth-area relations for California local-storm PMP for a 1-mi^2, 6-hour to 1-hour depth-duration ratio equal to 1.2.*

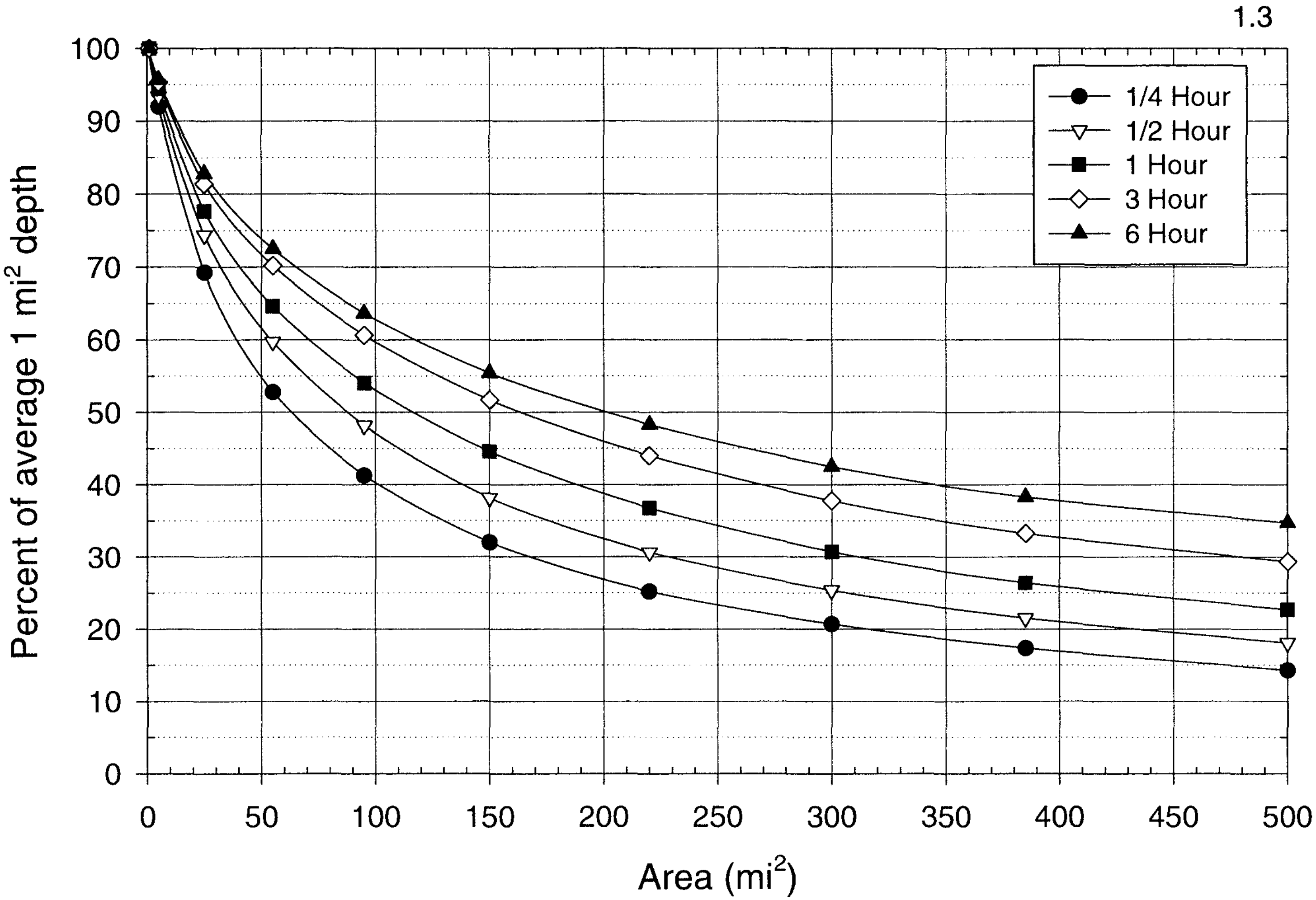


Figure 2.27. *Depth-area relations for California local-storm PMP for a 1-mi², 6-hour to 1-hour depth-duration ratio equal to 1.3.*

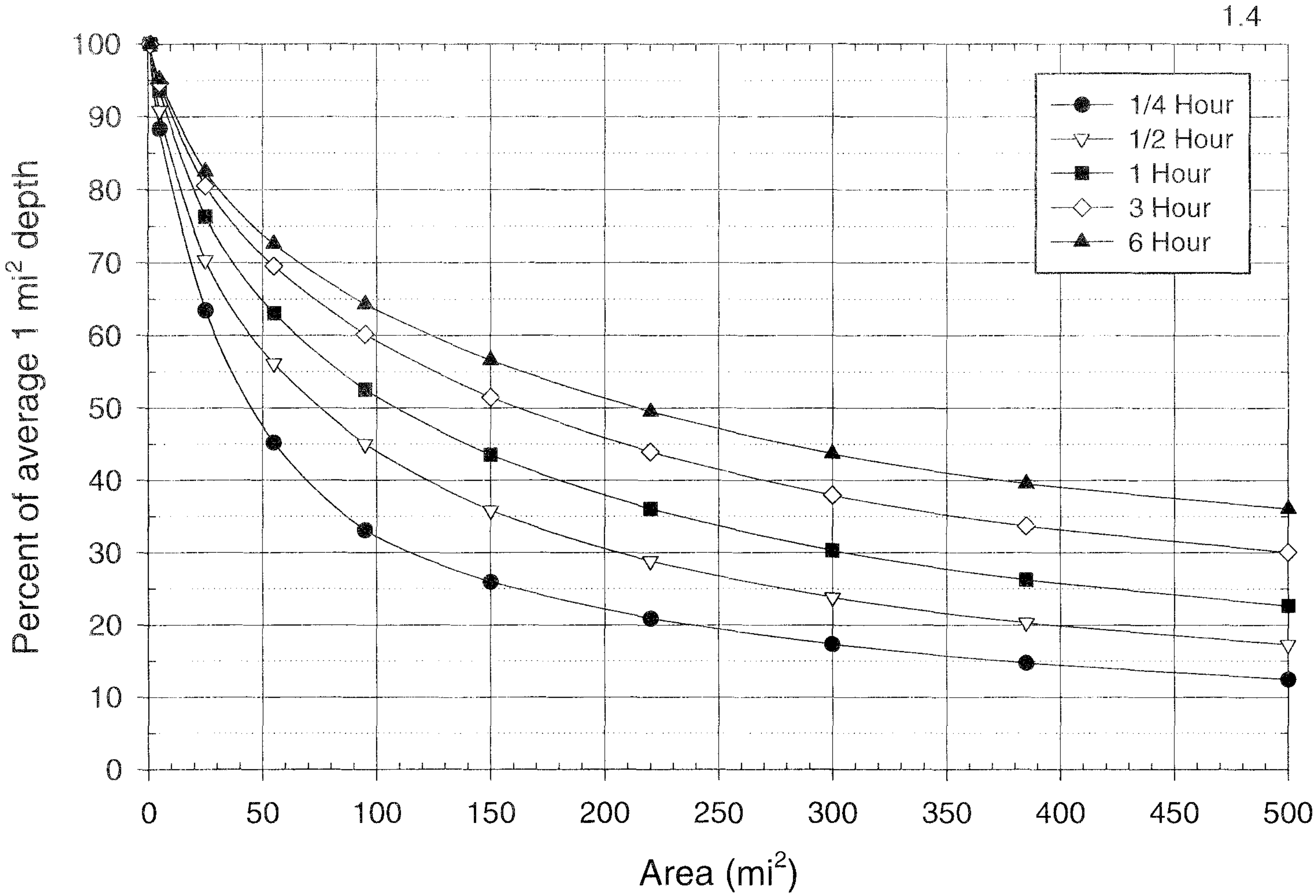


Figure 2.28. *Depth-area relations for California local-storm PMP for a 1-mi², 6-hour to 1-hour depth-duration ratio equal to 1.4.*

in the first hour. The recommended sequence of hourly increments is as follows: arrange the hourly increments from largest to smallest as obtained directly by successive subtraction of values read from the smoothed depth-duration curve. The most intense 1-hour of precipitation occurs in the first hour of the storm, the second most intense hour in the second hour, and so forth.

Table 2.10. *Depth-duration relations (percent of 1-hour amount) for 1-mi^2 PMP for California local storms.*

	Relationship Designator (see Figure 2.23)			
Duration (hours)	A	B	C	D
0	0	0	0	0
1/4	55	55	55	55
1/2	79	79	79	79
3/4	91	91	91	91
1	100	100	100	100
2	109.5	110.5	114	117
3	112	116	120	126
4	114	118	125	132
5	114.5	119	128	137
6	115	120	130	140

6. Areal Distribution for Local-Storm PMP

The elliptical pattern in Figure 2.20 and the tabulated percentages in Tables 2.11 to 2.14, are used to describe the areal distribution of precipitation of a local PMP storm. The 2:1 ratio of the major to minor axis of Figure 2.20 should be used or "placed" only on a map at a 1:500,000 scale. The average index value from Step 2 (or Step 1 if no elevation adjustment is made) is multiplied by each of the percentages from the appropriate table (Tables 2.11 to 2.14) to obtain the value for each lettered isohyet

Table 2.11. *Isohyetal label values (percent of 1-hour, 1-mi² average depth) to be used in conjunction with isohyetal pattern of Figure 2.20 and basin-average depths from Figure 2.25.*

	Duration (hours)								
Isohyet	1/4	1/2	3/4	1	2	3	4	5	6
A	55	79	91	100	109.5	112	114	114.5	115
B	35	57	68	74.8	83.5	85.5	87.5	88	88.5
C	24	40	49	56	62.9	4.5	66	66.5	67
D	18.5	30.5	39	43	48	49.5	50.6	51.1	51.5
E	13	22.5	29	32.2	36.6	37.7	38.6	39	39.5
F	7.5	14.0	19	22.4	25	25.7	26.3	26.7	27.0
G	4.5	8.5	12	14.0	16.2	16.8	17.4	17.9	18.2
H	1.8	3.5	5	6.5	8.3	8.8	9.3	9.8	10.3
I	0.4	0.7	0.9	1.1	2.2	2.7	3.2	3.7	4.1
J	0.1	0.3	0.5	0.7	1.2	1.7	2.2	2.6	2.9

Table 2.12. *Isohyetal label values (percent of 1-hour, 1-mi² average depth) to be used in conjunction with the isohyetal pattern of Figure 2.20 and basin-average depths from Figure 2.26 .*

	Duration (hours)								
Isohyet	1/4	1/2	3/4	1	2	3	4	5	6
A	55	79	91	100	110.5	116	118	119	120
B	35.5	55	68	78	88	95	99	101	102.5
C	24	39	49	57	66	72	75	77	78.5
D	19	30	39	44	51.5	56	58.5	60	61
E	13.5	22	28	33	39	42.7	44.5	46	47
F	8.5	15	20	23	28	31.5	33.5	35	36
G	5.5	9.5	13	15	19	22	24	25	26
H	2	4.5	6.0	7.5	11.5	14.5	16.5	17.5	18.5
I	1	2	3	4	8	11	13	14.5	15.5
J	1	2	3	4	7	10	12	13.5	14.5

Table 2.13. *Isohyetal label values (percent of 1-hour, 1-mi² average depth) to be used in conjunction with the isohyetal pattern of Figure 2.20 and basin-average depths from Figure 2.27.*

	Duration (hours)								
Isohyet	1/4	1/2	3/4	1	2	3	4	5	6
A	55	79	91	100	114	120	125	128	130
B	44	66	77.6	86	100	106	111	114	116
C	26	44	53.6	61	74	81	86	89	91
D	17	31	40.2	46.5	58	65	70	73	75
E	11	20	26.8	32.5	42	49	54	57	59
F	6.6	13	19	24	32	38	43	46	48
G	6.5	11	14	16	23	28	33	36	38
H	5	8	10.5	12	17.5	21.5	25.5	29	31
I	3	6.0	8.5	10.5	16	20	24	27.5	30
J	2.5	5.5	8	10	15	19	23	26.5	29

Table 2.14. *Isohyetal label value (percent of 1-hour, 1-mi² average depth) to be used in conjunction with the isohyetal pattern of Figure 2.20 and basin-average depths from Figure 2.28.*

	Duration (hours)								
Isohyet	1/4	1/2	3/4	1	2	3	4	5	6
A	55	79	91	100	117	126	132	137	140
B	39	61	74	84	100	109	115	120	123
C	24	42	52	60	76	85	91	96	99
D	15	28	37	44	59	67	73	78	81
E	9	19	26	32	44	52	58	63	67
F	6	13.5	19	24	34	40	45	50	54
G	6	10	13.5	16	24	30	35	39	42
H	4	7	10	13	19	24	28	32	35.5
I	3.3	6.5	9	11	18	23	27	31	34.5
J	3	5.5	8	10	17	22	26	30	33.5

(A - J). Once the labels have been determined for each application, the pattern can be moved to different placements on the basin. In most instances, the greatest volume of precipitation will be obtained when the pattern is centered in the drainage. However, peak flows may actually occur with placements closer to the drainage outlet. The basin-averaged depth of precipitation is obtained for chosen local PMP storm placements, by using planimetry, a GIS, or other area-averaging methods.

2.5 Example of Local-Storm PMP Calculation

We have selected a small area in southeastern California known as the McCoy Wash to illustrate the steps for calculating local-storm PMP. The Wash has an area size of 167 mi^2 and its boundary, along with selected contours of elevation, is shown in Figure 2.29. We will illustrate both options A and B referenced in the previous section.

Local-Storm PMP for McCoy Wash

Step

1. One-hour, 1-mi^2 PMP

   The centroid of the Wash is near latitude 33.75° N and longitude 114.75° W. Interpolation to this centroid on Figure 2.21 gives an average local PMP value (1-hour, 1-mi^2) of 11.4 inches to the nearest tenth of an inch. Interpolation was appropriate here since there is little, if any, gradient of index values across the Wash. For locations where significant gradients of index values exist, an average index value should be found.

2. Adjustment for Mean Drainage Elevation

   The mean elevation of the Wash is well below 6,000 feet as shown on Figure 2.29. No elevation adjustment is needed, and the local-storm PMP from Step 1 remains at 11.4 inches.

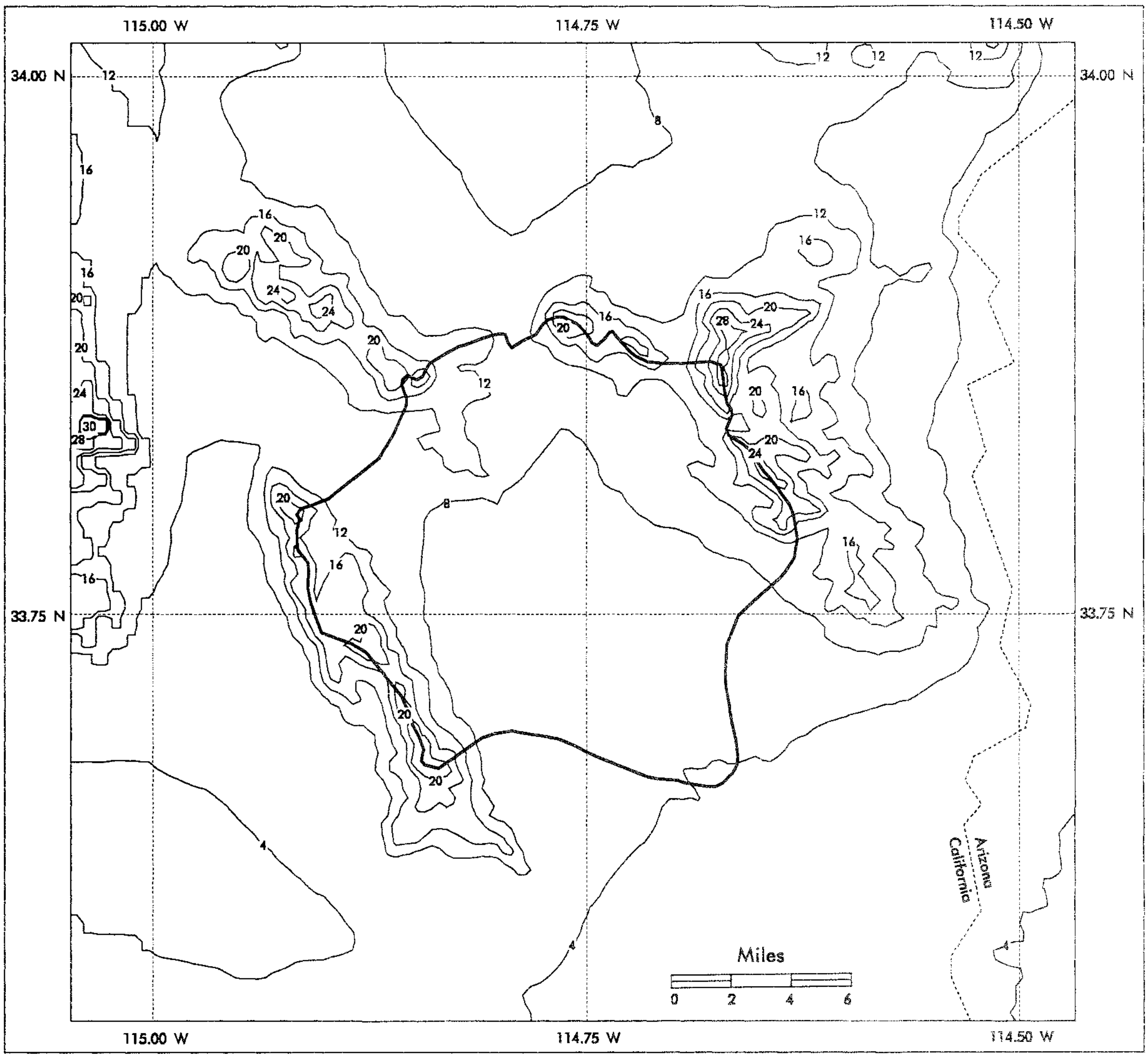


Figure 2.29. *McCoy Wash, California drainage boundary (solid, heavy line) with elevation contours (solid, thin lines) in hundreds of feet.*

3. Adjustment for Duration

The value of the 6-hour to 1-hour ratio near the Wash's centroid found in Figure 2.24 is 1.3. The depth-duration curve which applies here is curve "C" from Figure 2.23, and column "C" from Table 2.10 is also applicable.

Multiplication of the column "C" percentages by the average depth from Step 2 gives the average 1-mi^2 values for the Wash:

	Duration (hours)								
	1/4	1/2	3/4	1	2	3	4	5	6
1-mi^2 Average Depth (inches)	6.3	9.0	10.4	11.4	13.0	13.7	14.3	14.6	14.8

4. Adjustment for Basin Area

Figure 2.27 gives the depth-area relations for a 6-hour to 1-hour ratio of 1.3 The reduction ratios used to obtain average depths basin from 1-mi^2 depths for the 167 mi^2 and their depths are:

	Duration (hours)				
	1/4	1/2	1	3	6
Reduction Ratio	.31	.37	.43	.50	.54
167-mi^2 Average Depth (inch)	2.0	3.3	4.9	6.9	8.0

These results are shown, and a smooth curve fitted to these depths as shown in Figure 2.30.

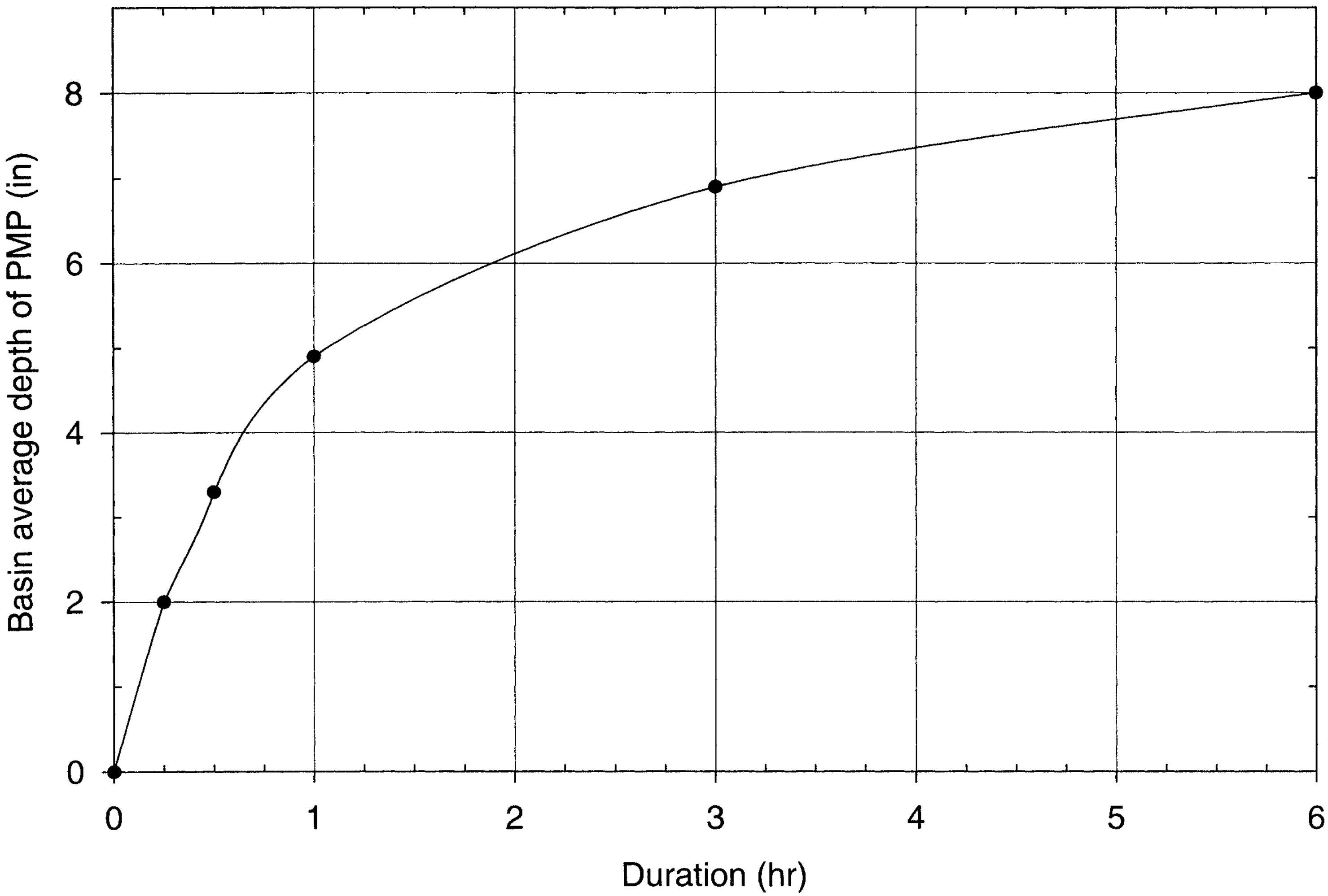


Figure 2.30. *Average depth of local-storm PMP for the 167-mi² McCoy Wash, California.*

5. Temporal Distribution

The smoothed cumulative hourly values from Step 4 and the incremental hourly values resulting from successive subtractions are:

Hourly Intervals						
	1	2	3	4	5	6
Cumulative PMP (inch)	4.9	6.1	6.9	7.4	7.7	8.0
Incremental PMP (inch)	4.9	1.2	0.8	0.5	0.3	0.3

The highest increment to lowest increment sequence shown above is the recommended chronology for local-storm PMP at McCoy Wash.

6. Areal Distribution of Local-Storm PMP

The areal distribution of local-storm PMP is given by the isohyets of Figure 2.20. Remember these isohyets are meant to be placed within a basin boundary at the 1:500,000 map scale. For this example, the percentages from Table 2.13 apply for a basin with a 6-hour to 1-hour ratio of 1.3. When the 6-hour to 1-hour ratio is 1.15, 1.2, or 1.4, Tables 2.11, 2.12, or 2.14 apply respectively.

It is important to note that when Tables 2.11 to 2.14 are used in a particular case, that the percentages from the selected table apply only to the 1-mi^2, 1-hour average local-storm PMP from Step 2, and NOT to the values from Step 3. In this example, the average depth is 11.4 inches, and the isohyetal labels of Table 2.15 result. An average 6-hour depth of 8.0 inches for the 167-mi^2 McCoy Wash Basin is given (Step 4). Using Figure 2.20 the isohyetal labels range from 14.82 inches enclosing 1 mi^2 to 4.33 inches enclosing 220 mi^2 for that duration.

Remember that the isohyetal labels in Step 6 produce the average depths from Step 4 only if the basin in consideration is elliptical with a 2:1 ratio of the major to minor axis and the ellipses are centered in a "perfect" drainage. The ellipses with the indicated values from this step when placed in an irregularly shaped drainage and then averaged, will produce average depths less than those resulting from Step 4. The PMP level for the drainage comes from Step 4, with the isohyetal labels of Step 6 giving an idea of a possible areal distribution for the storm.

Table 2.15. *Isohyetal label values for local-storm PMP, McCoy Wash, California (167 mi²).*

Isohyetal Tag (mi^2)	Duration (hours) 1/4	1/2	3/4	1	2	3	4	5	6
A (1)	6.27	9.01	10.37	11.40	13.00	13.68	14.25	14.59	14.82
B (5)	5.02	7.52	8.85	9.80	11.40	12.08	12.65	13.00	13.22
C (25)	2.96	5.02	6.11	9.65	8.44	9.23	9.80	10.15	10.37
D (55)	1.94	3.53	4.58	5.30	6.61	7.41	7.98	8.32	8.55
E (95)	1.25	2.28	3.06	3.71	4.79	5.59	6.16	6.50	6.72
F (150)	.75	1.48	2.17	2.74	3.65	4.33	4.90	5.24	5.47
G (220)	.74	1.25	1.60	1.82	2.62	3.19	3.76	4.10	4.33
H (300)	.57	.91	1.20	1.37	2.00	2.45	2.91	3.31	3.53
I (385)	.34	.68	.97	1.20	1.82	2.28	2.74	3.14	3.42
J (500)	.29	.63	.91	1.14	1.71	2.17	2.62	3.02	3.31

Endnote[1]

Plates 1 and 2 have limited detail in some regions. The Hydrometeorological Design Studies Center will provide supplemental map(s) containing a more complete set of isohyets or digital values for specific drainages areas, upon request.

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APPENDIX

Snowmelt Parameters

In HMR 36 a snowmelt procedure was provided. Information was included for determination of temperatures, dew points, precipitation, and winds during and prior to a PMP storm. The development of new snowmelt parameters was beyond the scope of this report. However, during peer review, inclusion of snowmelt parameter procedures was mentioned by most reviewers as highly desirable. This Appendix is in response to those requests.

The core of the Appendix is a worksheet consisting of five sections (A-E). It is essentially the same worksheet that appeared in HMR 36. An example for the Auburn drainage above Folsom Dam is provided for mid-November. The figures referenced in Chapter X of HMR 36 dealing with variation of precipitable water, temperature/elevation relations, temperature prior to a PMP storm, and winds have not been changed except for new figure numbers. The seasonal variation of maximum moisture table (Table 4-1 in HMR 36) was replaced by Table A1. The revision of this table was based on new dew-point data. The durational variation of maximum moisture, Table A2, is unchanged. The seasonal variation of maximum moisture, Table A1, is a function of the regional DAD boundaries for Figure 2.11.

An important part of this methodology is the wind speed expected at the surface of a snow pack; these winds and reduction factors are needed in Steps D.1 and D.2 of the worksheet. The recommended factors for basins not sheltered from the winds by topographic features in advance of a PMP storm are a function of regions.

The factors for the regions are:

Region	Factor
1, 3, 6	.80
2, 5	.75

In cases where basins are sheltered from the winds the reduction factors should reduce the surface winds speeds even more. The amount of the reduction should be decided by the user.

We have assumed that snowmelt is not an important factor for basins in regions 4 and 7. If snowmelt parameters are needed for basins in these regions, use the factor in the above list from the region closest to the basin of concern.

Data values from Figures A1 to A7 may vary, and there will be some difference from user to user. Figure A8 gives the dew-point temperatures for February over California.

Table A1. *Monthly variation of maximum moisture (percent/100 of February maximum). See Figure 2.11 for region boundaries.*

	Month						
Region	October	November	December	January	February	March	April
3, 4, 6	1.22	1.13	1.08	1.03	1.00	1.03	1.06
7	1.35	1.11	1.03	0.97	1.00	1.03	1.06
1, 2	1.29	1.14	1.12	1.05	1.00	1.00	1.08
5	1.29	1.17	1.11	1.03	1.00	1.03	1.09

Table A2. *Durational variation of maximum moisture (percent of 12-hour precipitable water).*

Duration (Hour)	6	12	18	24	30	36	42	48	54	60	66	72
Percent	104	100	97	95	93	91	89	88	86	85	84	83

Snowmelt Parameters Worksheet

Drainage:__________ Average elevation (nearest 100 feet):______

Month:______________ Region:_______

A. **Temperatures and Dew Points During PMP Storm**

1) Average 12-hour February 1000 mb persisting dew point over basin (Figure A8): __________

2) Precipitable water (W_p) for temperature from Step A.1 (Figure A1): _______

3) Seasonal adjustment for month selected (Table A1): _______

4) Line 2 ______ x line 3 = ________

	6-Hour Period											
	1	2	3	4	5	6	7	8	9	10	11	12
5) W_p corresponding to 6-hour temperature increments during PMP storm. Line 4 x %'s of Table A2 (inches).												
6) 6-hour incremental sea-level temperatures and dew points from Figure A1 (°F).												
7) Sea-level temperatures and dew points adjusted to average basin elevation. Figure A2 (°F).												
8) Height of 32°F above mean sea-level. Figure A2 (1000's feet). Use dew points from line 6.												

9) The temperatures and elevations in Steps A.7 and A.8 should be arranged in time sequence corresponding to the selected PMP storm sequence (see E).

B. Temperatures Prior to PMP Storm

	Hours Prior to Storm Onset							
	48	42	36	30	24	18	12	6
1) Differences between temperature at the beginning of storm and at indicated hours prior to storm. From Figure A3, in range from curve A_1 to curve B (°F).								

2) The above differences are added to the initial temperature determined in Step A.9.

C. Dew Points Prior to PMP Storm

	Hours Prior to Storm Onset							
	48	42	36	30	24	18	12	6
1) Differences between dew point at the beginning of storm and at indicated hours prior to storm. Figure A3, curve C (°F).								

2) The above differences are subtracted from the initial temperature (dew point) determined in Step A.9.

D. Snowmelt Winds

	6-Hour Period											
	1	2	3	4	5	6	7	8	9	10	11	12
1) Winds from Figure A5 (Regions 1, 3, 6) or A6 (Regions 2, 5) and interpolations at average basin elevation (feet msl) reference Figure A4 (mph).												
2) Winds reduced to surface conditions. See text for factor to be used. Step D.1 winds x factor (mph).												
3) Surface winds adjusted to month selected. Step D.2 winds x ______ (from Figure A7) (mph).												

4) Arrange 6-hour winds (Step D.3) in time sequence similar to arrangement of precipitation and temperatures in PMP storm (see E).

E. Time Sequence of Temperatures, Winds and Precipitation During PMP Storm

	6-Hour Period 1	2	3	4	5	6	7	8	9	10	11	12
1) Month of concern 6-hourly PMP increments for the selected drainage obtained by procedures of Chapter 2 (inches).												

	Time in Hours From Beginning of Storm 6	12	18	24	30	36	42	48	54	60	66	72
2) 6-hour PMP increments arranged according to sequence adopted in Section 2.2, Step 8 (inches).												
3) 6-hour temperatures from A.7 arranged in same sequence (°F).												
4) 6-hour winds from D.3 arranged in same sequence (mph).												
5) Height of freezing level from A.8 in same sequence (1000's feet).												

	Hours Prior to Storm Onset 48	42	36	30	24	18	12	6	0
6) Temperature prior to storm. Differences of B.1 added to the temperature from E.3, 6-hour column.									
7) Dew points prior to storm. Differences of C.1 subtracted from the temperature from E.3, 6-hour column.									

8) Winds prior to storm may be assumed to be the 72-hour duration value from D.3 for two days prior to storm.

Snowmelt Parameters Worksheet
(Example)

Drainage: Auburn — Average elevation (nearest 100 feet): 4700
Month: Mid-November — Region: Sierra (5)

A. Temperatures and Dew Points During PMP Storm

1) Average 12-hour February 1000 mb persisting dew point over basin (Figure A8): 60° F

2) Precipitable water (W_p) for 60° F (Figure A1): 1.38

3) Seasonal adjustment for November (Table A1): 1.17

4) 1.38 times 1.17 = 1.61 inches

	6-Hour Period											
	1	2	3	4	5	6	7	8	9	10	11	12
5) W_p corresponding to 6-hour temperature increments during PMP storm. 1.61 x %'s of Table A2 (inches).	1.67	1.61	1.56	1.53	1.50	1.47	1.43	1.42	1.38	1.37	1.35	1.34
6) 6-hour incremental sea-level temperatures and dew points from Figure A1 (°F).	63.8	63.0	62.3	62.0	61.6	61.1	60.8	60.6	60.0	59.9	59.6	59.3
7) Sea-level temperatures and dew points adjusted to 4700 feet elevation. Figure A2 (°F).	51.5	50.7	49.8	49.4	49.0	48.4	48.0	47.6	47.3	47.0	46.7	46.3
8) Height of 32° F above mean sea level. Figure A2 (1000's feet). Use dew points from line 6.	11.6	11.3	10.9	10.8	10.7	10.4	10.2	10.1	9.9	9.8	9.7	9.6

9) The temperatures and elevations in Steps A.7 and A.8 should be arranged in time sequence corresponding to the selected PMP storm sequence (see E).

B. **Temperatures Prior to PMP Storm**

	Hours Prior to Storm Onset							
	48	42	36	30	24	18	12	6
1) Differences between temperature at the beginning of storm and at indicated hours prior to storm. From Figure A3, selecting curve A_1 (°F).	10.0	9.5	9.0	8.0	7.0	6.0	4.5	3.5

2) The above differences are added to the initial temperature determined in Step A.9.

C. **Dew Points Prior to PMP Storm**

	Hours Prior to Storm Onset							
	48	42	36	30	24	18	12	6
1) Differences between dew point at the beginning of storm and at indicated hours prior to storm. Figure A3, curve C (°F).	3.5	2.5	2.0	2.0	1.5	1.0	1.0	0.5

2) The above differences are subtracted from the initial temperature (dew point) determined in Step A.9.

D. **Snowmelt Winds**

	6-Hour Period											
	1	2	3	4	5	6	7	8	9	10	11	12
1) Winds from Figure A6 and interpolations at 4700 feet msl (4700 feet = 840 mb) reference Figure A4 (mph).	78	69	64	60	57	54	52	50	49	48	47	46
2) Winds reduced to surface conditions similar to Auburn. Step D.1 winds x 0.75 (mph).	59	52	48	45	43	40	39	38	37	36	35	35
3) Surface winds adjusted to November. Step D.2 winds x 0.82 (from Figure A7) (mph).	48	42	39	37	35	33	32	31	30	30	29	29

4) Arrange 6-hour winds (Step D.3) in time sequence similar to arrangement of precipitation and temperatures in PMP storm (see E).

E. Time Sequence of Temperatures, Winds and Precipitation During PMP Storm

	6-Hour Period 1	2	3	4	5	6	7	8	9	10	11	12
1) November 6-hourly PMP increments for the selected drainage obtained by procedures of Chapter 2 (inches).	6.9	4.3	3.4	3.2	3.0	2.9	2.9	2.8	2.1	1.2	1.1	1.0

	Time in Hours From Beginning of Storm 6	12	18	24	30	36	42	48	54	60	66	72
2) 6-hour PMP increments arranged according to sequence adopted in Section 2.2, Step 8 (inches).	3.0	2.9	2.8	2.9	3.2	4.3	6.9	3.4	1.2	1.0	2.1	1.1
3) 6-hour temperatures from A.7 arranged in same sequence (°F).	49.0	48.4	47.6	48.0	49.4	50.7	51.5	49.8	47.0	46.3	47.3	46.7
4) 6-hour winds from D.3 arranged in same sequence (mph).	35	33	31	32	37	42	48	39	30	29	30	29
5) Height of freezing level from A.8 in same sequence (1000's feet).	10.7	10.4	10.1	10.2	10.8	11.3	11.6	10.9	9.8	9.6	9.9	9.7

	Hours Prior to Storm Onset 48	42	36	30	24	18	12	6	0
6) Temperature prior to storm. Differences of B.1 added to the temperature from E.3, 6-hour column.	59.0	58.5	58.0	57.0	56.0	55.0	53.5	52.5	49.0
7) Dew points prior to storm. Differences of C.1 subtracted from the temperature from E.3, 6-hour column.	45.5	46.5	47.0	47.0	47.5	48.0	48.0	48.5	49.0

8) Winds prior to storm may be assumed to be 29 mph for two days prior to storm.

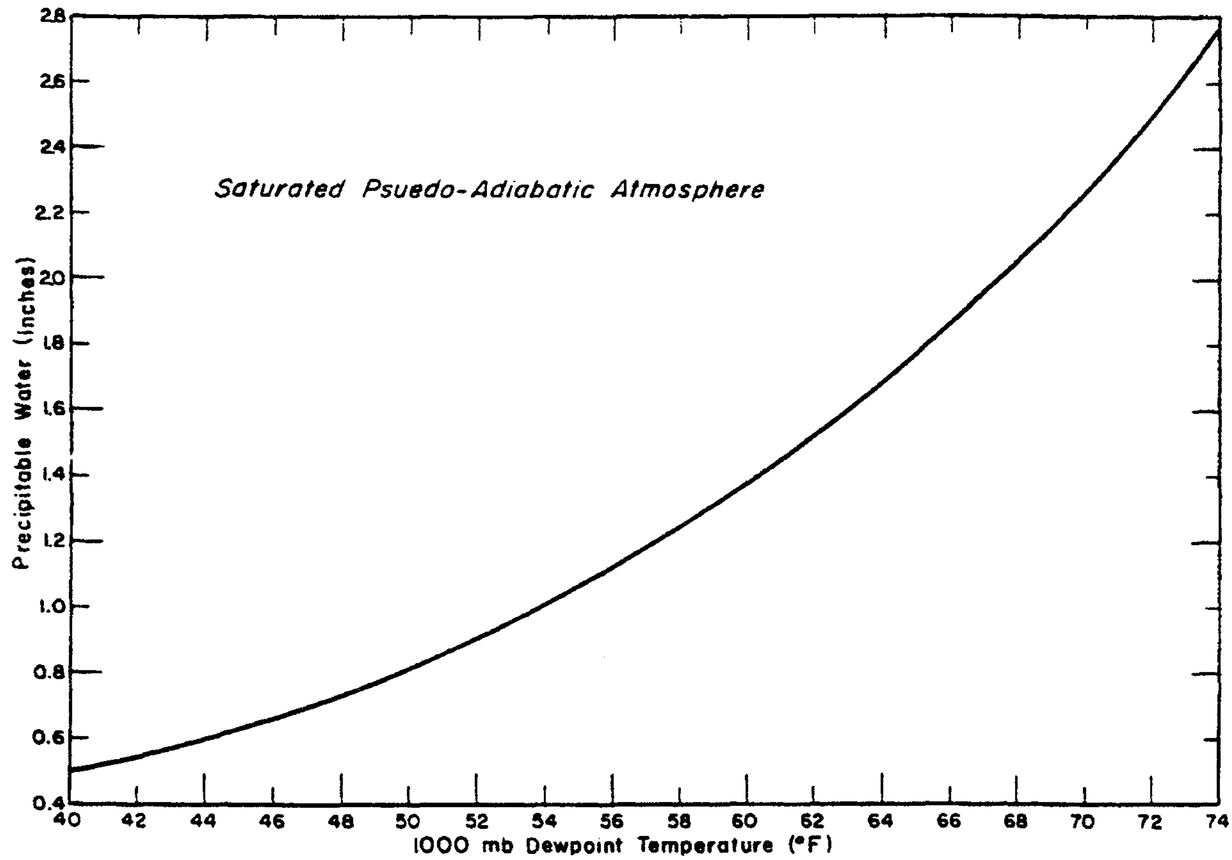

Figure A1. *Variation of precipitable water with 1000-mb dew point temperature.*

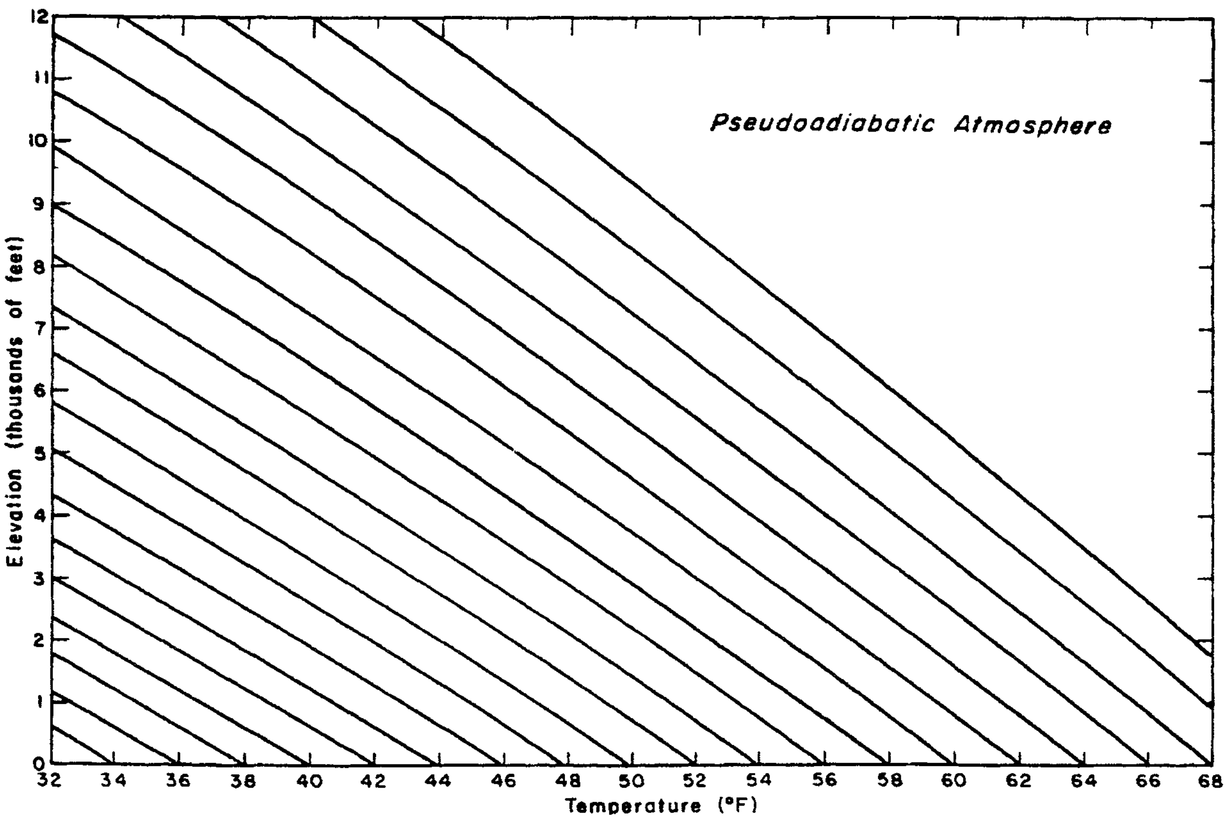

Figure A2. *Decrease of temperature with elevation.*

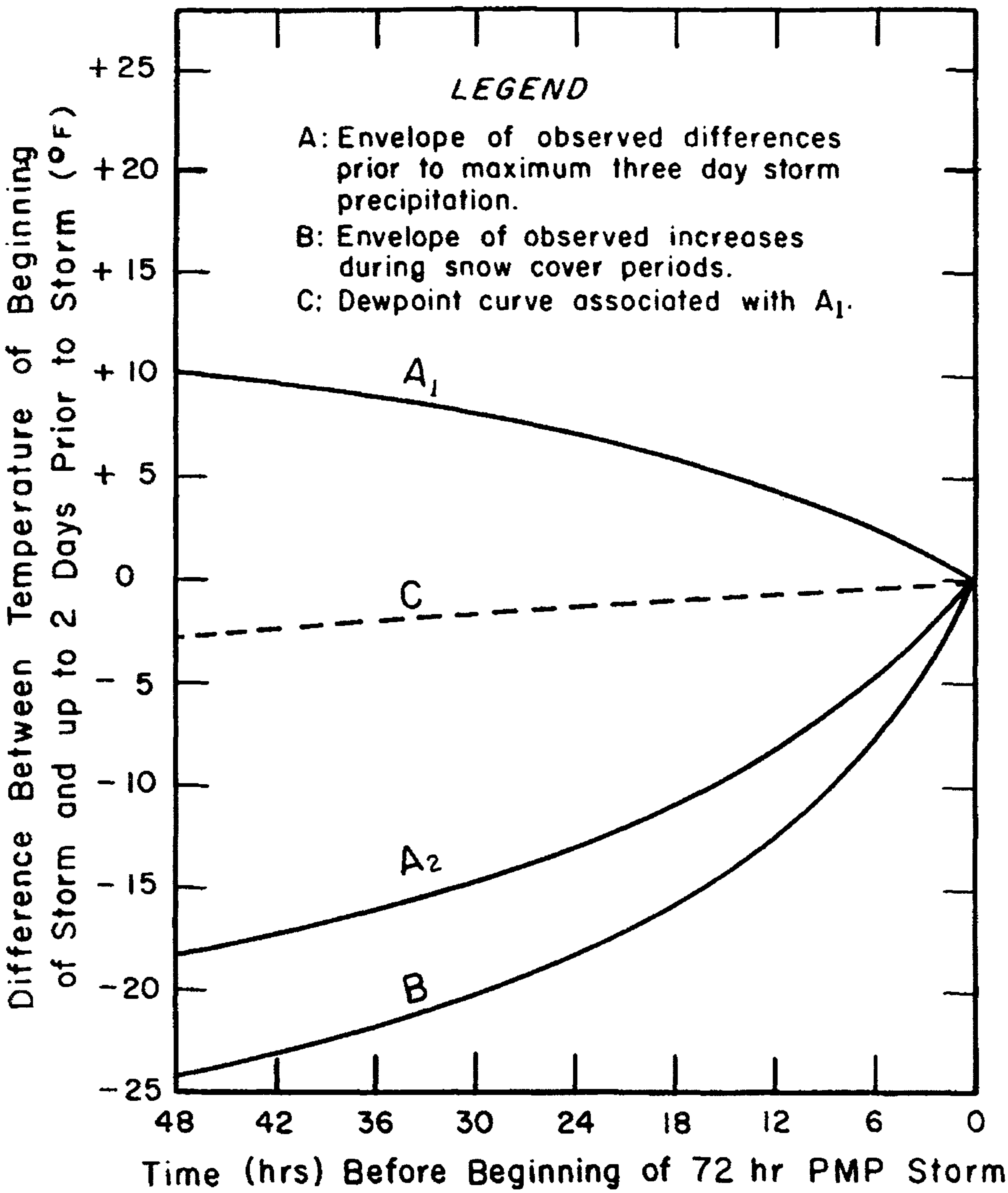

Figure A3. *Temperature prior to a PMP storm.*

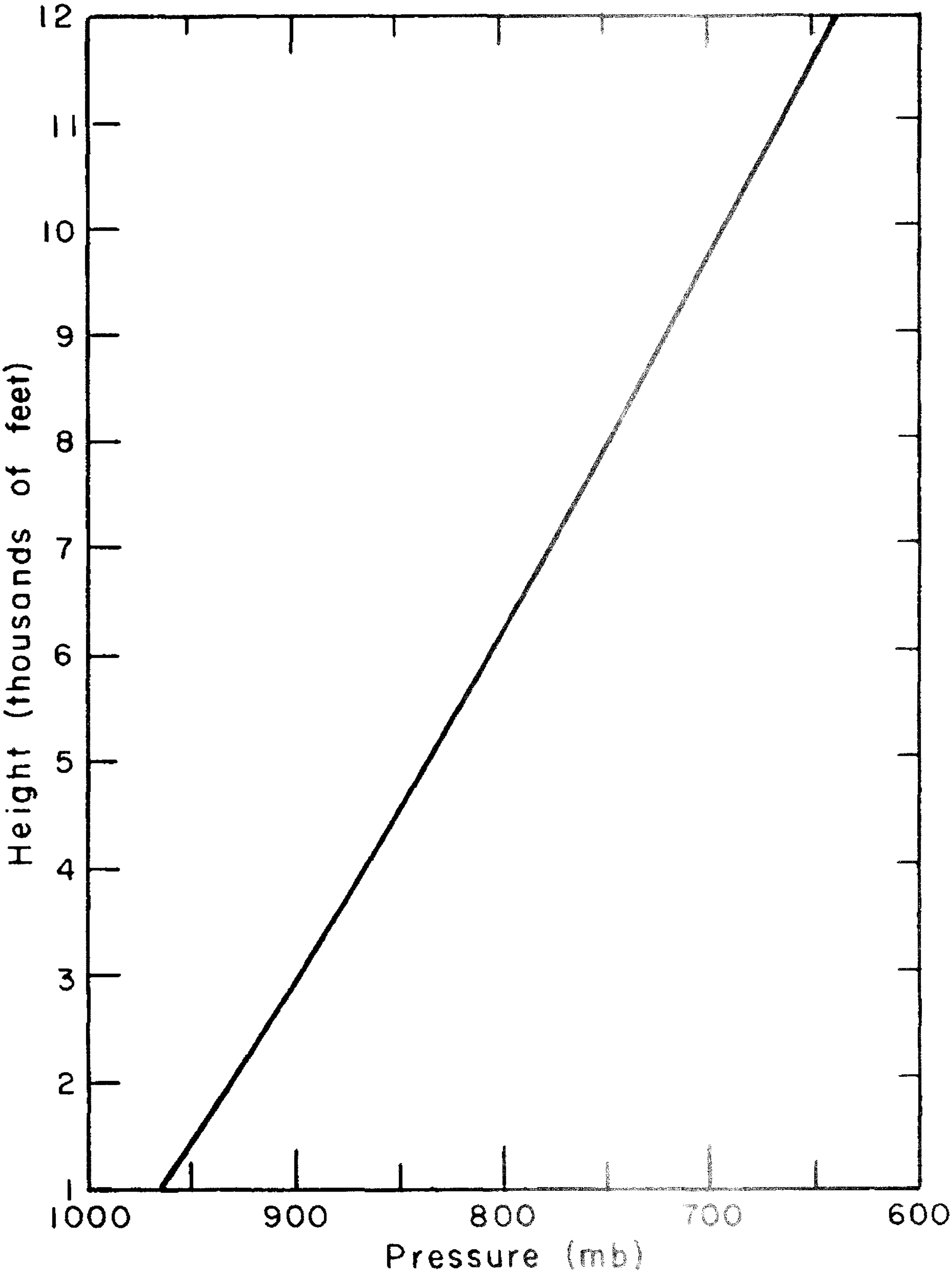

Figure A4. *Pressure-height relation.*

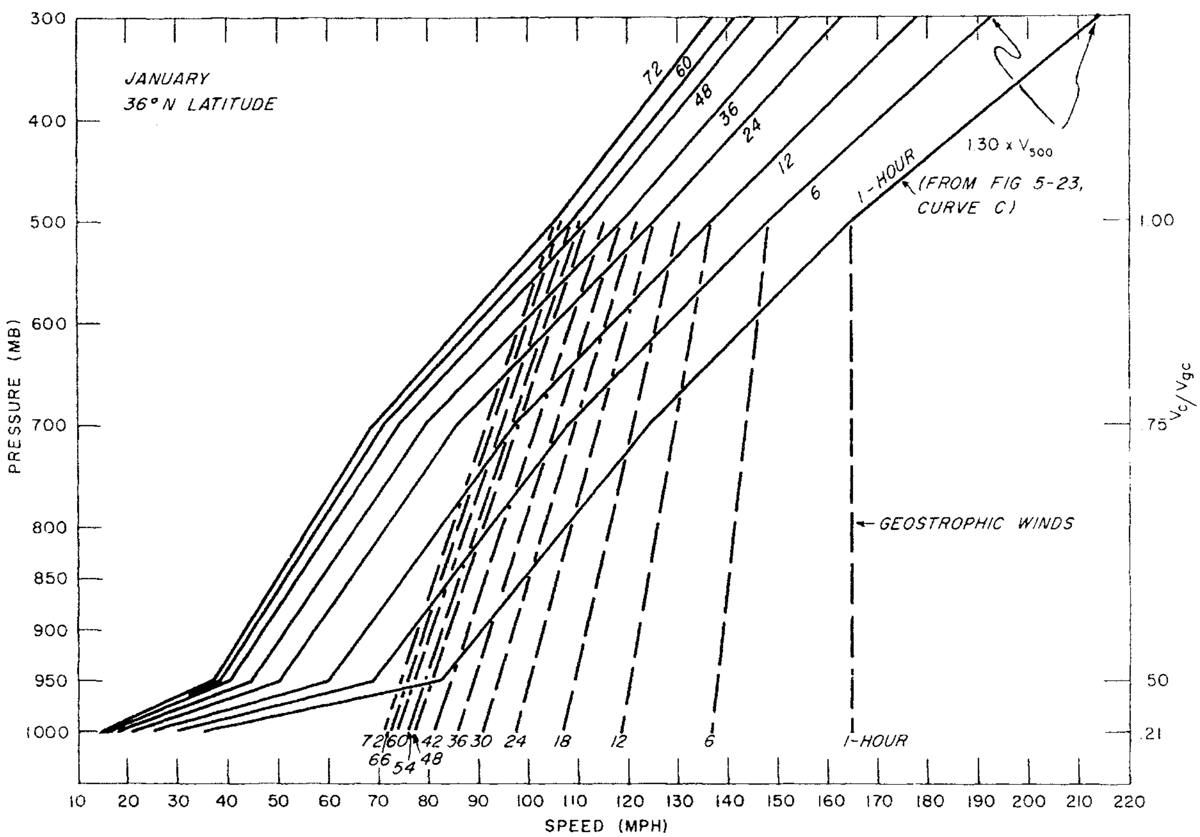

Figure A5. *Maximum winds normal to coast range.*

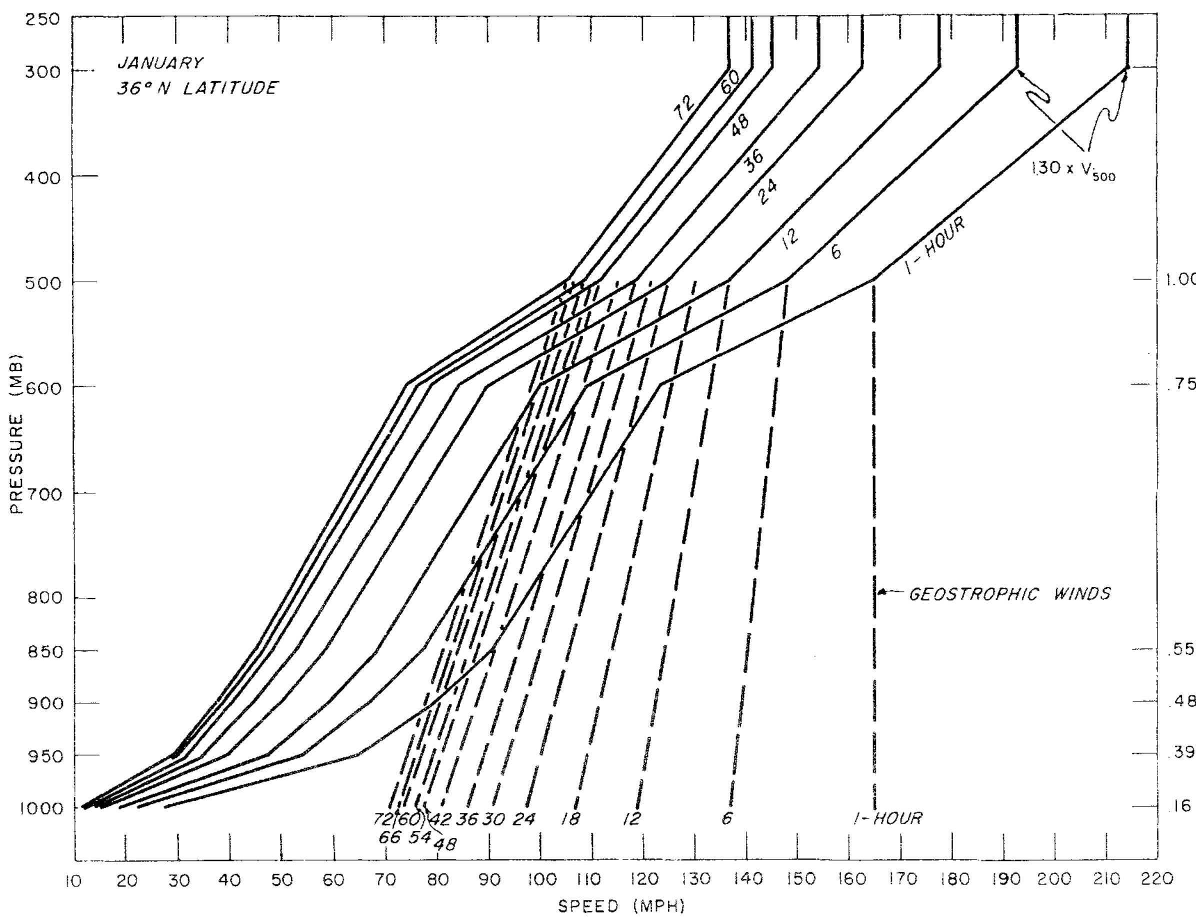

Figure A6. *Maximum winds normal to the Sierra mountains.*

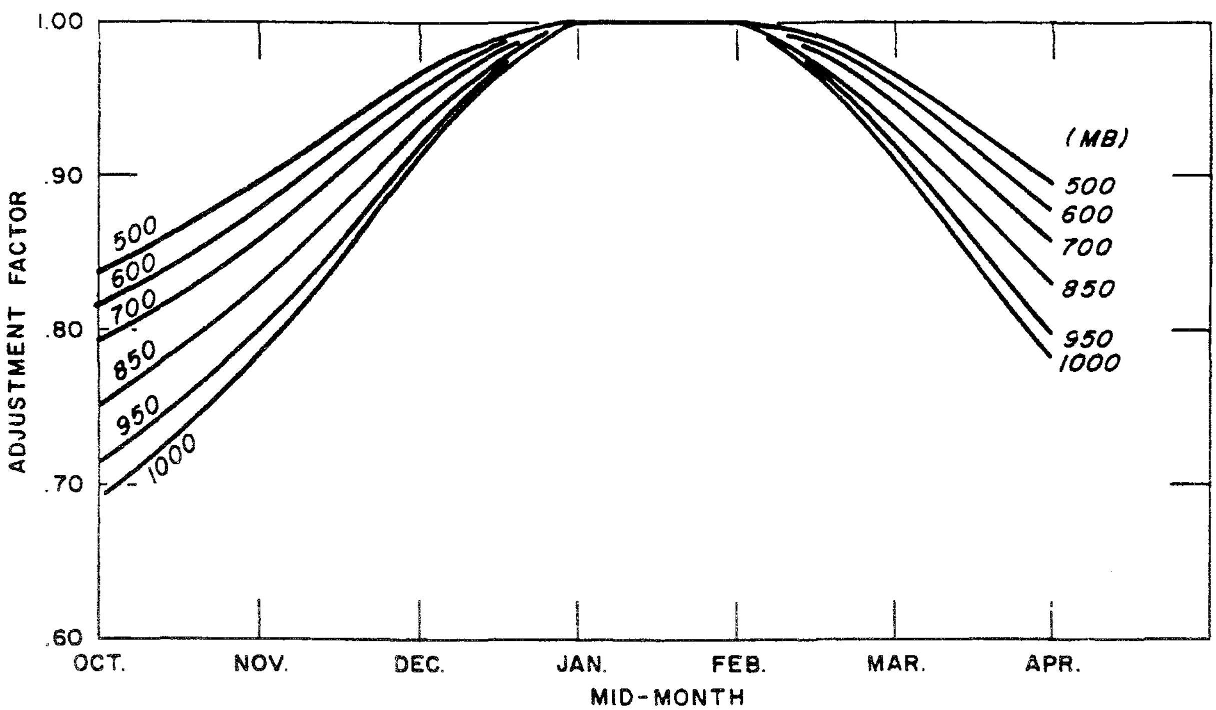

Figure A7. *Seasonal variation of maximum winds.*

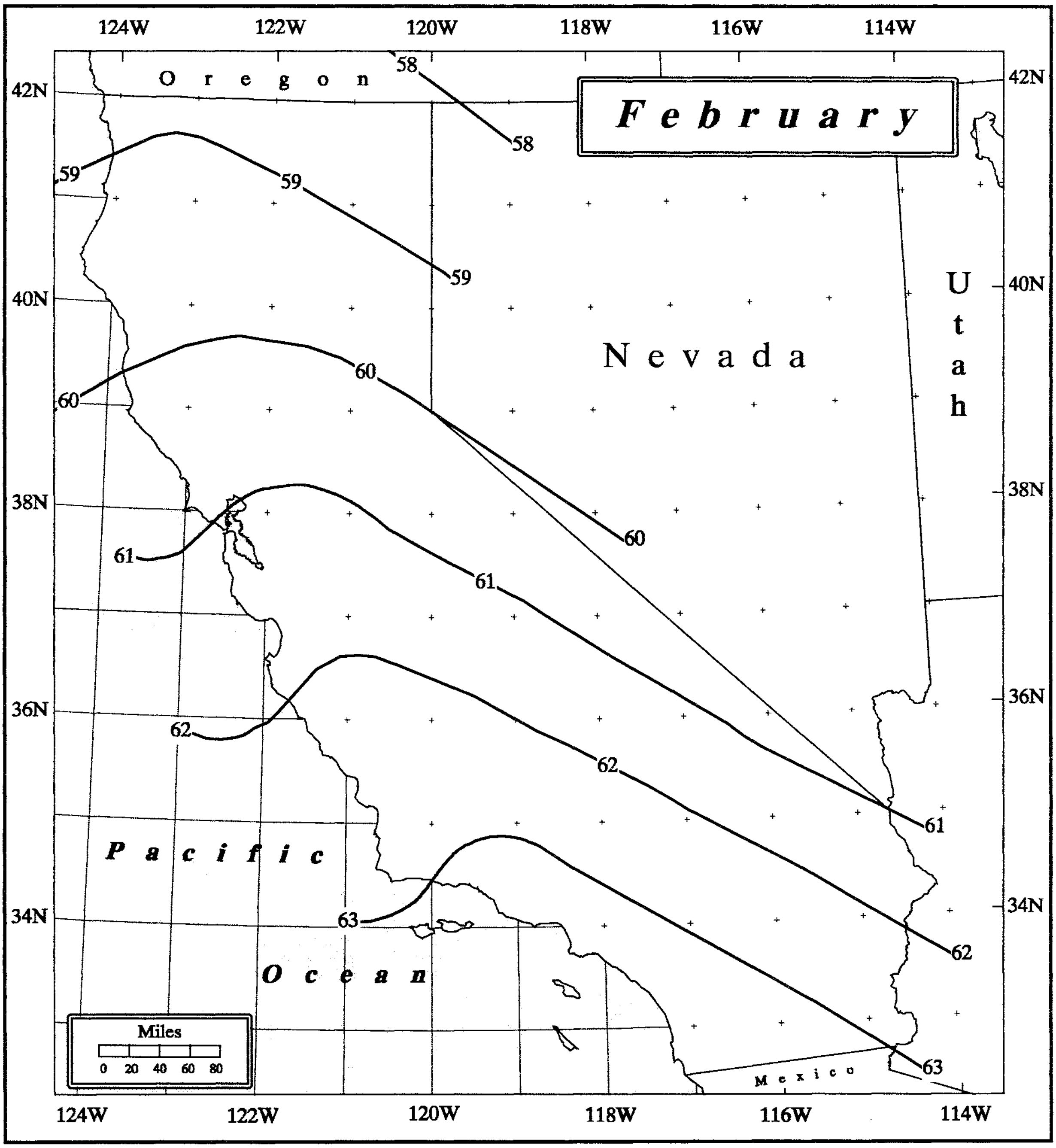

Figure A8. *12-hour maximum persisting 1000-mb dew point temperatures (°F) for February.*

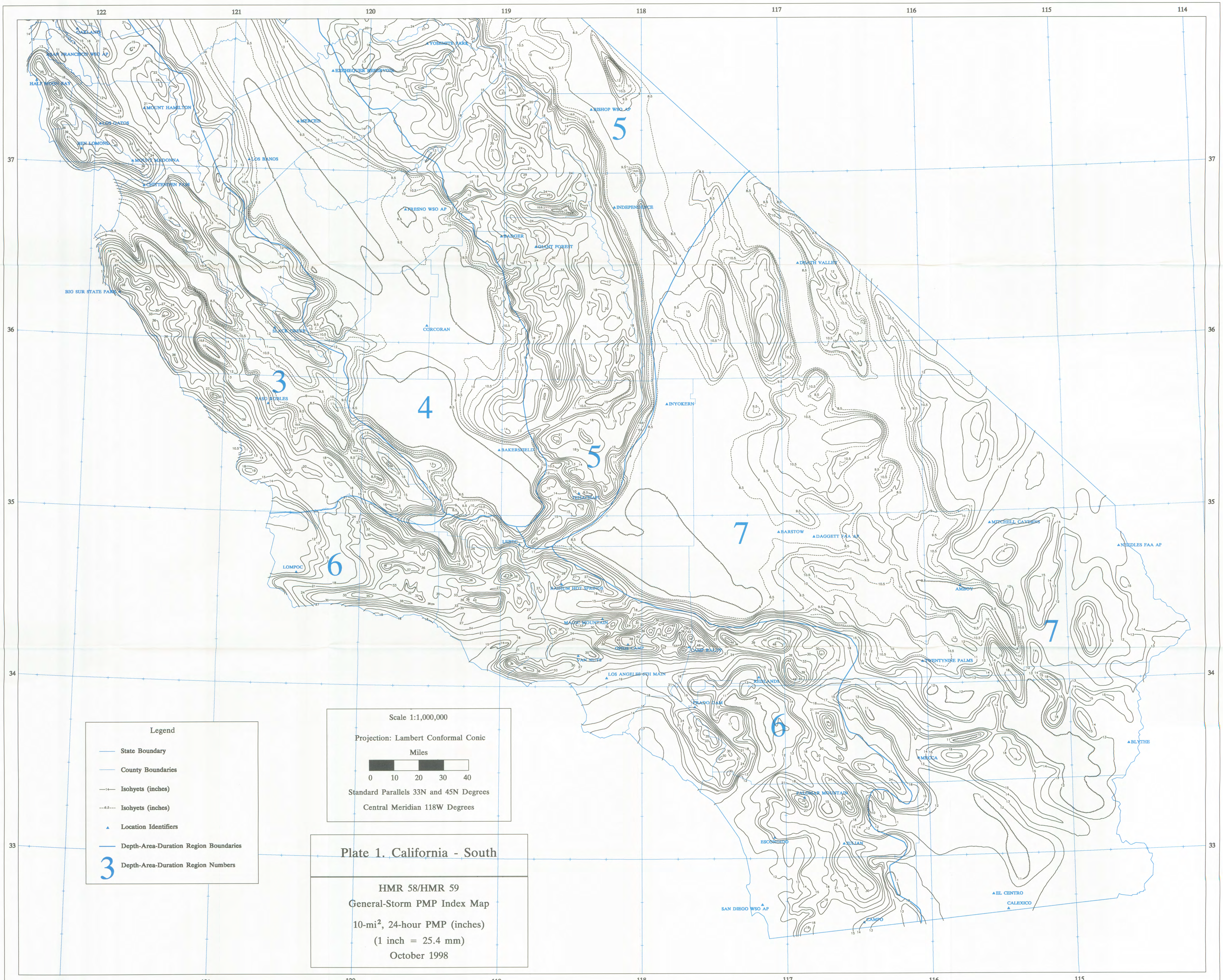

Plate 1. California - South

HMR 58/HMR 59
General-Storm PMP Index Map
10-mi², 24-hour PMP (inches)
(1 inch = 25.4 mm)
October 1998

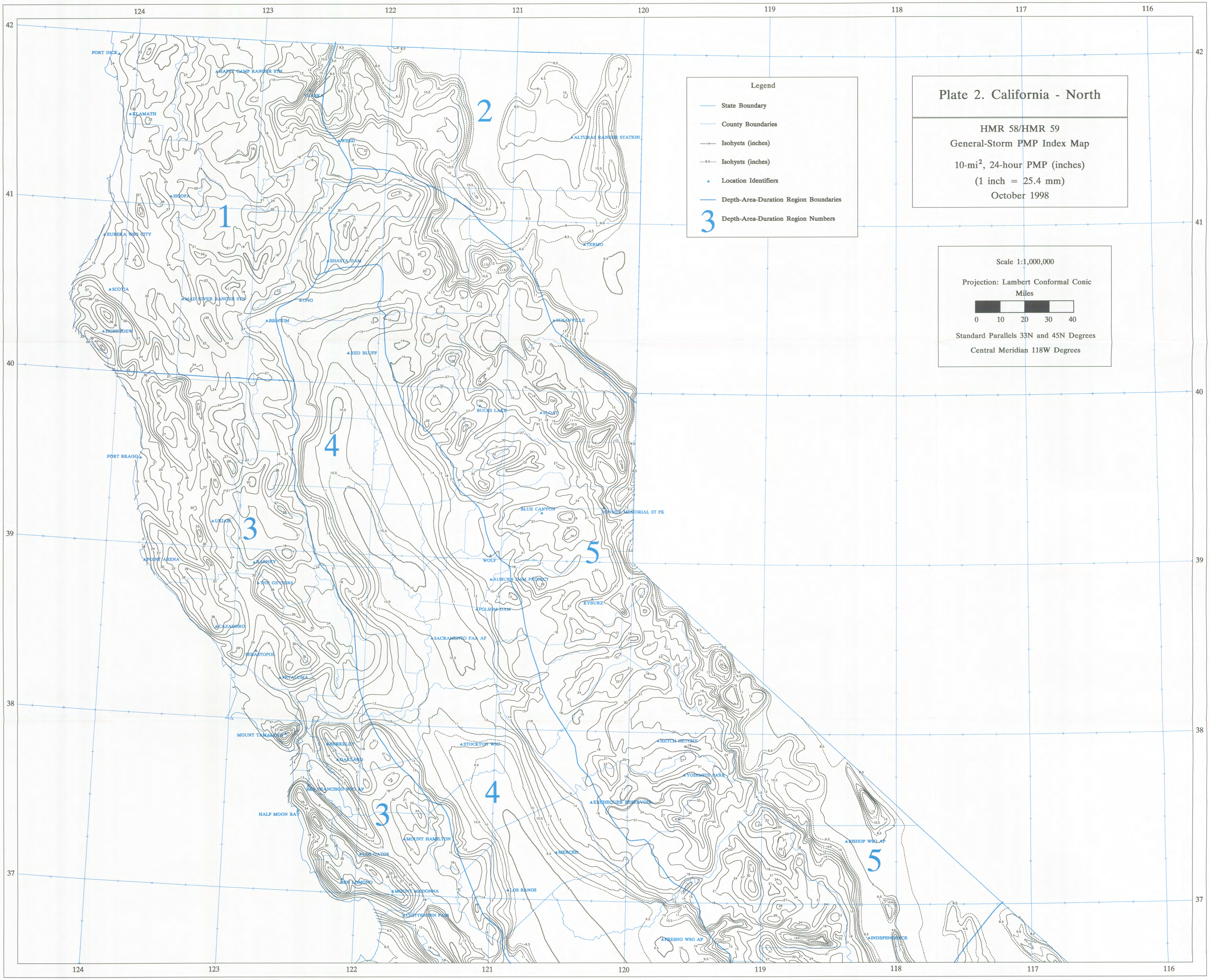
Plate 2. California - North
HMR 58/HMR 59
General-Storm PMP Index Map
10-mi², 24-hour PMP (inches)
(1 inch = 25.4 mm)
October 1998
Legend
State Boundary
County Boundaries
Isohyets (inches)
Isohyets (inches)
Location Identifiers
Depth-Area-Duration Region Boundaries
3 Depth-Area-Duration Region Numbers
Scale 1:1,000,000
Projection: Lambert Conformal Conic
Miles
0 10 20 30 40
Standard Parallels 33N and 45N Degrees
Central Meridian 118W Degrees

(Continued from inside front cover)

No. 49. Probable maximum precipitation estimates, Colorado River and Great Basin drainages. 1977.
No. 50. The meteorology of important rainstorms in the Colorado River and Great Basin drainages. 1982.
No. 51 .Probable maximum precipitation estimates, United States east of 105th meridian. 1978.
No. 52. Application of probable maximum precipitation estimates–United States east of the 105th meridian. 1982.
No. 53. Seasonal variation of 10-square-mile probable maximum precipitation estimates, United States east of the 105th meridian. 1980.
No. 54. Probable maximum precipitation and snowmelt criteria for southeast Alaska. 1983.
No. 55. Probable maximum precipitation estimates-United States between the Continental Divide and the 103rd meridian. 1984.
No. 55A. Probable maximum precipitation estimates-United States between the Continental Divide and the 103rd meridian. 1988.
No. 56. Probable maximum and TVA precipitation estimates with areal distribution for Tennessee River drainages less than 3,000 mi^2 in area. 1986.
No. 57. Probable maximum precipitation-pacific northwest states Columbia River (including portions of Canada), Snake River and pacific coastal drainages. 1994.