B. Temperatures prior to PMP storm

(1) From A (7) find the temperature for the first 6-hour period of the storm in sequence.

(2) Read the difference between the temperature at the storm beginning and the temperature at each 6-hour duration prior to storm from Figure 15.13.

(3) Add the differences determined in B (2) to the first 6-hour temperature to determine the temperatures for each antecedent 6-hour period.

C. Dew points prior to PMP storm

(1) From the dew point curve of Figure 15.13, determine the differences between the first period dew point and the dew point for each duration prior to storm.

(2) Subtract the differences from the temperature (dew point) determined in B (1).

D. Winds during PMP storm

(1) To use the figures pertaining to wind relationships, transform the basin average elevation to pressure by the pressure-height relation shown in Figure 15.33.

(2) a. West of the Cascade Divide Basin. Determine the January maximum free-air wind at basin pressure from Figure 15.14.

b. East of the Cascade Divide Basin. Determine the January maximum surface wind at basin pressure from dashed curve on Figure 15.17.

(3) Figure 15.15 shows the adopted seasonal variation of maximum wind expressed in percent of the mid-January value. These percent ratios apply either east or west of the Cascades.

(4) Multiply windspeed of D (2) by ratio for the desired month from D (3).

(5) Obtain durational wind factors given in Figure 15.16.

(6) Multiply the maximum 6-hour windspeed of D (4) by the D (5) ratios to obtain all 6-hour speeds for the 3-day storm. For west of the Cascade Divide Basins, multiply these by 0.75 to obtain anemometer-level winds.

(7) Arrange 6-hour winds to conform to the selected PMP storm sequence.

E. Winds prior to PMP storm

The least of the twelve windspeeds calculated in D (6) may be maintained for the 72-hour period prior to the PMP storm.

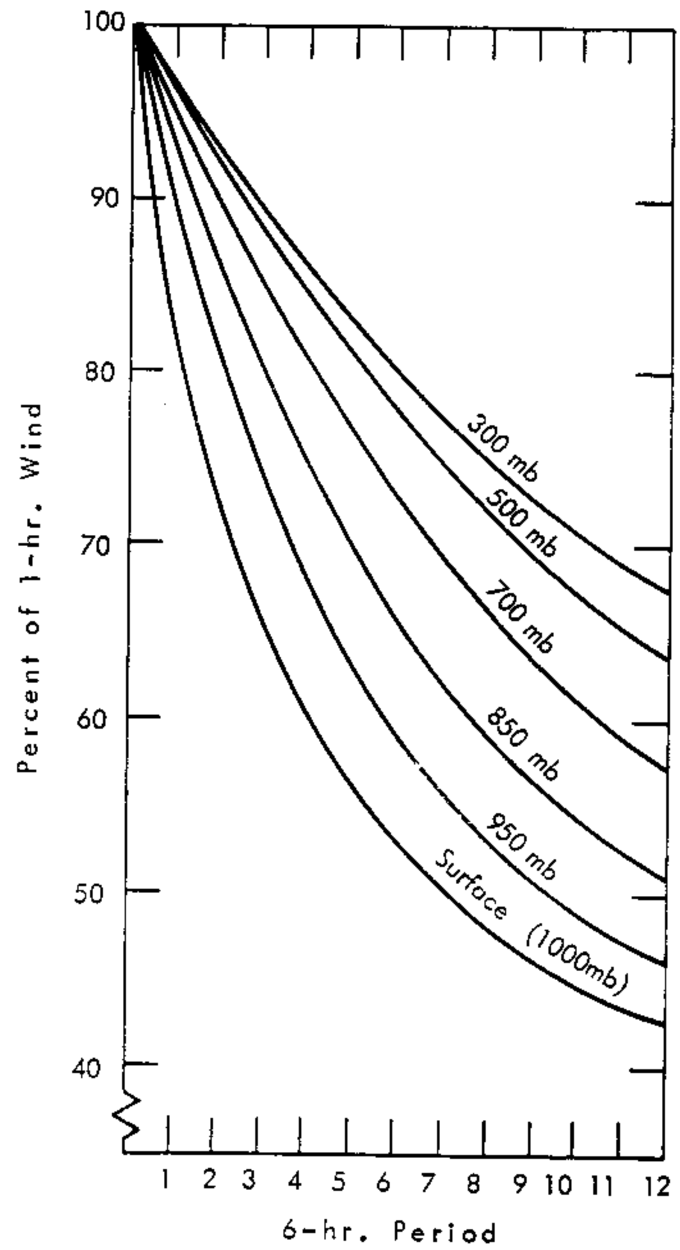


Figure 15.16.--Durational variation of PMP winds by 6-hour increments (HMR 43).

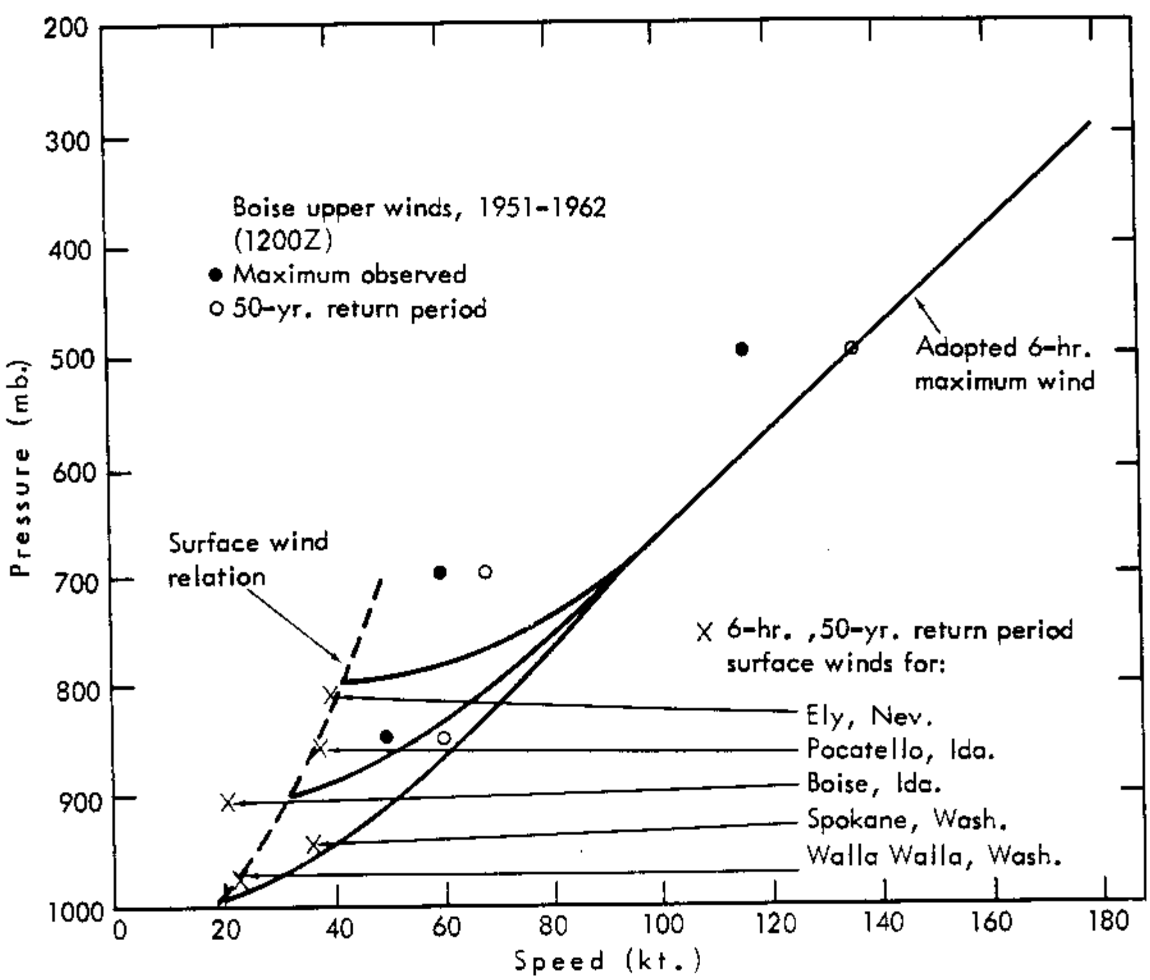


Figure 15.17.--Maximum winds east of the Cascade Divide (HMR 43).

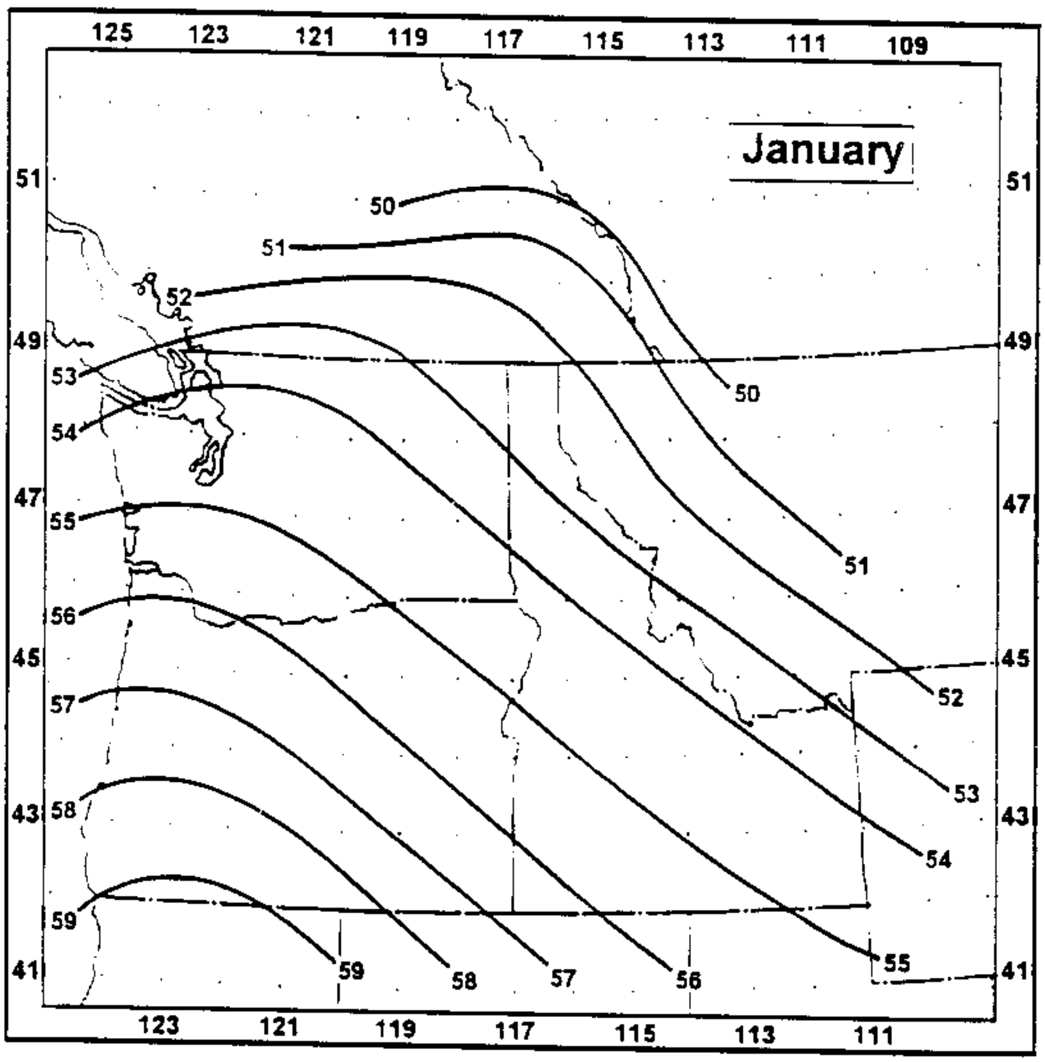


Figure 15.18.--12-hour maximum persisting 1000-mb dew point analysis (°F), January.

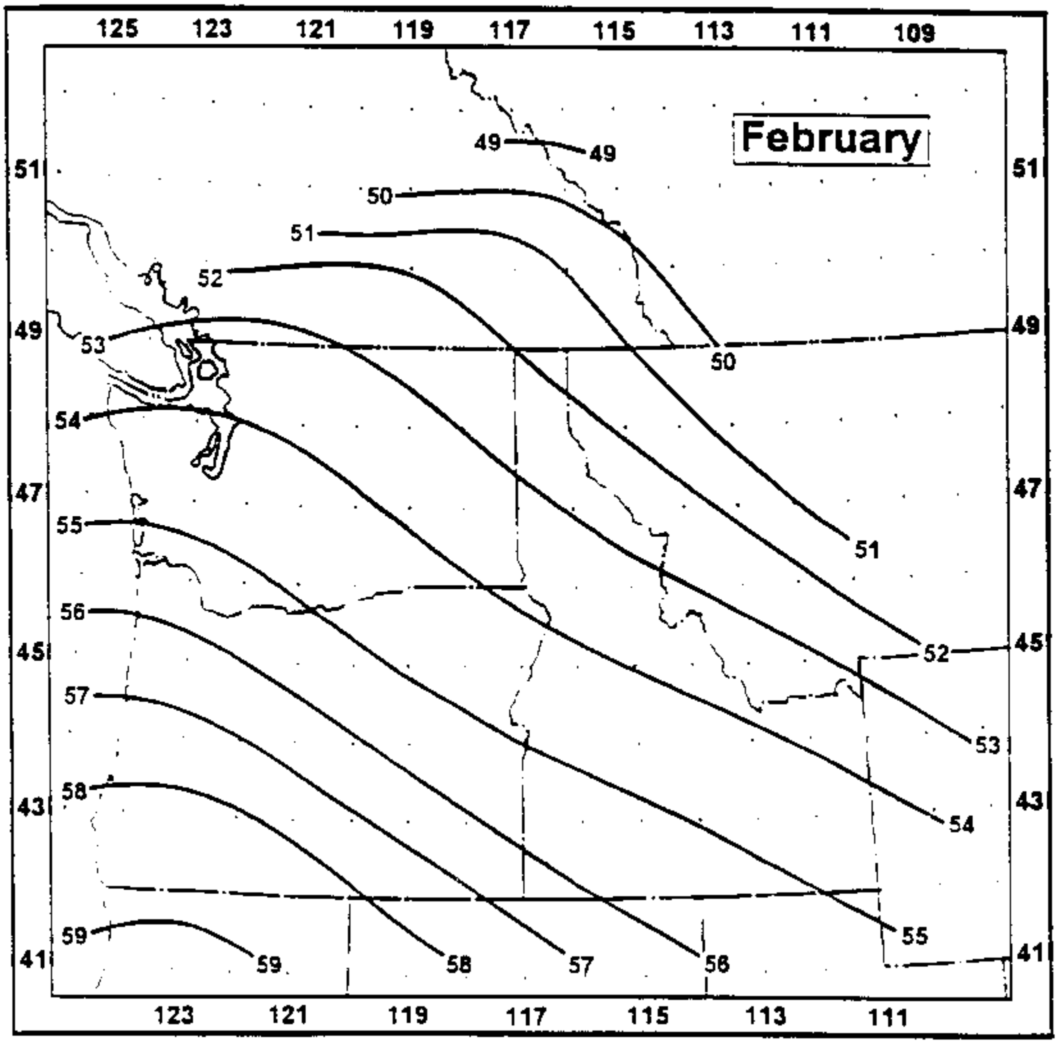


Figure 15.19.--12-hour maximum persisting 1000-mb dew point analysis (°F), February.

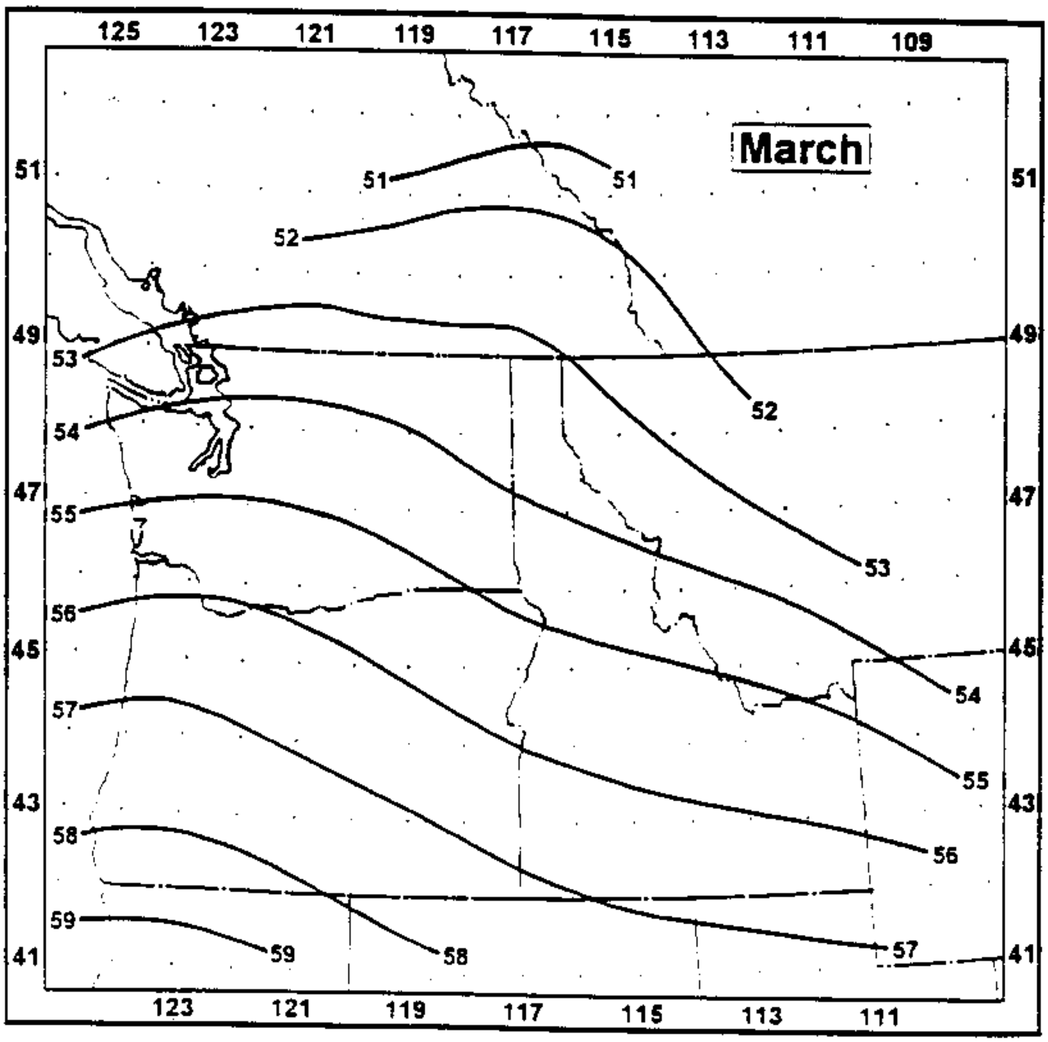


Figure 15.20.--12-hour maximum persisting 1000-mb dew point analysis (°F), March.

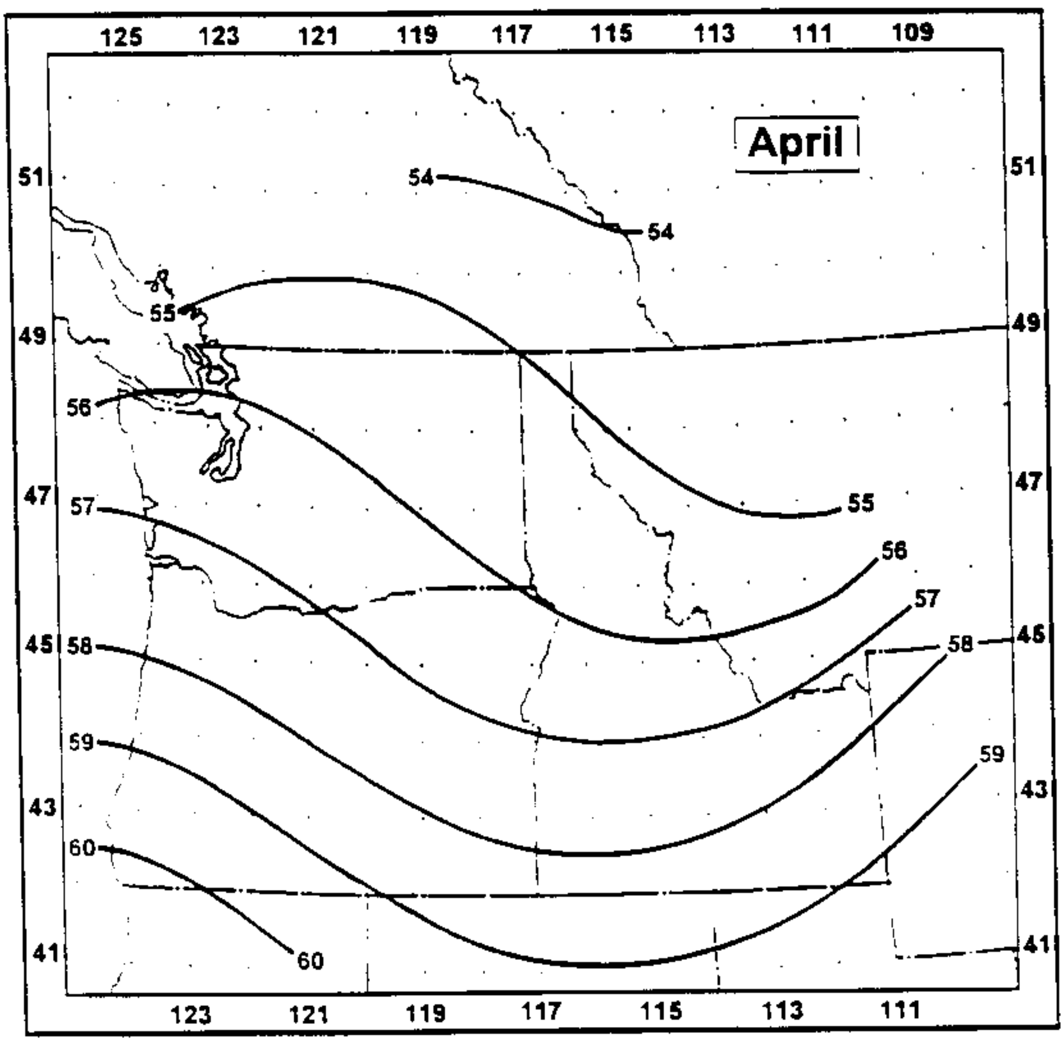


Figure 15.21.--12-hour maximum persisting 1000-mb dew point analysis (°F), April.

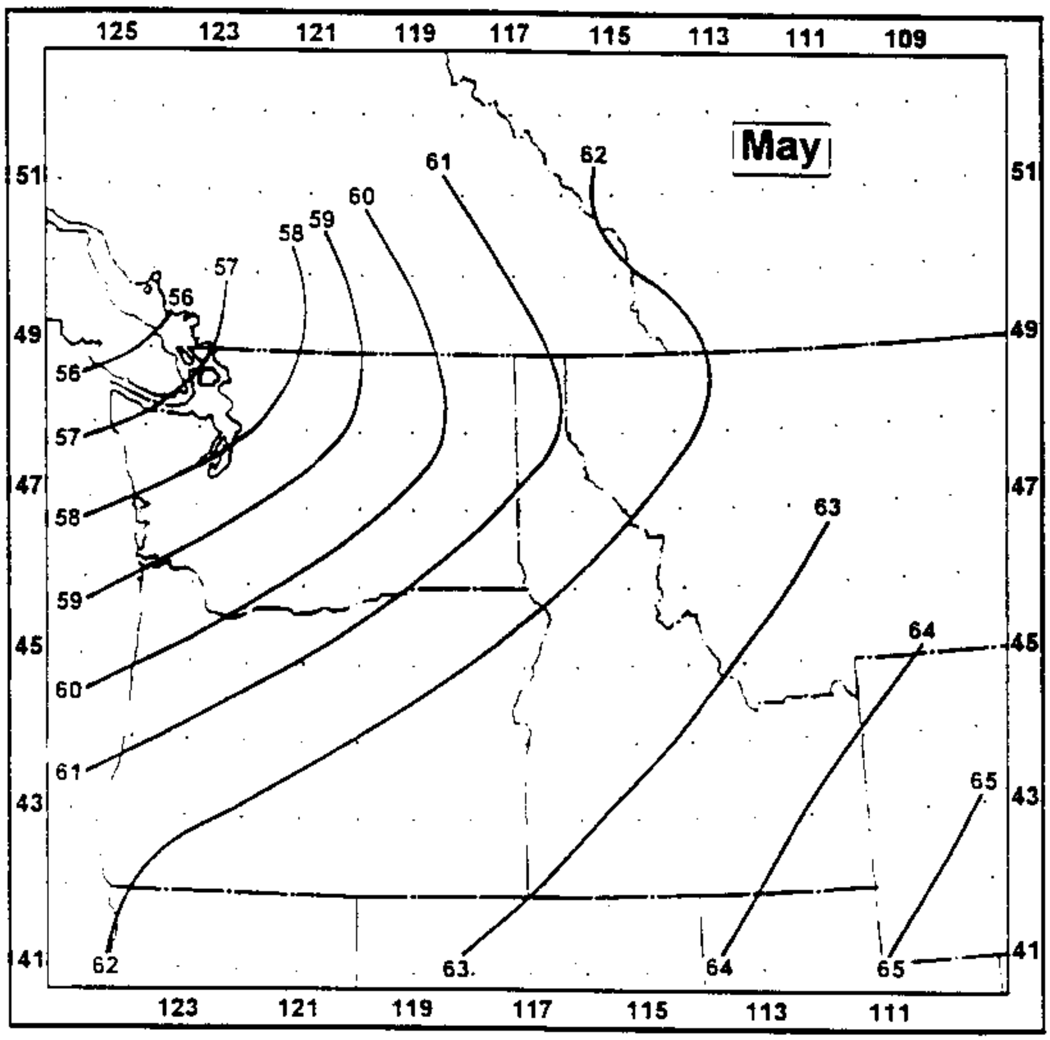


Figure 15.22.--12-hour maximum persisting 1000-mb dew point analysis (°F), May.

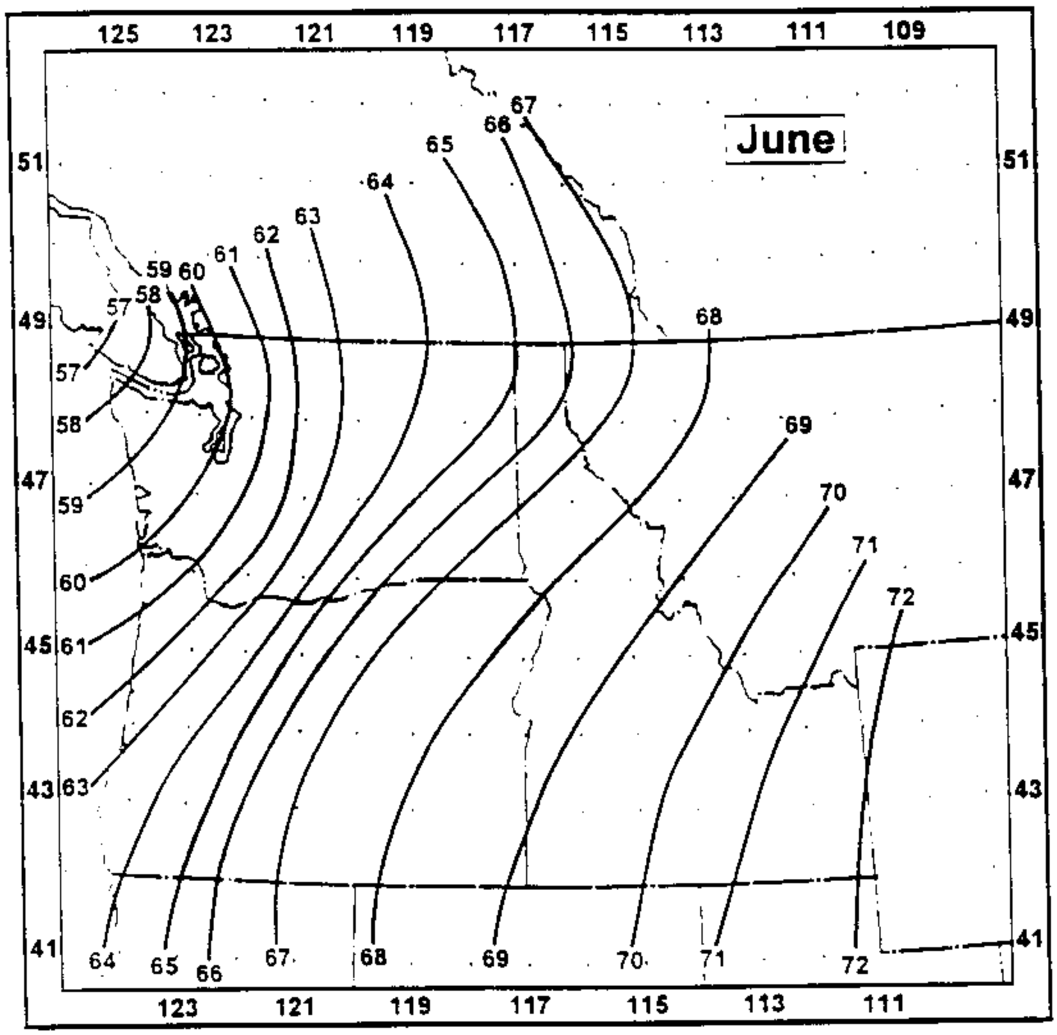


Figure 15.23.--12-hour maximum persisting 1000-mb dew point analysis (°F), June.

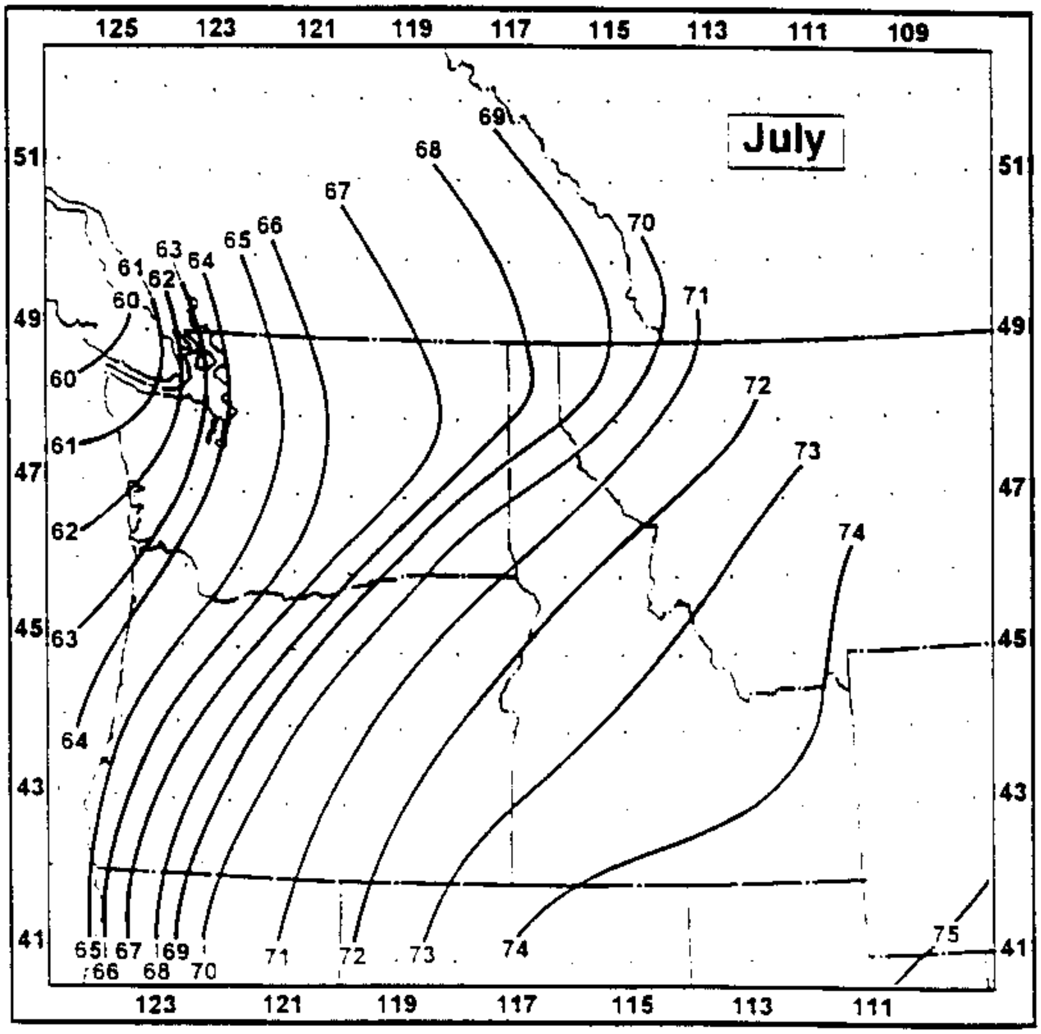


Figure 15.24.--12-hour maximum persisting 1000-mb dew point analysis (°F), July.

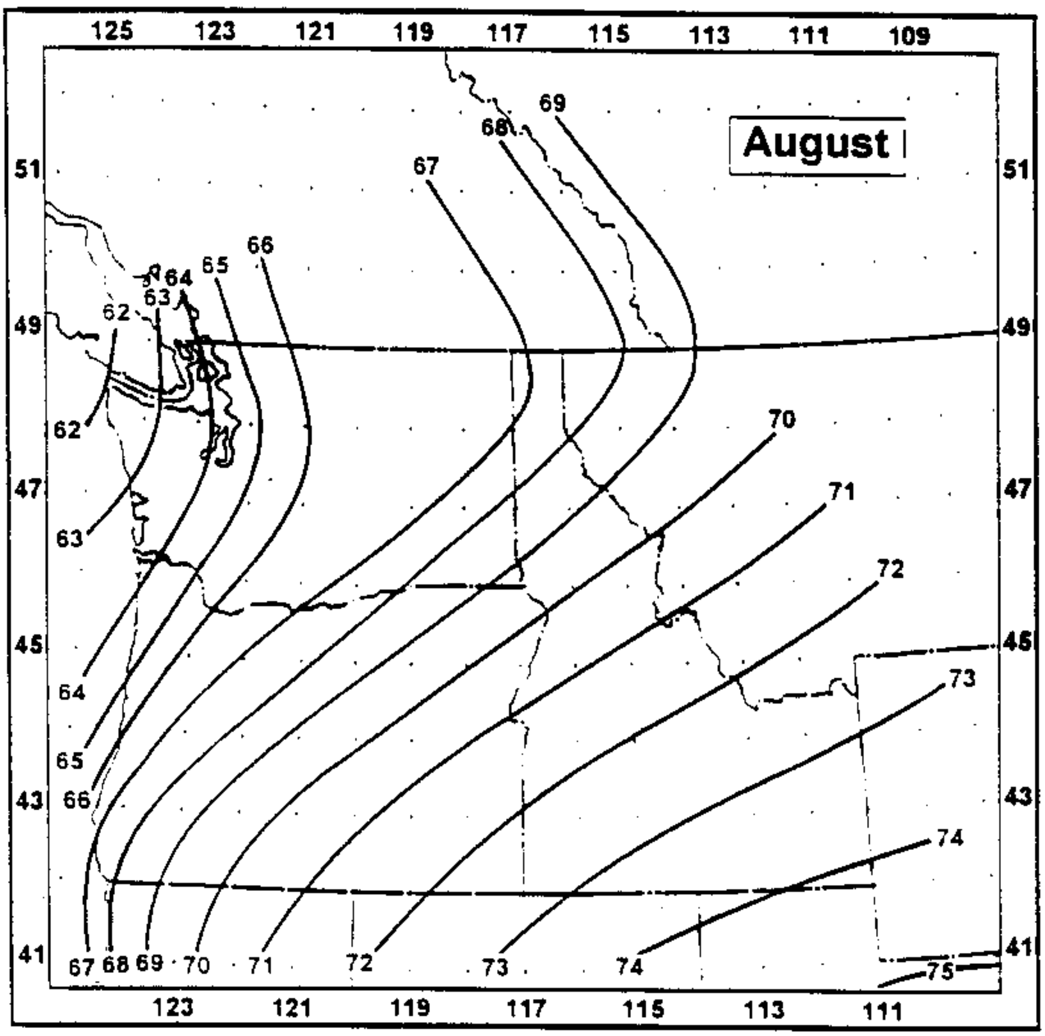


Figure 15.25.--12-hour maximum persisting 1000-mb dew point analysis (°F), August.

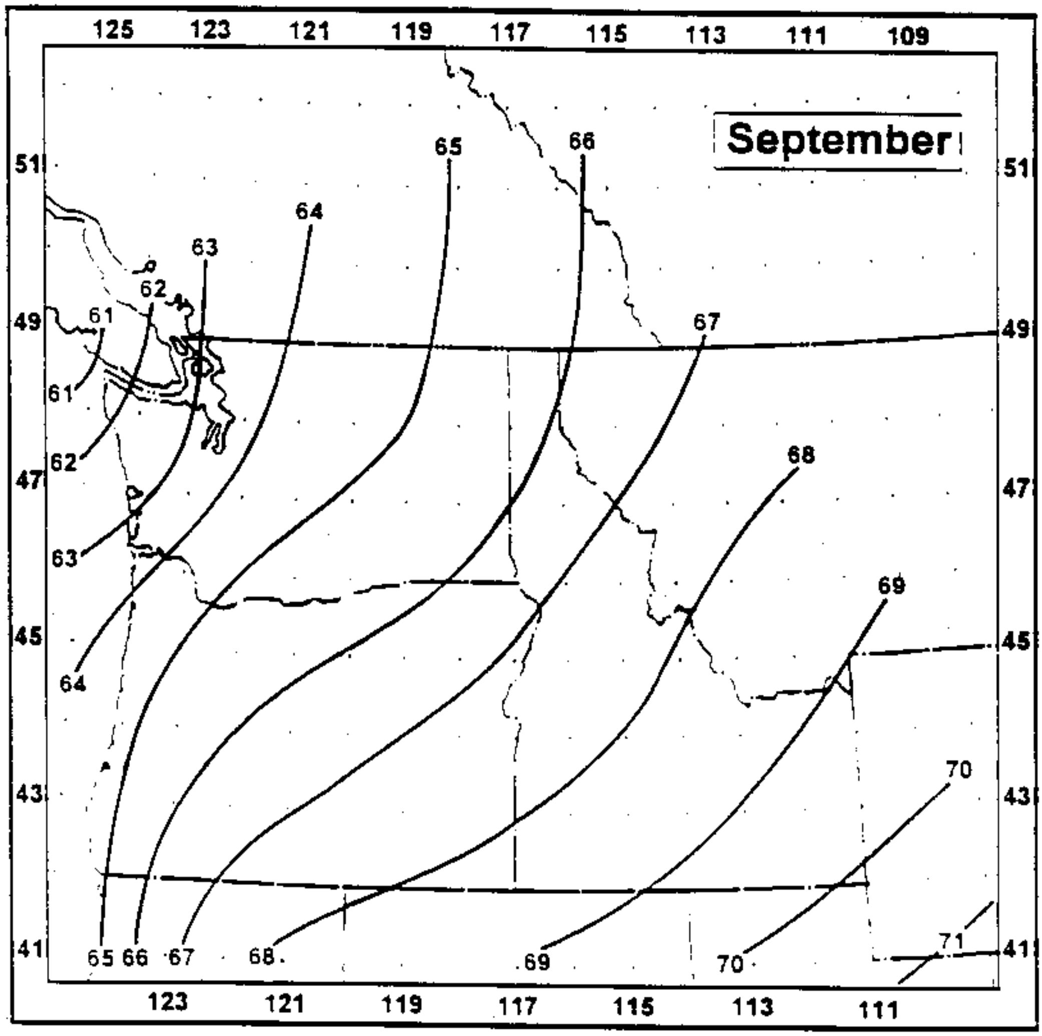


Figure 15.26.--12-hour maximum persisting 1000-mb dew point analysis (°F), September.

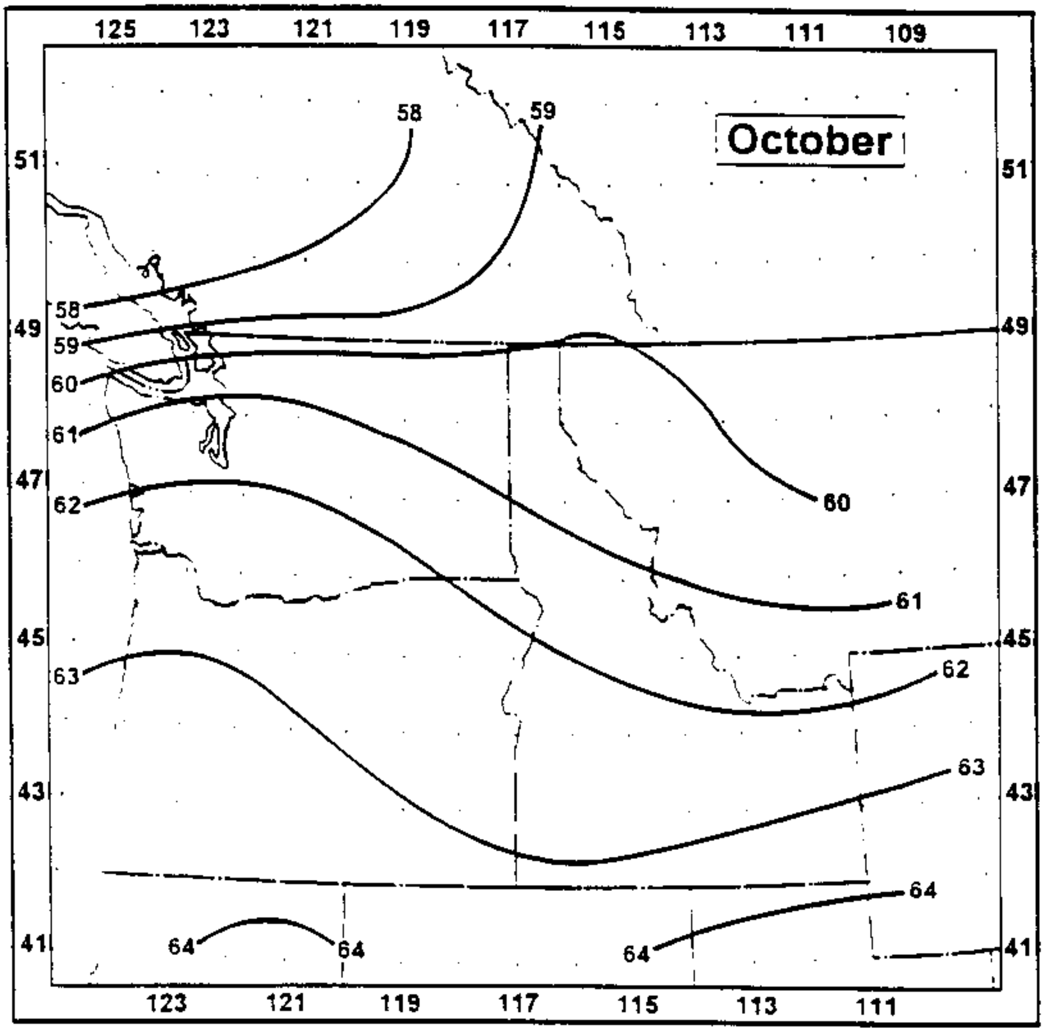


Figure 15.27.--12-hour maximum persisting 1000-mb dew point analysis (°F), October.

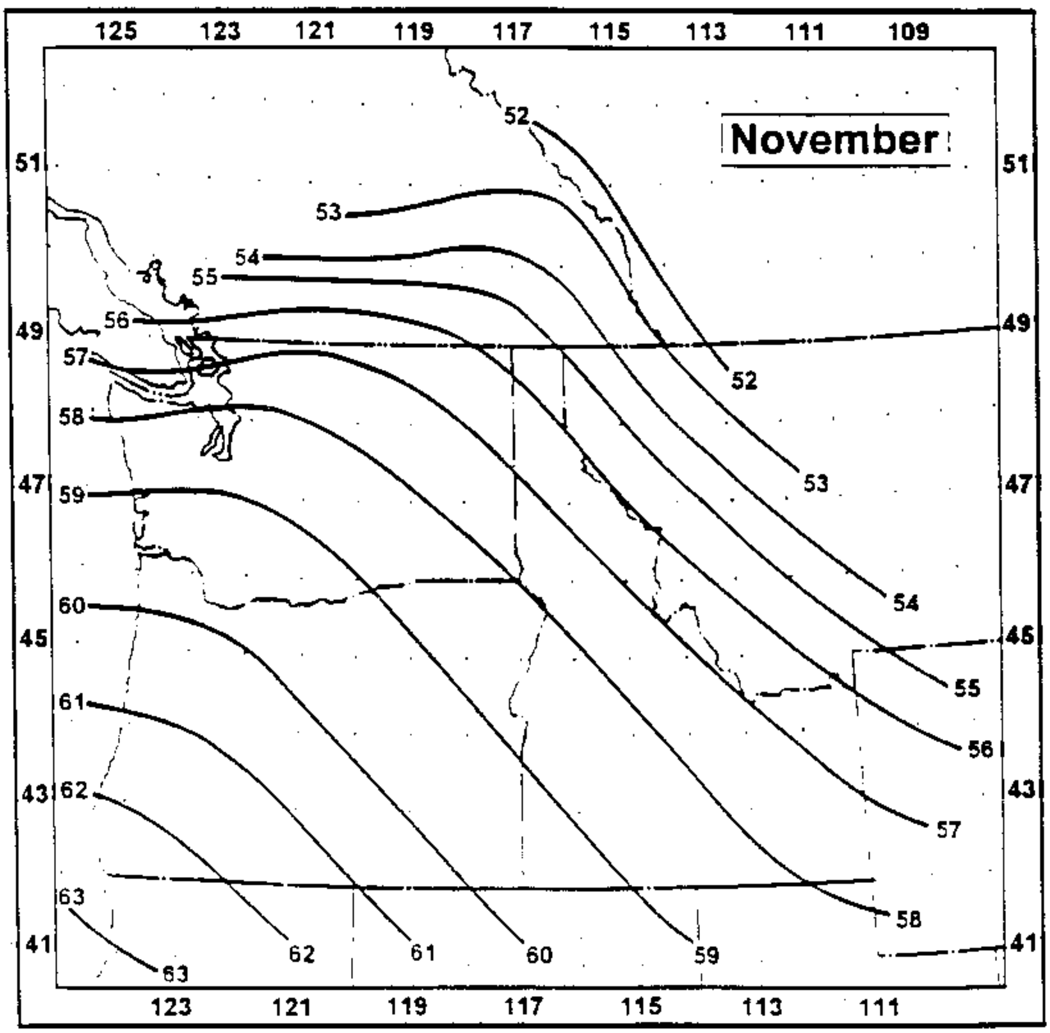


Figure 15.28.--12-hour maximum persisting 1000-mb dew point analysis (°F), November.

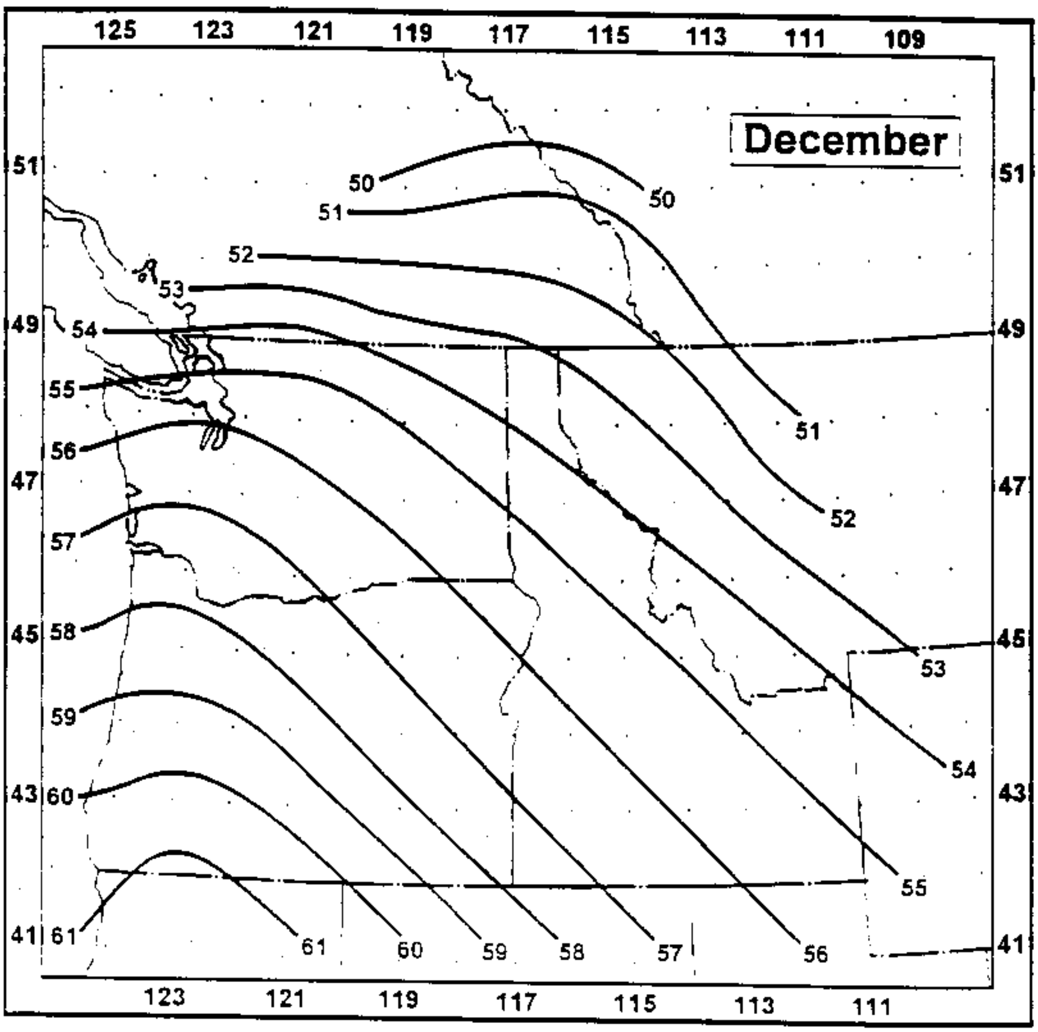


Figure 15.29.--12-hour maximum persisting 1000-mb dew point analysis (°F), December.

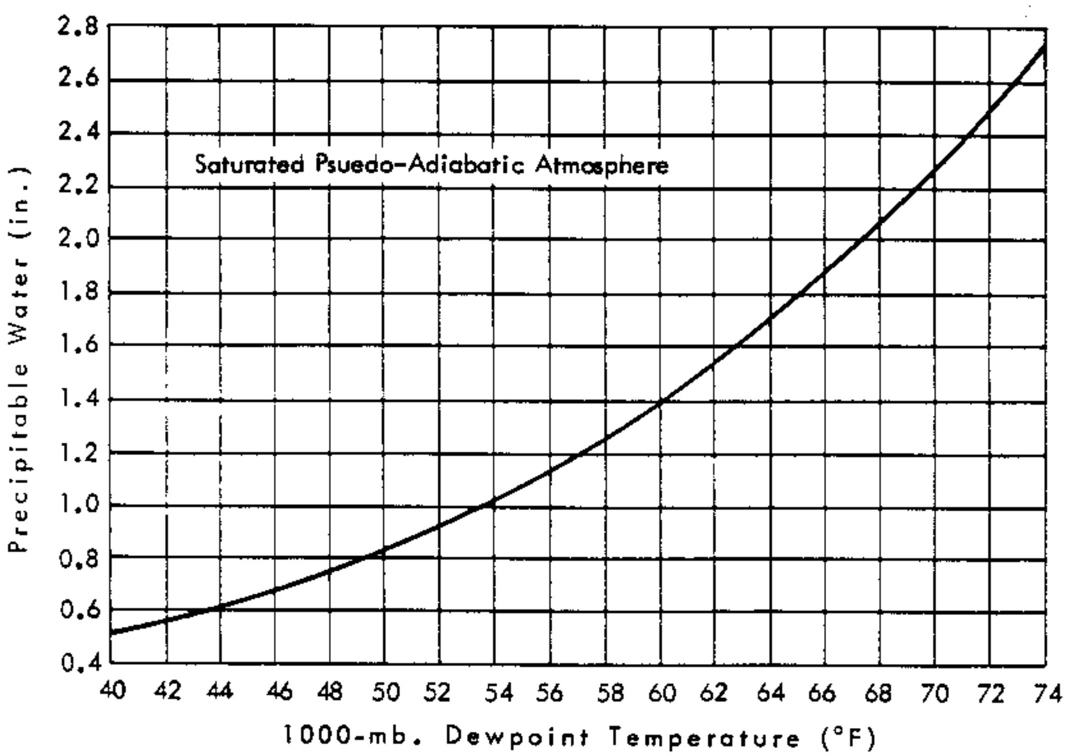


Figure 15.30.--Variation of precipitable water with 1000-mb dew point temperature (HMR 43).

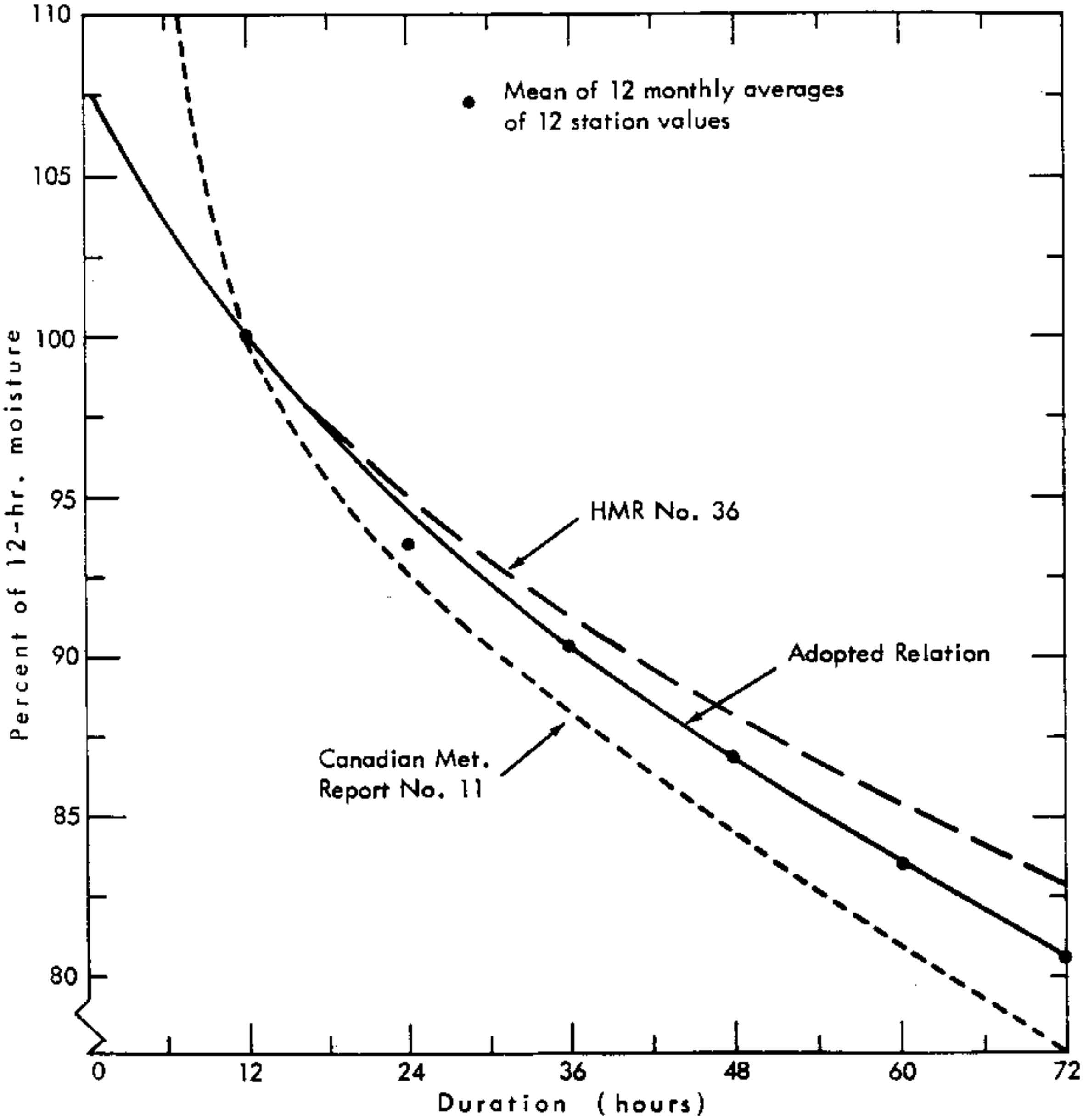


Figure 15.31.--Durational variation of maximum moisture (HMR 43).

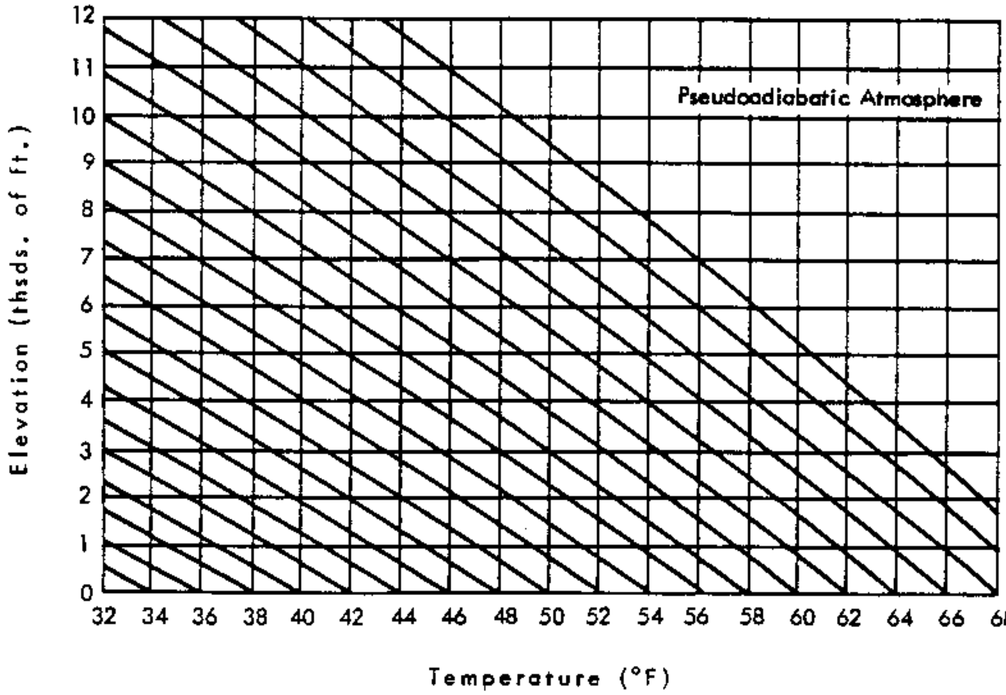


Figure 15.32.--Decrease of temperature with elevation (HMR 43).

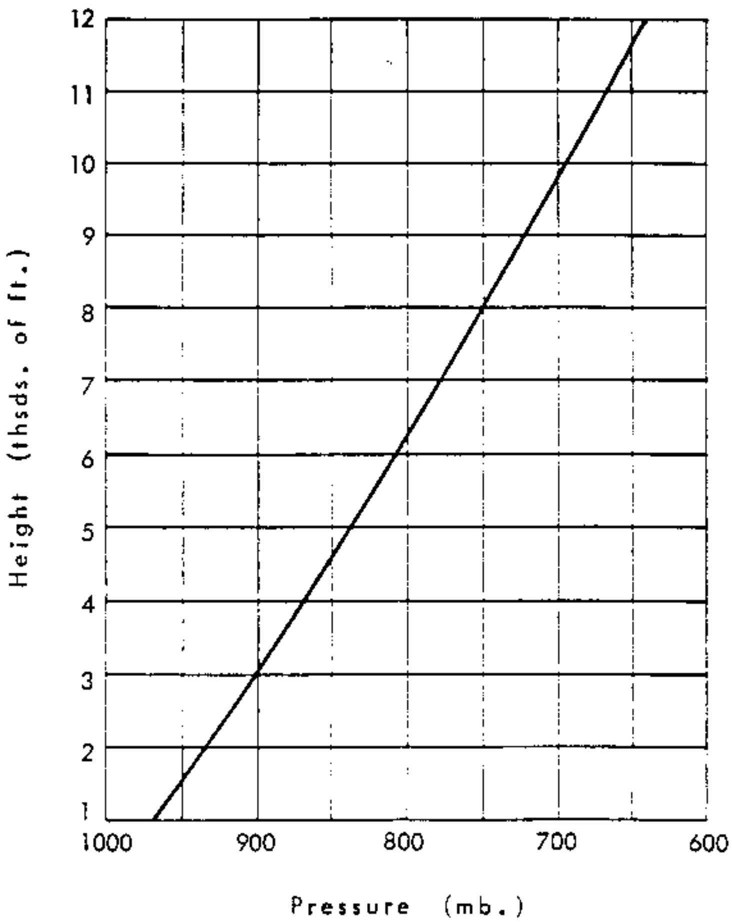


Figure 15.33.--Pressure-height relation (HMR 43).

15.3 Example of General-Storm PMP Computation

As an example of the application of the simple stepwise procedure outlined above, the White River basin above Mud Mountain Dam in Washington State has been chosen. This basin (402-mi^2) was one of the 47 identified in Chapter 12. The White River basin lies directly north and northeast of Mount Rainier (14,411 feet), the tallest peak in the Cascades. This peak is permanently snow covered above about 10,000 feet, and therefore, poses some interesting questions.

Because of the permanent snow cover, the high elevation portions of the basin would not be expected to contribute to runoff in a PMP storm, so a decision needs to be made as to the elevation limit of contributing runoff. The elevation of snow cover varies seasonally. For this example, the all season snow line has not been considered here. This choice is to be made by the hydrologist.

<u>Step</u>

1. Drainage outline

   The outline for the White River drainage above Mud Mountain Dam (402-mi^2) is shown in Figure 15.34a, at 1:1,000,000 scale. Elevation contours for this same drainage are presented in Figure 15.34b for comparison.

2. User decision

   We will limit this example to all-season PMP. From Figure 15.3, it can be seen that all season PMP occurs from November through February.

3. All-season index PMP estimate

   Figure 15.34c shows the drainage outline relative to the 10-mi^2, 24-hour index PMP field from Chart 1 (from attached folder to this report). Note the sheltering influence provided by Mount Rainier relative to the moisture bearing southwesterly inflows. A uniform grid was developed for this drainage that resulted in 43 grid points within the drainage. Reading index values at these points and averaging gave a drainage averaged 10-mi^2, 24-hour value of 18.16 inches.

4. Not applicable in this example

5. Depth-duration

Using Chart 1, the White River drainage falls completely within subregion 4, orographic terrain west of the Cascades. Table 15.1 gives the following durational estimates as a ratio of 24-hour amount.

Duration (hours)	1	6	24	48	72
Ratio to 24 hours (from Table 15.1)	0.10	0.40	1.00	1.49	1.77
Depth (inches) (Step 3 x ratios)	1.82	7.26	18.16	27.06	32.14

6. Areal reduction factors

From Figure 15.10 for orographic depth-areal relations at 402-mi^2, we read the following areal reduction percentages by which to multiply the corresponding depths from step 5:

Duration (hours)	1	6	24	48	72
Areal reduction (%) (from Figure 15.10)	76.7	82.0	84.3	85.2	86.3
Depth (inches) (Step 5 x percentages)	1.40	5.95	15.31	23.06	27.74

These results are plotted in Figure 15.35 and fitted by a smooth curve that represents the drainage averaged all-season PMP for this example. Comparison of these results with those computed for December by Reclamation in Table 12.1 shows differences of about one percent. It is to be expected that different analysts will get slightly different basin average depths when using the index charts, but the differences should be negligible.

Note that in the event that answers were needed for April, as an example, reference should be made to Figure 15.5. A weighted average adjustment factor of 0.68 is estimated for this drainage and would be applied to the 18.16-inch drainage average estimate to get 12.35 inches in step 4. This reduced value would then be used to complete steps 5 and 6.

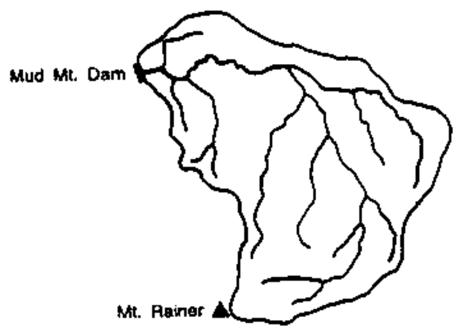


Figure a. Mud Mountain drainage; dam and White River tributaries.

Figure b. Elevation contours in thousands of feet.

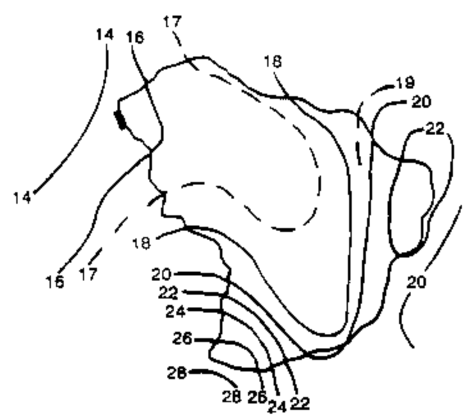


Figure c. 10 mile sq. 24hr PMP from index map on Mud Mt. drainage.

Figure 15.34.--Application of PMP to drainage for Mud Mountain, Washington (402-mi²). Scale 1:1,000,000.

7. Incremental estimates

The smooth curve in Figure 15.35 is used to read off estimates at 6-hour intervals as follows:

	Duration (hours)											
	6	12	18	24	30	36	42	48	54	60	66	72
PMP (inches)	5.75	9.45	12.50	15.30	17.70	19.75	21.50	23.00	24.35	25.55	26.65	27.75

To obtain 6-hour increments, subtract each durational amount from the next longer amount (e.g., 6 hours from 12 hours, 12 hours from 18 hours, etc.), to get:

6-hour intervals	1	2	3	4	5	6	7	8	9	10	11	12
PMP increment (inches)	5.75	3.70	3.05	2.80	2.40	2.05	1.75	1.50	1.35	1.20	1.10	1.10

8. Temporal distribution

Rank the results from step 7 from high to low in a sequence following the guidelines given for temporal distribution in step 8. The hydrologically most critical sequence for a drainage requires information from the user. However, an example of a sequence that may be critical using results from step 7 above is:

6-hour intervals	1	2	3	4	5	6	7	8	9	10	11	12
PMP increment (inches)	1.75	2.40	2.05	1.50	2.80	3.70	5.75	3.05	1.35	1.20	1.10	1.10

9. Areal distribution of general storm PMP

This step is left to the user because of individual practices applied by various agencies.

10. Temperature and wind for snowmelt

This step is left to the user. Guidance to the stepwise procedure recommended in HMR 43 is given in Appendix 5 of this report.

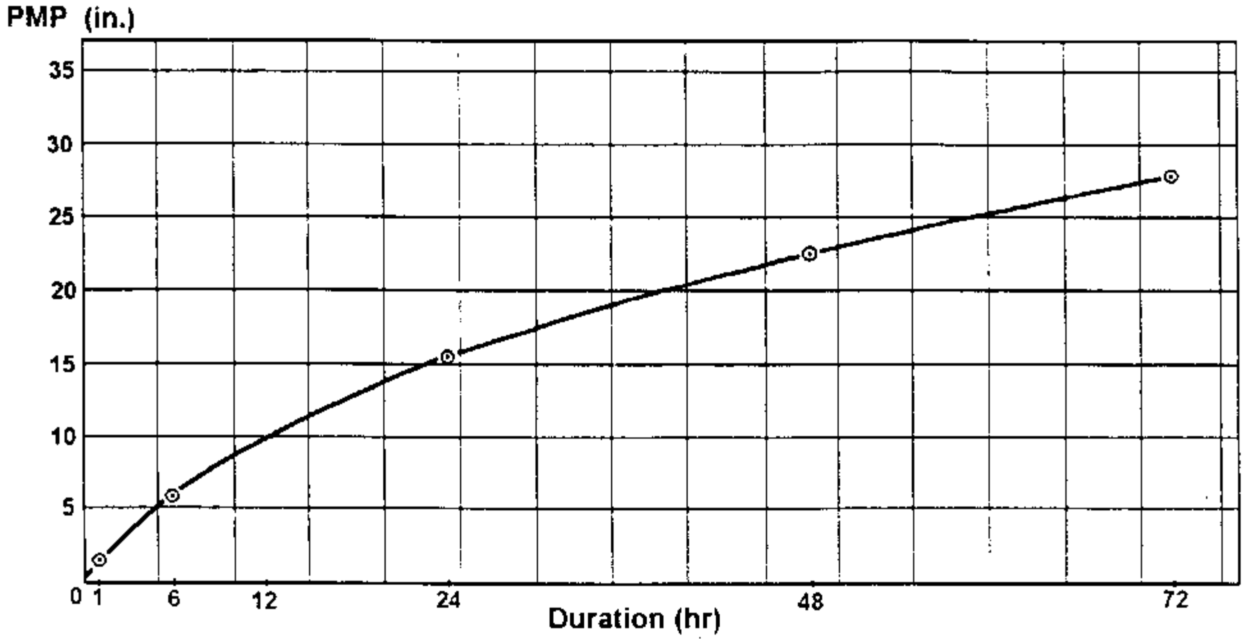


Figure 15.35.--Depth-duration curve for basin-averaged PMP for Mud Mountain dam basin (402-mi^2), Washington.

15.4 Local Storm Procedure

The background for the various figures and tables used in this procedure are discussed in detail in Chapter 11.

<u>Step</u>

1. **1-hour, 1-mi^2 PMP for elevations at or below 6,000 feet**

   Locate the basin on Figure 15.36 and determine the basin average 1-hour, 1-mi^2 local storm index PMP. Linear interpolation is assumed to apply.

2. **Adjustment for mean drainage elevation**

   Determine the mean elevation of the drainage in question. No adjustment is necessary for elevations of 6,000 feet or less. If the mean elevation is greater than 6,000 feet, reduce the index PMP from Step 1 by 9 percent for every 1,000 feet above the 6,000-foot level. Figure 15.37 can also be used to graphically determine this value.

   An example of the elevation adjustment is as follows: Take 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 (or 2.7 X .09 in this case), yielding an elevation-

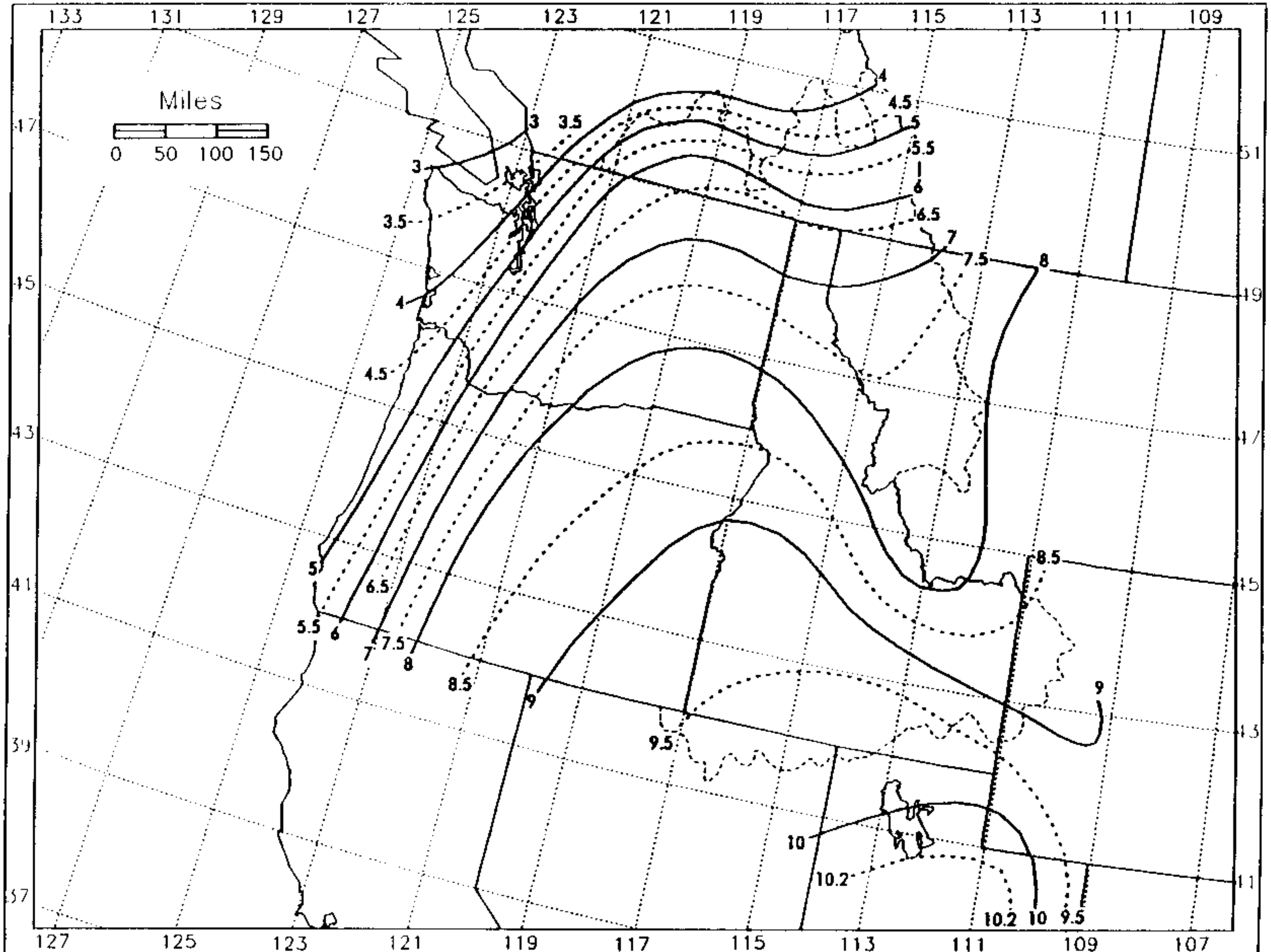


Figure 15.36.--1-hr 1-mi² local storm PMP in inches for elevations to 6000 ft.

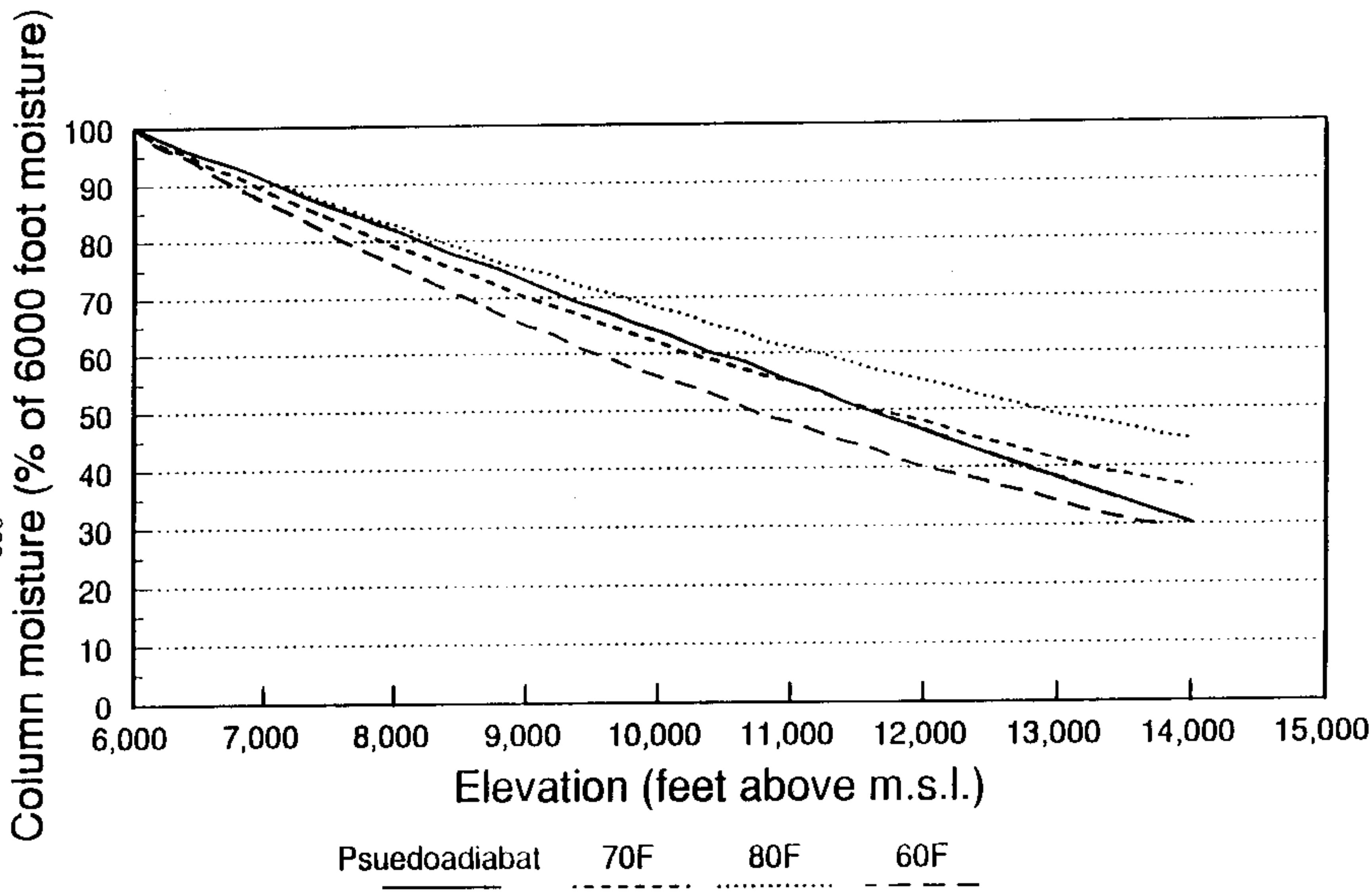


Figure 15.37.--Pseudoadiabatic decrease in column moisture for local storm basin elevations (Appendix 4).

adjusted index PMP of 76 percent (rounded) of full PMP at 6,000 feet. Had Figure 15.37 been used, a value of about 76 percent is read off the line labeled pseudoadiabat for an elevation of 8700 feet.

3. **Adjustment for duration**

1-mi^2 local storm PMP estimates for durations less than one hour and up to 6 hours are obtained from Figure 15.38, as a percentage of the 1 hour amount from step 2. Amounts for certain specific durations are also specified in the table contained in this figure.

4. **Adjustment for basin area**

Determine the basin area in square miles. Figure 15.39 shows the depth-area relationship, which gives the areal reduction in PMP to 500-mi^2. The percentage reductions at 1/4, 1/2, 3/4, 1, 3, and 6-hours for the area of the basin from the figure are to be multiplied by the respective results from step 3, and a smooth curve drawn for the plotted values in order to obtain estimates for durations not specified.

5. **Temporal distribution**

Review of local storm temporal distributions for this region show that most storms have durations less than 6 hours and that the greatest 1-hour amount occurs in the first hour. The recommended sequence of hourly increments is as follows: arrange the hourly increments from largest to smallest as directly obtained by successive subtraction of values and read from the smooth depth-duration curve.

6. **Areal distribution for local-storm PMP**

The elliptical pattern in Figure 15.40, along with the tabulated percentages in Table 15.2, are to be used in deriving the areal distribution of local storm PMP. In the event of choosing this option, steps 3 and 4 can be ignored and the results from step 2 (or 1, if no elevation adjustment is made) are multiplied by each of the percentage factors in Table 15.2. The products represent the labeled isohyets of the idealized pattern placed over the specific drainage. The example in 15.4 should clarify this application.

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 PMP will be obtained when the pattern is centered in the drainage. However, peak flows may actually occur with placements closer to the drainage outlet. Regardless of where the storm is centered, it should be remembered that the results from step 4 give "PMP for the basin" regardless of the spatial distribution.

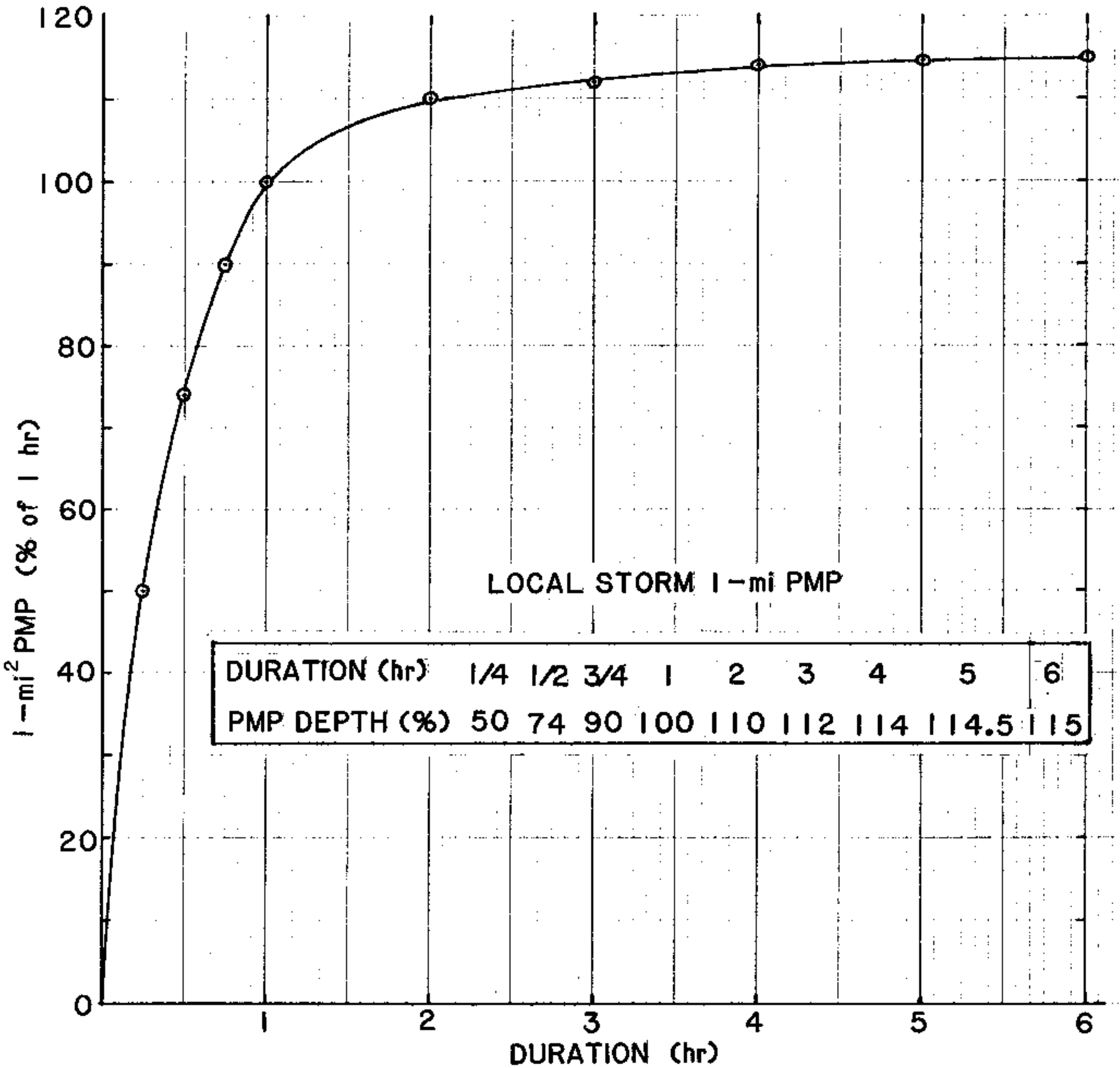


Figure 15.38.--Depth-duration relationship for 1-mi^2 PMP Pacific Northwest states (Section 11.7.2).

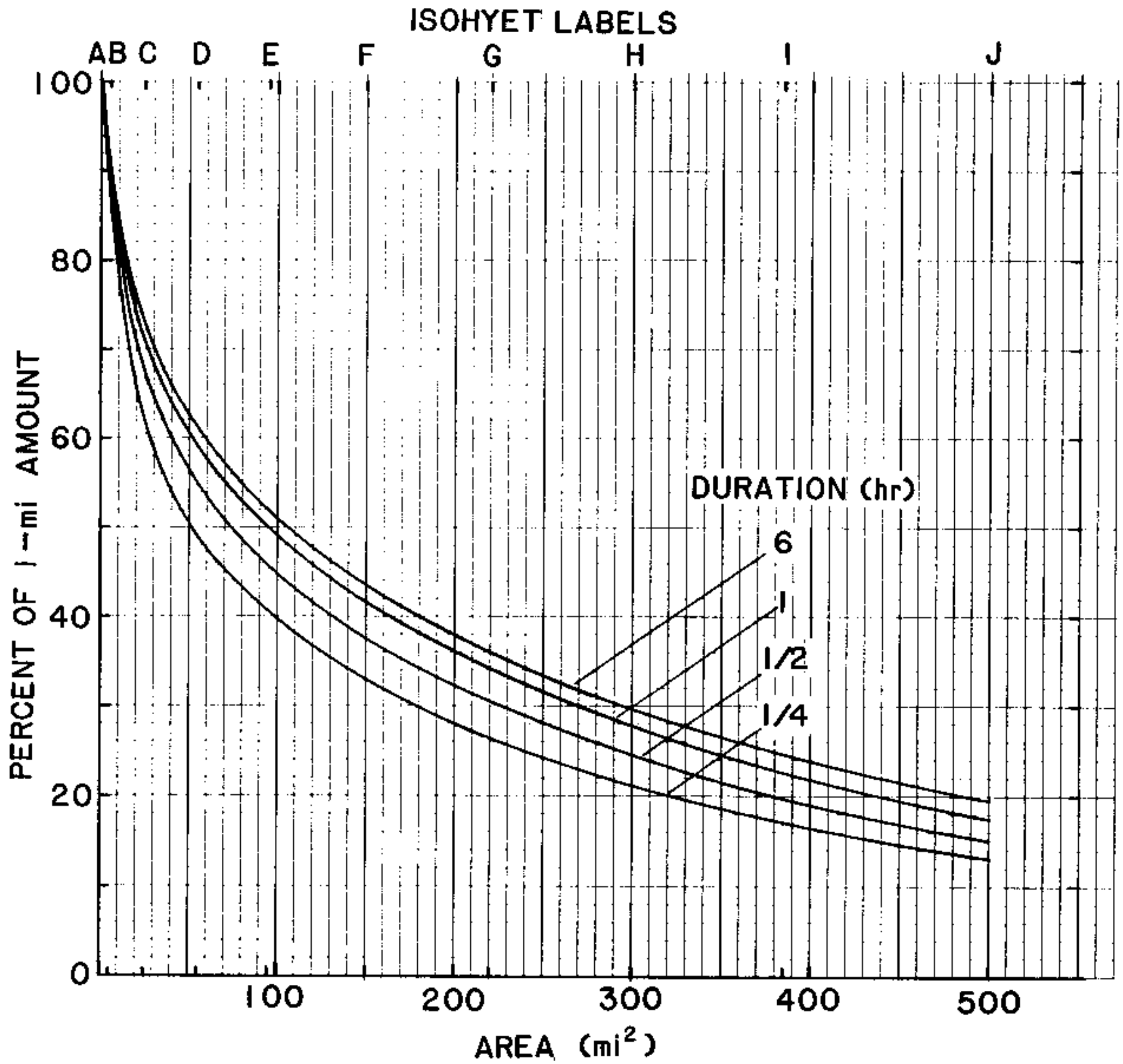
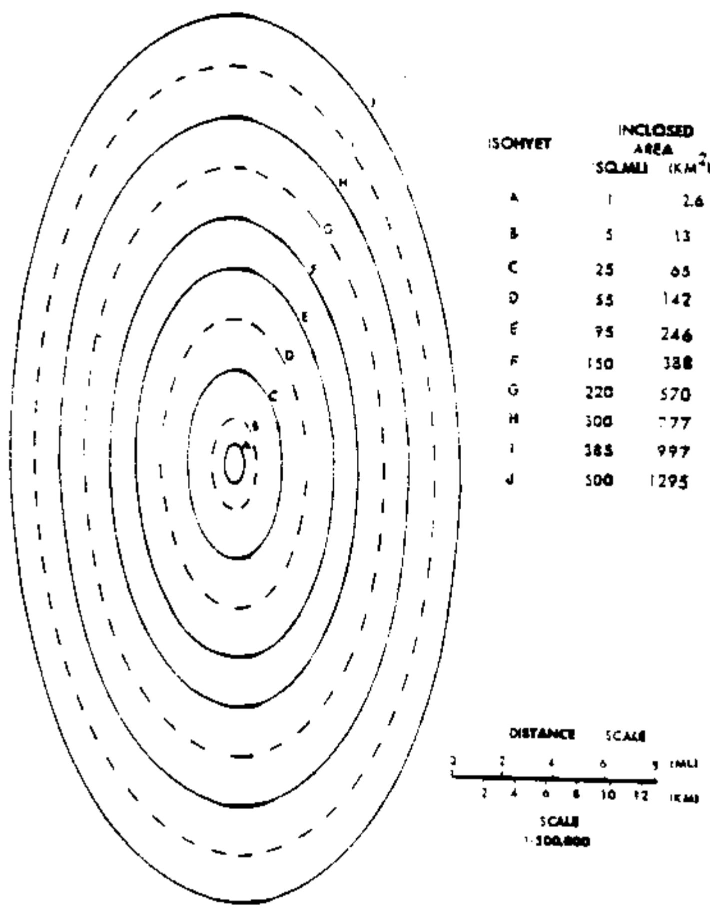


Figure 15.39.--Depth-area relations for local storm PMP Pacific Northwest states (Section 11.8).



ISOHYET	INCLOSED AREA (SQ.MI.)	INCLOSED AREA (KM²)
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

Figure 15.40.--Idealized isohyetal pattern for local storm PMP areas up to 500 mi² (from Hansen, et. al., 1978 - see also sect. 11.8.3)

Table 15.2--PMP Profile Values (accumulative % of 1-hour, 1-mi² amount).									
	Duration (hours)								
Isohyet	1/4	1/2	3/4	1	2	3	4	5	6
A	50.0	74.0	90.0	100.0	110.0	112.0	114.0	114.5	115.0
B	32.0	53.0	67.0	74.8	83.5	85.5	87.5	88.0	88.5
C	22.0	37.5	48.0	56.0	63.0	65.0	66.0	66.5	67.0
D	17.0	28.5	38.0	43.0	48.0	49.5	50.5	51.0	51.5
E	12.0	21.0	28.0	32.2	37.0	38.0	38.5	39.0	39.5
F	7.5	14.0	19.0	22.4	25.0	25.7	26.2	26.7	27.2
G	5.0	8.5	12.0	14.0	16.2	16.7	17.2	17.7	18.2
H	2.0	3.5	5.0	6.5	8.3	8.8	9.3	9.8	10.3
I	0.4	0.7	1.0	1.2	2.2	2.7	3.2	3.7	4.2
J	0.2	0.3	0.4	0.5	1.0	1.5	2.0	2.5	3.0

15.5 Example of Local-Storm PMP Computation

If the White River basin above Mud Mountain Dam (402-mi^2) is again chosen, this time to determine the local storm PMP, follow the steps outlined in Section 15.4.

Step

1. The basin outline is placed on Figure 15.36 and the basin average 1-mi^2, 1-hour PMP is read as 6.35 inches.

2. The average drainage elevation is below 6,000 feet although higher elevations occur near the border of the basin. No adjustment is needed for this basin.

3. Durational 1-mi^2 values are obtained from Figure 15.38 as follows:

	Duration (hours)								
	1/4	1/2	3/4	1	2	3	4	5	6
(%)	50	74	90	100	110	112	114	114.5	115
PMP (inches)	3.18	4.70	5.72	6.35	6.99	7.11	7.24	7.27	7.30

4. The areal reduction factors are obtained from Figure 15.39 for 402-mi^2 to give basin average PMP at the durations indicated. Multiply the respective factor times the results of step 3.

	Duration (hours)					
	1/4	1/2	3/4	1	3	6
Factor (%)	16.0	19.0	21.0	22.0	23.0	24.0
PMP (inches)	0.51	0.89	1.20	1.40	1.64	1.75

The areally reduced PMP in step 4 needs to be plotted on a depth-duration diagram and a smooth curve drawn in order to determine PMP for any other intermediate duration.

5. The temporal distribution is given by plotting the results of step 4, such as shown in Figure 15.41 and reading off smoothed hourly values. Note that the smoothed values may differ slightly from the calculated values.

Hourly intervals	1	2	3	4	5	6
PMP (inches)	1.38	1.55	1.64	1.70	1.73	1.75
Increments (inches)	1.38	0.17	0.09	0.06	0.03	0.02

These increments are arranged in the recommended sequence for front-loaded local-storm PMP. It is also possible that the storm could be mid-loaded. See Chapter 11 for more details about possible temporal distributions for local storms.

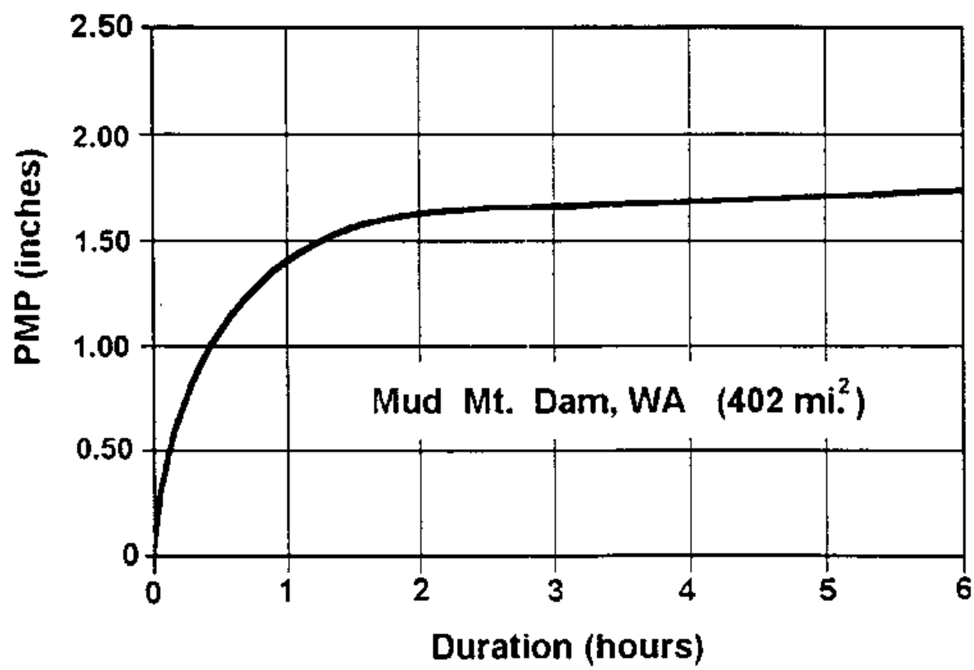


Figure 15.41.--Temporal distribution relation for Mud Mountain Dam.

6. In the event the areal distribution provided by the idealized elliptical pattern in Figure 15.40 is needed, the isohyet labels (A, B, ...) are determined by reference to Table 15.2. In this example, the step 1 result of 6.35 inches is multiplied by each of the percentages in Table 15.2 to get the label values in inches in Table 15.3.

Table 15.3.--Isohyetal label values for local-storm PMP, White River, Washington (402-mi²).

Isohyet (mi^2)	Duration (hours)								
	1/4	1/2	3/4	1	2	3	4	5	6
A (1)	3.18	4.70	5.72	6.35	6.99	7.11	7.24	7.27	7.30
B (5)	2.03	3.37	4.25	4.75	5.30	5.43	5.56	5.59	5.62
C (25)	1.40	2.38	3.05	3.56	4.00	4.13	4.19	4.22	4.25
D (55)	1.08	1.81	2.41	2.73	3.05	3.14	3.21	3.24	3.27
E (95)	0.76	1.33	1.78	2.04	2.35	2.41	2.44	2.48	2.51
F (150)	0.48	0.89	1.21	1.42	1.59	1.63	1.66	1.70	1.73
G (220)	0.32	0.54	0.76	0.89	1.03	1.06	1.09	1.12	1.16
H (300)	0.13	0.22	0.32	0.41	0.53	0.56	0.59	0.62	0.65
I (385)	0.03	0.04	0.06	0.08	0.14	0.17	0.20	0.23	0.27
J (500)	0.01	0.02	0.03	0.03	0.06	0.10	0.13	0.16	0.19

The isohyet label values given in Table 15.3 are to be applied to the isohyetal pattern shown in Figure 15.40 for each duration. The pattern may be placed over the drainage to maximize the precipitation volume into the drainage or positioned to obtain a maximized peak runoff.

It is apparent that the general storm at about 6 inches (for 6 hours) is dominant for this drainage, when compared to the local storm PMP estimate of 1.75 inches. It is believed that this dominance is typical for large orographic basins west of the Cascade Mountain ridgeline. Note that these results are also in agreement with those given in Chapter 12 for basin comparisons.

ACKNOWLEDGEMENTS

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REFERENCES

Abbs, D.J. and R.A. Pielke, 1986: Thermally forced surface flow and convergence patterns over northeast Colorado. Monthly Weather Review, 114, 2281-2296.

American Meteorological Society, 1959: Glossary of Meteorology, Boston, MA, 638 pp.

Australian National Committee on Large Dams (ANCOLD), 1988: Workshop on Spillway Design Floods. Conference proceedings for workshop held February 4, 1988 in Canberra, Australia. Published by the Water Authority of Western Australia, Leederville, Australia, 81 pp.

Barnes, S.L. and C.W. Newton, 1981: Thunderstorms in the synoptic setting. Thunderstorms: A Social, Scientific and Technological Documentary, Vol. 2, E. Kessler, Ed., U.S. Department of Commerce, NOAA, ERL, pp. 109-170.

Bates, F.C., 1963: The mechanics of Great Plains tornadoes. Conference Review of Third Conference on Severe Local Storms. Amer. Meteor. Soc., Boston, MA, 7 pp.

Bauman, D.J., 1980: Profile of a flash flood-prone community--Heppner, OR. Preprints, Second Conference on Flash Floods, Amer. Meteor. Soc., Atlanta, GA, pp. 80-84.

Beebe, R.G. and F.C. Bates, 1955: A mechanism for assisting in the release of convective instability. Monthly Weather Review, 83, 1-10.

Berkofsky, L., 1967: Comments on "Note on the relationship between total precipitable water and surface dew point." Journal of Applied Meteorology, 6, 959-960.

Bolsenga, S.J., 1965: The relationship between total atmospheric water vapor and surface dew point on a mean daily and hourly basis. Journal of Applied Meteorology, 4, 430-432.

Boner, F.C., and Stermitz, F., 1967: Floods of June 1964 in Northwestern Montana. U.S. Geological Survey Water-Supply Paper 1840-B, Washington, DC, 242 pp.

Browning, K.A., 1968: The organization of severe local storms. Weather, 23, 634-639.

Browning, K.A., 1981: General circulation of mid-latitude thunderstorms. In Thunderstorms: A Social, Scientific and Technological Documentary, Vol. 2, E. Kessler, ed., U.S. Department of Commerce, NOAA, ERL, pp. 211-247.

Bryson, R.A., 1957a: The annual march of precipitation in Arizona, New Mexico and northwestern Mexico. University of Arizona Institute of Atmospheric Physics, Technical Report No. 6, Tucson, AZ, 24 pp.

Bryson, R.A., 1957b: Some factors in Tucson summer rainfall. University of Arizona Institute of Atmospheric Physics, Technical Report No. 4, Tucson, AZ, 26 pp.

Carleton, A.M., D.A. Carpenter and P.J. Weser, 1990: Mechanisms of interannual variability of the southwest United States summer rainfall maximum. Journal of Climate, 3, 999-1015.

Carlson, T.N., S.J. Benjamin, G.S. Forbes and Y.F. Li, 1983: Elevated mixed layers in the regional severe storm environment: Conceptual model and case studies. Monthly Weather Review, 111, 1453-1473.

Changery, M.J., 1981: National thunderstorm frequencies for the contiguous United States. U.S. Nuclear Regulatory Commission Report, NUREG/CR-2252, Washington, DC, 22 pp.

Changnon, S.A., 1988a: Climatography of thunder events in the conterminous United States, Part I: Temporal aspects. Journal of Climate, 1, 389-398.

Changnon, S.A., 1988b: Climatography of thunder events in the conterminous United States, Part II: Spatial aspects. Journal of Climate, 1, 399-405.

Changnon, S.A., F.A. Huff, P.T. Schickedanz, and J.L. Vogel, 1977: Summary of METROMEX, Volume 1: Weather anomalies and impacts. Illinois State Water Survey, Urbana, IL, Bulletin 62, 260 pp.

Changnon, S.A. and J.L. Vogel, 1981: Hydroclimatological characteristics of isolated severe rainstorms. Water Resources Research, 17, 1694-1700.

Chappell, C.F., 1986: Quasi-stationary Convective Events in Mesoscale Meteorology and Forecasting, Peter Ray, Ed., Amer. Meteor. Soc., Boston, MA, 793 pp.

Chappell, C.F. and D.M. Rodgers, 1988: Meteorological Analysis of the Cheyenne, Wyoming Flash Flood and Hailstorm of 1 August 1985. NOAA Technical Report ERL 435-FSL 1, US Department of Commerce, NOAA, Environmental Research Laboratories, Boulder, CO, 51 pp.

Cooper, C.F., 1967: Rainfall intensity and elevation in southwestern Idaho. Water Resources Research, 3, 131-137.

Corrigan, P. and J.L. Vogel, 1993: Meteorological analysis of a local flash flood near Opal, Wyoming, 16 August 1990. Preprints 13th Conference on Weather Analysis and Forecasting, August 2-6, 1993, Vienna, VA, pp. 375-378.

Cotton, W.R. and R.A. Anthes, 1989: Storm and cloud dynamics. Academic Press, San Diego, CA, 883 pp.

Crutcher, H.L. and J.M. Meserve, 1970: Selected level heights, temperatures and dewpoints for the northern hemisphere, Naval Weather Service Command, Washington DC.

Dietrich, T.L. 1979: Occurrence and Distribution of Flash Floods in the Western Region. NOAA Technical Memorandum NWS WR-147, 43 pp.

Doswell, C.A., III, 1982: The operational meteorology of convective weather, Vol. I: Operational Mesoanalysis. NOAA Technical Memorandum, NWS-NSSFC-5, Kansas City, MO.

Doswell, C.A. III, A.R. Moller and R. Przybylinski, 1990: A unified set of conceptual models for variations on the supercell theme. Preprints, 16th Conference on Severe Local Storms, Kananaskis Park, Alberta, Canada, Amer. Meteor. Soc., Boston, MA, 40-45.

Doswell, C.A. III and D.L. Keller, 1990: An analysis of the temporal and spatial variation of tornado and severe thunderstorm watch verification. Preprints, 16th Conference on Severe Local Storms, Kananaskis Park, Alberta, Canada, Amer. Meteor. Soc., Boston, MA 294-299.

Easterling, D.R. and P.J. Robinson, 1985: The diurnal variation of thunderstorm activity in the United States. J. Climate Appl. Meteor., 24, 1048-1058.

Electrical Power Research Institute (EPRI), 1993a: New techniques and data sources for probable maximum precipitation. Vols. 1-5. Studies performed by Climatological Consulting Corporation under contract RP 3113-01, Palo Alto, CA (in preparation).

Electrical Power Research Institute (EPRI), 1993b: Probable maximum precipitation study for Wisconsin and Michigan, Vol. 1. Research Report No. TR-101554, (prepared by North American Weather Consultants), Palo Alto, CA, 88 pp.

Farmer, E.E. and J.E. Fletcher, 1972: Some intra-storm characteristics of high intensity rainfall bursts. In Distribution of Precipitation in Mountainous Areas, World Meteorological Organization, Geilo, Norway, pp. 525-531.

Federal Emergency Management Agency (FEMA), 1990: Probable maximum precipitation and probable maximum flood workshops. Proceedings of workshop held May 1-4, 1990, Berkeley Springs, WV, Washington, DC, 25 pp.

Fenn, D.D., 1985: Probable maximum precipitation estimates for the drainage above Dewey Dam, John's Creek, Kentucky. NOAA Technical Memorandum, NWS HYDRO #41, National Weather Service, U.S. Department of Commerce, Silver Spring, MD, 33 pp.

Flanagan, R.P., 1982: Elk Creek Lake project, spillway design. U.S. Army Corps of Engineers' letter to Commander, North Pacific Division, 4 pp.

Fleming, E.L. and L.E. Spayd, 1986: Characteristics of western region flash flood events in GOES imagery and conventional data. NOAA Technical Memorandum, NESDIS 13, 82 pp.

Gabriel, R.K. and S.A. Changnon, Jr., 1989: Temporal features in thunder days in the United States. Climatic Change, 15, 455-477.

Hagemeyer, B.C., 1991: A lower-tropospheric thermodynamic climatology for March through September: Some implications for thunderstorm forecasting. Weather and Forecasting, 6, 254-270.

Hales, J.E., 1972: Surges in maritime tropical air northward over the Gulf of California. Monthly Weather Review, 100, 298-306.

Hambidge, R.E., 1967: "K" Chart Application to Thunderstorm Forecasts over the Western United States. ESSA Technical Memorandum, WRTM 23.

Hansen, E.M., 1975: Moisture source for three extreme local rainfalls in the southern intermountain region. National Weather Service Technical Memorandum, NWS HYDRO 26, 57 pp.

Hansen, E.M., D.D. Fenn, L.C. Schreiner, R.W. Stodt and J.F. Miller, 1988: Probable Maximum Precipitation Estimates--United States Between the Continental Divide and the 103rd Meridian. Hydrometeorological Report Number 55A, National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, MD, 242 pp.

Hansen, E.M. and F.K. Schwarz, 1981: Meteorology of Important Rainstorms in the Colorado and Great Basin Drainages. Hydrometeorological Report Number 50, U.S. Department of Commerce, National Weather Service, Silver Spring, MD, 167 pp.

Hansen, E.M., L.C. Schreiner and J.F. Miller, 1982: Application of Probable Maximum Precipitation Estimates--United States East of the 105th Meridian. Hydrometeorological Report Number 52, National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, DC, 168 pp.

Hansen, E.M., F.K. Schwarz and J.T. Riedel, 1977: Probable Maximum Precipitation Estimates, Colorado River and Great Basin drainages. Hydrometeorological Report Number 49, National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, MD, 161 pp.

Haurwitz, B. and J.M. Austin, 1944: Climatology, McGraw-Hill Book Company, Inc., New York and London, 409 pp.

Hendricks, E.L., 1963: Summary of Floods in the United States During 1957. U.S. Geological Survey Water Supply Paper 1652-C, U.S. Government Printing Office, Washington, DC, 98 pp.

Hendricks, E.L., 1964: Summary of floods in the United States during 1956. U.S. Geological Survey Water Supply Paper 1530, Washington, DC, 85 pp.

Hershfield, D.M., 1961: Rainfall Frequency Atlas of the United States. Technical Paper Number 40, U.S. Weather Bureau, U.S. Department of Commerce, Washington, DC, 61 pp.

Henz, J.F., 1974: Colorado High Plains Thunderstorm Systems - A Descriptive Radar-Synoptic Climatology. Master of Science Thesis, Department of Atmospheric Science, Colorado State University, Fort Collins, CO, 82 pp.

Henz, J.F. and R.A. Kelly, 1989: Survey of Thunderstorm Rainfall Characteristics in the Colorado Central Front Range Above 7500 Feet From 1979 to 1988 (Storm Data). Report for Colorado Water Conservation Board, Denver, CO.

Hogg, W.D. and D.A. Carr, 1985: Rainfall Frequency Atlas for Canada. Canadian Government Publishing Center, 94 pp.

Hosking, J.R.M., 1990: L-moments: Analysis and Estimation of Distributions Using Linear Combinations of Order Statistics. Journal of Statistics, Soc. B., 51, 3 pp.

Hosking, J.R.M. and J.R. Wallis, 1991: Some statistics useful in regional frequency analysis. IBM Research Report RC 17096, Yorktown Heights, NY, 23 pp.

House, D.C., 1963: Forecasting tornadoes and severe thunderstorms. In Severe Local Storms, Meteorological Monograph 5, Amer. Meteor. Soc., 141-155.

Hudson, H.R., 1971: On the relationship between horizontal moisture convergence and convective cloud formation. Journal of Applied Meteorology, 10, 755-762.

Huff, F.A., 1967: Time Distribution of Rainfall in Heavy Storms. Water Resources Research, 3, 1007-1019.

Jarrett, R.D., 1989: Hydrology and Paleohydrology Used to Improve the Understanding of Flood Hydrometeorology in Colorado. Proceedings of the International Symposium on Design of Hydraulic Structures, American Society of Civil Engineers, Fort Collins, CO, June 26-29, 1989.

Jarrett, R.D. and J.E. Costa, 1986: Evaluation of the Flood Hydrology in the Colorado Front Range Using Streamflow Records and Paleoflood Data for the Big Thompson River Basin. International Symposium on Flood Frequency and Peak Analyses, May 14-17, 1986, American Water Resources Association.

Jennings, A.H., 1952: Maximum 24-hour Precipitation in the United States. U.S. Weather Bureau, Technical Paper Number 16, U.S. Department of Commerce, Washington, DC, 284 pp.

Kelly, D.L., Schaefer, J.T. and C.A. Doswell, III, 1985: Climatology of Non-Tornadic Severe Thunderstorm Events in the U.S. Monthly Weather Review, 113, 1997-2014.

Kennedy, M.R., J. Pearce, R.P. Canterford and L.J. Minty, 1988: The Estimation of Generalized Probable Maximum Precipitation in Australia, ANCOLD Bulletin Number 79, Leederville, Western Australia 6007, pp. 6-16.

Lee, R.F. 1973: A Refinement of the Use of K-values in Forecasting Thunderstorms in Washington and Oregon. NOAA Technical Memorandum NWS WR-87, 21 pp.

Legates, D.R. and C.J. Willmott, 1990: Mean Seasonal and Spatial Variability in Guage-Corrected, Global Precipitation. International Journal of Climatology, 10, 111-127.

Ludlam, F.H., 1963: Severe Local Storms: A Review. Meteorol. Monogr., 5, Amer. Meteor. Soc., Boston, MA.

Lussky, G.R., 1986: The MCC--An Overview and Case Study on its Impact in the Western United States. NOAA Technical Memorandum, NWS WR-193, Salt Lake City, UT, 50 pp.

Maddox, R.A., L.R. Hoxit and F. Canova, 1980: Meteorological characteristics of heavy precipitation and flash flood events over the western United States. NOAA Technical Memorandum, ERL-APCL 23, Boulder, CO.

McKay, G.A., 1963: Persisting dew points in the prairie provinces. Canadian Department of Agriculture, Prairie Farm Rehabilitation Administration Meteorological Report Number 11, 23 pp.

McNulty, R.P., 1983: Some basic elements of thunderstorm forecasting. NOAA Technical Memorandum, NWS-CR-69, 13 pp.

Miller, J.F., 1993: Probable Maximum Precipitation Estimates for Columbia River Basin above the Lower Border Dam Site below Confluence with the Pend D'Oreille River. B. C. Hydroelectric Report No. H 2719, 46 pp. plus tables figures and appendices.

Miller, J.F., 1982: PMP estimate for Elk Creek, Oregon. National Weather Service Office Memorandum For The Record, 2 p.

Miller, J.F., R.H. Frederick and R.J. Tracey, 1973: Precipitation frequency atlas of the western United States, Vol. I, Montana; Vol. V, Idaho; Vol. IX, Washington, and Vol. X, Oregon. NOAA Atlas 2, National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, MD.

Miller, J.F., E.M. Hansen and D.D. Fenn, 1984: Probable maximum precipitation for the Upper Deerfield River drainage, Massachusetts/Vermont. NOAA Technical Memorandum, NWS HYDRO 39, National Weather Service, U.S. Department of Commerce, Silver Spring, MD, 36 pp.

Miller, R.C., 1967: Notes on analysis and severe storm forecasting procedures of the Air Force Global Weather Center. Technical Report 200, Air Weather Service, Scott AFB, IL.

Myers, V.A., 1965: Estimates of probable maximum precipitation for Elk Creek, Lost Creek and Applegate River, Oregon. U.S. Weather Bureau Office Memorandum, 3 pp.

National Climatic Data Center (NCDC), 1948- : Local Climatological Data (Station). NESDIS, U.S. Department of Commerce, Asheville, NC (ongoing publication).

National Climatic Data Center (NCDC), 1951- : Hourly Precipitation Data (State). NESDIS, U.S. Department of Commerce, Asheville, NC (ongoing publication).

National Climatic Data Center (NCDC), 1992: Maps of annual 1961-90 normal temperature, precipitation and degree days. Climatography of the United States Number 81 - Supplement Number 3. U.S. Department of Commerce, Asheville, NC, 6 pp.

National Research Council (NRC), 1985: Safety of dams, floods and earthquake criteria. Water Science and Technology Board, National Academy Press, Washington, DC, 321 pp.

National Research Council (NRC), 1988: Estimating probabilities of extreme floods, methods and recommended research. Water Science and Technology Board, National Academy Press, Washington, DC, 141 pp.

National Weather Service, 1981: Revision of April 1981 to Hydrometeorological Report Number 43. Office Note, U.S. Department of Commerce, Silver Spring, MD, 5 pp.

Newark, M.J., 1984: Canadian wind data. Paper presented at the Fourth Canadian Workshop on Wind Engineering, Toronto, Canada, November 19-20, 1984.

Office of Water Data Coordination (OWDC), 1986: Feasibility of assigning a probability to the probable maximum flood. Hydrology Subcommittee of the Interagency Advisory Committee on Water Data, Washington, DC, 79 pp.

Osborn, H.B., L.V. Lane and V.A. Myers, 1980: Rainfall/watershed relationships for southwestern thunderstorms. Transactions, American Society of Agricultural Engineers, 23, pp. 82-91.

Palmen, E. and C.W. Newton, 1969: Atmospheric Circulation Systems. Academic Press, New York, NY, 603 pp.

Peck, E.L., J.C. Monro and M.L. Snelson, 1977: Hydrometeorological data base for the United States. Proceedings of Second Conference on Hydrometeorology, October 25-27, 1977, Toronto, Ontario, Canada, pp. 75-78.

Peppler, R.A., 1988: A review of static stability indices and related thermodynamic parameters. Illinois State Water Survey, Champaign, IL, 87 pp.

Randerson, D. 1986: A Mesoscale Convective Complex Type Storm Over the Desert Southwest. NOAA Technical Memorandum NWS WR-196, 53 pp.

Reid, J.K., 1975: Summary of Floods in the United States During 1969. U.S. Geological Survey Water Supply Paper 2030, Washington, DC, 173 pp.

Reitan, C.H., 1963: Surface dew point and water vapor aloft. Journal of Applied Meteorology, 2, pp. 776-779.

Reyes, S. and D.L. Cadet, 1988: The southwest branch of the North American monsoon during summer 1979. Monthly Weather Review, 116 pp.

Riedel, J.T. and L.C. Schreiner, 1980. Comparison of generalized estimates of PMP with greatest observed rainfalls. NOAA Technical Report NWS-25, 66 pp.

Rostvedt, J.O., 1972: Summary of Floods in the United States During 1967. U.S. Geological Survey Water Supply Paper 1880-C, Washington, DC, 114 pp.

Sampson, R.J., 1978: Surface II Graphics System. Kansas Geological Survey, Lawrence, KS, 240 pp.

Schaefer, M.G., 1980: Personal communication.

Schaefer, M.G., 1989: Characteristics of extreme precipitation events in Washington State. Washington State Department of Ecology Report 89-51, 109 pp.

Schaefer, M.G., 1990: Regional Analyses of Precipitation Annual Maxima in Washington State. Water Research Resources, 20, 119-131.

Schreiner, L.C. and J.T. Reidel, 1978: Probable Maximum Precipitation Estimates--United States East of the 105th Meridian. Hydrometeorological Report Number 51, National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, MD, 87 pp.

Sellers, W.D., 1964: Arizona Climate. University of Arizona Press, Phoenix, AZ, 60 pp.

Simiu, E., M.J. Changery and J.J. Filliben, 1979. Extreme Wind Speeds at 129 Stations in the Contiguous United States. National Bureau of Standards Building Science Series 118, U.S. Department of Commerce, Washington, DC, 15 pp.

Stodt, R.W., 1994: Manual for Automated Depth-Area-Duration Analysis of Storm Precipitation. U.S. Bureau of Reclamation Technical Report (in preparation).

Styner, W.H., 1975: Use of National Weather Service revised precipitation-frequency maps and estimation of 10-day precipitation values. TSC Technical Note - Hydrology PO-6 (Rev. 2), Engineering and Watershed Planning Unit, Regional Technical Service Center, Soil Conservation Service, Department of Agriculture, Portland, OR.

Tomlinson, E.M. and C.S. Thompson, 1992: Probable Maximum Precipitation in New Zealand. Report produced by the New Zealand Meteorological Service for the Electricity Corporation of New Zealand, Ltd., 273 pp.

Trewartha, G.T. and L.H. Horn, 1980: An Introduction to Climate, McGraw-Hill Book Company, New York, NY, 416 pp.

Uccellini, L.W., 1990: The relationship between jet streaks and severe convective Systems. Preprints, 16th Conference on Severe Local Storms, Kananaskis Park, Alberta, Canada, Amer. Meteor. Soc., Boston, MA, 121-130.

U.S. Army Corps of Engineers (USCOE), 1945-1980: Storm rainfall in the United States, depth-area-duration data. Washington, D.C.

U.S. Army Corps of Engineers (USCOE), 1982: Elk Creek Lake Project, Spillway Design. Office Memorandum, North Pacific Division, 16 August 1982, 4 pp.

U.S. Department of Commerce, 1968: Climatic Atlas of the United States. Environmental Science Services Administration, Washington, DC, 80 pp.

U.S. Navy Marine Climatic Atlas of the World (NAVAIR50-1C-65), Volume IX, Naval Oceanographic Command Detachment, Asheville, NC, May 1981.

U.S. Weather Bureau (USWB), 1896- : Climatological Data (State). NOAA, U.S. Department of Commerce, Asheville, NC (ongoing publication).

U.S. Weather Bureau (USWB), 1946: Manual for depth-area-duration analysis of storm precipitation. Cooperative Studies Technical Paper Number 1. U.S. Department of Commerce, Washington, DC, 73 pp.

U.S. Weather Bureau (USWB), 1947. Thunderstorm rainfall. Hydrometeorological Report 5, Washington, DC.

U.S. Weather Bureau (USWB), 1951: Tables of precipitable water and other factors for a saturated pseudo-adiabatic atmosphere. Technical Paper Number 14, U.S. Department of Commerce, Washington, DC, 27 pp.

U.S. Weather Bureau (USWB), 1953: Critical meteorological conditions for design floods in Snake River basin. Technical Bulletin Number 10, Washington, DC.

U.S. Weather Bureau (USWB), 1956: Maximum station precipitation for 1, 3, 6, 12 and 24 hours. Technical Paper Number 15. U.S. Department of Commerce, Washington, DC, 23 parts.

U.S. Weather Bureau (USWB), 1957-1960: Rainfall intensity-frequency regime. Technical Paper Number 29, Washington, DC, 5 Parts.

U.S. Weather Bureau (USWB), 1960: Generalized Estimates of Probable Maximum Precipitation West of the 105th Meridian. Technical Paper Number 38, Washington DC.

U.S. Weather Bureau (USWB), 1961: Interim Report, Probable Maximum Precipitation in California. Hydrometeorological Report Number 36, U.S. Department of Commerce, Washington, DC, 202 pp.

U.S. Weather Bureau (USWB), 1966: Probable Maximum Precipitation, Northwest States. Hydrometeorological Report Number 43, Environmental Science Services Administration, U. S. Department of Commerce, Washington, DC, 228 pp.

Verschuren, J.P. and Wojtiw, L., 1980: Estimate of the maximum possible precipitation for Alberta River Basins. University of Alberta press.

Vogel, J.L., F. Bartlo and P. Corrigan, 1990: Climatological characteristics of heavy convective storms in the Pacific Northwest. Preprints - Eighth Conference on Hydrometeorology, Amer. Meteor. Soc., October 22-26, 1990, Kananaskis Park, Alberta, Canada, pp. 225-228.

Wallace, J.M., 1975: Diurnal variations in precipitation and thunderstorm frequency over the conterminous United States. Monthly Weather Review, 103, 406-419.

Weisman, M.L. and J.B. Klemp, 1986: Characteristics of isolated convective storms. In Mesoscale Meteorology and Forecasting, Peter Ray, ed., Amer. Meteor. Soc., Boston, MA, pp. 331-358.

World Meteorological Organization (WMO), 1986: Manual for estimation of probable maximum precipitation. Operational Hydrology Report Number 1, WMO Number 332, Geneva, Switzerland, 269 pp.

APPENDIX 1

MASTER STORM LIST

Table A1 comprises the master listing of general-type storms compiled at the onset of this study to revise PMP for the Pacific Northwest. The list was derived from storms that had been listed by the Corps of Engineers, National Weather Service or the Bureau of Reclamation. They cover a period of record between 1901 and 1975. A check was made in the daily precipitation files of Climatological Data and in Storm Data published reports for storms since 1975, but none were found of a magnitude sufficient for inclusion in this study. The master storm list is organized as follows:

Column 1. - storm number
2. - date(s) of significant rainfall
3. - latitude
4. - longitude
5. - town identified with storm maximum
6. - reference source (Corps of Engineers index number, National Weather Service (NWS), Bureau of Reclamation (USBR)

The Corps of Engineers (COE) index numbers are assigned according to COE division: NP = North Pacific Division, etc. Storms are assigned index numbers to identify them in the event a storm study is done. A storm study normally concludes with the development of a matrix of depth-area-duration (DAD) data and a brief storm synoptic description. In the western United States, although a number of major storms were identified and assigned index numbers, few were officially completed.

The list is dominated by storms in Washington, Oregon and Idaho, with the addition of a few storms that occurred in western Montana, northwestern Wyoming and the northern parts of Utah, Nevada and California.

A secondary listing of 130 storms (Table A2) reported in northern California (37° N - 42° N) has been assigned numbers exceeding 500. Only date and latitude/longitude is given to these storms and none were transposed into the region of this study.

Table A1. Master Storm File for the Northwest Region

Storm Number	Date	Latitude	Longitude	Nearest Town	Ref. Source
1	1/1-3/01	42°03	122°36	Siskiyou, OR	USBR
2	7/2-4/02	48°21	116°50	Priest River, ID	NP 1-26
3	1/20-24/03	42°10	123°39	Buckhorn Farm, OR	NP 3-2
4	6/14/03	45°19	119°24	Heppner, OR	USBR/NWS
5	5/26-30/06	45°50	118°25	Nr. Weston, OR	NP 4-1
6	11/11-16/06	45°20	123°50	Glenora, OR	NP 1-1
7	1/28-2/5/07	42°26	124°25	Gold Beach, OR	NP 3-3
8	2/1-5/07	41°28	115°25	Charleston, NV	NWS-CS
9	10/13-14/08	48°12	115°41	Snowshoe, MT	NP 2-19
10	11/1-4/09	45°20	123°50	Glenora, OR	NWS
11	11/2-5/09	48°12	115°41	Snowshoe, MT	NWS
12	11/18-19/09	48°12	115°41	Snowshoe, MT	NP 2-18
13	11/17-22/09	45°20	123°50	Glenora, OR	NP 1-2
14	11/18-23/09	43°37	115°44	Rattlesnake Ck, ID	NP 4-6
15	11/26-12/1/09	47°28	123°51	Quinault, WA	NP 1-3
16	2/25-3/2/10	45°20	123°50	Glenora, OR	NP 3A-5
17	1/16-19/11	44°07	123°44	Greenleaf, OR	NP 1-17
18	5/15/11	43°02	116°44	Silver City, ID	NWS-CS
19	10/10-11/11	45°46	113°28	Bowen, MT	USBR
20	11/16-20/11	47°28	123°51	Quinault, WA	NP 1-5
21	11/16-20/11	47°25	121°44	Snoqualmie Pass, WA	NP 1-5
22	1/5-8/12	44°41	122°07	Hoover, OR	USBR
23	7/30-31/12	43°32	116°04	Boise, ID	NP 4-15
24	7/23-26/13	43°38	116°41	Caldwell, ID	NWS-CS
25	7/23-26/13	42°44	112°29	Pocatello, ID	NWS-CS
26	7/23-26/13	44°30	111°44	Yellowstone Pk, ID	NWS-CS
27	10/24/13	44°21	117°16	Huntington, OR	USBR
28	3/29-4/3/15	47°29	123°16	Lk. Cushman, WA	NP 1-18
29	6/19-22/16	47°38	112°42	Sun River Can., MT	NP 1-27
30	2/23-25/17	43°28	114°48	Soldier Creek, ID	NWS
31	12/11-15/17	47°25	121°44	Cedar Lake, WA	NP 1-6
32	12/16-19/17	45°48	121°56	Wind River, WA	NP 1-7
33	12/16-20/17	47°28	115°55	Wallace, ID	NP 4-17
34	2/28-3/3/19	44°15	115°55	Sheep Hill, ID	NWS-CS
35	8/28-29/20	47°25	121°25	Snoqualmie Pass, WA	USBR
36	9/11-14/20	47°25	121°25	Snoqualmie Pass, WA	USBR
37	11/18-22/21	44°24	115°59	Alpha, ID	NP 4-7
38	11/18-22/21	45°48	121°56	Wind River, WA	NP 3-6
39	12/8-13/21A	47°57	124°22	Forks, WA	NP 1-10
40	12/8-13/21B	48°05	121°35	Silverton, WA	NP 1-10
41	1/4-7/23	43°18	115°03	Hill City, ID	NP 4-14
42	1/4-8/23	45°40	121°54	Cascade Locks, OR	NP 3-7
43	1/6-8/24	47°57	124°22	Forks, WA	NP 2-21
44	2/10-12/24	47°57	124°22	Forks, WA	NP 1-19
45	6/7/24	48°56	113°21	Babb, MT	NP 2-21
46	10/27-30/24	45°05	116°42	Cuprum, ID	NP 4-13
47	10/28-11/2/24	42°55	124°26	Willow Ck., OR	NP 3-8
48	2/16-21/27	43°28	114°48	Soldier Ck., ID	NP 4-8
49	2/17-21/27	44°21	117°16	Huntington, OR	USBR
50	2/17-21/27	44°12	115°58	Pyle Ck., ID	USBR

Table A1. Continued

Storm Number	Date	Latitude	Longitude	Nearest Town	Ref. Source
51	2/18-22/27	45°23	121°42	Bull Run Lake, OR	NP 3-9
52	9/10-14/27	46°01	118°07	Mill Creek, WA	NP 4-2
53	11/6-10/27	44°00	115°50	Grimes Pass, ID	NP 4-9
54	11/24-29/27	46°07	117°56	Touchet Ridge, WA	NP 4-3
55	11/12-17/30	47°21	115°40	Roland, ID	NWS
56	11/12-17/30	41°28	115°25	Charleston, NV	USBR
57	3/28-4/1/31	44°51	123°40	Valsetz, OR	NWS
58	3/30-4/2/31A	46°09	115°36	Pete King RS, ID	NP 3-10
59	3/30-4/2/31B	46°01	118°07	Mill Creek, WA	NP 4-4
60	12/16-19/31B	48°04	121°31	Big Four, WA	NP 4-4
61	12/16-19/31A	47°20	123°39	Wynoochee Oxbow, WA	NP 2-16
62	12/23-29/31	44°19	115°38	Deadwood, ID	NP 2-16
63	2/23-27/32B	47°25	121°25	Snoqualmie Pass, WA	USBR
64	2/23-27/32A	47°28	123°51	Quinault, WA	NP 1-12
65	3/15-19/32	44°09	111°03	Bechler River, WY	NP 1-12
66	3/16-19/32	42°03	124°17	Brookings, OR	RI 1-29A
67	3/16-20/32	46°09	115°36	Pete King RS, ID	NP 3-11
68	11/11-16/32	47°25	121°25	Snoqualmie Pass, WA	NP 4-12
69	6/8-9/33	42°03	124°17	Brookings, OR	NP 1-13
70	12/5-12/33	47°20	123°39	Wynoochee, WA	NP 3-12
71	12/6-12/33	47°21	115°40	Roland, ID	NP 3A-3
72	12/17-22/33	45°29	123°51	Tillamook, OR	NP 2-8
73	12/17-19/33	47°21	115°40	Roland, ID	NP 3-13
74	12/18-23/33	45°48	121°56	Wind River, WA	NP 2-9
75	12/18-23/33	47°21	115°40	Roland, ID	NP 1-20
76	12/21-26/33	47°28	115°56	Wallace, ID	NP 2-22
77	12/21-26/33	46°07	117°56	Touchet Ridge, WA	NP 4-5
78	10/21-26/34	46°04	122°17	Nr. Cougar, WA	NP 4-5
79	11/2-7/34	46°04	122°17	Nr. Cougar, WA	NP 1-14
80	1/20-25/35	47°28	123°51	Quinault, WA	NP 1-15
81	1/21-24/35	47°21	115°40	Roland, ID	NP 1-21
82	3/24-26/35	47°23	115°24	Haugan, MT	NP 2-11
83	4/7-9/35	44°03	114°28	Baker Ranch, ID	NP 2-12
84	1/10-15/36	42°44	124°30	Port Orford, OR	USBR
85	2/11-14/36	43°48	115°08	Atlanta, ID	NP 3-14
86	10/26-28/37	48°52	121°41	Mt. Baker Lodge, WA	NP 4-11
87	12/9-12/37	44°01	115°50	Grimes Pass, ID	NP 1-22
88	12/25-30/37	44°51	123°40	Valsetz, OR	NP 4-10
89	12/28-30/37	48°04	121°31	Big Four, WA	NP 3-16
90	6/22/38	44°30	119°45	Birch Creek, OR	NP 3-16
91	12/13-17/39	47°20	123°38	Wynoochee, WA	NWS
92	3/25-4/1/40	44°44	116°26	Council, ID	NP 1-23
93	11/12-17/41	48°04	121°31	Big Four, WA	NWS-CS
94	11/12-17/41	46°38	115°30	Bungalow RS, ID	R1, 1-20
95	12/1-4/41	43°48	115°08	Atlanta, ID	R1, 1-20
96	12/14-20/41	44°19	115°38	Deadwood, ID	NWS-CS
97	10/30-11/4/42	47°25	121°44	Cedar Lake, WA	R1, 2-2A
98	*				R1, 1-22
99	12/26/42-1/2/43	42°39	124°04	Illahe, OR	NP 3A-6
100	12/27/42-1/2/43	43°43	116°00	Sheep Hill, ID	R1, 2-3
	*Eliminated				

Table A1. Continued

Storm Number	Date	Latitude	Longitude	Nearest Town	Ref. Source
101	1/19-23/43	44°19	115°35	Deadwood, ID	R1, 1-23A
102	1/20-23/43	43°45	114°00	Hyndman Park, ID	NWS-USBR
103	6/8/43	42°02	123°18	Copper, OR	USBR
104	6/10-13/43	41°52	115°26	Jarbridge, NV	USBR
105	6/7-12/44	43°40	113°35	Nr. Grouse, ID	R1, 1-24
106	6/26-27/44	44°14	112°14	Dubois, ID	USBR
107	6/3-10/45	44°21	112°11	Spencer, ID	R1, 2-5A
108	12/25-27/45	46°00	118°03	Walla Walla, WA	R1, 1-25
109	12/26-30/45	41°52	123°58	Gasquet, CA	NP 3A-7
110	10/1-2/46	43°48	115°08	Atlanta, ID	USBR
111	11/17-20/46	44°19	115°38	Deadwood, ID	NWS-USBR
112	11/18-20/46	43°31	114°21	Sun Valley, ID	R1, 1-26
113	12/8-15/46	46°03	112°12	Peterson's Ranch, WA	USBR
114	6/8-12/47	40°44	111°55	Terminal, UT	R4, 1-30
115	9/16-18/47	44°05	115°37	Lowman, ID	NWS-CS
116	9/16-18/47	41°52	112°28	Blue Creek, UT	USBR
117	9/25-27/47	46°25	117°01	Lewiston, ID	USBR
118	10/15-16/47	44°19	115°35	Deadwood, ID	R1, 1-28
119	1/1-7/48	42°39	124°03	Illahe, OR	USBR
120	1/1-8/48	47°30	116°00	Mullen, ID	NWS-CS
121	6/10-13/48	47°39	120°04	Waterville, WA	USBR
122	5/12-17/48	47°49	124°04	Spruce, WA	USBR
123	2/13-18/49	47°49	124°04	Spruce, WA	USBR
124	8/22/49	43°34	116°43	Moose Creek, ID	USBR
125	6/17/50	46°28	117°35	Nr. Pomeroy, WA	USBR
126	10/26-29/50	42°12	123°37	Kerby, OR	NWS
127	2/7-12/51	47°28	123°51	Quinault, WA	NWS-USBR
128	8/10/52	46°34	120°25	Moxee City, WA	USBR
129	1/15-20/53	42°39	124°04	Illahe 1 W, OR	USBR
130	11/21-23/53	42°12	123°17	Williams 1 SW, OR	USBR
131	6/15/54	44°46	117°10	Richland, OR	NWS
132	10/25/55	47°28	123°51	Quinault, WA	NWS
133	11/3-4/55	47°28	123°51	Quinault, WA	NWS
134	12/18-21/55	42°44	124°30	Port Orford, OR	NWS
135	12/25-27/55	44°53	122°39	Silver Ck. Falls, OR	NWS
136	12/25-27/55	42°26	124°25	Gold Beech, OR	NWS
137	1/1-6/56	44°51	123°40	Valsetz, OR	NWS
138	7/13/56	44°40	120°10	Girds Creek, OR	NWS
139	7/13/56	44°35	120°11	Mitchell, OR	NWS
140	7/21/56	43°19	114°43	Simon Ranch, ID	NWS
141	12/8-10/56	47°48	124°04	Spruce, WA	NWS-USBR
142	2/23-26/57	47°25	123°13	Cushman Dam, WA	NWS-USBR
143	9/30-10/3/57	45°49	119°17	Hermiston 2 S, OR	NWS-USBR
144	11/17-24/59	46°47	121°44	Mt. Rainier, WA	NWS-USBR
145	11/19-23/59	47°22	123°36	Camp Grisdale, WA	COE
146	12/14-16/59	47°27	123°53	Amanda Park, WA	NWS
147	12/14-15/59	47°44	121°25	Grotto, WA	NWS-COE
148	2/9-12/61	44°50	123°40	Valsetz, OR	NWS
149	11/20-24/61	42°38	124°03	Illahe, OR	NWS-USBR
150	6/19/62	43°13	116°34	Nr. Murphy, ID	NWS-USBR

Table A1. Continued

Storm Number	Date	Latitude	Longitude	Nearest Town	Ref. Source
151	11/18-21/62	47°27	123°53	Amanda Park, WA	NWS-USBR
152	12/1-3/62	44°44	122°15	Detroit Dam, OR	NWS-USBR
153	1/29-2/3/63	43°50	115°50	Idaho City, ID	NWS
154	2/3-7/63	46°03	118°24	Walla Walla, WA	NWS
155	6/6-8/64	48°19	113°21	Summit, MT	COE-USBR
156	12/19-24/64	42°39	124°04	Illahe, OR	USBR
157	12/20-25/64	44°19	115°38	Deadwood Dam, ID	NWS-USBR
158	1/23-30/65	44°51	123°40	Valsetz, OR	NWS-USBR
159	12/27-30/65	42°38	124°03	Illahe, OR	NWS-USBR
160	6/6-15/67	47°04	112°22	Rodgers Pass, MT	NWS-USBR
161	8/20/68	43°52	117°00	Nyssa, OR	NWS
162	6/8-9/69	44°40	121°09	Machas, OR	NWS
163	6/9/69	44°28	118°44	Prairie City, OR	NWS-USBR
164	5/25/71	45°20	119°24	Heppner, OR	USBR
165	1/11-18/74	44°51	123°40	Valsetz, OR	NWS
166	1/11-18/74	47°22	123°00	Hoodsport, WA	NWS
167	1/12-19/74	42°45	124°30	Port Orford 5 E, OR	NWS
168	1/13-16/74	47°30	116°00	Mullen, ID	NWS
169	12/19-22/74	44°51	123°40	Valsetz, OR	NWS
170	1/23-26/75	45°18	121°51	Gov't. Camp, OR	NWS-USBR
171	*				
172	12/1-7/75	47°28	123°51	Quinault, WA	NWS-USBR
173	2/13-15/79	47°30	115°53	Wallace, ID	
174	12/13-16/79	47°57	124°22	Forks, WA	
175	12/24-27/80	44°51	123°40	Valsetz, OR	
176	11/30-12/4/75	47°44	121°05	Stevens Pass, WA	
177	11/30-12/4/75	47°16	123°42	Aberdeen 20 NNE, WA	
178	11/30-12/4/75	45°49	123°46	Nehalem 9 NE, OR	
	*Eliminated				

Table A2. Important storms located south of the Northwest Study region.

Storm Number	Date	Latitude	Longitude	Storm Number	Date	Latitude	Longitude
501	12/19-20/1866	37°46	122°28	551	5/11-14/1941	39°30	121°00
502	11/22/1874	38°31	123°15	552	9/18-23/1941	37°41	108°02
503	4/20/1880	38°35	121°30	553	11/15-19/1942	39°00	120°30
504	1/30/1888	40°15	124°11	554	1/19-24/1943	37°35	119°25
505	8/11/1890	37°27	117°42	555	1/20-24/1943	38°49	106°37
506	10/10-15/1899	39°23	108°06	556	1/21-23/1943	37°36	115°14
507	2/12/1904	37°57	122°33	557	5/4-9/1943	40°21	106°55
508	1/12-19/1906	40°00	122°00	558	5/31-6/5/1943	40°36	111°35
509	2/1-5/1907	41°40	115°25	559	6/1-3/1943	39°33	107°20
510	3/15-27/1907	39°55	121°25	560	6/10-13/1943	41°40	115°25
511	12/14-17/1908	37°30	108°30	561	1/30-2/3/1945	37°35	119°30
512	1/11-16/1909	39°00	120°25	562	8/17-19/1945	37°37	114°30
513	8/28-9/2/1909	39°30	110°50	563	12/27/1945	37°54	112°34
514	9/3-7/1909	37°34	107°48	564	10/27-29/1946	37°25	114°07
515	1/23-31/1911	39°55	121°25	565	5/9-14/1947	40°45	109°40
516	5/18/1911	39°41	120°59	566	6/4-5/1947	40°30	121°15
517	10/4-6/1911	37°53	107°39	567	6/8-12/1947	41°09	111°55
518	3/19-21/1912	39°01	107°31	568	11/15-21/1950	39°10	120°30
519	8/4/1913	39°34	111°39	569	11/20/1950	41°22	124°01
520	12/3-6/1913	40°06	105°50	570	7/19/1955	37°44	118°15
521	12/29/1913- 1/3/1914	39°55	121°25	571	12/21-23/1955	39°30	119°47
				572	12/21-24/1955	39°36	121°06
522	1/23-2/2/1915	41°10	121°00	573	8/16/1958	41°03	111°38
523	5/9/1915	40°23	112°12	574	9/18/1959	40°36	122°23
524	5/9-11/1915	39°45	121°15	575	10/11-13/1962	39°42	121°18
525	1/1-4/1916	39°50	121°35	576	1/31-2/1/1963	40°19	111°34
526	2/20-22/1917	37°35	119°35	577	12/19-23/1964	39°42	121°12
527	3/4-9/1918	38°49	106°37	578	8/1/1968	37°49	109°23
528	9/12/1918	37°08	121°55	579	8/27/1970	40°50	115°40
529	9/13-14/1918	40°10	122°14	580	9/3-7/1970	37°38	109°04
530	11/18/1920	38°31	123°15	581	8/7/1971	38°59	119°50
531	4/14-15/1921	40°06	105°50	582	2/7-8/1909	40°39	111°30
532	8/3/1924	37°12	108°29	583	1/24-31/1911	40°39	111°30
533	4/5-6/1925	41°45	115°25	584	5/27-28/1913	39°28	119°04
534	6/26-29/1927	37°30	107°10	585	11/25-30/1919	37°29	107°10
535	9/6-10/1927	37°33	107°49	586	3/25-26/1920	40°36	111°35
536	3/22-27/1928	40°00	122°00	587	8/25-27/1920	39°28	119°04
537	10/11-14/1928	40°20	110°30	588	8/17-25/1921	37°08	107°38
538	7/27-8/7/1929	37°33	107°49	589	8/21-22/1921	37°29	107°10
539	12/8-13/1929	41°05	122°10	590	9/15-19/1923	37°29	107°10
540	11/12-17/1930	41°40	115°25	591	4/7-8/1935	38°35	121°30
541	8/25-29/1932	37°49	107°40	592	7/8-13/1937	41°36	109°13
542	2/1-3/1936	40°36	111°36	593	7/16/1940	38°40	108°59
543	2/19-24/1936	40°36	111°36	594	6/24/1943	38°52	106°58
544	12/9-12/1937	38°51	122°43	595	7/30/1945	40°46	111°54
545	12/9-12/1937	37°35	119°30	596	8/11-14/1943	37°29	107°10
546	2/27-3/4/1938	37°36	115°14	597	8/13/1946	40°06	108°48
547	2/28-3/5/1938	37°24	112°30	598	6/11-12/1947	38°52	106°58
548	6/20-23/1938	38°52	106°58	599	6/18/1949	41°14	112°02
549	8/31-9/3/1938	38°49	106°37	600	11/13-20/1950	39°19	120°38
550	2/24-29/1940	39°55	121°25	601	10/12-15/1957	39°31	107°47

Table A2. Continued

Storm Number	Date	Latitude	Longitude	Storm Number	Date	Latitude	Longitude
602	6/6/1958	39°07	108°32				
603	7/13/1962	40°46	111°54				
604	10/8-15/1962	39°21	120°39				
605	1/29-2/2/1963	38°00	119°50				
606	7/18/1965	40°27	111°43				
607	7/30/1965	40°46	111°54				
608	8/21/1965	40°46	111°54				
609	9/5-6/1965	40°46	111°54				
610	9/1/1965	40°46	111°54				
611	8/7/1967	38°52	107°35				
612	9/5/1967	37°41	108°02				
613	1/8-27/1970	40°59	121°59				
614	6/21/1970	40°46	111°54				
615	9/5/1970	40°46	111°54				
616	7/19/1971	40°46	111°54				
617	8/28/1971	40°46	111°54				
618	6/31/1972	40°46	111°54				
619	1/15-19/1973	39°34	121°06				
620	5/25/1973	40°46	111°54				
621	7/13/1973	40°46	111°54				
622	7/19/1973	40°46	111°54				
623	3/25-4/2/1974	40°43	122°25				
624	7/8-9/1974	39°19	120°38				
625	7/17/1974	40°46	111°54				
626	10/7/1975	40°46	111°54				
627	7/15/1977	37°46	108°54				
628	8/18/1977	41°44	111°49				
629	6/4/1978	39°34	107°20				
630	1/3-4/1982	37°45	122°30				

APPENDIX 2

DEPTH-AREA-DURATION TABLES
and
SYNOPTIC DESCRIPTIONS

This appendix contains depth-area-duration (DAD) tables computed by the ministorm procedure (see Chapter 5) for each of the United States storms listed in Table 2.1. These 28 storms were selected from the master storm listing given in Appendix 1 (Table A1), and believed to be the most significant storms affecting the Northwest region, depending on magnitude, location and season of occurrence. Synoptic descriptions for some of the storms in Table 2.1 follow the DAD tables in this Appendix.

Half of the 28 storms in this sample have multiple centers, and DAD results are given for both the "Entire Storm" and for any additional centers. Latitude and longitude (in degrees/minutes) of the various centers have been annotated on the DAD printouts for convenience. It should be noted that the location of these centers, as well as those in Table 2.1, may be somewhat different from the positions shown for the same storms in Appendix 1 (Table A1). The locations shown on the DAD tables and in Table 2.1 were taken from the isopercental centers for each storm, while those in Appendix 1 (Table A1) represent the location of the observed rainfall maxima prior to the reanalysis of this study. It should also be noted that in rows where "0" square miles is the lowest area size shown (such as the entire storm 32 table), the actual area size being represented is some value ranging from a point to less than 1 square mile.

STORM 5 - MAY 28-30, 1906

ENTIRE STORM

46 01'N 118 04'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48
7	0.47	2.47	4.18	5.33	6.16	7.15	8.26	8.71	9.29
10	0.47	2.47	4.18	5.33	6.16	7.15	8.26	8.71	9.29
50	0.47	2.47	4.18	5.33	6.16	7.15	8.26	8.71	9.29
100	0.47	2.46	4.16	5.30	6.14	7.13	8.23	8.68	9.27
200	0.43	2.27	3.84	4.89	5.75	6.76	7.88	8.33	8.95
500	0.38	1.98	3.35	4.27	5.13	6.13	7.23	7.68	8.29
1000	0.31	1.64	2.77	3.57	4.36	5.33	6.37	6.80	7.39
2000	0.25	1.18	1.99	2.73	3.34	4.30	5.25	5.69	6.22
5000	0.19	0.88	1.55	2.17	2.54	3.04	3.71	4.10	4.44
10000	0.14	0.68	1.22	1.69	2.06	2.44	2.76	3.13	3.34
16378	0.14	0.57	1.00	1.40	1.72	2.05	2.29	2.56	2.71

STORM 12 - NOV 17-19, 1909

ENTIRE STORM

48 12'N 115 41'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48
7	0.55	1.47	2.20	3.05	3.87	4.19	4.79	5.57	6.34
10	0.55	1.47	2.20	3.05	3.87	4.19	4.79	5.57	6.34
50	0.53	1.42	2.13	2.95	3.74	4.06	4.64	5.39	6.14
100	0.50	1.34	2.01	2.78	3.53	3.83	4.38	5.08	5.79
200	0.45	1.23	1.81	2.50	3.17	3.44	3.95	4.60	5.23
500	0.41	1.13	1.56	2.16	2.74	3.01	3.51	4.08	4.63
1000	0.39	1.08	1.39	1.92	2.44	2.72	3.22	3.73	4.22
2000	0.37	1.02	1.22	1.68	2.13	2.43	2.92	3.39	3.82
5000	0.30	0.88	1.02	1.34	1.68	1.99	2.38	2.78	3.14
10000	0.22	0.74	0.84	1.06	1.32	1.55	1.84	2.19	2.49
17344	0.16	0.58	0.65	0.83	1.05	1.20	1.42	1.71	1.96

STORM 29 - JUNE 19-22, 1916

ENTIRE STORM

47 41'N 112 43'W

AREA (SQ. MI.)	DURATION (HR) 1	6	12	18	24	30	36	42	48	54	60	66	72
14	1.20	3.54	5.60	6.91	7.34	7.93	8.31	8.86	9.14	9.25	9.27	9.27	9.27
50	1.20	3.54	5.60	6.91	7.34	7.93	8.31	8.86	9.14	9.25	9.27	9.27	9.27
100	1.18	3.46	5.50	6.79	7.21	7.80	8.18	8.74	9.03	9.14	9.16	9.16	9.16
200	1.11	3.28	5.24	6.50	6.91	7.48	7.85	8.45	8.76	8.87	8.89	8.89	8.89
500	0.98	2.89	4.69	5.92	6.29	6.85	7.24	7.88	8.22	8.33	8.35	8.36	8.36
1000	0.85	2.49	4.08	5.25	5.61	6.14	6.55	7.21	7.55	7.67	7.69	7.70	7.70
2000	0.68	2.00	3.32	4.34	4.68	5.13	5.51	6.13	6.47	6.59	6.62	6.64	6.65
5000	0.43	1.29	2.24	2.95	3.33	3.67	3.99	4.46	4.83	5.03	5.08	5.16	5.18
10000	0.28	0.90	1.63	2.13	2.51	2.81	3.05	3.40	3.77	4.01	4.06	4.15	4.18
18924	0.18	0.69	1.25	1.66	1.99	2.21	2.42	2.64	2.97	3.20	3.24	3.31	3.34

STORM 32 - DEC 16-19, 1917
WESTERN OREGON CENTER
44 55'N 123 46'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
0	1.46	6.41	7.58	8.45	10.66	11.95	13.55	13.84	15.32	15.49	17.41	17.43	17.43
10	1.46	6.41	7.58	8.45	10.66	11.95	13.55	13.84	15.32	15.49	17.41	17.43	17.43
50	1.41	6.21	7.34	8.18	10.32	11.69	13.11	13.47	15.11	15.33	17.16	17.22	17.23
100	1.37	6.02	7.11	7.93	10.01	11.09	12.71	12.99	14.58	14.89	16.53	16.67	16.70
200	1.29	5.66	6.71	7.52	9.54	10.21	12.14	12.45	13.57	13.92	15.38	15.57	15.60
500	1.11	4.87	5.88	6.74	8.76	9.38	11.19	11.67	12.47	13.10	14.24	14.38	14.42
1000	0.97	4.27	5.26	6.16	8.17	8.84	10.47	11.09	11.73	12.61	13.50	13.60	13.65
2000	0.78	3.42	4.29	5.06	6.82	7.50	8.81	9.40	10.29	11.11	12.09	12.19	12.24
5000	0.53	2.34	2.94	3.49	4.82	5.76	6.35	7.04	8.18	8.70	9.71	9.79	9.83
5444	0.51	2.23	2.82	3.35	4.63	5.59	6.12	6.83	7.94	8.43	9.41	9.51	9.54

STORM 32 - DEC 16-19, 1917
ENTIRE STORM
44 55'N 123 46'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
0	1.46	6.41	7.58	8.45	10.66	11.95	13.55	13.84	15.32	15.49	17.41	17.43	17.43
10	1.46	6.41	7.58	8.45	10.66	11.95	13.55	13.84	15.32	15.49	17.41	17.43	17.43
50	1.41	6.21	7.34	8.18	10.32	11.69	13.11	13.47	15.11	15.33	17.16	17.22	17.23
100	1.37	6.02	7.11	7.93	10.01	11.09	12.71	12.99	14.58	14.89	16.53	16.67	16.70
200	1.29	5.66	6.71	7.52	9.54	10.21	12.14	12.45	13.57	13.92	15.38	15.57	15.60
500	1.11	4.87	5.88	6.74	8.76	9.38	11.19	11.67	12.47	13.10	14.24	14.38	14.42
1000	0.97	4.27	5.26	6.16	8.17	8.84	10.47	11.09	11.73	12.61	13.50	13.60	13.65
2000	0.78	3.42	4.29	5.06	6.82	7.50	8.81	9.40	10.29	11.11	12.09	12.19	12.24
5000	0.53	2.34	3.11	3.99	4.82	5.76	6.35	7.04	8.18	8.70	9.71	9.79	9.83
10000	0.40	1.76	2.57	3.48	4.22	4.99	5.52	6.17	7.19	7.64	8.47	8.58	8.63
20000	0.30	1.23	2.14	2.99	3.74	4.29	4.85	5.41	6.34	6.73	7.39	7.53	7.59
33167	0.24	0.98	1.84	2.72	3.38	3.81	4.35	4.73	5.40	5.75	6.32	6.44	6.50

STORM 32 - DEC 16-19, 1917
CASCADES CENTER
45 29'N 121 52'W

AREA (SQ. MI.) / DURATION (HR)

AREA (SQ. MI.)	1	6	12	18	24	30	36	42	48	54	60	66	72
2	1.07	4.00	5.75	7.73	8.13	9.34	9.86	9.86	10.70	11.76	12.48	12.93	13.08
10	1.07	4.00	5.72	7.59	7.98	9.17	9.68	9.68	10.51	11.56	12.25	12.68	12.82
50	0.92	3.51	5.16	6.93	7.29	8.37	8.84	8.84	10.21	11.36	12.02	12.45	12.57
100	0.84	3.22	4.80	6.45	6.79	7.79	8.23	8.23	9.97	11.08	11.73	12.14	12.25
200	0.76	2.93	4.51	6.06	6.37	7.32	7.72	7.82	9.52	10.57	11.20	11.58	11.70
500	0.64	2.56	4.15	5.56	5.85	6.74	7.12	7.26	8.82	9.77	10.35	10.70	10.79
1000	0.56	2.30	3.89	5.20	5.47	6.36	6.71	6.89	8.30	9.18	9.70	10.01	10.08
2000	0.48	2.03	3.47	4.59	4.94	5.78	6.14	6.34	7.71	8.44	8.98	9.28	9.35
5000	0.38	1.60	2.69	3.49	4.08	4.79	5.17	5.78	6.82	7.39	7.91	8.16	8.24
8374	0.30	1.36	2.26	2.87	3.59	4.23	4.62	5.48	6.43	6.88	7.40	7.61	7.70