ADMINISTRATIVELY RESTRICTED

U. S. Department of Commerce
Weather Bureau

U. S. Department of the Army
Corps of Engineers

Hydrometeorological Report No. 28

GENERALIZED ESTIMATE OF MAXIMUM POSSIBLE PRECIPITATION OVER NEW ENGLAND AND NEW YORK

Reprinted September 1952

Prepared by
Hydrometeorological Section
Division of Hydrologic Services
U. S. Weather Bureau

Washington, D.C.
March 1952

CONTENTS

FIGURES

Introduction. The Chief of Engineers, Department of the Army, in May 1951, requested the Hydrometeorological Section of the Weather Bureau to prepare a generalized estimate of maximum possible precipitation over New England and New York. The study, required to meet the needs of the Federal Inter-Agency River Basin Committee, was to be a revision and extension of Hydrometeorological Report No. 23, Generalized Estimates of Maximum Possible Precipitation over the United States East of the 105th Merdian. In that report New York and most of New England were classified as a region of least reliability of the maximum precipitation estimate because of the rough terrain and the paucity of processed storm data. It was requested that means be found, if possible, to increase the reliability of the estimate of maximum precipitation, that the estimate be extended to areas of 5000 square miles, and that the results be presented on a map of larger scale.

The generalized estimates of maximum possible precipitation furnished here are not to be construed as supplying directly the maximum storm for particular projects. For final studies these estimates should be reconsidered for specific basins. Furthermore, having obtained the best available estimate of the maximum possible precipitation, the recommendation of the Hydrometeorological Section and the current practice of the Engineers is not to employ the entire range of maximum depth-duration-area values for a flood storm. Short-duration small-area storms tend to be of a different type than large-area long-duration storms, and it is not likely that all maximum possible values would be closely approached in a single storm. One or more observed pattern storms are transposed to the basin concerned and fitted to the position for most critical precipitation by permissible rotation, then adjusted upward so that the maximum possible precipitation is matched at one duration and area. Procedures for doing this are suggested in Chapter V of Hydrometeorological Report No. 27, Estimate of Maximum Possible Precipitation, Rio Grande Basin, Fort Quitman to Zapata, and in various Preliminary Estimate reports.

Basic generalized charts. In Hydrometeorological Report No. 23 the generalized estimates of maximum possible precipitation were presented as a series of isohyetal charts for the region of the United States east of the 105th meridian. A chart was given for each of various durations for areas of 10, 200, and 500 square miles. In the present study similar charts were constructed for the New England-New York region for durations and areas of 6, 12, 24, 36, 48, and 72 hours and 10, 200, 500, 1000, 2000, and 5000 square miles. Figure 1 gives the new chart for 24 hours, 500 square miles. The remaining 35 charts of the set were consolidated, by methods to be described later, to a single diagram (figure 2) relating them to figure 1.

Hydrometeorological procedure. The same hydrometeorological procedure followed in Report No. 23 was repeated in developing the set of 36 basic generalized charts referred to above. Transposition limits were determined for storms occurring in and transposable to the region concerned. Depth-duration-area values for these storms were transposed to various points within the limits and adjusted for the appropriate moisture potential. Finally, values for each duration and area were plotted on maps, and enveloping isohyets constructed.

As the procedure of Report No. 23 was repeated step by step for the New England-New York region, refinements, made possible by concentration on the smaller region, were introduced. These refinements will be discussed in turn.

Storm data. Available storm studies supplied most of the basic precipitation data. One purpose of the project, however, was to insure that pertinent storms were not overlooked. Toward that end both United States and Canadian meteorological records were searched, and sixty-odd storms not previously worked up were selected. Enough data was processed for each of these to determine whether or not it would give controlling values on the generalized charts. This screening produced controlling values for the charts from two new storms. One was a hurricane passing over Nova Scotia in September 1942, (transposed to New England coast). The other was the storm of December 29, 1948, to January 1, 1949, centered at Berlin, N. Y., (transposed to the upper Hudson Valley). Several storms that did not give controlling values were near controlling, and contributed some guidance and confidence to the construction of enveloping isohyets on the generalized charts.

Moisture adjustment. Considerable attention was given to improved moisture adjustment for storms near the coast whose previously adopted representative dewpoints were not considered satisfactory because of lack of dewpoint observations in the tropical air. For these storms, coastal dewpoints had been employed in previous studies when the warm sector actually was over the sea. The improvement was accomplished by estimating dewpoints from ship weather observations assembled from various sources. (The new representative dewpoints resulted in lower moisture adjustments for seven out of nine major storms.) Because of the fewness and mobility of the ships, it was not feasible to take the dewpoints from specific observations as is normally done. Rather, dewpoint isopleths for the western Atlantic were constructed for each storm from such data as were available, full consideration being given to relating the dewpoint to air and sea surface temperatures and the trajectory of the air. Dewpoints were then read from the isopleths at whatever point was considered most representative of the inflowing tropical air.

Maps were also prepared of maximum possible dewpoint over the western Atlantic, where no direct data were available. The maximum dewpoint maps were derived from maximum values of dewpoint at island and coastal stations and from charts of maximum air temperature and ocean water temperature by application of emperical interrelationships of dewpoint and air and sea temperature. These interrelationships were established largely from three years of weather reports from a United States weather observation and air-sea rescue patrol vessel stationed halfway between Bermuda and New York. The maximum air and sea temperature charts are themselves rather crude products, and a revision of the maximum dewpoint charts would be desirable whenever the climatological services of the world produce better maximum air and sea temperature charts for the oceans.

Because of practical difficulties, a departure was made from the standard hydrometeorological procedure of working with maximum dewpoints persisting over 12 hours as the indices of inflowing moisture. Both the individual storm dewpoints estimated over reaches of the ocean and the charts of maximum possible dewpoint over the ocean are for single observations instead of 12-hour periods.

For storms whose representative dewpoints occurred over land, refinements in moisture adjustment were obtained by searching records of additional first-order weather stations in New England, New York, and Canada for maximum observed 12-hour dewpoints, reduced to 1000 mb. The maximum dewpoint maps were revised accordingly.

Transposition limits. The storms that furnished controlling values for any of the 36 generalized charts are listed with their transposition limits in the appendix. Transposition limits for old storms were carefully reviewed and some changes made.

Orographic influences. A considerable portion of the effort of the project was expended on the problem of orographic control of precipitation. The first problem was whether or not there is a real orographic influence on precipitation in New England and New York. An analysis of mean annual rainfall leads to an affirmative answer, as the observed areal distribution of mean annual precipitation can be explained in no other logical way. The problem thus evolved into an attempt to determine the direction from which rain-bearing air currents might be expected in various parts of the region and the orographic effect for each direction. A cross-tabulation of hourly precipitation and hourly surface wind direction for first-order Weather Bureau stations provided a basis for forming some judgments on the rain-bearing wind directions. This tabulation suggests that for New England precipitation the seaward slopes should be considered the windward slopes. Storms with the flow predominantly from the west are of lesser importance. In New York either of two types is important: storms with easterly flows carrying moisture back into the interior from the Atlantic, and storms bringing up Gulf air west of the Appalachians. These conclusions were supported by a review of the inflow trajectories in major storms.

As to the influence of the topography in increasing or inhibiting the release of moisture from an air current of a particular direction, many procedures failed to establish parameters for well-defined statistical estimation. Lacking an objective procedure, the maximum isohyets on the 24-hour 500-square-mile base chart (figure 1) have been subjectively modified up to about one-half inch. This is in line with opinion derived from study of many isohyetal patterns, the distribution of mean annual precipitation, and meteorological reasoning that a slight packing of the isohyets should be expected behind the southern New England coast, along the first principal ridges in New England, and along the Catskill-Adirondack axis in New York.

The Hydrologic Investigations Section of the Weather Bureau is carrying out further work on orographic control of precipitation in New England and New York.

Ratio chart. Maximum possible precipitation is an inherent characteristic of the climate of a region. In studies such as the present one we seek to assess this climatic factor. The ratio of maximum precipitation for one duration and areal-extent to that for some other duration and areal-extent changes less from region to region than the depth of precipitation itself. Thus, while the maximum possible precipitation over 500 square miles in 24 hours on Long Island is about 100% greater than that over northern Maine, the ratio of 72-hour 1000-mile maximum rainfall to the 500-mile 24-hour value varies only 7% or 8% between the regions. This lesser variation of the ratios has permitted the preparation of the ratio diagram of figure 2, which presents the ratios of maximum possible precipitation for durations from 6 to 72 hours and areas from 10 to 5000 square miles to the maximum possible precipitation for 24 hours and 500 square miles. To derive these ratios, first, values were read from the 36 generalized charts at 46 points throughout New England and New York. Then, at each point, ratios of the other values to the 24-hour 500-square-mile value were computed. Mean ratios were obtained for each duration and area by averaging. Each generalized chart was reconstructed by multiplying the base 24-hour 500-square-mile value at every point by the mean ratio for the particular duration and area. By successive trials the base 24-hour 500-square-mile chart was modified slightly to minimize the differences between the computed generalized charts and the basic set. Various trials were also made with mean ratios for various sub-areas rather than for the entire area. Figure 2 represents the outcome of these trials. There is less regional variation of the ratios for larger areas than for smaller areas, particularly 10 square miles. This may well be the real climatic situation and not just a limitation of the data. Therefore, on the final ratio chart, figure 2, mean ratios for the entire region are employed for the longer durations and larger areas, but two sets of ratios are presented for part of the diagram. The solid lines apply to all of New England and New York, dashed lines to New York west of the Catskill-Adirondack axis, and the dash-dot curves to the remainder of New York and New England. The line of demarcation of the zones is marked on figure 1 with dashes.

To construct maximum depth-duration-area curves for a particular site proceed as follows. Obtain the 24-hour 500-square-mile maximum possible precipitation for the site from figure 1. Then, obtain all other values by multiplying this base depth by the proper ratios taken from figure 2.

Differences in ratio values and basic chart values. The ratio chart represents the addition of one step to the procedure followed in Report No. 23, a smoothing step that spreads and intermingles the influence of the various storms beyond their own transposition limits to a greater extent. In no case is the computed (ratio chart) depth at any duration or area less than that in an observed storm, adjusted for moisture, in its place of occurrence. In some instances storm values, adjusted for moisture, are "undercut" at the extreme limits of the respective transposition areas by 0.5 inch to 0.7 inch. This undercutting amounts, in effect, to a slight contraction of the transposition limits. In some regions the ratio diagram reduced the original values on the 36 charts as much as two inches, but in these regions the basic analysis was an envelopment, and the data itself is not undercut. In other regions the basic analysis is exceeded. The greatest exceedance is for 10-square-mile areas in Maine, at short durations. Adoption of these higher values is tantamount to saying that sampling of small-area very intense storms is particularly inadequate in Maine, and that the best estimate is obtained by "smoothing." In other words, on the basis of what has occurred over larger areas, the maximum precipitation estimate for small areas in Maine is placed intermediately between the highest small-area values observed there (or directly transposable there) and small-area values for storms not directly transposable but occurring within a 600- or 700- mile radius.

Snow melt. Potential snow melt forms an important portion of the flood threat in the region covered by this study. For example, in the December 29, 1948 - January 1, 1949 storm, a controlling storm on the generalized charts, the resulting flood was greatly augmented by snow melt. The question of snow melt in New England was discussed in Hydrometeorological Report No. 1, Maximum Possible Precipitation over the Ompomponoosac Basin above Union Village, Vt. Snow melt is not treated in the present report, and the maximum possible precipitation, irrespective of season or snow, is the end product.

Acknowledgments. The project leader was Vance A. Myers, and the principal contributor was James F. Appleby. Other contributors included W.A. Hass, R.E. Helbush, R.E. Johnson, J.T. Moran, and Mrs. Pearl Pierce (all of whom are no longer with the Section), A.E. Brown, J.L. Keister, and John T. Lindgren. Editing was by Lillian K. Rubin, typing by Miss Marian Hammer and Mrs. Violet Fowler. Figures were drafted by C. W. Gardner.

APPENDIX

Controlling Storms and Their Transposition Limits

1. Canton, Conn. (NA 1-2) Oct. 1-5, 1869.

   West to Catskills in New York and Green Mountains in Vermont, north to Canadian border, east to Coast, south to 40°N.

2. Wellsboro, Pa. (SA 1-1) May 30-June 1, 1889.

   West to Appalachian Divide, north to 43°N, east to 500-ft elevation contour, south to 34°N. (Apply only to Wellsboro, Pa., center of the storm.)

3. Jewel, Md. (NA 1-7) July 26-29, 1897.

   West to 1000-ft elevation contour, north to Canadian border, east to Coast, south to 36°N.

4. Paterson, N.J. (GL 4-9) Oct. 8-9, 1903.

   West to 1000-ft elevation contour, north to latitude of Boston, east to Coast, south to 36°N.

5. Beaulieu, Minn. (UMV 1-11a) July 18-23, 1909

   Cooper, Mich. (GL 2-16) Aug. 31 - Sept. 1, 1914

   Boyden, Iowa (MR 4-24) Sept. 17-19, 1926

   Stanton, Nebr. (MR 6-13) June 10-13, 1944

   East to a line from Chattanooga, Tenn., through Erie, Pa. into Canada, north into southern Canada, south to 35°N.

6. Kinsman Notch, N. H. (NA 1-17) Nov. 2-7, 1927

   West to eastern border of New York, north to Canadian border of Vermont and New Hampshire and latitude of Mt. Katahdin in Maine (45°55'N), east to longitude of Mt. Katahdin (68°55'W) and Coast, south to Connecticut-Rhode Island coast.

7. Westerly, R.I. (NA 1-20) Sept. 16-17, 1932

Northeastward to 45°N 68°W, south to 36°N, from East Coast inland as far as actually occurred. (Apply to Westerly, R.I., center only.)

8. Hector, N. Y. (NA 1-27) July 6-10, 1935

Limits bounded by line joining the points 42°N 77°W, 45°N 77°W, 47 1/2°N 75°W, 47 1/2°N, 73°W, 44°N 73°W, 42°N 75°W. (Apply to Hector, N. Y., center only.)

9. Ewan, N. J. (NA 2-4) Sept. 1, 1940

South to 33°N, west to 500-ft elevation contour from 33°N through New Jersey, north to Poughkeepsie and Boston, east to Coast.

10. Smethport, Pa. (OR 9-23) July 17-18, 1942

North to 43°N, east to Appalachian Divide, south to southern Tennessee border, west to 150 miles west of divide.

11. Stellarton, Nova Scotia Sept. 20-24, 1942

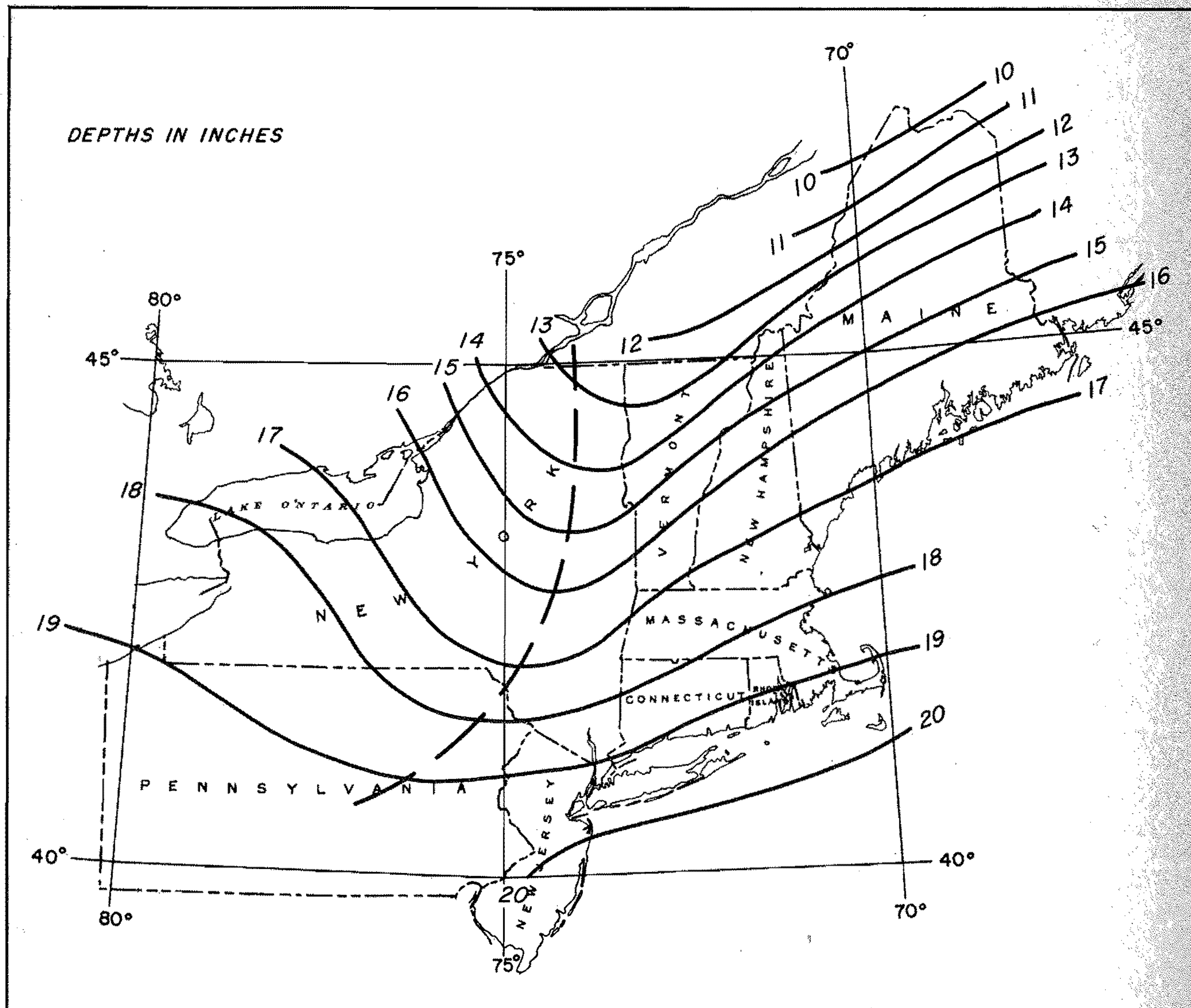
South to 40°N, from East Coast inland to 500-ft elevation contour or a maximum of 100 miles, northeastward into New Brunswick.

12. Berlin, N. Y. (NA 2-18) Dec. 29, 1948 - Jan. 1, 1949

North to latitude of Mt. Katahdin (45° 55'N), east to longtitude of Mt. Katahdin (68° 55'W), south to 40°N, from Coast inland to second principal range. (Adirondack - Catskill line in New York, Green Mountains in northern Vermont and New Hampshire-Canadian border).

GENERALIZED ESTIMATE OF MAXIMUM POSSIBLE PRECIPITATION

24 HOURS — — 500 SQUARE MILES



RATIOS OF MAXIMUM PRECIPITATION TO 24-HR 500-SQUARE-MILE DEPTH

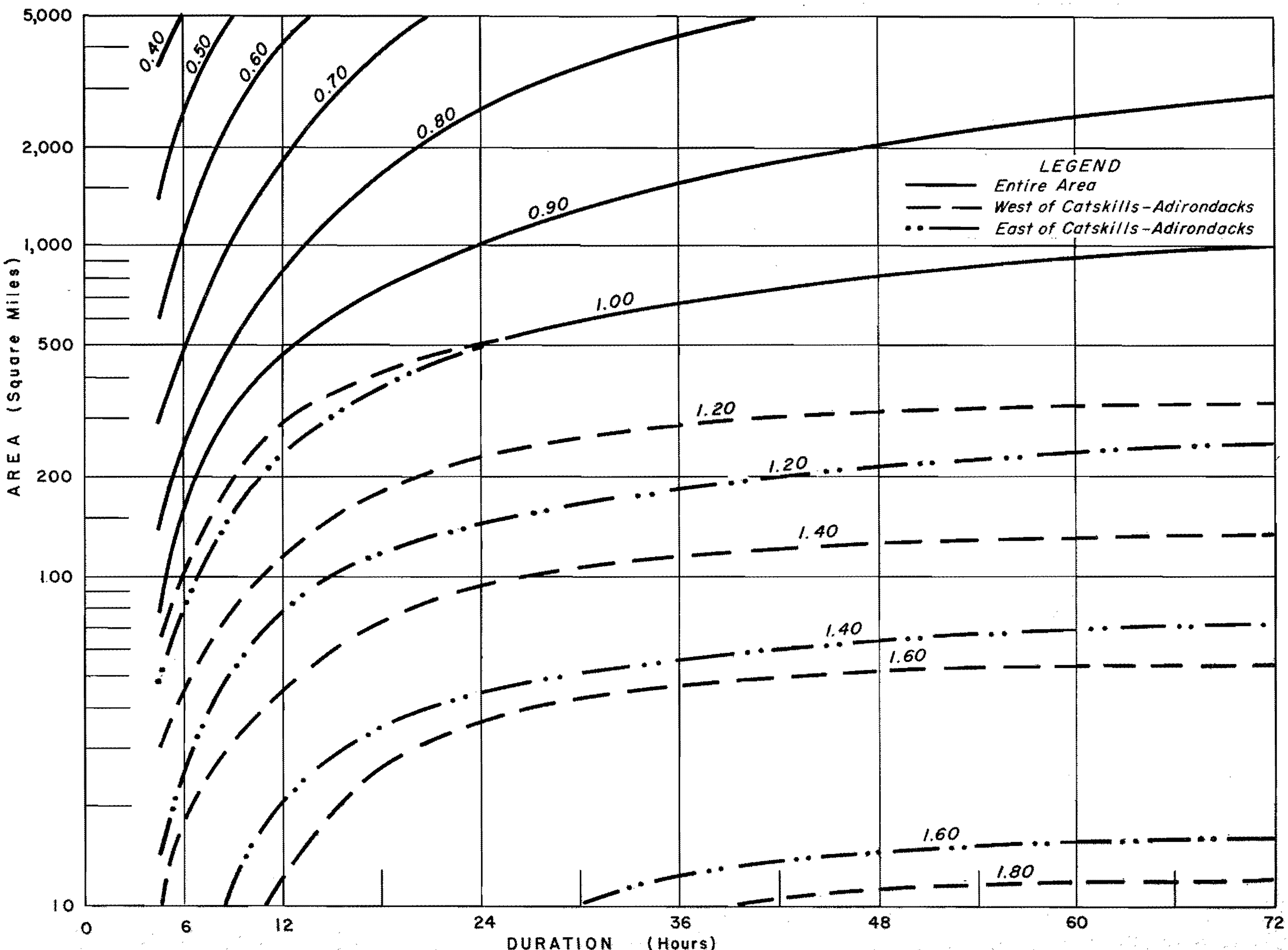


Figure 2