3.1.3 Mean annual and seasonal precipitation

Mean annual and seasonal precipitation at different locations in mountainous terrain can be influenced greatly by the varying frequency of relatively light rains. Some weather situations produce precipitation on mountains when little or no precipitation is observed in valleys, and storm precipitation generally has longer durations in the mountains. Thus, the variation indicated by mean annual or seasonal precipitation maps is not necessarily a reliable index of geographic variation in PMP unless adjusted for these biases. An adjustment technique frequently used is based on the mean number of rainy days at stations in the project area and a map showing the average station or point precipitation per rainy day (which is usually defined as any day with measurable precipitation, although a higher threshold value, for example 2 mm, is sometimes used). The most representative mean annual and seasonal precipitation maps are those based on other data in addition to precipitation (Nordenson, 1968; Solomon and others, 1968), and such maps should be used whenever possible.

3.1.4 Precipitation-frequency values

Precipitation-frequency values represent an equal probability level of rainfall. The values for the rarer recurrence intervals, for example the 50-year or 100-year recurrence interval, are associated with severe weather systems. Therefore, they are better indicators of the geographic variation of PMP than mean seasonal or annual precipitation maps. Ratios of precipitation-frequency values between those at a storm location and those over an individual basin have been used to adjust rainfall amounts when storms have been transposed in mountainous regions. Since precipitation-frequency values represent equal probability, they can also be used as an indicator of the effects of topography over limited regions. If storm frequency, moisture availability, and other precipitation-producing factors do not vary, or vary only slightly, over an orographic region, differences in precipitation-frequency values should be directly related to variations in orographic effects. This concept was used to adjust convergence PMP for orographic variations in an American study (Miller and others, 1984*b*) and as an index to the geographic distribution of the orographic component of PMP in other studies (Hansen and others, 1977; United States Weather Bureau, 1961*a*, 1966).

3.1.5 Storm transposition

Because of the dual nature of precipitation in mountainous regions, the similarity between storm precipitation patterns and topography is limited, varying with the precipitation-producing factors involved. Nevertheless, in mountainous terrain, orographic influences on precipitation can be significant, even in major storms. For this reason, caution should be exercised in transposing storms in such regions because their precipitation patterns are usually linked to the orography where they were observed.

3.1.6 Probable maximum precipitation

PMP estimates for orographic regions must be based on two precipitation components:

(a) orographic precipitation, which results from orographic influences;
(b) convergence precipitation, which results from atmospheric processes presumed to be independent of orographic influences.

Both components must be evaluated in making PMP estimates in orographic regions.

3.1.6.1 Estimation of PMP in orographic regions using the orographic separation method

The orographic separation method consists of estimating each precipitation component separately and then adding them, keeping in mind some necessary restrictions on their addition (United States Weather Bureau, 1961*a*). One method, which is described in sections 3.2 and 3.3, involves the use of an orographic model for evaluating the orographic component (United States Weather Bureau, 1961*a*, 1966). A second method estimates the orographic component using indirect procedures (Hansen and others, 1977). This method is described in section 5.3.5.

3.1.6.2 Modification of non-orographic PMP for orography

Another approach is to first estimate a non-orographic PMP. One technique in this approach is to develop the convergence PMP estimate for the relatively flat regions adjoining the mountains using only storms from non-orographic regions. A second technique is to estimate the convergence component of all storms over a region, both in the orographic and non-orographic portions, and draw generalized charts of convergence PMP. Modifications for terrain influences are then introduced on the basis of differences in storm rainfall data, both in the project basin and surrounding areas, and on sound meteorological judgement derived from storm analyses (Schwarz,