CHAPTER 10

ANALYSIS OF MIXED POPULATIONS

10-1. Definition. The term mixed population, in a hydrologic context, is applied to data that results from two or more different, but independent, causative conditions. For example, floods originating in a mountainous area or the northern part of the United States at a given site could be caused by melting snow or by rain storms. Along the Gulf and Atlantic coasts, floods can be caused by general cyclonic storms or by intense tropical storms. A frequency curve representing the events caused by one of the climatic conditions may have a significantly different slope (standard deviation) than for the other condition. A frequency plot of the annual events, irrespective of cause, may show a rather sudden change in slope and the computed skew coefficient may be comparatively high. In these situations, a frequency curve derived by combining the frequency curves of each population can result in a computed frequency relation more representative of the observed events.

10-2. Procedure.

a. The largest annual event is selected for each causative condition. As Bulletin 17B (46) cautions, "If the flood events that are believed to comprise two or more populations cannot be identified and separated by an objective and hydrologically meaningful criterion, the record shall be treated as coming from one population." Also, Bulletin 17B states, "Separation by calendar periods in lieu of separation by events is not considered hydrologically reasonable unless the events in the separated periods are clearly caused by different hydrometeorologic conditions."

b. The frequency relations for each separate population can be derived by the graphical or analytical techniques described in Chapter 2 and then combined to yield the mixed population frequency curve. The individual annual frequency curves are combined by "probability of union." For two curves, the equation is:

$$P_c = P_1 + P_2 - P_1 P_2 \qquad (10\text{-}1)$$

where:

P_c = Annual exceedance probability of combined populations for a selected magnitude.

P_1 = Annual exceedance probability of same selected magnitude for population series 1.

P_2 = Annual exceedance probability of same magnitude selected above for population series 2.

c. Figure 10-1 illustrates a combined annual-event frequency curve derived by combining a hurricane event frequency curve with a nonhurricane event curve for the Susquehanna River at Harrisburg, PA. For more than two population series, n curves may be more easily combined by the following form:

$$P_c = 1 - (1-P_1)(1-P_2)\ldots(1-P_n) \qquad (10\text{-}2)$$

NOTE: The exceedance probability (percent chance exceedance divided by 100) must be used in the above equations.

d. If partial duration curves are to be added, the equation is simply $P_c = P_1 + P_2$. This assumes that the events in both series are hydrologically independent. When the combined curve is used in an economic analysis, the events in both series must also be economically independent.

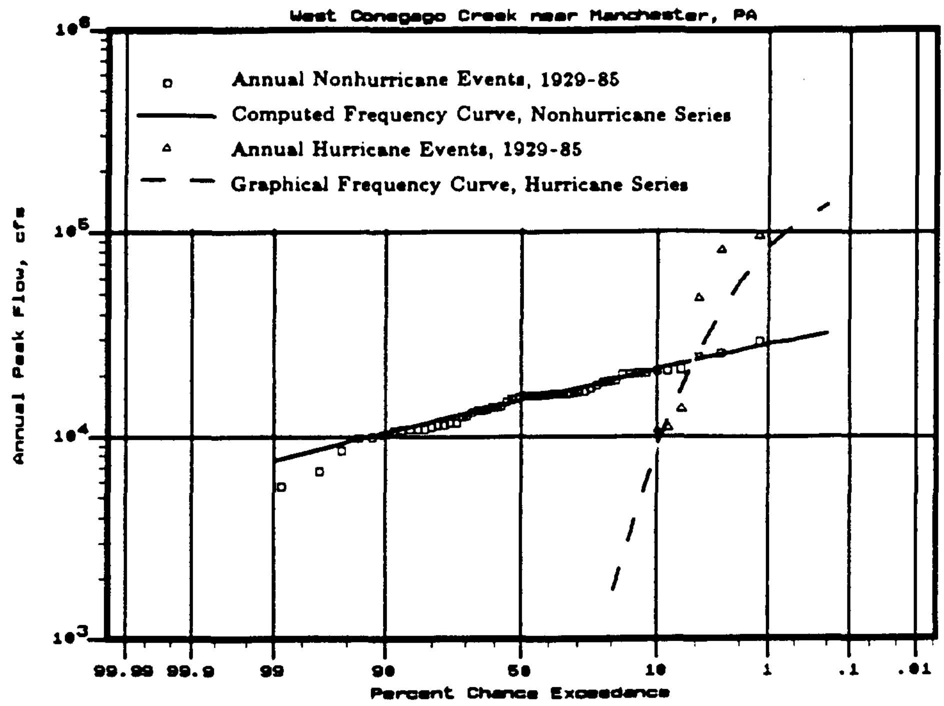
10-3. Cautions.

a. If annual flood peaks have been separated by causative factors, a generalized skew must be derived for each separate series to apply the log-Pearson Type III distribution as recommended by Bulletin 17B. Plate 1 of Bulletin 17B or any other generalized skew map based on the maximum annual event, irrespective of cause, will not be applicable to any of the separated series. Derivation of generalized skew relations for each series can involve much effort.

b. Some series may not have an event each year. For example, tropical storms do not occur every year over most drainage areas in the United States, and quite often there are only a few flood events for the series. Extensive regionalization may be necessary to reduce the probable error in the frequency relations which results from small sample sizes.

c. Sometimes frequency relations of particular seasons are of interest, i.e., quarterly or monthly, and the curves are combined to verify the annual series curve. The combined curve will very likely fit the annual curve only in the middle parts of the curve. The lower end of the curve will have a partial duration shape as many small events have been included in the analysis. Also, it is possible that the slope of the frequency relation will be higher at the upper end of the curve as the one season or month with the maximum event included in its series will likely have a higher slope than that of the annual series.

d. A basic assumption of this procedure is that each series is independent of the other. Coincidental frequency analysis techniques must be used where dependance is a factor. For instance, the frequency curves of two or more tributary stations cannot be combined by the above equation to derive the frequency curve of a downstream site. This is because the downstream flow is a function of the summation of the coincident flows on each of the tributaries.



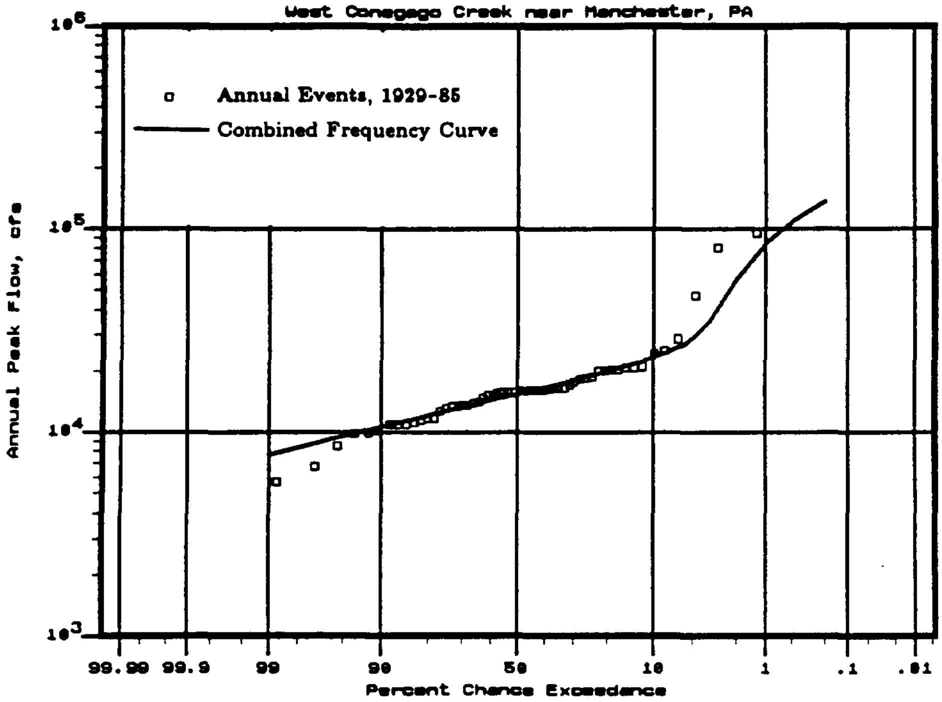


Figure 10-1. Nonhurricane, Hurricane, and Combined Flood Frequency Curves.