6.3

UNIT HYDROGRAPH FROM STREAMFLOW DATA

The area under the hydrograph represents the volume of runoff from a watershed. The area under a unit hydrograph represents the volume of runoff equivalent to a unit depth (1 in.) over the entire watershed. It is a description of the many watershed characteristics that affect the runoff process. The shape of the unit hydrograph expresses a set of characteristics of the land and soil that are assumed to be repeated for similar duration storms. If the duration changes, the time base of the hydrograph changes.

The method for determining unit hydrographs from streamflow data evolved from the work of Sherman (1932). Others (Clark, 1945) expanded on this work. It was originally assumed that the rainfall excess occurs over a fixed hydrograph time base, and consequently, for a given watershed, the hydrograph shape, time to peak, and recession time were constant. For a specific watershed, the unit hydrograph resulting from a given quantity of rainfall excess can be used to generate another hydrograph from a different quantity of rainfall excess if the storm durations are the same. For longer storm durations, the rainfall excess can be divided into smaller time periods, each of duration equal to that used for the unit hydrograph. This assumes that the unit hydrograph does not change with watershed conditions. If the soil becomes saturated or channel velocities increase with increasing cumulative rainfall excess, the shape of the unit hydrograph may change.

A unit hydrograph may be derived from streamflow data or by assuming a specific shape based on watershed conditions. Using streamflow records, the base flow (and other groundwater flows, if present) are subtracted from the streamflow. The resulting hydrograph is the runoff hydrograph. Thus, the runoff hydrograph for the watershed can be specified. Next, the area under the runoff hydrograph (rainfall excess) is calculated. The rainfall excess is in cubic feet if the streamflow is measured in cubic feet per second and the base of the hydrograph is converted to seconds. The volume of runoff is divided by the watershed area obtaining a depth of rainfall excess. Frequently, it is called runoff depth. Since the duration of rainfall excess has been assumed to be constant and the base of the hydrograph is constant, the volume of runoff resulting from various rainfall excesses is proportional to the corresponding discharge (ordinate) values. Thus, the proportionality factor of a given runoff depth to the unit hydrograph runoff depth (1 in.) can be used to convert discharge values in any hydrograph to those resulting from a unit hydrograph. Steps for the calculation procedure are illustrated in Figure 6.11.

The following guidelines should be considered for developing the unit hydrograph if the procedures of Figure 6.11 are followed:

1. Independence in storm event and streamflow (one runoff event does not affect another).
2. For most situations, direct runoff should be greater than one-half inch (this improves the accuracy of the unit hydrograph).
3. Record many storms and average the ordinate values.

Since the assumption that two storms would have the same duration and area distribution is rarely true, there arose a need to improve and generalize the unit hydrograph method. Early studies (Clark, 1945) introduced the concept of instantaneous unit graphs: that rainfall intensities of short duration (minutes) produce instantaneous hydrographs. In the lagging procedure (Morgan and Hullinhors, 1939), each of these instantaneous hydrographs is added to produce a final hydrograph. Hydrographs from long duration storms are assumed to consist of several instantaneous unit hydrographs. For example, a 2-hr unit hydrograph is created from two 1-hr unit hydrographs, and two 4-hr unit hydrographs form an 8-hr hydrograph, and so on. Also, a combination unit hydrograph can be formed by adding the ordinates of the two smaller duration storms and then dividing by 2 (see Figure 6.12). Note that the lagging procedure uses storms of equal duration.

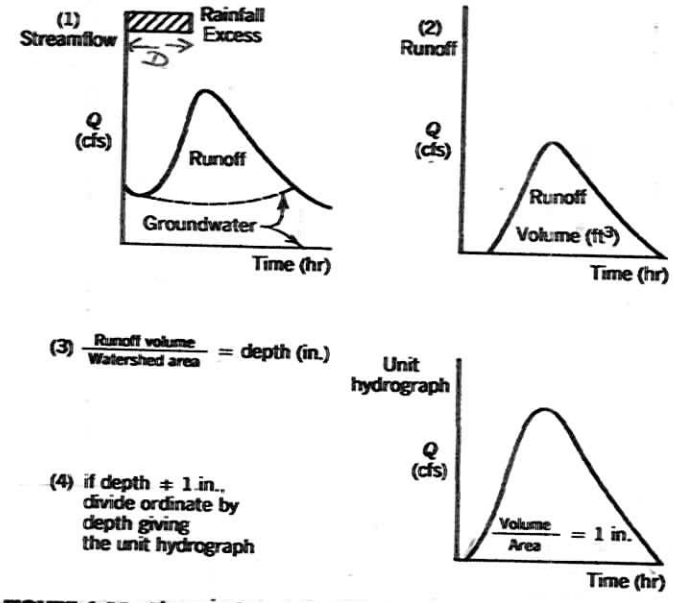

FIGURE 6.11 The steps for calculating a unit hydrograph.

REFERENCE: Wanielista, M., Kersten R., and Eaglin, R., Hydrology, John Wiley & Sons, 1977

"DECONVOLUTION"