3.1.6 Clark Unit Hydrograph

In Knox County, use of the Clark Unit Hydrograph method is acceptable only for hydrologic calculations that are prepared for flood studies and flood elevation calculations. See Volume 2, Chapter 9 for more information on flood study preparation.

The Clark method defines a unit hydrograph for a given basin using the concept of the instantaneous unit hydrograph (IUH). An IUH is a theoretical hydrograph that would result when a single unit of rainfall excess was spread out evenly over an entire basin and allowed to run off. The IUH can be converted to a unit hydrograph of a desired duration by conventional techniques for developing unit hydrographs (Hoggan, 1997).

The Clark method is based on the effects of translation and attenuation as the primary forces involved in the flow of water through a watershed. Translation is defined as the 'downhill' flow of water as a result of the force of gravity. Attenuation is defined as the resistance of flow that is caused by either friction in the channel or water storage. According to Clark, translation in a watershed can be described with a time-area curve. This curve displays the portion of watershed area that is contributing runoff as a function of time. The curve should start at the point in which effective precipitation begins. Effective precipitation is any precipitation that does not infiltrate into the soil or is retained in a ponding area. Equation 3-19 presents these concepts.

Equation 3-19

$$S = RO$$

where:

S = Storage
R = Attenuation (Watershed Storage) Constant
O = Outflow

A synthetic hydrograph could be produced by proportionally routing an inch of direct runoff to the channel in accordance with the time-area curve. The runoff entering the channel would then be routed through a linear reservoir. More recent studies have indicated that it is not necessary to produce detailed time-area curves in order to produce accurate synthetic hydrographs. The dimensionless time-area curve included in HEC-1 and HEC-HMS hydrologic models (developed by the United States Army Corps of Engineers) have produced accurate synthetic hydrographs. In order to apply the Clark method in a HEC-1 or HEC-HMS model, the time of concentration (tc) and a watershed storage constant (R) are required as inputs. In stormwater master plans prepared for Knox County in the late 1990's and early 2000's, research indicated that Equation 3-20, which equates to setting $R = T_c$, produced accurate estimates of peak discharges for small drainage areas. However, the engineer performing the flood study should determine the most appropriate equation to determine the value of R.

Equation 3-20

$$\frac{R}{T_c + R} = 0.5$$

where:

R = Attenuation (Watershed Storage) Constant
T_c = Time of concentration