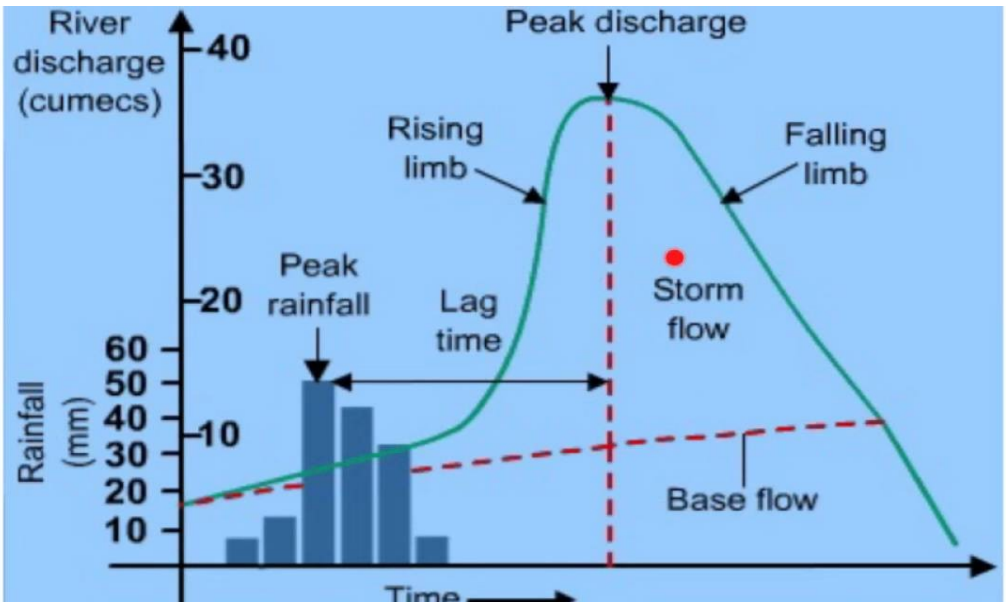
Lecture notes of 30-04-2020, 11:45 AM

Compiled by Dr M. L. Sahu Associate Professor SWE, CoAE, JNKVV Jabalpur (MP)

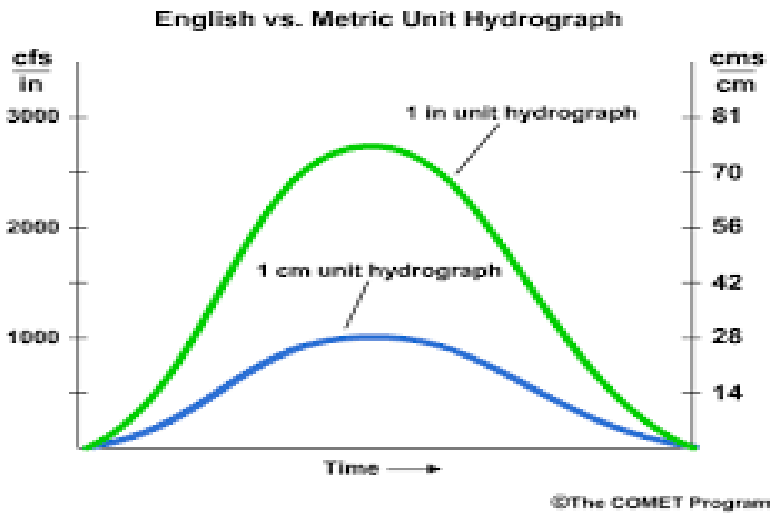
Hydrograph:

It is a graph between the rate of flow (m^3/s) & Time (h or day or month or year). Discharge is measured in a stream / nallah / river. Discharge is generated due to rainfall of different depth & different duration in the watershed / catchment / drainage area / basin of the stream



Unit Hydrograph:

It is a graph between the rate of flow (m^3/s) & Time (h or day or month or year). Discharge is measured in a stream / nallah / river. Discharge is generated due to effective rainfall of 1 cm depth & different duration in the watershed / catchment / drainage area / basin of the stream



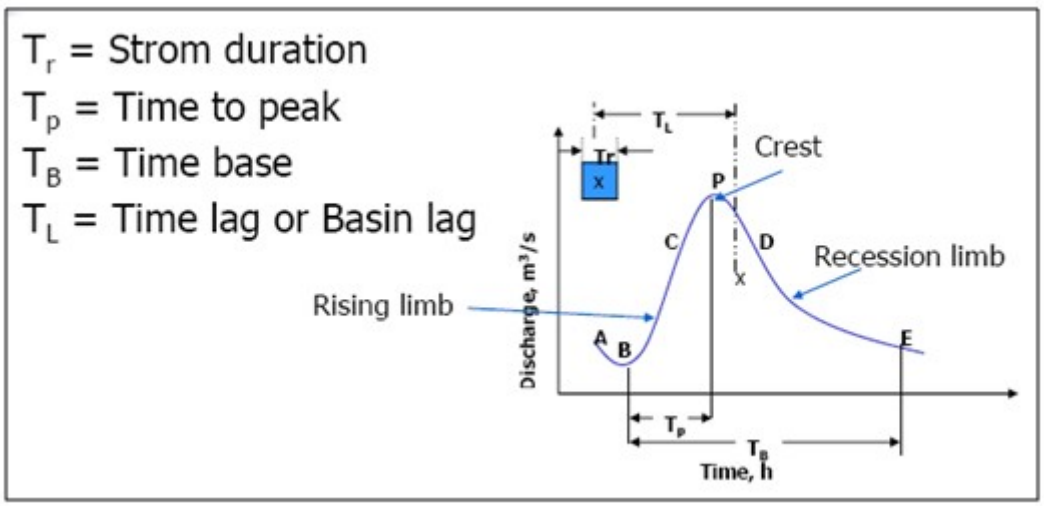
Some important terms:

Time Base of Hydrograph (T_B)
It is the time from the beginning to the end of the direct runoff. Point B to point E.

Lag Time (T_L)
It is the time between the center of mass of rainfall and center of mass runoff.

Time to Peak (T_P)
It is the time between the beginnings of direct runoff to peak discharge. (point B to point P)

Rainfall Duration (T_r)
It is the effective rainfall duration, which causes the direct runoff.



Derivation of Unit Hydrograph

Derivation of Unit Hydrograph from a Simple Storm

Steps for derivation of UH

Step 1: Select an isolated storm hydrograph from recording stream gauge station.

Storm hydrographs used in the analysis should be selected so as to meet the following desirable features with respect to the storms responsible for them:

1. The storms should be isolated storms occurring individually
2. The rainfall should be fairly uniform during the duration and should cover the entire catchment area
3. The duration of rainfall should be 1/5 to 1/3 of the basin lag (T_L)
4. The rainfall excess of the selected storm should be high (A range of ER values of 1.0 to 4.0 cm is preferred)

Step 2: Separate the base flow.

Step 3: Evaluate the area under Direct Runoff Hydrograph (DRH).

Step 4: Determine the volume of runoff.

Step 5: Find out the effective rainfall (ER).

Step 6: Determine the volume of runoff.

Step 7: Divide the ordinates of the various DRHs by the respective ER values to obtain the ordinates of the Unit hydrograph.

Tutorial 1:

A gauging station is located at the outlet of a watershed area of 210 km^2. A hydrograph of 4 h individual storm was prepared it was of triangular shape having time base (T_B) of 66 h. The ordinate of peak flow is 30 m^3/s. The time to peak (T_P) is 10 h. Develop the 4-h unit hydrograph for this watershed.

Solution:

We have given

i) Watershed area = 210 km^2 or 21,000 ha

(1 km^2=100 ha)

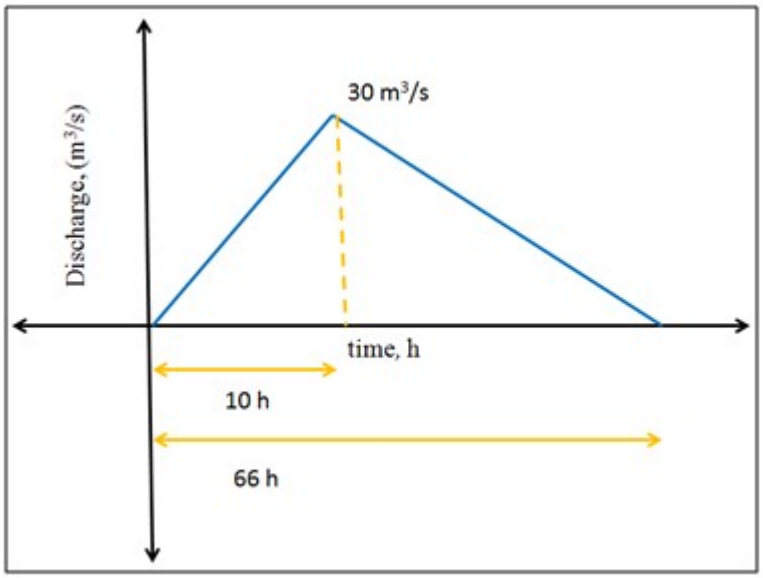
ii) Duration of rainfall = 4 h

iii) Time base (T_B) = 66 h

iv) Peak runoff = 30 m^3/s

v) Base flow = 0

vi) Time to Peak (T_P) = 10 h



From Figure

Runoff Volume = 1/2 X Base X Hight

= 1/2 X 66 h X 30 m^3/s

= 1/2 X (66 X 60 X 60 s) X 30 m^3/s

= 35,64,000 m^3

Therefore,

Effective Rainfall = 35,64,000 m^3 / 21,000 ha

= 35,64,000 m^3 / (21,000 X 10,000 m^2)

= 0.017 m

= 0.017 X 100 cm or 1.7 cm

The peak of 30 m^3/s is the result of 1.7 cm effective rainfall.

But in Unit Hydrograph we need peak of 1cm effective rainfall.

Hence peak of UH = (30 m^3/s) / 1.7 cm

= 17.65 m^3/s

This peak will occur at 10 h from the start

Answer: Peak of 4h UH is 17.65 m^3/s at 10 h from start of runoff.

Tutorial 2:

A flood hydrograph of a river draining a catchment of 189 km^2 due to a 6 h isolated storm is in the form of a triangle with a base of 75 h and a peak ordinate of 36 m^3/s occurring at 15 hours from the start. Assuming zero base flow, develop the 6-hour unit hydrograph for this catchment.

Derivation Of Unit Hydrographs

1. A number of isolated storm hydrographs caused by short spells of rainfall excess, each of approximately the same duration (0.9 to 1.1D h) are selected from a study of continuously gauged runoff of the stream
2. For each of these surface runoff hydrographs, the base flow is separated
3. The area under DRH is evaluated and the volume of direct runoff obtained is divided by the catchment area to obtain the depth of ER
4. The ordinates of the various DRHs are divided by the respective ER values to obtain the ordinates of the unit hydrograph

• A number of unit hydrographs of a given duration are derived as mentioned above and then plotted

• Because of spatial and temporal variations in rainfall and due to deviations of the storms from the assumptions in the unit hydrograph theory, the various unit hydrographs developed will not be exactly identical