7. Hydrographs

7.1 Hydrograph definition

A hydrograph is a plot of the discharge in a stream plotted against time chronologically

❖ *Depending upon the unit of time involved, we have*

(1) Annual hydrographs showing the variation of daily or weekly over a year.

A study of the annual hydrographs of streams enables one to classify the streams in

to three classes as:

(i) Perennial: Always carries some flow in it (Fig. 7.1). There is considerable amount of GW flow throughout the year. Even during the dry seasons, the WT will be above the bed of the stream;

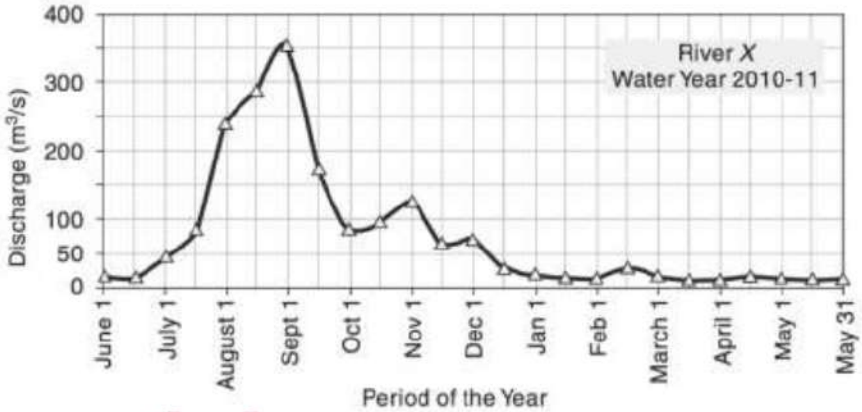


Fig. 7.1 Perennial stream

(ii) Intermittent: ***h***as limited contribution from the GW., Fig. 7.2.

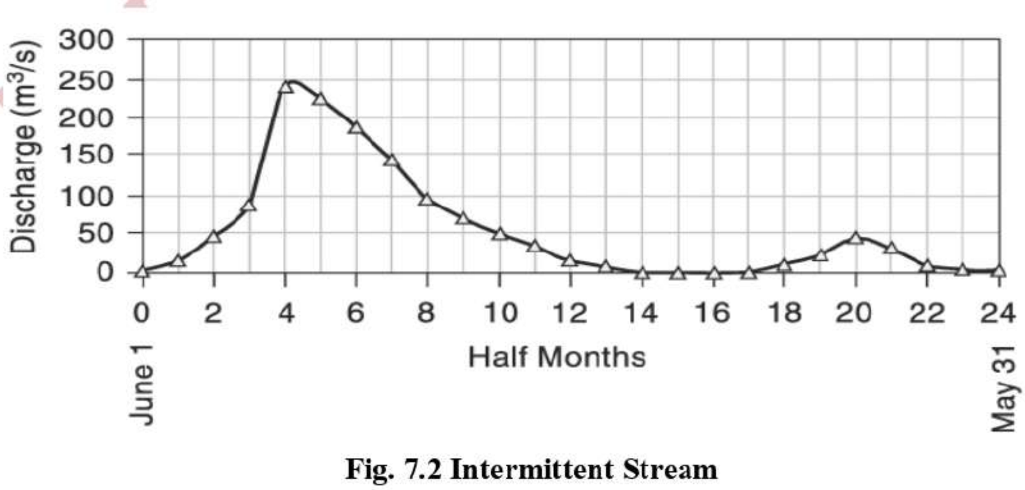


Fig. 7.2 Intermittent Stream

(iii) ephemeral: ***d***oes not have any base-flow contribution, Fig. 7.3.

- Most of the rivers in arid zones are of the ephemeral kind.

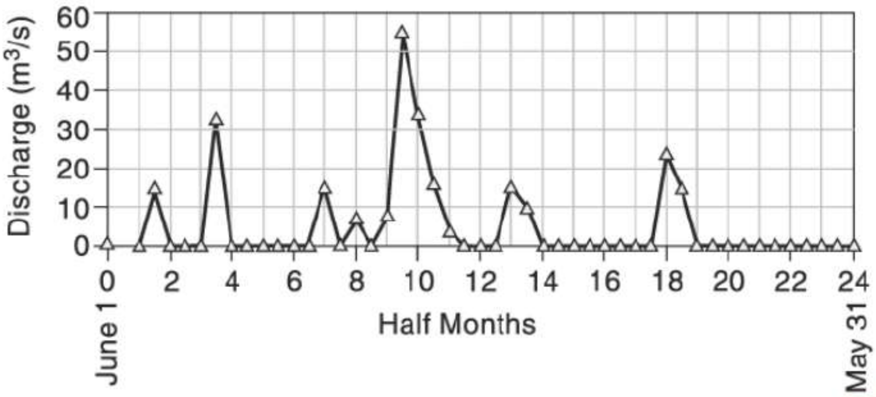


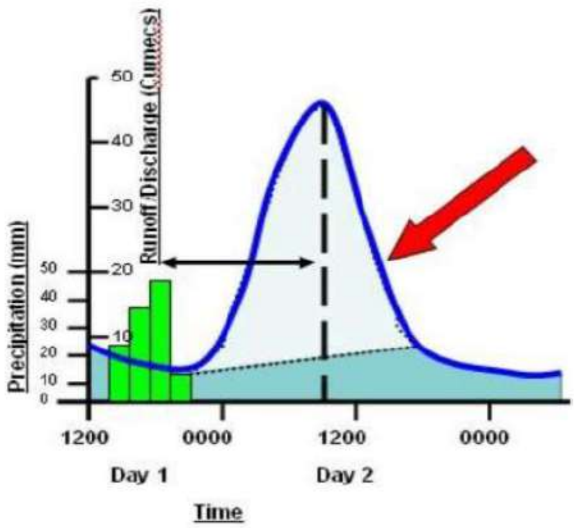
Fig. 7.3 Ephemeral Stream

(2) Monthly hydrographs showing the variation of daily mean flows over a month

(3) Seasonal hydrographs depicting the variation of the discharge in a particular season such as the monsoon season or dry season

(4) Flood/Storm hydrographs representing stream flow due to a storm over a catchment

Fig. 7.4 Flood/Storm hydrograph



7.2 Hydrograph components

The various components of a natural hydrograph are shown in Fig. 7.5.

- At the beginning, there is only base flow gradually depleting in an exponential form (*MA*).
- After the storm commences, the initial losses like interception and infiltration are met

and then the surface flow begins. The hydrograph gradually rise and reaches its ***peak value (P)*** after a time t_p (called lag time/basin lag) measured from the centroid of the hyetograph of net rain.

- Thereafter it declines and there is a change of slope at ***the inflection point (C)***, i.e., there has been, inflow of the rain up to this point and after this there is gradual withdrawal of catchment storage.
- By this time the GW table has been built up by the infiltrating and percolating water, and now the GW contributes more into the stream flow than at the beginning of storm, but thereafter the GWT declines and the hydrograph again goes on depleting in the exponential form called the GW ***depletion curve or the recession curve (DN)***.
- If a second storm occurs now, again the hydrograph starts rising till it reaches the new peak and then falls and the GW recession begins, Fig. 7.5.

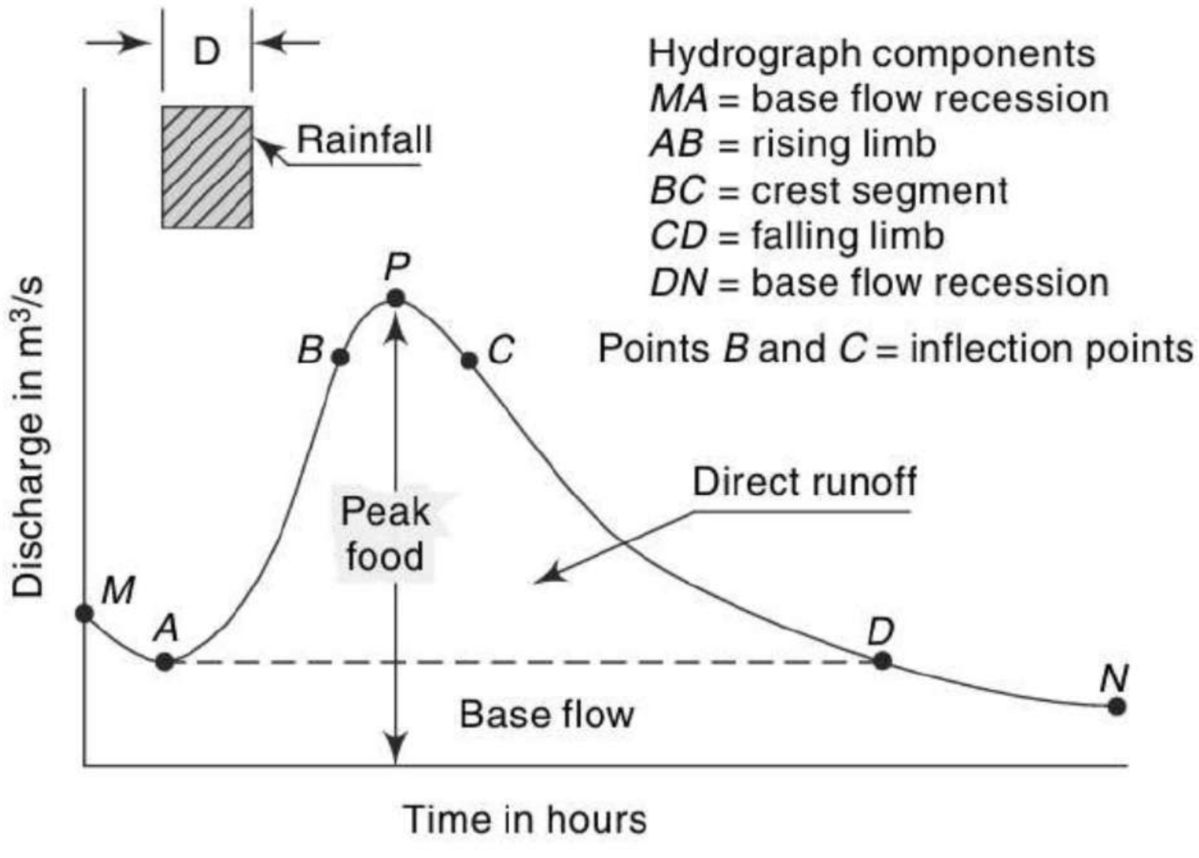


Fig. 7. 5 Elements of a flood hydrograph

Hydrograph has three characteristic regions:

(1) The Rising Limb (AB); depends on: the intensity and duration of the rain storm, the basin area, and river characteristics;

(2) The Crest Segment BC;

(3) The Falling Limb or Depletion Curve (CD): depends on: the change in the basin storage after the end of the storm;

(4) Base Flow Recession (AB) & (DN).

7.3 Factors affecting hydrograph shape

(1) Climatic factors (the intensity, duration and direction of storm movement), Fig. 7.6;

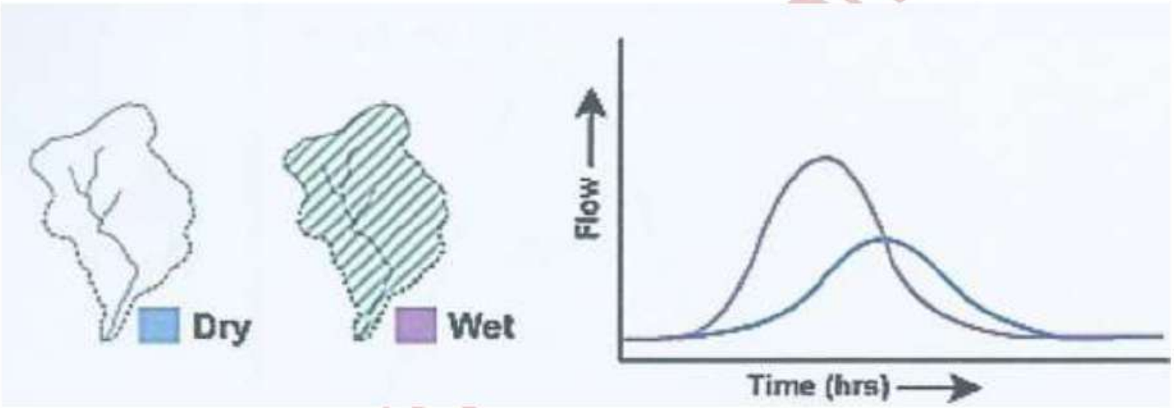


Fig. 7.6 The climatic characteristic

(2) Physiographic factors (basin (shape, size, slope), drainage density, land use, urbanization, Fig. 7.7.

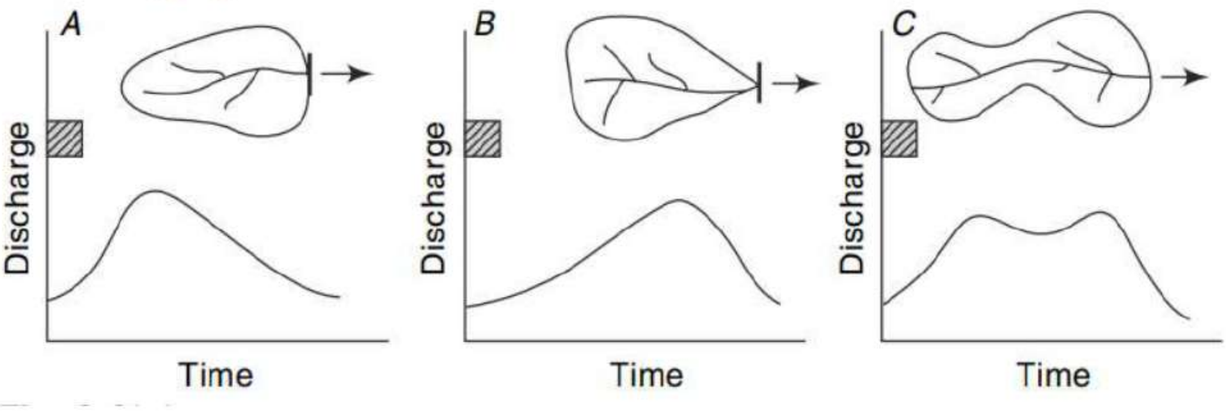


Fig. 7.7 (a) Effect of Catchment Shape on the Hydrograph

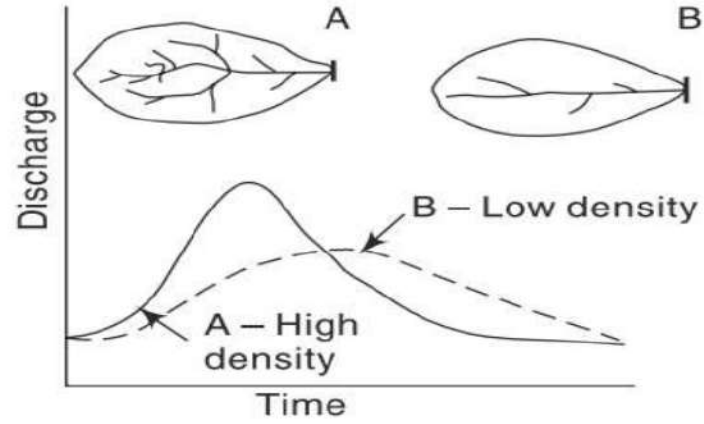
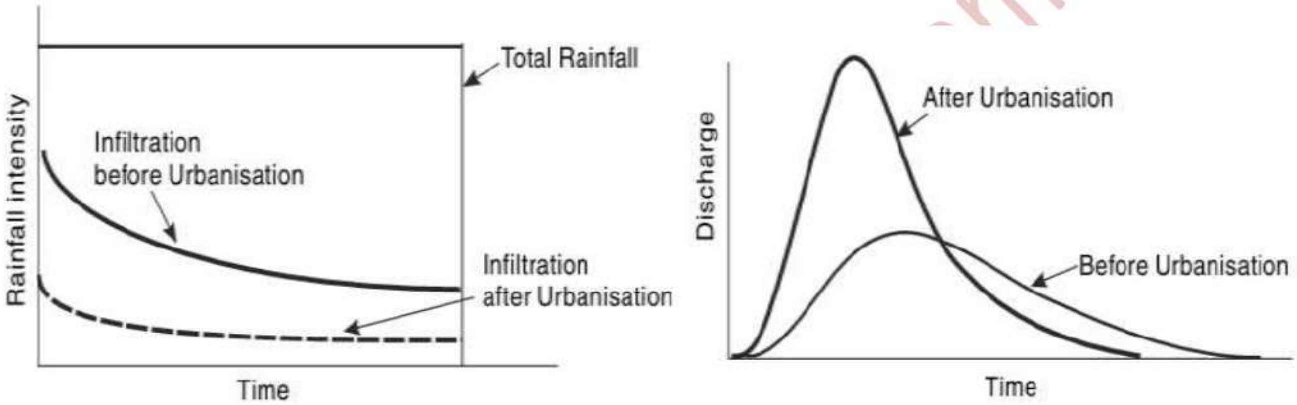


Fig. 7.7 (b) Role of Drainage Density on the Hydrograph



(a) Effect of Urbanisation on Infiltration (b) Effect of Urbanisation on the Hydrograph

Fig. 7.7 (c) Effect of Urbanisation

7.4 Hydrograph analysis/Base flow separation

For the derivation of unit hydrograph, the base flow has to be separated from the total runoff hydrograph (i.e., from the hydrograph of the gauged stream flow). Some of the well-known base flow separation procedures are given below.

(1) Straight line method

Drawing a straight line AB from the point of rise to the point B on the hydrograph N days after the peak, Fig 7.8.

$$N = b \times A^{0.2}$$

Where A = area of drainage (km^2/mi^2)

b = constant

= 1 if A (mi^2); and

= 0.8 if A (km^2)

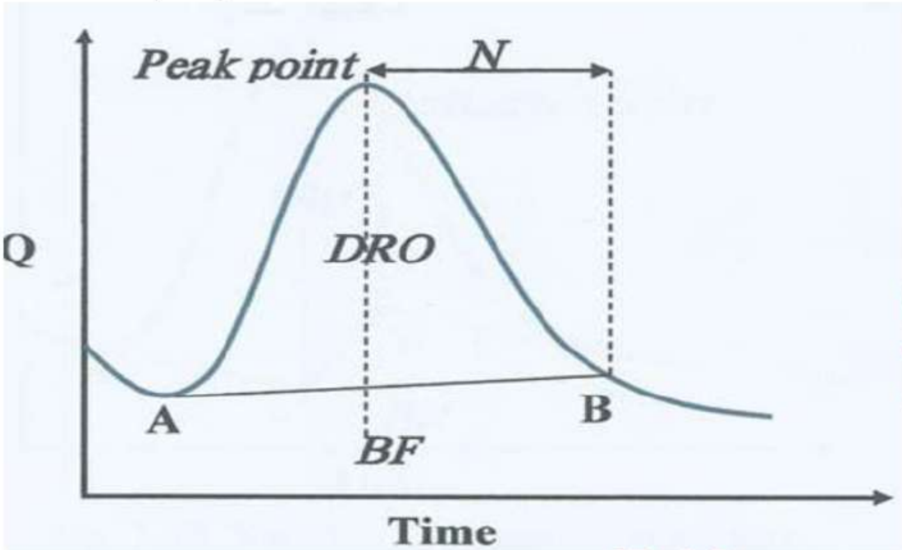


Fig. 7.8 Straight line method separation.

(2) Fixed base length method: extending the recession curve prior to the occurrence of the storm up to the point C directly under the peak of the hydrograph and then drawing a straight line BC, where a point on the hydrograph N days after the peak, Fig. 7.9.

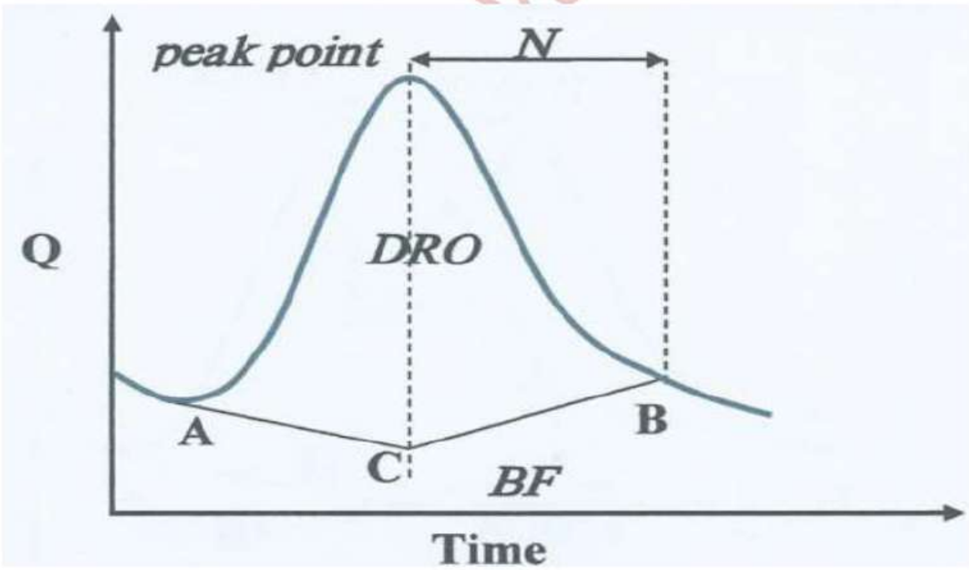


Fig. 7.9 Fixed base length method.

(3) Variable slope method: construct a tangential line BD to the GW recession curve after the storm to a point D directly under the inflection point of the falling limb. Extending the recession curve existing prior to the occurrence of the storm up to the point C directly under the peak of the hydrograph and then drawing a straight line CD or sometimes sketch an arbitrary curve line from the point of rise of the hydrograph A to connect with the point D, Fig. 7.10. This method is preferred where the GW storage is relatively large and reach the stream fairly rapidly, as in lime-stone terrains.

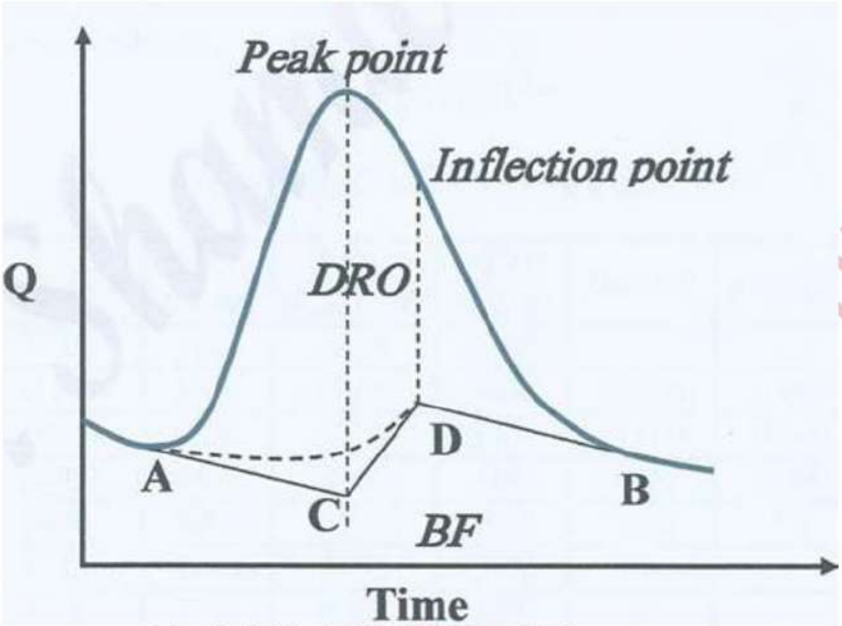


Fig. 7.10 Variable slope method.

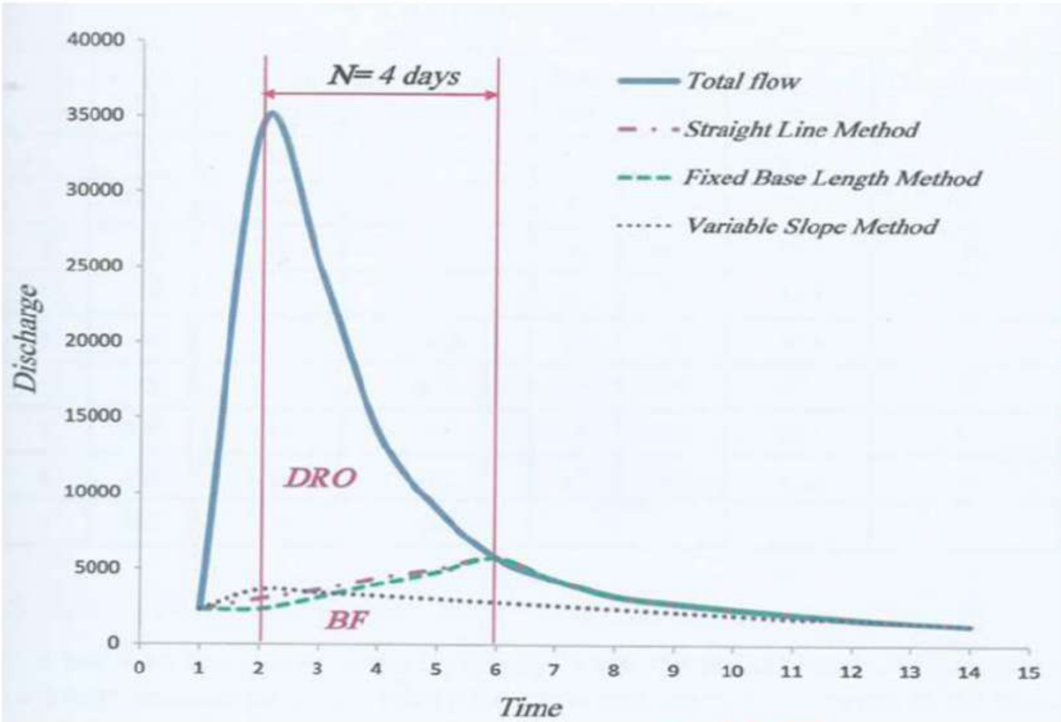
Example 1: Compute the volume of the direct runoff of the following if the basin area is 5033 km^2.

Time (day)	Total flow (m^3/s)	Time (day)	Total flow (m^3/s)
1	2340	8	3230
2	34300	9	2760
3	25000	10	2390
4	14000	11	2060
5	8960	12	1770
6	5740	13	1520
7	4300	14	1320

***Solution*:**

$$N = 0.8 \times A^{0.2}$$

$$N = 0.8 \times (5033)^{0.2} \approx 4 \text{ days}$$



Time (day)	Total flow (m^3/s)	BF_1 SLM	BF_2	BF_3	DRH_1	DRH_2	DRH_3
1	2340	2340	2340	2340	0	0	0
2	34300	3000	2340	3600	31300	31960	30700
3	25000	3600	3100	3400	21400	21900	21600
4	14000	4400	4000	3200	9600	10000	10800
5	8960	5000	4800	3000	3960	4160	5960
6	5740	5740	5740	2800	0	0	2940
7	4300	4300	4300	2600	0	0	1700
8	3230	3230	3230	2400	0	0	830
9	2760	2760	2760	2200	0	0	560
10	2390	2390	2390	2000	0	0	390
11	2060	2060	2060	1800	0	0	260
12	1770	1770	1770	1770	0	0	0
13	1520	1520	1520	1520	0	0	0
14	1320	1320	1320	1320	0	0	0
Sum	109690	43430	41670	33950	66260	68020	75740

Volume of direct runoff by the:

1^{st} method = 66260 x 24 x 3600 = 5725 MCM

2^{nd} method = 68020 x 24 x 3600 = 5877 MCM

3^{rd} method = 75740 x 24 x 3600 = 6544 MCM