Abstract:

An experiment that shows how to draw the unit hydrograph step by step, by the help of a standard basin. The unit hydrograph model (Figure 1.3) is used.

Introduction:

The basin model that considers the stream basin as a linear system converting the rainfall excess to direct runoff is known as the unit hydrograph model. The unit hydrograph is defined as follows. It is the hydrograph of the direct runoff that is produced by rainfall excess of unit (1 cm) depth of constant intensity distributed uniformly over the basin.

Following assumptions are made in the unit hydrograph theory;

a) Rainfall excess has constant intensity.

b) Rainfall excess is distributed over the basin uniformly.

c) Duration of the direct runoff due to rainfall excess of certain duration is the same for rainfalls of any intensity. This assumption is not quite correct. The base length will be shorter when the intensity is greater because the velocity of flow will increase and the concentration time will decrease.

d) Ordinates of direct runoffs of rainfalls of a given duration are proportional to the rainfall excess depth.

e) The hydrograph of a rainfall of constant intensity with a given duration is the same for each storm. This implies that the basin characteristics do not vary time, which is not always correct because the vegetation and some other basin characteristics may change with the season, causing the unit hydrograph to be variable.

The hydrograph of a flow caused by a given rainfall can be determined by the unit hydrograph. A design rainfall is selected. It is return period may be 10, 20... years depending on the problem. The hydrograph is then obtained using the unit hydrograph. In major problems such as the spillways of large dams, probable maximum precipitation is taken as the design rainfall.

In basins where snowmelt has a contribution to the large floods, the hydrograph due to snowmelt is obtained using the maximum observed degree-day factors and the maximum temperatures in the snowmelt season. This hydrograph is then superposed to the hydrograph due to rainfall and the base flow to obtain the total flow hydrograph.

Apparatus:

Basin. (Figure 1.1)
Gages. (Figure 1.2)
Ruler.
Chronometer.

Procedures:

- Started precipitation on the basin that lasts 23.5 seconds.
- When the ground flow begins, we stared the slider mechanism under the gages.
  (Slider moves $3.4 \frac{\text{gage}}{\text{sec}}$)
- After the 17th gages we measured the depths of water in the gages.

Data:

Gage №	Water Depth (mm)	Gage №	Water Depth (mm)
1	3.0	10	9.5
2	5.5	11	9.5
3	8.5	12	8.5
4	10.5	13	8.0
5	12.0	14	8.0
6	12.0	15	7.5
7	12.0	16	7.5
8	11.0	17	6.5
9	10.5		

Basin area = $84 \times 123 = 10,332 cm^2$

Gage base area = $2 \times 19 = 38 cm^2$

Each gage time=3.4sec

Precipitation=23.5sec

Total time=65sec

Calculations:

We first calculate the total volume.

$$V = \begin{pmatrix} 3+5.5+8.5+10.5+12+12+12+11+ \\ 10.5+9.5+9.5+8.5+8+8+7.5+7.5+6.5 \end{pmatrix} \times (20 \times 190)\, mm^3$$

$$V = 570 cm^3$$

We may assume that this volume is equal to total rain volume. When we divide this volume to the basin area times time, we calculate the precipitation intensity. (constant intensity)

$$t = 23.5 \sec$$

$$i = \frac{570}{84 \times 123 \times 23.5} \times 3600$$

$$i = 8.451 \frac{cm}{hr}$$

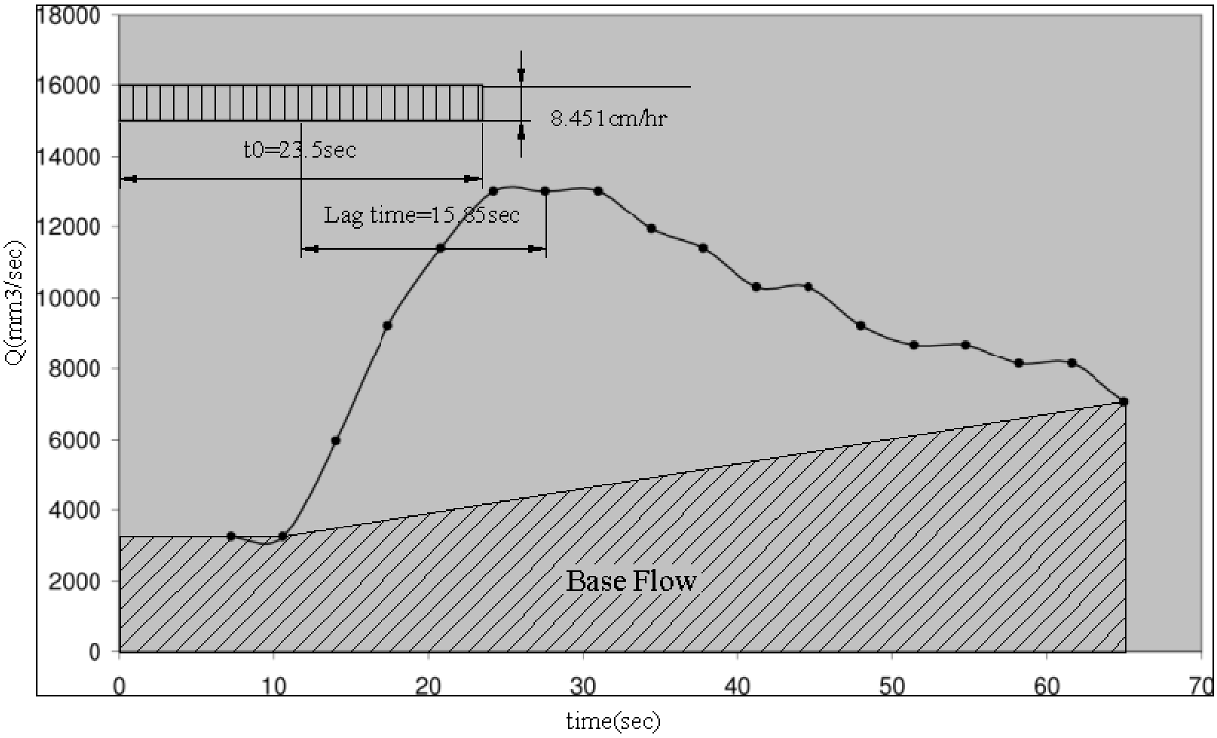
Then we calculate the volumes,

Gage №	Volume(mm^3)	Gage №	Volume(mm^3)
1	11400	10	36100
2	20900	11	36100
3	32300	12	32300
4	39900	13	30400
5	45600	14	30400
6	45600	15	28500
7	45600	16	28500
8	41800	17	24700
9	39900		

After calculating volumes we divide the volumes by time (3.5sec) to find the discharge (Q).

Gage №	Discharge $\left(\frac{mm^3}{\sec}\right)$	Gage №	Discharge $\left(\frac{mm^3}{\sec}\right)$
1	3257.143	10	10314.29
2	5971.429	11	10314.29
3	9228.571	12	9228.571
4	11400	13	8685.714
5	13028.57	14	8685.714
6	13028.57	15	8142.857
7	13028.57	16	8142.857
8	11942.86	17	7057.143
9	11400		

Now we may draw our hydrograph. Since total time is 65 sec we should start discharge at 10.6sec



Here peak is about 27.6 so,
Lag time = 15.85sec
The values of the hydrograph is:

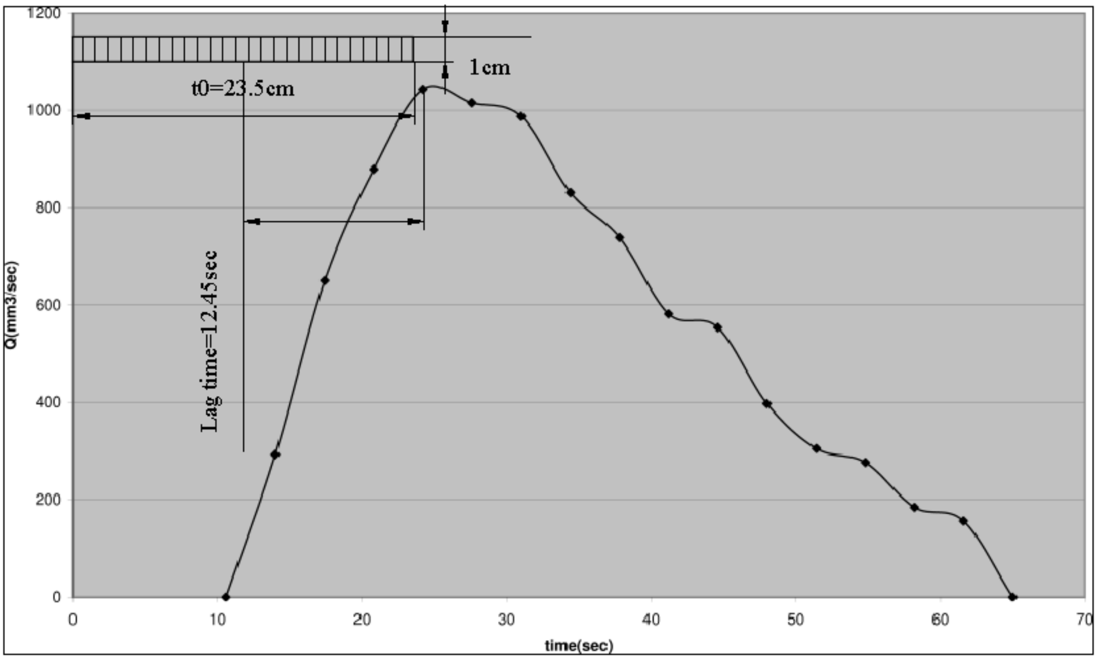
time(sec)	Discharge $\left(\frac{mm^3}{\sec}\right)$	time(sec)	Discharge $\left(\frac{mm^3}{\sec}\right)$
10.6	3257.143	41.2	10314.29
14	5971.429	44.6	10314.29
17.4	9228.571	48	9228.571
20.8	11400	51.4	8685.714
24.2	13028.57	54.8	8685.714
27.6	13028.57	58.2	8142.857
31	13028.57	61.6	8142.857
34.4	11942.86	65	7057.143
37.8	11400		

We should first find the base flow to evaluate the unit hydrograph. We should add 237.5 to the first discharge every 3.4sec to find base flow.
The base flow is about;

time(sec)	Discharge $\left(\frac{mm^3}{\sec}\right)$	time(sec)	Discharge $\left(\frac{mm^3}{\sec}\right)$
10.6	3257.143	41.2	5394.643
14	3494.643	44.6	5632.143
17.4	3732.143	48	5869.643
20.8	3969.643	51.4	6107.143
24.2	4207.143	54.8	6344.643
27.6	4444.643	58.2	6582.143
31	4682.143	61.6	6819.643
34.4	4919.643	65	7057.143
37.8	5157.143		

After that we subtract the base flow and divide by 8.451(intensity) to evaluate the unit hydrograph. The values of unit hydrograph is;

time(sec)	Discharge $\left(\frac{mm^3}{\sec}\right)$	time(sec)	Discharge $\left(\frac{mm^3}{\sec}\right)$
10.6	0	41.2	582.1374
14	293.0761	44.6	554.0342
17.4	650.388	48	397.4593
20.8	879.2282	51.4	305.1203
24.2	1043.833	54.8	277.0171
27.6	1015.729	58.2	184.6781
31	987.6261	61.6	156.5749
34.4	831.0513	65	0
37.8	738.7122		



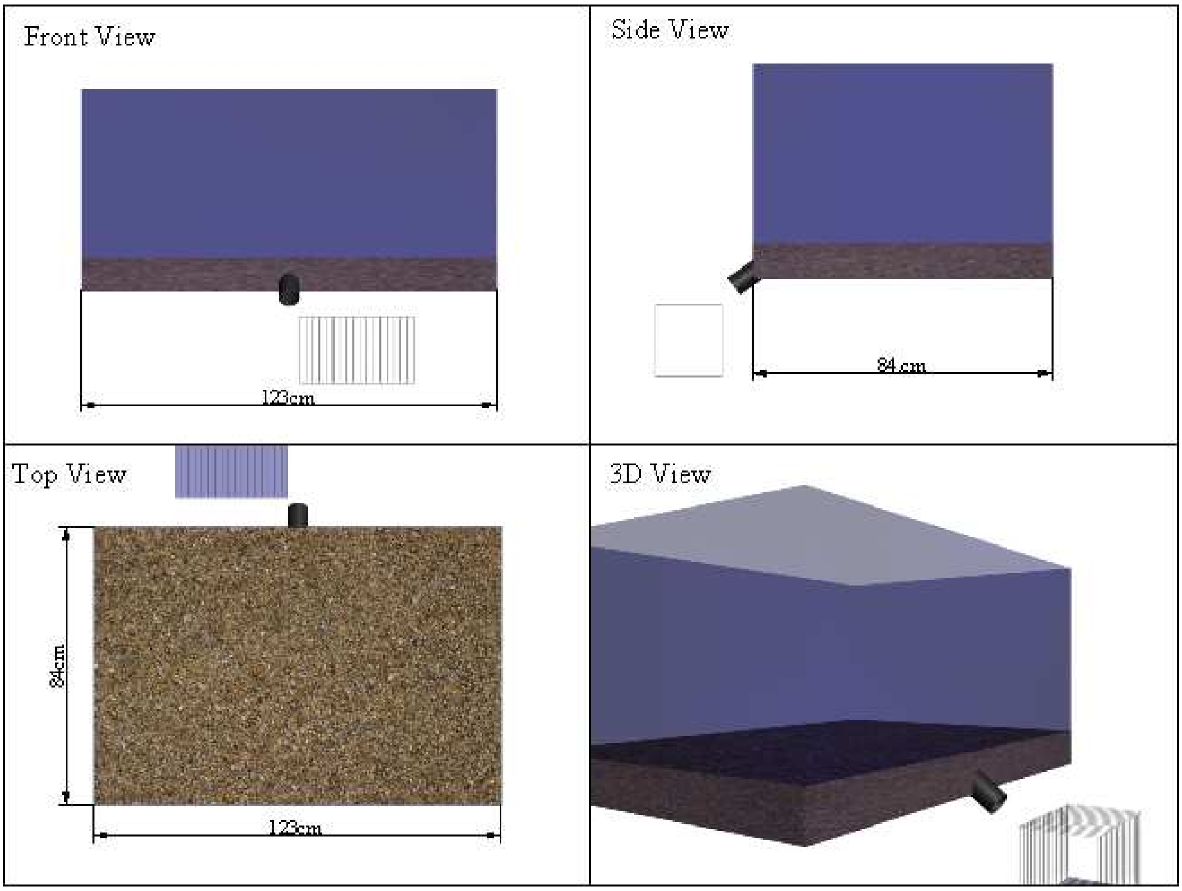


Figure 1.1

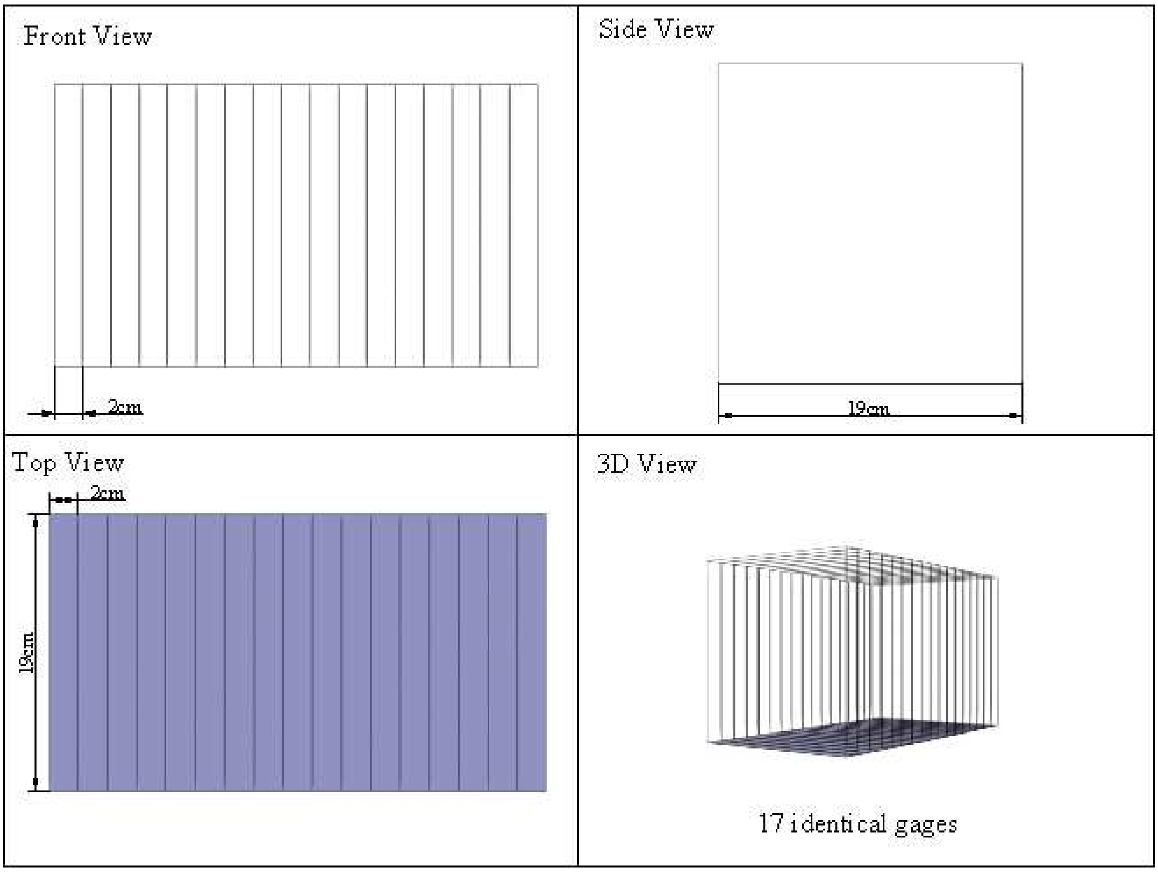
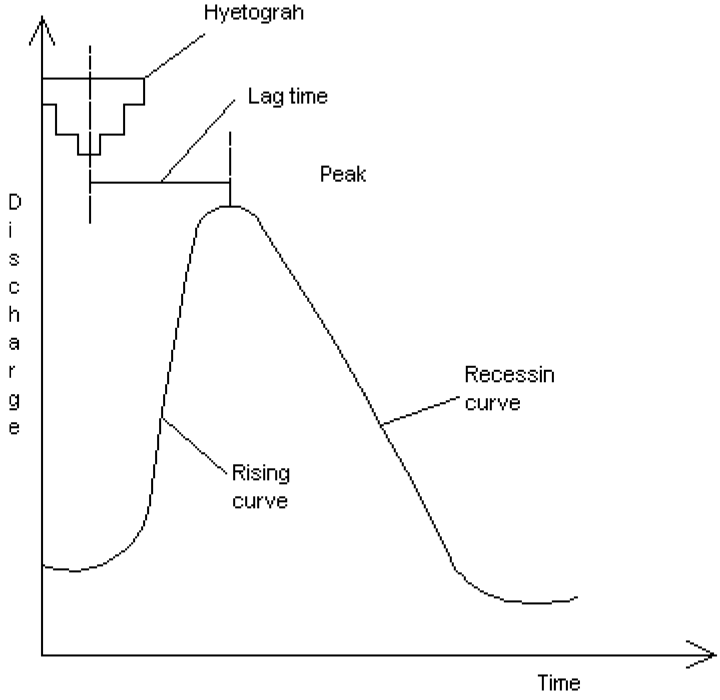


Figure 1.2



Elements of a hydrograph

Figure 1.3