Water Resource Engineering

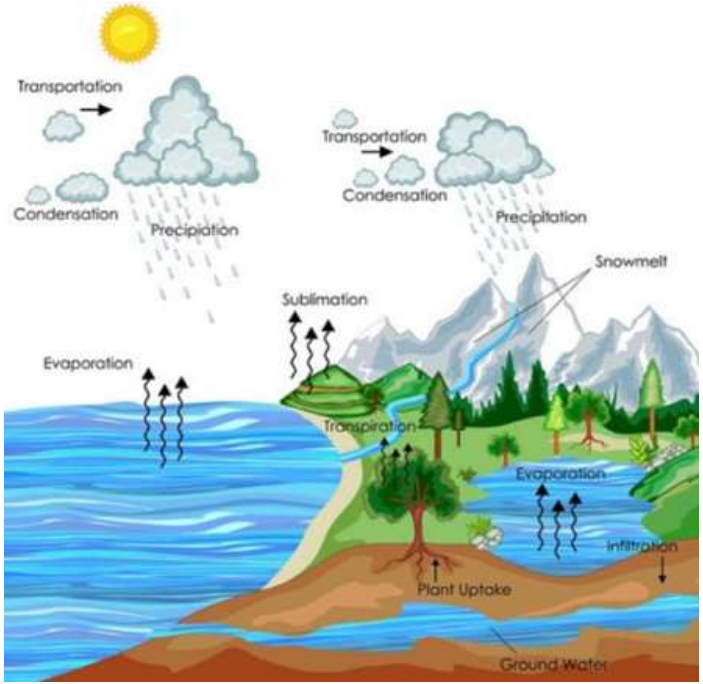
Topic : Introduction to Hydrology

HYDROLOGY

•Hydrology is the science of water.
• Science which deals with occurrence, circulation & distribution of water of the earth & the earth's atmosphere.
• It deals with estimation of water resource.

Hydrological Cycle :

It is also known as water cycle. The hydrologic cycle is a continuous process in which water is evaporated from water surfaces and the oceans, moves inland as moist air masses, and produces precipitation, if the correct vertical lifting conditions exist.

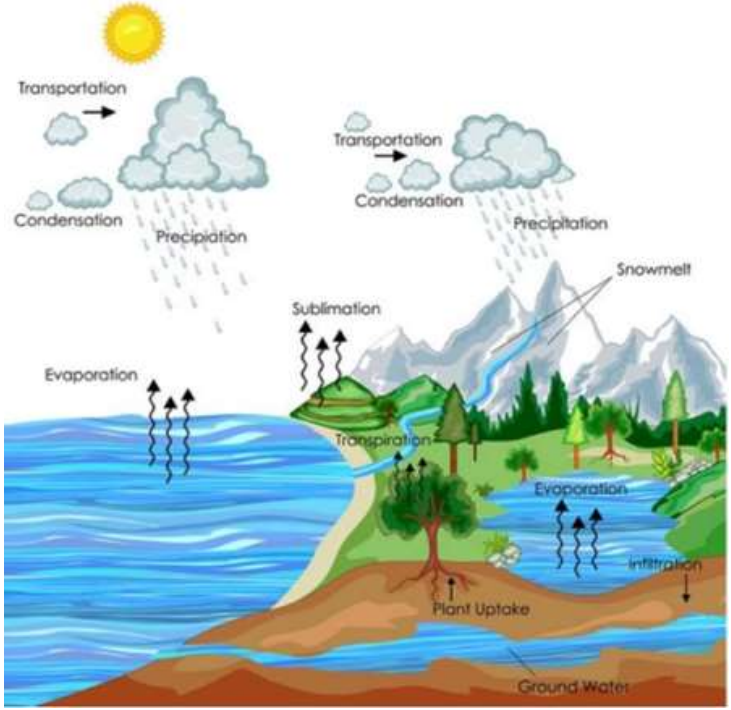


Hydrological Cycle

STAGES OF HYDROLOGICAL CYCLE :

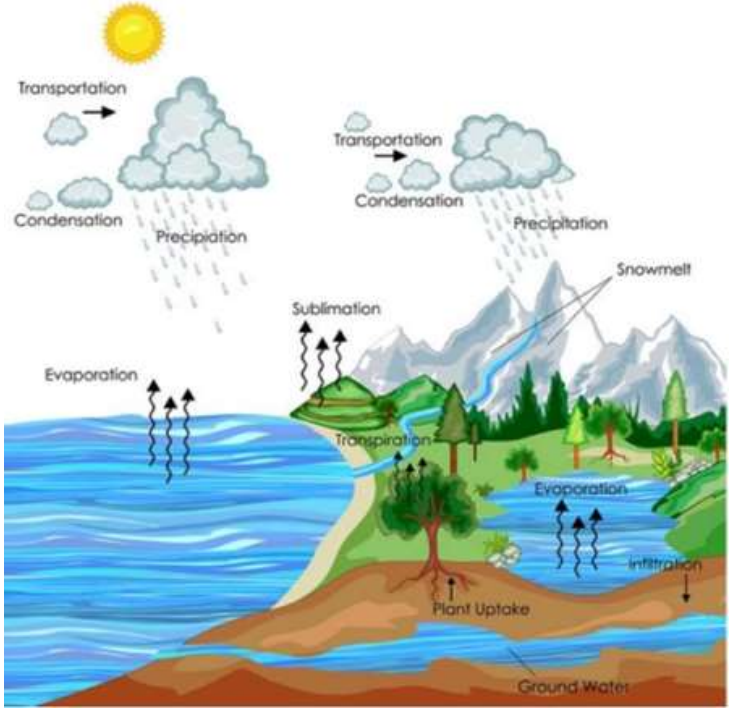
1. Precipitation
2. Infiltration
3. Interception
4. Depression storage
5. Run-off
6. Evaporation
7. Transpiration
8. Groundwater

Precipitation:
The deposition of water on Earth surface as, snow, rain, hailstone, etc
Evaporation: Change of water from liquid to gaseous state.
Interception:
Short term retention of rain water on vegetation, rooftops, etc
Infiltration:
Movement of water into the soil from surface.
Percolation:
Movement of water from one soil layer to another
Transpiration: It is water absorbed from the ground and evaporated into atmosphere through leaves.
Interflow:
Ground water flowing horizontally above the ground water table and below the surface (Sub surface flow)



Depression storage:
Rain water accumulated in small depressions and ditches above the surface.
Runoff : Volume of water drained by river at outlet of catchment area.

Catchment Area



Catchment Area

• It is the area of land where surface water from rain and melting snow converges to a single point known as Catchment Outlet where water joins other water bodies such as River or oceans
• Catchment area is also called as "River Basin" or "Basin"
• Each catchment is separate topographically from adjacent catchments by Geographical barriers called Ridges (elevated land), hills or mountain.

Rainfall = Initial losses + Infiltration + Runoff

Important Points :

Limnology = Study of Lakes
Potamology = Streams
Cryology = Snow and Ice
Ocenology = Occeans

** Chemical Uses for Artificial Rainfal – Silver Iodide, Dry Ice.
** Total Quantity of water in the whole world is about -1386 M km^3

Rain Gauge :

It's a instrument to measure Precipitation.

Types of Raingauges :

1. Non Recording Raingauge.
2. Recording Raingauge.

1. Non Recording Raingauge :

1. Symon's Raingauge (5 inch Raingauge) :

Dia of Raingauge = 5 inch or 127 mm , Height of Symon's R. G = 30 cm
Rain fall measured everyday at 8.30 a.m
Max. 10 cm depth of rainfall can be stored in glass bottle.
Metal container alone is used for measuring snowfall.
Collected Area = 200cm^2 and 100cm^2.

2. Recording Type Raingauge or Automatic Raingauge :

An instrument that automatically records the amount of precipitation collected as a function of time is called an Automatic rain gauge or Recording type rain gauge.

The recording rain gauges can be further classified into the following types:

A) Tipping Bucket Type Rain Gauge
B) Weighing Bucket Rain Gauge
C) Floating Types of Rain Gauge

Number of Raingauge Factors :

1. Size of the Area.
2. Topographical Features.
3. Finance.

IS Codal provision for number of Raingauge :

As per IS : 4987 : 1968

a. For the plain area 1 R.G station per 520 sq.km area.
b. For the Elevated area 1 R.G station per 260 – 390 sq.km area.
c. For the hilly area 1 R.G Station per 130 sq.km area.

** At least 10% of the raingauge provided should be Recording Type raingauge.

$$N = \left(\frac{C_v}{\epsilon}\right)^2$$

Where,

C_v is the coefficient of variation

ϵ is error percentage

The coefficient of variation is given by

$$C_v = \frac{\sigma_{n-1}}{\bar{P}}$$

Where,

$\bar{P}$ is average rainfall

σ is the standard deviation

Number of Raingauge Station Required.

AVERAGE DEPTH OF PRECIPITATION :

1. Arithmetic Mean Method

It is the least accurate method.
It is suitable for plain areas.
It is suitable when rain gauge distribution is uniform.

$$P(avg) = \{ P1 + P2 + \ldots\ldots\ldots + Pn \} / n$$

2. THIESSEN POLYGON FETHOD

It gives weightage to area. (Area weightage method)
It is suitable for plain areas.
It takes care of non uniform distribution of rain gauge.

$$P(avg) = \{ P1A1 + P2A2 + \ldots\ldots\ldots + PnAn \} / \{ A1 + A2 + \ldots\ldots\ldots\ldots\ldots + An\}$$

Runoff :

- It is referred as stream flow, river discharge or catchment yield.
- Based on time delay between precipitation and runoff, it is categorized as —

1. Direct runoff
2. Base flow

1. Direct runoff

- It is that part of precipitation which enters the stream immediately after precipitation.
- It includes surface run off , prompt interflow and direct precipitation.

i. SURFACE RUNOFF : It has two components —

a) Overland flow — it follows laminar regime.

b) Channel flow — it follows turbulent regime.

ii. INTERFLOW : Water which infiltrates the soil surface and then moves laterally through the stream channel, above the main ground water table is called interflow.

Depending upon the time delay between infiltration and its outflow, from the upper crest of soil, the interflow is further classified as —

a) Prompt interflow (hand to hand)

b) Delayed interflow

iii. DIRECT PRECIPITATION : It is that part of precipitation which falls directly on to the channel surface.

2. Base Flow

- The delayed flow that reaches a stream as ground water is called Base flow.
- Delayed interflow is also sometimes included in base flow.

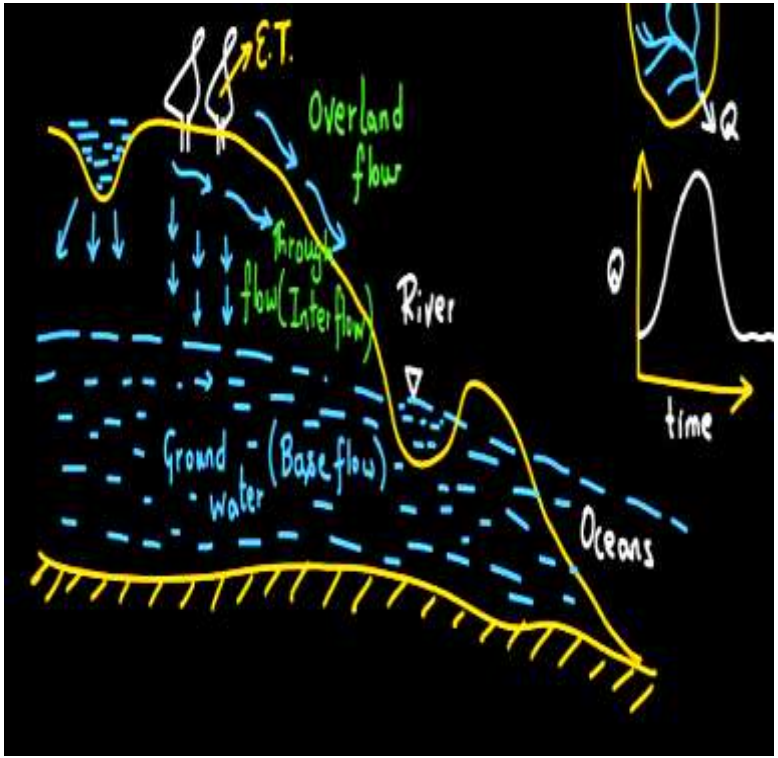
FACTORS AFFECTING RUNOFF DISTRIBUTION

1. Type of precipitation
2. Rainfall duration
3. Rainfall distribution
4. Catchment area
5. Slope of catchment
6. Geology
7. Vegetation
8. Direction of storm movement
9. Drainage density

1. Type of precipitation —
• Precipitation falling as rain contributes directly to run off whereas in case of snow fall, it will contribute after it melts, and hence runoff is delayed.

2.Rainfall duration
• A rainfall of duration greater than concentration time will give maximum run off
Q max = I effective x catchment area

3. Rainfall distribution
• A rainfall of constant intensity over a catchment may lead to delayed runoff if it is uniformly distributed than compared to a rainfall which is localized near the catchment outlet.



4. Catchment Factors

• Form Factor —

Form factor is divided by the width of the catchment by its axial length measured along the main stream channel from the remotest point to the catchment outlet. For same area, catchment with high form factor will produce a higher peak of runoff.

• Compactness Coefficient—

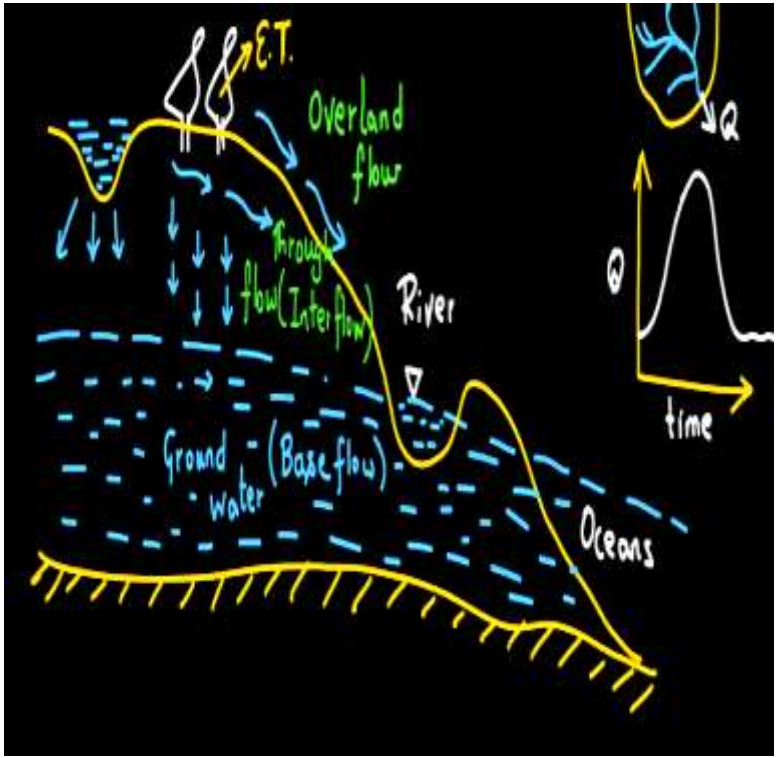
It is derived by dividing the periphery of the catchment by the circumference of a circle with the same area. A catchment with high compactness coefficient will give lower peak of runoff. Minimum value of compactness coefficient is unity (for completely circular catchment)

5. Slope of catchment

• If the slope of catchment is large, the catchment will give higher and early peak.

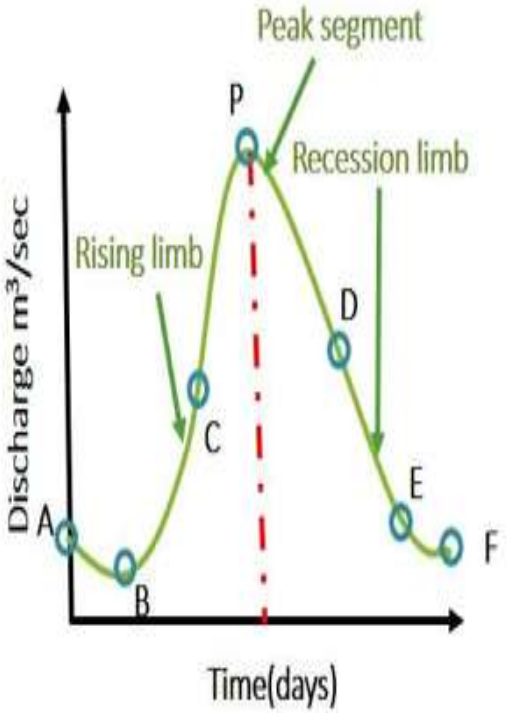
6. Geology

• Coarse textured soil will give a lower peak than clayey soil.



HYDROGRAPH

• It is a plot of discharge against time.
• Components of Hydrograph
> Hydrograph generally contains the following three parts.
Start of
1. Rising Limb
2. Peak (or Crest) Segment
3. Falling (or Recession) Limb



- A – Start of rainfall
- ABEF – Base Flow
- B – Start of Direct Runoff
- BC – Rising limb
- CPD – Crest Segment
- P – Peak of hydrograph
- C and D – Inflection points
- DE – Recession Limb
- E – Point where overland flow seizes
- D – Point which marks end of direct runoff
- BCPDE – Direct Runoff Hydrograph

Components of Hydrograph

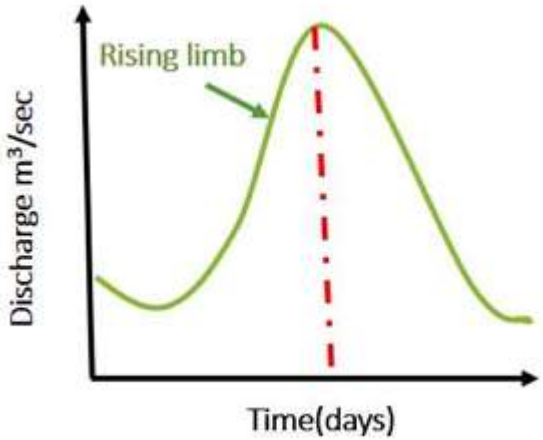
1. Rising Limb

It is the ascending curved portion of the hydrograph.

The rising limb rises slowly in the early stage of the flood but more rapidly toward the end portion.

The shape of rising limb depends on duration and intensity distribution Of rainfall.

This is because in early stages the losses is more and water reaches to the stream faster.

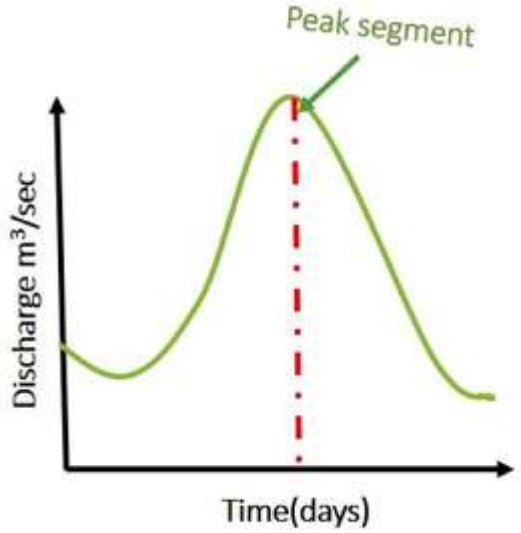


2. Peak Segment

Peak segment is shown by inverted U in the hydrograph.

Peak of hydrograph occurs when all parts of basins contribute at the outlet simultaneously at the maximum rate.

Depending upon the rainfall-basin characteristics, the peak may be sharp, flat or may have several well defined peaks.

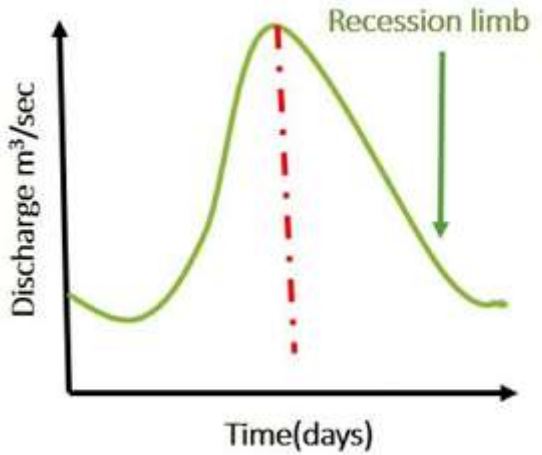


3. Recession Limb

Recession Limb represents the withdrawal of water from the storage built up during the early phase of hydrograph.

It extends from the point of inflection at the end of the crest to the beginning of the natural groundwater flow.

The shape of recession limb depends upon basin characteristics only and independent of the storm.



MAXIMUM FLOOD ESTIMATION

1. Rational method —

a) Applicable for small size catchments (< 50km2) for urban drainage design, small culverts and bridges.

peak flood discharge ,

$$Q = AIR / 360$$

$$Q = KPcA / 360$$

K = coefficient of runoff

A = Catchment area in hectares

R or Pc = design intensity of rainfall in mm/hr.

2. Empirical Method :

a) Dicken's Formula —

$$Q = C_D A^{\frac{3}{4}}$$

Q = Discharge in cumecs
A = Area of basin in sq. km
C_D = Dicken's coefficient (between 6 to 30)

b) Ryve's Formula —

$$Q = C_R A^{\frac{2}{3}}$$

Q = Discharge in cumecs
A = Area of basin in sq. km
C_R = Ryve's coefficient (between 6.8 to 10.2)

c) Inglis Formula –

$$Q = \frac{123A}{\sqrt{A + 10.4}}$$

Thank You