Water Resources Engineering Lecture 7

Hydrologic Analysis-Rainfall-Runoff Modeling

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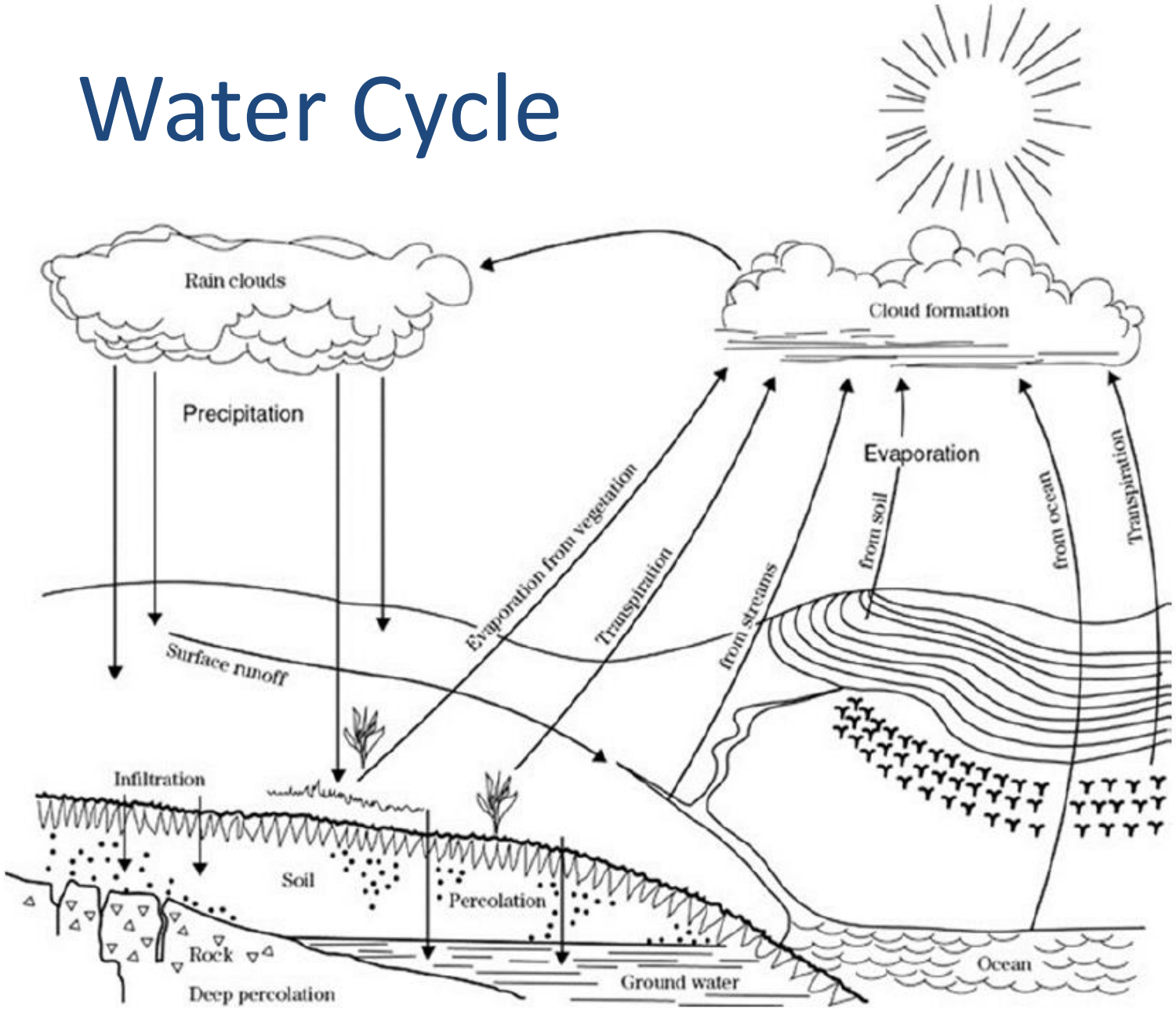
Water Cycle


Rain clouds
Cloud formation
Precipitation
Evaporation
Evaporation from vegetation
Transpiration
from soil
from streams
from ocean
Transpiration
Surface runoff
Infiltration
Soil
Percolation
Rock
Deep percolation
Ground water
Ocean

Runoff Overview

- **Runoff**

is a fundamental part of the hydrologic (water) cycle, defined as the flow of water (from precipitation like rain or melted snow/ice) that moves across the land surface and eventually reaches streams, rivers, lakes, and oceans.

Occurrence:

Runoff primarily occurs when the rate of water supply (e.g., rainfall intensity) exceeds the rate at which the ground can absorb it (infiltration capacity) or when the soil is completely saturated.

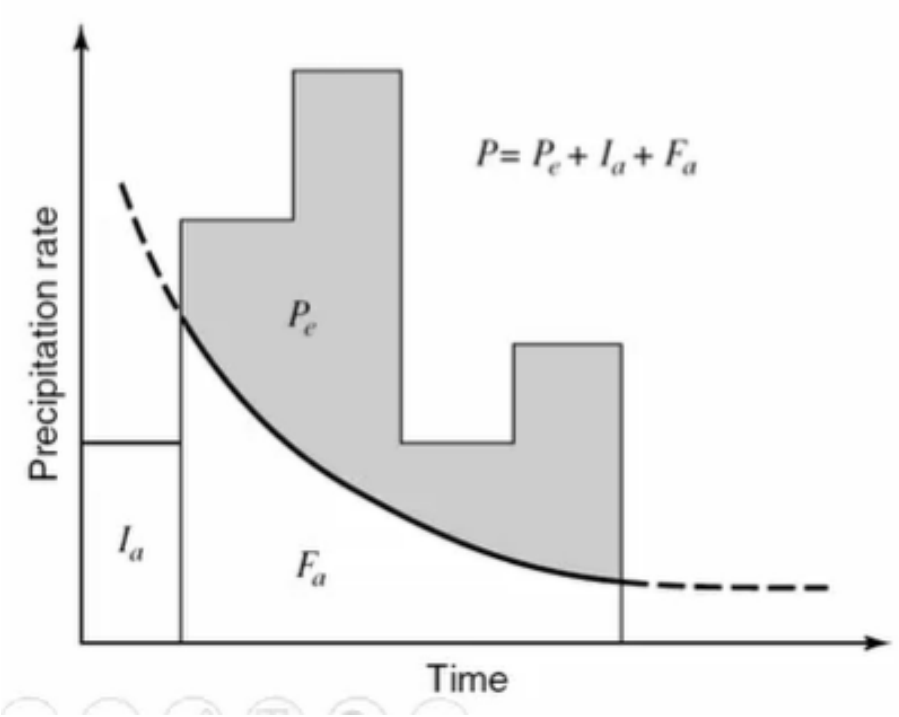
Runoff

P (Precipitation): The total depth or amount of rainfall accumulated over a given time. In the graph, this is the entire area of the bar chart.

Ia **Initial Abstraction):** All the water "losses" that occur *before* surface runoff begins. This includes interception by vegetation, surface storage (puddles), evaporation, and initial infiltration into dry soil.

Fa **(Continuing Abstraction/Infiltration):** The ongoing water loss due to infiltration into the soil *after* the initial abstraction requirements are met and runoff has begun.

Pe **(Precipitation Excess or Direct Runoff):** The portion of precipitation that **runs off** the land surface and forms streamflow. This is the accumulated volume of water that is not captured by initial or continuing abstractions.

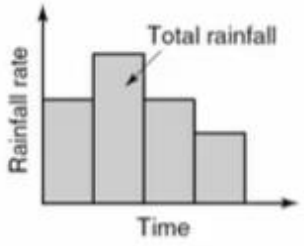


$$P=Pe+Ia+Fa$$

Rainfall-Runoff Modeling

A Watershed Model Works to Define…

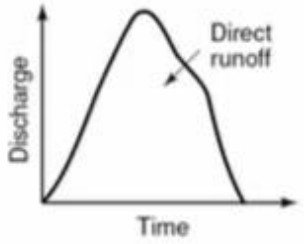
Rainfall
(Temporal Distribution)



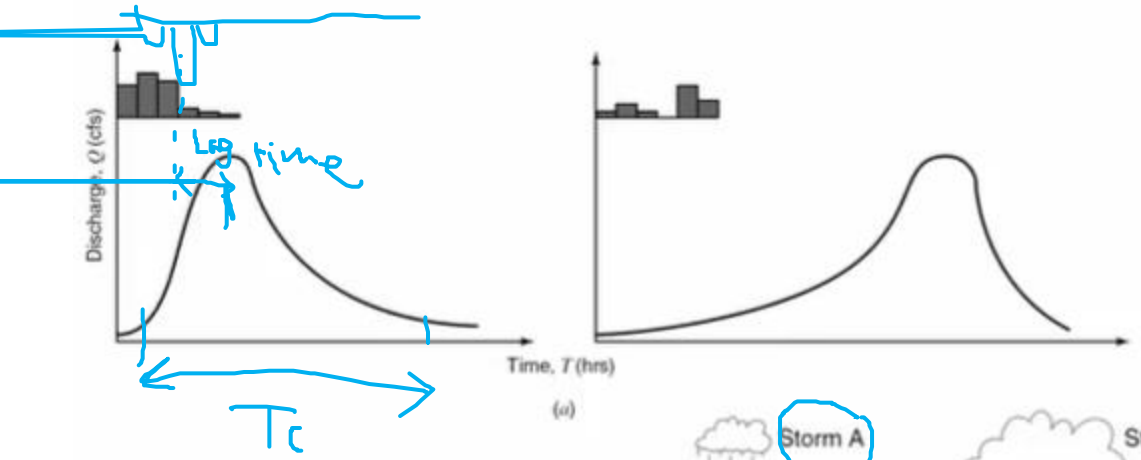
Influencing Factors:

- Soil properties
- Land cover
- Abstractions (interception, surface wetting, minor ponding)
- Ground slope
- Stream characteristics
- Watershed geometry (size, shape, stream density)

Runoff
(Temporal Distribution)

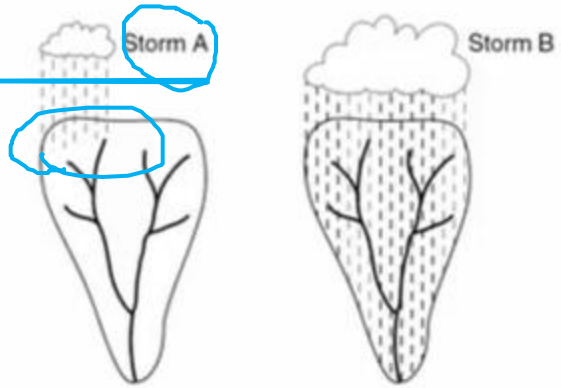


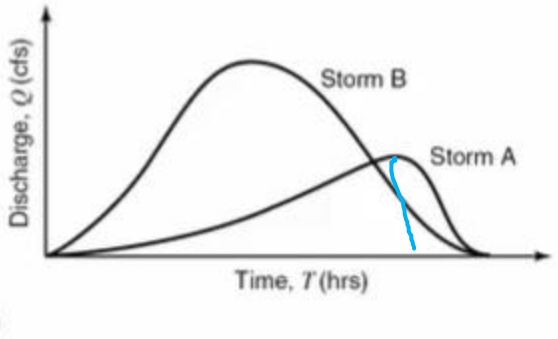
Hydrograph Shape, cont...

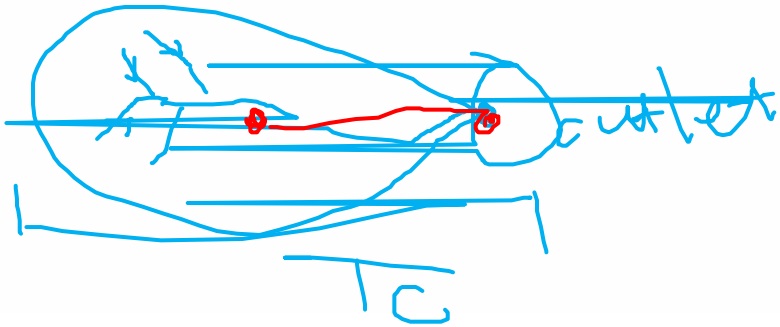


Temporal distribution of rainfall

Geographic size of storm / spatial distribution







Factors affecting Runoff

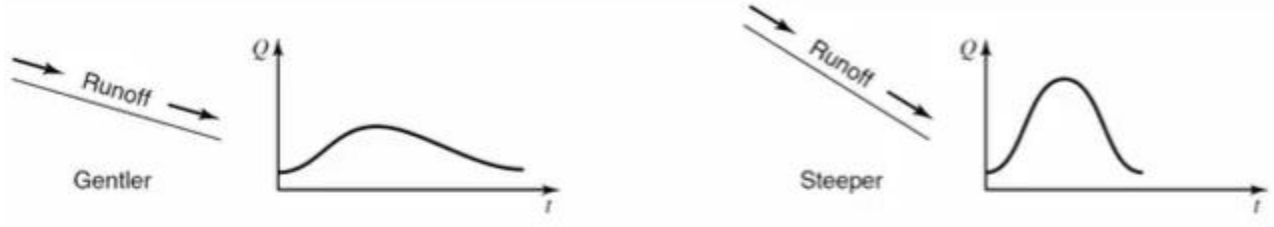
Estimating Runoff

Introduction to Hydrologic Methods

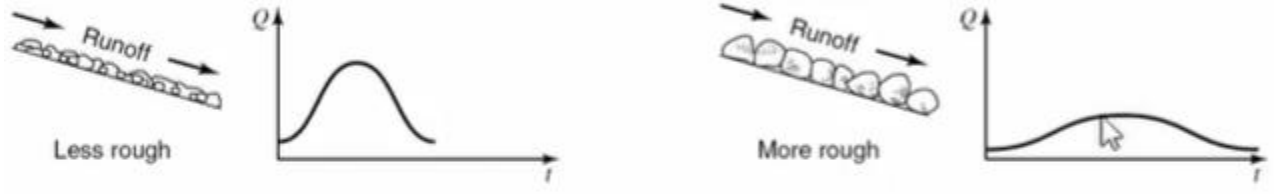
Hydrology deals with estimating flow peaks, volumes, and time distributions of storm water runoff. The analysis of these parameters is fundamental to the design of storm water management facilities, such as storm drainage systems and structural storm water controls. In the hydrologic analysis of a development/redevelopment site, there are a number of variable factors that affect the nature of storm water runoff from the site. Some of the factors that need to be considered include:

- Rainfall amount and storm distribution
- Drainage area size, shape, and orientation
- Ground cover and soil type
- Slopes of terrain and stream channel(s)
- Antecedent moisture condition
- Rainfall abstraction rates (Initial and continued)
- Storage potential (floodplains, ponds, wetlands, reservoirs, channels, etc.)
- Watershed development potential
- Characteristics of the local drainage system

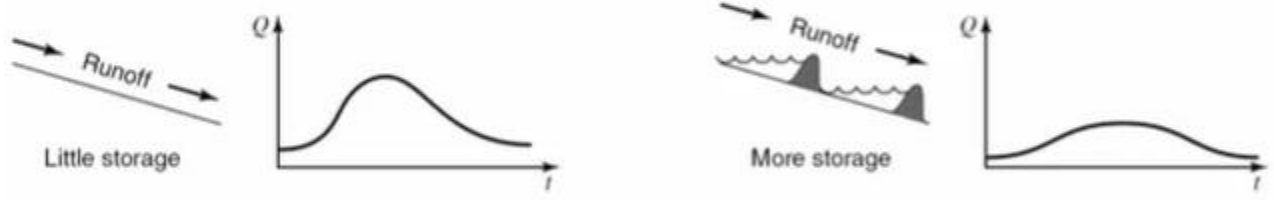
Search



Slope



Hydraulic Roughness



Storage

Drainage Density

Channel Length

Runoff Classification

Classification of runoff according to travel time to a stream:

- Direct runoff – Portion of the total runoff hydrograph at a stream which is caused by and directly following a rainfall or snowmelt event. It consists of:
  - Overland flow, and
  - Quick interflow. It contributes rather quickly to stream flow.
- Baseflow, base runoff, delayed runoff – Portion of the total runoff hydrograph at a stream location which is composed of contributions from:
  - groundwater runoff, and
  - Delayed interflow.

Baseflow is the result of water from previous storms accumulating below the water table and being released over an extended period of time.

Runoff Estimation and Modeling

- To estimate the magnitude of a flood peak the following alternative methods are available:

- 1. Unit-hydrograph technique
- 2. Time-Area Method
- 3. Semi-Empirical method (rational method).
- 4. Empirical method (SCS curve number method)

Semi-Empirical formulae

There many empirical or Semi-Empirical formulae used to estimate the runoff discharge from catchment area. These formulae can be classify into three categories:

1. Formulae consider the area only into calculation, like **Dickens, Ryves, Ingles** and others. The formulae take forms as $Q=CA^n$; n exponent is almost <1.

2. Formulae consider Area and some other factors such as **Craig , Lillie and Rhinds** (Taking velocity , and may be intensity, depth or max, depth of rainfall).

3. Formulae consider the recurrence interval ,like **Fullers , Hortons , Pettis** and other.

Which Method to Use

- Above all , two methods depend on semi-empirical bases are preferable for storm design and have a wide use by the designer. The **Rational method** **and the** **SCS-CN method** **.** Further the Rational formula is only applicable to small-size (< 50 km^2) catchments, and the unit-hydrograph method is normally restricted to moderate-size catchments with areas less than 5000 km