CE-2/1 Geomorphology Civil '09 2/1
Mahfizur Rahman Sir 2021
Sec-A,B,C Set-1

CE- 203

Dr. Md. Mafizur Rahman

DEFINITION OF GEOMORPHOLOGY:

The study of the landforms of the earth including their history and process of origin. This is the systematic examination of the landforms and their interpretation as records of the past history.

The information is utilized by members of the different groups of sciences such as those related to geography, geology, geophysics in addition to geomorphology.

- Actually interest of different groups overlap
- No clear line of distinction among these groups.

ASPECTS OF GEOMORPHOLOGY

- It establishes relation between the land forms and the underlying rocks and is concerned with the interaction between the denundational process and rock forming

Denundation is a useful term for the total action of all processes by which the exposed rocks of the continents are worn away and the resulting sediments are transported to the sea by the fluid agents. **Denundation is an overall lowering of the land surface.**

- It studies the evolution of landscape, which is often called the "Denundational chronology".

- It studies the actual process of erosion which give rise of land forms.

PRINCIPAL ZONES OF EARTH

Atmosphere: It is the gaseous envelop encircling the earth. Distribution of heat, pressure and water vapor content within this envelope gives rise to the global weather and climate.

RUNOFF AND RUNOFF RELATIONS

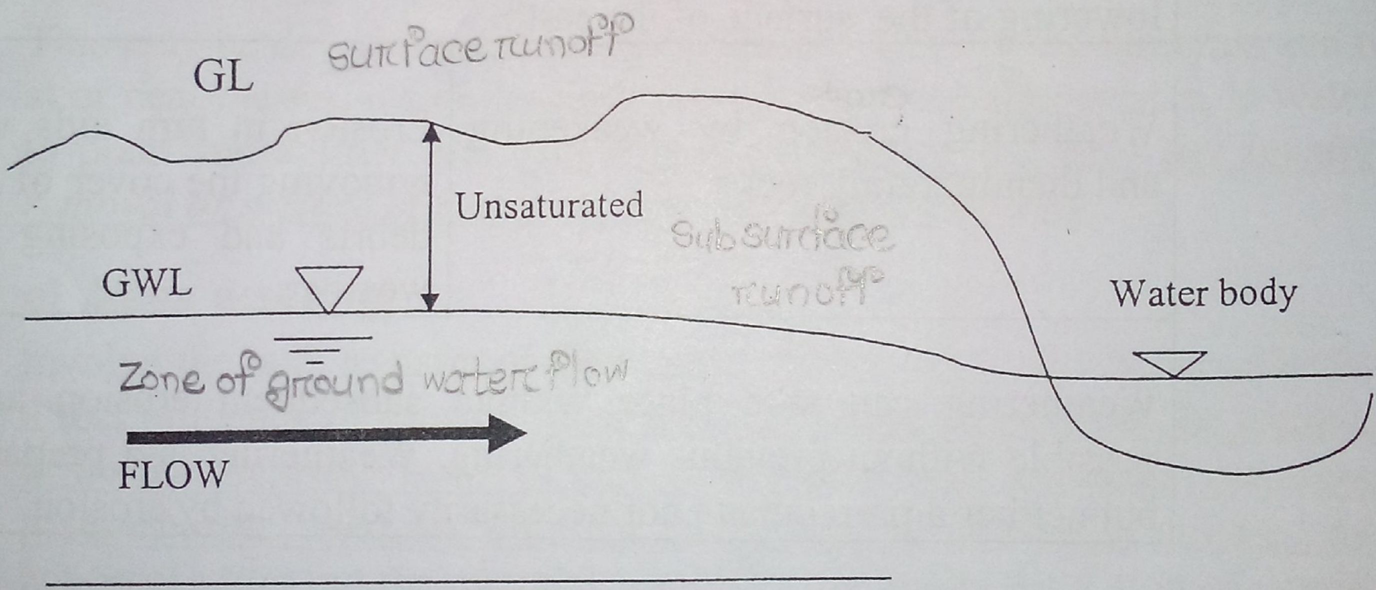
✓ INTRODUCTION:

The water reaching the surface of the earth in the form of precipitation reaches the stream ultimately. From the point where precipitation reached the earth surface it may take different paths on it's way to the stream.

Precipitation is the general term for all forms of moisture emanating from the cloud and falling on the ground.

Some part of the water flows over the land surface and reaches the stream immediately after the precipitation. The other part of the precipitation infiltrates through the soil surface and flows through the soil surface to reach the stream.

✓ COMPONENTS OF THE TOTAL FLOW:



Visualization of the three main routes of travel is very easy. These are

- Overland flow or surface runoff
- Interflow or subsurface run off and
- Ground water flow.

✓ **Surface runoff:** It is that part of water which travels over the ground surface to the channel without infiltrating or percolating to the water table. The term channel as used here indicates all sorts of depressions which is capable of holding water for a short period of time after the rainfall.

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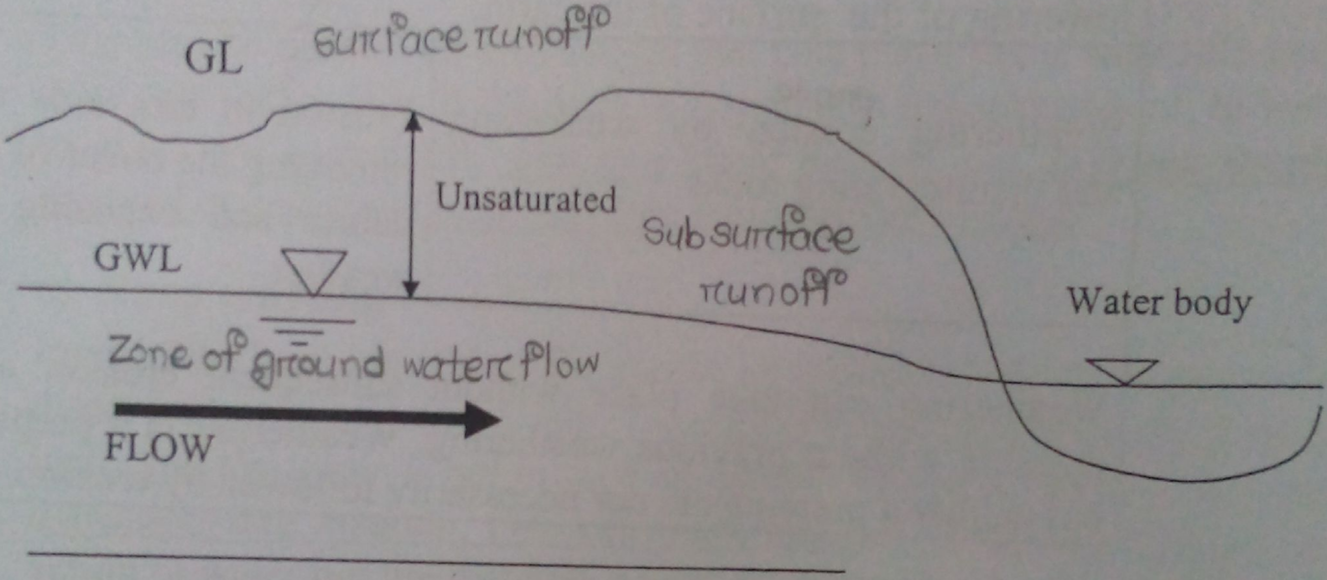

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Surface runoff: It is that part of water which travels over the ground surface to the channel without infiltrating or percolating to the water table. The term channel as used here indicates all sorts of depressions which is capable of holding water for a short period of time after the rainfall.

Sub-surface runoff: It is that portion of the total flow which after infiltrating the soil surface move laterally through the upper soil layer until it enters the channel. Subsurface runoff reaches the channel more slowly than the surface runoff and hence reaches the stream later.

Ground Water Flow: Some portion of the precipitation percolates downward until it reaches the ground water table. This ground water storage may discharge into the stream if the water table intersects the stream channels of the basin. This discharge is called the Ground Water Flow.

Runoff: Runoff is the collective term which refers to all the three components of the total flow, ie., surface runoff, sub-surface runoff and the ground water flow.

For Engg. # In practice it is customary to consider the total flow to be divided into two parts such as

1. Direct runoff and (Surface runoff + a part of sub-surface runoff
2. Base flow. Total G.W flow + remaining part of sub-

Direct runoff is presumed to consist mainly of overland flow and a substantial portion of subsurface runoff whereas the base-flow is considered to be consisting of the ground water flow.

FACTORS AFFECTING RUNOFF:

1. Characteristics of precipitation:

a) ***Type of precipitation:*** Precipitation generally occurs in the form of rain or snow depending on which the runoff pattern varies. Rain produces immediate runoff whereas that in the form of snow produces runoff at a slower rate.

b) ***Rainfall intensity:*** If the rainfall intensity increases the ruoff also increases. For example if the rainfall intensity increases by four times the runoff may increase by nine times.

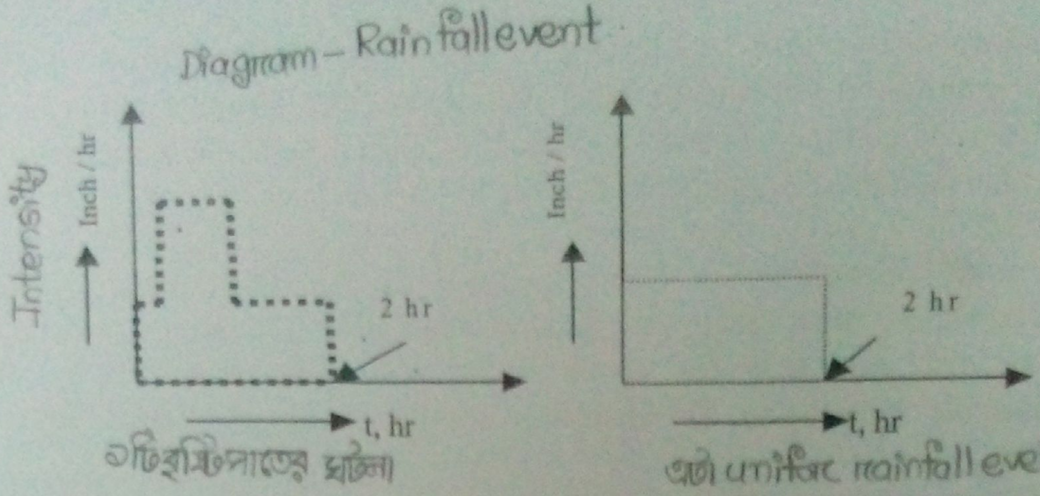


Fig. 2 (a) (b)

An intense rain as shown in Fig. 2(a) will definitely produce much more runoff than that produced by the uniform rainfall as shown in Fig.2(b) provided the infiltration capacity remains the same throughout the storm period.

c) Duration of rainfall: Duration of rainfall is important regarding the fact that the infiltration capacity of the soil goes on decreasing as the rainfall continues for longer duration. As the infiltration decreases the surface runoff increases. Thus rain of a longer duration may produce a considerable runoff even when the intensity is mild.

proper reasoning

d) Rainfall distribution: All the above discussion is made based on the assumption that the rainfall is evenly distributed over the whole catchment area which does not happen in reality. In reality, rain falls on a small part of the whole basin. [For small drainage basins the peak flow are the results of intense rain falling over the small areas whereas for the large basins the peak flows are results of storms of less intensity but covering a large area.]

e) Soil Moisture deficiency: The runoff depends on the soil moisture present at the time if rainfall. If the rain occurs after a long dry spell of time, the soil is dry and it can absorb huge amount of water and thus intense rain may fail to produce appreciable runoff. On the other hand, if the rain falls after a rainy season, the soil will already be wet and there will be less infiltration and even small rainfall may cause appreciable runoff.

surface runoff কম, infiltration বেশি

বর্ষাকালে → surface runoff বেশি
infiltration কম

COMPUTATION OF RUNOFF: কেন করি ?

→ design করতে হবে peak runoff জানতে। তাই max কত runoff হতে পারে তা measure করতে হবে।

RATIONAL METHOD

Introduction:

The Rational Method is an intensity based rainfall method, meaning that it can be used to predict peak flows based on the characteristics of the catchment area and a rainfall event. This makes the Rational Method a popular choice for storm sewer analyses.

Objectives of Rational Method:

Many hydrologic design problems require simply an estimation of the peak flow rate generated by a river system under specified conditions. In such problems, the general shape of the flood hydrograph and the time of occurrence of the peak flow rate are no special significance and need not be taken into account. In such cases the Rational Method can be applied to estimate the peak flow rate.
Also when adequate data are not available this method can be applied.

Assumptions:

#The rainfall is uniform both spatially and temporally.
#The drainage area is small.
#The duration of the rainfall is equal to the catchment's time of concentrations.
#Peak flow occurs when the entire catchment area is contributing.
The recurrence interval of the peak discharge is equal to that of the rainfall intensity.

Rational Formula:

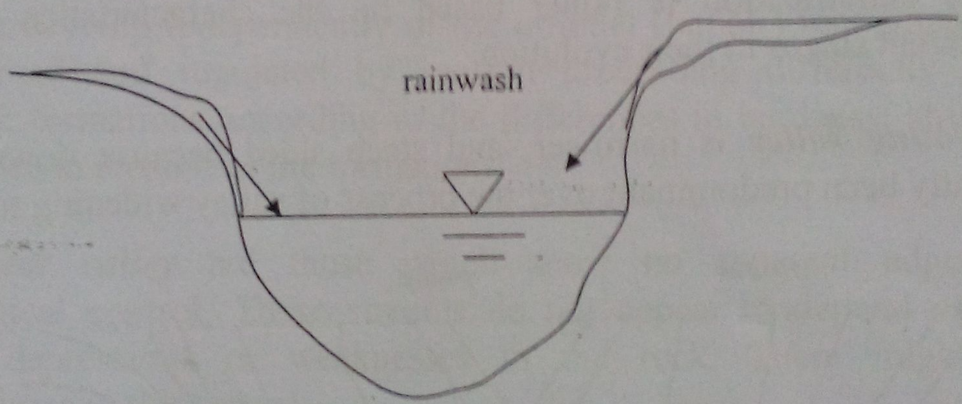
Peak discharge, **Q= kICA**

2) **VALLEY WIDENING:** Valley width is the linear distance between the two sides of it. This is expressed along with the different locations of the valley reach.

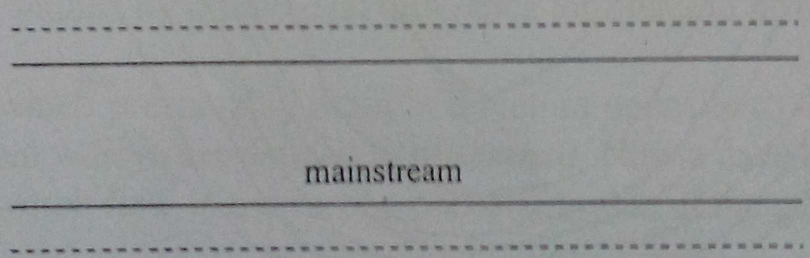
Valley widening may be accomplished in the following ways:

a) Lateral erosion: Storm in a valley may remove materials from the base of the valley side through hydraulic and corrosive action. This results in the oversteepening of the valley floor which favors slumping of the materials into the stream. নদীর পাড়ভাঙা

b) Rainwash or sheetwash: Contributes in an important way in valley widening. Loose weathered materials are washed down the valley side by rain.



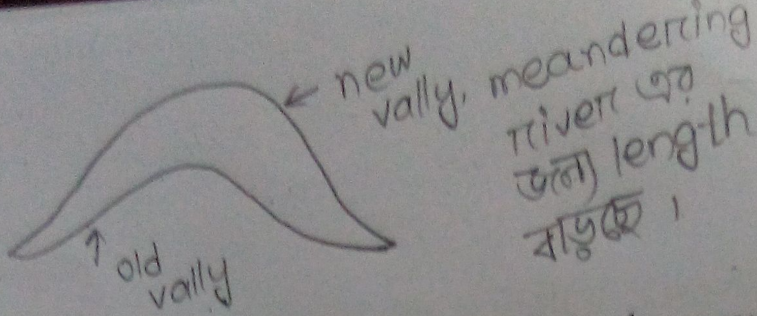
c) Gulleying on valley sides:



Gullies are mini streams which with every fresh supply of water, become deeper, longer and wider. After a time gullies are large enough to be called valleys.

d) ***Weathering and mass wasting:*** Weathering may loosen material which moves directly downslope into the stream channel by different types of mass wasting.

e) ***Incoming tributaries*** contribute to the valley widening even though they are nothing more than the overgrown gullies.



3) **VALLEY LENGTHENING:** May take place in three ways. These are:

- By the process of headward erosion
- Through increase in size of their meanders
- Valley also may lengthen at their termini. Uplift of the land or lowering of the lake level will result in extension of the valley form across the newly exposed land.

CLASSIFICATION OF VALLEYS:

A. According to the stage in the geomorphic cycle valleys are classified as:

1. Young
2. Mature, and
3. Old.

This classification is rather based on the characteristics developed at different stages in their evolution.

A ***young valley*** is narrower, and steep sided because down-cutting had greatly been predominant over the process of valley widening till this age.

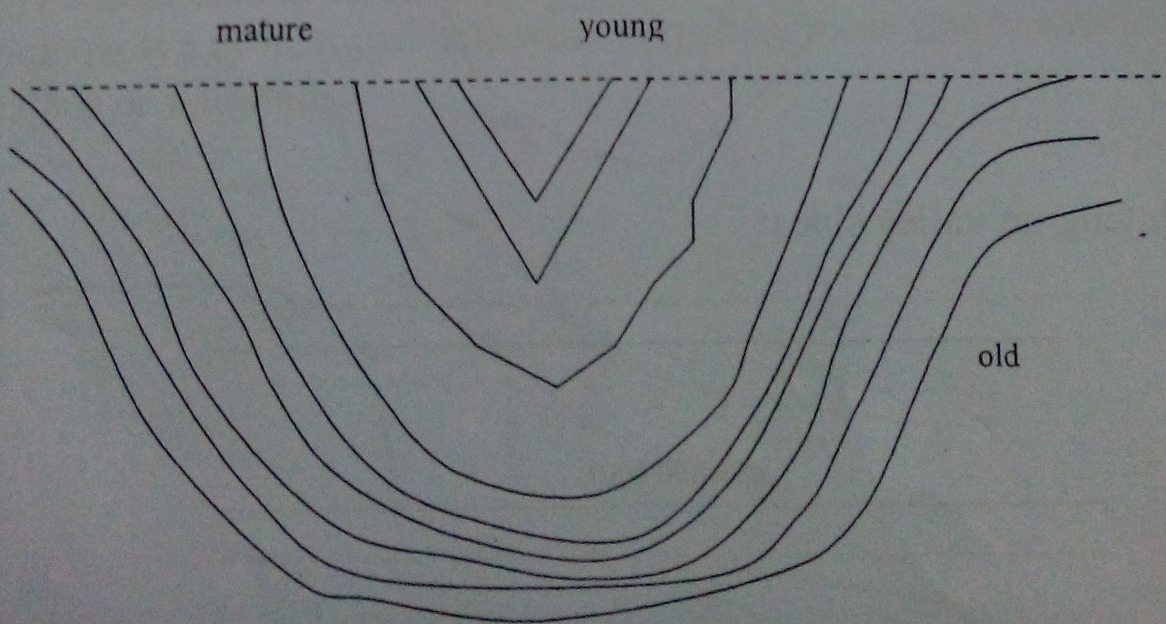


Fig. Cross profile of valleys at different stages of development

RIVER TRANSPORTATION

Activities of running water: The water that flows along the river does the following works:

- It transports the debris
- It erodes the river channel deeper into the land
- It deposits sediments at various points along the valley or delivers them to lakes or oceans

River transportation: River transportation is the ability of the river to carry along the particles that a stream picks up directly from it's own channel or that is supplied to it by slope wash, tributaries or mass movement.

Factors affecting the transportation power of river:

- Size of particle to be carried
- Volume of total load
- Velocity of river

Some important definitions:

Load: The amount of material that a river carries at any time is called its load. (load Ton এ হিসাব করা হয়) amount of load is a function of Time

Capacity: The total **amount of material** a river is **capable of carrying** under any given set of conditions is called the capacity of the river.

Capacity of a river varies approximately with the third power of the velocity if a fair proportion of all grain sizes are available, with a higher power if all the materials are fine grained and with a lower power if the material is coarse. The capacity is a function of discharge and velocity.

Competence: The maximum size of particle that a river can carry is called its competence. The competence of a river is a statement of its ability to move materials in terms of material size. Competence is a function of velocity only. The diameter of a particle that a river can move varies approximately with the square of the stream velocity.

competence $\propto v^2$

CLASSIFICATION OF LOAD

- Load carried in solution
- Load carried mechanically as sediment

Dissolved load: These are the **soluble materials** and are **carried in solution** in the form of ions. The amount of dissolved load depends upon 1) Climate, 2) Season, and 3) Geologic setting.

Suspended load: This is the load carried mechanically as sediment. These are the particles of solid matter that are swept along in the turbulent current of the stream and **remain in suspension**. The amount of this load depends upon 1) intensity of turbulence of water, and 2) terminal velocity of each individual particle.

Bed Load: These are solid particles, which **move along the riverbed**. Bed load mainly consists of gravel and sand.

MOVEMENT OF BED LOAD:

Particles in the bed load move in three ways:

1. By saltation,
2. By rolling , and
3. By sliding.

1) **Saltation:** A particle moving by saltation jumps from one point of the stream to another. First, it is picked up by a current of turbulent water and flung upwards and if it is too heavy to remain in suspension, it drops to the stream floor again at some spot downstream.
2) **Rolling and sliding:** Some particles are too large and too heavy to be picked up by the water current. But they may be pushed along the streambed and depending upon their shape, they move forward either by rolling or by sliding.

CHANNEL CHANGES IN THE FLOOD:

We think the flood as the change in the height of water surface and subsequent inundation but apart from that change occurs in the stream bed which we can not see because of the turbidity of water flowing through the stream.

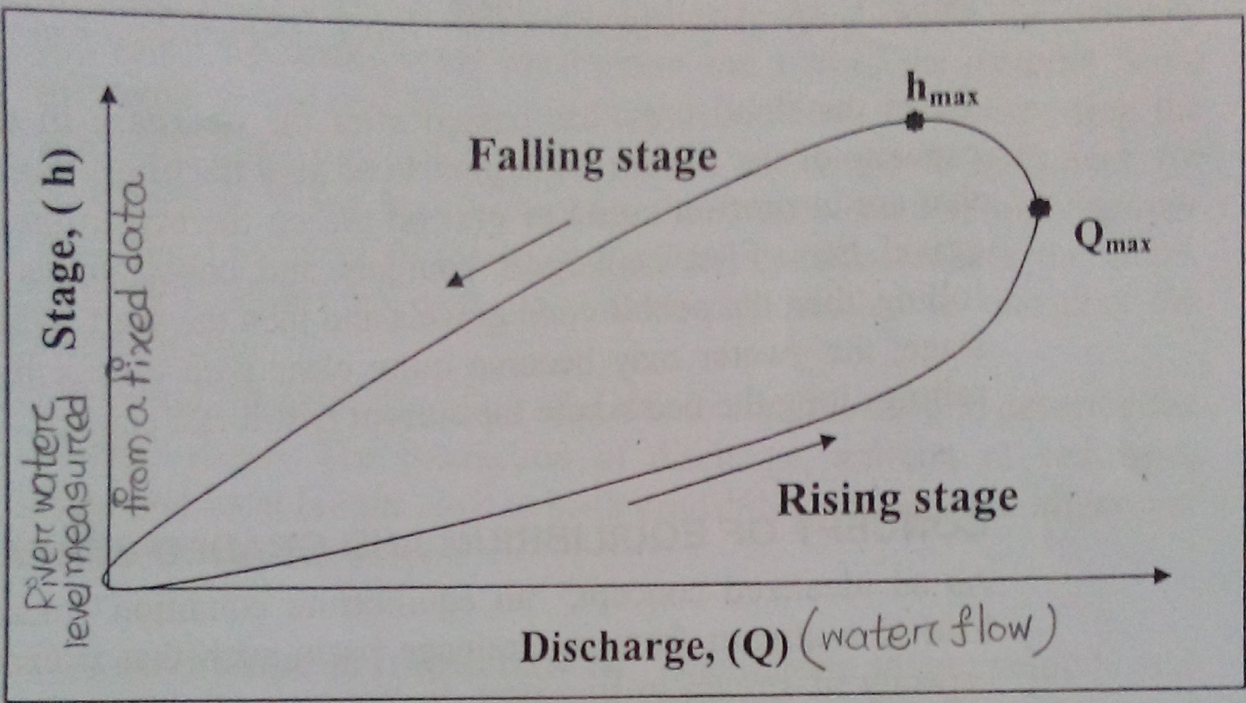


Fig: Stage discharge behavior in unsteady flow condition (For 1 flood season)

The figure above, represents the unsteady behavior of stage-discharge relationship at a location of the stream. The maximum stage and the maximum discharge occur at different times. The changes of the channel bed form that take place during the flood need a clear understanding of this unsteady behavioral pattern.

River channel changes in configuration with this rising and falling stage.

- At first the **bed** may be **built up** by large amounts of bed load supplied in the stream during the first phase of heavy runoff. [Observe the **elevated bed** level as result of it] . This stage disappears soon.

- The bed is actively deepened by scour as the stream stage rises. This is quite interesting to mark the **lowest elevation of the bed level at the highest stage**.

- In the next stage which can be identified by the falling stage of the stage discharge curve, the stage starts to fall and the bed is built back up by the deposition of the bed load.

In the example shown in the figure, about 10ft of thickness of alluvium was **reworked**, that is, moved about in the complete cycle of rising and falling stage.

When the flood crest has passed after the **decrease in the discharge**, the capacity of the stream **transport load also declines**. Some of the **particles** that are in **motion come to rest** on the on the bed in the form of sand and gravel bars. First he largest boulders and cobblestones will cease (stop) rolling, then the pebbles and gravels and then the sand. When restored to low stage, the water may become quite clear with only a few grains of sand rolling along the bed where the current is still fast enough.

CONCEPT OF EQUILIBRIUM AND GRADED STREAM:

As an idealized concept, "an equilibrium condition" means the supply of load to a stream from its drainage basin such that it exactly matches the capacity of stream to transport. In this type of stream the hydraulic factors are changing continuously to bring about a state of equilibrium. This sort of stream is called the **graded stream**.
Based on the concept of Mackin, a geomorphologist:

A graded stream is one which the **slope** is delicately adjusted over a period of years **to provide,** alongwith the available discharge and prevailing channel characteristics, just the velocity required for the transportation of the load supplied to it by the drainage basin.

FACTORS CONTROLLING EQUILIBRIUM OF THE STREAM:

a) **Stream Discharge (Q):** Usually measured in ft^3/sec or m^3/s. Dependent mainly on climate. The relationship $Q=A * V_m$ is important.
   V_m= mean velocity of the section
   A = Area of the section perpendicular to the direction of flow.

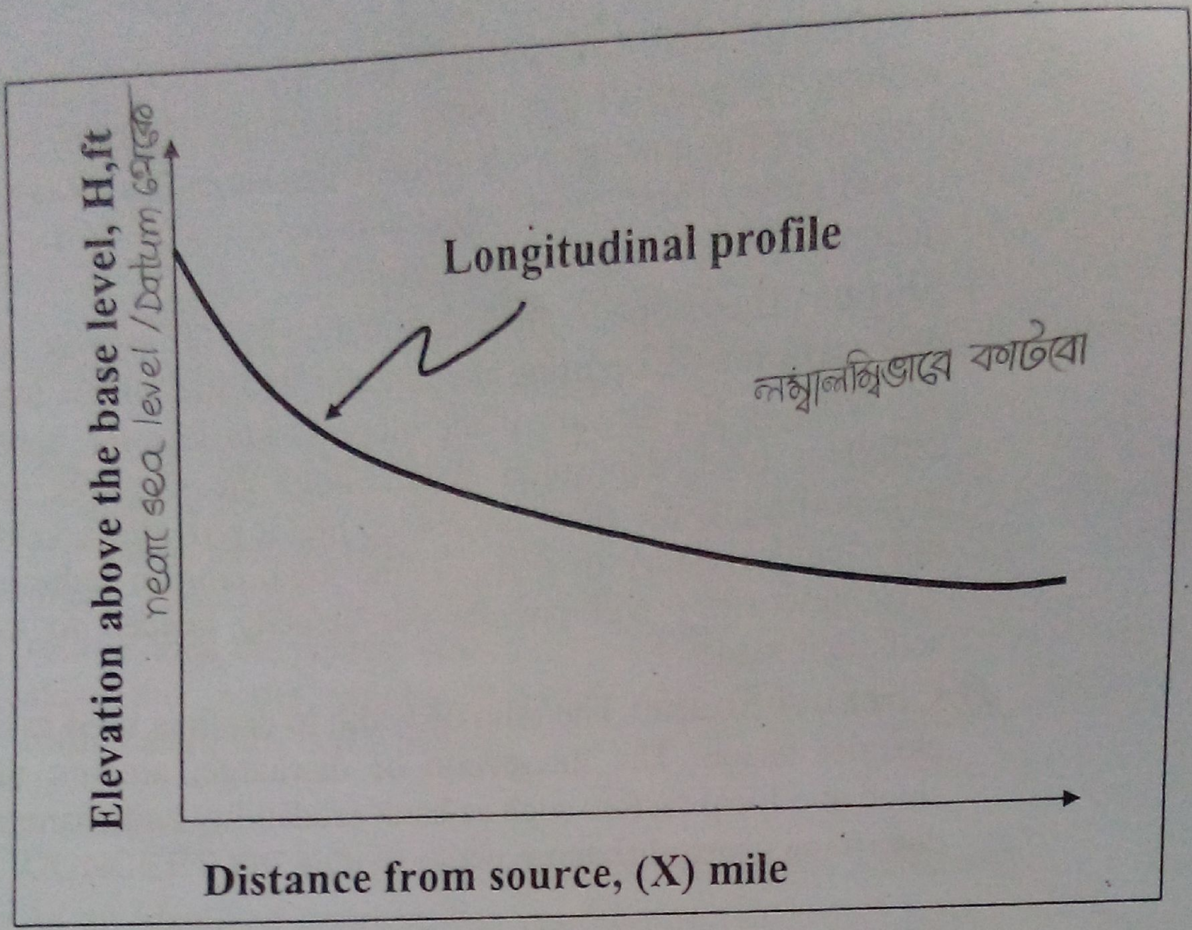


Fig. **Schematic diagram of longitudinal profile of a stream**

EQUATION OF LONGITUDINAL PROFILE:

Assumption: The tendency of a stream to erode at any particular point along its profile is directly proportional to the height of the stream above the base level.

If,
H = Elevation above base level or MSL in feet
X = Distance downstream from source in mile

Then based on the assumption:

river bed এর elevation যত বেশি, rate of erosion তত বেশি

$$\frac{dH}{dX} \alpha - H$$

$$\text{or, } \frac{dH}{dX} = -bH$$

$$\text{or, } \frac{dH}{H} = -bdX$$

or, $\log_e H = -bX + \log_e C$

or, $\log_e H - \log_e C = -bX$

or, $\log_e (H/C) = -bX$ c, b এরা constant

or, $H/C = e^{-bX}$

is the equation of the longitudinal bed profile.

READJUSTMENT OF THE STREAM GRADE:

A graded stream delicately adjusted to its environment of supply of water and rock waste from the upstream sources is highly sensitive to changes in those controls. Changes in climate and in land surface of the water shade bring changes in discharge and load at downstream points and these changes in turn require channel readjustment.

Effect of increase in bed load:
[Increase of bed load beyond stream capacity → acumulation of coarse sediment on the stream bed → elevation of stream bed] → Aggradation

As consequence of aggradation

In the upstream direction: Reduces the channel slope in the u/s direction → reduction of stream capacity in the reach → accumulation of the bed materials in the u/s direction

In the downstream direction: The channel slope is increased → velocity increases → more bed materials gragged downstream

Aggradation ***changes the channel cross section*** from a narrow and deep form to a wide and shallow one. Formation of bars continuously → Division of flow into multiple directions → Braided channel.

Effect of decrease in bed load: This change can come along in a number of ways:

- Reforestation of an abandoned farmland
- Building of dam, trapping sediment in the upstream reservoir

DRAINAGE PATTERN:

Definition:

Distribution of stream courses and their spatial relationship to one other

Types: (Qualitative) দেখতে কেমন তার ভিত্তিতে

1. Dendritic
2. Trellis
3. Rectangular
4. Radial
5. Annular
6. Parallel
7. Irregular

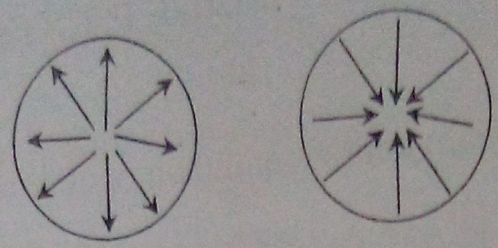
1. Dendritic:
- Irregular branching of tributary streams in many directions at almost any angle (Usually less than or at right angle)
- Most likely to be found upon horizontal rocks or in areas of massive igneous/metamorphic rocks
- Looks similar to that of the roots of trees

2. Trellis:
- These are formed in places where the bands of rock resistant to weathering alternate with bands(of rock) that erode more rapidly
- The main streams frequently make nearly right angled bends to cross or pass between aligned ridges
- Primary tributary streams are usually at right angles to the main stream and are joined at right angles by the secondary tributaries whose courses are commonly parallel to the main stream
- This is a special variety of the rectangular pattern

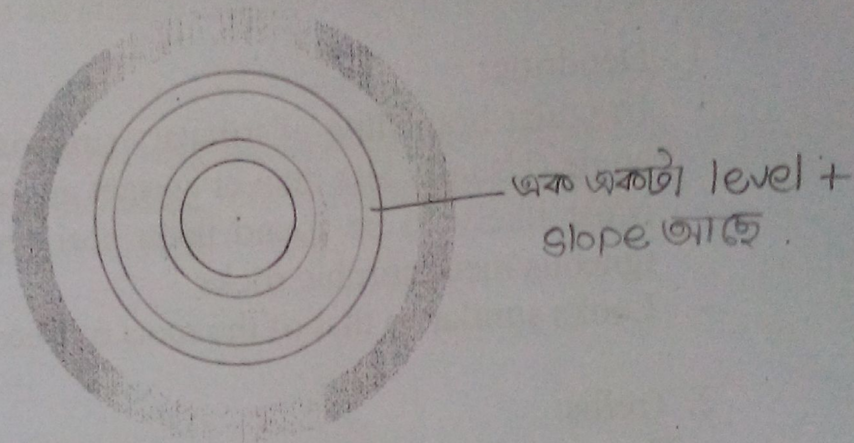
3. Rectangular:
- Characterized by the bends in both the tributaries and the master streams
- Generally right angle joints

4. Radial:
- In the ***radial outward*** pattern the drainage lines radiate outward from a common center. This center is located at an elevated location.

- In the ***centripetal or radial inward*** type the streams flow into a common center from the circular basin walls.

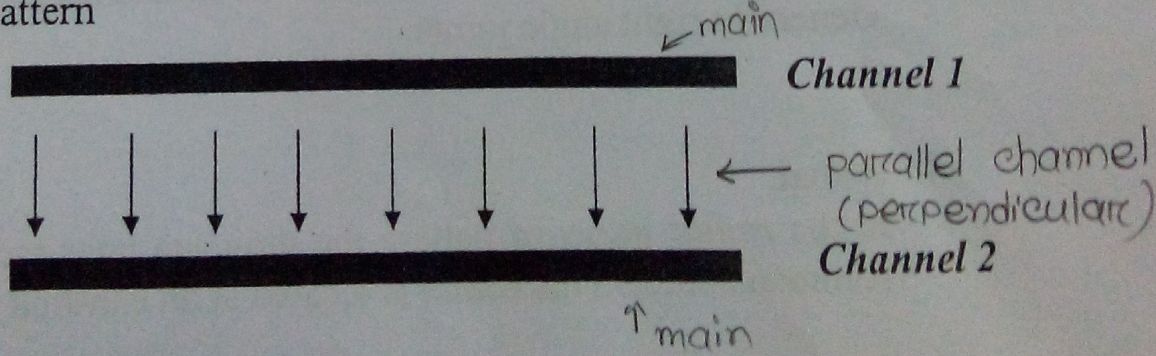


5. Annular:
- May be found around maturely dissected domes which have alternating belts of strong and weak rocks encircling them



- As breaching proceeds the initial radial drains completely disappear, influence of slope control ceases and concentric arrangements of streams (the annular pattern) on the least resistant formations will develop if other factors are negligible

6. Parallel:
- It consists of parallel master and tributary streams
- Pronounced regional slopes, parallel faults and parallel topographic features are the controlling factors in the formation of this type of drainage pattern



7. Irregular:
- Guess what!!

*যখন uniform slope থাকে, তখন এটা হয়

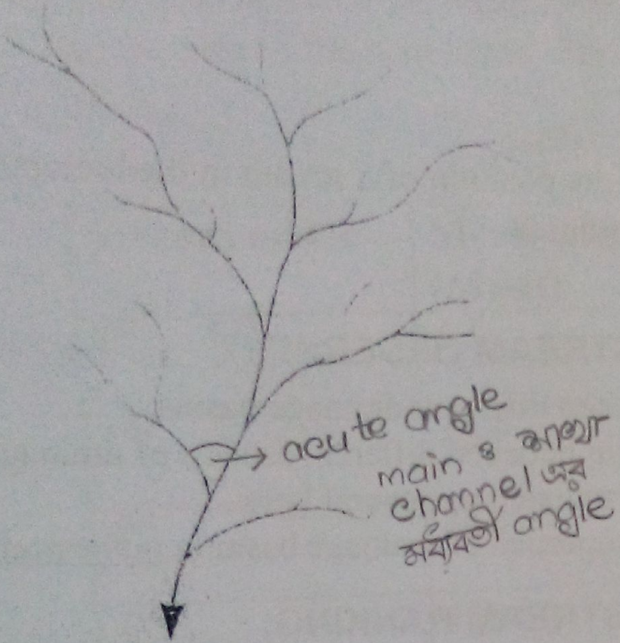


Figure 9-39
Typical dendritic drainage pattern, characterized by a branching pattern similar to that of the limbs or roots of trees.

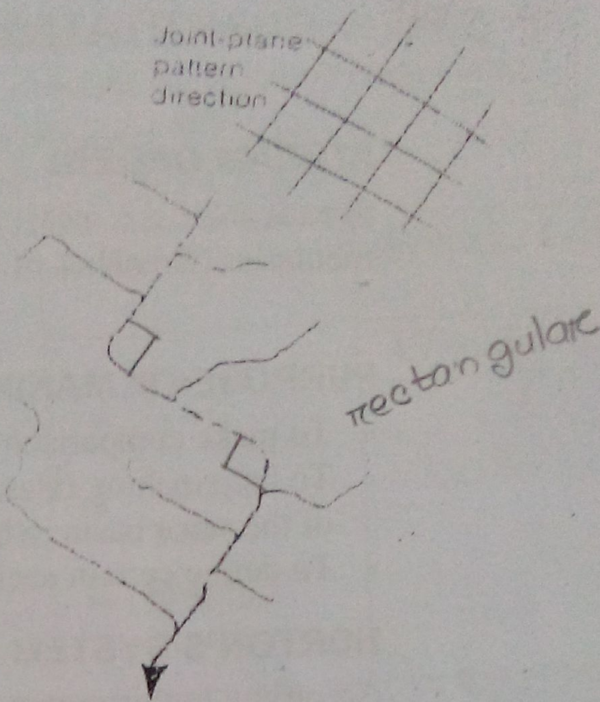


Figure 9-40
Typical rectangular drainage pattern developed on a strongly jointed rocky terrain. Drainage tends to follow the joint pattern.

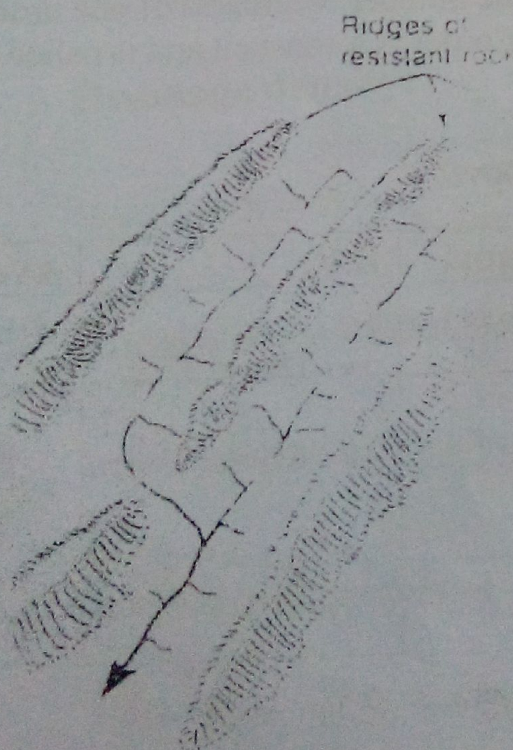
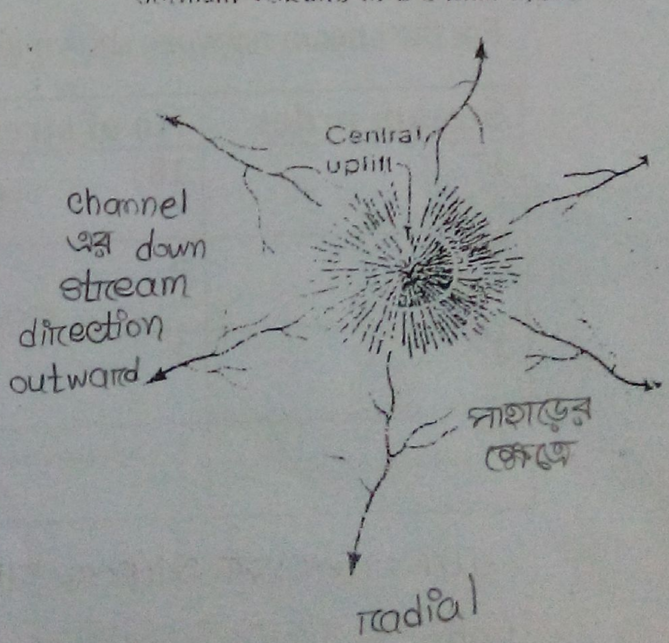


Figure 9-41
Typical trellis drainage developed in valley and ridge terrain, in which rocks of varying resistance to erosion ar

Figure 9-42
Typical radial drainage pattern develope on a large single peak, such as a large dormant volcano or a domal uplift.



1 টি 1Q. Term from this topic

QUANTITATIVE ANALYSIS OF STREAM NETWORK

STREAM ORDER:

Stream order is a measure of the position of a stream in the hierarchy of tributaries (Branches of stream).

PURPOSE OF MAKING STREAM ORDER:

- To make comparison between different drainage basins
- To help making relationship between different aspects of drainage pattern of the same basin to be formulated as general laws.
- To define certain useful properties of drainage basin in numerical terms

HORTON'S SYSTEM OF STREAM RANKING:

According to this system of stream ranking- a stream which has no tributaries (শাখা) is a stream of *1st order*.
A stream which has tributaries of order 1, is a *second order* stream.
A stream which has first and second order tributaries, is a stream of *third order*.

BIFURCATION RATIO:

The ratio between (Mean ratio) the number of streams of one order to the number of streams of next higher order is a constant and is called bifurcation ratio (B.R.).

For the stream network shown above:

Stream order	No of streams	B.R.	Average B.R.
1st	18	18/6 = 3 ①	$\frac{3+2+3}{3} = \frac{8}{3} = 2.667$
2nd	6	6/3 = 2 ②	
3rd	3	3/1 = 3 ③	
4th	1		

4টা order এর stream থাকলে 3টি B.R পাব।
ratio এর জন্য বড় মান ÷ ছোট মান

Length Ratio(L.R.) :

The ratio between the mean length of stream of an order to the mean length of streams of the next lower order is a constant and is called length ratio (L.R.)

প্রত্যেকটা stream length বের করে যোগ করে Total stream সংখ্যা দিয়ে ভাগ

Stream order	Mean length (Miles)	L.R.	Average L.R.
1st	5.3	24.8/ 5.3 = 4.7	$\frac{4.7+2.83+2.14}{3}$ =3.218
2nd	24.8	70.2/ 24.8 = 2.83	
3rd	70.2	150.5/ 70.2 = 2.14	
4th	150.5		

CONSTANT OF CHANNEL MAINTENANCE:

It is the drainage area required to be sustained by unit length of the channel.
Length of channel (L) is given by the empirical formula: $L = 1.4\ A_d^{0.6}$

L = Mean length of the channel (mi), A_d = the area of the drainage basin (mi^2)
The value of A_d for L =1 unit, is the constant of channel maintenance.

একক length এর channel যে water drainout করে তাই channel maintenance

Drainage density:

$$\text{Drainage density} = \frac{\sum Length}{\sum Area_d} = \frac{L}{A_d};$$ Unit is '1/ mile'

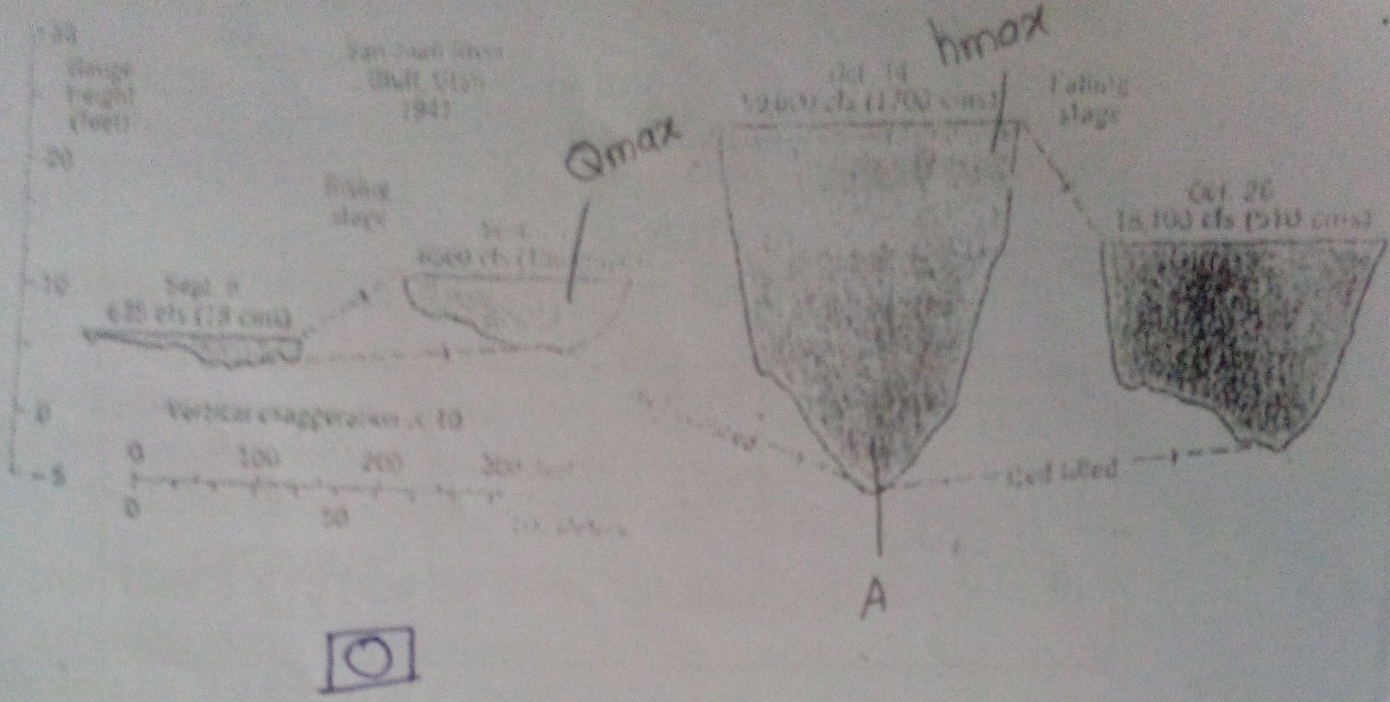
Length of overland flow:

$$\text{Length of overland flow} = \tfrac{1}{2} \times \frac{1}{DrainageDensity} = \frac{\sum A_d}{2\sum L};$$ Unit is mile

Stream Frequency: $\text{Stream Frequency} = \frac{\text{No of streams in a network}}{\text{Total area of drainage basin}}$

south এ বেশি stream frequency

Figure 32.2 Changes in channel from of the San Juan River near Bluff, Utha,during the progress of a flood. (Based on data of L.B. Leopold and T. Maddock, 1953, U.S. Geological Survey, Professional Paper 252, p. 32, Figure 22).

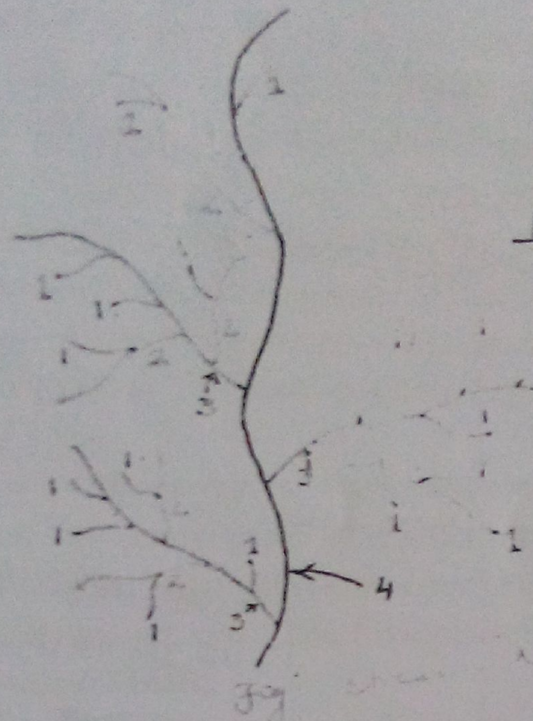


Scanned by CamScanner

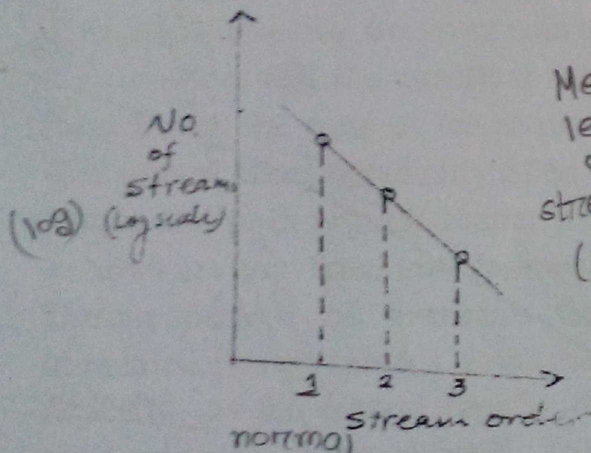
Hint Try to trace orders from the lowest (i.e. 1st order) to the higher one.

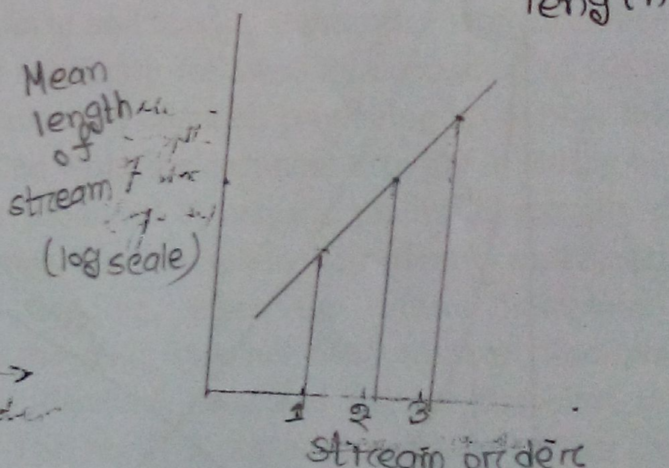
process → stream Ranking

করার ফলে যা পাই — stream order

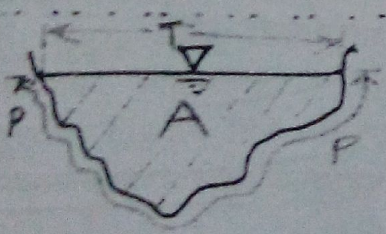


Law of stream number





Channel sectional properties.-

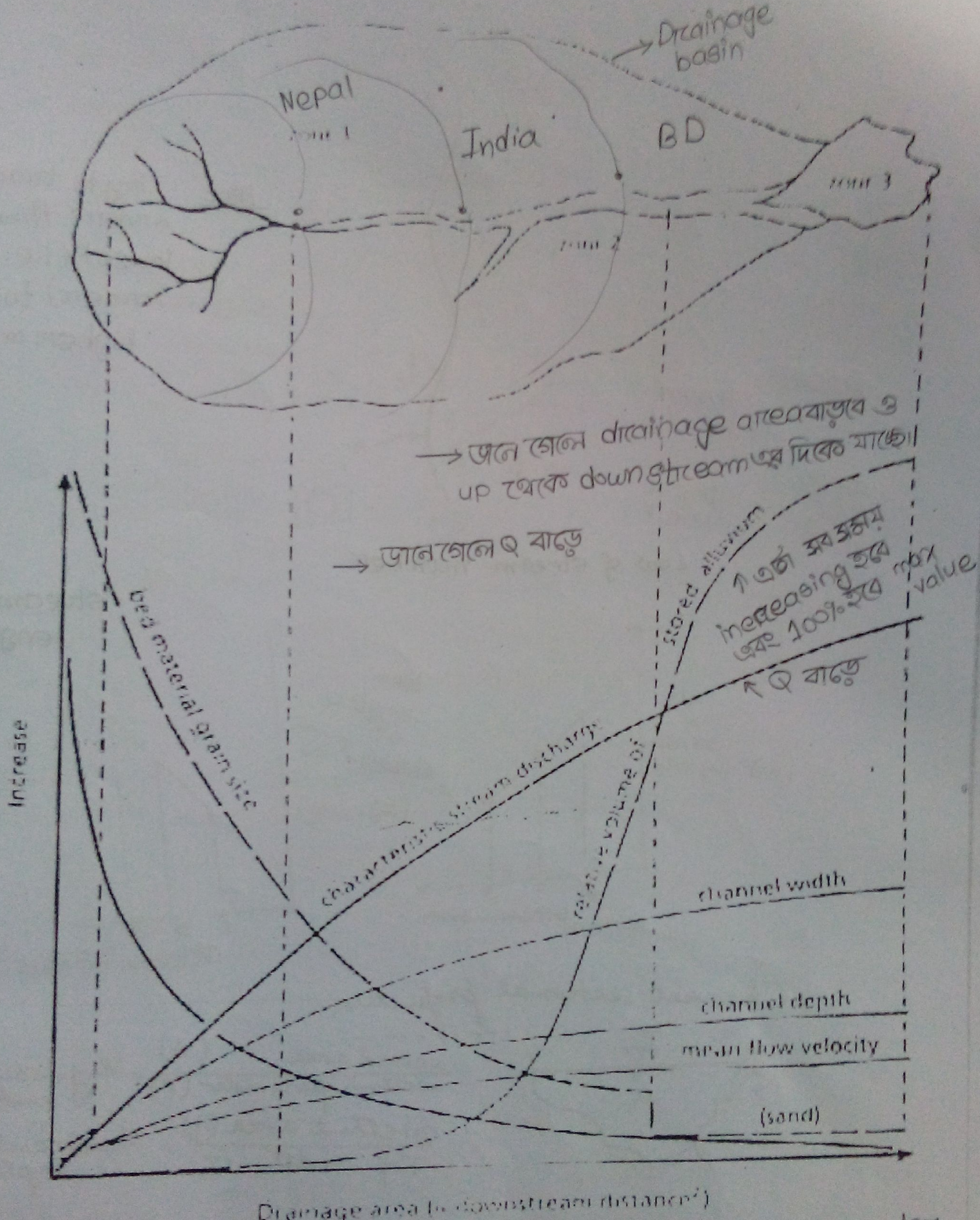


$$\frac{\text{wetted area (A)}}{\text{wetted perimeter (P)}} = \text{hydraulic radius (R)}$$

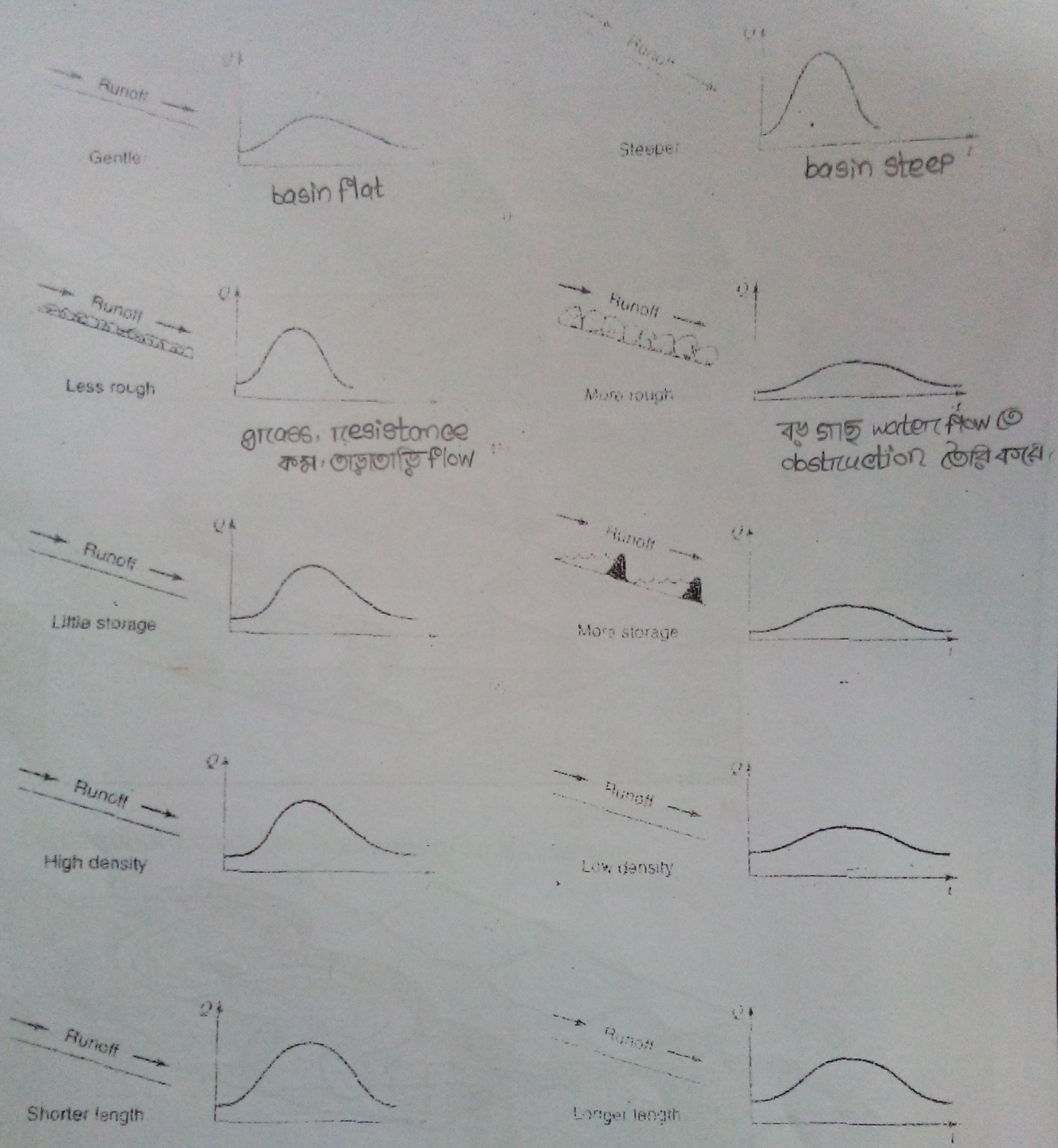
$$\frac{\text{wetted area (A)}}{\text{Top width (T)}} = \text{hydraulic depth (D)}$$

এরা Dinamic parameter, পানির stage উঠানামা করলে R, D change হয় কারণ A, P, T change হয়

Q. এই Diagram এর মাধ্যমে BD river এর parameter গুলো explain কর।



variation of river morphological parameter along downstream direction



Effects of basin characteristics on the flood hydrograph.
(a) Relationship of slope to peak discharge; *(b)* Relationship of hydraulic roughness to runoff. (c) Relationship of storage to runoff. *(d)* Relationship of drainage density to runoff. *(e)* Relationship of channel length to runoff (from Masch (1984)).

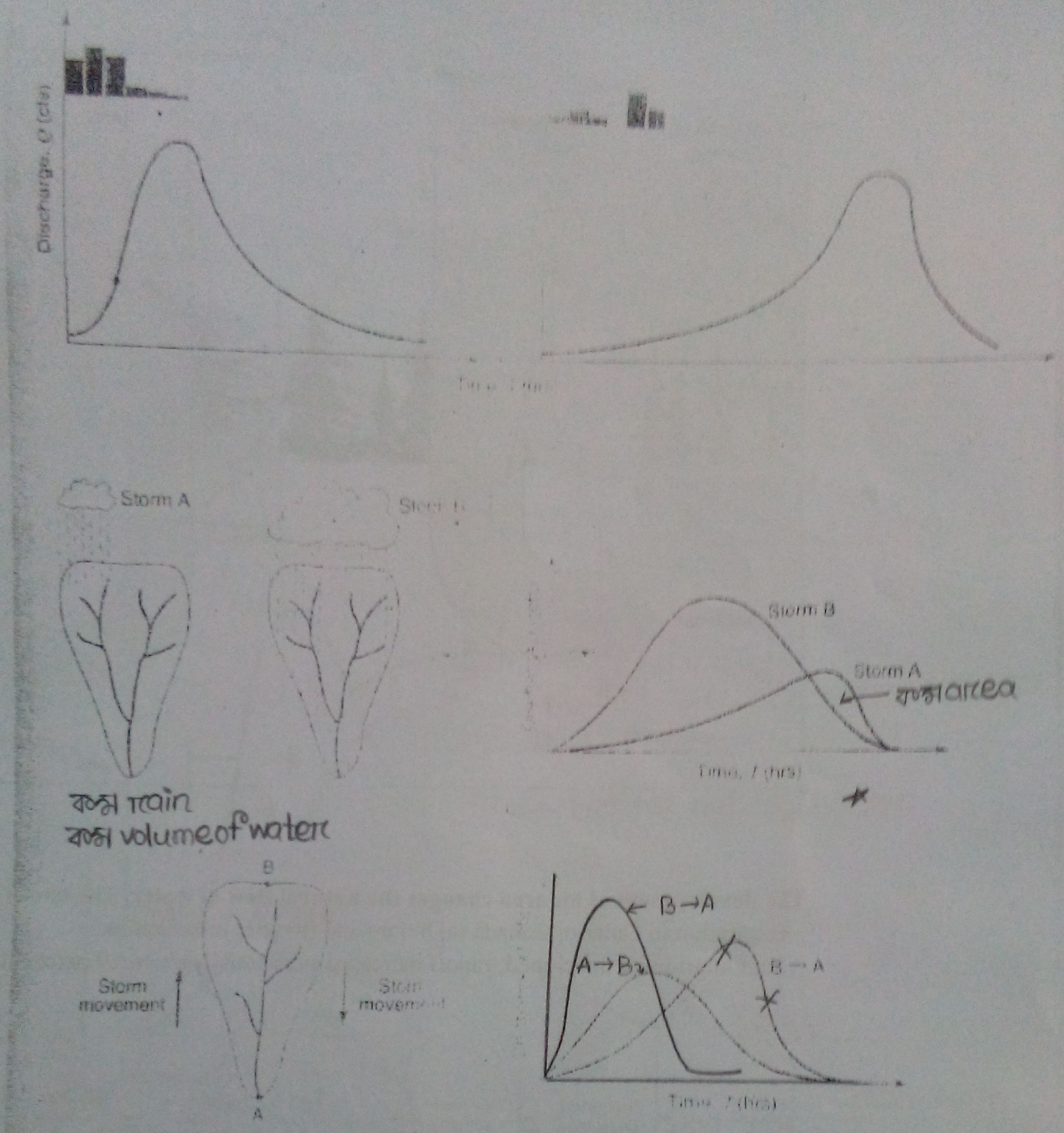
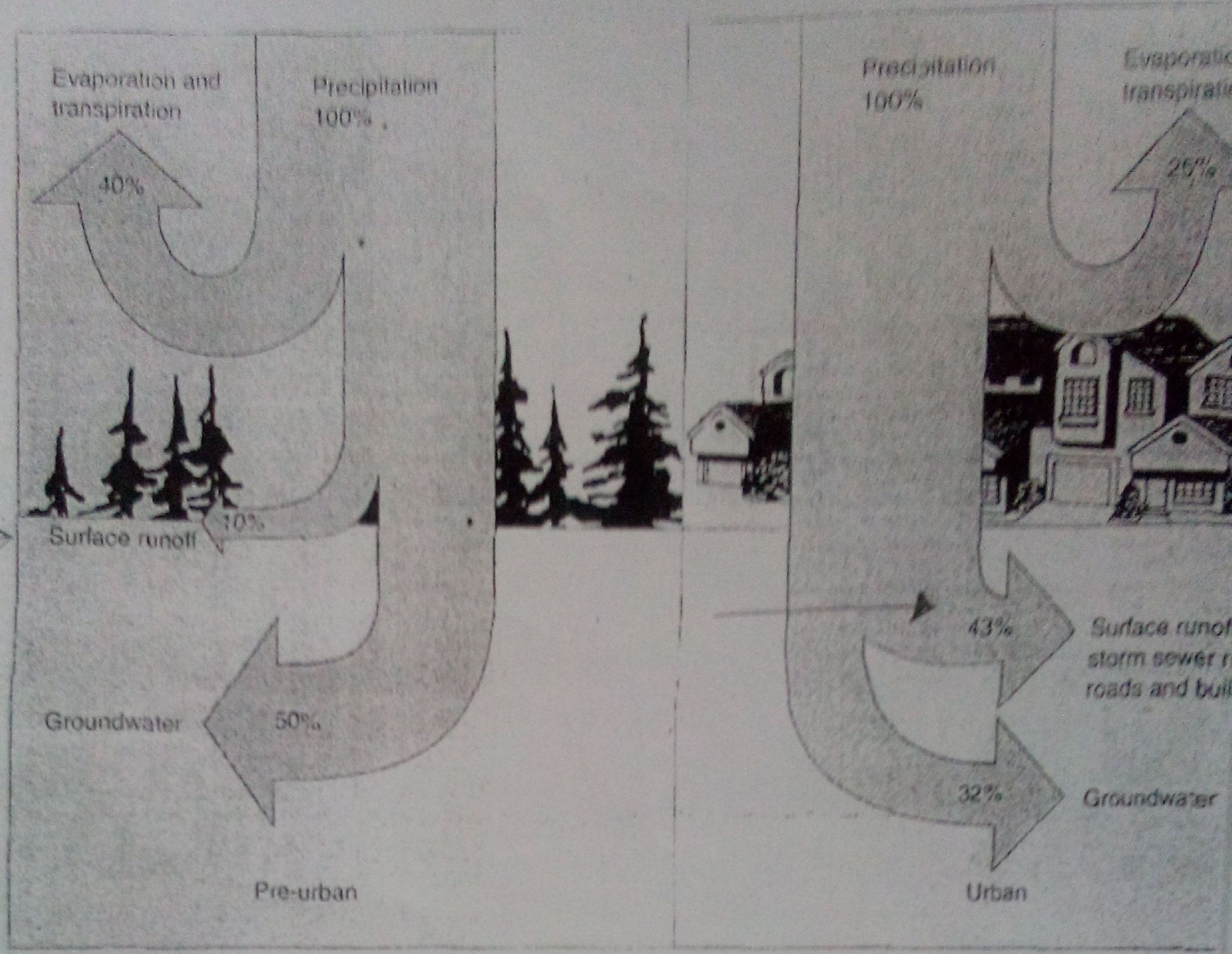


Figure **8.1.5 Effects of storm shape, size, and movement on surface runoff.** (a) Effect of time variation of rainfall intensity on the surface runoff; *(b)* Effect of storm size on surface runoff. (c) Effect of storm movement on surface runoff (from Masch 1984)).

* Storm A. outlet থেকে অনেক দূরে, তাই পানি outlet এ আসতে অনেক সময় লাগে, তাই অনেক সময় পর intensity বাড়ে।



(a) (b)

The development of an area changes the natural flow of water. The fate of precipitation in Ontario, Canada (a) before and (b) after urbanization.
After Ontario was developed, runoff increased substantially, from 10 percent to 43 percent.

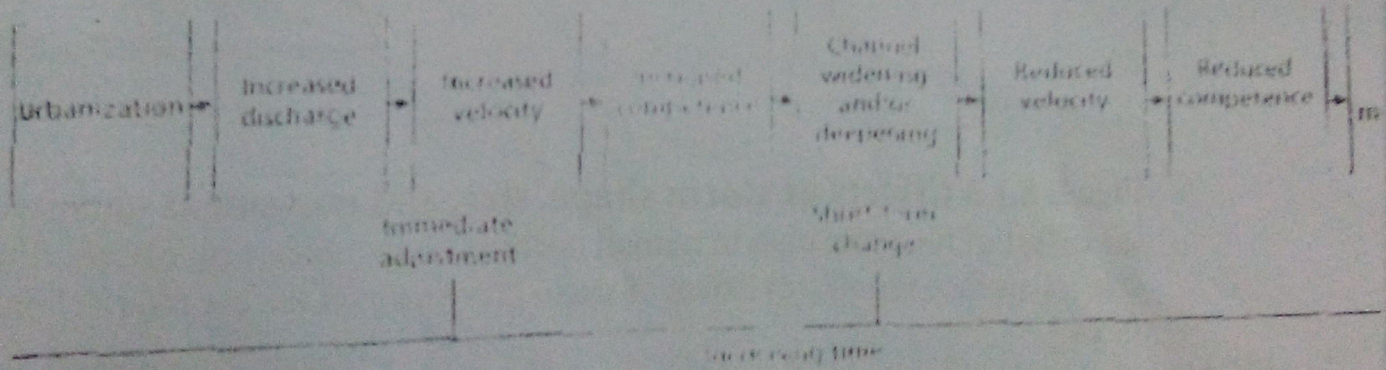


Fig. 4.2 Impact of urbanization (after Murisawa 1985).

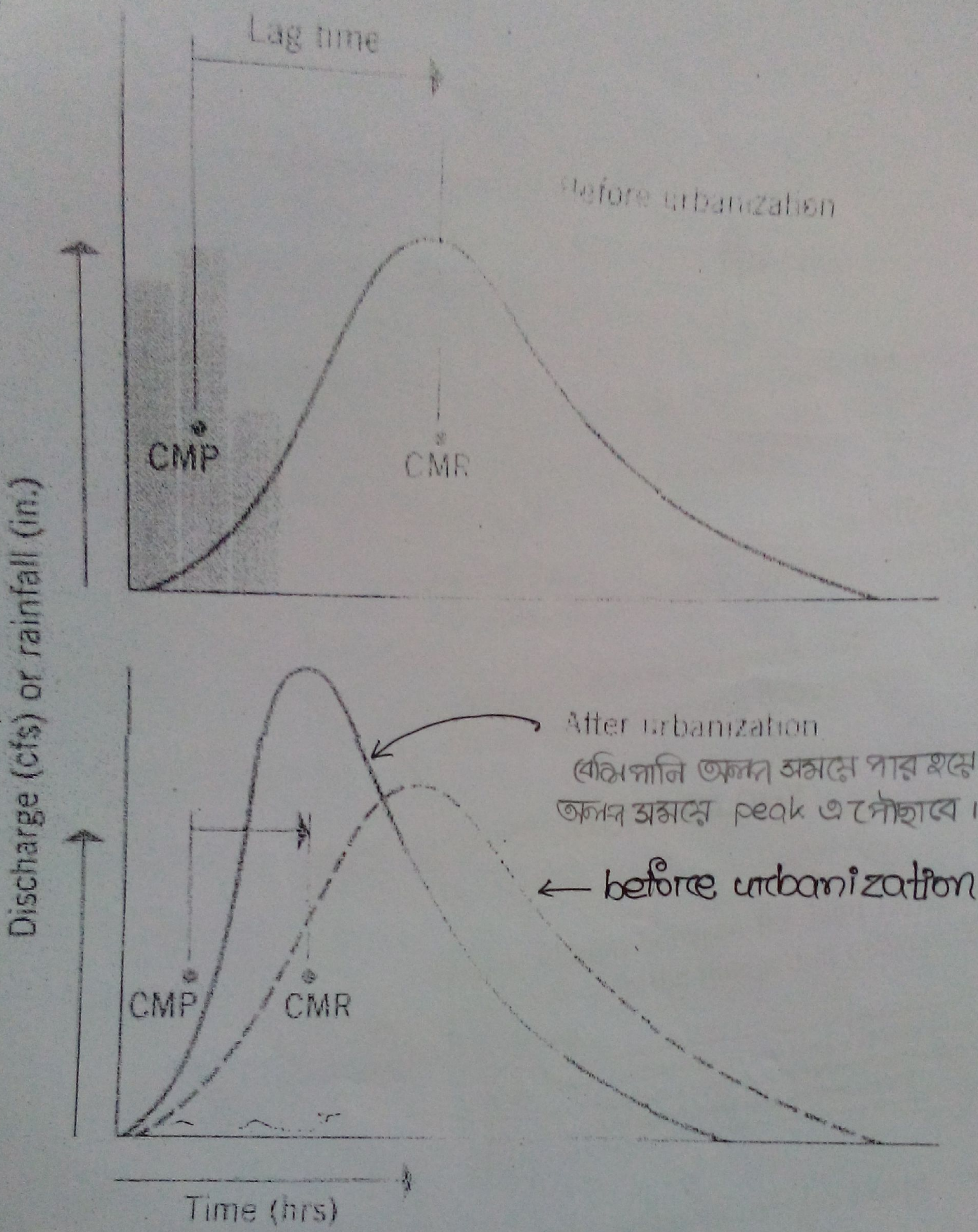


Figure 28.7 Schematic hydrographs showing effect of urbanization as reducing lag time and increasing peak discharge. Points CMP and CMR are centers of mass of rainfall and runoff, respectively, as in Figure 28.3. (After L. B. Leopold [1968] U.S. Geological Survey, Circular 554.)