SNS COLLEGE OF TECHNOLOGY

An Autonomous Institution Coimbatore – 35

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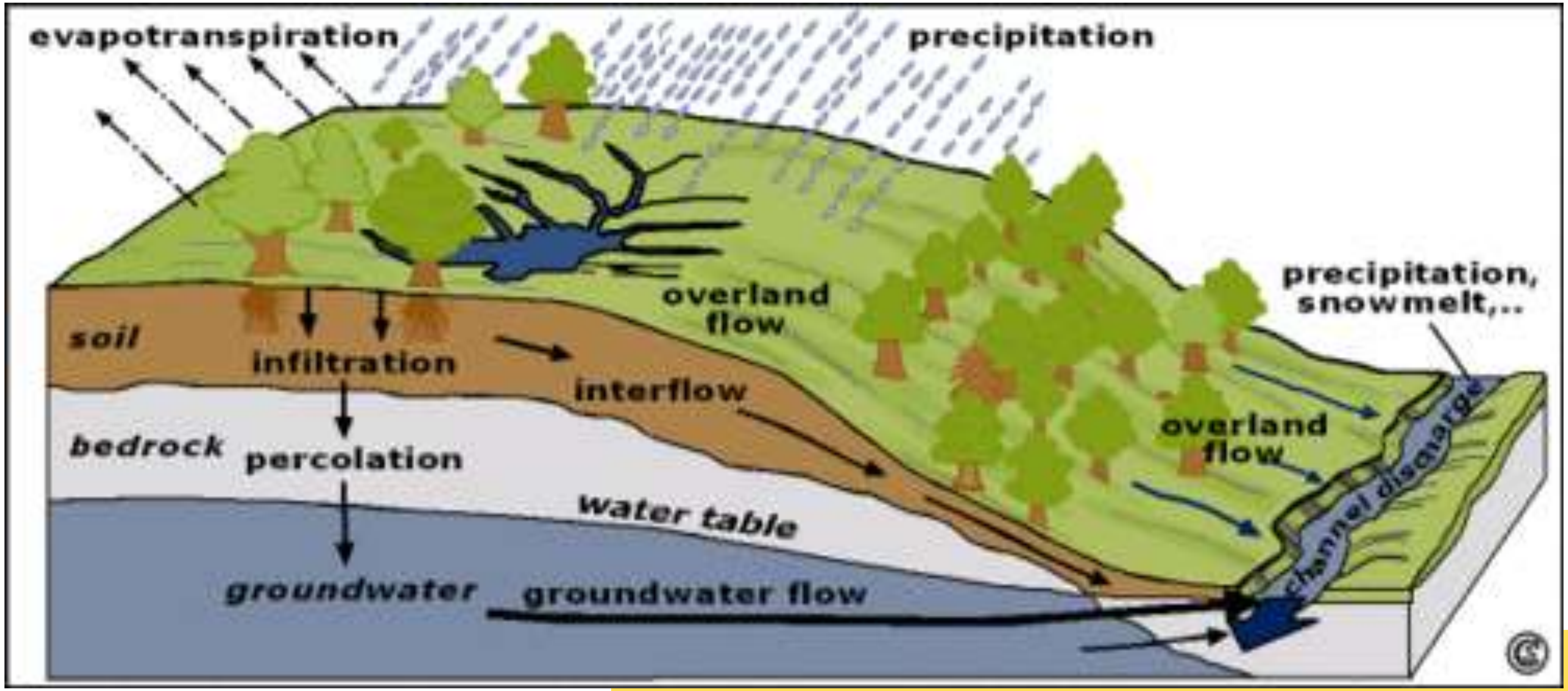
DEPARTMENT OF AGRICULTURAL ENGINEERING

19AGE308
WATERSHED PLANNING AND MANAGEMENT

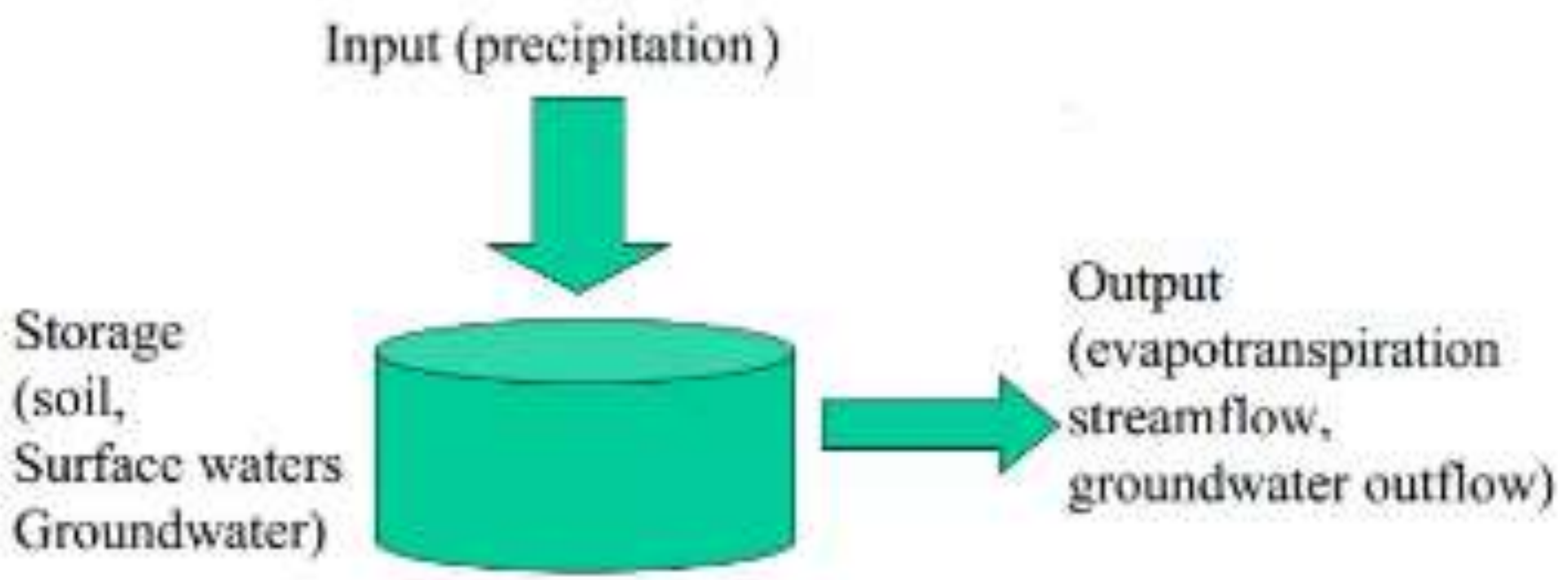
WATER YIELD

Water yield is defined as the net amount of water flowing past a point on a stream during a given period . It is also understood as the average amount of water produced by the watershed from contributions of surface, lateral, and ground water over a certain time period



Water Budget

Mass Balance: Input – Output = Change in Storage



- Water balance equation in its most fundamental form is given by

$$P - Q - E - \Delta S = 0$$

- Where, P=precipitation, E =evaporation, Q = runoff and ΔS = change in storage

- Stream flow is measured in units of discharge (m3/s) occurring at a specified time and constitutes historical data. The measurement of discharge in a stream forms an important branch of *Hydrometry,* the science and practice of water measurement.

STREAM FLOW MEASUREMENT

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Discharge (Ft^3./ Sec.)

This is a product of mean velocity by the cross-section area of flow

Mean Velocity

It is the average of velocities at the two segments.

Stage

It is the vertical depth of water at the gauging point. The stage is permanently fixed at the gauging point and should not be disturbed during the metering process.

Measurement techniques

- Stream flow measurement techniques can be broadly classified into two categories as

(i) direct determination

- (a) Area-velocity methods
- (b) Dilution techniques,
- (c) Electromagnetic method, and
- (d) Ultrasonic method.

(ii) indirect determination

- (a) Hydraulic, structures, such as weirs, flumes and gated structures, and

-(b) Slope-area method.

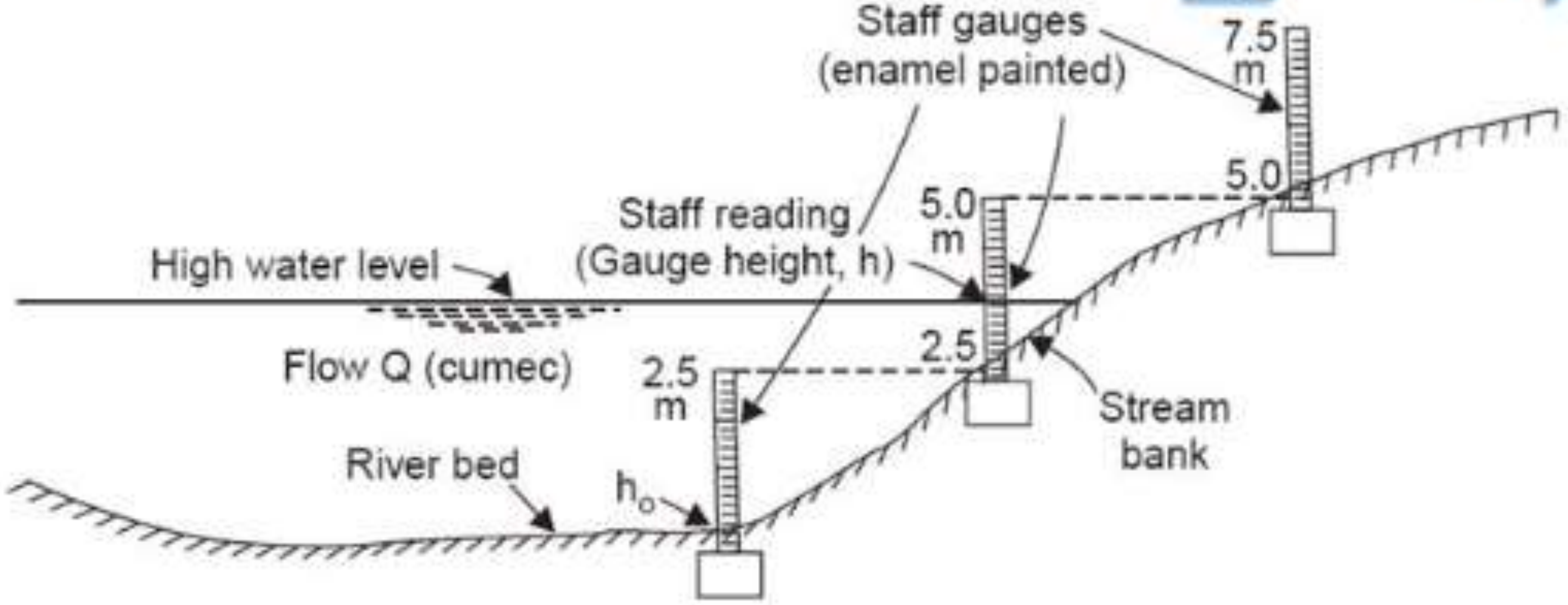
4.2 Measurement of Stage

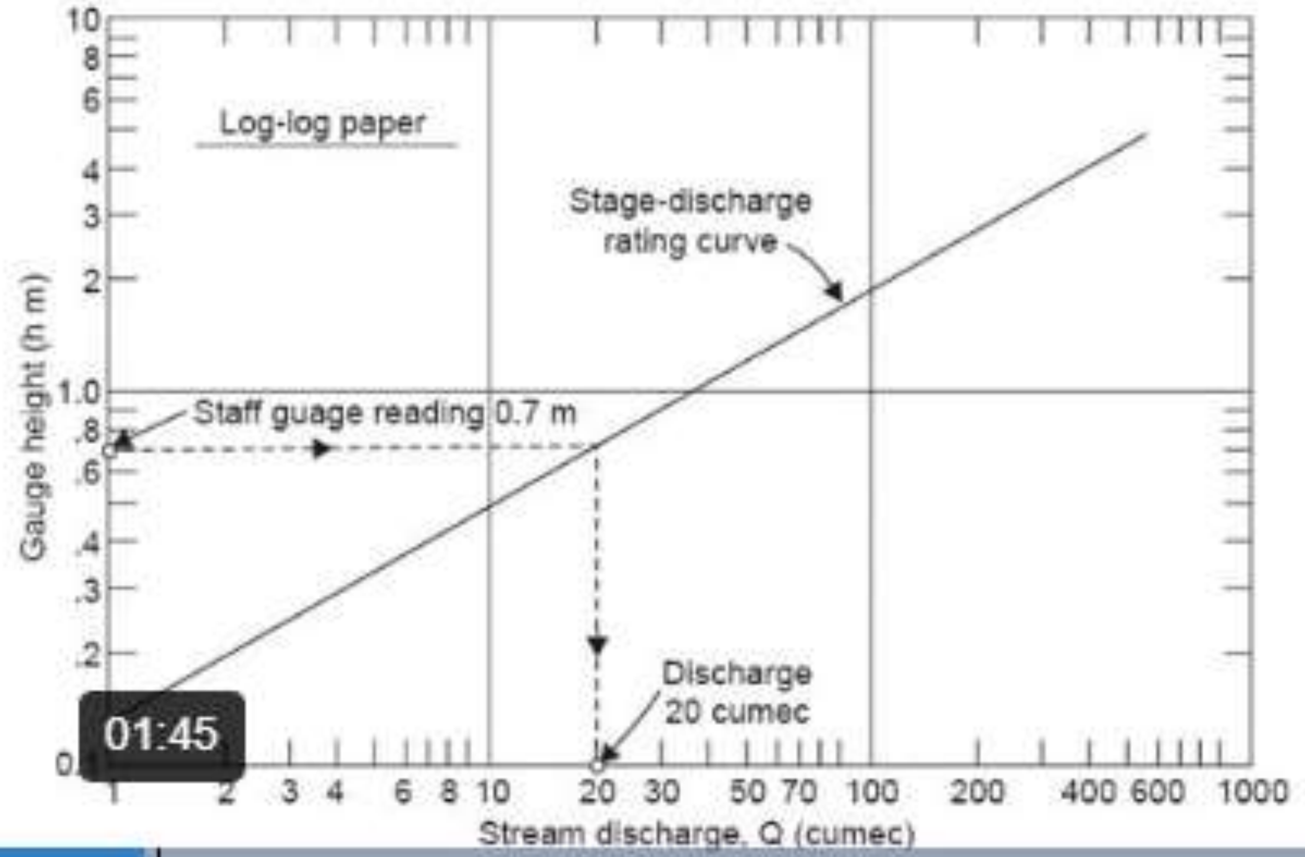
- Direct measurement of discharge is a very time-consuming and costly procedure.

Two steps are followed:

1- the stage of the stream (elevation of water surface above a datum) is measured by many methods such as staff Gauge, wire gauge, automatic stage recorder…. etc. the results is stage hydrograph (Figure 4.7).

2- The discharge is related with the stage in well known stage-discharge relationship (rating curve)



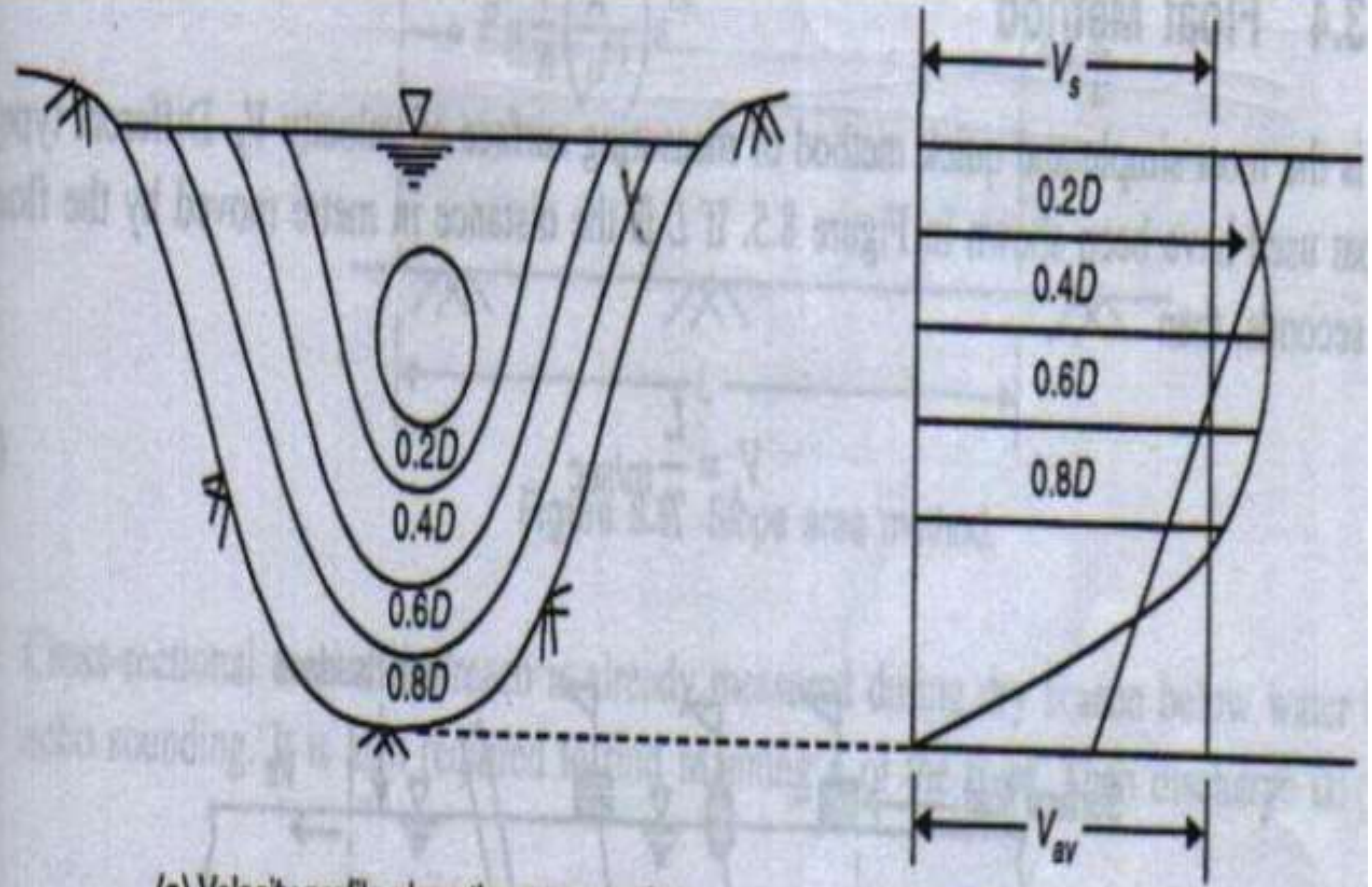


rating curve

4.3 Measurement of Velocity

- The measurement of velocity is an important aspect of many direct stream-flow measurement techniques.
- A mechanical device, called current meter, consisting essentially of a rotating element is probably the most commonly used instrument for accurate determination of the stream-velocity field.
- Approximate stream velocities can be determined by floats.

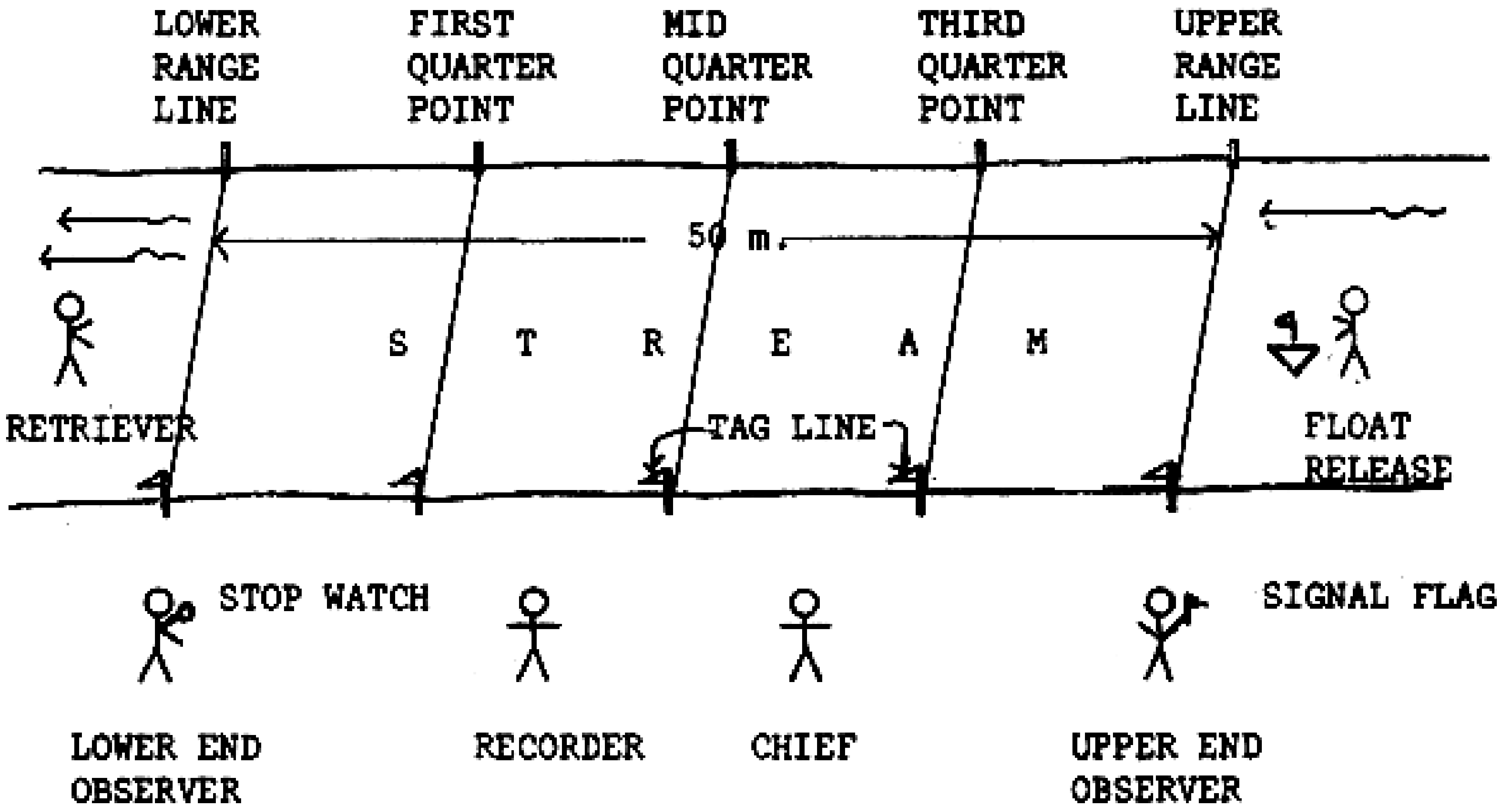
STREAM FLOW MEASUREMENT



(a) Velocity profile along the cross-section.

(b) Velocity profile along vertical.

- FLOAT METHOD



STREAM FLOW MEASUREMENT

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Float Method

- It is the most simple and quick method of surface velocity measurements. The distance travelled during the specific time by the surface flow is measured. If L is the distance moved by the float in T seconds. Then;

$$V_S = L/T \text{ m/sec}$$

- This surface velocity is multiply by reeducation factor (varies from 0.79 to 0.95) for calculating the average velocity of river.
- This method gives batter results where the flow is stream lined having impervious channel prism.

4.3.2 Velocity Measurement by Floats

- A floating object on the surface of a stream when timed can yield the surface velocity by the relation.

$$v_s = \frac{S}{t}$$

- where S = distance travelled in time t.
- This method of measuring velocities while primitive still finds applications in special circumstances, such as (i) a small stream in flood, (ii) small stream with a rapidly changing water surface, and (iii) preliminary or exploratory surveys.

- CURRENT METER

4.3.1 Current Meters

- The most commonly used instrument in hydrometry to measure the velocity at a point in the flow cross-section is the current meter.
- It consists essentially of a rotating element which rotates due to the reaction of the stream current with an angular velocity proportional to the stream velocity.
- Historically, Robert Hooke (1663) invented a propeller-type current meter to measure the distance traversed by a ship.

- The present day cup-type instrument and the electrical make-and-break mechanism were invented by Henry in 1868. There are two main types of current meters.

1. Vertical-axis meters, and
2. Horizontal-axis meters.

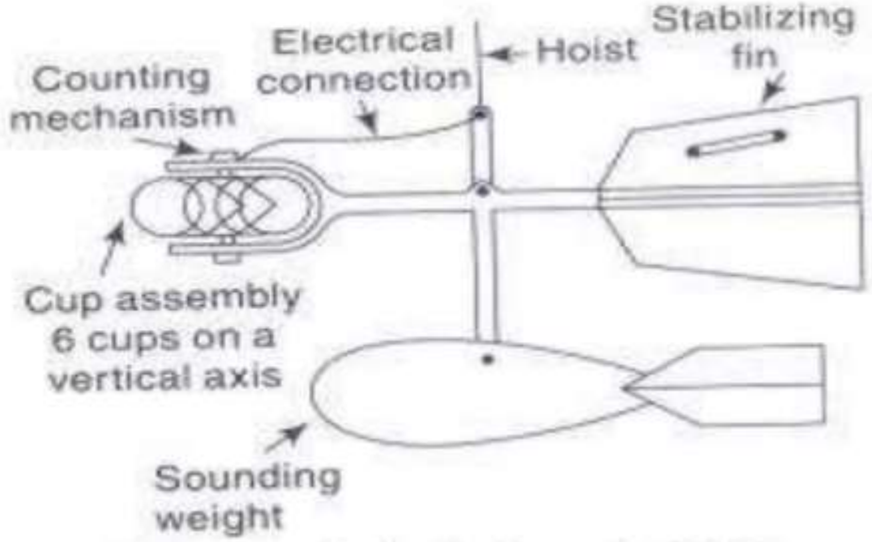


Fig. 4.8 *Vertical-axis Current Meter*

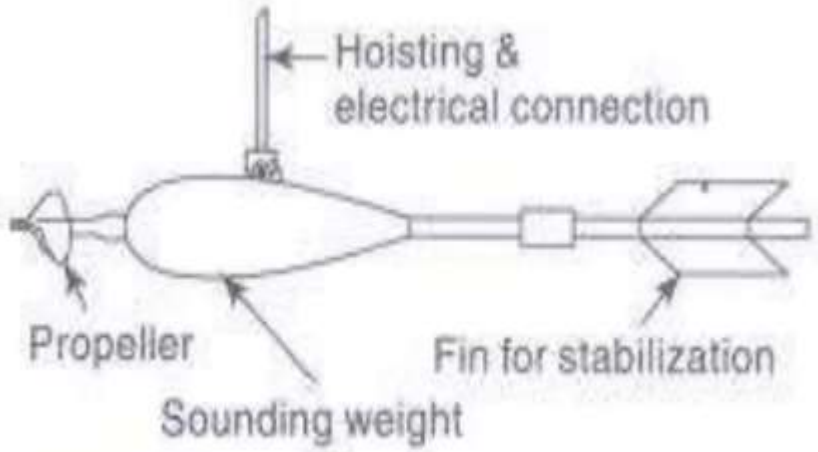


Fig. 4.11 *Horizontal-axis Current Meter*

WEIRS

A weir is basically an obstruction in the flow path in an open channel. The weir will cause an increase in the water depth as the water flows over the weir. In general, the greater the flow rate, the greater will be the increase in depth of flow, The height of water above the top of the weir is the measurement usually used to correlate with flow rate.

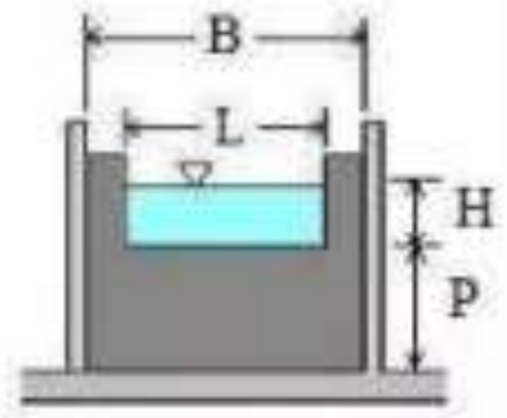
- <u>CONTRACTED RECTANGULAR WEIR</u>

A contracted rectangular weir is one for which the weir extends across only part of the channel, so that the length of the weir, L, is different from as the width of the channel. The discharge over contracted rectangular notch can be calculated as:

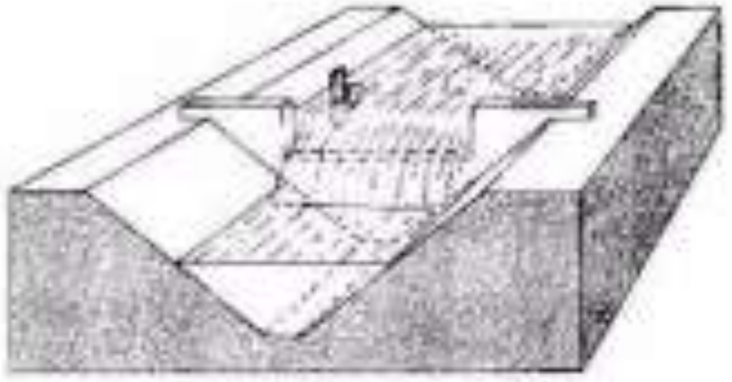
$$Q = 1.84(L - 0.2H)H^{3/2}$$

where

- **Q** is the water flow rate in m^3/sec,
- **L** is the length of the weir in m, and
- **H** is the head over the weir in m.
- **B** is the width of the channel in m, and
- H_{max} is the maximum expected head over the weir in m.



contracted rectangular weir (L < B)


Contracted Rectangular Weir

Triangular or V-Notch Weir

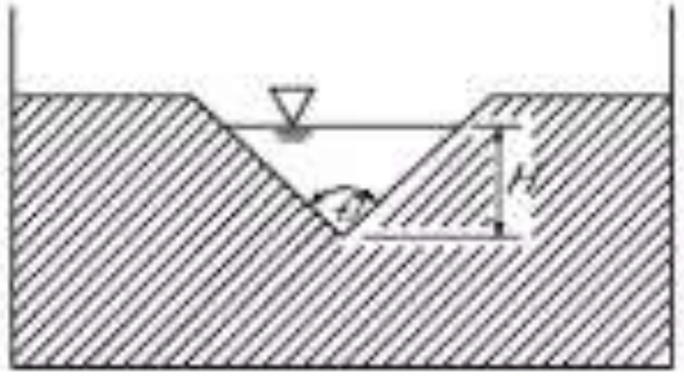
Triangular or V-notched weirs measure low discharges more accurately than horizontal weirs. The V-notch is most commonly a 90° opening with the sides of the notch inclined 45° with the vertical. Since the V-notch weir has no crest length, much smaller flows are represented by a given head than for a rectangular weir

For a triangular or v-notch weir the flow rate can be expressed as:

$$q = 8/15\ c_d (2\ g)^{1/2} \tan(\vartheta/2)\ h^{5/2}$$

where

- *ϑ = v-notch angle*
- *h= head of weir*
- *c_d= discharge constant for the weir*
- *- must be determined*
- *$g = 9.81\ (m/s^2)$ - gravity*

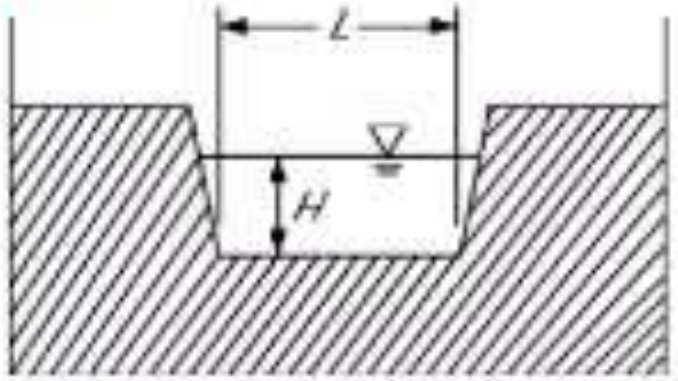


TRAPOZOIDAL SHARP-EDGE WEIR

- The Cipolletti or Trapezoidal Sharp-edge Weir is similar to a rectangular weir with end contractions except that the sides incline outwardly at a slope of 1 horizontal to 4 vertical. This slope causes the discharge to occur essentially as though it were without end contraction. The advantage of this weir is that no correction for end contraction is required. A disadvantage is that measurement accuracy is inherently less than that obtainable with a rectangular suppressed or V-notch weir. The Cipolletti Weir is commonly used in irrigation systems. The formula generally accepted for computing the discharge through Cipolletti weirs is :

$$Q = 3.367\ L\ h_1^{3/2}$$

- where:
- L = length of weir crest in ft
  h_1 = head on weir crest in ft



(a)

(b)

DILUTION TECHNIQUE

Tracer dilution is a method of determining the flow rate in a ground or surface water environment where a hydraulic structure (flume / weir) cannot be installed either due to cost, monitoring duration, or ecological reasons.

STREAM FLOW MEASUREMENT

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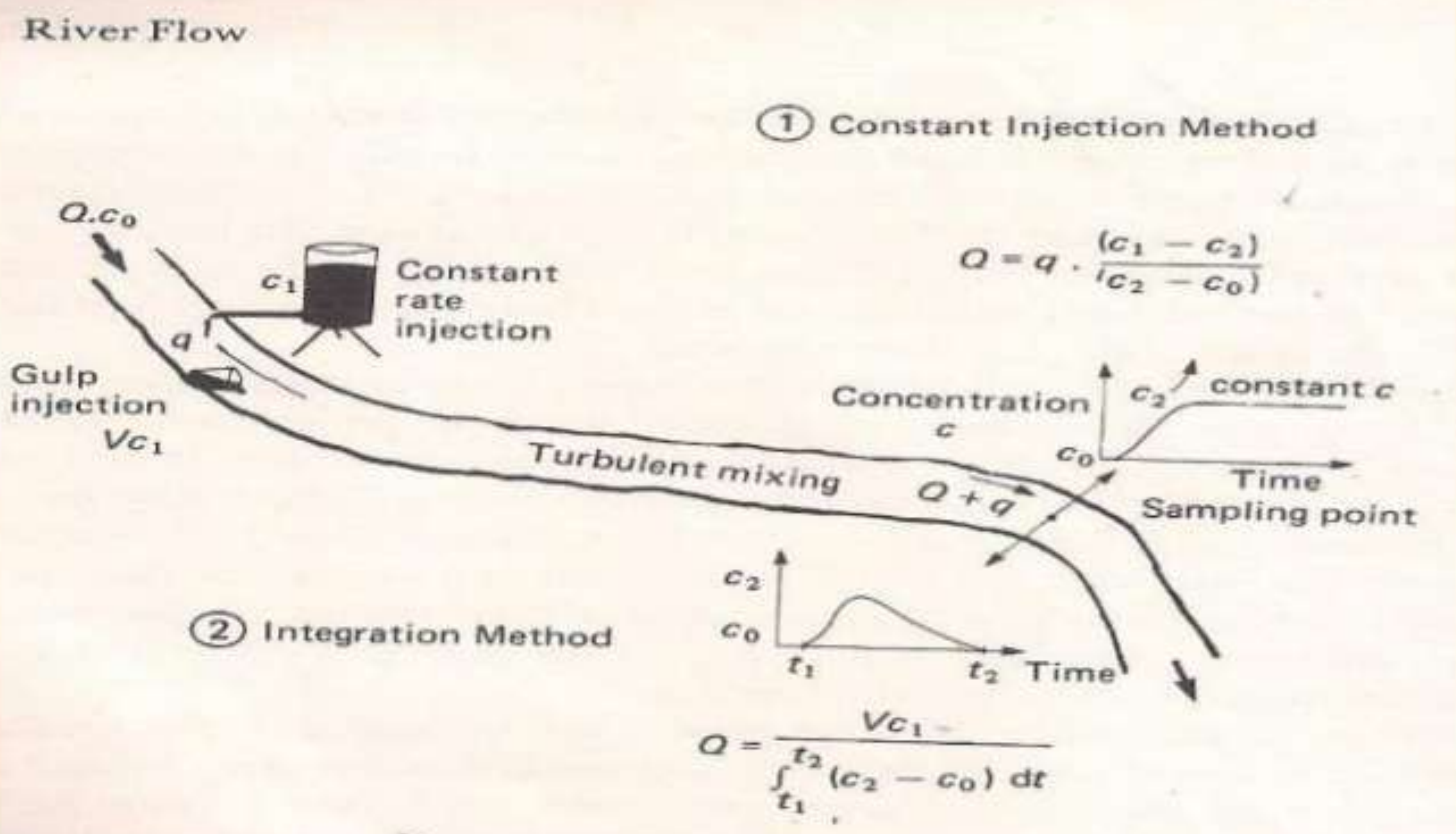
Dilution Gauging

- **Constant Rate Injection Method**
  - This method of measuring the discharge in a stream or pipe is made by adding a ***chemical solution or tracer of known concentration*** to the flow and then measuring the concentration of the solution downstream where the chemical is completely mixed with the stream water.
  - Let c_0, c_1 and c_2 are chemical concentrations (e.g. g litre-1); c_0 is the 'background' concentration already present in the water (and may be negligible),
  - c_1 is the known concentration of tracer added to the stream at a constant rate q, and c_2 is a sustained final concentration of the chemical in the well mixed flow.
  - Thus $Qc_0+qc_1=(Q + q)\ c_2$, whence:

$$Q = (c_1 - c_2) / (c_2 - c_0)\ q$$

STREAM FLOW MEASUREMENT

Dilution Gauging



.22 Dilution gauging: two basic methods.

4.8 indirect method

Slope-Area method

- The Manning equation

$$Q = \frac{1}{n} A R^{\frac{2}{3}} S_f^{\frac{1}{2}}$$

Where

Q = *discharge (m3/s)*

n = *Manning's roughness coefficient (range between 0.01 and 0.75)*

A = *cross-section area (m2)*

R = *the hydraulic radius, equal to the area divided by the wetted perimeter (m)*

S = *the head loss per unit length of the channel, approximated by the channel slope*

R=A/P
P = witted parameter

STREAM FLOW MEASUREMENT

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Discharge Calculation (Empirical Formulae)

i) **Rectangular Weir**

$Q = \frac{2}{3} c_d L \sqrt{2g}\, H^{3/2}$ – With out Velocity of approach

ii) **For Triangular notch**

$Q = 8/15\ c_d \sqrt{2g} \tan \theta/2\ H^{5/2}$

L = Length of weir

H = head of water

V_a = velocity of approach

c_d = Coefficient of discharge

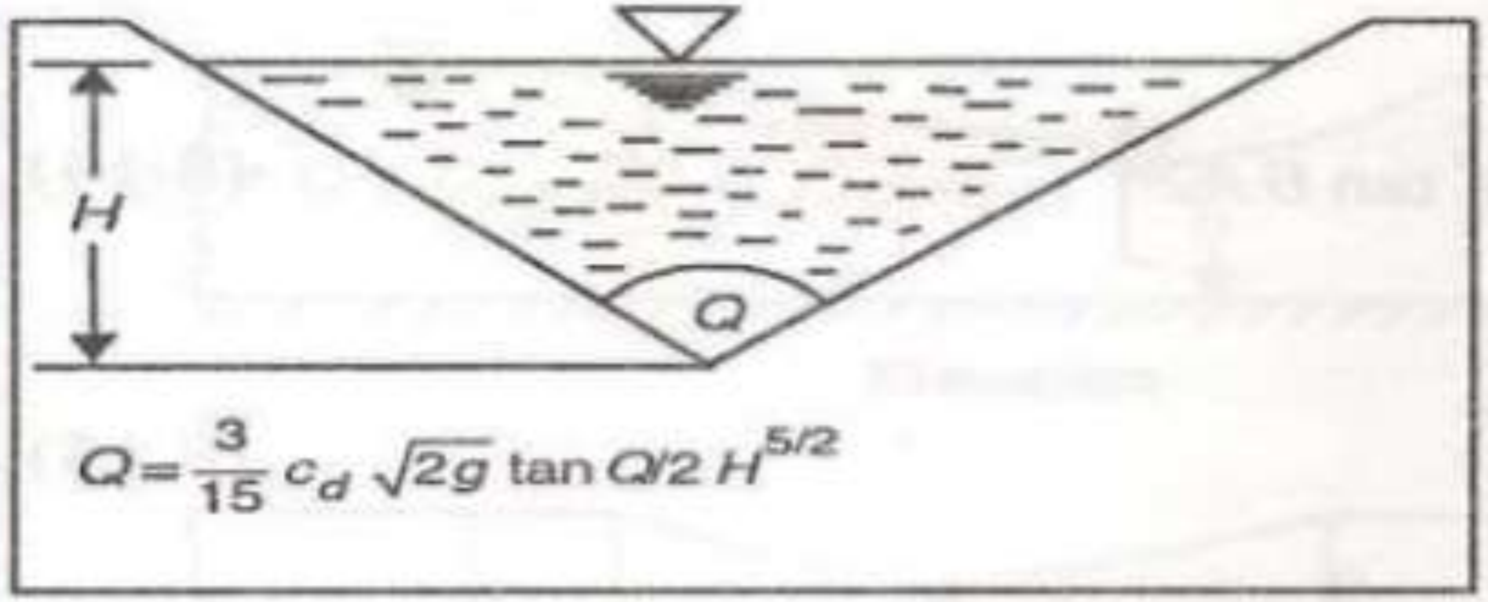
iii) **Broad crested weirs**

$$Q = CLH^{3/2}$$

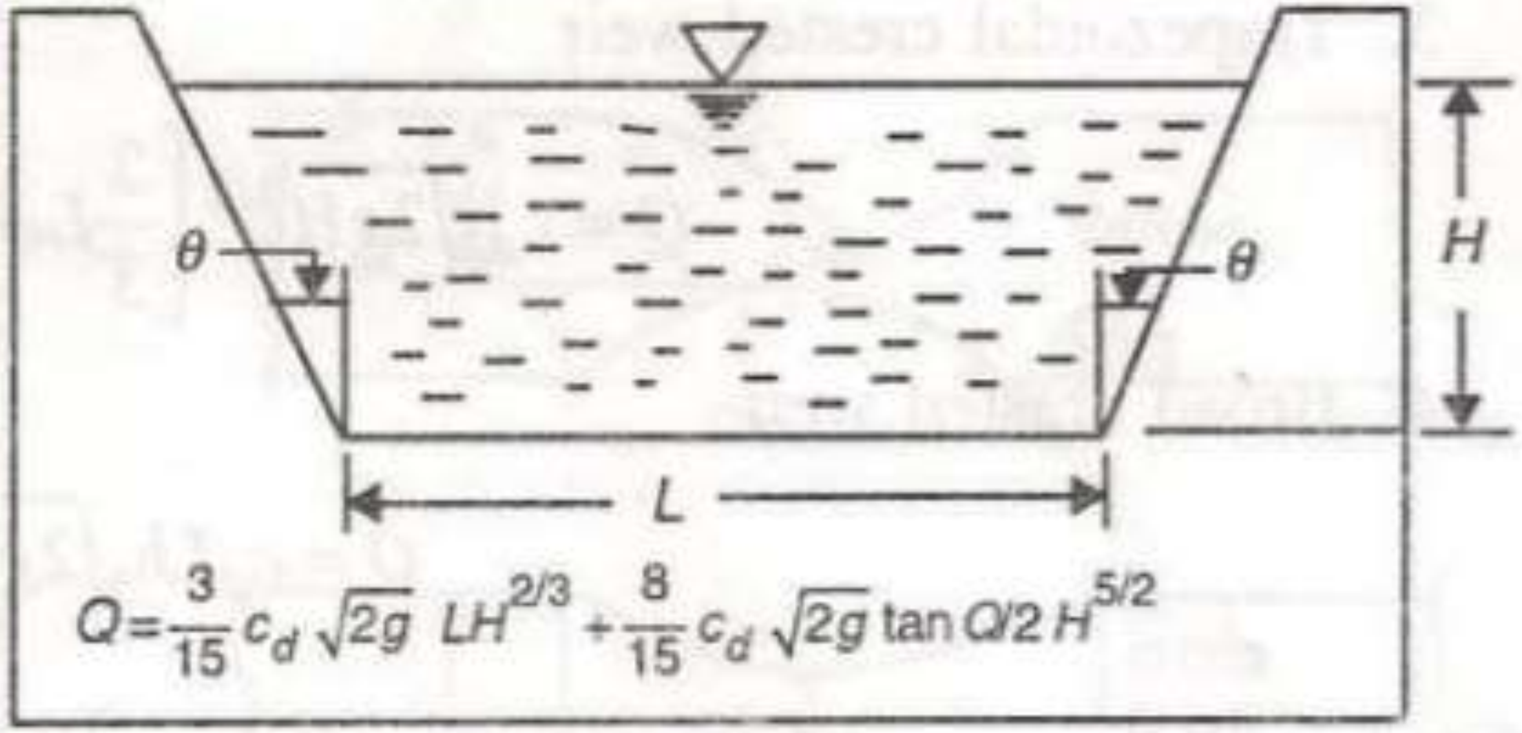
C is coefficient of discharge and its values have to be determined for the range of head over the crest.

STREAM FLOW MEASUREMENT

Discharge Observation by Empirical Formula



(c) Triangular weir or notch



(d) Trapezoidal notch or weir.