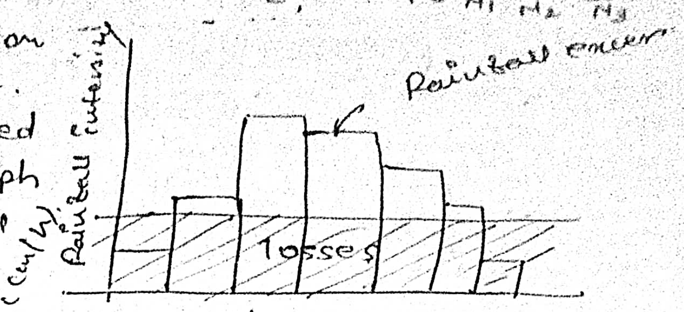
Hydrograph :

Normal ratio method missing data.
$\left[P_x = \frac{N_x}{N-1}\left[\frac{P_1}{N_1} + \frac{P_2}{N_2} + \frac{P_3}{N_3} \cdots + \frac{P_n}{N_n}\right]\right]$

→ The initial loss and infiltration losses are subtracted from it. The resulting losses are subtracted from it. The resulting hyetograph is known as effective Rainfall Hyetograph.

→ expressed ERH is usually in cm/h potted against time.



Time (hours), hyetograph of a storm.

$\phi = \frac{\text{Rainfall} - \text{Runoff}}{\text{Total time}}$

$\phi = \frac{\text{Eff. Rainfall} - R}{\text{Effective time}}$

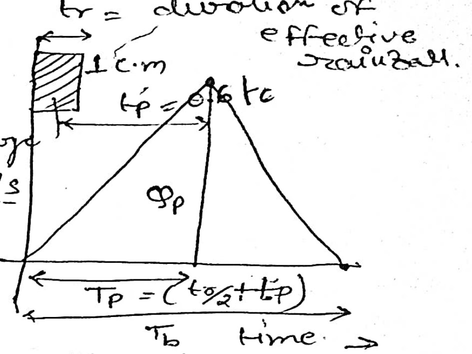
→ The area of ERH multiplied by the catchment area gives the total volume of direct runoff, which is the same as the area of DRH.

Unit Hydrograph:-

The problem of predicting the flood hydrograph resulting from a know storm in a catchment has received considerable Imp attention.

→ A unit hydrograph is defined as the hydrograph of direct runoff resulting from one unit depth (1 cm) of rainfall excess occurring uniformly over the basin and a uniform rate for a specified duration D.) (D-h) duration)

t_r = duration of effective rainfall.



T_p = time of rise/peak.
T_b = lag time

→ The net DRH, the estimated base flow is then added to obtain the total flood hydrograph.

[flood hydrograph = [DRH + base flow]]

(basically triangular hydrograph method used in small watershed) SCS triangular Unit Hydrograph (Soil conversation Services)

$Q_p = 2.08\frac{A}{T_p}$ (m^3/s)

$t_p = 0.6\,t_c$

$T_p = \left(\frac{t_r}{2} + t_p\right)$

$T_b = 2.67\,T_p$ by lagging

→ An empirical equation for the time interval N.

$N = 0.83A^{0.2}$

A = drainage area in km^2
N = in days.

Imp
1. unity Hydrograph = $\frac{DRH}{ER}$
2. ER = $\frac{\text{derived D-hr UH}}{\text{used D-hr UH}}$
3. triangular hydrograph
$\frac{1}{2} Q \times T_b$ = Volume
$\frac{1}{2} \times Q \times T_b$ = area × 1 cm (unit depth)
volume

Unit Hydrographs of different durations:-

Two Method are available for this purpose.
1. Method of superposition
2. The S-curve

Note [Transpiration measured by → Phytometer]

(1) S-curve :- The average intensity of ER producing the S-curve is 1/D cm/h and equilibrium discharge

$$\Rightarrow \boxed{Q_s = \frac{A}{D} \times 10^4 \ m^3/h}$$

A = area of catchment in km^2

D = duration in hours of ER of the unit hydrograph used in deriving the S-curve.

$$\Rightarrow \boxed{Q_s = 2.778 \frac{A}{D} \ m^3/s}$$

Use and limitation of unit Hydrograph :-

great use → (1) The development of flood Hydrographs for extreme rainfall and hydraulic structure

(2) extension of flood flow records based on rainfall records.

(3) development of flood forecasting and warning systems

imp

Instantaneous Unit Hydrograph (IUH)

A finite unit hydrograph is indicated as the duration $D \to 0$. The limiting case of a unit Hydrograph of zero duration is known as instantaneous unit hydrograph (IUH).

(काल्पनिक)

Thus IUH is a fictitious conceptual unit hydrograph which represents the surface runoff from the catchment due to an instantaneous precipitation of the rainfall excess volume of 1 cm.

Note (1) The precipitation is collected and measured in a raingauge. Term such as pluviometer, ombrometer and hyetometer.

imp (2) The average annual rainfall for the entire country is estimated as 118.3 cm (1183 mm)

$$\text{Cofficient of Veration (Cv)} = \frac{100 \times \text{standard deviation} \ (\sigma_{n-1})}{\text{Mean} \ (\bar{x} = \sum_{i=1}^{m} P_i / m)}, \quad \sigma_{n-1} = \sqrt{\frac{\sum(\bar{x} - x_i)^2}{m-1}}$$

(3) The recurrence interval (also know as return period).

$$\boxed{T = 1/p}$$

If the probability of an event occuring is P,

$$P_{r,n} = {}^{n}C_r \, P^r q^{n-r} = \frac{n!}{(n-r)! \, r!} P^r q^{n-r}$$

(a) The probability of an event of exceedence probability P occuring 2 time in n successive year is,

$$\boxed{P_{2,n} = \frac{n!}{(n-2)! \, 2!} P^2 q^{n-2}}$$

(b) The probability of the event not occuring at all in n successive year is

$$\boxed{P_{0,n} = q^n = (1-P)^n}$$

Imp (c) The probability of the event occurring at least once in n successive years

$$P_1 = 1 - q^n = 1 - (1-P)^n$$

Note (1) cetyl ~~alcohol~~ alchol is found to be the most suitable chemical (hexadecanol) for use as an evaporation inhibitor.

Two stage is importance in evapotranspiration (1) field capacity (2) wilting point

(2) field capacity: field capacity is the maximum quantity of water that the soil can retain against the force of gravity.

(3) permanent wilting point: is the moisture content of a soil at which the moisture is no longer available in sufficient quantity to sustain the plants.

Infiltration Indices :-

The defined average infiltration rate is called infiltration index and two ~~group~~ types of Indices are in common

Imp (a) **ϕ- Index :-** The average rainfall above which the rainfall volume is equal to the runoff volume. The ϕ-Index is derived from the rainfall hyetograph with knowledge of the resulting runoff volume. The initial loss is also considered as infiltration.

Total rainfall $P = \sum_{I=h}^{N} I_i \cdot \Delta t$

Value of ϕ-index = then $P - \phi t_e = R_d$

t_e = duration of rainfall excess.

$$\frac{P - R_d}{t_e} = \phi$$

Rational formula :-

$Q = \frac{CIA}{3.6}$

I = mm/h

A = km2

c = costant

$C = \frac{A_1C_1 + A_2C_2 + A_3C_3}{A_1 + A_2 + A_3}$

$\phi = \frac{\text{infiltration}}{\Delta t}$

Imp (b) **W-Index :-** The initial losses are separated from the total abstractions and an average value of Infiltration rate, called W-index, is defined

average infiltration rate Imp

$$W = \frac{P - R - I_a}{t_e}$$

P = total storm precipitation (cm)

R = total storm runoff (cm)

I_a = Initial losses

t_e = duration of rainfall excess.

Imp Rainfall and runoff correlation

CWC has found the following the estimation of ϕ index for flood producing storm,

$$R = \alpha I^{1.2}$$

$$\phi = \frac{I - R}{24}$$

α = cofficient depends upon soil type,

R = runoff in cm from, 24-h rainfall intensity

I = intensity cm/h

The measurement of discharge in a stream form an important branch of **Hydrometry**

→ MEASUREMENT OF VELOCITY IS AN IMPORTANT ASPECT OF MANY DIRECT STREAM-FLOW MEASUREMENT TECHNIQUES. A MECHANICAL DEVICE, CALLED CURRENT METER.

⇒ **Dilution Method** :- ↳ chemical method :- (Steady flow) assumption

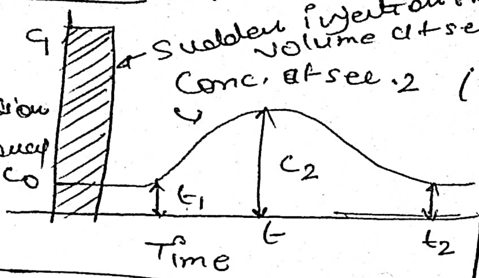
constant injection method or plateau gauging

$$Q = \frac{Q_t (C_1 - C_2)}{(C_2 - C_0)}$$

C_1 = The tracer of concentration

C_0 = The concentration Background value.

C_2 = constant value.



(continuity equation)

Ultrasonic Method

$$v = \frac{L}{2\cos\theta}\left(\frac{1}{t_1} - \frac{1}{t_2}\right)$$

⇒ **RUNOFF** :-

Interflow = prompt + delayed (तुरंत) + विलंबित

Base flow :- The delayed flow that reaches a stream essentially as groundwater flow is called base flow.

Base flow = (delayed - interflow + Groundwater flow)

Runoff characteristics of stream

One to classify the stream in to three classes

① perennial (सदाबहार) ② intermittent ③ ephemeral.

(a) perennial stream is one that, ↓ there is considerable amount of groundwater flow throughout the year. Even during the dry seasons,

(b) intermittent stream :- (कभी-कभी होने वाला) has limited contribution from the ground water During the wet season, there is contribution the base flow to the stream flow. (base flow + stream flow)

(c) ephemeral stream :- (अल्पकालिक) is one that does not have any base-flow contribution.

① Stream Density (Sd) :- The ratio of the Number of streams Ns of all orders to the area of the basin (A) is know as stream density (Sd). $= \frac{N}{A}$

$$Sd = N/A$$

② Drainage Density (Dd) :- The ratio of the total length of streams of all orders within a basin to its area.

$$Dd = \frac{\Sigma L}{A}$$

① Note :- The term consumptive use is also used to denote this loss by evapotranspiration

Important stage: field capacity + wilting point ↳ obviously dependent on the availability of water.

Different Catchment Shape parameters:

(1) Form factor → $\frac{\text{Catchment area}}{(\text{Catchment length})^2} = \frac{A}{L^2}$

(2) Slope factor → $\frac{(\text{Catchment length})^2}{\text{Catchment area}} = \frac{L^2}{A}$

(3) Compactness coefficient → $\frac{\text{perimeter of the catchment}}{\text{perimeter of the circle whose area is that of the basin}} = \frac{0.2821P}{\sqrt{A}}$

(4) Circulatory ratio :- $\frac{\text{Catchment area}}{\text{Area of circle of catchment perimeter}} = \frac{12.57A}{P^2}$

(5) Elongation ratio → $\frac{\text{Diameter of circle}}{\text{catchment length}} \Rightarrow \frac{1.128\sqrt{A}}{L}$

SCS-CN Method of Estimating Runoff volume.

Basic theory → SCS-CN Method is based on the water balance equation

$$P = I_a + F + Q$$

P = total precipitation, I_a = initial abstraction

F = cumulative infiltration excluding I_a and Q

Q ⇒ direct surface runoff

$$Q = \frac{(P-\lambda S)^2}{P+(1-\lambda)S} \quad \text{for } P > \lambda S$$

$Q = 0$ for $P \le \lambda S$

$I_a = \lambda S$

$I_a = 0.2S$

I_a = initial abstraction (आदिहानि)

100 represent a condition of zero potential abstraction; catchment curve no. retention; CN=0 represent an infinitely abstracting catchment

Curve No. is now related to S as.

"The recharge capacity of the watershed" → dependent "AMC"

$$CN = \frac{25400}{S+254}$$

$100 \ge CN \ge 0$

S = potential maximum retention after runoff begins (watershed wetness)

#Imp

CN - depends upon

(1) Soil type

(2) Antecedent Moisture condition

(3) Land use/ cover.

Antecedent Moisture Condition (AMC)

M.C present in the soil at the beginning of the rainfall-runoff

three level of AMC are recognized by SCS as follows.

(1) AMC-I :- Soil are dry but not wilting point, satisfactory cultivation has taken place. (Lowest runoff potential)

(2) AMC-II :- Average condition.

(3) AMC-III :- Sufficient rainfall has occurred within immediate past 5 days. saturated soil conditions prevail. (Highest runoff potential).

Impervious Surface C = 1.0 and CN = 100 the relationship b/w CN and C are "nonlinear"

SCS-CN Calculation for various conditions:

λ varying in the range 0.1 ≤ λ ≤ 0.4

→ $Q = \frac{(P-0.15)^2}{P+0.98}$ for P > 0.15

valid for Black soil under AMC of Type (II and III)

→ $Q = \frac{(P-0.35)^2}{P+0.78}$ for P > 0.35 valid for Black Soil under I, II, III types.

Compactness factor:

↳ $\frac{\text{Perimeter of watershed}}{\text{Circumference of circle}} = \frac{P}{2\pi A}$

Leaching requirement: "It is defined, the fraction of irrigation water passing out or drained out through the root zone, and expressed."

c = ppm ds/m
640 ppm-mg/l (LR)

$$LR = \frac{EC_w}{5EC_e - EC_w}$$

where LR = minimum leaching requirement

EC_w = Salinity of the applied irrigation water in ds/m

EC_e = average soil salinity tolerated by crop, as measured on a soil saturated exhaust.

$$\frac{EC_{iw}}{EC_{dw}} = \frac{d_{dw}}{d_{iw}} = LR$$

EC_{iw} / $EC_e \times 2$

LR = important calculate the depth of irrigation water.

d_{dw} = depth of drainage water

d_{iw} = depth of irrigation water.

EC_{iw} = Electrical conductivity of Irrigation water

EC_{dw} = Electrical conductivity of drainage water.

total depth of irrigation: $\frac{D_i}{D_w} = \frac{1}{1-LR}$ (Irrigation requirement)

$$LR = \frac{d_{DW}}{d_{IW}} = \frac{d_{DW}}{d_{IW}} = \frac{EC(IW)}{EC(DW)} = \frac{EC_{IW}}{2 \times EC(e)}$$

$d_r = \frac{\det - d_r}{1 - LR}$

d_r = effective rainfall

⇒ ① Risk:- $R = 1-(1-P)^n = 1-(1-\frac{1}{T})^n$

P = probability = $\frac{1}{T}$

② Reliability:- $Re = 1 - R = (1-\frac{1}{T})^n$

$S = K[xI^m + (1-x)Q^m]$

we know that $m=1$ putting value.

Now muskingum equation

(storage) → $S = K[xI + (1-x)Q]$

Now evaluated

$Q = C_0 I_2 + C_1 I_1 + C_2 Q_1$ —①

equation $x=0$, now the storage is also function of discharge is

① $C_0 = \frac{-Kx + 0.5\Delta t}{K - Kx + 0.5\Delta t}$

② $C_1 = \frac{Kx + 0.5\Delta t}{K - Kx + 0.5\Delta t}$

③ $C_2 = \frac{K - Kx - 0.5\Delta t}{K - Kx + 0.5\Delta t}$

Note ① linear storage and linear reservoir

$S = KQ$

Motor performance :-

Rx (1) Volumetric efficiency

$$\eta_v = \frac{D_m \times \Theta_m}{Q}$$

⇒ D_m = motor displacement
Θ_m = motor speed
Q = flow rate.

(2) Torque efficiency / Mechanical efficiency

$$\eta_T = \frac{T_L \times 2\pi}{D_m \times \Delta P}$$

T_L = Torque out
ΔP = pressure drop across Motor

(3) overall efficiency

$$\eta_{oa} = \frac{P_{out}\ (\text{actual power})}{P_{in}\ (\text{hydraulic power})} = \frac{T_L \times \Theta_m}{Q_1 \times \Delta P}$$

$$\eta_{oa} = \eta_v \times \eta_T = \frac{D_m \times \Theta_m}{Q} \times \frac{T_L}{D_m \times \Delta P} = \frac{\Theta_m \times T_L}{Q \times \Delta P}$$

(4) accumulators :- Storing energy in a hydraulic system

(5) Kinematic viscosity measured using many instrument by "Saybolt Universal viscometer"

(6) The kingpin torque T required to turn the wheel under vertical load w,

$$\Rightarrow T = wf\sqrt{\frac{I_o}{A} + e^2} \quad \text{—(1)}$$

f = effective friction coefficient
I_o = polar moment of inertia of tire print
e = kingpin offset
A = tire print area
w = vertical load

putting the value $\frac{I_o}{A} = \frac{b^2}{8}$ equation (1)

$$T = wf\sqrt{\frac{b^2}{8} + e^2}$$

discharge permeability $b \times N_f$ → No. of flow channel ... of potential drop [illegible] calculation for [illegible]

Indicated [illegible] per revolution

$= \frac{60 \times [illegible]}{N \eta_m}$ [illegible]

P = BPO (Brake power [illegible])

N = engine speed rpm

η_m = mechanical efficiency

(2) air flow requirement that [illegible] for [illegible] four stroke cycle engine.

$Q (m^3/s) = \frac{\text{displacement (liters)} \times \text{rpm} \times \text{volumetric efficiency}}{1.2 \times 10^5}$; diesel engine [illegible]

(3) vibration is usually measured with : Accelerometer

(4) Effective temperature scale (ET) based on physiological response.

(5) Transmissibility $= \left[\frac{1 + 4\psi^2 \frac{\omega_e}{\omega_s}}{\left[1 - \left(\frac{\omega_e}{\omega_s}\right)^2\right]^2 + 4\psi^2 \left(\frac{\omega_e}{\omega_s}\right)^2} \right]^{0.5}$

ψ = damping ratio $= \frac{C}{C_c} = \frac{\text{seat suspension rate}}{\text{critical damping rate}}$

ω_e = [illegible] forcing frequency $C_c = 2\sqrt{MK}$

ω_s = undamped natural frequency of the seat rad/s $\omega_s = \sqrt{k/M}$; spring rate of [illegible] system

(6) $T = 2\pi \sqrt{\frac{I_o}{W R_o}}$

I_o = moment of inertia.

W = weight of tractor

R_o = distance b/w pivot & center of gravity of tractor.

(7) overturning condition in tire (Moment)

$\frac{W_t V^2}{gR} \cos\gamma \, Z_g - W_t A = 0$

A = moment arm = Tread width/2 = $\frac{B}{2}$; Y/2

Z_g = height (vertical distance of C.G from ground)

$V_s = \sqrt{\frac{g A R}{Z_g \cos\gamma}}$ → gravitational [illegible]

(8) Volumetric efficiency :-

① for cylinder

$\eta_v = \frac{\text{actual volume of air intake into the cylinder } m^3}{\text{swept volume of air inside cylinder } m^3}$

$V_s = A \times L$

$\eta_v = \frac{V_{actual}}{V_s} = \frac{m_a}{\rho_a \times V_s}$ → mass of air consumed / density of air × V_s

① diameter of actuators

$D = \sqrt{\frac{4aT}{\pi S p E_a E_I} + d^2}$

D = piston dia. mm

a = lock to lock steering

T = required [illegible] force N

S = piston stroke mm

P = effective pressure at piston MPa

E_a = actuator efficiency

d = piston rod dia.

E_I = linkage efficiency

② displacement actuators

$V = \frac{aT}{p E_a E_I}$