FLOOD ROUTING

FLOOD ROUTING

- *Is the technique of determining the flood hydrogrph at a section of a river by utilizing the data of flood flow from one or more upsteram sections.*
- *is the process of determining the hydrograph at a location downstream of a reservoir or a channel section from the knowledge of the upper stream inflow.*

- *Flood Routing is broadly classified into two groups*

  Reservoir routing

  Channel routing

FLOOD ROUTING

- *Flood Routing helps to fix the capacity of the spillway of reservoirs, water control structures, and forecasting of floods.*
- The passing of floods in reservoir and channel is an unsteady flow phenomenon.(GVUF)
- It is a gradually unsteady varied flow All hydrological routings follow the principles of continuity equation

storage=inflow-outflow

$$I - Q = \frac{ds}{dt}$$

FLOOD ROUTING

- for a small change of time (Δt) the difference in the total inflow and outflow is the change in storage.

$$\overline{I}\Delta t - \overline{Q}\Delta t = \Delta S$$

- Use the average inflow and outflow of that reach and written as

$$\left(\frac{(I_1 + I_2)}{2}\right)\Delta t - \left(\frac{(Q_1 + Q_2)}{2}\right)\Delta t = (S_2 - S_1)$$

FLOOD ROUTING

- The time interval should be sufficiently short so that the inflow and outflow hydrograph assumed to be straight lines in that time interval.
- change time must be shorter than time of transit of the flood wave through the reach.

The uses of Reservoir routing method

- For flood forecasting in the lower parts of a river basin after passing through reservoir,
- For sizing spillways and determining dam / cofferdam height
- For conducting river basin watershed studies for watersheds where one or more storage facilities exist. Specifically, for watersheds in which existing reservoir are located,
- To evaluate watershed plans such as location of water supply structures, and regional flood control measures

The uses of Reservoir routing method

- In reservoir routing the outflow and the storage are the function of elevation (water level in the reservoir), again the water level by itself change in time
- Consider the variation of **I**(Inflow), **S** (storage), **h** (Water level),and **Q** (outflow) with time

Data Requirement

- Storage volume vs elevation for the reservoir (capacity curve)
- Water-surface elevation Vs outflow (Rating curve)
- storage Vs outflow discharge
- Inflow hydrograph I= I(t)
- Initial values of S, I, and Q at time t = 0

- There are methods availiable for routing of floors through a reservoir all of them use $\overline{I}\Delta t - \overline{Q}\Delta t = \Delta S$ in various manners.
- Storage routing(level pool routing) assumes horizontal water surface in the reserevoir.

Modified puls method

$$\overline{I}\Delta t - \overline{Q}\Delta t = \Delta S$$

Is Arranged as

$$\left(\frac{I_1 + I_2}{2}\right)\Delta t + \left(S_1 - \frac{Q_1 \Delta t}{2}\right) = \left(S_2 + \frac{Q_2 \Delta t}{2}\right)$$

Known at the beginning of time step ΔT

steps

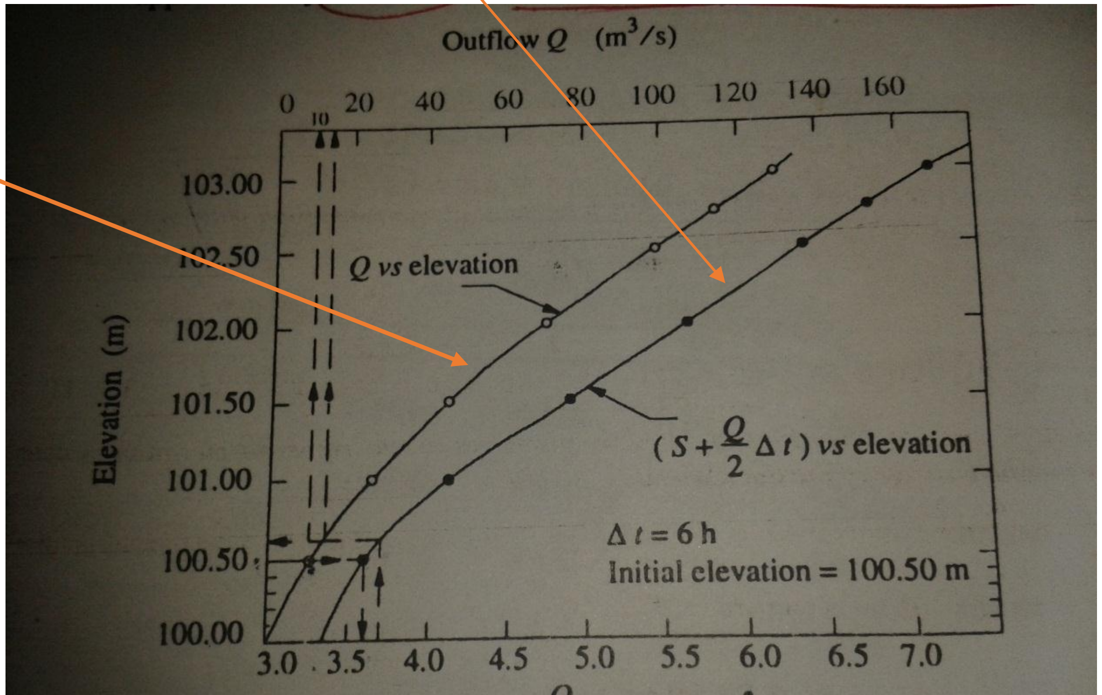
1. Decide the time step Δt of routing .

This should be chosen such that the peak of inflow hydrograph is not missed.

Approximately 20-40% of the time of rise of the inflow hydrograph.

2. prepare a curve of $\left(S + \frac{Q\Delta t}{2}\right)$ vs elevation from the known Storage elevation and discharge-elevation data.

On the same plot prepare a curve of outflow discharge vs elevation



3.Compute the values of , all other values are known at the first stage

$$\left(\frac{I_1 + I_2}{2}\right)\Delta t \qquad \left(S_1 - \frac{Q_1 \Delta t}{2}\right) \xrightarrow{\text{determine}} \left(S_2 + \frac{Q_2 \Delta t}{2}\right)$$

knowns

4.Using step 2s plot elevation(S2) and discharge(Q2) are determined

5.Deducting $Q_2 \Delta t$ from $\left(S_2 + \frac{Q_2 \Delta t}{2}\right)$ gives $\left(S + \frac{Q \Delta t}{2}\right)_1$ for the beginning of the next time step

Repeat the steps untill the entire inflow hydrograph is routed.

example

- *A reservoir has elevation, discharge and storage relationship presented in table 1 below, when the reservoir water level was 100.5m the flood its hydrograph presented in table 2 entered the reservoir. Route the flood and obtain Outflow hydrograph Reservoir elevation-time curve during the passage of the flood wave.*soln

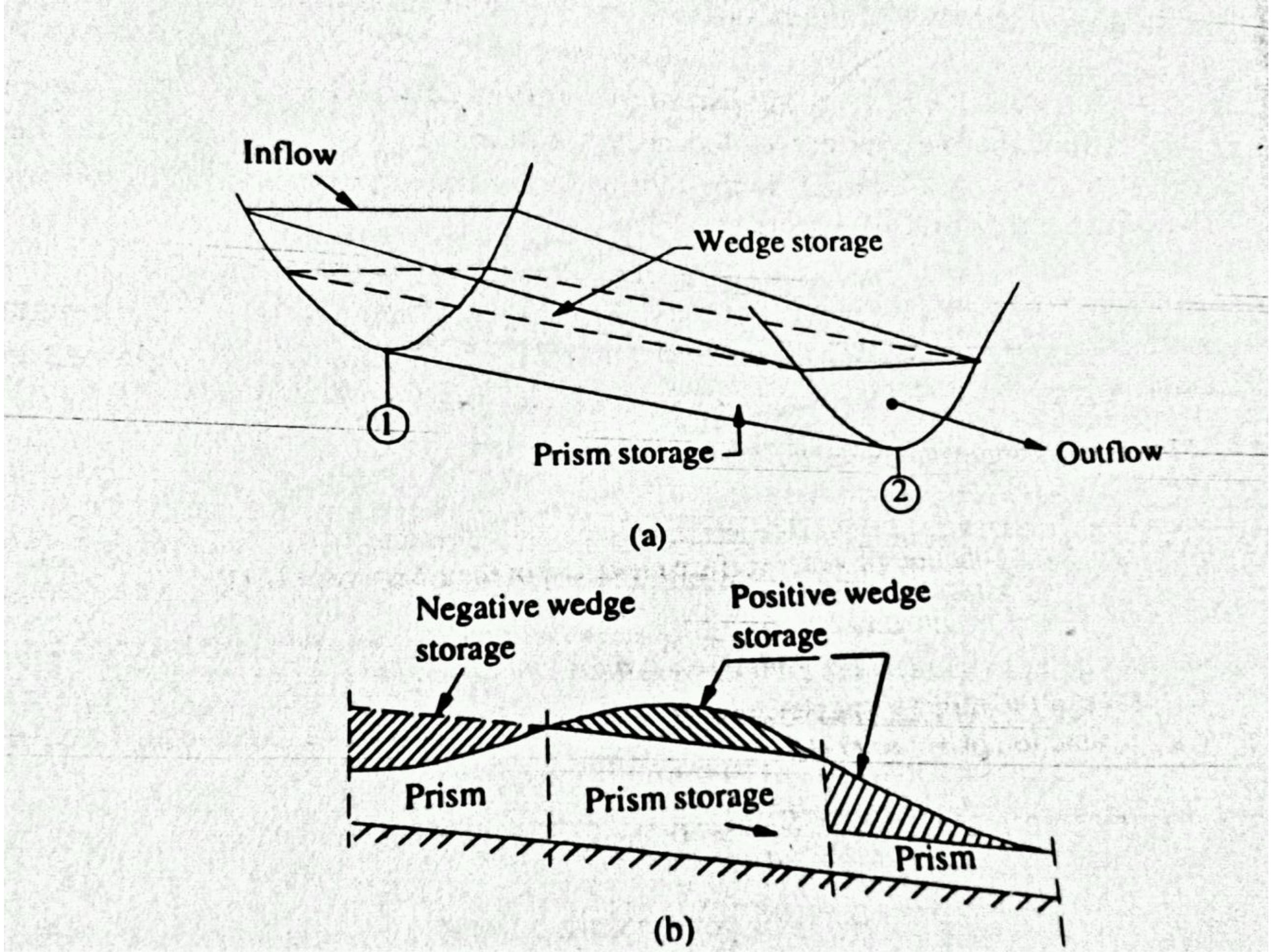
E(m)	100.0	100.5	101.1	101.5	102.0	102.5	102.75	103.0
S (10^6 m^3)	3.350	3.472	3.880	4.383	4.882	5.370	5.5527	5.856
Q (m^3/s)	0	10	26	46	72	100	116	130

Time (hr)	0	6	12	18	24	30	36	42	48	54	60	66	72
Q (m^3/s)	10	20	55	80	73	58	46	36	55	20	15	13	11

CHANNEL ROUTING

S=f(Q)…..reservoir routing

S=f(Q) & S=f(I)….channel routing



CHANNEL ROUTING

- Channel reach refers to a specific length of river channel possessing certain translation and storage properties.
- Two general approaches to river routing are recognized:

– hydrologic (Employs continuity equation)and

– Hydraulic river routing is based on the continuity equation & principles of mass and momentum conservation.

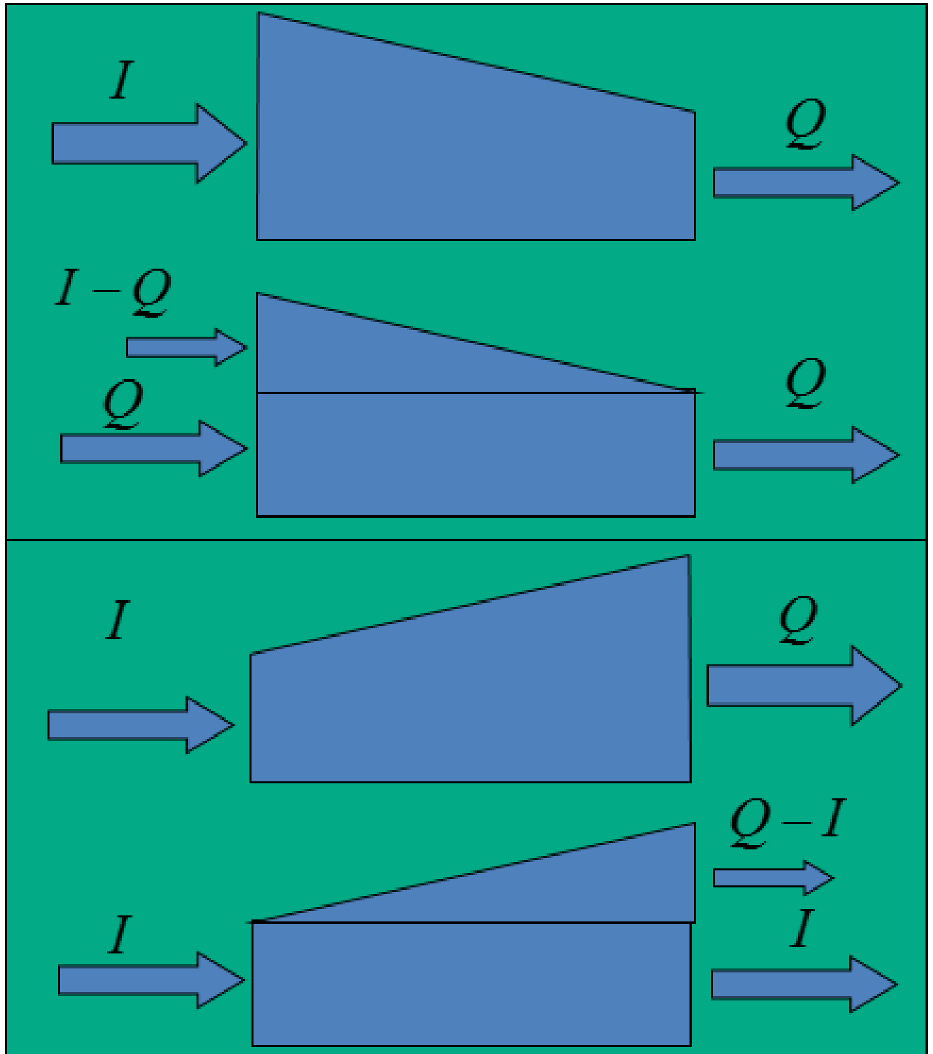
CHANNEL ROUTING

- Hybrid model, possessing essential properties of the hydrologic routing and hydraulic routing methods are being developed.

Example The Muskingum-Cung method.

- The Muskingum method of flood routing was developed in the 1930s in connection with the design of flood protection schemes in the Muskingum River Basin, Ohio, USA.
- It is the most widely used method of hydrologic river routing, with numerous applications throughout the world.

CHANNEL ROUTING



CHANNEL ROUTING

The prism storage(Sp) can be expressed as a function of discharge

=> f(Q)= KQ

The wage storage(Sw) can be expressed as a function of discharge

=> f(I-Q)= b(I-Q)

Total storage=S = bI + (K-b)Q = K [(b/K) I + (1 -b/k)Q] and writing X = b/K,

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

K m & X are constants m=[0.6,1]=[rectangilar,natural channels]

Muskingum-Cung method

m is assumed to be 1(Storage is linear function of I and Q)

S= K[x I+(1-x)Q] ………… Muskingum equation

X is weighting factor[0,0.5]

X=0 → storage is a function of outflow

X=0.5 → storage is a function of inflow and outflow

K is storage time constant {sec.}approximately equal to the time of travel of a flood wave through the channel reach

Muskingum-Cung

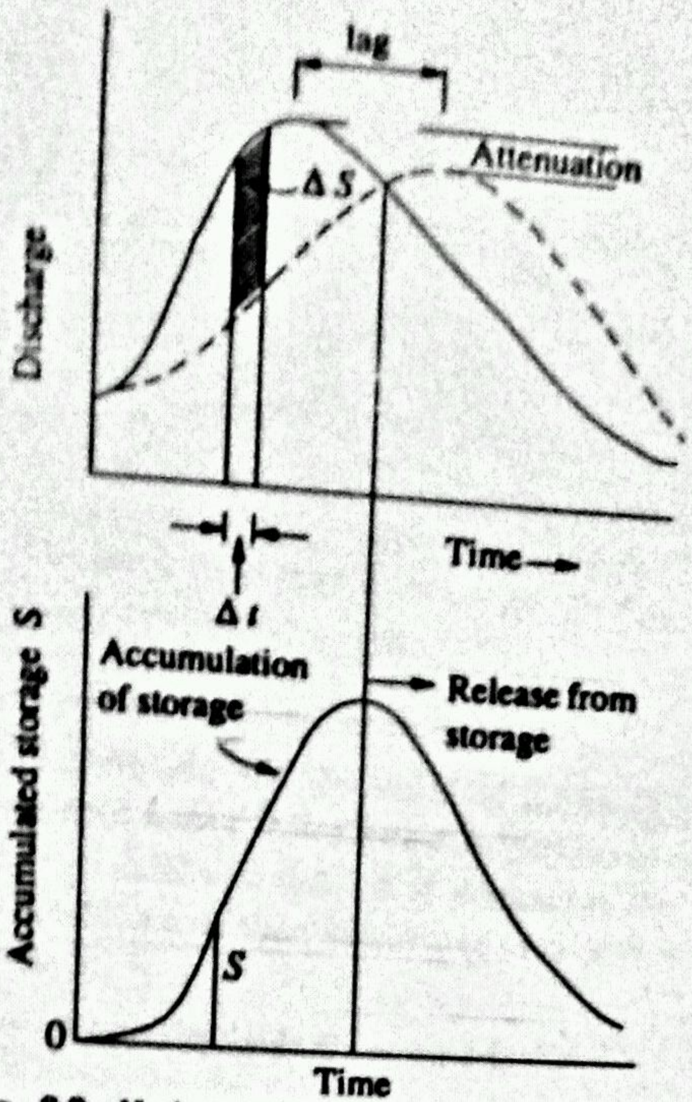


Fig. 8.8 Hydrographs and storage in channel routing

Muskingum-Cung met

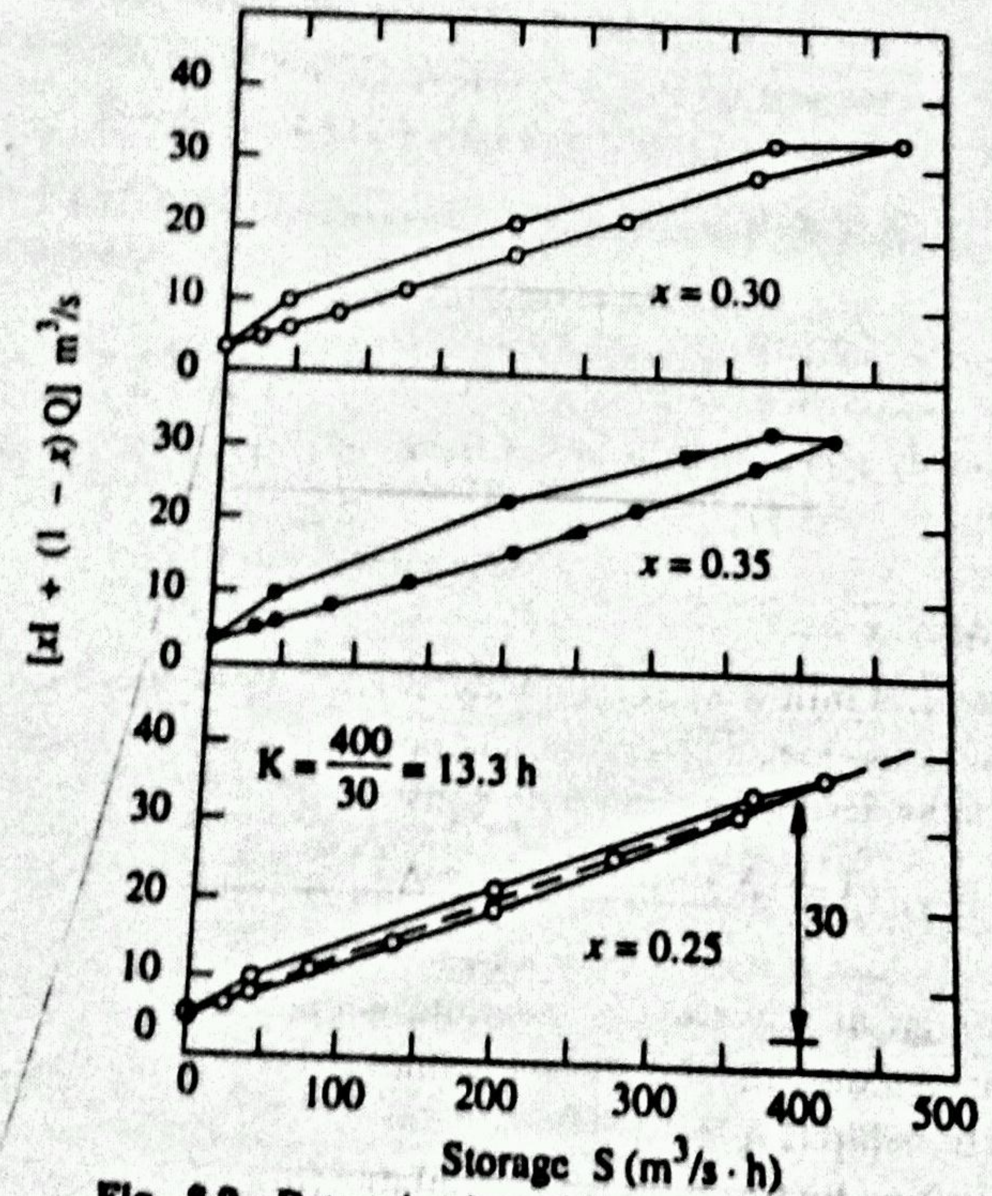


Fig. 8.9 Determination of *K* and *x* for a channel reach

example(soln)

- The following inflow and outflow hydrographs were observed in a river reach.estimate the values of K & X applicable to this reach for use in muskingum equation.

time(h)	0	6	12	18	24	30	36	42	48	54	60	66
inflow(m3/sec)	5	20	50	50	32	22	15	10	7	5	5	5
out flow(m3/sec)	5	6	12	29	38	35	29	23	17	13	9	7

Muskingum-(

- We can Write

  $S_1 = K[I_1X + (1\text{-}X)Q_1]$ and $S_2 = K[I_2X + (1\text{-}X)Q_2]$

  $S_2 – S_1 = K[X(I_2\text{-}I_1) + (1\text{-}X(Q_2\text{-}Q_1)]$

- Continuity equation

  Inflow(I) – Outflow(Q) = change in storage

$$\frac{I_1 + I_2}{2} - \frac{Q_1 + Q_2}{2} = \frac{S_1 - S_2}{\Delta t}$$

$$\frac{I_1 + I_2}{2}\Delta t - \frac{Q_1 + Q_2}{2}\Delta t = S_2 - S_1$$

$$\frac{I_1 + I_2}{2}\Delta t - \frac{Q_1 + Q_2}{2}\Delta t = K\left[X\left(I_2 - I_1\right) + (1 - X)(Q_2 - Q_2)\right]$$

Solve the equation for Q_2 and you get the general equation

$$Q_2 = C_1I_2 + C_2I_1 + C_3Q_1$$

Muskingum-C

$$Q_{j+1} = C_1 I_{j+1} + C_2 I_j + C_3 Q_j$$

where

$$C_1 = \frac{\Delta t - 2KX}{2K(1-X) + \Delta t}$$

$$K = \frac{0.5\Delta t[(I_{j+1} + I_j) - (Q_{j+1} + Q_j)]}{X(I_{j+1} - I_j) + (1-X)(Q_{j+1} - Q_j)}$$

$$C_2 = \frac{\Delta t + 2KX}{2K(1-X) + \Delta t}$$

$$X = \frac{0.5\Delta t}{K} \leq 1 - X \quad and \quad X \leq 0.5$$

$$C_3 = \frac{2K(1-X) - \Delta t}{2K(1-X) + \Delta t}$$

- X is a dimensionless weighting factor indicating the relative importance of I and Q in determining the storage in the reach and also the length of the reach
- The parameter K is the time of travel of the flood wave through the channel reach and should have the same time unit as Δt the time interval of the inflow hydrograph.
- The condition is that $C_1 + C_2 + C_3 = 1$, and often the range for Δt is $K/3 \leq \Delta t \leq$. K.
- If observed inflow and outflow hydrograph are available for a river reach, the values of K and X can be determined

Example(sol2)

- Route the following hydrograph through a river reach for which K=12h and x=0.2.at the beginning of the inflow flood, the outflow discharge is 10m3/s.

t(h)	**0**	**6**	**12**	**18**	**24**	**30**	**36**	**42**	**48**	**54**
inflow(m3/s)	**10**	**20**	**50**	**60**	**55**	**45**	**35**	**27**	**20**	**15**

RESERVOIR CAPACITY

- **Reservoir:** Collects water behind a dam or barrier
- Reservoirs are constructed for:

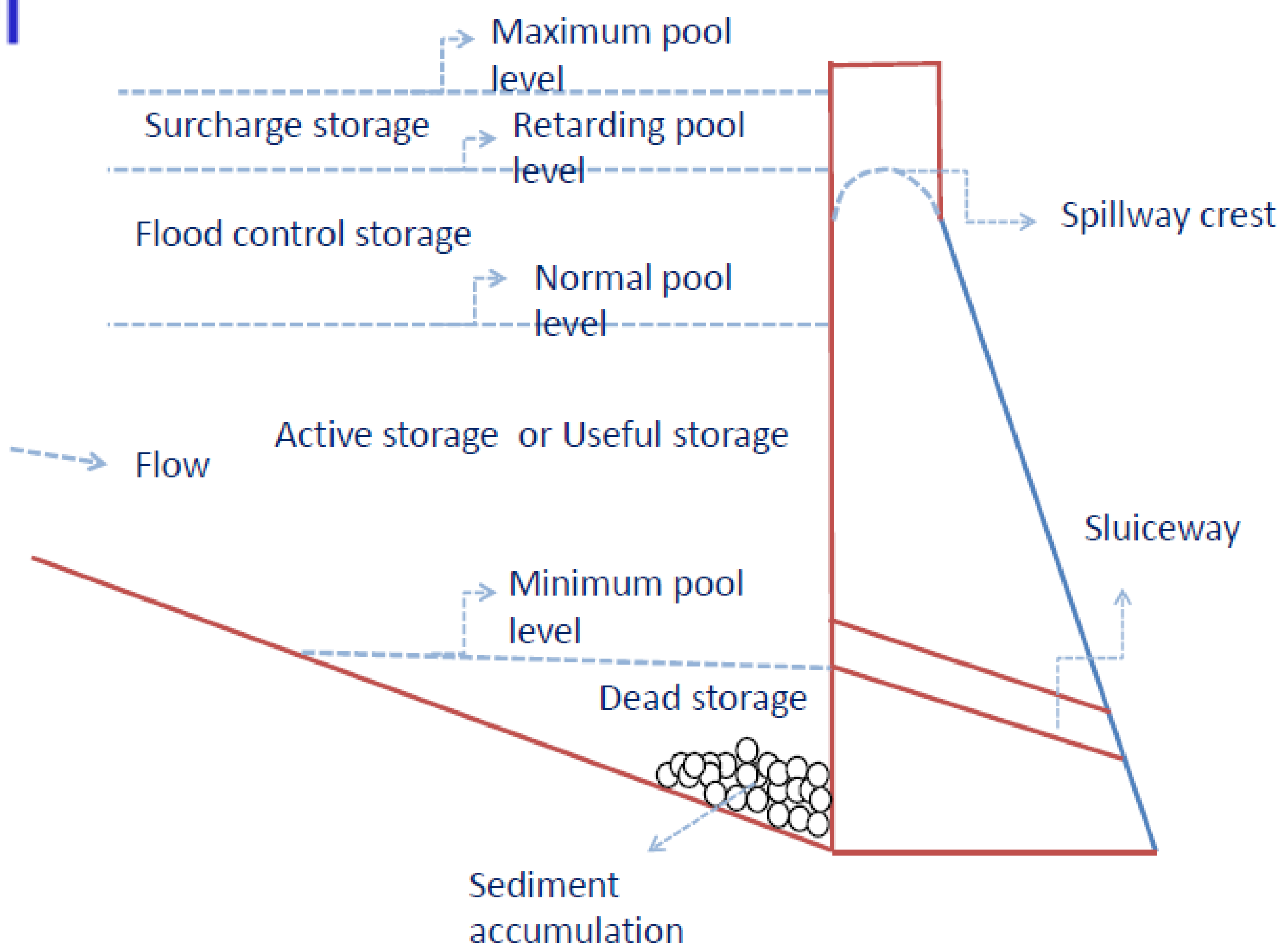
  Drinking water,

  Irrigation,

  Hydropower,

  Flood mitigation…
- During a specified time interval;

S (supply) < D (demand) Need for "water storage


Maximum pool level
Surcharge storage
Retarding pool level
Spillway crest
Flood control storage
Normal pool level
Active storage or Useful storage
Flow
Sluiceway
Minimum pool level
Dead storage
Sediment accumulation

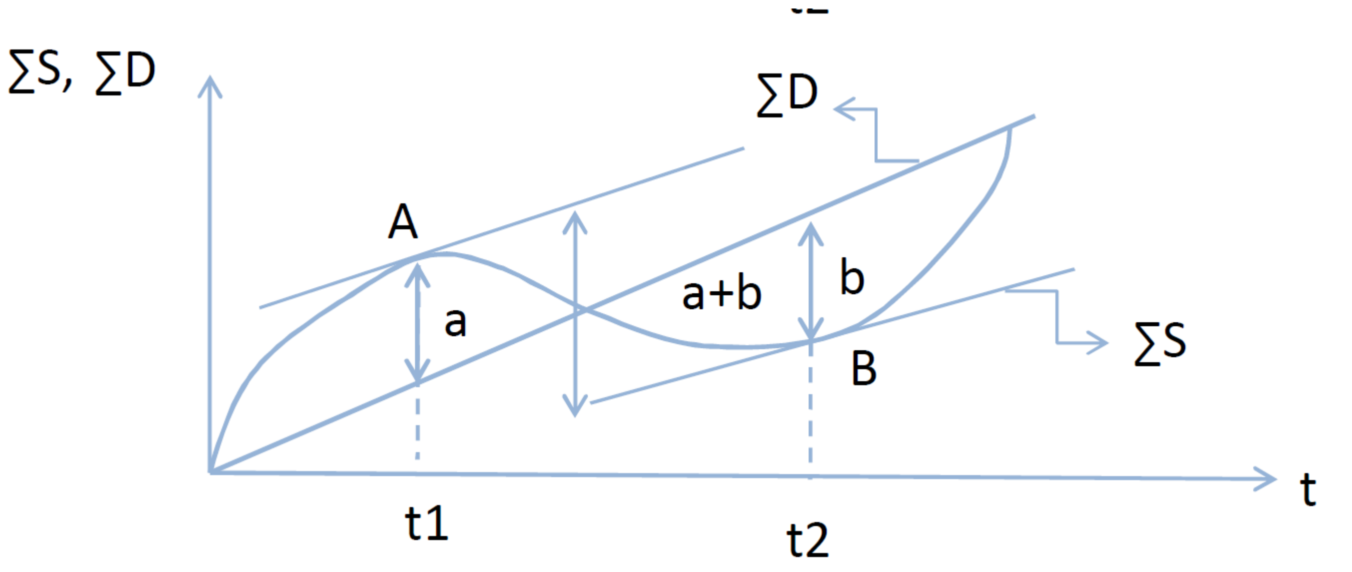
- Designing the capacity of a storage reservoir involves with determination of the critical period during Inflow < Demand

- There are 4 approaches to determine the capacity
    1) Mass curve (Ripple diagram) method;X
    2) Sequent-peak algorithm;X
    3) Operation study; O
    4) Optimization analysis O

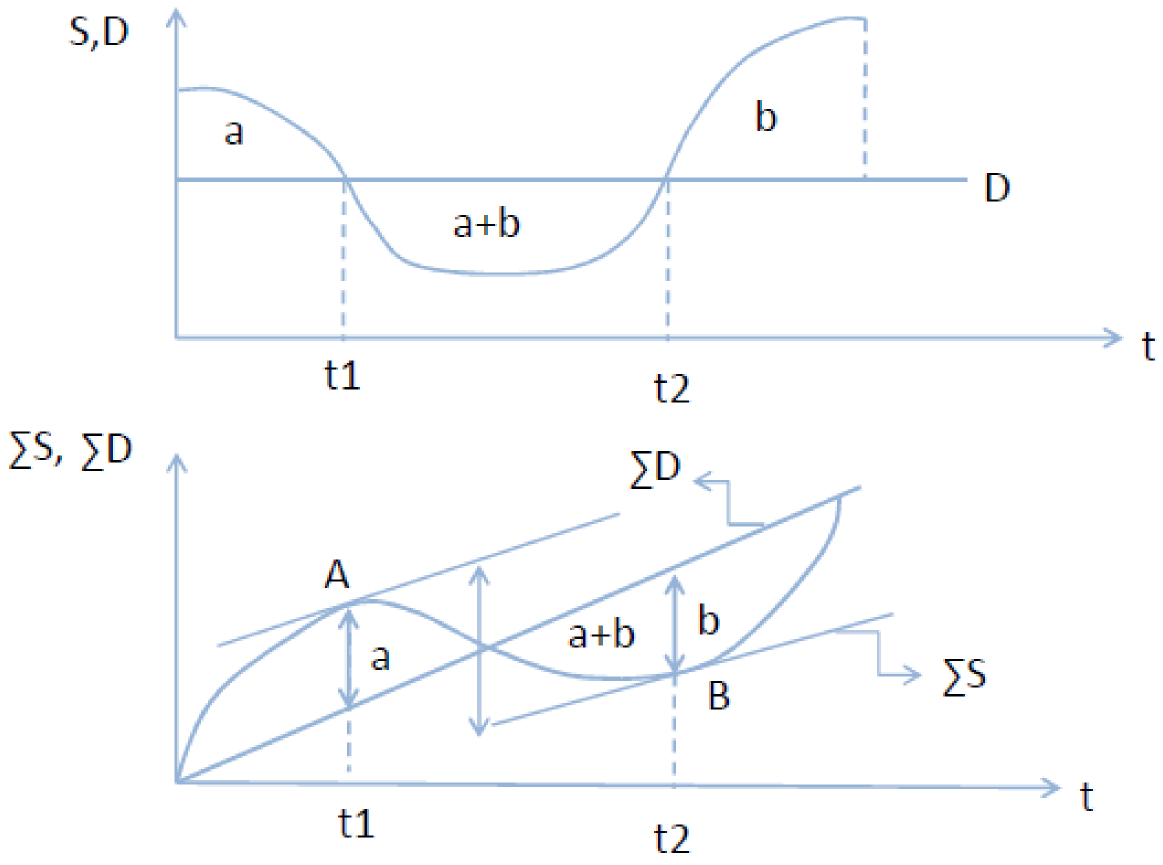
Mass curve (Ripple diagram) method

This method is very easy to use when analysing short period data

- Cumulative plotting of net reservoir inflow.
- Slope of mass curve gives the value of inflow (S) at that time.
- Slope of demand curve gives the demand rate (D) or yield.



- The difference between the lines (a+b) tangent to the demand line (ΣD) drawn at the highest and lowest points (A and B, respecRvely) of mass curve (ΣS) gives the rate of withdrawal from reservoir during that critical period
- The maximum cumulative value between tangents is the required storage capacity (active storage)


S,D
a
b
D
a+b
t
t1
t2
∑S, ∑D
∑D
A
a
a+b
b
∑S
B
t
t1
t2

Sequent-Peak Analysis

- SPA is a modification of the Mass Curve analysis for lengthy time series and particularly suited to computer coding.
- The steps of sequent-peak analysis are as follows:
  - *Plot* Σ (Inflow-Withdrawal) : in symbolized fashion Σ(S-D)
  - *Locate* the initial peak and the next peak
  - *Compute* the storage required which is the *difference* between the initial peak and the lowest trough in the interval,

– *Repeat* the process for all sequent peaks,

– *Determine* the largest value of storages as “STORAGE CAPACITY”.

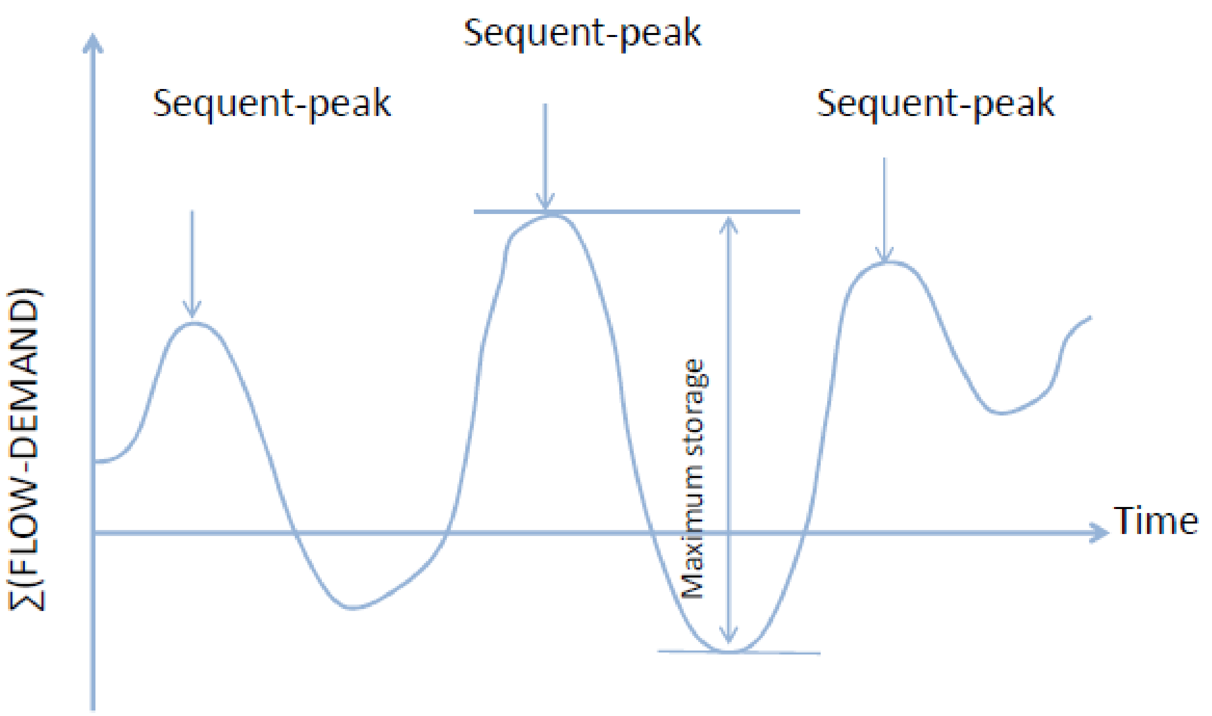


Illustration of the sequent –peak algorithm