* Flood Routing

UNIT- 4

*Introduction

A flood is an unusually high stage in a river – normally the level at which the river overflows its banks and inundates the adjoining area. The damages caused by floods in terms of loss of life, property and economic loss due to disruption of economic activity are very high. Flood peak values are required in the design bridges, culvert waterways, spillways for dams, and estimation of scour at a hydraulic structure.

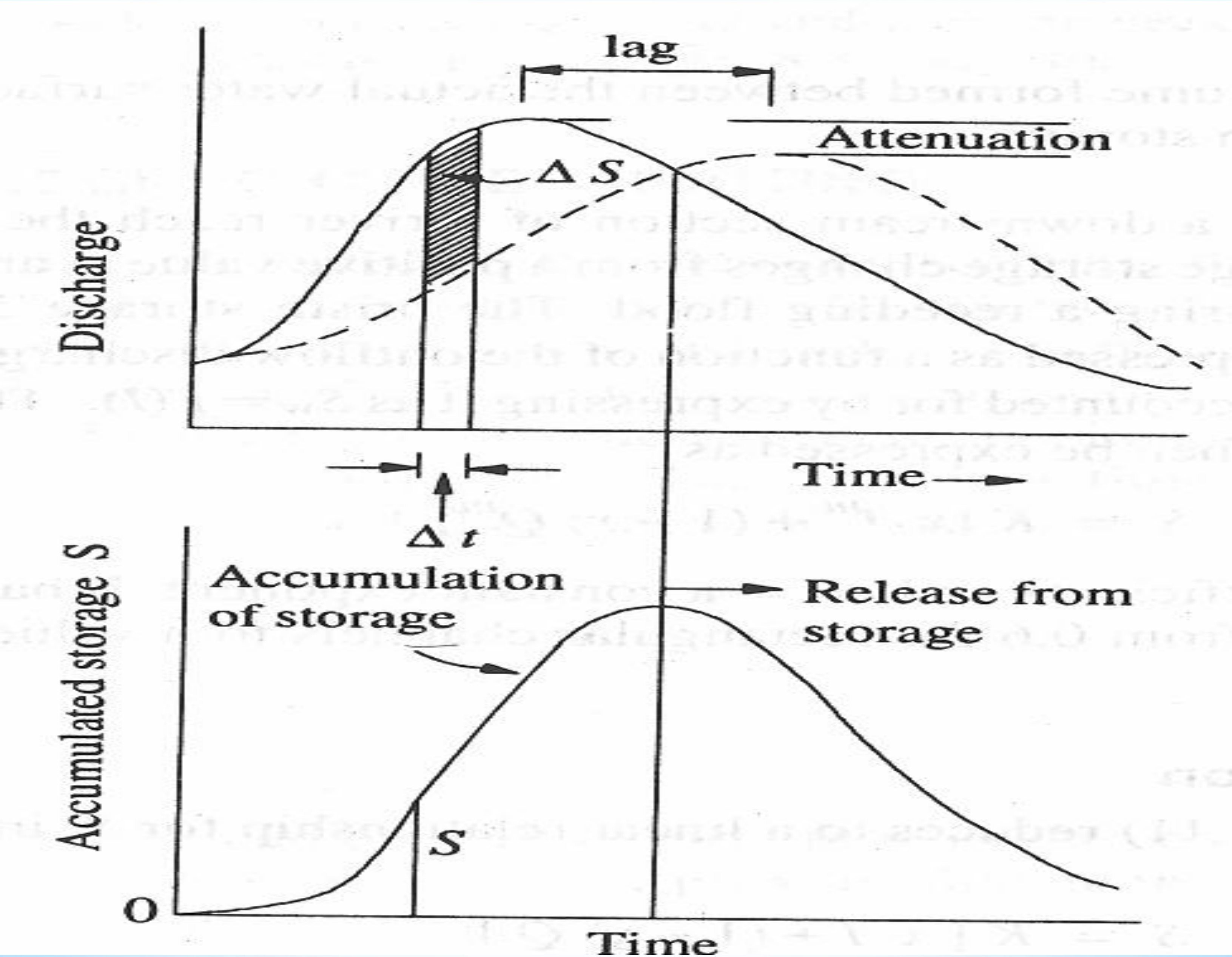
- At a given location in a stream, flood peaks vary from year to year and their magnitude constitutes a hydrologic series. To estimate the magnitude of a flood peak the following methods are adopted:

1. Rational method
2. Empirical equations
3. Flood frequency studies
4. Unit hydrograph technique

*FLOOD ROUTING

The flood hydrograph is in fact a wave. The stage and discharge hydrographs represent the passage of waves of stream depth and discharge respectively. As this wave moves down, the shape of the wave gets modified due to channel storage, resistance, lateral addition or withdrawal of flows etc. When a flood wave passes through a reservoir its peak is attenuated and the time base is enlarged due to effect of storage

The reduction in the peak of the outflow hydrograph due to storage effects is called attenuation. Further the peak of outflow occurs after the peak of the inflow; the time difference between the peaks of inflow and outflow hydrographs is known as lag. Modification in the hydrograph is studied through flood routing. Flood routing is the technique of determining the flood hydrograph at a section of a river by utilizing the data of flood flow at one or more upstream sections.


lag
Attenuation
Δ S
Discharge
Time
Δ t
Accumulated storage S
Accumulation
of storage
Release from
storage
S
O
Time

Basic Equation for hydrologic routing

The passage of a flood hydrograph through a reservoir or a channel reach is a gradually varied unsteady flow. If we consider some hydrologic system with input I(t), output O(t), and storage S(t), then the equation of continuity in hydrologic routing methods is the following:

dt

dS

I −O =

If the inflow hydrograph, I(t) is known, this equation cannot be solved directly to obtain the outflow hydrograph, O(t), because both O and S are unknown. A second relation, the storage function is needed to relate S, I, and Q. The particular form of the storage equation depends on the system; a reservoir or a river reach.

* Modified Puls
* Kinematic Wave
* Muskingum
* Muskingum-Cunge
* Dynamic

*Routing Methods

*Modified Puls

- The modified puls routing method is probably most often applied to reservoir routing
- The method may also be applied to river routing for certain channel situations.
- The modified puls method is also referred to as the storage-indication method.
- The heart of the modified puls equation is found by considering the finite difference form of the continuity equation.

*Modified Puls

$$\frac{I_1+I_2}{2}-\frac{(O_1+O_2}{2}=\frac{S_2-S_1}{\Delta t}$$

Continuity Equation

$$I_1+I_2+\left(\frac{2S_1}{\Delta t}-O_1\right)=\frac{2S_2}{\Delta t}+O_2$$

Rewritten

The solution to the modified puls method is accomplished by developing a graph (or table) of O -vs- [2S/Δt + O]. In order to do this, a stage-discharge-storage relationship must be known, assumed, or derived.

*Kinematic Wave

- ➢Kinematic wave channel routing is probably the most basic form of hydraulic routing.
- ➢This method combines the continuity equation with a very simplified form of the St. Venant equations.
- ➢Kinematic wave routing assumes that the friction slope is equal to the bed slope.
- ➢Additionally, the kinematic wave form of the momentum equation assumes a simple stage-discharge relationship.

*Muskingum Notes :

- The method assumes a single stage-discharge relationship.
- In other words, for any given discharge, Q, there can be only one stage height.
- This assumption may not be entirely valid for certain flow situations.
- For instance, the friction slope on the rising side of a hydrograph for a given flow, Q, may be quite different than for the recession side of the hydrograph for the same given flow, Q.
- This causes an effect known as hysteresis, which can introduce errors into the storage assumptions of this method.

* Muskingum-Cunge formulation is similar to the Muskingum type formulation
* The Muskingum-Cunge derivation begins with the continuity equation and includes the diffusion form of the momentum equation.
* These equations are combined and linearized,

Muskingum-Cunge

$$\frac{\partial Q}{\partial t} + \frac{\partial Q}{\partial x} = \mu \frac{\partial^2 Q}{\partial x^2} + cq_{Lat}$$

*Muskingum-Cunge "working equation"

* The solution of the St. Venant equations is known as dynamic routing.
* Dynamic routing is generally the standard to which other methods are measured or compared.
* The solution of the St. Venant equations is generally accomplished via one of two methods : 1) the method of characteristics and 2) direct methods (implicit and explicit).
* It may be fair to say that regardless of the method of solution, a computer is absolutely necessary as the solutions are quite time consuming.
* J. J. Stoker (1953, 1957) is generally credited for initially attempting to solve the St. Venant equations using a high speed computer.

Full Dynamic Wave Equations