Chapter 1

INTRODUCTION

Hydrology is a branch of Earth Science. The importance of hydrology in the assessment, development, utilisation and management of the water resources, of any region is being increasingly realised at all levels. It was in view of this that the United Nations proclaimed the period of 1965-1974 as the International Hydrological Decade during which, intensive efforts in hydrologic education research, development of analytical techniques and collection of hydrological information on a global basis, were promoted in Universities, Research Institutions, and Government Organisations.

1.1 WORLD'S WATER RESOURCES

The World's total water resources are estimated at 1.36×10^8 M ha-m. Of these global water resources, about 97.2% is salt water mainly in oceans, and only 2.8% is available as fresh water at any time on the planet earth. Out of this 2.8% of fresh water, about 2.2% is available as surface water and 0.6% as ground water. Even out of this 2.2% of surface water, 2.15% is fresh water in glaciers and icecaps and only of the order of 0.01% is available in lakes and streams, the remaining 0.04% being in other forms. Out of 0.6% of stored ground water, only about 0.25% can be economically extracted with the present drilling technology (the remaining being at greater depths). It can be said that the ground water potential of the Ganga Basin is roughly about forty times the flow of water in the river Ganga.

1.2 WATER RESOURCES OF INDIA

The important rivers of India are shown in Fig. 1.1 and their approximate water potentials are given below:

Sl. no.	*River basin*	*Water potential (M ha-m)*
1.	West flowing rivers like Narmada and Tapti	30.55
2.	East flowing rivers like Mahanadi, Godavari, Krishna, Cauvery and Pennar	35.56
3.	The Ganges and its tributaries	55.01
4.	Indus and its tributaries	7.95
5.	The River Brahmaputra	59.07
	Total	**188.14**

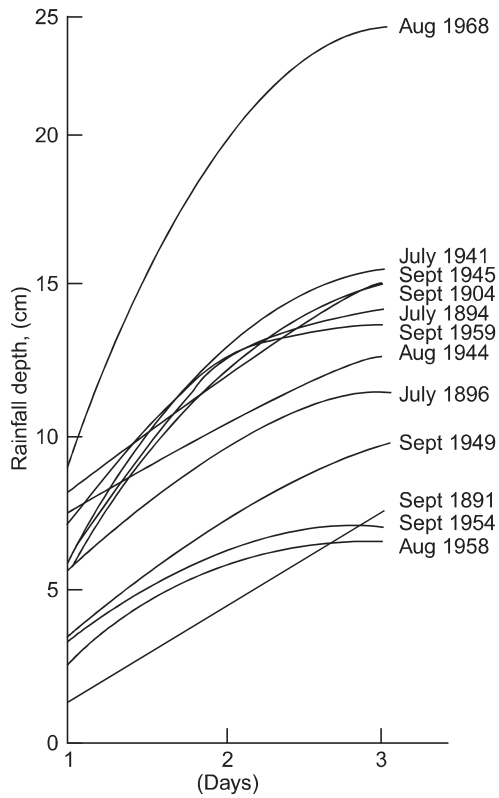

Fig. 1.5 Depth-duration curves for heavy-rain storms of Tapti basin

For the 3-day storm of 1968, the rainfall of 25.96 cm has resulted in a surface runoff of 11.68 cm, thus giving a coefficient of runoff of $\frac{11.68}{25.96} = 0.43$ for the whole catchment. During this flood, there was a wind storm of 80 km/hr blowing over the city of Surat. There was simultaneous high tide in the river. There was heavy storm concentration in the lower catchment. The total loss due to the devastating floods of 1968 was around Rs. 100 lakhs.

In Chapter 15, the magnitudes and return periods (recurrence intervals) of the high floods are determined by the deterministic, probabilistic and stochastic approaches using the annual flood data of the lower Tapti river at Ukai for the 30-years period from 1939 to 1968. The Gumbel's method, based on the theory of extreme values gives a 100-year flood of 49210 cumec and hence this method can be safely adopted in the estimation of design flood for the purpose of safe design of hydraulic structures, while the stochastic approach may give a suitable value of MPF.

1.4 HYDROLOGY AND HYDROLOGIC CYCLE

Hydrology is the science, which deals with the occurrence, distribution and disposal of water on the planet earth; it is the science which deals with the various phases of the hydrologic cycle.

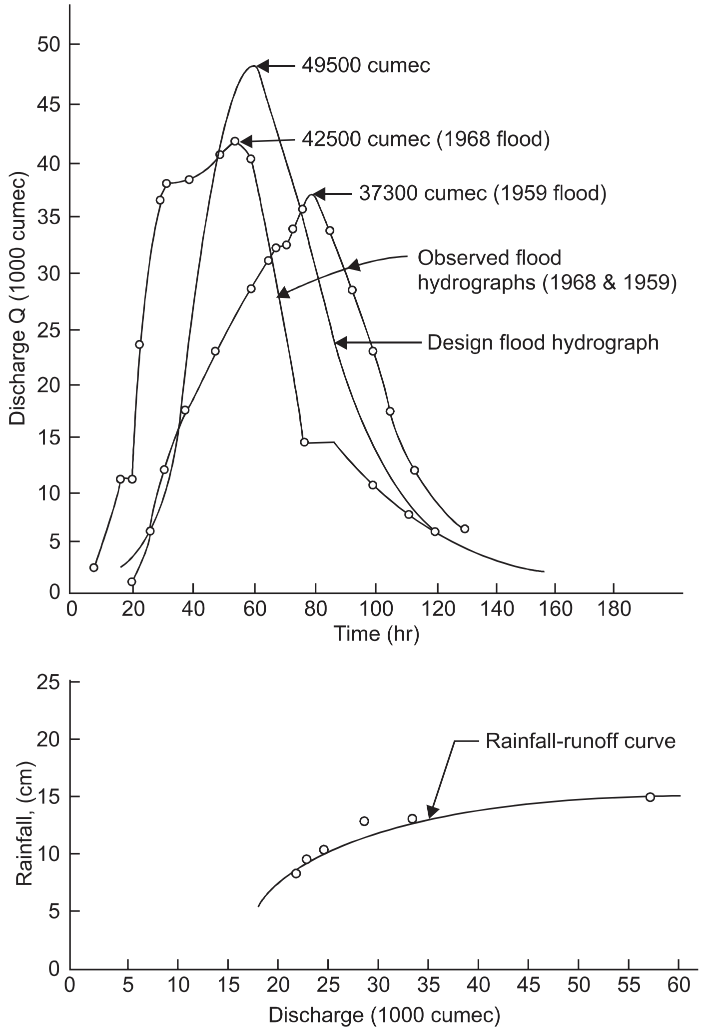

Fig. 1.6 Flood hydrographs of river Tapti at Ukai

Hydrologic cycle is the water transfer cycle, which occurs continuously in nature; the three important phases of the hydrologic cycle are: (*a*) Evaporation and evapotranspiration (*b*) precipitation and (*c*) runoff and is shown in Fig. 1.7. The globe has one-third land and two-thirds ocean. Evaporation from the surfaces of ponds, lakes, reservoirs. ocean surfaces, etc. and transpiration from surface vegetation *i.e.,* from plant leaves of cropped land and forests, etc. take place. These vapours rise to the sky and are condensed at higher altitudes by condensation nuclei and form clouds, resulting in droplet growth. The clouds melt and sometimes burst resulting in precipitation of different forms like rain, snow, hail, sleet, mist, dew and frost. A part of this precipitation flows over the land called runoff and part infilters into the soil which builds up the ground water table. The surface runoff joins the streams and the water is stored in reservoirs. A portion of surface runoff and ground water flows back to ocean. Again evaporation starts from the surfaces of lakes, reservoirs and ocean, and the cycle repeats. Of these three phases of the hydrologic cycle, namely, evaporation, precipitation and runoff, it is the 'runoff phase', which is important to a civil engineer since he is concerned with the storage of surface runoff in tanks and reservoirs for the purposes of irrigation, municipal water supply hydroelectric power etc.

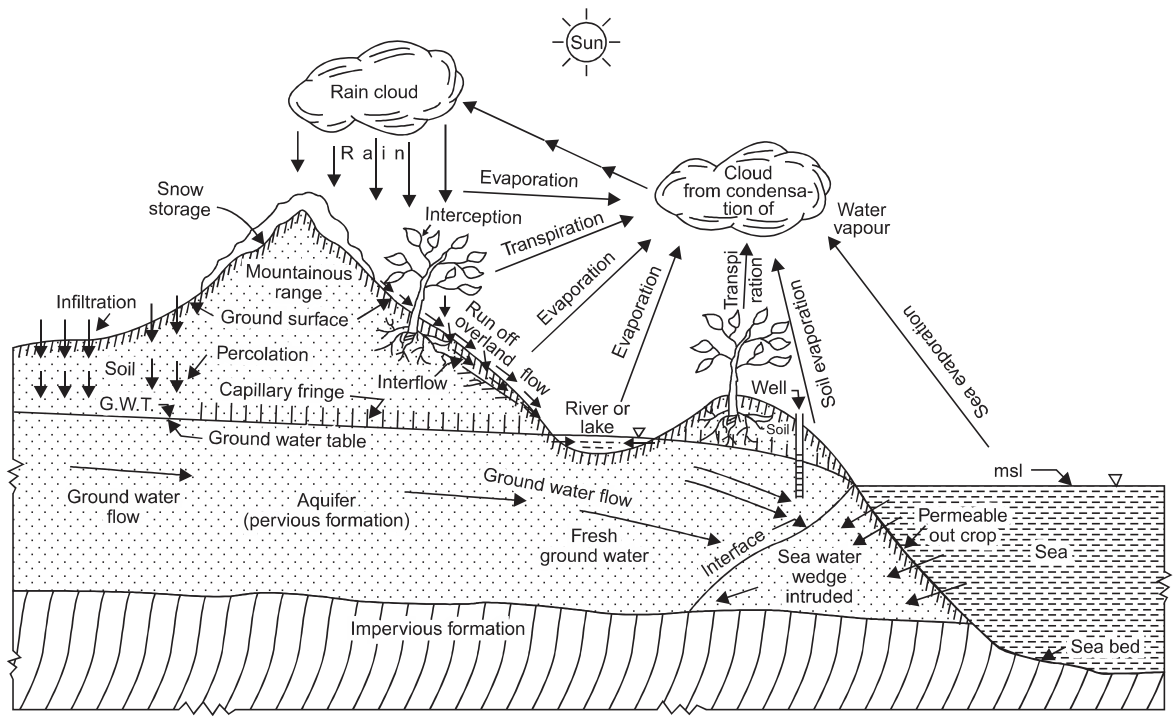

Fig. 1.7 The hydrologic cycle

1.5 FORMS OF PRECIPITATION

Drizzle	— a light steady rain in fine drops (0.5 mm) and intensity <1 mm/hr
Rain	— the condensed water vapour of the atmosphere falling in drops (>0.5 mm, maximum size—6 mm) from the clouds.
Glaze	— freezing of drizzle or rain when they come in contact with cold objects.
Sleet	— frozen rain drops while falling through air at subfreezing temperature.
Snow	— ice crystals resulting from sublimation (*i.e.,* water vapour condenses to ice)
Snow flakes	— ice crystals fused together.
Hail	— small lumps of ice (>5 mm in diameter) formed by alternate freezing and melting, when they are carried up and down in highly turbulent air currents.
Dew	— moisture condensed from the atmosphere in small drops upon cool surfaces.

Frost — a feathery deposit of ice formed on the ground or on the surface of exposed objects by dew or water vapour that has frozen

Fog — a thin cloud of varying size formed at the surface of the earth by condensation of atmospheric vapour (interfering with visibility)

Mist — a very thin fog

1.6 SCOPE OF HYDROLOGY

The study of hydrology helps us to know

(*i*) the maximum probable flood that may occur at a given site and its frequency; this is required for the safe design of drains and culverts, dams and reservoirs, channels and other flood control structures.

(*ii*) the water yield from a basin—its occurence, quantity and frequency, etc; this is necessary for the design of dams, municipal water supply, water power, river navigation, etc.

(*iii*) the ground water development for which a knowledge of the hydrogeology of the area, *i.e.,* of the formation soil, recharge facilities like streams and reservoirs, rainfall pattern, climate, cropping pattern, etc. are required.

(*iv*) the maximum intensity of storm and its frequency for the design of a drainage project in the area.

1.7 HYDROLOGICAL DATA

For the analysis and design of any hydrologic project adequate data and length of records are necessary. A hydrologist is often posed with lack of adequate data. The basic hydrological data required are:

(*i*) Climatological data

(*ii*) Hydrometeorological data like temperature, wind velocity, humidity, etc.

(*iii*) Precipitation records

(*iv*) Stream-flow records

(*v*) Seasonal fluctuation of ground water table or piezometric heads

(*vi*) Evaporation data

(*vii*) Cropping pattern, crops and their consumptive use

(*viii*) Water quality data of surface streams and ground water

(*ix*) Geomorphologic studies of the basin, like area, shape and slope of the basin, mean and median elevation, mean temperature (as well as highest and lowest temperature recorded) and other physiographic characteristics of the basin; stream density and drainage density; tanks and reservoirs

(*x*) Hydrometeorological characteristics of basin:

  (*i*) a.a.r., long term precipitation, space average over the basin using isohyets and several other methods (Rainbird, 1968)

  (*ii*) Depth-area-duration (DAD) curves for critical storms (station equipped with self-recording raingauges).

(*iii*) Isohyetal maps—Isohyets may be drawn for long-term average, annual and monthly precipitation for individual years and months

(*iv*) Cropping pattern—crops and their seasons

(*v*) Daily, monthly and annual evaporation from water surfaces in the basin

(*vi*) Water balance studies of the basin

(*vii*) Chronic problems in the basin due to a flood-menacing river (like Tapti or Tapi in central India) or siltmenacing river (like Tungabhadra in Karnataka)

(*vii*) Soil conservation and methods of flood control

1.8 HYDROLOGIC EQUATION

The hydrologic equation is simply the statement of the law of conservation of matter and is given by

$$I = O + \Delta S \qquad \text{...(1.1)}$$

where I = inflow

O = outflow

ΔS = change in storage

This equation states that during a given period, the total inflow into a given area must equal the total outflow from the area plus the change is storage. While solving this equation, the ground water is considered as an integral part of the surface water and it is the subsurface inflow and outflow that pose problems in the water balance studies of a basin.

QUIZ I

I Choose the correct statement/s in the following:

1 The hydrological cycle

(*i*) has beginning but does not end

(*ii*) has both beginning and end

(*iii*) occurs continuously in nature

(*iv*) is a water transfer cycle

(*v*) has three phases—precipitation, evaporation and runoff

2 Hydrology deals with

(*i*) occurrence of water and formation of snow

(*ii*) movement of water on earth and water vapour in atmosphere

(*iii*) occurrence of floods and droughts

(*iv*) consumptive use of crops and crop planning

(*v*) prevention of drought

(*iv*) the hydrologic cycle

3 Hydrologic studies are made

(*i*) to determine MPF

(*ii*) to determine design flood for spillways and bridges

(*iii*) to asses the ground water potential of a basin

(*iv*) for the preparation of land drainage schemes
(*v*) to determine the hydro-power potential
(*iv*) for irrigation and crop planning
(*vii*) for all the above

4 The hydrologic equation states that
(*i*) the inflow into the basin is equal to the outflow from the basin at any instant
(*ii*) the difference between inflow and outflow is the storage
(*iii*) subsurface inflow is equal to the subsurface outflow
(*iv*) the water balance over the basin = Σ inflow — Σ outflow

II Match the items in 'A' with items in 'B'

A	**B**
(*i*) Runoff	(*a*) Deals with hydrologic cycle
(*ii*) Snow, hail	(*b*) Water transfer cycle
(*iii*) Hydrology	(*c*) Important phase of hydrologic cycle
(*iv*) Hydrologic cycle	(*d*) Forms of precipitation
(*v*) Evaporation, precipitation and runoff	(*e*) Law of conservation of matter
(*vi*) Hydrologic equation	(*f*) Three phases of hydrologic cycle

QUESTIONS

1 Explain the hydraulic cycle in nature with the help of a neat sketch, indicating its various phases.

2 What are the basic data required for hydrological studies? Name the agencies from which the data can be obtained?

3 What is the function of hydrology in water resources development? What are the basic hydrological requirements for a river basin development?

4 Explain 'hydrologic equation'.