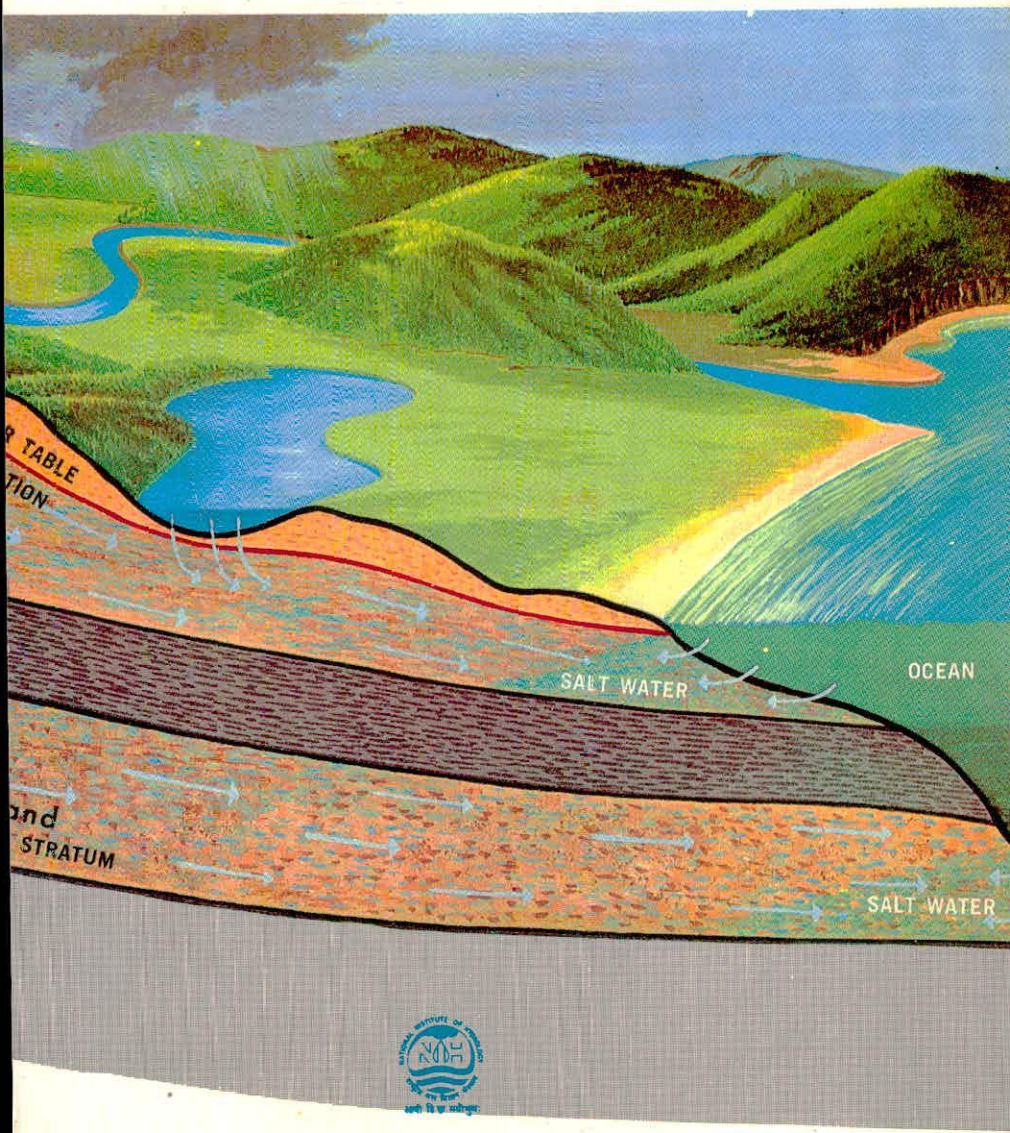
WATER — NATURE'S WONDER
HYDROLOGIC CYCLE



NATIONAL INSTITUTE OF HYDROLOGY
ROORKEE

HYDROLOGIC CYCLE

Water occurs practically everywhere in one form or the other varying in quantity from an almost unlimited supply in oceans to nil in desert regions. On the earth's surface, it is found in the oceans, in lakes and rivers. In atmosphere it occurs in the form of water vapour, clouds and precipitation. Beneath the ground surface it occurs as underground reservoirs

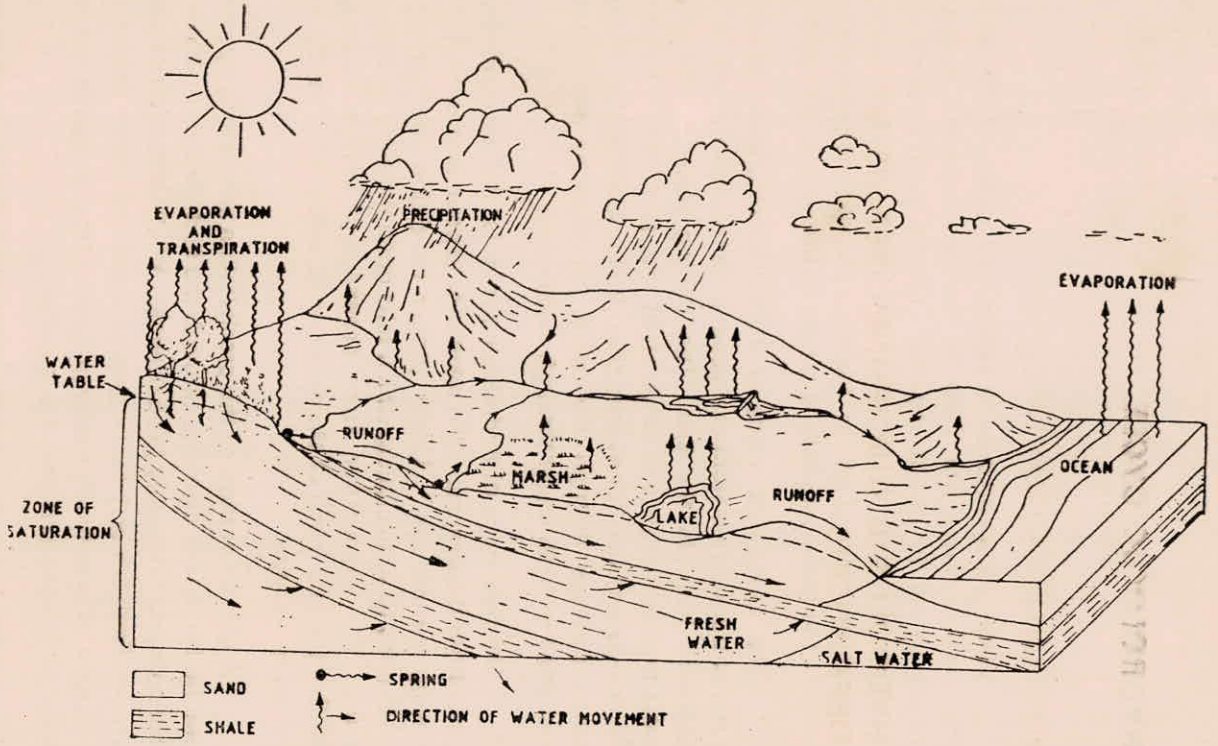
The hydrologic cycle is a continuous process by which water is transported from the oceans to the atmosphere, to the land and back to the sea. The driving force for the global water transport system is provided by the sun, which furnishes the energy required for evaporation. Water quality also changes during passage through the cycle, for example sea water is converted to fresh water through evaporation.

The first stage of hydrologic cycle is the evaporation of water from the oceans. The resulting vapour is transported by moving air masses. Under proper condition the vapour is condensed to form clouds, which falls upon the earth in different forms. The evaporation from oceans and earth's surface is continuous and much of the evaporated water falls directly over the ocean surface.

A greater portion of the precipitation which falls upon the land finds it's way over and through the surface soil to streams, channels and ultimately joins oceans. While a fraction of precipitation finds it's way to the ground water reservoirs. Under the influence of gravity ultimately ground water also moves towards lower elevations and joins the oceans.

It has been observed that about two thirds of precipitation which reaches the land surface is returned to the

* COMPONENT BASED



Hydrologic Cycle : Pictorial representation

atmosphere by evaporation from water surface, soil and vegetation and through transpiration by plants. The remaining one third precipitation also ultimately returns to oceans, It has been observed that moisture evaporated from the land surface is less than 10% of the total atmospheric moisture. Thus the hydrologic equation can be written as

Inflow = Outflow + storage

HYDROLOGIC DISCIPLINE : TERMS & DEFINITIONS

Hydrology :

Hydrology is an inter disciplinary science that deals with all water of earth, including their origin, occurrence, circulation and distribution on and in the earth, their chemical and physical properties and their reactions with their environment, including their relations with living things. The scope of hydrology, therefore, encompasses the full history and behaviour of water in the earth system.

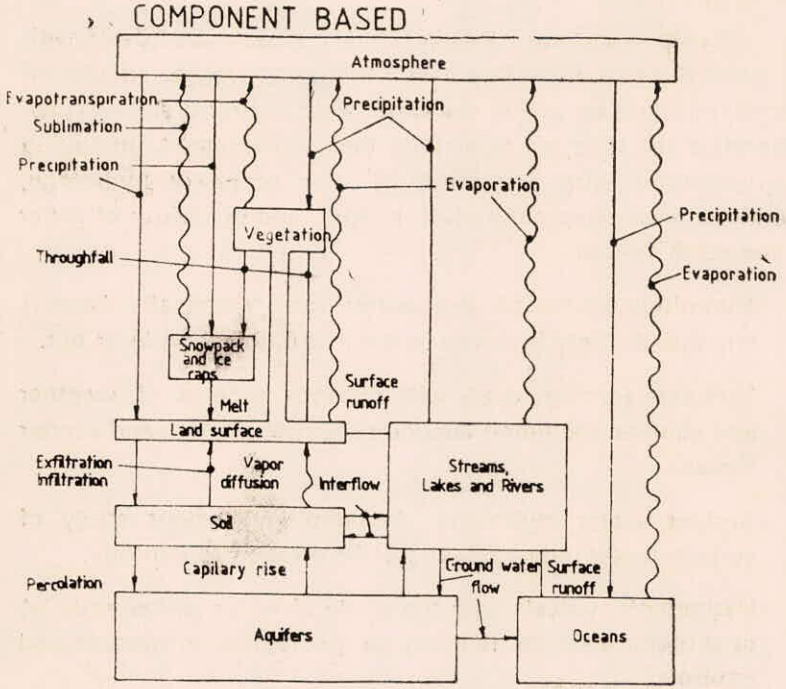
* Hydrology covers all free water (not chemically bound) whether actively involved in the hydrological cycle or not.
* Hydrometeorology deals with aqueous aspects of weather and climate, including evaporation, precipitation and vapour fluxes.
* Surface water hydrology (potamology) covers study of surface water independently of its relation to geology.
* Hydrogeology deals with the study of water either surficial or subterranean in relation to geological influences and controls.
* Subterranean hydrology covers study of water in all subsurface zones-soil zone, nonsaturated zone and unsaturated zone.

* Ground water hydrology deals with the study of water in subsurface zone of saturation.

* Glaciology (cryology) covers the study of water in the solid phase, whether in glaciers, icecaps, sea ice or permafrost.

* Limnology deals with the study of lake waters, whether fresh or saline.

* Oceanology covers the study of hydrological aspects of oceanic waters and water of inland areas.



ESTIMATE OF WATER BUDGET

World Water Budget :

Source		Volume (km^3)	%
Oceans	—	1348000000	97.37
Polar Ice caps, Icebergs, Glaciers	—	227820000	2.01
Ground water, Soil moisture	—	8062000	0 58
Lakes and rivers	—	225000	0.02
Atmosphere	—	13000	0.001
	Total	1384120000	100
	Fresh water	36020000	2.60%

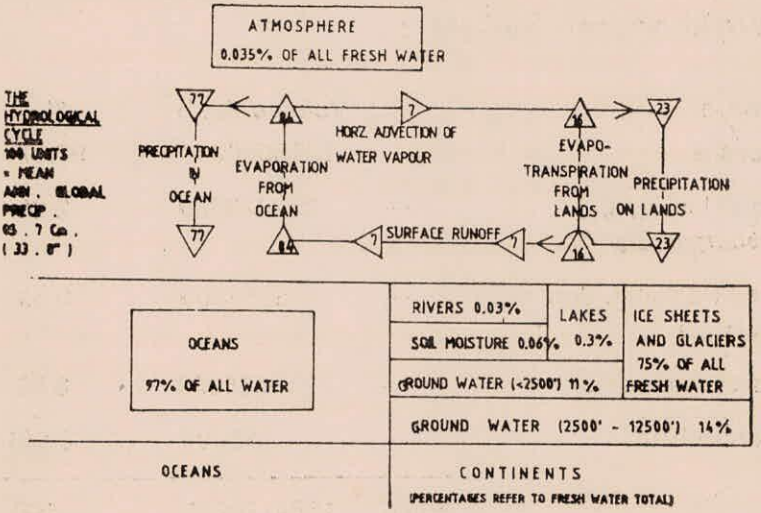
Fresh water as a percent of its total :

Polar Ice Caps, Ice bergs, glaciers	77.23%
Ground water to 800 m depth	9 86%
Ground water from 800 m to 4000m depth	12.35%
Soil moisture	0.17%
Lakes (fresh water)	0.35%
Rivers	0 003%
Hydrated earth minerals	0.001%
Plants, animals, humans	0.003%
Atmosphere	0.04%
Sum	100.00%

The total volume of water as a ratio of earth's volume (1.082×10^{12} km^3) is about 1 : 7772 or 0.00129.

FLOW CHART OF HYDROLOGIC CYCLE

* DATA BASED



Water Balance of Continents

(All figs. in mm depth of water per year)

Continent	Precipitation mm	Evaporation mm	Runoff mm
Europe	734	— 415	— 319
Asia	726	— 433	— 293
Africa	686	— 547	— 139
N. America	670	— 383	— 287
S. America	1648	— 1065	— 583
Australia	440	— 393	— 47
Average	834	— 540	— 294
Greenland			— 180
Antarctica			— 250
Average for all continents	760	— 480	— 280

Source : Man's Influence on Hydrologic Cycle Irrigation Drainage Paper, Special Issue, 17, FAO, Rome, 1973

India's Water Wealth

* India has a geographical area of nearly 3.3 M square kms.

* Normal annual rainfall of the country varies from 100 mm in Western Rajasthan to over 11000 mm at Cherapunji.

* The average annual rainfall of the country is of the order of 1170 mm depth which is nearly 4000 km^3.

* The average flow in the river basins of the country has been estimated to be 1880 km^3.

* 90% of the annual runoff in peninsular rivers and over 80% of annual runoff in Himalayan rivers occur during the four monsoon months of June to September.

* Recent estimates confirm that the water resources utilisable through surface structures are about 690 km^3 (about 36% of the total).

* The ground water resource potential in the state and union territories of the country as in 1983-84 was that total utilisable resources are 418.53 km^3/yr with the potential available for future development as 318.60 km^3/yr.

* The ground water resource potential in the river basins of India for the year 1983-84 indicate that total utilisable resources are of the order of 418.54 km^3/yr with the potential available for future development as 318.60 km^3/yr.

* The recent estimates indicate that the utilisable ground water is about 450 km^3.

* The study of basin wise annual utilisable water resources indicates that total utilisable flow in all the basins of the country is 690.00 km^3/yr excluding ground water. The total utilisable flow in all the basins of the country is 1110 Km^3.

* The total state-wise/basin-wise live storage capacity in the country is 222.072 km^3.

COMPONENTS OF HYDROLOGIC CYCLE

* Precipitation :

It refers to all forms of water derived from atmospheric vapour and deposited on earth's surface. Precipitation occurs due to condensation of atmospheric water vapour. The different forms of precipitation are rain, hail, mist and snow.

* Interception :

The rain that falls on the vegetative cover is partly retained by vegetation and the balance goes to the ground. The portion of the rainfall that is retained by vegetation is referred to as interception.

* Infiltration :

A part of the precipitation reaching the land surface enters the soil. The process by which water enters surface strata of the soil and moves downward is known as infiltration.

* Runoff :

The portion of precipitation that makes its way towards streams, lakes and oceans as surface or subsurface flow is known as runoff.

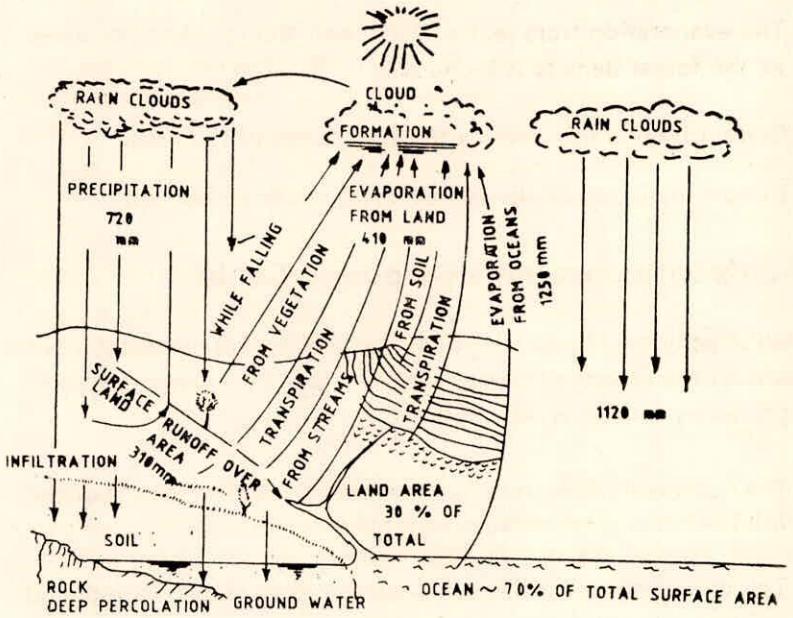
* Evaporation :

The conversion of water in the liquid form to vapour and transportation in this form to atmosphere is known as evaporation. In the hydrologic cycle evaporation takes place from water surface, land surface as well as from intercepted water.

* Transpiration :

It is the process by which water in the soil is transferred to the atmosphere by plants as water vapour.

* DATA BASED:



* Ground Water :

The water stored in the confined or unconfined soil aquifers is known as ground water.

Forest Influence on Hydrologic Cycle

As reported by various studies in the country and abroad forest influences hydrologic cycle in a number of ways :

* Forest cover intercepts more water and thus increases waterloss.

* The presence of good leaf litter cover of forest results in higher infiltration rate.

* Forest reduces evaporation from land surface as they provide shade to the soil surface.

* The evaporation from leaf surface and transpiration increases as the forest density is increased.

* Certain forests may reduce the watertable of the area.

* Runoff increases as density of forest cover is reduced.

Man's Influence on Hydrologic Cycle

Man's activities have a pronounced effect on hydrologic cycle. Some of the effects of human activity on hydrologic cycle as reported by several researchers are :

* The deforestation results in reduced interception, reduced infiltration and an increased runoff and soil loss.

* The urbanisation and industrialization also result in reduced infiltration and increased runoff. Besides this, quality of water is also sometimes deteriorated.

* The faulty agriculture practices may also result in less infiltration, more evaporation and greater flood hazards.

* The storage structures for the conservation of water may result in higher evaporation of fresh water stored.

Industrialisation—Hydrologic Cycle

* The effects of industrialisation have many features in common with those of urbanisation even when the industrial plant is located in the open country side.

* The disposal of industrial waste has a marked effect on the quality of water in the various phases of cycle.

Major River Basins of the Country

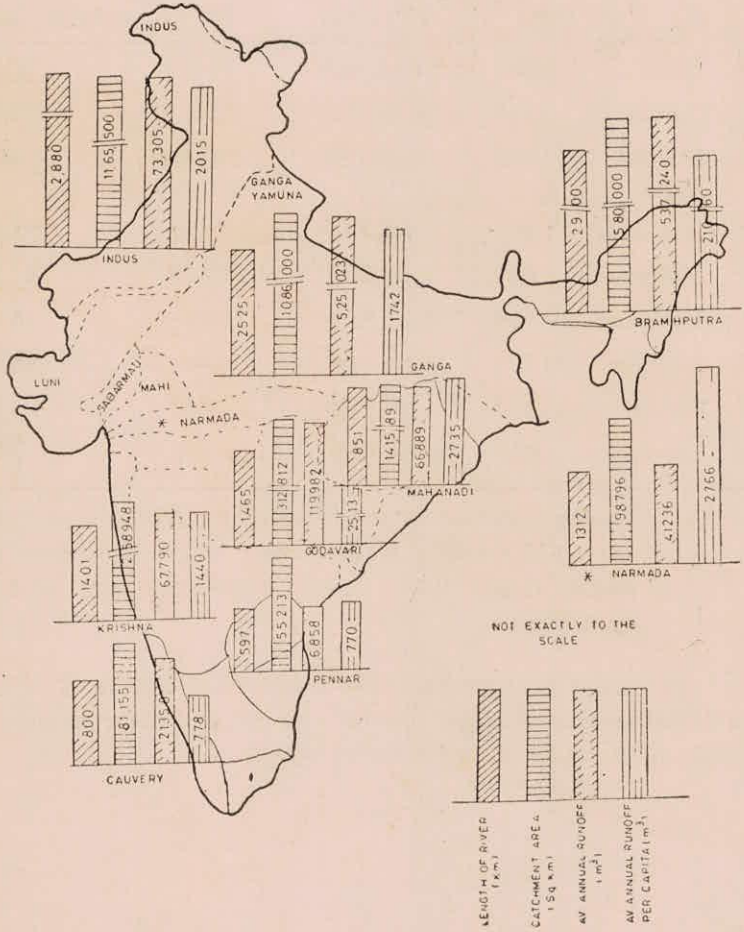
Sl No	River Basin	Length of river (km)	Catchment area (Sq km)	Av. Annual run-off (m^3)	Av. Annual run-off/ capita (m^3)
1.	Indus	2880	11,65,500	73305	2015
2.	Ganga	2525	10,86,000	525023	1742
3.	Brahma-putra	2900	5,80,000	537240	21060
4.	Narmada	1312	98,796	41273	2766
5.	Mahanadi	851	1,41,589	66879	2735
6.	Godavari	1465	3,12,812	118982	2513
7.	Krishna	1401	2,58,948	67790	1440
8.	Pennar	597	55,213	6858	770
9.	Cauvery	800	81,155	21358	778

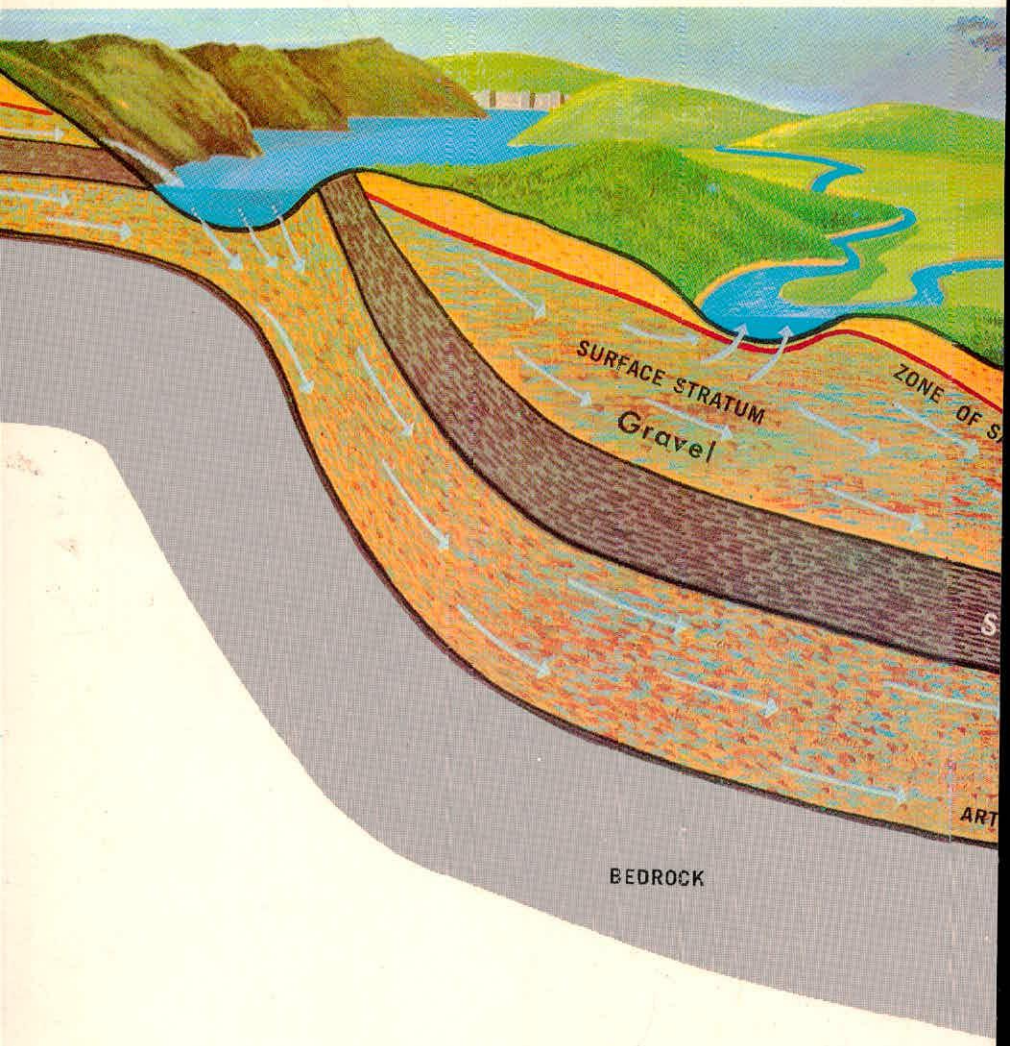
Source : Theme paper on 'Water for Future' Water Resources Day 1990, CWC, New Delhi, "Water Resources of India" CWC, New Delhi. Publication No. 30/88, April 1988.

The major river basins of India showing lengths of rivers, catchment areas, average annual run-off and average annual runoff/capita are given in following figure.

Note : The information/statistics presented in the brochure have been extracted from published literature and all authors are hereby acknowledged.

MAJOR RIVER BASINS OF INDIA




SURFACE STRATUM
Gravel
ZONE OF
S
ART
BEDROCK