Water Supply Engineering

Chapter 2

Sources Of Water

Lecture 2 (Week 2)

Sources of water and its Classification, Numerical on capacity determination of impounded reservoir, Ground sources, Confined and unconfined aquifers, Springs, Wells, Infiltration galleries and wells, Selection of water sources

Lecturer: Asst. Prof. Sunil Rakhal

Learning Objectives

- Understanding the Classification of Water Sources
- Exploring Surface Water Sources and Understanding Groundwater Sources
- Selection Criteria for Water Sources
- Assess the quality, quantity, reliability, and sustainability of water sources.
- Understand different considerations in water source selection.

2. Sources of Water

Water is one of the most essential natural resources, supporting life and ecosystems on Earth. It is found in various natural sources, both above and below the Earth's surface. The primary sources of water include:

- **Surface Water**
- **Groundwater**
- **Rainwater**
- **Glaciers and Ice Caps**
- **Desalinated Water**

Hydrological cycle

The total water on the earth, excluding deep ground water is in constant circulation from earth to atmosphere and back to earth and oceans.

This cycle of water among earth, ocean & atmospheric system is known as hydrological cycle.

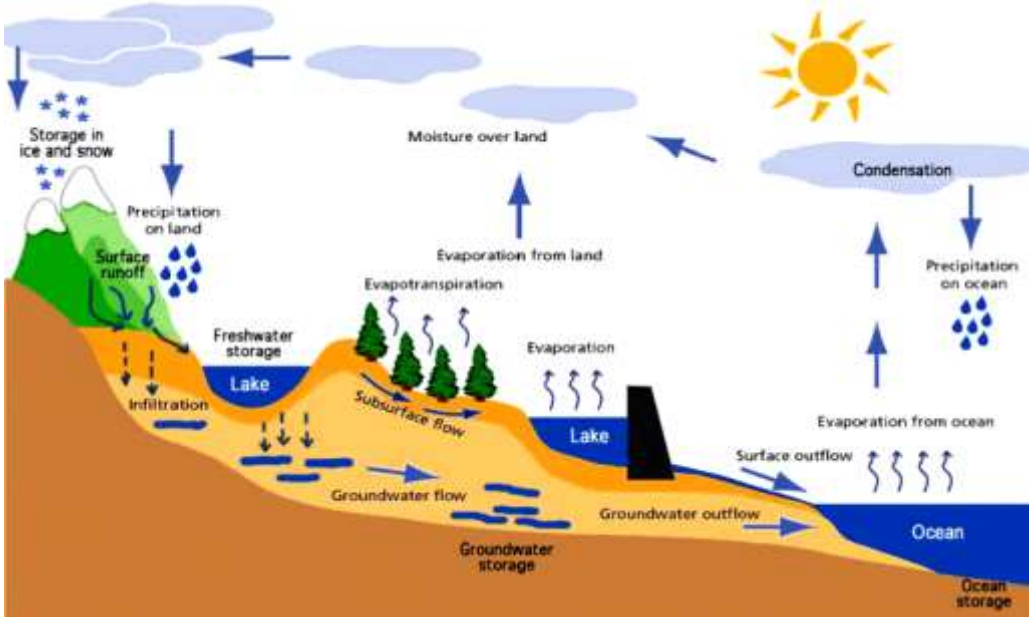


Figure 1: Hydrological Cycle (source: (Solanki, n.d.)

The phases in the cycle are:

- Evaporation
- Transport
- Condensation
- Precipitation
- Groundwater
- Run-off

a. Evaporation and Transpiration

Water is moved from the surface to the atmosphere through evaporation,the transformation of water from liquid to vapour. The sun provides the heat energy to evaporate water off the earth's surface. Oceans and rivers, lakes, and land release a steady stream of water vapour into the air and plants release water into the air (transpiration).

b. Transport

Transport is the term applied to the movement of water in the air, from over the oceans to over the continents. Part of the earth's transport of moisture is in the form of clouds, which are tiny water droplets and/or ice crystals.

The clouds are moved from location to location by the jet stream or surface mechanisms such as land and sea breezes or other processes. The typical cloud, 1 km thick, has only as much water in it as will form a millimetre of rain, while the total amount of water in the air is 10-50 times larger.

c. Condensation

The water vapor carried is eventually condensed and creates small droplets in clouds.

d. Precipitation

The main process by which water is transported from the atmosphere to the Earth's surface is precipitation.

When the clouds reach the cold air over land, rainfall, sleet or snow is induced and water is deposited on land (or sea). A portion of atmospheric precipitation evaporates.

e. Groundwater

A portion of the precipitation permeates the soil, and it is the major source for the formation of the other bodies of water that are found on the earth, including rivers, lakes, groundwater, and glaciers.

Some of the groundwater gets trapped between rock or clay layers, a process known as groundwater. Infiltrated water moves downward through the soil until it reaches impermeable rock, where it starts flowing sideways. Areas where this sideways flow of water takes place are termed 'aquifers.'

Groundwater then finds its way back to the surface via these aquifers, which discharge.

into rivers, lakes and oceans. Under extreme conditions, groundwater can even move upwards in artesian wells.

Groundwater movement is considerably slower than run-off with speeds typically expressed in centimetres per day, metres per year or even centimetres per year.

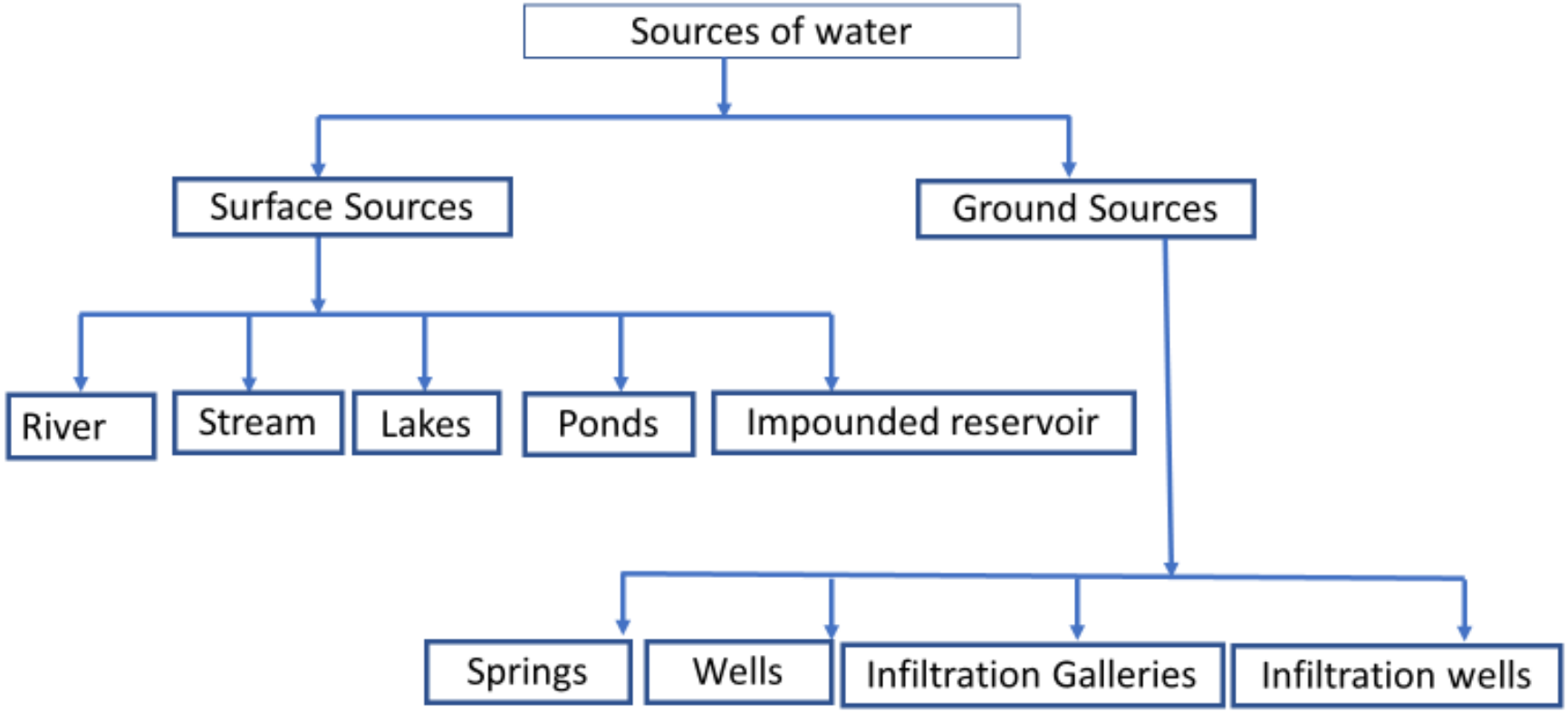
f. **Run-off**

Most water returned to land slopes downward as run-off. Some of It percolates and recharges groundwater, and the surplus, as river flow, makes its way back to the oceans, where it is again evaporated. As there is an addition or subtraction of amounts of groundwater, the water table goes up or down respectively.

When the whole land surface becomes saturated with water, flooding occurs as all the surplus rainwater remains on the surface.

Different surfaces hold different amounts of water and absorb it at different speeds. With reducing permeability of a surface, increasing amounts of water will be held on the surface, and there are higher likelihoods of flooding. Flooding is extremely common in winter and early spring due to the fact that frozen soil is completely non permeable, and the majority of the meltwater and rainwater is run-off. (Applied Hydrology, (1988))

2.1 Classification of Sources of Water



2.2 Surface sources

Surface sources of water are bodies of water that are found on the Earth's surface and are directly accessible for use. These sources are replenished by precipitation, runoff, and groundwater seepage. The main surface water sources include:

Rivers and Streams

Lakes and Ponds

Reservoirs

2.2.1 River

- ❖A River is a natural channel that carries surface runoff from high gradient path to low gradient path.
- ❖It starts from the run-off and end to the ocean, reservoir or desert.
- ❖It is formed by the combination of the streams and springs.
- ❖It receives runoff from area or drainage basin.
- ❖At higher altitude better quality of water is found and at lower altitude poor quality of water is found.

Types of River

1) Perennial river

Water is available throughout the year in river

2) Non-perennial river

Water is available at seasonal period in river

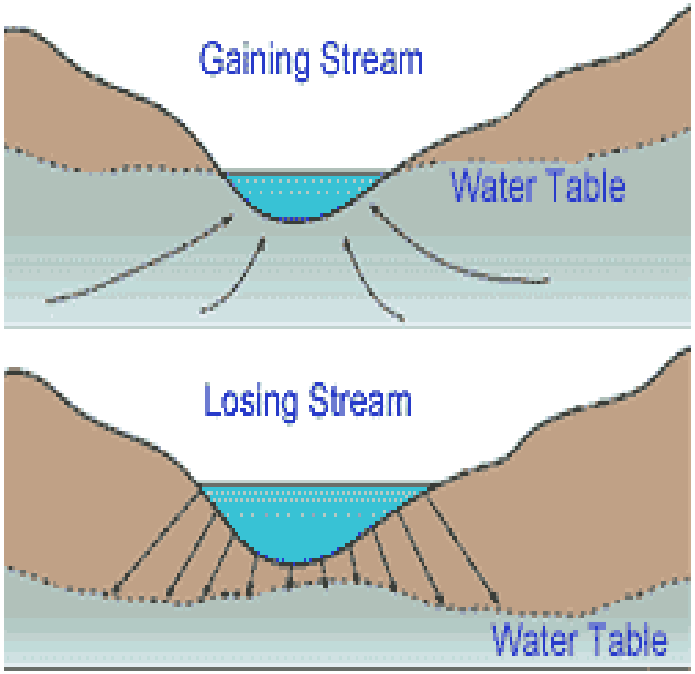
Comparison on Perennial River and Non-perennial river

Feature	**Perennial River**	**Non-Perennial River**
Water Availability	Available throughout the year	Available only during certain seasons
Water Source	Glaciers, springs, regular rainfall	Seasonal rainfall or melting snow
Flow Consistency	Continuous and steady	Discontinuous, dries up in dry season
Examples	Ganga, Amazon, Nile	Koshi, Godavari, Todd and local stream
Main Uses	Drinking, irrigation, power generation	Seasonal irrigation, temporary water supply

2.2.2 Stream

- Steams are Natural drainage channel found in mountainous region .
- It starts from runoff and end into the river.
- Discharge is more in rainy season &either zero or less in dry season.
- Quality of water is good except at first runoff.
- Streams may be perennial (snow fed) or non-perennial (fed from surface runoff).
- Quantity of water in stream (small catchment area) <Quantity of water in river.

- **A gaining(effluent) stream** is one in which the channel bottom is lower than the level of the surrounding groundwater table. Through the course of the summer, water moves from the ground into the channel.
- **A losing stream** is one which is above the groundwater table, and water moves from the channel into the surrounding ground. (www.Quora.com, n.d.)



2.2.3 Lakes

- A large natural depression or hollow formed in earth surface ,which is filled with water is called a lake.
- It collects water from spring, rain, stream, etc.
- The quality of water mainly depends upon the characteristics of the catchments.
- Lake situated at high altitudes have very good quality water. Example: Rara Lake
- Lake situated at low land areas would be contaminated with impurities.
- The quantity of water depends upon the basin capacity, catchment area, annual rain falls, porosity of ground, etc.

2.2.4 Ponds

- A pond is naturally depressed a man made body of standing water smaller than lake .
- They are formed by digging of ground & are filled up by water.

- Quantity of water in ponds < quantity of water in lakes .
- Quality of pond water is very poor so not suitable for drinking purpose.
- It is constructed for swimming ,fish farming and irrigation purpose.

2.2.5 Impounded Reservoir

- These are the basin built in the valley of stream or river performs the function of stream flow regulation.
- They are constructed when river lacks sufficient release of water to meet the summer demand.
- The water quality in reservoir is based on the quality of river water.

Primary purpose of impounded reservoir :

1) To collect and conserve water for useful purposes.

2) To retard flood.

Points Considered During Site Selection Of Reservoir

- Site should be located higher elevation than that of treatment plant and distribution area.
- It must also have adequate water supply on site.
- The catchment area must be free from industries or sewage discharge.
- Site topography should be good & possess plenty of construction material.
- Significant infrastructure must not be underwater while building.
- The water source should be clear of undue contamination and pollution.
- Location should be distant from active fault lines to prevent earthquake hazards.
- Landslide zones must be avoided.

Conclusion:

- **Surface water sources** (rivers, lakes, ponds) are easily accessible but prone to pollution.
- **Groundwater sources** (springs, wells) are naturally filtered and provide a reliable source of water.

Both types are essential for daily use, agriculture, industry, and ecosystem balance

The surface waters are more susceptible to the contamination of agricultural runoff, industrial discharges and urban pollutants, which leads to the decrease in water quality in many regions (Loucks and Van Beek, 2017).

2.2.6Numerical on capacity determination of impounded reservoir

Q) The city has average water demand of 6202 million liters per month. Calculate the capacity of impounded reservoir. The flow in the river is shown.

month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Inflow (m^3/s)	2.97	1.99	1.00	.00	.51	1.0	2.00	3.0	4.0	5.0	4.00	2.80

month	inflow	inflow	demand	C. inflow	C. demand	C. surplus	C. defict
	m^3/s	(ML)	(ML)	(ML)	(ML)	(ML)	(ML)
jan	2.97	7955.0	6202.0	7955.0	6202.0	1753.0	
feb	1.99	4814.0	6202.0	12769.0	12404.0	365.0	
mar	1.00	2678.0	6202.0	15447.0	18606.0		3159.0
apr	0.00	0.0	6202.0	15447.0	24808.0		9361.0
may	0.51	1366.0	6202.0	16813.0	31010.0		14197.0
jun	1.00	2592.0	6202.0	19405.0	37212.0		17807.0
jul	2.00	5357.0	6202.0	24762.0	43414.0		18652.0
aug	3.00	8035.0	6202.0	32797.0	49616.0		16819.0
sept	4.00	10368.0	6202.0	43165.0	55818.0		12653.0
oct	5.00	13392.0	6202.0	56557.0	62020.0		5463.0
nov	4.00	10368.0	6202.0	66925.0	68222.0		1297.0
dec	2.80	7500.0	6202.0	74425.0	74424.0	1.0	

Capacity of impounded reservoir=maximum cumulative surplus + maximum cumulative deficit – total inflow + total demand

=1753.0+18652.0-74425.0+74424.0

=20404.0ML

2.3 Ground sources

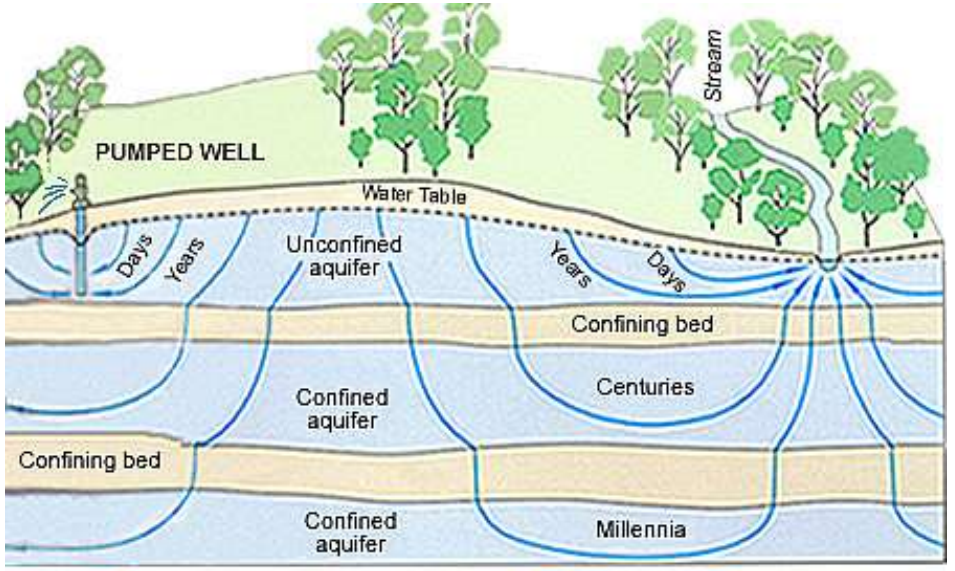
- Resources that occur beneath the earth surface.
- The process by which surface water infiltrates into groundwater, later descending deep into the ground and stored as groundwater, is referred to as groundwater recharge.
- Recharge can be natural or artificial.
- Natural recharge include precipitation water flowing in stream and river lake and other natural water bodies.
- Artificial recharge includes excess irrigation, canal seepage leakage from tanks or reservoirs.

2.3.1Confined and unconfined aquifers

1. **Confined aquifer**

- In such aquifer groundwater is confined under the pressure greater than atmospheric pressure by overlying relatively impermeable strata.

- Confined aquifers have a layer of impenetrable rock or clay above them.
- Also known as artesian aquifer.
- supplying water to confined aquifer by recharge area.
- In a well penetrating such aquifer the water will rise to the level of artesian head, or up to the piezometric surface.



Courtesy of U.S.Geological Survey

2. Unconfined aquifers

- Topmost water bearing stratum
- No confined impermeable over burden lying over it.
- Also known as non-artesian aquifer or water table aquifer.
- unconfined aquifers lie below a permeable layer of soil

- Water table is not stationary surface it may rise or fall.

2.3.2 Springs

A natural flow of ground water as current or stream of flowing water.

Gravity spring:

a.Depression springs: formed due to overflowing of the water table, where the ground surface intersects water table.

b. Contact or Surface Springs:

Created by a permeable water bearing formation over lying a less permeable or impermeable formation that intersects the ground surface.

c. Artesian springs:

- Formation of springs when ground water rises through a fissure in the upper impervious stratum.
- Generally, have constant flow, because water comes out by a constant pressure**.**

2.3.3 Water Well and Their Types

- A well is a hole or shaft, with or without a supporting casing, extending from the ground surface to or into water-bearing earth materials.
- Permit extraction of groundwater.
- If the aquifer is artesian, pumping requirements are less or prohibited if sufficient flow is at the ground surface.

- Two types :

1. Open well or dug well
2. Tube well

1) Open well or dug well

- Have comparatively large diameter , low yield and not very deep.
- Diameter vary from 1 to 10m. And Depth may vary from 2 to 20m.
- Usually constructed by digging so known as dug well.
- Wall may be of brick masonry concrete masonry or precast rings.
- Thickness varies from 0.5 to 0.75m depending upon depth of well. (Kansakar, 2015)

Open well or dug well classification

Shallow open well	**Deep open well**
➢ Rest on top water bearing strata.	Rest on impervious strata.
➢ Draw water from surrounding permeable material.	Draw water from permeable formation lying below impervious strata through bore hole.
➢ Less yield.	More yield.
➢ Quantity of water available is uncertain due to fluctuation of water.	Quantity of water available is more uniform
➢ Use for an individual household.	Use for small community
➢ Open to risk of contamination.	Free from suspended particle and bacterial contamination.
➢ Dissolved impurities are less.	Dissolved impurities are more.

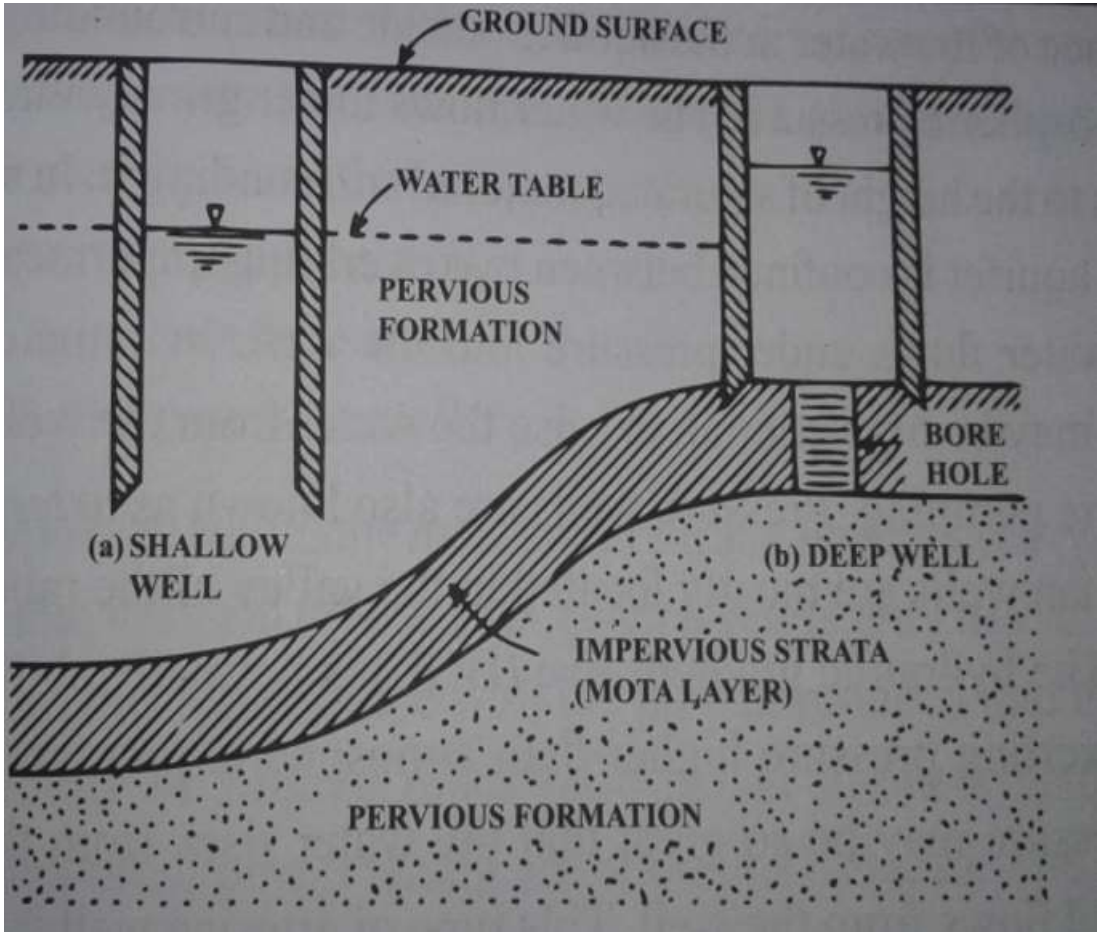


Figure 2: Shallow and Deep Open well (Source: (Kansakar, 2015)

2.3.4 Infiltration Galleries and wells

Infiltration Galleries

- Generally horizontal or nearly horizontal tunnel ,usually rectangular in cross section and having permeable boundaries so that ground water can infiltrate into it .
- Generally located near a perennial recharge source such as bank or under bed of river and 3 to 10 meters below the ground.
- Constructed by the cut and covers method
- Made up with dry brick masonry wall or porous concrete blocks with weep holes and R.C.C slab roof or an arch roof.
- No. of openings provided to permit entry of water into gallery.
- Openings covered with graded to prevent entry of fine sand particles into the gallery.
- Manholes provided on roof for purposes of cleaning and inspection.

Infiltration Wells

- Shallow wells constructed in series along the banks and sometimes under the bed of rivers to collect water seeping through the banks of river.
- Constructed of brick masonry with open joints or concrete rings.
- The water infiltrates through the walls and bottom of these wells and has to pass sand bed and gets purified to some extent.
- The water collected in the infiltration wells flows by gravity into the jack well through porous pipes.
- Quantity of water is small here in comparison of infiltration gallery.

- Water should be analyzed to determine its suitability for drinking purpose.

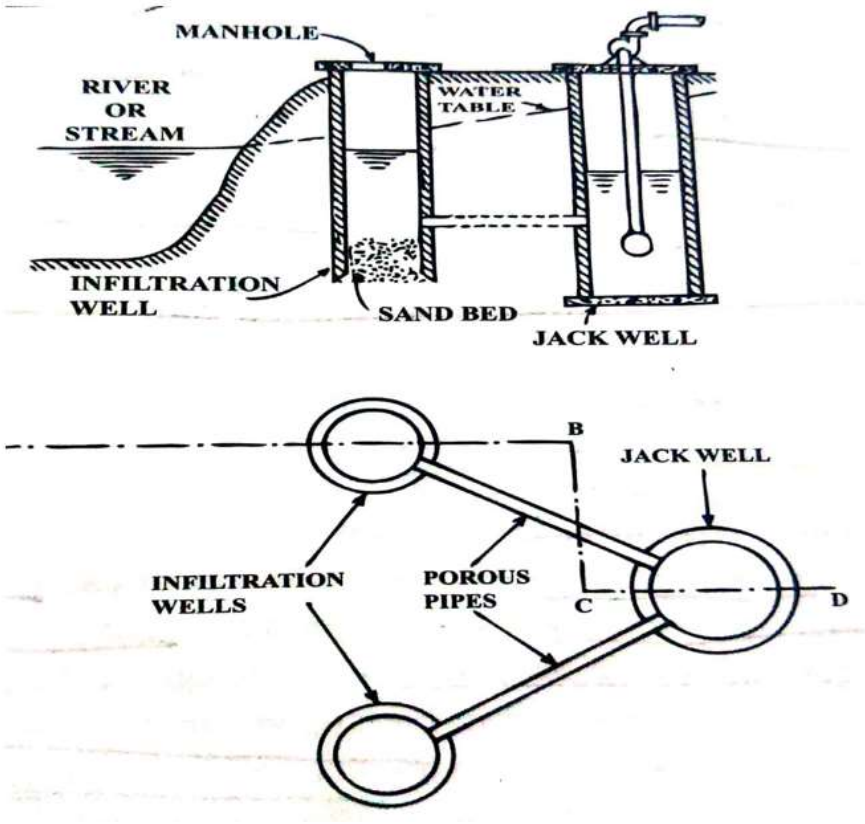


Figure 3: Infiltration Well (Source: (Secretariat, 2014))

2.4 Selection of water sources

Choosing a good water source is crucial in offering a sustainable and reliable water supply for domestic, agricultural, and industrial use. The choice is determined by various factors such as quality, quantity, reliability, sustainability, environmental impact, and cost.

1. Factors Affecting the Choice of a Water Source

a) Water Quality

- The selected water source should be free from harmful contaminants like bacteria, chemicals, and heavy metals.
- Water should be in accordance with drinking water standards set by organizations such as WHO or local health authorities.
- Treatment requirements should be minimal in order to reduce purification costs.

b) Water Quantity

- The water source should be able to meet water demands for daily and seasonal usage.
- Flow rate and storage capacity should be established to prevent shortages.
- The source should be able to provide water in the future due to increased population or industry expansion.

c) Reliability of Supply

- The water source should be perennial with negligible seasonal fluctuations.
- Perennial sources (rivers, lakes, groundwater) are superior to non-perennial ones.
- Backup water sources need to be considered for drought or emergencies.

d) Sustainability

- Water should not be excessively extracted to prevent depleting natural resources.
- Water sources should be planned based on which they can become available in the long term for upcoming generations.
- Conservation techniques like rainwater harvesting and drip irrigation can turn the system more sustainable.

e) Nearness of the Supply Area

- The end users and the water source must be close to one another to save on transportation costs.
- Neighboring sources help reduce pumping and infrastructure costs.
- In the event that a distant source is used, adequate distribution systems (canals, pipelines) must be installed.

f) Environmental Considerations

- Deforestation, pollution, and land degradation should be considered while selecting the water source.
- Extraction of water should not harm aquatic life or disrupt natural habitats.
- Environmentally friendly practices must be employed to minimize environmental impact.

g) Economic Viability

- Water extraction, treatment, and distribution cost must be low.

- Costs of pipeline maintenance, pumps, and treatment facilities must be taken into account.
- Alternative methods like rainwater harvesting and desalination must be considered as cost-effective.

Conclusion

- The selection of an origin of water is founded on quality, quantity, dependability, sustainability, environmental impact, and affordability.
- Permanent sources such as rivers, lakes, and groundwater are more desirable than seasonal ones.
- Means of conserving water should be included to enhance sustainability.
- Economic and environmental factors need to be balanced for long-term water security.

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Thank You!!!