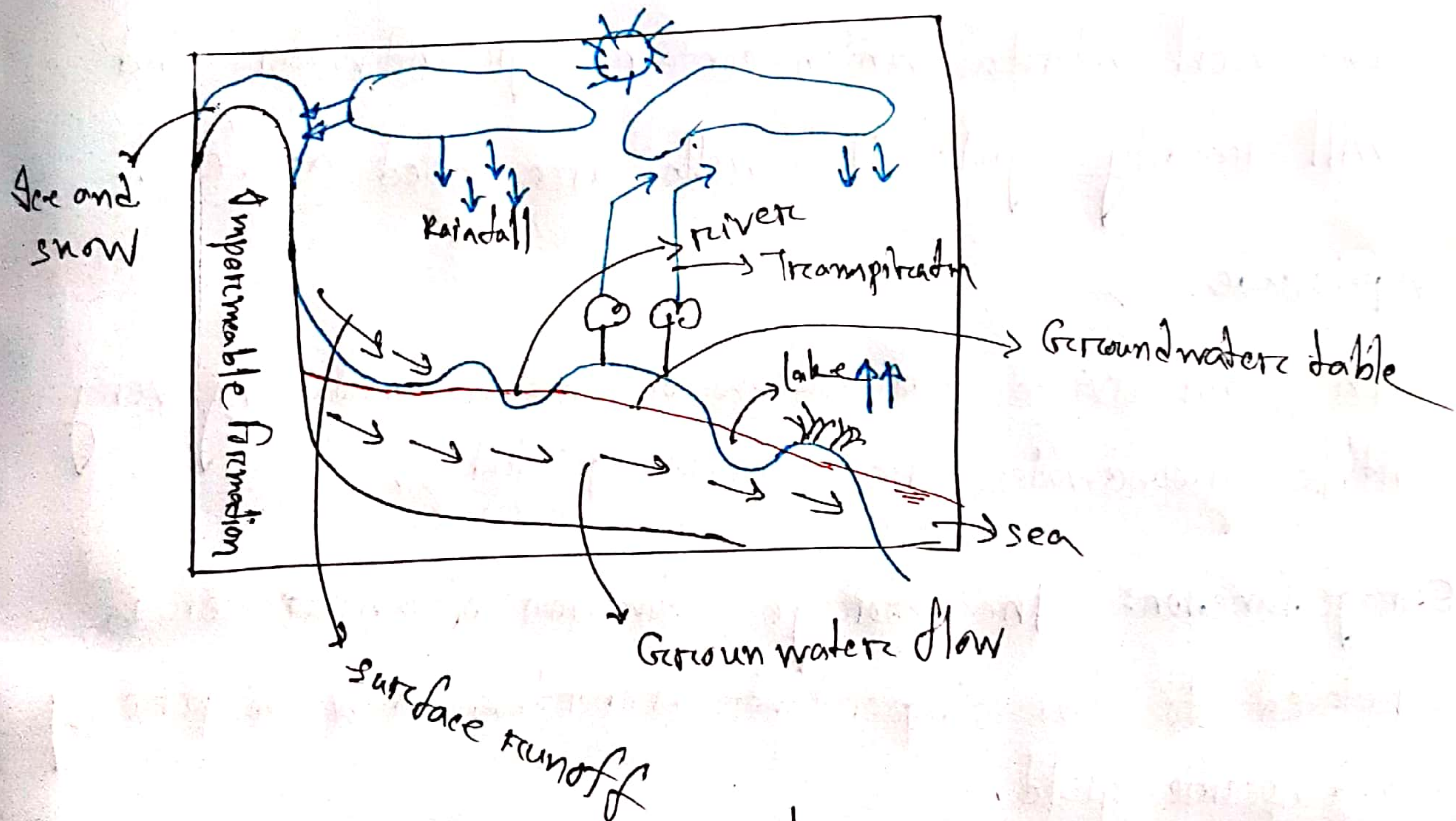
SOURCES of WATER

Hydrological Cycle →

Hydrological cycle refers to the circulation of water in its liquid, vapor or solid states from oceans to air, air to land, over land surfaces or underground and back to the oceans.



→ Hydrological cycle

Groundwater aquifer →

The water available in the saturation zone (pores completely filled with water) is known as ground water. Groundwater is available in large quantities in shallow depths and constitutes the most important source of fresh water supply.

Aquifers →

The soil strata which contain groundwater and will readily yield it to wells are called aquifer.

Aquicludes →

The impervious formations or strata containing very little groundwater are termed aquicludes.

torage function: The storage function of an aquifer is related to two important properties know as porosity and specific yield.

$$P = P_s + P_r$$

- P_r → specific retention
- P_s → specific yield
- P → porosity

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Conduit function: The property of water realted to the conduit function is known as permeability. Permeability is the measure of the capacity of an aquifer to transmit water.

Darcy's law

$V = ki$

- i → hydraulic gradient
- k → co-efficient of permeability
- V → velocity of flow

Co-efficient of permeability depends ON:

- particle size of the aquifer materials

$K = CD_{10}^2$

- C → C is constant
- D_{10} → effective size of the particles of the aquifer

[particle size corresponding to 10% finer → D_{10}]

$Q = AV$

$$\boxed{Q = KAi}$$

Co-efficient of permeability: Is defined as the quantity of water that will flow through a unit cross-sectional area of aquifer in unit time under a hydraulic gradient of unity at a specific temperature.

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Unconfined aquifer: A water table aquifer is one, which is not confined by an upper impermeable layer. Hence, it is also called unconfined aquifer.

Artesian aquifer: An artesian aquifer is one in which the water ~~table aquifer~~ is confined under a pressure greater than the atmospheric pressure by an overlying, relatively impermeable layer.

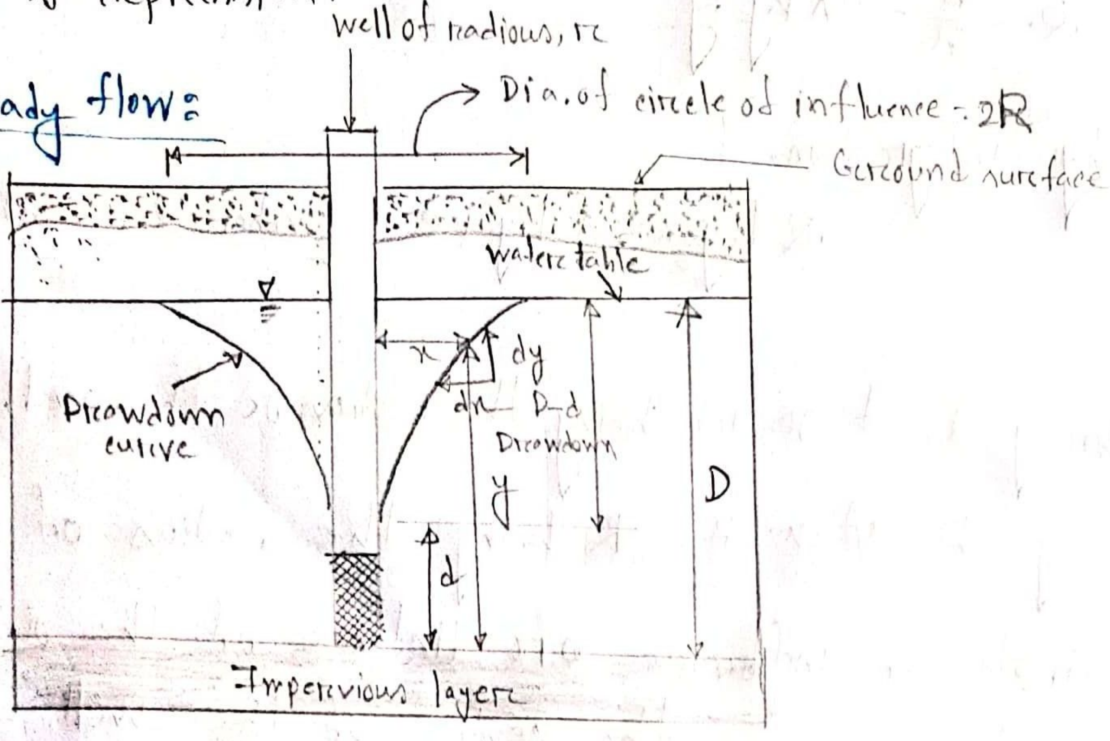
Static water level: When the well is at rest, the water level in the well is called the static water level.

Pumping water level: The lowest water level in the well is known as the pumping water level

Draw down: The difference between the static water level and surface of the cone of depression is called the draw down;

Cone of Depression: The increasing velocity towards the well is therefore accompanied by an increasing hydraulic gradient. The water surface or the piezometric surface develops a steeper slope towards the well and takes the form of an inverted cone is the cone of depression.

Unconfined steady flow:



Hydraulics of flow in a well through unconfined aquifer

It is assumed that the flow of ground water is horizontal and radial towards the centre of the well. The slope of the cone of depression and area of flow at a distance x from the centre of the well is respectively given by

$$i = \frac{dy}{dx} \quad \text{and} \quad A = 2\pi xy$$

~~subsitite~~ Substituting these values in ~~the~~ equation $Q = KAi$

$$Q = K\, 2\pi xy \frac{dy}{dx}$$

$$Q = 2K\pi xy \frac{dy}{dx}$$

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$\Rightarrow Q \cdot \frac{dx}{x} = 2\pi k y \, dy$

by integration,

$Q \log_e x = \pi k y^2 + c$ [where c is constant]

for $y = d$, at $x = r$, being the radius of the well and $y = D$ at $x = R$, R being the radius of the circle of influence or distance of the outer boundary from the centre of the well,

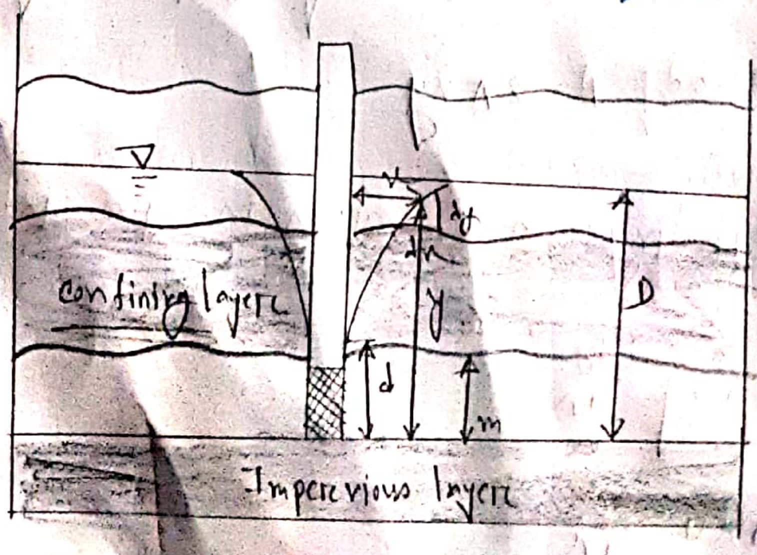
$$Q = \frac{\pi k (D^2 - d^2)}{\log_e \left(\frac{R}{r}\right)}$$

→ Quantity of flow per unit time / Well discharge (m^3/d)

k → co-efficient of permeability (m/d)

Confined steady flow:

$D - d$ → draw down



$i = \frac{dy}{dx}$ $A = 2\pi x m$

↳ thikness of the confined aquifer

$Q = 2K\pi x m \left(\frac{dy}{dx}\right)$

$\Rightarrow Q \frac{dx}{x} = 2k\pi m \, dy$

$\Rightarrow$ by integration $Q \log_e x = 2k\pi m y + C$

between the limits $x = r$ for $y = d$ and $x = R$ for $y = D$

$$Q = \frac{2\pi k m (D-d)}{\log_e (R/r)}$$

→ Q: Quantity of flow per unit time

→ D: Depth of the aquifer

→ d: static head

→ R: Radious of circle of influence,

→ r: radious of well

In confined aquifer $Q \propto (D-d)$

Specific capacity of tube well = rate of flow per unit draw down

$$= \frac{Q}{D-d}$$

$$= \frac{\frac{\pi k (D^2 - d^2)}{\log_e (R/r)}}{(D-d)}$$

$$\text{Specific capacity of tubewell} = \frac{\pi k (D+d)}{\log_e (R/r)}$$

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Problem in groundwater development

(i) Arsenic in groundwater
(ii) excessive dissolved iron
(iii) Salinity in the coastal areas
(iv) lowering of groundwater level
(v) rock/stony layers in hilly areas.

(i) Arsenic in groundwater →

⇒ According to WHO max. concentration of arsenic in ~~ground~~ drinking water should be 0.01 mg/L

⇒ ~~According to~~ In Bangladesh max. concentration of arsenic in ~~ground~~ drinking water ~~is~~ is considered to be 0.05 mg/L

(ii) Excessive dissolved iron →

⇒ In Bangladesh permissible ~~min~~ limit is 1 mg/L

⇒ In rural water supply, ~~xx~~ upto 5 mg/L is acceptable

Example-11

A 100 mm diameter tubewell is sunk 35 m below static ground water level. The depth of water in the tubewell while pumping is 33 m. The radius of draw down is 30 m and the co-efficient of permeability of the aquifer is 0.5 L/s/m². Calculate the probable discharge of the well.

Soln:

$$Q = \frac{2\pi K (D^2 - d^2)}{\log_e (R/r)}$$

$$= \frac{2\pi \times 0.5 \times (35^2 - 33^2)}{\log_e (30/0.05)}$$

$$Q = 33.375 \text{ lps}$$

Here,

$d_i = 100$ mm $= 0.1$ m

$r = 0.05$ m

$K = 0.5$ lps/m²

$R = 30$ m

$D = 35$ m

$d = 33$ m

Ex-2

A 100 mm diameter tubewell is sunk to withdraw water from a 10 m thick confined aquifer having co-effietent of permeability equal to 0.75 lps/m². The depth of water below the piezometric level is 30 m and it falls 2 m in the tubewell while pumping. Calculate the discharge of the tubewell when the radius of the circle of influence is 30 m.

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Soln:

$$Q = \frac{2\pi k m (D-d)}{\log_e (R/r)}$$

$$= \frac{2\pi \times 0.75 \times 10 \times (30-28)}{\log_e \left(\frac{30}{0.05}\right)}$$

$$= 14.73 \text{ lps}$$

Here,

dia = 100 mm = 0.1 m

r = 0.05 m

D = 30 m

m = 10 m

d = 30 − 2 = 28 m

R = 30 m

k = 0.75 lps/m²

P-51 Ex-3

A 150 mm dia tubewell produce 100 lps with a draw down of 3 m and a circle of influence of 120 m in diameter. The static depth of water in the well is 40 m. calculate the co-efficients of permeability of the aquifer in which the tubewell is sunk.

Soln:

$$Q = \frac{\pi k (D^2 - d^2)}{\log_e (R/r)}$$

$$\Rightarrow 100 = \frac{\pi \times k (40^2 - 37^2)}{\log_e \left(\frac{60}{0.075}\right)}$$

$$\Rightarrow k = \frac{100 \times \log_e \left(\frac{60}{0.075}\right)}{\pi \times (40^2 - 37^2)}$$

$$\therefore k = 0.927 \text{ lps/m}^2$$

Here,

dia = 150 mm

r = 0.075 m

2R = 120 m

R = 60 m

Q = 100 lps

D = 40 m

D − d = 3 m

d = 40 − 3 = 37 m

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Ex-4 | CT-16

A tubewell having dia of 20 cm taps on artesian aquifer of thickness 25 m. If drawdown is 4.5 with radius of zone of influence is 300m and permeability is 40 m3/unit area per day, calculate the yield of tube well in litters per hour. What variation will take place for drawdown if zone of influence is restricted to 200 m for two times of yield?

Solⁿ:

$$Q = \frac{2\pi k m (D-d)}{\log_e (R/r)}$$

$$= \frac{2\pi \times 40 \times 25 \times 4.5}{\log_e (300/0.1)}$$

$= 3531.4806$ m3/day

$$= \frac{3531.4806}{24} \times 1000$$

$= 147145.0361$ L/h

Here,

dia = 20 cm = 0.2 m

r = 0.1 m

m = 25 m

D − d = 4.5 m

R = 300 m

k = 40 m3/unit area per day