SNS COLLEGE OF TECHNOLOGY

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DEPARTMENT OF AGRICULTURAL ENGINEERING

19AGE308

WATERSHED PLANNING AND MANAGEMENT

What Is Artificial Recharge

- Artificial recharge is the process by which the ground water is augmented at a rate much higher than those under natural condition of percolation.

Why Artificial Recharge

- In most low rainfall areas of the country the availability of utilizable surface water is so low that people have to depend largely on ground water for agriculture and domestic use.
- So in order to improve the ground water situation it is necessary to artificially recharge the depleted ground water aquifers.

Identification Of Areas For Recharge

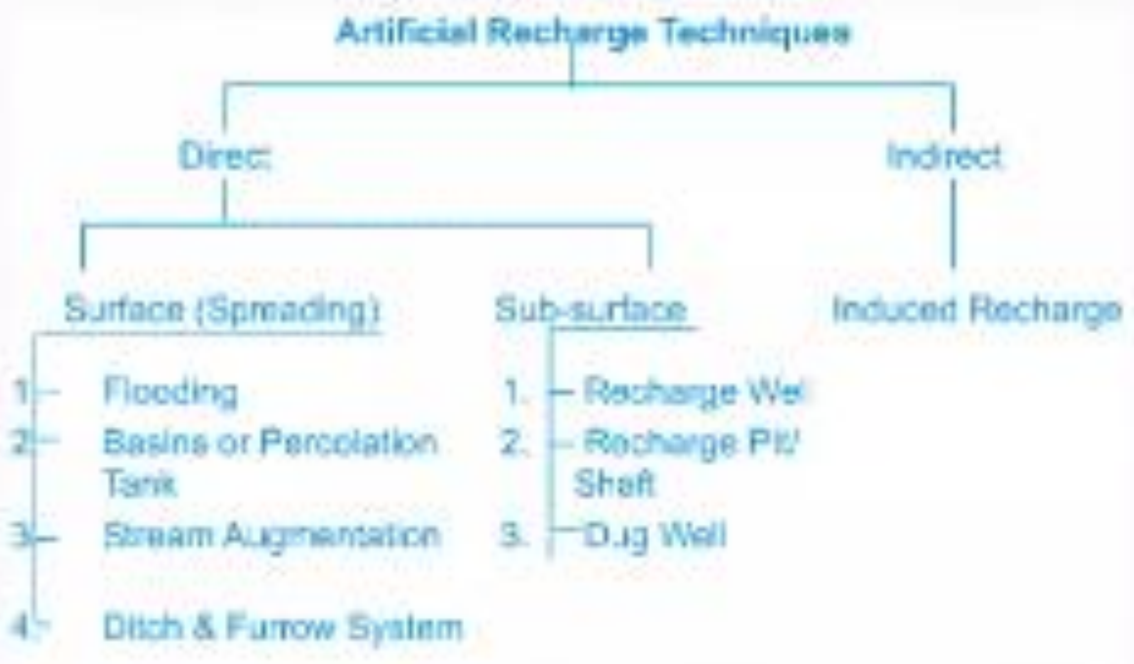
- Where ground water levels are declining due to over-exploitation .
- Where substantial part of the aquifer has already been desaturated i.e. regeneration of water in wells and hand pumps is slow after some water has been drawn .
- Where availability of water from wells and hand pumps is inadequate during the lean months.
- Where ground water quality is poor and there is no alternative source of water.

Advantages Of Artificial Recharge

- 1. To enhance the groundwater yield in depleted the aquifer due to urbanization.
- 2. Conservation and storage of excess surface water for future requirements
- 3. To improve the quality of existing groundwater through dilution.
- 4. To remove bacteriological and other impurities from sewage and waste water by natural filtration, so that water is suitable for re-use

Methods Of Artificial Recharge

- Artificial recharge is the process by which the ground water is augmented at a rate much higher than those under natural condition of replenishment.
- The techniques of artificial recharge can be broadly categorized as follows:

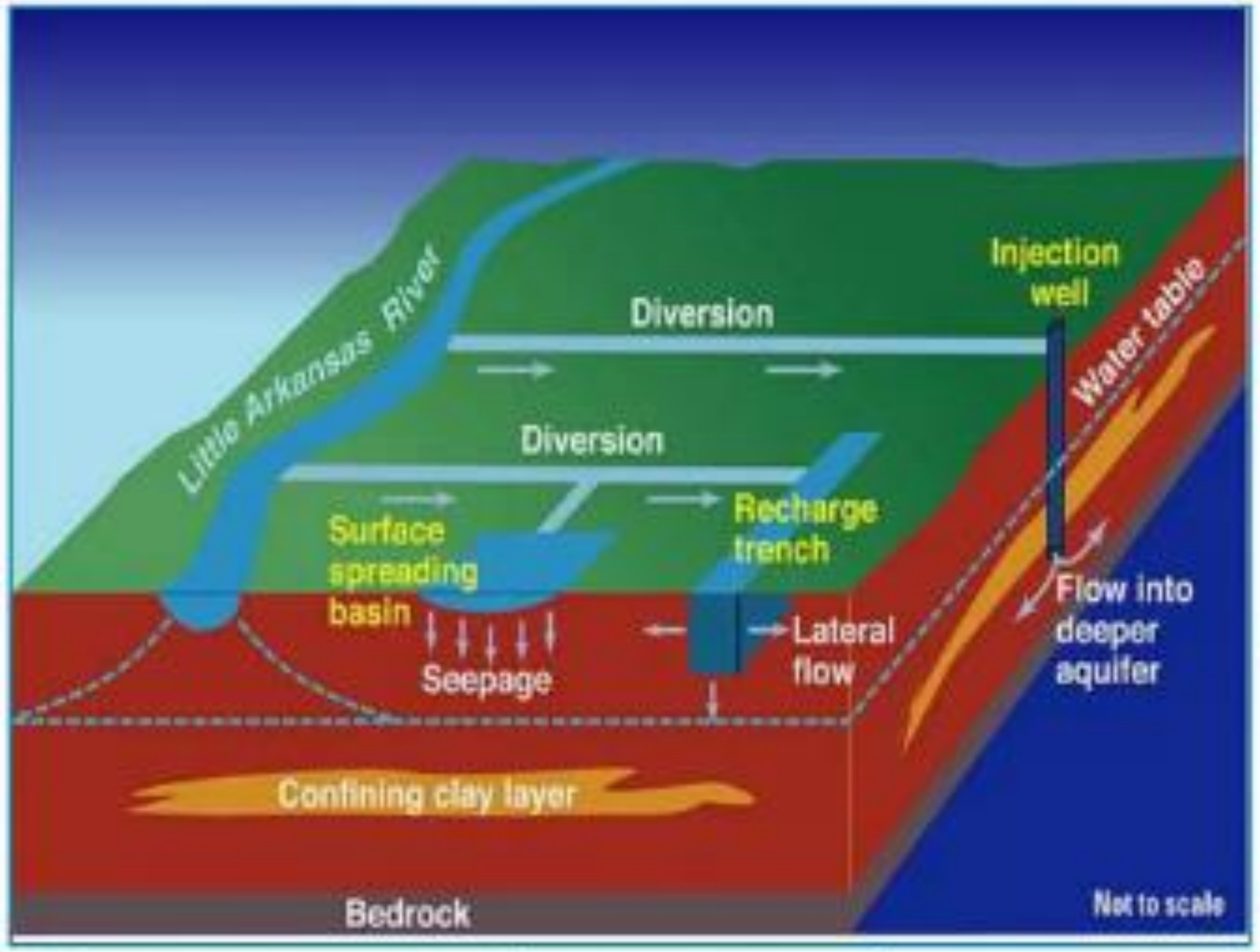


ARTIFICIAL RECHARGE STRUCTURES

A wide spectrum of techniques are being implemented to recharge the ground water reservoir. The artificial recharge structures, which are feasible in varied hydrogeological situation, are:

1. PERCOLATION TANKS
2. CHECK DAM/ NALA BUND
3. GABION STRUCTURE
4. MODIFICATION OF VILLAGE TANKS AS RECHARGE STRUCTURE
5. DUG WELL RECHARGE
6. RECHARGE SHAFTS
7. INJECTION WELL
8. GROUND WATER DAMS OR SUB SURFACE DYKES OR UNDERGROUND BANDHARAS
9. ROOF TOP RAIN WATER HARVESTING

Surface (Spreading) Method



Source: www.indiawaterportal.org

Figure 1 : Surface Spreading Basin

- These methods are suitable where large area of basin is available and aquifers are unconfined without impervious layer above it.
- The rate of infiltration depend on nature of top soil if soil is sandy the infiltration will be higher then those of silty soil.
- The presence of solid suspension in water used for recharge clogs the soil pores leading to reduction in infiltration rate i.e. recharge rate.
- Water quality also affects the rate of infiltration. The various spreading methods are as below:-

2.Basin & Percolation Tanks

Fig. A percolation tank about to get dry towards beginning of summer. Location: Village: Ralegan Siddhi, District: Nagar, Maharashtra State.

Source: www.indiawaterportal.org

Figure 2 : Percolation Tank

- This is the most common method for artificial recharge.
- In this method, water is impounded in series of basins or percolation tank.
- The size of basin may depend upon the topography of area, in flatter area will have large basin.
- This method is applicable in alluvial area as well as hard rock formation.
- The efficiency and feasibility of this method is more in hard rock formation where the rocks are highly fractured and weathered.

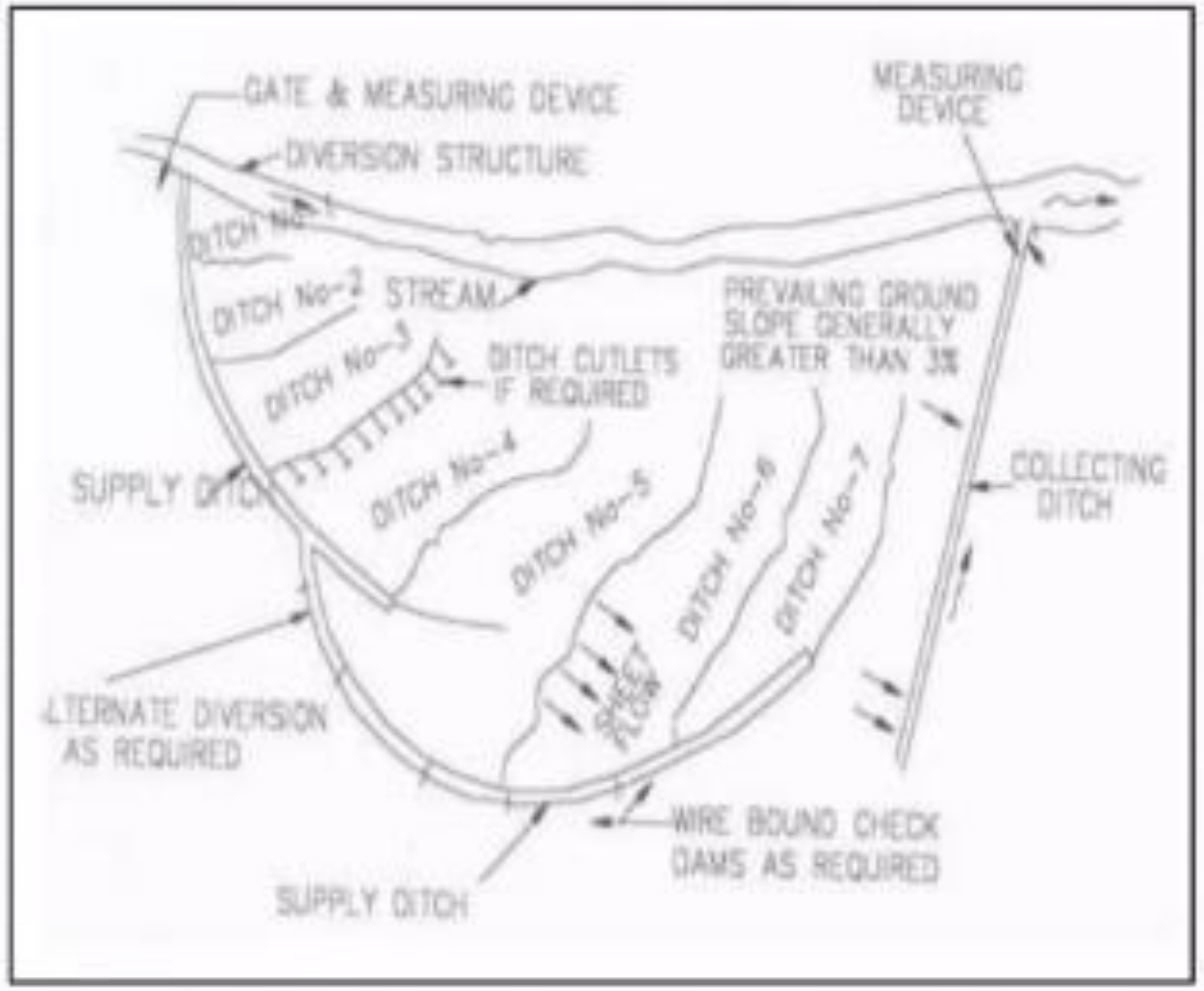
3. Stream Augmentation

Source: www.indiawaterportal.

Figure 3 : Check dam

- Seepage from natural streams or rivers is one of the most important source of recharge of the ground water reservoir.
- When total water supply available in a stream / river exceeds the rate of infiltration, the excess is lost as run off.
- This run off can be arrested through check bunds or widening the steam beds thus larger area is available to spread the river water increasing the infiltration.
- The site selected for check dam should have sufficient thickness of permeable bed or weathered formation to facilitate recharge of stored water within short span of time.
- The water stored in these structures is mostly confined to stream course and height is normally less than 2 m. To harness maximum run off, a series of such check dam may be constructed.

4. Ditch & Furrow System

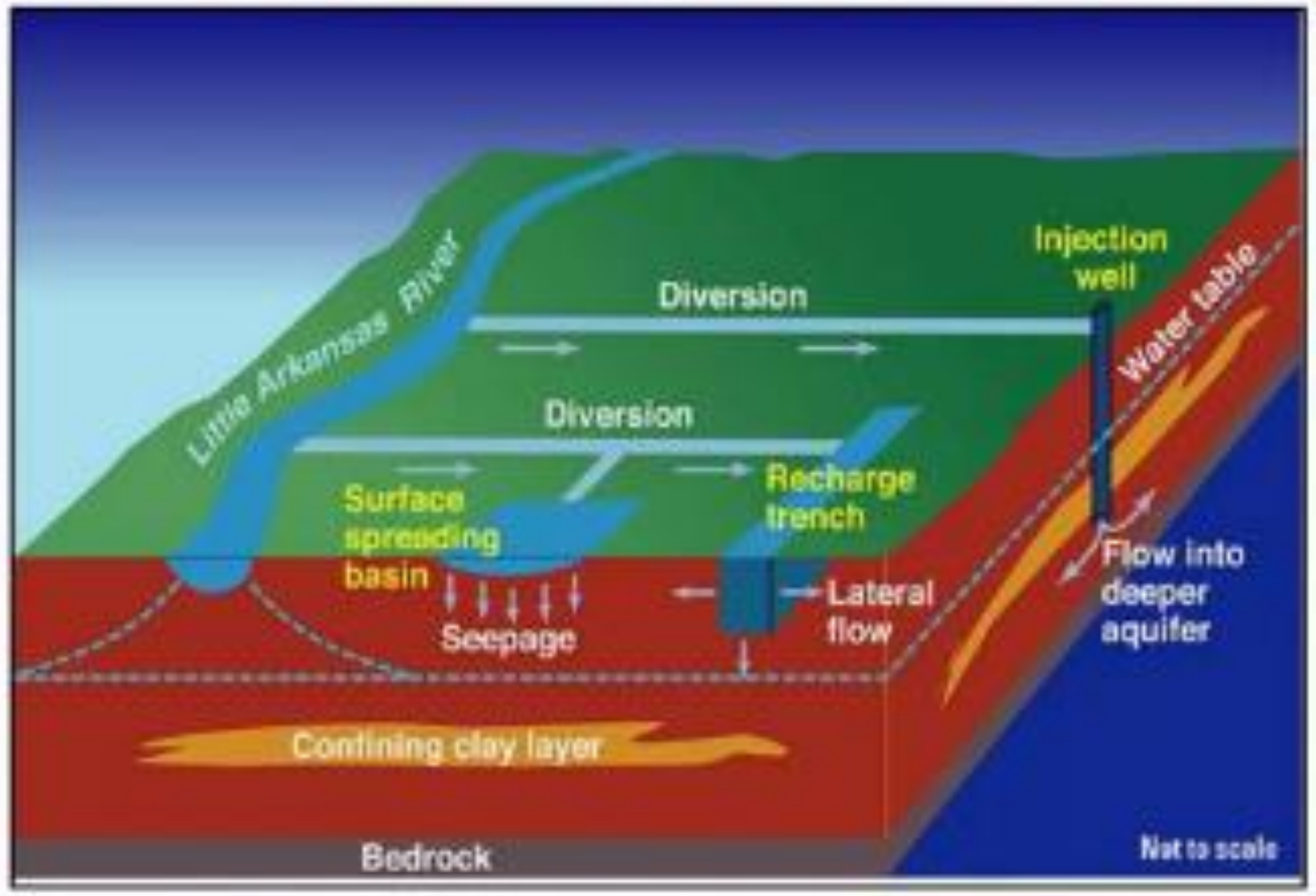


Source: megphed.gov.in

Figure 4 : Ditch and Furrow System

- In areas with irregular topography ditches or furrow provide maximum water contact area for recharge.
- This technique consists of a system of shallow flat bottomed and closely spaced ditches / furrow which are used to carry water from source like stream /canals and provide more percolation opportunity.
- This technique required less soil preparation and is less sensitive to silting.

B.Sub-Surface Method

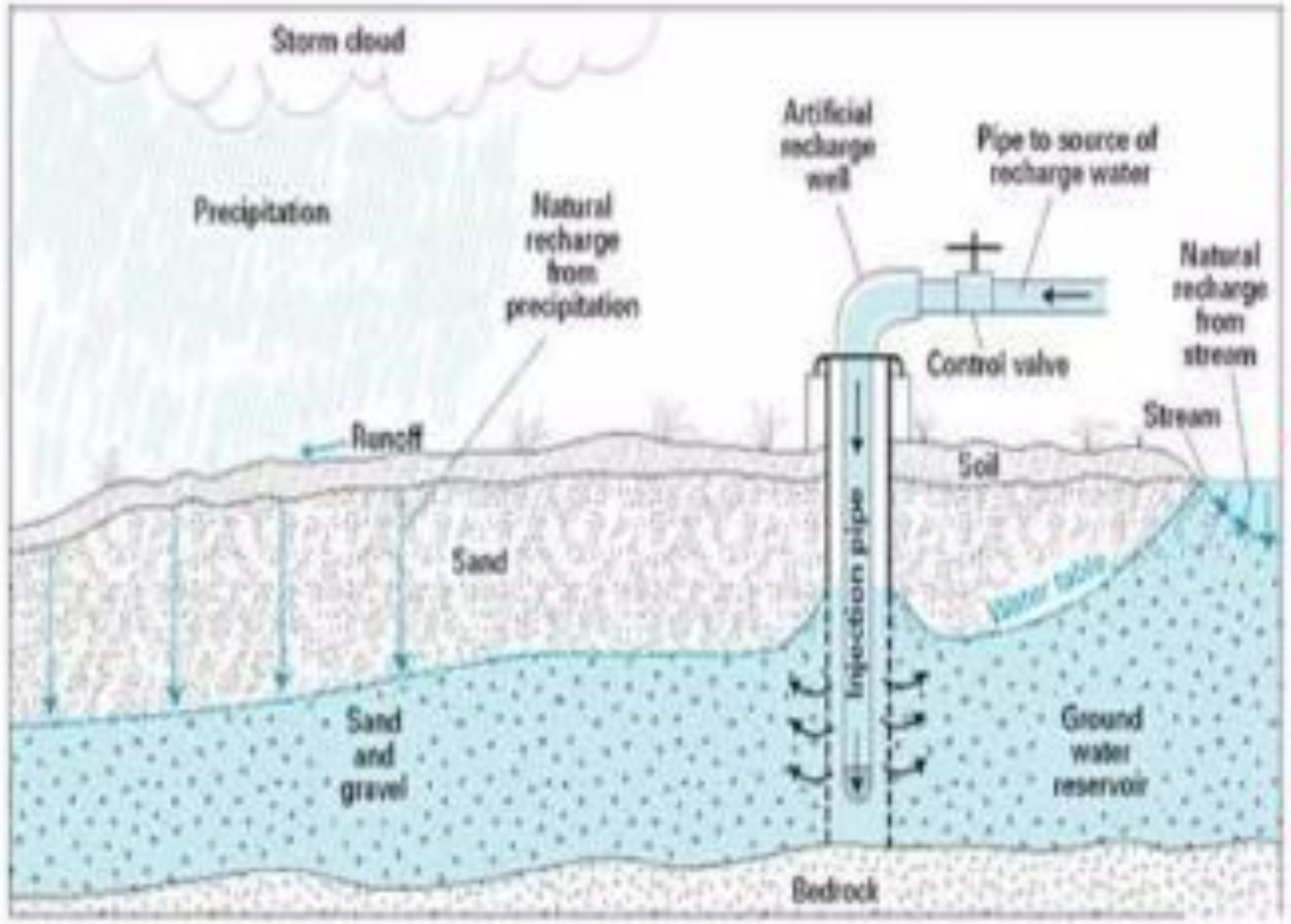


Source: www.indiawaterportal.org

Figure 5 : sub surface method

- In this method the structure lies below the surface and recharges ground water directly.
- The important structures commonly use are Recharge wells, Recharge shaft, Dug wells etc.

1.Recharge Well

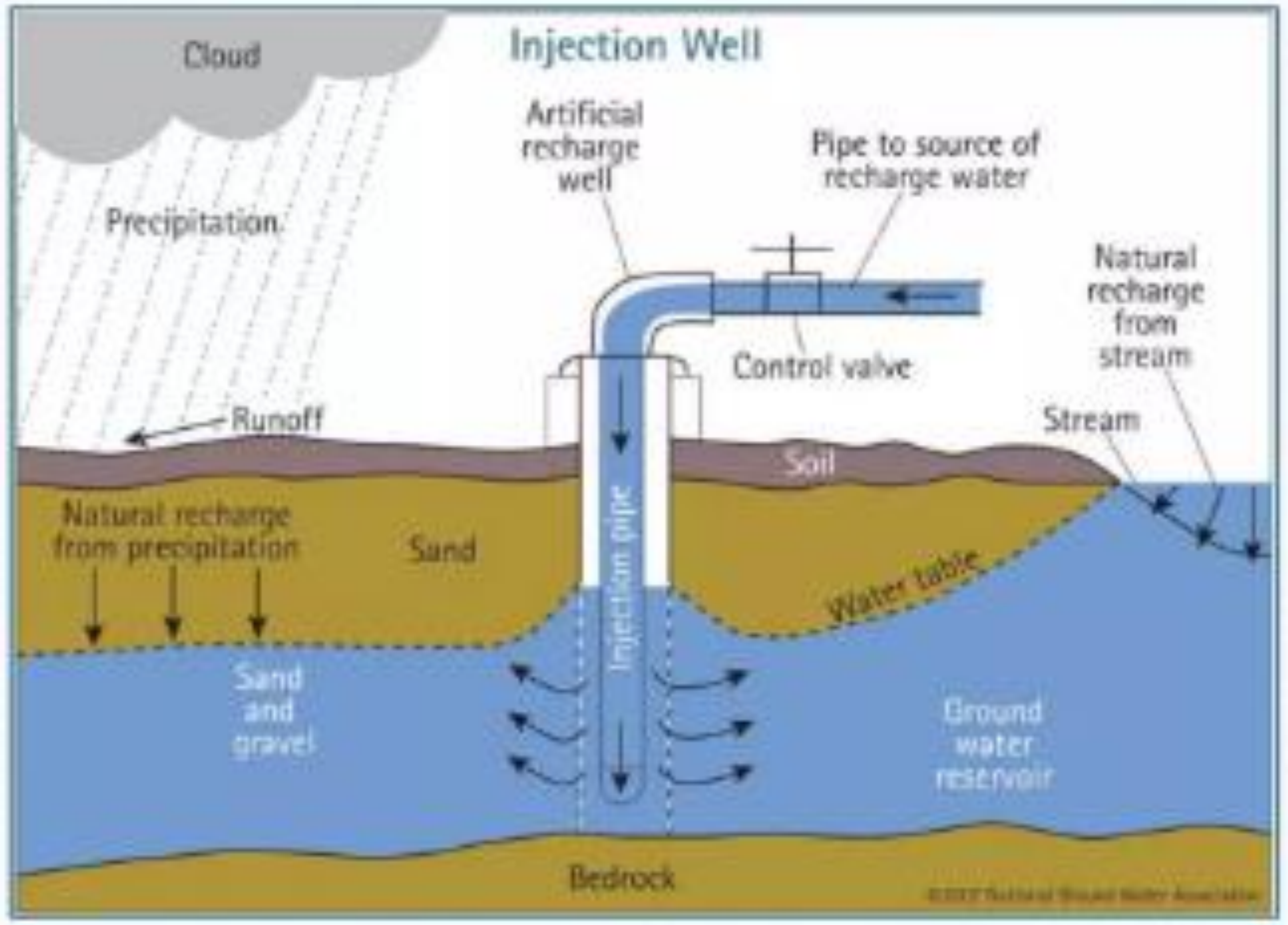


Source:www.ngwa.org

Figure 6 : Injection well

- Recharge wells can be of two types -
- (a) Injection well, where water is “pumped in” for recharge and
- (b) Recharge well, where water flows under gravity.

(a) Injection Well



Source: www.ngwa.org

Figure (7) : Injection well

- The Injection wells are similar to a tube well.
- This technique is suitable for augmenting the ground water storage of deeper aquifers by "pumping in" treated surface water.
- These wells can be used as pumping wells during summers.
- The method is suitable to recharge single aquifer or multiple aquifers.
- The recharge through this technique is comparatively costlier and required specialized technique

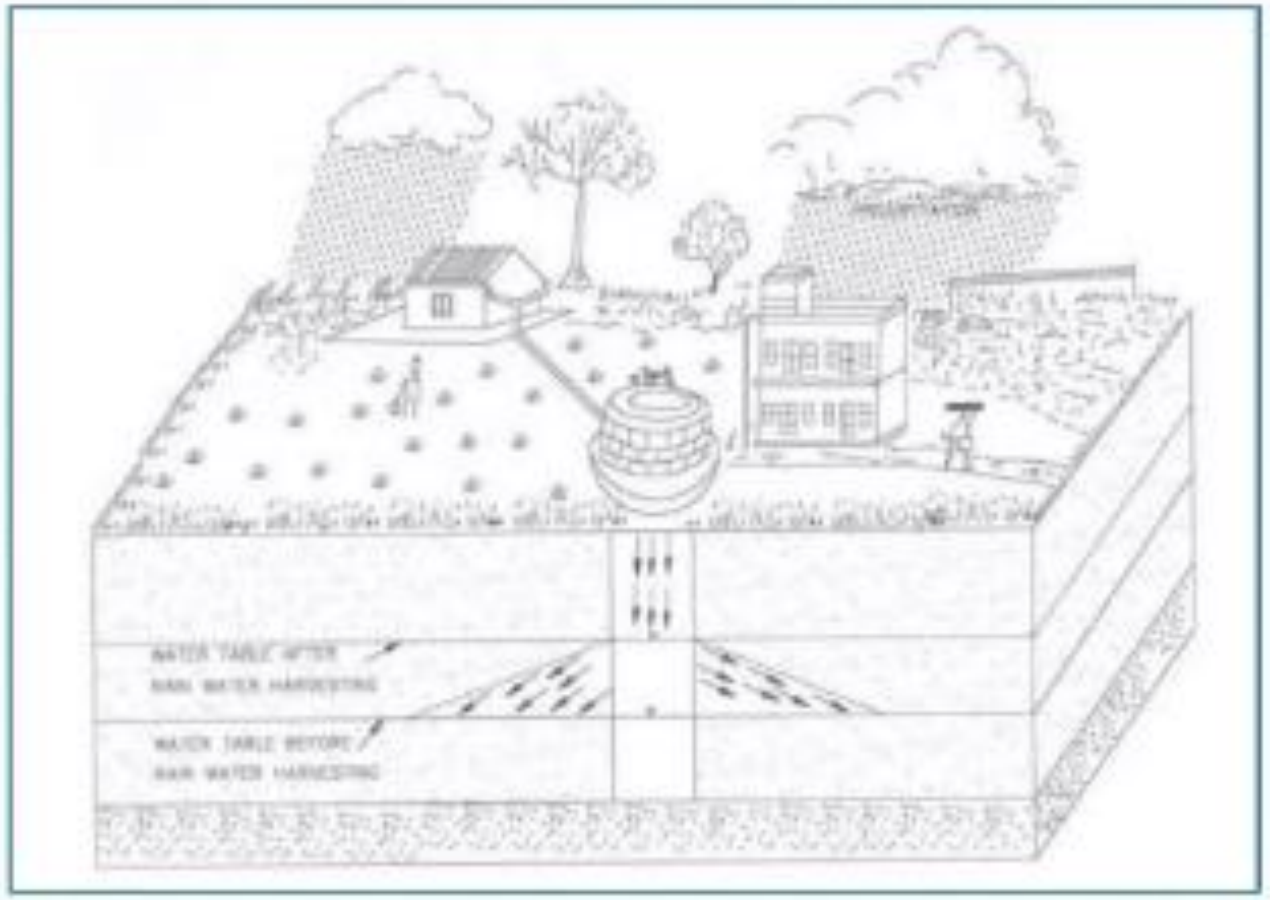
(b) Recharge Well

Source: www.indiawaterportal.org

Figure 8 : Simple Recharge well

- The recharge well for shallow water table aquifers up to 50 m are cost effective because recharge can take place under gravity flow only.
- These wells could be of two types, one is dry and another is wet.
- The dry types of wells have bottom of screen above the water table. In such wells excessive clogging is reported due to release of dissolved gasses as water leaves the well and on other hand redevelopment methods have not been found effective in dry type of wells.
- The wet type of wells are the wells in which screen is kept below water table. These wet type wells have been found more successful.

3. Dug Wells



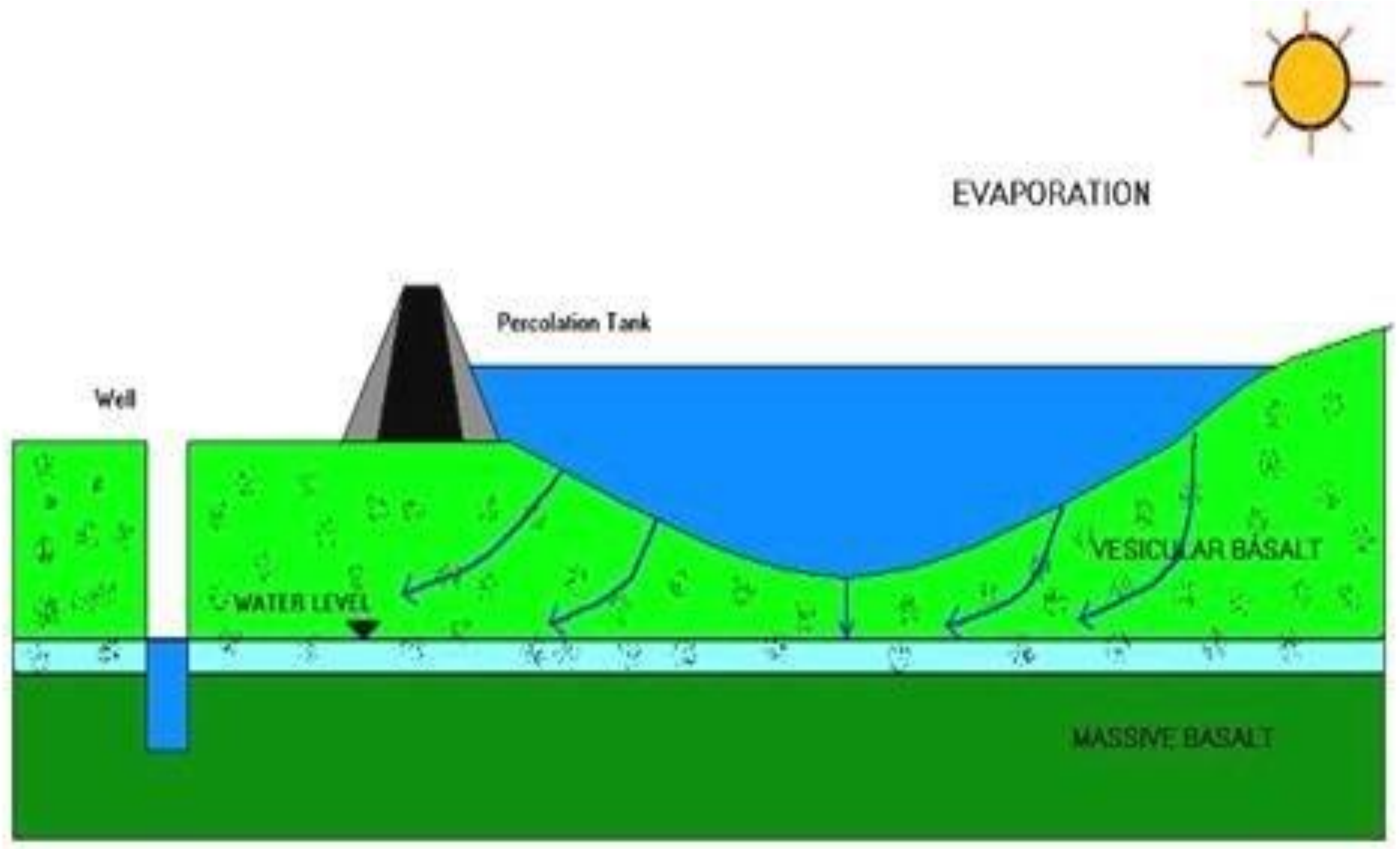
Source: megphed.gov.in

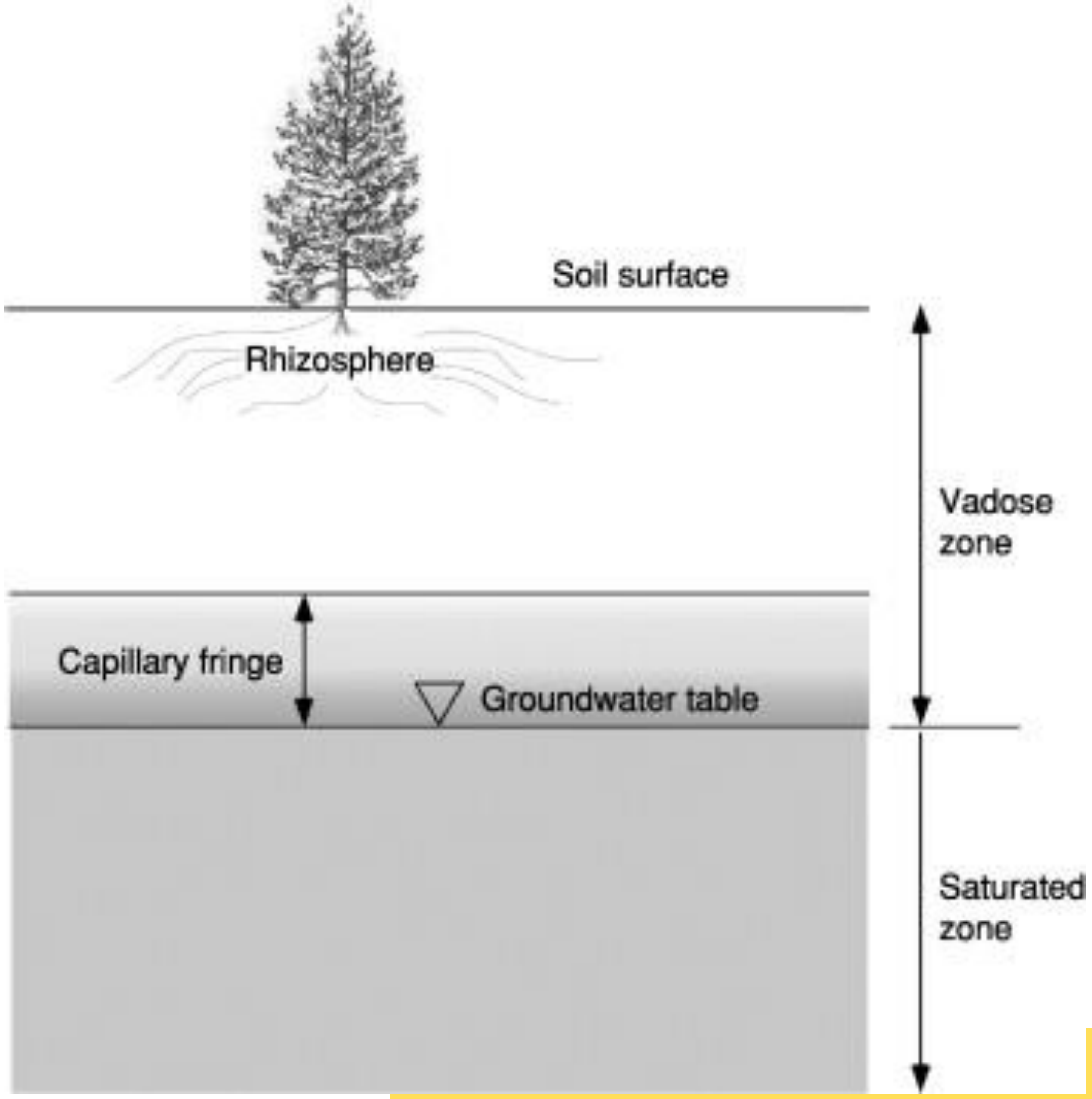
Figure (10) : Recharge through Dug Wells

- In alluvial as well as hard rock areas there are thousand of dug wells have either gone dry due to considerable decline of water levels.
- These dug wells can be used as recharge structure storm water and other surplus water from canal etc. can be diverted into these structures to directly recharge the dried aquifer.
- The water for recharge should be guided through a pipe to the bottom of well to avoid entrapment of bubbles in the aquifer.

PERCOLATION TANKS

- The percolation tanks are mostly earthen dams with masonry structure only for spillway. These are the most prevalent structures in India as a measure to recharge the groundwater reservoir both in alluvial as well as hard rock formations.
- Percolation tank is an artificially created surface water body, submerging in its reservoir a highly permeable land so that surface runoff is made to percolate and recharge the ground water storage.
- Percolation tank should be constructed preferably on second to third order streams, located on highly fractured and weathered rocks, which have lateral continuity downstream.
- Percolation tank should be located on highly fractured and weathered rock for speedy recharge. In case of alluvium, the bouldary formations are ideal for locating percolation tanks.
- The aquifer to be recharged should have sufficient thickness of permeable vadose zone to accommodate recharge.


EVAPORATION
Percolation Tank
Well
VESICULAR BASALT
WATER LEVEL
MASSIVE BASALT


Soil surface
Rhizosphere
Vadose zone
Capillary fringe
Groundwater table
Saturated zone

- The downstream of recharge area should have sufficient number of wells and cultivable land to get benefit from the augmented ground water.
- In Peninsular India with semi arid climate, the storage capacity of percolation tank should be designed such that the water percolates to ground water reservoir by January/February, since the evaporation losses would be high subsequently.
- The size of a percolation tank should be governed by the percolation capacity of the strata in the tank bed rather than yield of the catchment. In case, the percolation rate is not adequate, the impounded water is locked up and wasted more through evaporation losses, thus depriving the downstream area from the valuable water resource.
- Detailed analysis of the rainfall pattern, number of rainy days, dry spells, evaporation rate and detailed hydrogeological studies are necessary to demarcate suitable percolation tank sites.
- Detailed hydrological studies should be done for runoff assessment and designed capacity should normally not be more than 50 percent of the total quantum of utilizable runoff from the catchment.

DESIGN OF PERCOLATION TANK

Capacity of the percolation tank has to be calculated on the basis of the rainfall and catchment area of the tank. Also the weir length (surplus weir) has to be calculated. The procedure is as follows:

1. Select the site for the percolation tank.

2. From the toposheet, find out the correct catchment area of the watershed at that location.

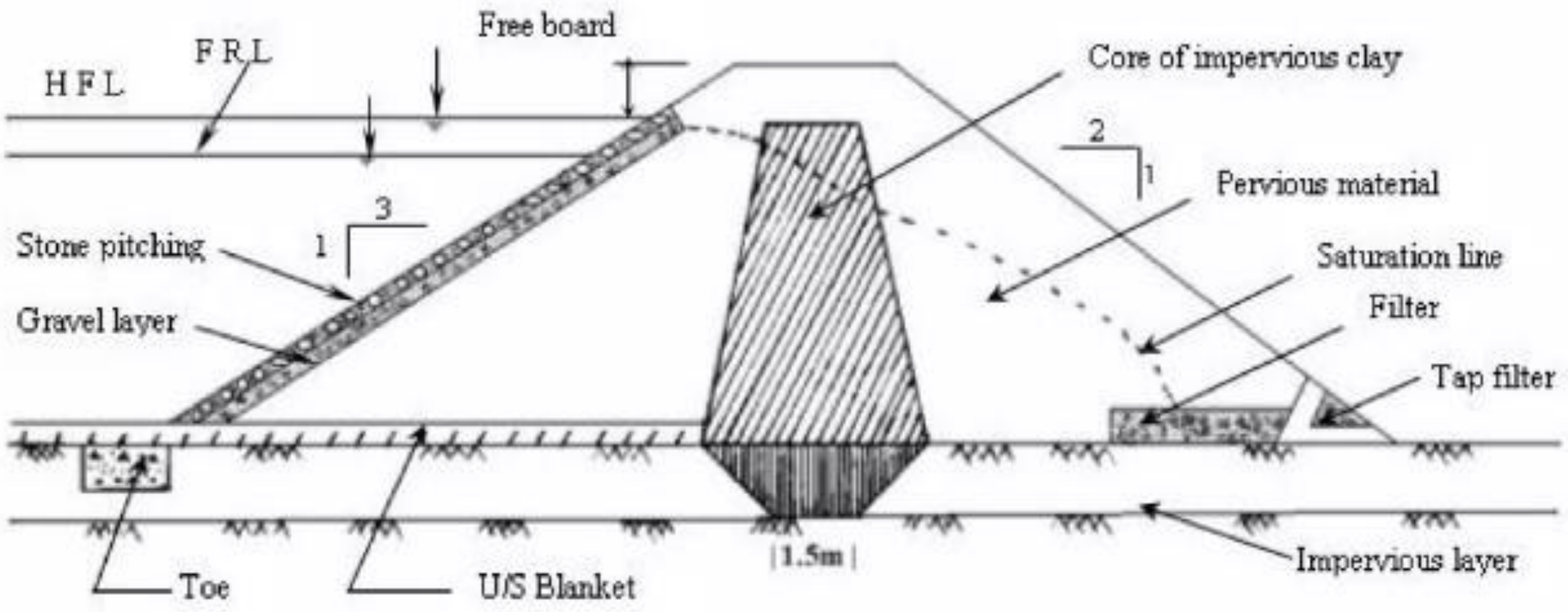
3. Compute catchment yield from rainfall and runoff coefficient or Strange's table (using monsoon rainfall; nature of catchment - good, average or bad; and catchment area).

4. Make suitable assumptions - such as number of fillings per year (say 2), utilization of yield per filling (say 5%) etc. Compute capacity of percolation tank (based-upon utilization of yield per filling).

5. Development of stage-capacity curve/table: Draw the contour lines at every 50 cm interval between the bed level and the highest ground level at the site. From these contour lines, the capacity of the tank at 0.5 m, 1.0 m, 1.5 m, 2.0 m, …. height above the bed level is calculated.

6. Compute full tank level (FTL) from stage-capacity curve/table.

Embankment



Free board
F R L
H F L
Core of impervious clay
2
1
Pervious material
3
1
Stone pitching
Saturation line
Filter
Gravel layer
Tap filter
|1.5m|
Impervious layer
Toe
U/S Blanket

7. Make allowances for free board and settlement.

Free Board

$F = 1.5\ h_w$ = free board in m

$h_w = 0.014\ (D_m)^{0.5}$ = wave height in m

D_m = fetch length (the longest exposed water surface on the reservoir) in m

Settlement

- Depends upon the type of fill material and the method and speed of construction.
- Varies from 10% of design height for hand compacted (normally constructed) fill to 5% for machine compacted (rolled at optimum moisture) fill.

8. Compute top width of embankment.

$W = H/5 + 1.5$

W = top width of embankment (m);
H = total height of embankment (m).

9. Compute length of embankment.

Length of the embankment is the distance between the points where the height intersects the contour having same elevation.

10. Based-upon the type of material, assign suitable side slopes for embankments.

Type of material	Upstream slope	Downstream slope
Homogeneous well graded	2.5:1	2:1
Homogeneous coarse silt	3:1	2.5:1
Homogeneous silty clay (i) Height less than 15 m (ii) Height more than 15 m	 2.5:1 3:1	 2:1 2.5:1
Sand or sand and gravel with central clay core	3:1	2.5:1

11. Compute peak discharge depending upon the catchment area and type of corresponding data available.

Rational method: $Q = CIA/36$

Q = peak discharge, m^3/s; C = runoff coefficient; I = Intensity of rainfall for duration equal to the time of concentration of the watershed, cm/hr; A = catchment area of the watershed, ha.

Dicken's formula: $Q = CA^{3/4}$

Q = peak discharge, m^3/s; A = catchment area in km^2; C = constant (for North India, C = 11.5; Central India, C = 14 to 19.5; Western India, C = 22 to 25). The formula is generally useful for catchments of North India. An average value of C equal to 11.5 is generally used and it is increased for hilly catchments and vice versa.

Ryve's formula: $Q = CA^{2/3}$

Q = peak discharge, m^3/s; A = catchment area in km^2; C = constant (for areas within 80 km from coast, C = 6.8; areas within 80-2400 km from coast, C = 8.8; areas near hills, C = 10.1; actual observed values, C upto 40). The formula is applicable to catchments in South India. The average value of C to be used is 6.8 with less value for flat catchments and more for hilly catchments.

12. Compute length of spillway using peak discharge.

For small tanks, the height of flow over weir is taken between 0.30 m - 0.60 m and this level is known as maximum water level (MWL).

To decide the length of the surplus weir -

$Q = CLh^{3/2}$

$\mathbf{L = Q/Ch^{3/2}}$

C = Constant =1.67 (for broad crested weir)
L = Length of the weir (m)
h = Flow height over the weir (m)

13. Compute width of horizontal floor.

- The width of horizontal floor of masonry weirs with vertical drop, from the foot of the drop wall to the downstream edge of the floor should not be less than 2(D+H), where D is the height of the drop wall and H is the maximum head of water over the wall.

- The rough stone apron forming a talus below the last wall may be taken from 2.5(D+H) to 5(D+H) depending upon the nature of the soil and the velocity.

14. Check the stability of the structure by locating the saturation line on the base.

Design Example of Earthen Embankment for Percolation Tank

Design an earthen embankment using the following data:

Catchment area = 21 ha
Intensity of rainfall = 17 cm/hr
RL of ground surface = 100 m
RL of HFL = 103.00 m
Runoff coefficient C = 0.3
Soil type is sandy loam
Slope of saturation line = 4:1
Assume a fetch of 500 m

Hints

- Compute height of water upto HFL.
- Compute height of waves.
- Compute free board.
- Compute allowance for settlement.
- Assign upstream and downstream slopes from table.
- Compute peak discharge.
- Compute length of spillway (assume head over spillway crest = 0.3 m).
- Compute width of horizontal floor.
- Locate the saturation line for checking stability.

Solution

Height of water upto HFL	=	103.00 – 100.00 = 3.00 m
Height of waves, h_w	=	$0.014\ (D_m)^{0.5}$
	=	$0.014 * 500^{0.5}$
	=	0.31 m
Freeboard, F	=	$1.5\ h_w$
	=	1.5 * 0.31
	=	0.46 m
Height of embankment	=	3.00 + 0.46
	=	3.46 m

Consolidation (5 %)	=	(5/100) * 3.46
	=	0.17 m
Total height of embankment, H	=	3.46 + 0.17
	=	**3.63 m**
Top width of embankment	=	H/5 + 1.5
	=	3.63/5 + 1.5
	=	**2.23 m**

Using the respective table, adopt the following side slopes of embankment for sandy loam –

Upstream slope	=	**3 : 1**
Downstream slope	=	**2.5 : 1**

Peak discharge, Q = C I A / 36

= 0.3 * 17 * 21 / 36

= 2.975 m^3/s

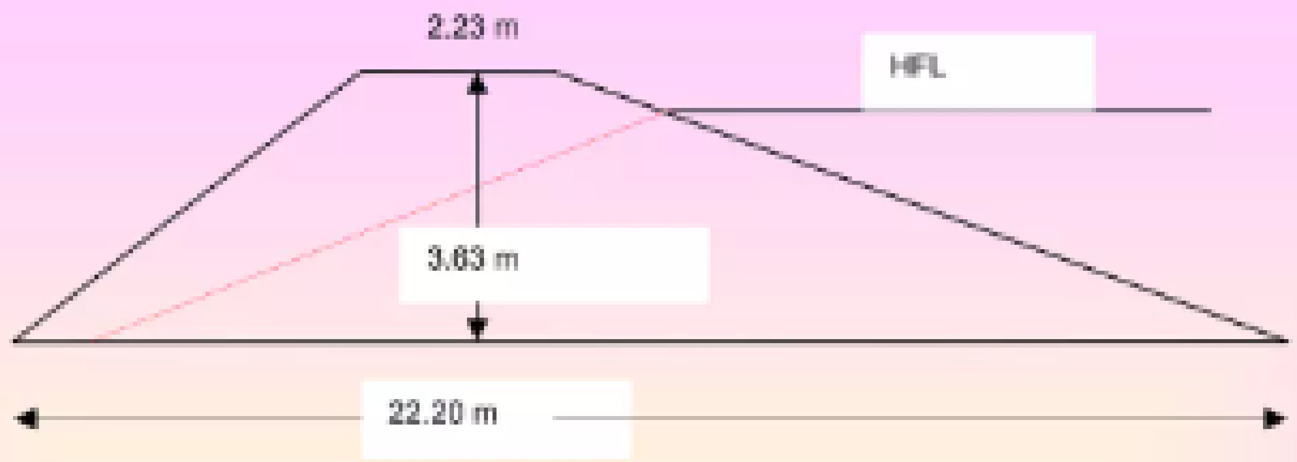
Length of spillway, L = Q / (C $h^{3/2}$)

= 2.975 / (1.67 * $0.3^{3/2}$),

(assuming head over spillway crest, h as 0.3 m)

= **10.84 m**

Width of horizontal masonry floor, W1	=	2 (D + H)
	=	2 (3.00 + 0.3)
	=	**6.60 m**
Width of rough stone talus, W2	=	4 (D + H)
	=	4 (3.00 + 0.3)
	=	**13.20 m**



Actual length required for saturation line to be in the base of embankment

$$= 3 * 4 + 3 * 3$$

$$= 21 \text{ m}$$

Length available for saturation line to be in the base of embankment

$$= 3.63 * 2.5 + 2.23 + 3.63 * 3$$

$$= \mathbf{22.20\ m}$$

The saturation line meets the base of embankment, therefore the **section is stable**.