

Module 3 – (L8-L11): Integrated Watershed Management
Introduction to Integrated Approach, Integrated Water Resources
Management, Conjunctive Use of Water Resources, Rainwater
Harvesting; Roof Catchment System.

WATERSHED MANAGEMENT

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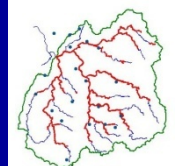
Department of Civil Engineering,
IIT Bombay

Lecture No - 11

**Rainwater Harvesting &
Roof Catchment System**

L11– Rainwater Harvesting & Roof Catchment System

- **Topics Covered**
- Rainwater harvesting system, Roof water catchment system, Urban water scarcity, RWH- costs, safety & water quality, Maintenance, Case study
- **Keywords:** Rainwater harvesting system, Roof water catchment, urban water scarcity



Roof Top Rainwater Harvesting

- Rooftop Rain Water Harvesting - technique through which rain water is captured from roof catchments & stored in reservoirs.
- Harvested rain water can be stored in storage tanks to meet the household needs or sub-surface ground water reservoir by adopting artificial recharge techniques.
- **Main Objective:** to make water available for future use.
- Capturing and storing rain water for use is particularly important in dry land, hilly, urban and coastal areas.
- In alluvial areas energy saving for 1m. rise in ground water level is around 0.40 kilo watt per hour.



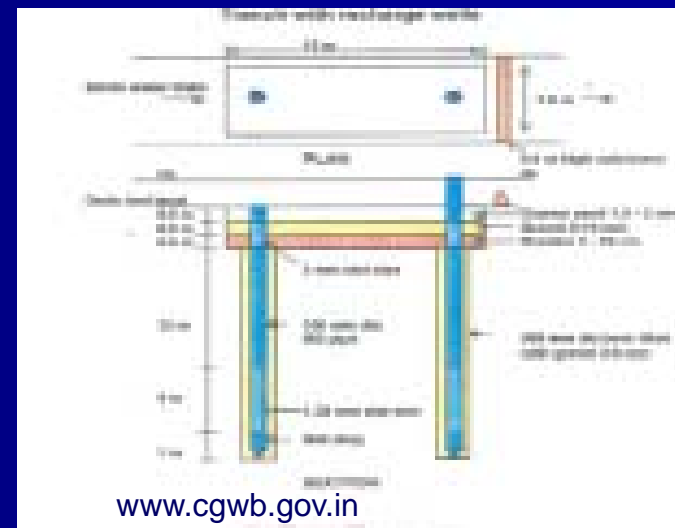
Need for Roof Top RWH

- To meet the ever increasing demand for water
- To reduce the runoff which chokes storm drains
- To avoid flooding of roads
- To augment the ground water storage and control decline of water levels
- To reduce ground water pollution
- To improve the quality of ground water
- To reduce the soil erosion
- To supplement domestic water requirement during summer, drought etc.



Roof Top RWH - Methodology

- Storage in Tanks
- Storage in groundwater reservoir – through recharge.
 - Recharge may be through dug well, bore well, recharge pit, shaft, trenches etc.
- Integrated system – in Tanks & Recharge



Roof Top RWH System

- **How much can be collected?.**
- **Collection efficiency -**
 - How efficiently the rainfall can be collected depends on several considerations such as roof, material, rainfall conditions, weather conditions etc.
 - Normally, a collection efficiency of 80% are often used depending on the specific design
- **Rainfall reliability** – average rainfall pattern considered
- **Total quantity of water to be collected (cu.m.) = Roof Top Area (Sq.m) x Avg. Rainfall (m)xCollection efficiency**
- **Rooftop area Vs Rainfall Availability of Water for RWH**



WATERSHED MANAGEMENT

How Much Rainwater Can You Collect?.

Rain Water through Rooftop Rain Water Harvesting - Collection effi. 80%

Rooftop Area (sq.m.)	Rainfall (in mm)													
	100	200	300	400	500	600	800	1000	1200	1400	1600	1800	2000	
Volume of Water (in cum)														
20	1.6	3.2	4.8	6.4	8	9.6	12.8	16	19.2	22.4	25.6	28.8	32	
30	2.4	4.8	7.2	9.6	12	14.4	19.2	24	28.8	33.6	38.4	43.2	48	
40	3.2	6.4	9.6	12.8	16	19.2	25.6	32	38.4	44.8	51.2	57.6	64	
50	4	8	12	16	20	24	32	40	48	56	64	72	80	
60	4.8	9.6	14.4	19.2	24	28.8	38.4	48	57.6	67.2	76.8	86.4	96	
70	5.6	11.2	16.8	22.4	28	33.6	44.8	56	67.2	78.4	89.6	100.8	112	
80	6.4	12.8	19.2	25.6	32	38.4	51.2	64	76.8	89.6	102.4	115.2	128	
90	7.2	14.4	21.6	28.8	36	43.2	57.6	72	86.4	100.8	115.2	129.6	144	
100	8	16	24	32	40	48	64	80	96	112	128	144	160	

Urban Water Scarcity– Solution Strategies

- Identify potential zones in overexploited areas, & design & implement suitable, site-specific roof water & surface water harvesting structures to raise the groundwater table.
- Promulgate roof and surface water harvesting techniques through Community Rainwater Harvesting methods
- Sustain existing water supply schemes by artificial recharge
- Introduce water-harvesting structures on unpolluted storm water drains, open areas, parks & playgrounds.
- Use stagnant water for recharge purposes in relatively low-lying areas, store floodwater in appropriate locations, & construct suitable recharge structures in water logging areas.
- Introduce site-specific artificial recharge structures on wide roads, which become waterways during heavy downpour in the monsoon season.

Urban Water Scarcity – Solution Strategies ...

Convert dry tube wells and bore wells into recharge wells.

- Design projects for Recycling and Reuse of wastewater
- Construct site-specific artificial recharge structures, like Percolation pits, Dug cum Bore wells, Mini Artificial Aquifer System, Trench cum Percolation Pits, Percolation Ponds, Recharge wells
- Develop mass awareness programs
- Make roof water harvesting a people's movement
- Commence and sustain training programs for executives of Government and Non Government Organizations, and strengthen ongoing awareness projects.

Design Considerations of Roof Top RWH

- Area contributing for runoff – harvestable roof top catchment area

- Rainfall pattern for the area.
- Collection efficiency.
- Demand for water & type of use
- Storage for how many months?.
- Storage related issues
- Water quality issues.
- Maintenance related issues
- For recharge -Hydrogeology of the area
- Recharge structures - based on availability of space, availability of runoff, depth to water table & lithology of the area.



Design Criteria of Recharge Structures

- The runoff should be assessed accurately for designing the recharge structure and may be assessed by following formula.

- *Runoff = Catchment area * Runoff Coefficient * Rainfall*
- *Runoff coefficient plays an important role in assessing the runoff availability and it depends upon catchment characteristics. General values are tabulated below which may be utilized for assessing the runoff availability.*

<i>Type of catchment</i>	<i>Runoff coefficient</i>
<i>Roof top</i>	<i>0.70 - 0.90</i>
<i>Paved area</i>	<i>0.50 - 0.85</i>
<i>Bare ground</i>	<i>0.10 - 0.20</i>
<i>Green area</i>	<i>0.05 - 0.10</i>

Cost of Recharge Structures

Cost of each recharge structure varies from place to place. Following are approximate cost of few of the structures: -

S.No.	Recharge Structure	Approximate cost (Rs.)
1.	Recharge pit	2500 – 5000
2.	Recharge Trench	5000 – 10000
3.	Recharge through hand pump	1500 – 2500
4.	Recharge through dug well	5000 – 8000
5.	Recharge well	50000 – 80000
6.	Recharge shaft	60000 – 85000
7.	Lateral Shaft with Bore well	Shaft per m. 2000 – 3000 Bore well 25000 - 35000

How You Can Do Rooftop RWH ?. –1

Components of Roof Top Rainwater Harvesting Systems



How You Can Do Rooftop RWH ?. – 2

Catchment Area – Roof

- Catchment area is the surface through which rain water runoff is harvested i.e. roof.
- Water to be used for non-drinking purposes can be collected from any roof.
- Water to be used for drinking purposes should, however, not be collected from roofs with damaged asbestos sheets or from roofs covered with asphalt and lead flashings or lead based paints as lead contamination may occur in the collected water.
- Regardless of roofing material, generally a loss of upto 20% may take place due to evaporation & inefficiencies in collection processes. Thus only 80% of rainfall can be harnessed through rooftop.



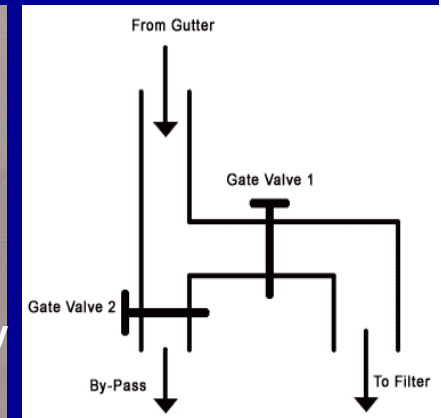
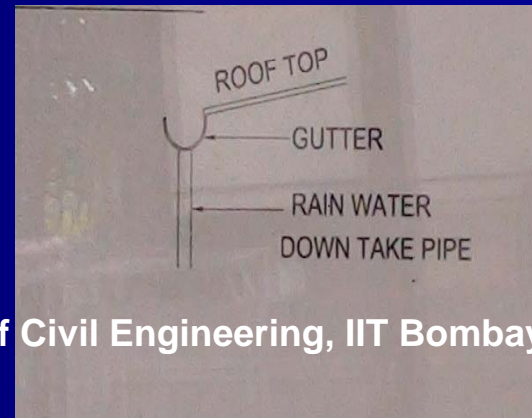
How You Can Do Rooftop RWH ?. – 3

Inflow Structures

Gutters: collect rain water from the roof and transport it to the inflow pipe. The gutters could be of various shapes, sizes and material.

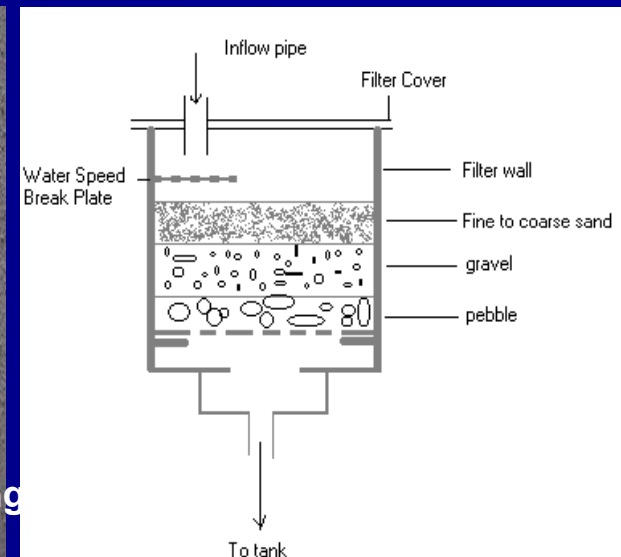
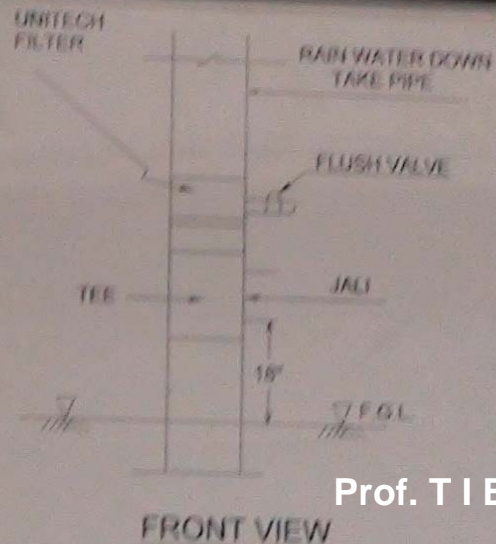
Inflow Pipe: Inflow pipe or drainpipe is the pipe which connects the gutter to the filter and then to tank or reservoir.

For domestic consumption through tanks.



How You Can Do Rooftop RWH ? – 4

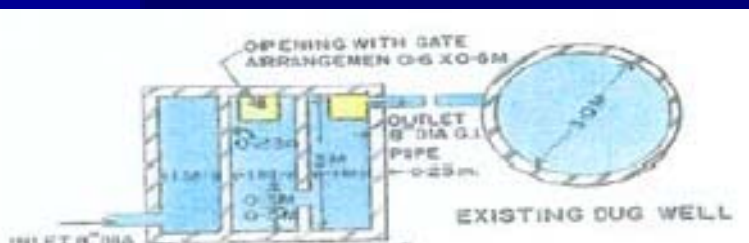
- Filter: Filter is to be used when the water is to be stored in tanks for direct consumption.
- Filtration and disinfection of water are necessary before human consumption.
- Filtration also required before recharge.



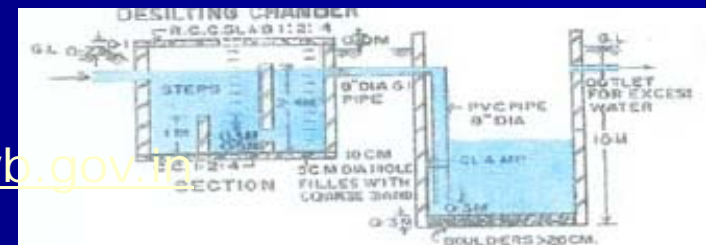
How You Can Do Rooftop RWH ? . – 5

For Recharge to Groundwater Reservoirs :-

- For storage in ground water reservoir the filter in the inflow structure is not required.
- The water, however, should pass through a desilting pit before entering the aquifer.
- A desilting pit is essential to let the suspended material settle down before the water is introduced into the aquifer.
- Except for the recharge through hand pump or tube well, the filter should be constructed

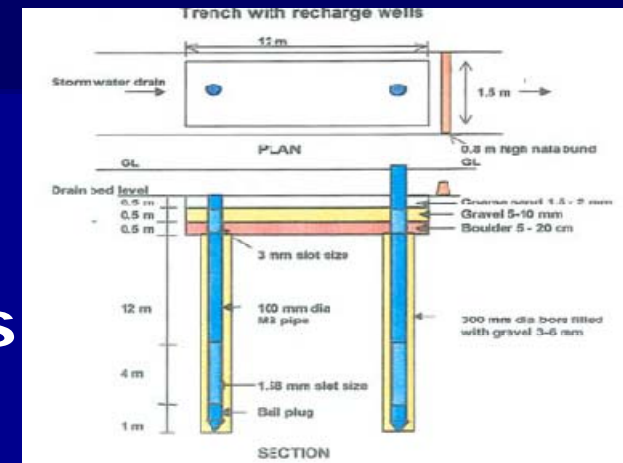


Source: <http://cgwb.gov.in>



How You Can Do Rooftop RWH ? . – 6

- Recharge shaft
- Defunct bore well
- Trench with injection wells
- Collection in Tanks
 - Above ground tanks can be made either from RCC, PVC or cement.
 - Underground tanks are designed and constructed in such a way that there is no leakage

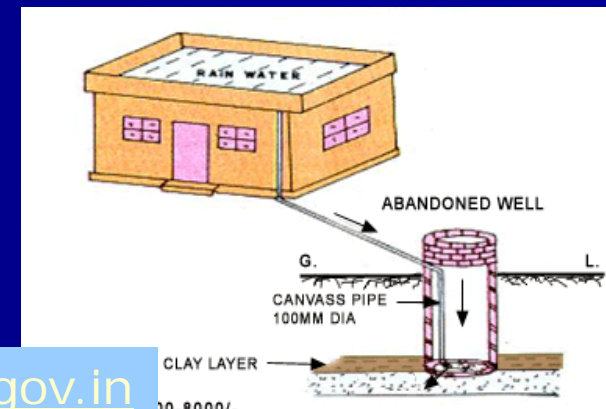
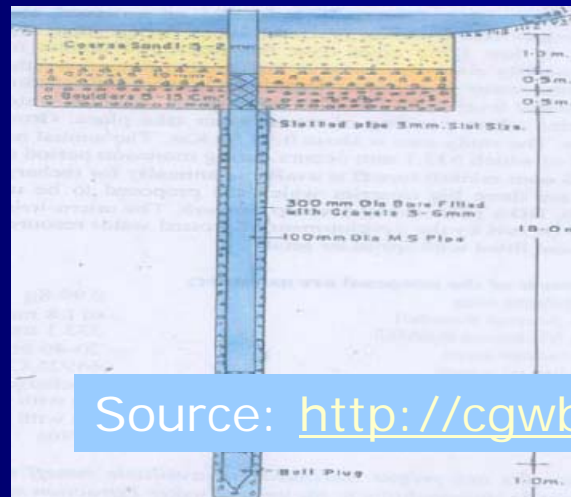
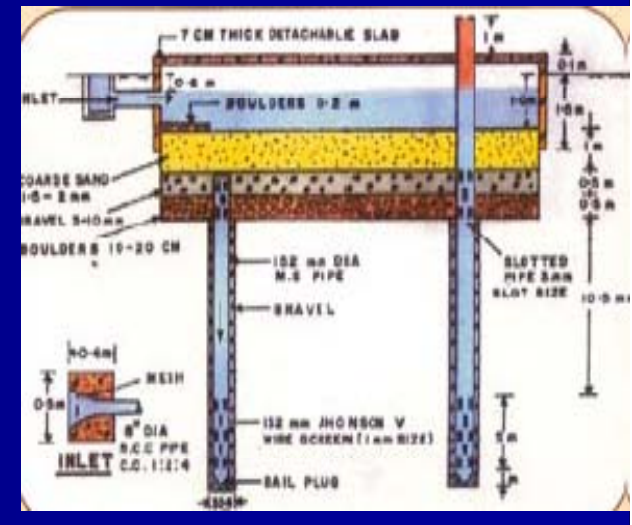


Source: <http://cgwb.gov.in>

How You Can Do Rooftop RWH ?. – 7

Storage:

- Storage tanks
- Dug, well, Abandoned dug well
- Recharge well, recharge shaft
- Recharge trenches
- Tube well



Source: <http://cgwb.gov.in>

Recharge through abandoned well



Roof RWH - Cost Analysis -1

- Cost of a Rainwater harvesting system - designed as an integrated component of a new construction project is generally low.
- Designing a system onto an existing building is costlier because many of the shared costs (roof and gutters) has to be separate.
- In general, maximizing storage capacity & minimizing water use through conservation and reuse are important rules to keep in mind.
- With careful planning and design, the cost of a rainwater system can be reduced considerably.

Roof RWH - Cost Analysis -2

- Rainwater harvesting methods are site specific & hence it is difficult to give a generalized cost.
- But first of all, the major components of a rainwater harvesting system - rain & catchment area - are available free of cost.
- A good proportion of the expenses would be for the pipe connections.
- By judiciously fixing up the slopes of roofs and location of rainwater outlets, this could be brought down considerably.
- However cost varies widely depending on the availability of existing structures like wells and tanks which can be modified and used for water harvesting.

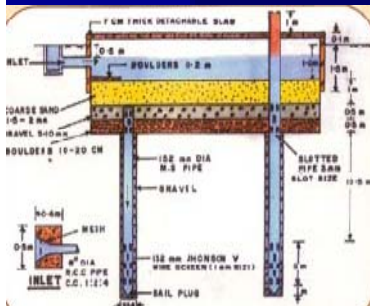
Roof RWH - Cost Analysis -3

- Typically, installing a water harvesting system in a building would cost between Rs 3,000 to 50,000 for buildings of about 300 sq. m.
- The cost estimate above is for an existing building.
- For instance, RWH system in the CSE building in Delhi, was set up with a cost of Rs 30,000 whereas those in the model projects ranged between Rs 70, 000 and Rs 8 lakh.
- The costs would be comparatively less if the system were incorporated during the construction of the building itself.
- When community come together to harvest rain, per-capita cost goes down. For eg., Panchsheel Park Colony, New Delhi - about 1000 residents pooled in Rs 4.5 lakh to harvest more than 170 million litres of water annually.

Roof RWH – Safety Considerations -1

Storage in Ground Water Reservoir

- For rooftop rain water harvesting through existing tube wells and hand pumps, filter or desilting pit should be provided so that the wells are not silted.
- Such tube wells if pumped intermittently, increase the efficiency of recharge.
- If the ground water reservoir is recharged through, shaft, dug well etc., inverted filter may be provided



Source: <http://cgwb.gov.in>

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Roof RWH – Safety Considerations -2

Storage in Tanks

1. A storage tank should not be located close to a source of contamination, such as a septic tank etc.
2. A storage tank must be located on a lower level than the roof to ensure that it fills completely.
3. A rainwater system must include installation of an overflow pipe which empties into a non-flooding area. Excess water may also be used for recharging the aquifer through dug well or abandoned hand pump or tube well etc.
4. A speed breaker plate must be provided below inlet pipe in the filter so as not to disturb the filtering material.
5. Storage tanks should be accessible for cleaning.
6. The inlet into the Storage tank should be screened in such way that these can be cleaned regularly.
7. Water may be disinfected regularly before using for drinking purpose by chlorination or boiling etc.

RWH – Operation & Maintenance

- Proper operation & maintenance of RWH systems helps to protect water quality in several ways.
 - Regular inspection & cleaning of catchment, gutters, filters and tanks reduce the likelihood of contamination.
 - Water from other sources should not be mixed with that in the tank.
- Treatment:**
- Treatment of stored rainwater only makes sense if it is done properly & if hygienic collection & use of water will ensure it does not suffer from re-contamination.
 - There are several types of treatment possible: most common being chlorination, boiling, filtration and exposure to ultraviolet or natural sunlight.

Rain Water Harvesting – Water Quality -1

- To prevent leaves & debris from entering the system, mesh filters should be provided at the mouth of the drain pipe.
- Further, a first-flush device should be provided in the conduit before it connects to the storage container.
- If the stored water is to be used for drinking purposes, a sand filter should also be provided.
- Methods to protect rainwater quality include appropriate system design, sound operation and maintenance & use of first flush devices & treatment.
- It is extremely important to maintain the rainwater harvesting systems regularly for high quality performance.

Rain Water Harvesting – Water Quality -2

- **Tips to ensure quality of harvested rain**
- Just before the arrival of monsoon, the rooftop/ catchment area has to be cleaned properly.
- The roof outlet on the terrace should be covered with a mesh to prevent entry of leaves or other solid waste into the system.
- The filter materials have to be either replaced or washed properly before the monsoon.
- The diversion valve has to be opened for the first 5 to 10 minutes of rain to dispose off polluted first flush.
- All polluted water should be taken away from the recharge structures.
- The depth of bores (of recharge structures) shall be finalized depending on the actual site condition.

- **Example:** RWH system has to be designed for meeting drinking water requirement of a 5-member family living in a building with a rooftop area of 100 sq. m. Average annual rainfall in the region is 600 mm (average annual rainfall). Daily drinking water requirement per person (drinking and cooking) is 10 litres.

A) Following details are available:

- Area of the catchment (A) = 100 sq. m.
- Average annual rainfall (R) = 600 mm (0.6 m)
- Runoff coefficient (C) = 0.8

Annual water harvesting potential from 100 sq. m. roof

$$= A \times R \times C = 100 \times 0.6 \times 0.8 = 48 \text{ cu. m. (48,000 litres)}$$

- The tank capacity has to be designed for the dry period, i.e., the period between the two consecutive rainy seasons.
- With a monsoon extending over four months, the dry season is of 240 days
- Drinking water requirement for the family (dry season)
 $= 240 \times 5 \times 10 = 12,000 \text{ litres}$
- As a safety factor, the tank should be built 20 per cent larger than required, i.e., 14,400 litres.
- This tank can meet the basic drinking water requirement of a 5-

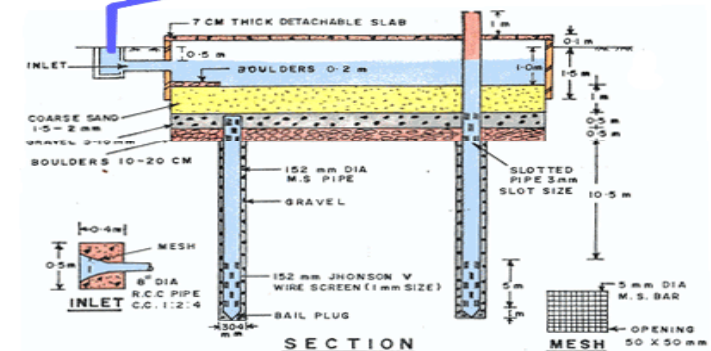
Case Studies – Success Stories -1

Artificial recharge to Groundwater using Rooftop Rainwater at Sharam Shakti Bhawan, New Delhi.

- Most suited for the area.
- Campus area – 11965 sq.m
- Depth to ground water level- 6.0 - 8.0 m.bgl
- Source of water- Rain water

Source: <http://cgwb.gov.in>

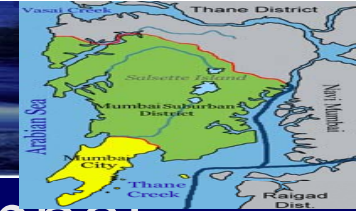
ROOFTOP RAIN WATER RECHARGE



Case Study 1:

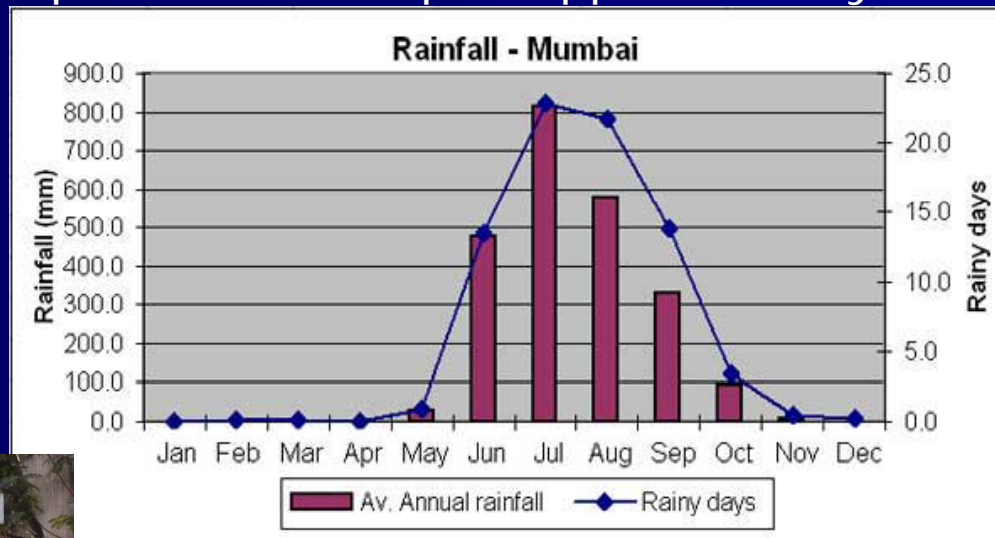
- Average Annual rainfall - 712.2 mm
- Rainwater runoff – 3325 cu.m
- Structures proposed - Recharge Trench with two injection wells
- Expected recharge - 3000 cum/yr.
- Expected rise in ground water level 2007- 1.68 -3.33m in 11965 sq. m area
- Cost of water recharge- Rs. 7.07 per 1000 litre
- The scheme is implemented by CPWD – Year 2001.
- Cost: Rs. 410,000/-
- Major benefit - proper utilization of available runoff, arresting the declining ground water levels in the area & sustainability to existing ground water abstraction structures.

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Case Study 2: IWWA Campus, Mumbai

- **RWH by Collection Tank – Roof top harvesting.**
 - Storage in Ferro-cement tank of 6000 lit. capacity
- Mumbai - Average total annual rainfall is 2335 mm.
- Roof top area – 300 sq.m. approximately



Mont h s	Av. Annual Rainfall (mm)	Rainy Day s
Jan	1.0	0.0
Feb	0.5	0.1
Mar	0.7	0.1
Apr	0.4	0.0
May	29.6	1.0
Jun	475.1	13.5
Jul	815.9	22.8
Aug	579.3	21.7
Sep	328.4	13.8
Oct	93.7	3.4
Nov	8.2	0.4
Dec	1.9	0.3
Total	2334.6	77.2



(Source: <http://rainwaterharvesting.org>)

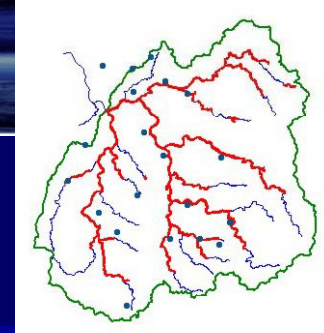
Case Study 2:

- Filter – geotextile based
- Over flowing water for recharge
- Water used for office toilet flushing
- Submersible pump used for pumping
- Sufficient for 4 monsoon months + one month after rainfall
- Cost for the scheme: Rs. 96,000/-
- Efficient direct roof top harvesting



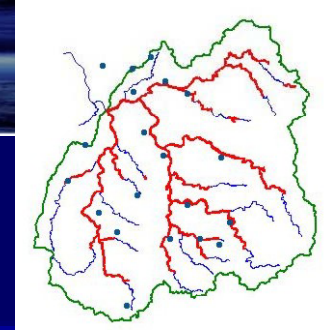
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Tutorials - Question!..?.

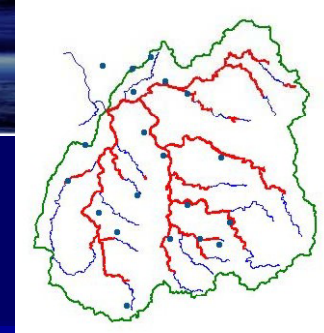
- 1) Describe the artificial recharge scheme for groundwater improvement with case studies.
- 2) Illustrate the rooftop rainwater harvesting with the help of two case studies: a) for direct use; b) Groundwater recharge.
- (Ref: <http://cgwb.gov.in>; www.rainwaterharvesting.org; www.cseindia.org)
- Illustrate the systems used for artificial recharge/ roof rain water harvesting.
- Illustrate the various schemes used for rooftop RWH/ Groundwater recharge schemes
- Discuss various techniques adopted at various locations.
- Discuss the merits and demerits of each systems.



Self Evaluation - Questions!.

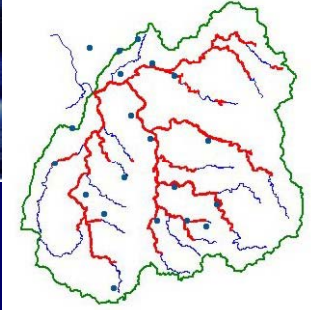
- Discuss the roof top RWH, need & its importance.
- How much water can be collected from a roof top catchment?.
- Discuss the important design considerations of roof top RWH.
- Discuss the cost analysis of Roof top RWH scheme.
- Describe the operation & maintenance of roof top RWH.

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Assignment- Questions?.

- Describe the methodologies of roof top RWH.
- What are the solution strategies for Urban water scarcity?.
- With details, explain how we can do roof top RWH?.
- What are the important safety considerations in roof top RWH?.
- Discuss water quality issues in RWH.



Unsolved Problem!

- For your residential building, prepare a master plan for rooftop based rainwater harvesting system.
- Identify the present supply & demand of water.
- Identify built up area
- Check the possibility of direct RWH in tanks & recharge.
 - Collect data – rainfall, soil data etc.
 - Design an integrated RWH scheme including groundwater recharge.

WATERSHED MANAGEMENT

THANK YOU

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