

Conservation Strategies Using Watershed Management and Rainwater Harvesting in Vishwaniketan's Campus

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Abstract: *Rainwater Harvesting & Watershed Management plays a major role in water conservation & also in reducing soil erosion. In coastal Maharashtra most of the districts face the problem of water storage at the time of monsoons due to the heavy rainfall, due to which the most of the water is percolated into the ground or flows to the river etc. which causes lack of availability of water after the end of monsoon seasons. This study aims to cater the water scarcity by implementing watershed management & rainwater harvesting systems. To model & analyze watershed & Rainwater harvesting project in our college (Vishwaniketan's IMEET) area to fulfill water requirement.*

Keywords: Watershed, Water conservation, Water scarcity, Rainwater harvesting, Water reuse

1. Highlights

- 1) The main aim of the project is to model & analyze watershed & rainwater harvesting project in vishwaniketan's campus to solve the problem of water scarcity, erosion of soil & cost optimization.
- 2) Contour survey of land which comes under watershed is carried out by us with the help of total station to determine the ground levels.
- 3) Designing of Tanks, for watershed a tank is required to collect water from a hill which is completely underground to recharge the ground water table. One tank is made for collecting water from roof top of college. For filtration of water from both the tank, filtration tank is constructed for each tank & then after filtration water is stored in storage tank from which water is supplied for college building, hostel building, and garden area.
- 4) Designing of R.C.C tank is done & details of tanks is done in AutoCAD software & for comparison of results of manual analysis of R.C.C tanks & software analysis, staad pro software is used for study of hydrostatic pressure, loads & deflection acting on tanks. Also primavera software is used to manage the project by which the duration of project is analyzed which is approximately 6 to 7 months.
- 5) IS 3370:1967, IS 11401:1990 (part 1 & 2), IS 8419:1977 part 1, IS 8419:1984 part 2 are use for design & filtration units.
- 6) For filtration slow sand filter if preferred & also it is tested by making a prototype of slow sand filter, before filtration & after filtration test were conducted on it which proves that the water after filtration can be used for domestic purpose
- 7) The estimated cost of project is 36, 56,715 which is high but can be recovered within 5 years as our college is spending 8 lakhs annually for water tankers.
- 8) This project is best suited in vishwaniketan's campus as it overcomes the problem of scarcity of water, collection

of water during monsoons, erosion of soil, and elimination of reduction of call for tankers.

2. Introduction

2.1 Watershed

Watershed is the hydro-geological unit of area from which the rain water drains through a single outlet [1]. When rain falls on the mountains, it flows down through small streams. Many such streams join to form bigger streams, which in turn join to form rivulets, which join to form river and so on. The entire area which supplies water to a stream or rivulet or a river at a particular point in its flow is called the watershed or catchment area or drainage basin of that particular point [7]. The top of the watershed is called hill or ridge portion. The ridge-line partitions one watershed from all the droplets of rain within the watershed will flow from another, or can be said to be the boundary of the watershed ridge portion through different drainage lines to the valley portion of the watershed and will be drained out of the watershed through a common exit point (Figure 1) [7].

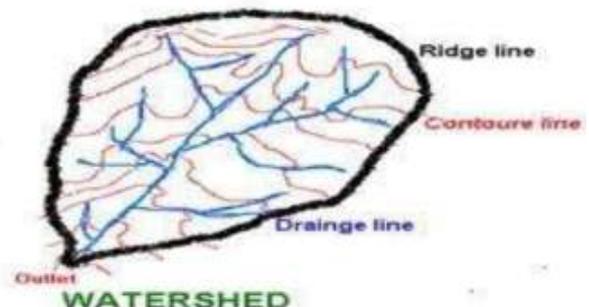


Figure 1: Watershed Network [9].

The prominent hill ranges, isolated hillocks, undulation etc., in the district give rise to higher runoff, rather than

natural recharge. These aquifers then are drained naturally due to sloping and undulation topography. As a result, the dug wells become dry by the month of February onwards [1].

2.2 Rainwater Harvesting

The technique of rainwater harvesting involves collecting the rain from localized catchment surfaces such as roofs, plain / sloping surfaces etc., either for direct use or to augment the ground water resources depending on local conditions (Figure 2) [6].



Figure 2: Rainwater Harvesting [10]

2.3 Watershed Management

Watershed management is a term which describes the process of implementing land use and water management practices to protect and improve the quality of water and other natural resources (Figure 3) [7].

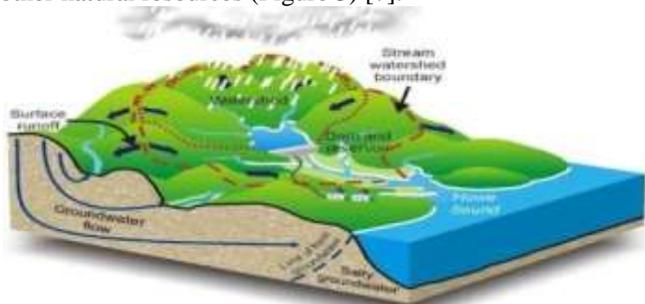


Figure 3: Watershed Management Network [8].

3. Literature Review

The Integrated Watershed Management Programme (IWMP) one of the Flagship programme of Ministry of Rural Development is under implementation by the Department of Land Resources since 2009-10 after integrating three area development programmes namely **Desert Development Programme (DDP)**, **Drought Prone Areas Programme (DPAP)** and **Integrated Wastelands Development Programme (IWDP)**, for development of rainfed/ degraded land in the country [5].

3.1 Structures adopted for conservation of water under Integrated Watershed Management Scheme

3.1.1 Continuous Contour Trenches [1].

Reduces surface water flow velocity, promotes infiltration, and prevents pollutants from draining into water bodies [1].



Figure 4: Continuous Contour Trenches [11].

3.1.2 Farm Ponds [1].

Ponds constructed on the upper side of the farms to block and store the runoff rain water which can be used during emergencies are called farm ponds [1].



Figure 5: Farm Ponds [12].

4. Case Study

The area taken for study is Vishwaniketn's imeet khalapur which is our college area. Total campus area is 14 Acres. Campus consists of 2 colleges (Engineering & Architecture), 1 canteen, 2 gardens, 1 hostel with total population of 1800 including hostel. The daily requirement of water for domestic purpose is 72900 litres. It is located near Mumbai pune expressway. Total area taken under mini water shed project is 1.4 hect. This watershed area comes under heavy rainfall zone even then during summer season water scarcity is noticed. The entire area absorbs water, but does not retain the water, because of the slope and ground condition. As a result the area faces water scarcity in rest of the season hence we have taken the college area for the watershed management and Rainwater harvesting project.



Figure 6: Vishwaniketn Campus

4.1 Present status of water source for domestic purpose in vishwaniketan's campus

- 1) In a week from Monday to Saturday there is a requirement of 3 tankers per day & on Sunday it is 2 no. of tanker.
- 2) Here 1 tanker = 10,000 liter capacity which cost Rs.900 therefore total monthly water requirement
- 3) = 10,000 x 20(no. of tankers) x 4(weeks)
- 4) = 8, 00,000 liters which costs approx Rs. 70,000
- 5) Annually = 96, 00,000 lit. which cost Rs. 8,64,000
- 6) If we proposed watershed & rainwater harvesting in our college area.
- 7) Then from rainwater harvesting we can collect 66, 59,933 lit. And from watershed we can collect 1,16, 55,000 lit.
- 8) Therefore total water which we can collect from rainwater harvesting & watershed management = 1, 83, 14,933 lit.
- 9) But from which 18% of rainwater percolates in the ground therefore from watershed we get = 95, 57,100 lit.
- 10) Hence from both watershed & rainwater harvesting we can get = 1, 62, 17,033 lit.

4.2 Water requirement in vishwaniketa's campus

Basic Requirement of water per day

Total No. of student in V-iMEET (Including Staff)
= **1800**

(A) No. of student staying in Hostel = **180**

(B) No. of remaining student (Non-staying)
= **1800 - 180 = 1620**

Basic Requirement of water (As per IS 1172-1993 in lpcd)

(A) Student staying in Hostel = $180 \times 135 = 24300$

(B) Student Non-staying in Hostel = $1620 \times 30 = 48600$

Total (A +B) = 72900 lit/day (for domestic purpose)

5. Methodology

(For project-1 i.e. Watershed Management)

5.1. Engineering Survey

- 1) Reconnaissance survey.
- 2) Preliminary survey.
- 3) Contour survey of the land by using Total Station.

5.2. Literature Review

- 1) History.
- 2) Research papers & Case study.
- 3) Rainfall data

5.3. Design of suitable water tank

- 1) Consumption of water per day.
- 2) Intensity of rainfall.

5.4. Purification of water

- 1) Filtration unit
- 2) Testing of water

5.5. Pure water storage and distribution

5.6 Software to be used

1. AutoCAD.
2. StaadPro.
3. Primavera.
4. SketchUp

6. Implementation of Work

6.1 Engineering Survey

The following fig.7 shows contour plan of area which comes under watershed. The highlighted portion shows location of the proposed watershed tank.

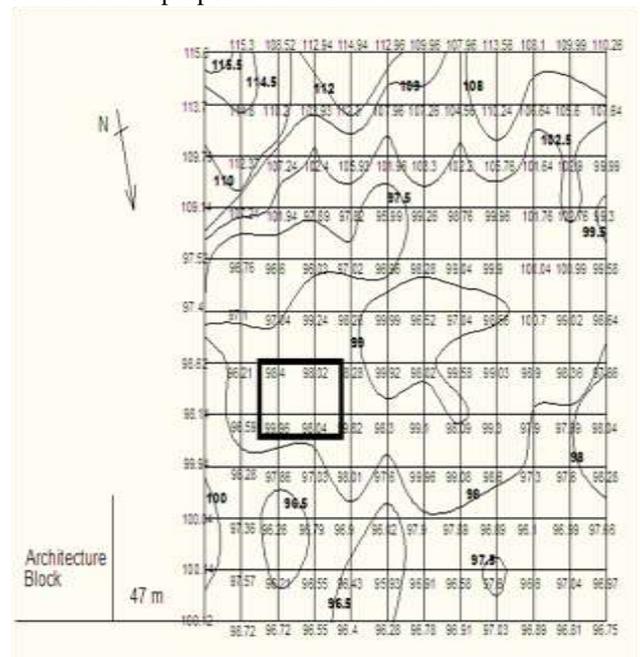


Figure 7: Contour Plan

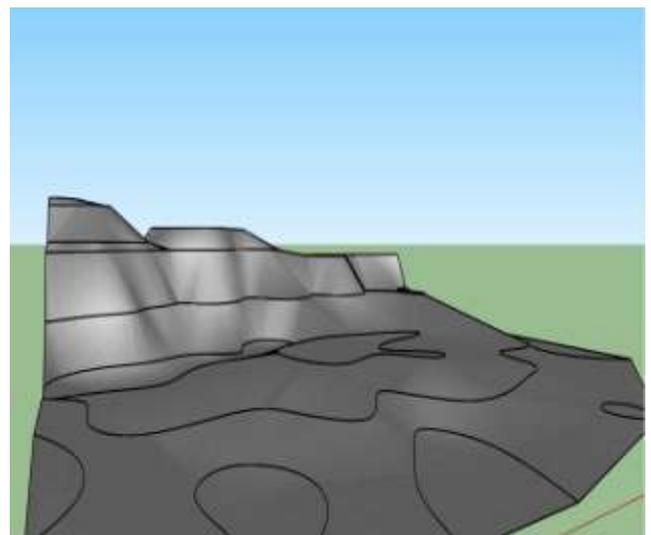


Figure 8: Contours in SketchUp software

6.2 Average Rainfall [Meteorological dept]

Rainfall was high with average rainfall of 3336.36 mm for past 10 years. The highest rainfall in last 10 years was

3921.4mm in 2009 and lowest rainfall was 2289.4mm in 2015.

2007-3293.5 mm	2008-3489.9 mm
2009-3921.4 mm	2010-3148.6 mm
2011-3234.2 mm	2012-3375.3 mm
2013-3913.5 mm	2014-3031.8 mm
2015-2289.4 mm	2016-3670.30 mm

6.3 Dimensions of Tank



Figure 9: Tank locations in ViMEET Campus

- Tank 1 (watershed tank): 4.6 x 3.0 x 6 m
- Tank 2 (rainwater harvesting tank): 5.5 x 3.7 x 4 m
- Tank 3 & 4 (filtration tank): 5.6 x 3.8 x 3 m
- Tank 5 (storage tank): 5.5 x 3.7 x 6 m

6.4 Manual Design & Software Analysis for Tank 1 (watershed)

6.4.1 Manual Design

- 1) Thickness of wall =280mm
- 2) Cover =25mm
- 3) Steel :

On long wall : 1st at corner
 On remote face = 16mm bar @ 45 mm c/c
 On liquid face = 8mm bar @ 95 mm c/c
 Vertical steel = 10mm bar @ 150 mm c/c
 2nd at mid span
 On remote face = 16mm bar @ 60 mm c/c
 On liquid face = 8mm bar @ 95 mm c/c
 Vertical steel = 10mm bar @ 150 mm c/c

On short wall : 1st at corner
 On remote face = 16mm bar @ 190 mm c/c
 On liquid face = 8mm bar @ 95 mm c/c
 Vertical steel = 10mm bar @ 150 mm c/c
 2nd at mid span
 On remote face = 16mm bar @ 260 mm c/c
 On liquid face = 8mm bar @ 95 mm c/c

Vertical steel = 10mm bar @ 150 mm c/c

6. Reinforcement Details: Wall dimensions is in meter

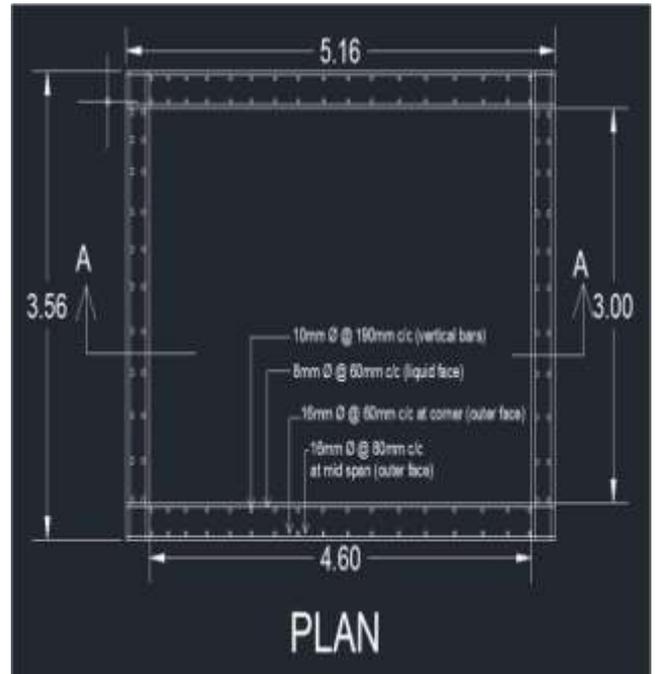


Figure 10: Plan of watershed tank

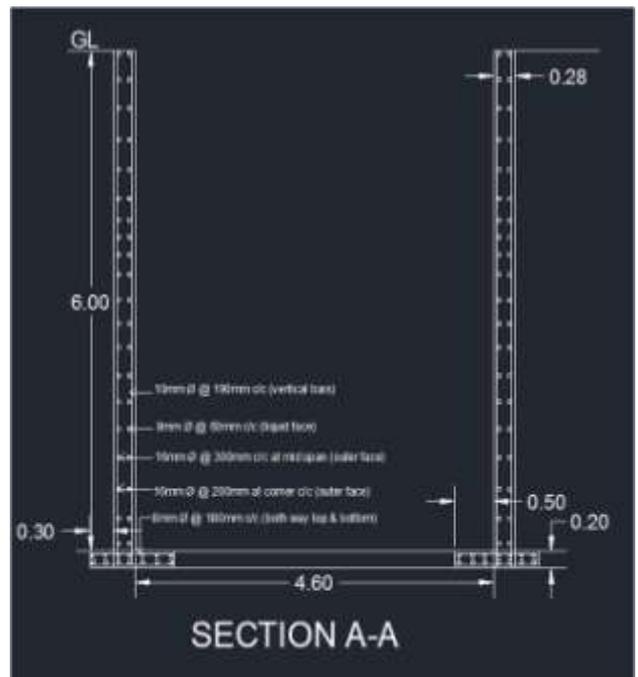


Figure 11: Section of watershed tank (watershed)

6.4.2 Software Analysis using Staad. Pro V8i

- 1) This software is used to do the study of load & pressure acting on tank like Hydrostatic pressure, soil pressure on the plate element.
- 2) It also helps to identify the safe & critical portion in a stress diagram. Also it gives the value of steel in tank design summary.

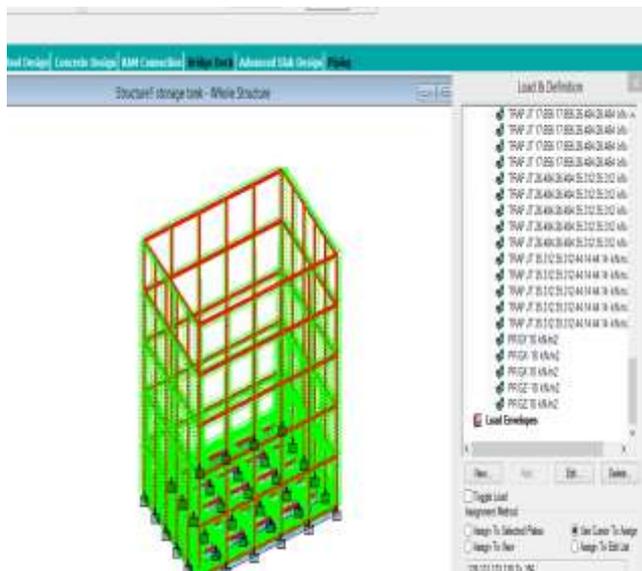


Figure 12: Loading details of Storage tank

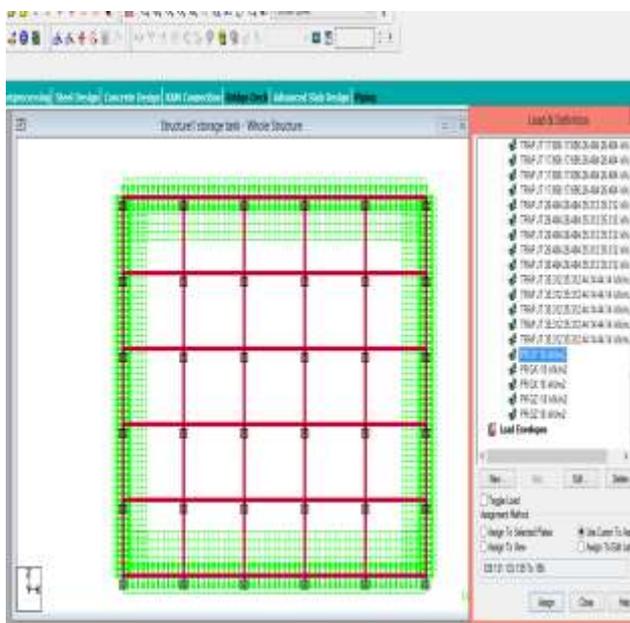


Figure 13: Top view of Storage tank

ELEMENT	LONG. REINFC (SQ. MM)	TRNSV. REINFC (SQ. MM)	TRNSV. REINFC (SQ. MM)	TRNSV. REINFC (SQ. MM)
13-ROF	872	0.00 / 0	372	0.00 / 0
ROFT	372	-54.88 / 1	372	-2.81 / 1
17-ROF	872	0.00 / 0	372	0.00 / 0
ROFT	372	-54.88 / 1	372	-1.41 / 1
20-ROF	872	0.00 / 0	372	0.00 / 0
ROFT	372	5.98 / 0	372	-1.52 / 1
21-ROF	872	0.00 / 0	372	0.00 / 0
ROFT	372	-54.88 / 1	372	-1.42 / 1
05-ROF	872	0.00 / 0	372	0.00 / 0
ROFT	372	-54.88 / 1	372	-0.81 / 1
05-ROF	872	0.00 / 0	372	0.00 / 0
ROFT	372	-6.82 / 1	372	-1.27 / 1
24-ROF	872	0.00 / 0	372	0.00 / 0
ROFT	372	-3.78 / 1	372	-0.46 / 1
07-ROF	872	0.00 / 0	372	0.00 / 0
ROFT	372	-6.81 / 1	372	-0.38 / 1
20-ROF	872	0.00 / 0	372	0.00 / 0

Figure 14: Element Design Summary

Note:

- 1) Similarly we had design for tank 2,3,4,5.
- 2) The structure proposed in the area for collection of rainwater for watershed management is like a farm pond. The reinforced cement concrete rectangle tank is proposed for collection of water. The tank 1 (watershed) will be open from top & bottom so that the rainwater should percolate into the ground for recharging the ground water table.

6.5 Filtration unit, Design of Slow Sand filter & Water Testing

Dimensions of filter: **5.6 x 3.8 x 3.0 m**

1. The bottom layer is of gravel material of thickness 70 cm which consist of 4 layers of gravels.

Table: Materials in Filter

Gravel	Depth	Size
Bottom layer	20 cm	60 mm
Intermediate layer	20 cm	40 mm
Intermediate layer	15 cm	20 mm
Top layer	15 cm	6 mm

2. Sand layer is of 90 cm thickness
3. Supernatant height is 1.2 m
4. Under drained consist of 76 nos laterals of length 1.67 m & 4.2 cm diameter place at 15 cm c/c spacing, each having 4 perforations of 13 mm size with 46 cm diameter manifold.

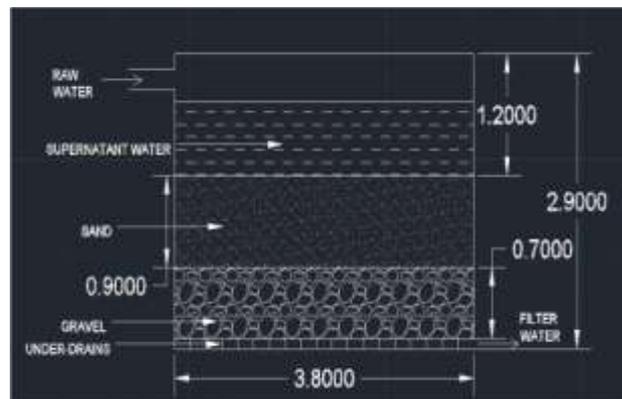


Figure 15: Slow Sand Filter

Note:

There will be a two filtration unit one for rainwater harvesting tank i.e. water from the roof & other for watershed tank.

6.5.1 Water testing before & after filtration



Figure 16: Source of Water

6.5.2 Prototype of slow sand filter



Figure 17: Materials used in slow sand filter

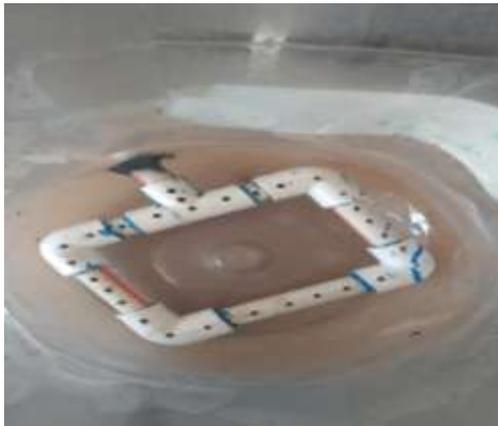


Figure 18: Under Drain

The above is the prototype of slow sand filter made by us to carry out the testing experiment on water before & after passing the water from prototype filter.

6.5.3 Test conducted on water

- pH test
- Turbidity test
- Alkalinity test
- Hardness test
- Flocculation test

Test results:

Sr. No.	Test	Sample water before filtration	Sample water after filtration	Standard as per IS 10500: 1991
1	Ph	8.08	7.47	6.5 – 8.5
2	Turbidity	6.3 NTU	3.9 NTU	1 – 5 NTU
3	Alkanity	97 mg/lit	88 mg/lit	80 – 120 mg/lit
4	Hardness	374.5 mg/lit	322 mg/lit	300 – 600 mg/lit
5	Jar test (alum dosage)		10 mg/lit (ph = 6.2)	



Figure 19: Jar testing Alum dosage of 10mg/lit is best suited.

7. Methodology

(for project-2 i.e. Rainwater Harvesting)

7.1. Collection of water from the roof through the gutter into the storage tank.

7.2. Literature Review

1. History. 2. Research papers & Case study. 3. Rainfall data.

7.3. Purification of water

1. Filtration unit. 2. Testing of water.

7.4. Pure water storage and distribution

7.5. Software to be used

1. Primavera. 2. AutoCAD.

8. Data Collected for Rainwater Harvesting

- 1) Area of catchment 2220 sq.m
- 2) Average annual rainfall 3336.79 mm
- 3) Runoff coefficient 0.90
- 4) Rainfall that can be harvested from the rooftop
- 5) Annual water harvesting potential = $2220 \times 3.33 \times 0.9 = 66,59,933$ lit.
- 6) Approximate requirement of water/day: 72000 lit
- 7) Population: 1800

9. Water storage & Distribution



Figure 20: Distribution Layout

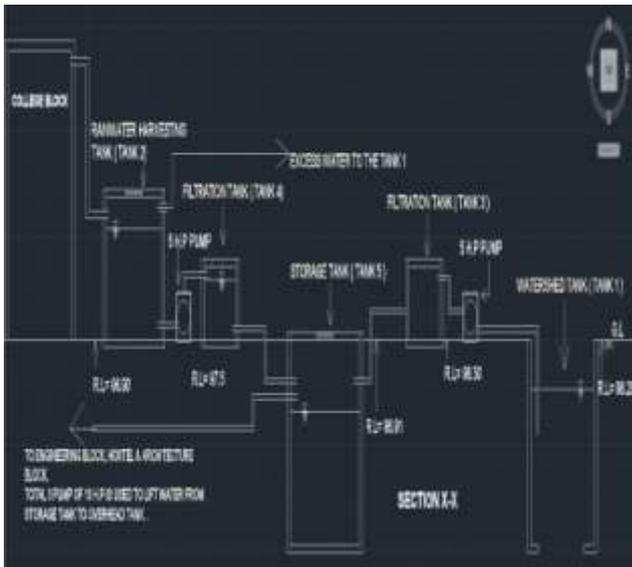


Figure 21: Sectional layout

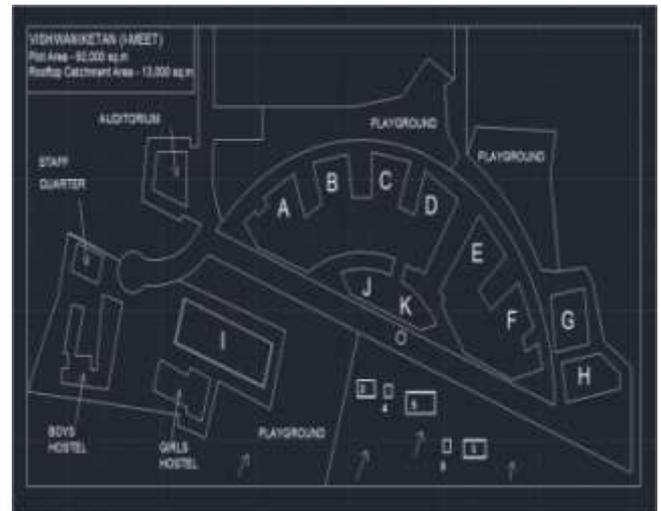


Figure 22: Vishwaniketan's Campus & Positions of water tanks

9.1 Collection & Distribution of Rain Water

- 1) The rain water during monsoon season is collected in watershed tank.
- 2) The collected water from the watershed tank is then transferred to slow sand filter unit for further purification using 5H.P motor Pump.
- 3) The filtered water is then transferred to storage unit by gravity.
- 4) Now, the water from roof top of block A & B is collected in rainwater harvesting tank.
- 5) From this the collected water from the rain water harvesting tank is then transferred to slow sand filter unit for further purification using 5H.P motor Pump.
- 6) The excess water i.e. overflows of water from the Rainwater harvesting tank can be send to the watershed tank.
- 7) The filtered water is then transferred to storage unit by gravity.
- 8) In storage tank, by using alum of 10mg/lit dosage we can see the change in colour. Also it improves the other properties of water.
- 9) For distribution of water from storage tank to Architecture building, Hostel & Engineering college building can be done by using 3 pump of 10 H.P.

9.1.1 Important Points

- 1) The watershed tank is open from top & bottom so rain water can easily percolate underground & it will recharge the ground water table.
- 2) So, when the scarcity begins we can dug bore wells at the side of tank or from the existing well & can extract the water & can store in the storage tank.

10. Vishwaniketan's campus details, water tank positions & final layout of the project



Figure 23: Front side 3D view of vishwaniketan's campus made in a Autocad which shows the positions of tanks.

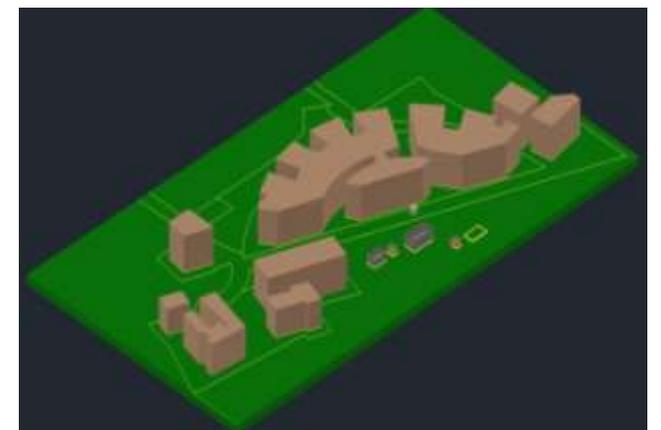


Figure 24: Back side 3D view of vishwaniketan's campus.

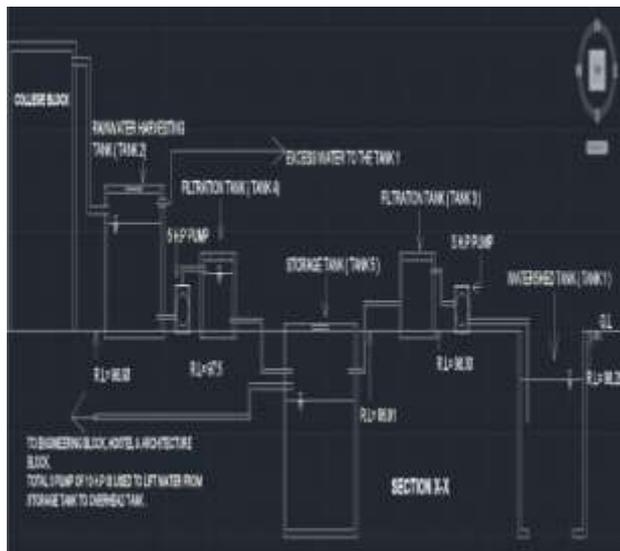


Figure 25: Layout of Project Watershed Management & Rainwater Harvesting

11. Estimate of the Project

Abstract Sheet

Rates are as per DSR 2015-16 PWD Alibaug.

S.no	Description	Unit	Rate	Quantity	Total amount
1	Excavation for foundation	M3	217	377.12	81835.14
2	P.C.C bed of M15 grade	M3	5126	15.35	78684.19
3	R.C.C concrete of grade M25	M3	8769	161.74	1418298.16
4	Backfilling of excavated soil	M3	70.40	79.38	5588.45
5	Steel reinforcement	M.T	54784	19.04	1043364.99
6	Pipes for carrying water	RPM	700	218	152600
7	Pumps 1)10 H.P 2)5 H.P		35000 20000	3 2	105000 40000
8	Total				2925370.93
9	Contingencies – 5 %				146268.54
10	Work charged establishment – 2 %				58507.41
11	Water supply & Electric Charges – 8 %				234029.67
12	Contractors profit – 10 %				292537.09
13	Total cost				36,56,715/-

Note:

The investment for the project is 36,56,715/- which is high but it can be recovered within 5 years. As already mentioned our college is spending 8 lakhs annually.

12. Conclusions

- 1) Plenty of water is available in monsoon season, particularly in Konkan region where more than 3000 mm rainfall is available.
- 2) After the end of rainy season around the month of December water scarcity starts & water demand increases, which further leads to lack of availability of water.

- 3) As large amount of ground water is drawn out from underground, reduction of ground water table occurs which interns reduces water level in well.
- 4) To cater this problem of water storage in vishwaniketan’s campus areas, the technique of watershed management & rainwater harvesting is best suited.
- 5) By this method ground water table increases thus providing sufficient water during summer season & reducing the call of tankers on which a lot of money is spent.
- 6) The initial cost of the project is high but it is economical.
- 7) The structure of tank is made by using R.C.C which can last for many years.

13. Acknowledgement

We would like to thanks our Project Guide **Prof. Shilpa Deshpande**, Co-guide **Prof. Rupesh Devale** who have invested their full effort in guiding the team in achieving the goal. We also would like to thank **Dr. Sunil Kirloskar**, whose contribution in stimulating suggestions and encouragement helped us to coordinate our project & also we would like to thank **Prof. Abhishek Shirsath** for his kind support throughout the project.

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