



ANDHRA UNIVERSITY

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Report on Rain Water Harvesting vis-à-vis Groundwater Recharge



**Andhra University
Visakhapatnam**

Report on the
**Rain Water Harvesting vis-à-vis
Groundwater Recharge
at Andhra University Campus,
Visakhapatnam**

**Prof. G.V.R. Srinivasa Rao
Prof. Y. Abbulu
Prof. S. Bala Prasad**

**Department of Civil Engineering
A.U. College of Engineering (A)**



**ANDHRA UNIVERSITY
VISA KHAPATNAM
2020**

INTRODUCTION

The increasing importance of Rain Water Harvesting (RWH) and Artificial Recharge of Groundwater became a vital element in strategy of sustainable development. Hence, the technological missions of Government of India have been advocating for the development of various methods to harness and manage the monsoonal rain water and research on rain water harvesting. National Water Mission (NWM) campaign 'Catch the Rain' wherein it has been decided to ensure the stakeholders to create Rain Water Harvesting Structures (RWHS) suitable to the climate. In this connection, the Honorable Governor of Andhra Pradesh and Chancellor of Andhra University directed the Vice-Chancellors to take up the RWHS in the university campus as per the objectives of the NWM.

The Andhra University took up the activity of groundwater recharging in a scientific manner with the support of DST. The Department of Science and Technology, Govt. of India supported the RWH vis-à-vis groundwater recharge project in the Andhra University vide Ref. No: DST/TM/WTI/2K14/196. The concept of studying the groundwater dynamics and augmenting the water supplies with suitable groundwater recharging systems has been in place to create awareness in the society for proper management of groundwater resources. The Andhra University is probably the first university to conduct a detailed study of groundwater recharge potential in the Andhra University campus, Visakhapatnam, by adopting suitable methodologies for rainwater harvesting in the campus.

THE ANDHRA UNIVERSITY

The Andhra University is one of the oldest premier educational institutions in the country, constituted in the year 1926 by the Madras Act of 1926. The 93-year-old institution works with the vision of creating new frontiers of knowledge in quest for development of a humane and just society. The University has more than 66 academic departments and centres as part of the constituent colleges: Arts, Commerce & Management, Law, Science & Technology and Engineering & Pharmacy. Institute of Yoga & Consciousness, a world class yoga village, caters to the emotional and physical health of the citizens of Visakhapatnam. The University promotes Fine Arts and Performing Arts through the Department of Fine Arts, Music, Dance and Theatre. Center of Environment, Sustainable Development and climate Change is the recent addition to extend the academic and extensive services to the government and society. The University is spread in a sprawling campus of 422 acres dotted with 170 buildings of academic, administrative and support services and 258 staff quarters with a roof top area of about 20 lakhs sq.ft.

More than 7000 students and 600 staff with their family members are residing in the campus. The area comprises of North and South campuses of the Andhra University which is surrounded by several residential colonies viz., Pithapuram Colony, Naukanagar, Chinna Waltair, HPCL Colony, Panduranga Puram, Siripuram, BalajiNagar, Resuvanipalem and Maddilapalem with a population of approximately 3,00,000. The layout of the Andhra University is depicted in the Figure 1. The Google Earth image of the Andhra University campus is shown in Figure 2.

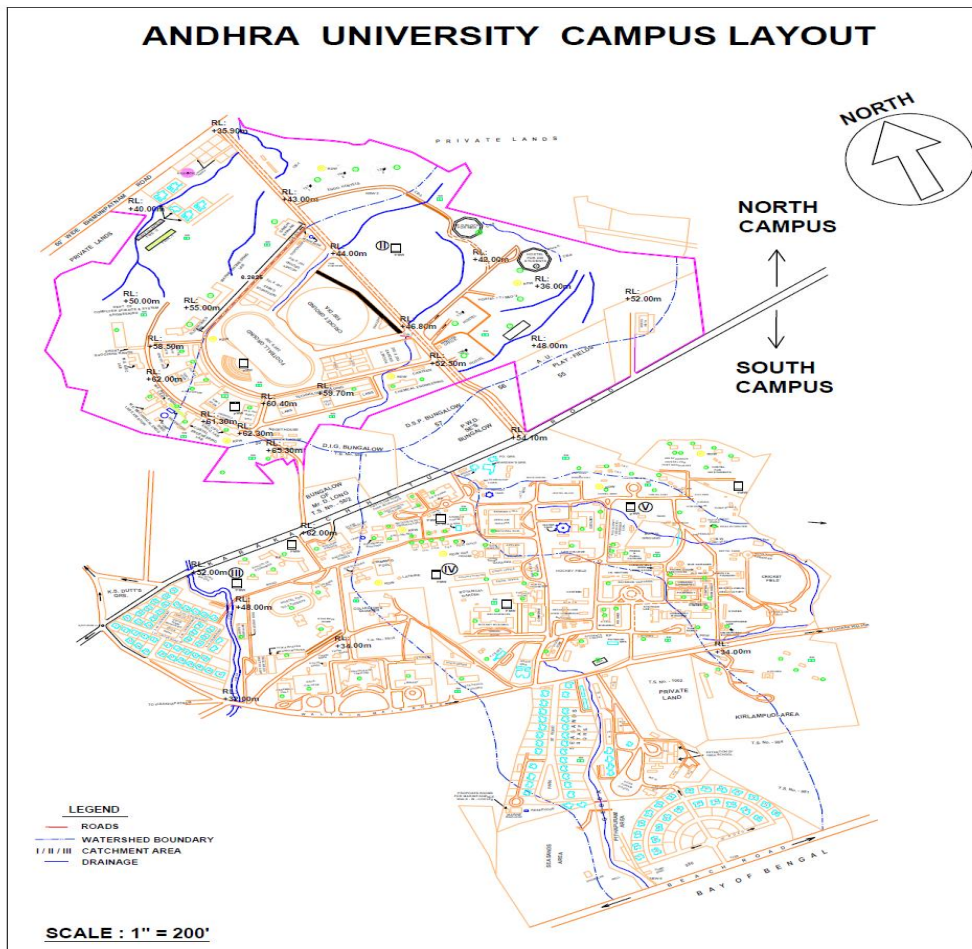


Figure 1: Andhra University Campus Layout along with the adjoining areas.

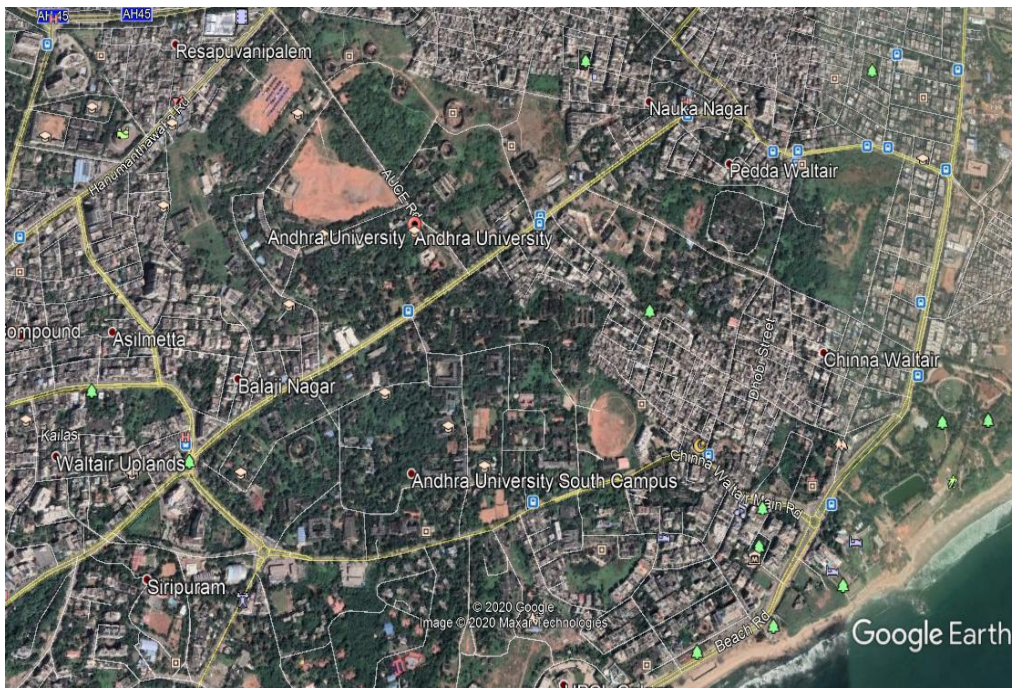


Figure 2: Google Image of the Andhra University Campus

THE ANDHRA UNIVERSITY: RAIN WATER HARVESTING

The campus is located in an upland area on the east coast and the ground levels vary from +72.00 m to +10.00 m making it a sloppy terrain. The contour differences are about 30 m in the northern portion and 50m in the southern portion of the campus. The contour map is presented in the Figure 3. The entire university area is covered with red loamy, laterite and sandy soils with high porosity and infiltration capacity. Red soils are formed from the parent khondalite rock whereas the sandy soils are confined to sea coast. Uneven land topography with gullied nature is observed. The hilly terrain contains a thin veneer of hydrophilic soils which supports luxuriant forest vegetation. The hilly terrain contains a thin layer of hydrophilic soils supporting forest vegetation. Table 1 shows the results of the geophysical studies conducted at different locations in the university campus. The details of the geological strata of the Andhra University area along with its immediate neighbourhood are shown pictorially in Figure 4 and Figure 5. The ground water pathways are shown in Figure 6. The micro watersheds in the university campus are shown in Figure 7.

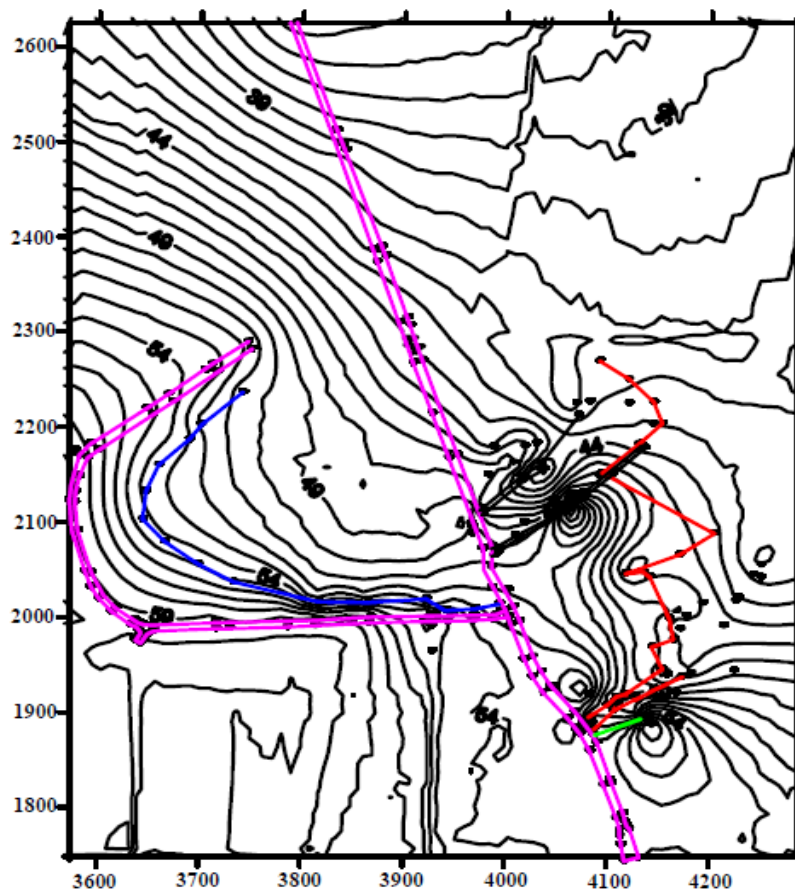


Figure 3: The Contour Map of Andhra University, Visakhapatnam.

The campus receives a total rainfall of 1121.60 mm per year on an average. The rainfall is distributed over 118 rainy days with maximum amount of rainfall occurring during months July to October every year. Owing to the varied topographical features most of the rainfall goes without tapped and utilized properly. On the other hand, to support the needs of nearly 9000 students, faculty and supporting staff residing in the campus and for other activities the university requires approximately 20 lakh litres of water per day. The groundwater sources of the university at present are able to supply only 7 to 9 lakh litres per day, the remaining amount of water being supplied by the municipal corporation at a specified rate. The university is

located on a dome like geological terrain surrounded by number of residential colonies on all sides; the effective recharging of rainwater in the campus may enrich the groundwater table in the surrounding colonies benefiting two to three lakhs of people residing there. Therefore, keeping in view of the above cited figures, there is a necessity to adopt and implement suitable rainwater harvesting systems through systematic study to tap the groundwater recharge potential at the campus. Hence, the Andhra University implemented the ‘Catch the Rain’ program through an effective RWH system in its campus.

The RWH systems in place in the Andhra University campus are i) Construction of suitable rainwater harvesting structures of different types like recharge wells, pits, check dams etc. throughout the campus; ii) Providing monitoring wells in the area of influence to study the water level fluctuations at regular intervals of time; and iii) dissemination of the knowledge gained through the RWH project and creating awareness in the society for proper management of groundwater resources.

Table 1: Results of Geophysical Studies Conducted at Different Places in Andhra University Campus.

Depth (ft)	Type of Soil/Rock				
	NCC Camp Office	CSE Department	Samatha Hostel	Dispensary, AU South Campus	Assembly Hall
0-10	Gravel	Gravel	Gravel	Gravel	Gravel
10-20	Gravel	Gravel	Gravel	Gravel	Gravel
20-30	Weathered Charnockite	Gravel	Gravel	Gravel	Weathered Liptinite
30-40	Weathered Charnockite	Loamy Red Soil	Gravel	Highly Weathered Liptinite	Weathered Liptinite
40-50	Weathered Charnockite	Loamy Red Soil	Red Loamy	Highly Weathered Liptinite	Weathered Liptinite
50-60	Weathered Charnockite	Highly Weathered Khondalite	Red Loamy	Weathered Liptinite	Weathered Liptinite
60-70	Fractured Charnockite	Highly Weathered Khondalite	Red Loamy	Weathered Liptinite	Fractured Liptinite
70-80	Fractured Charnockite	Highly Weathered Khondalite	Red Loamy	Weathered Liptinite	Fractured Liptinite
80-90	Fractured Charnockite	Highly Weathered Khondalite	Highly Weathered Khondalite	Fractured Liptinite	Fractured Liptinite
90-100	Fractured Charnockite	Weathered Khondalite	Highly Weathered Khondalite	Fractured Liptinite	Fractured Liptinite

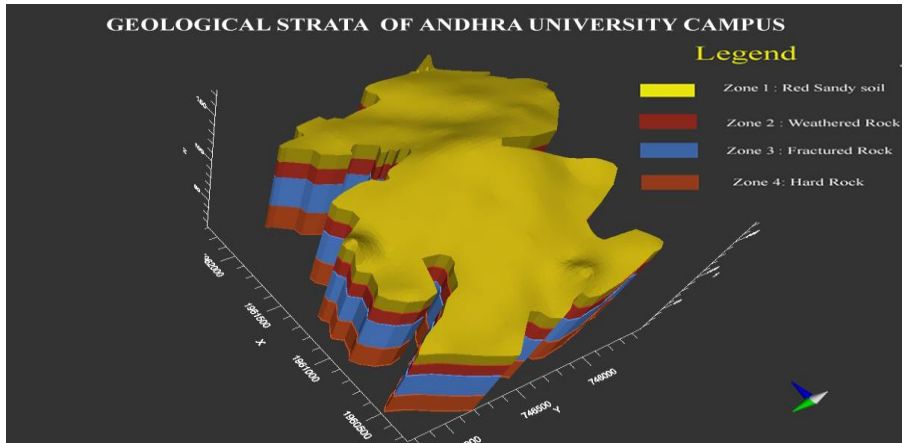


Figure 4: Geological Strata of Andhra University Campus

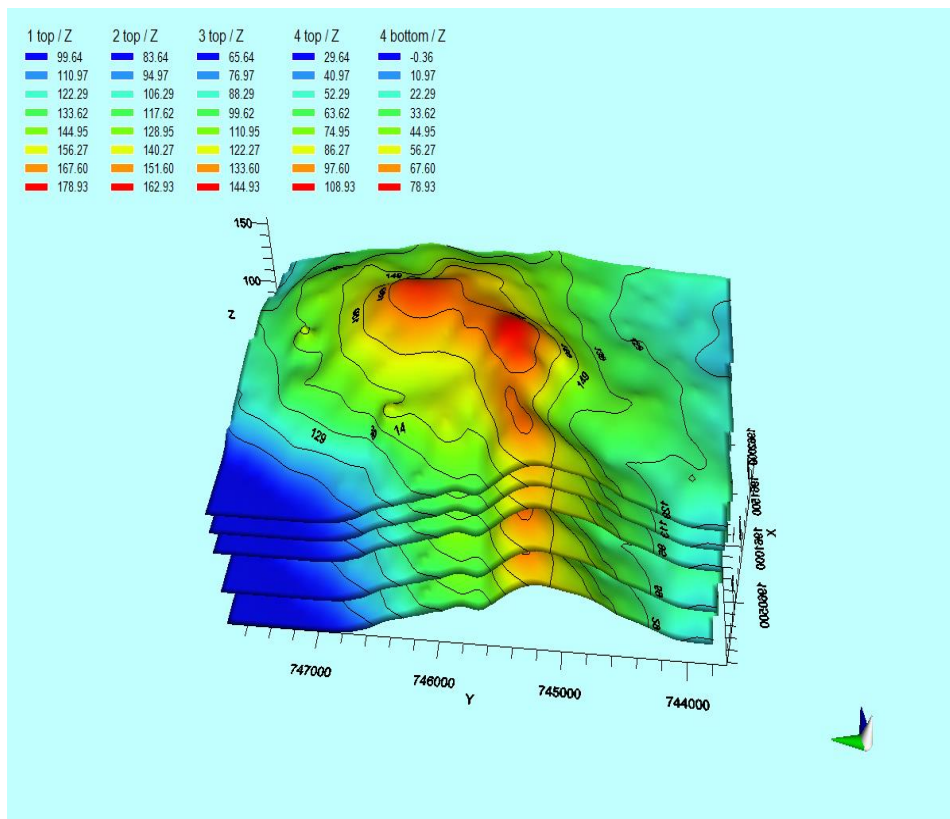


Figure 5: Geological Strata of the Andhra University along with its Neighbourhood

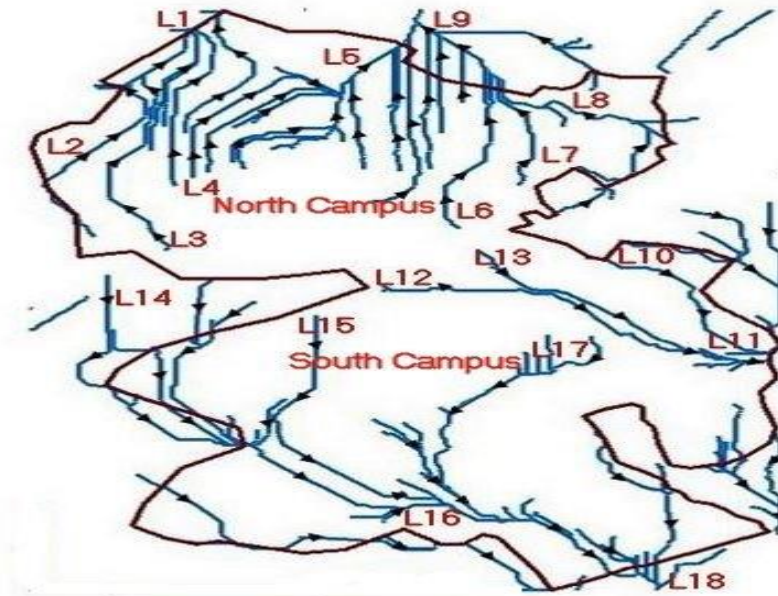


Figure 6: Groundwater Flow Pathways in the Andhra University, Visakhapatnam

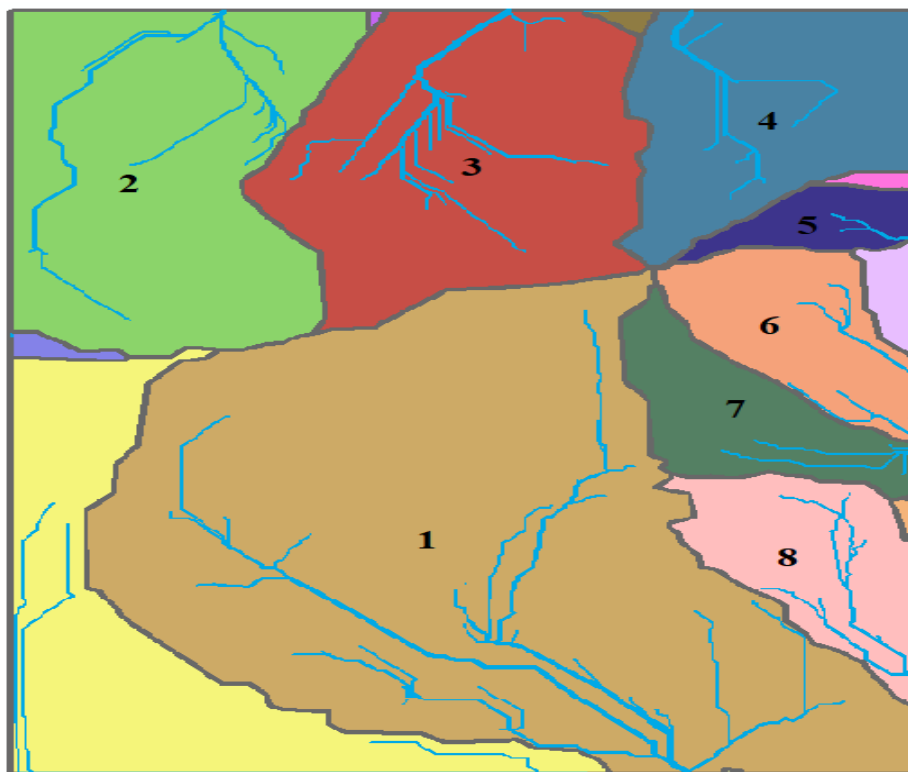


Figure 7: Delineation of Micro Watersheds in the University Campus

The major buildings in each of the watershed of the Andhra University campus are identified for placing the RWH systems. The topographical characteristics of the micro-watersheds are shown in Table 3. The details of identified major buildings in each of the watersheds are given in Table 4. The order of the channels or water courses or streams passing through the campus are presented in Table 5.

Table 3: Topographic Characteristics of the Micro-Watersheds

Micro watershed	Area (km ²)	Minimum elevation (m MSL)	Maximum elevation (m MSL)
MW1	0.781	8	75
MW2	0.306	38	75
MW3	0.282	38	75
MW4	0.182	38	60
MW5	0.005	45	60
MW6	0.089	30	60
MW7	0.031	30	60
MW8	0.100	8	45

Table 4: Major buildings/areas in Micro-watershed of the Andhra University, Visakhapatnam

Watershed No	Buildings / Areas covered	Watershed No	Buildings / Areas covered
1	Central administrative office	2	Maddilapalem Gate
	Avula Sambasiva Rao women's hostel		N.C.C. Building
	South Campus Post office		N.C.C. Opposite ground
	Commerce and Management department		Y.V.S. Murthy auditorium
	Sir CR Reddy convocation hall		Marine Department
	Nagarjuna hostel		ECE Department
	Officer's colony		CSE Department
	HPCL Waltair park		CSE new class rooms
	Resident quarters		EEE Department
	A.U. Yoga village		Engineering Exams cell
	Department of Marine Living Resources		Mechanical Department
A.U. High school	Civil Department		
3	P.G. Girls hostel	4	A.U Samatha hostel
	A.U. Engineering boys hostel		A.U International student hostel
	A.U. Engineering girls hostel		A.U Mamatha law hostel
	A.U. Engineering college ground		
5	Vidya Research Scholars hostel	6	Siddardha hostel
			Sathavahana hostel
			Sri Krishna Devaraya hostel
			AU Health centre
7	G.M.C. Balayogi Research scholars hostels	8	A.U. Platinum Jubilee Guest House
	A.U. South Campus Ground		School of Distance Education
	Dept. of Physical Sciences		APCET Office
	Dept. of fine arts		AU International Student Hostel (South Campus)
	T.L.N. Sabha Hall		
	Dept. of Physical education		

Table 5: Stream Order and Number of Streams in the Study Area in each of the Watersheds

Watershed	1-Order streams	2-Order streams	3-Order streams	4-Order streams	Total streams
1	32	6	2	1	41
2	11	2	1	0	14
3	15	5	1	1	22
4	8	2	1	0	11
5	2	1	0	0	3
6	6	2	0	0	8
7	4	1	0	0	5
8	6	2	1	0	9
Total	84	21	6	2	113

IDENTIFICATION OF POTENTIAL RECHARGE SITES

Apart from the buildings that are selected for roof top RWH, there are some sites that are suitable for rainwater harvesting through transient storage / ponding. These potential sites in the study area for groundwater recharge through structures like check dams are identified and are shown in Figure 7 and Table 6.

Table 6: Potential Recharge Sites in the Study Area apart from the Buildings

S.No	Potential recharge site no.	Location of potential recharge sites		Nearest building to identify the location
		latitude	longitude	
1	PRS1	17 ⁰ 43' 04.25''	83 ⁰ 19' 37.12''	A.U. Yoga village
2	PRS2	17 ⁰ 43' 56.26''	83 ⁰ 19' 11.40''	Opposite to NCC Office
3	PRS3	17 ⁰ 44' 0.41''	83 ⁰ 19' 19.70''	A.U Boys hostels (Engg. Campus)
4	PRS4	17 ⁰ 43' 55.89''	83 ⁰ 19' 41.02''	International Students hostel
5	PRS5	17 ⁰ 43' 46.13''	83 ⁰ 19' 39.30''	Vidya Research Scholars hostel
6	PRS6	17 ⁰ 43' 19.35''	83 ⁰ 19' 47.38''	AU Health centre, South Campus
7	PRS7	17 ⁰ 43' 22.73''	83 ⁰ 19' 47.05''	A.U South Campus Ground
8	PRS8	17 ⁰ 43' 26.76''	83 ⁰ 19' 47.65''	Platinum Jubilee Guest House

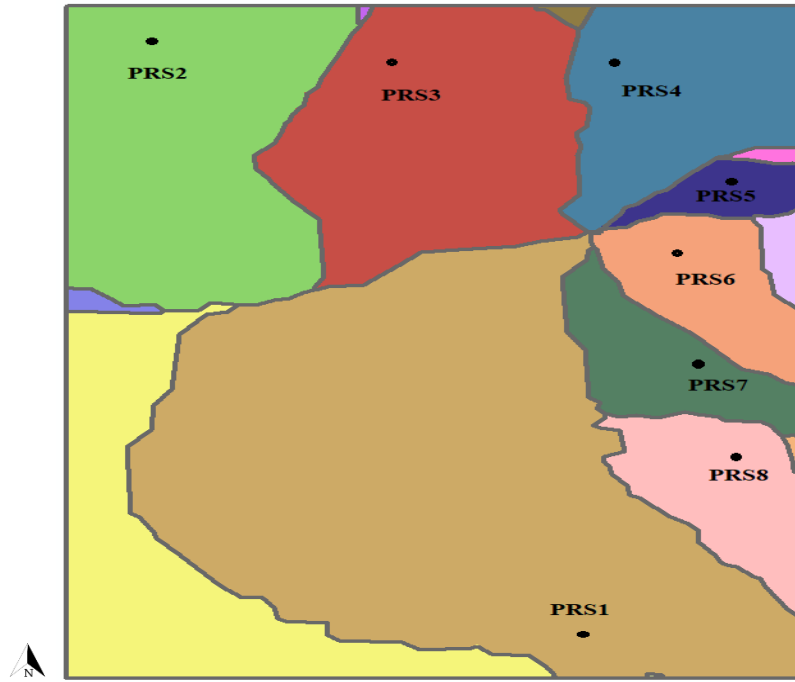


Figure 7: Potential Recharge Sites other than Buildings in the Andhra University Campus

ESTABLISHMENT OF RAINWATER HARVESTING STRUCTURES

The rainwater harvesting structures comprising of 211 recharge wells and these recharge wells are located in the potential recharge locations as identified in the delineation of micro-watersheds. The diameter and depth of each recharge well are 1.2 m and 2.1 m respectively. These wells are connected to 62 major buildings identified in all the micro-watersheds. Two Check dams are constructed as a part of the project in the campus. Table 7 gives the location's details of these wells. The locations of the recharge wells are shown in Figure 8.

Table 7: Locations of Recharge Wells in the University Campus

S.NO	Recharge Well Number	Location of Well	Latitude	Longitude
1	RWHS 1	Instrument Technology Building	17° 43' 44" N	83° 19' 25" E
2	RWHS 2		17° 43' 44" N	83° 19' 25" E
3	RWHS 3		17° 43' 44" N	83° 19' 25" E
4	RWHS 4		17° 43' 42" N	83° 19' 34" E
5	RWHS 5		17° 43' 42" N	83° 19' 34" E
6	RWHS 6	Chemical Technology Building	17° 43' 42" N	83° 19' 32" E
7	RWHS 7		17° 43' 44" N	83° 19' 21" E
8	RWHS 8		17° 43' 44" N	83° 19' 18" E
9	RWHS 9		17° 43' 41" N	83° 19' 18" E
10	RWHS 10		17° 43' 41" N	83° 19' 18" E
11	RWHS 11		17° 43' 41" N	83° 19' 18" E
12	RWHS 12		17° 43' 41" N	83° 19' 18" E
13	RWHS 13		17° 43' 41" N	83° 19' 18" E
14	RWHS 14		17° 43' 41" N	83° 19' 18" E
15	RWHS 15		17° 43' 41" N	83° 19' 18" E

16	RWHS 16	Civil Engineering Building	17° 43' 62" N	83° 19' 19" E
17	RWHS 17		17° 43' 63" N	83° 19' 19" E
18	RWHS 18	Mechanical Engineering Building	17° 43' 66" N	83° 19' 14" E
19	RWHS 19		17° 43' 67" N	83° 19' 14" E
20	RWHS 20		17° 43' 68" N	83° 19' 13" E
21	RWHS 21		17° 43' 67" N	83° 19' 15" E
22	RWHS 22		17° 43' 68" N	83° 19' 12" E
23	RWHS 23		17° 43' 69" N	83° 19' 13" E
24	RWHS 24	Electrical Engineering Building	17° 43' 74" N	83° 19' 11" E
25	RWHS 25		17° 43' 74" N	83° 19' 09" E
26	RWHS 26	Computer Science Engineering Building	17° 43' 77" N	83° 19' 09" E
27	RWHS 27		17° 43' 79" N	83° 19' 08" E
28	RWHS 28		17° 43' 80" N	83° 19' 07" E
29	RWHS 29		17° 43' 80" N	83° 19' 06" E
30	RWHS 30		17° 43' 79" N	83° 19' 06" E
31	RWHS 31		17° 43' 78" N	83° 19' 07" E
32	RWHS 32		17° 43' 77" N	83° 19' 07" E
33	RWHS 33	New Class Room Copm.	17° 43' 75" N	83° 19' 03" E
34	RWHS 34	Metallurgical Engineering Building	17° 43' 82" N	83° 19' 05" E
35	RWHS 35		17° 43' 83" N	83° 19' 06" E
36	RWHS 36		17° 43' 84" N	83° 19' 06" E
37	RWHS 37	ECE Building	17° 43' 81" N	83° 19' 18" E
38	RWHS 38		17° 43' 81" N	83° 19' 16" E
39	RWHS 39	Marine Engineering Building	17° 43' 82" N	83° 19' 18" E
40	RWHS 40		17° 43' 83" N	83° 19' 20" E
41	RWHS 41		17° 43' 85" N	83° 19' 21" E
42	RWHS 42		17° 43' 84" N	83° 19' 19" E
43	RWHS 43		17° 43' 84" N	83° 19' 19" E
44	RWHS 44		17° 43' 85" N	83° 19' 21" E
45	RWHS 45	Bhaskara Hostel	17° 43' 97" N	83° 19' 28" E
46	RWHS 46		17° 43' 97" N	83° 19' 28" E
47	RWHS 47		17° 43' 98" N	83° 19' 27" E
48	RWHS 48		17° 43' 98" N	83° 19' 30" E
49	RWHS 49		17° 43' 99" N	83° 19' 29" E
50	RWHS 50	Thomsa Alva Edison Hostel	17° 43' 98" N	83° 19' 31" E
51	RWHS 51		17° 44' 01" N	83° 19' 31" E
52	RWHS 52		17° 43' 99" N	83° 19' 33" E
53	RWHS 53		17° 44' 01" N	83° 19' 33" E
54	RWHS 54		17° 44' 01" N	83° 19' 33" E
55	RWHS 55	J C Bose Hostel	17° 44' 00" N	83° 19' 35" E
56	RWHS 56		17° 44' 01" N	83° 19' 35" E
57	RWHS 57		17° 44' 00" N	83° 19' 37" E
58	RWHS 58		17° 44' 01" N	83° 19' 37" E
59	RWHS 59		17° 44' 02" N	83° 19' 37" E
60	RWHS 60		Dr. B.R.Ambedkar Hostel	17° 43' 94" N
61	RWHS 61	17° 43' 96" N		83° 19' 41" E
62	RWHS 62	17° 43' 95" N		83° 19' 42" E
63	RWHS 63	17° 43' 93" N		83° 19' 42" E
64	RWHS 64	Ravindranath Tagore Hostel	17° 43' 82" N	83° 19' 43" E
65	RWHS 65		17° 43' 84" N	83° 19' 45" E
66	RWHS 66		17° 43' 83" N	83° 19' 46" E
67	RWHS 67		17° 43' 82" N	83° 19' 47" E
68	RWHS 68	Swamy Vivekananda Hostel	17° 43' 86" N	83° 19' 50" E

69	RWHS 69		17° 43' 86" N	83° 19' 51" E
70	RWHS 70		17° 43' 83" N	83° 19' 48" E
71	RWHS 71		17° 43' 84" N	83° 19' 50" E
72	RWHS 1	Nagarjuna Hostel	17° 43' 41" N	83° 19' 28" E
73	RWHS 2		17° 43' 43" N	83° 19' 27" E
74	RWHS 3		17° 43' 41" N	83° 19' 23" E
75	RWHS 4		17° 43' 39" N	83° 19' 23" E
76	RWHS 5		17° 43' 38" N	83° 19' 25" E
77	RWHS 6	Social Sciences Building	17° 43' 43" N	83° 19' 21" E
78	RWHS 7		17° 43' 43" N	83° 19' 20" E
79	RWHS 8		17° 43' 42" N	83° 19' 20" E
80	RWHS 9		17° 43' 44" N	83° 19' 22" E
81	RWHS 10	Music & Dance Building	17° 43' 45" N	83° 19' 19" E
82	RWHS 11		17° 43' 45" N	83° 19' 21" E
83	RWHS 12	IASE Building	17° 43' 46" N	83° 19' 23" E
84	RWHS 13		17° 43' 46" N	83° 19' 24" E
85	RWHS 14	Ranjani Guest House	17° 43' 46" N	83° 19' 35" E
86	RWHS 15		17° 43' 46" N	83° 19' 33" E
87	RWHS 16	DurgabhaiDeshmukh Centre for Women Studies	17° 43' 38" N	83° 19' 21" E
88	RWHS 17		17° 43' 37" N	83° 19' 19" E
89	RWHS 18		17° 43' 35" N	83° 19' 21" E
90	RWHS 19		17° 43' 35" N	83° 19' 19" E
91	RWHS 20	Department of Para - Psychology	17° 43' 32" N	83° 19' 21" E
92	RWHS 21		17° 43' 29" N	83° 19' 29" E
93	RWHS 22	Telugu Bhavan	17° 43' 31" N	83° 19' 23" E
94	RWHS 23		17° 43' 32" N	83° 19' 22" E
95	RWHS 24	Hindi Bhavan	17° 43' 32" N	83° 19' 28" E
96	RWHS 25		17° 43' 33" N	83° 19' 27" E
97	RWHS 26		17° 43' 33" N	83° 19' 25" E
98	RWHS 27	Arts College Building	17° 43' 29" N	83° 19' 31" E
99	RWHS 28		17° 43' 31" N	83° 19' 30" E
100	RWHS 29	Assembly Hall	17° 43' 27" N	83° 19' 26" E
101	RWHS 30		17° 43' 28" N	83° 19' 28" E
102	RWHS 31	Convocation Theatre	17° 43' 27" N	83° 19' 31" E
103	RWHS 32		17° 43' 31" N	83° 19' 35" E
104	RWHS 33		17° 43' 31" N	83° 19' 33" E
105	RWHS 34	Dr. V.S.Krishna Library	17° 43' 27" N	83° 19' 39" E
106	RWHS 35		17° 43' 29" N	83° 19' 38" E
107	RWHS 36		17° 43' 30" N	83° 19' 38" E
108	RWHS 37		17° 43' 30" N	83° 19' 40" E
109	RWHS 38		17° 43' 31" N	83° 19' 41" E
110	RWHS 39	Reading Room	17° 43' 30" N	83° 19' 42" E
111	RWHS 40		17° 43' 28" N	83° 19' 42" E
112	RWHS 41	Department of Statistics	17° 43' 28" N	83° 19' 46" E
113	RWHS 42		17° 43' 31" N	83° 19' 46" E
114	RWHS 43		17° 43' 28" N	83° 19' 43" E
115	RWHS 44		17° 43' 30" N	83° 19' 43" E
116	RWHS 45	Department of Geography	17° 43' 49" N	83° 19' 37" E
117	RWHS 46	Advanced Sciences Bhavan	17° 43' 42" N	83° 19' 42" E
118	RWHS 47		17° 43' 41" N	83° 19' 50" E
119	RWHS 48		17° 43' 43" N	83° 19' 49" E
120	RWHS 49		17° 43' 44" N	83° 19' 48" E
121	RWHS 50		17° 43' 46" N	83° 19' 48" E

122	RWHS 51		17° 43' 46" N	83° 19' 50" E
123	RWHS 52		17° 43' 44" N	83° 19' 49" E
124	RWHS 53		17° 43' 44" N	83° 19' 49" E
125	RWHS 54	Science and Technology Bhavan	17° 43' 48" N	83° 19' 52" E
126	RWHS 55		17° 43' 48" N	83° 19' 51" E
127	RWHS 56		17° 43' 48" N	83° 19' 51" E
128	RWHS 57		17° 43' 48" N	83° 19' 52" E
129	RWHS 58		17° 43' 49" N	83° 19' 53" E
130	RWHS 59		17° 43' 46" N	83° 19' 53" E
131	RWHS 60			17° 43' 47" N
132	RWHS 61	Department of Biochemistry	17° 43' 50" N	83° 19' 49" E
133	RWHS 62		17° 43' 46" N	83° 19' 49" E
134	RWHS 63		17° 43' 49" N	83° 19' 49" E
135	RWHS 64	CAO office	17° 43' 58" N	83° 19' 45" E
136	RWHS 65		17° 43' 58" N	83° 19' 44" E
137	RWHS 66	Department of Zoology	17° 43' 54" N	83° 19' 57" E
138	RWHS 67		17° 43' 55" N	83° 19' 50" E
139	RWHS 68		17° 43' 54" N	83° 19' 50" E
140	RWHS 69	Department of Geology	17° 43' 55" N	83° 19' 60" E
141	RWHS 70		17° 43' 55" N	83° 19' 59" E
142	RWHS 71		17° 43' 56" N	83° 19' 58" E
143	RWHS 72		17° 43' 54" N	83° 19' 57" E
144	RWHS 73		17° 43' 52" N	83° 19' 57" E
145	RWHS 74		17° 43' 51" N	83° 19' 57" E
146	RWHS 75		17° 43' 51" N	83° 19' 59" E
147	RWHS 76		17° 43' 51" N	83° 19' 60" E
148	RWHS 77		17° 43' 52" N	83° 19' 59" E
149	RWHS 78		17° 43' 52" N	83° 19' 58" E
150	RWHS 79		17° 43' 53" N	83° 19' 59" E
151	RWHS 80		17° 43' 53" N	83° 19' 59" E
152	RWHS 81	Research Scholars Hostel	17° 43' 52" N	83° 19' 63" E
153	RWHS 82		17° 43' 51" N	83° 19' 63" E
154	RWHS 83		17° 43' 52" N	83° 19' 63" E
155	RWHS 84		17° 43' 63" N	83° 19' 63" E
156	RWHS 85		17° 43' 53" N	83° 19' 63" E
157	RWHS 86		17° 43' 53" N	83° 19' 62" E
158	RWHS 87	AshokaVardhan Hostel	17° 43' 54" N	83° 19' 64" E
159	RWHS 88		17° 43' 57" N	83° 19' 59" E
160	RWHS 89		17° 43' 57" N	83° 19' 60" E
161	RWHS 90	SS Hostel	17° 43' 58" N	83° 19' 63" E
162	RWHS 91	VivekaVinyasa Hostel	17° 43' 55" N	83° 19' 68" E
163	RWHS 92		17° 43' 52" N	83° 19' 65" E
164	RWHS 93	Pharmaceutical Sciences Building	17° 43' 48" N	83° 19' 67" E
165	RWHS 94		17° 43' 51" N	83° 19' 67" E
166	RWHS 95		17° 43' 47" N	83° 19' 66" E
167	RWHS 96		17° 43' 47" N	83° 19' 71" E
168	RWHS 97	Department of Physics	17° 43' 27" N	83° 19' 63" E
169	RWHS 98		17° 43' 42" N	83° 19' 64" E
170	RWHS 99		17° 43' 42" N	83° 19' 65" E
171	RWHS 100		17° 43' 42" N	83° 19' 66" E
172	RWHS 101	Department of Chemistry	17° 43' 39" N	83° 19' 66" E
173	RWHS 102		17° 43' 38" N	83° 19' 65" E
174	RWHS 103	USIC	17° 43' 33" N	83° 19' 63" E

175	RWHS 104		17° 43' 38" N	83° 19' 63" E
176	RWHS 105	Arts College Principal Office	17° 43' 35" N	83° 19' 59" E
177	RWHS 106	MBA Annex Building	17° 43' 33" N	83° 19' 61" E
178	RWHS 107	Department of Botany	17° 43' 37" N	83° 19' 46" E
179	RWHS 108		17° 43' 38" N	83° 49' 47" E
180	RWHS 109		17° 43' 38" N	83° 19' 49" E
181	RWHS 110		17° 43' 40" N	83° 19' 47" E
182	RWHS 111		17° 43' 38" N	83° 19' 51" E
183	RWHS 112	Engineer's Office Building	17° 43' 63" N	83° 19' 50" E
184	RWHS 113		17° 43' 62" N	83° 19' 50" E
185	RWHS 114	SAARC StudiesCentre	17° 43' 30" N	83° 19' 80" E
186	RWHS 115	AU High School Telugu Medium	17° 43' 21" N	83° 19' 66" E
187	RWHS 116		17° 43' 20" N	83° 19' 65" E
188	RWHS 117		17° 43' 19" N	83° 19' 64" E
189	RWHS 118	AU High School English Medium	17° 43' 17" N	83° 19' 64" E
190	RWHS 119		17° 43' 16" N	83° 19' 63" E
191	RWHS 120	Department of Marine Living Resources	17° 43' 10" N	83° 19' 52" E
192	RWHS 121		17° 43' 10" N	83° 19' 50" E
193	RWHS 122	Anjali Guest house	17° 43' 43" N	83° 19' 53" E
194	RWHS 123		17° 43' 43" N	83° 19' 53" E
195	RWHS 124	HarshaVardhana Hostel	17° 43' 57" N	83° 19' 55" E
196	RWHS 125		17° 43' 58" N	83° 19' 56" E
197	RWHS 126		17° 43' 58" N	83° 19' 57" E
198	RWHS 127	SKD Hostel	17° 43' 59" N	83° 19' 72" E
199	RWHS 128	Dr. B.R.Ambedkar Law College	17° 43' 50" N	83° 19' 58" E
200	RWHS 129		17° 43' 49" N	83° 19' 59" E
201	RWHS 130		17° 43' 49" N	83° 19' 59" E
202	RWHS 131	AU Employment Bureau	17° 43' 50" N	83° 19' 63" E
203	RWHS 132	Centre for Bay of Bangal	17° 43' 50" N	83° 19' 34" E
204	RWHS 133		17° 43' 51" N	83° 19' 35" E
205	RWHS 134	Mamatha Hostel	17° 43' 80" N	83° 19' 62" E
206	RWHS 135		17° 43' 81" N	83° 19' 61" E
207	RWHS 136		17° 43' 82" N	83° 19' 59" E
208	RWHS 137		17° 43' 80" N	83° 19' 61" E
209	RWHS 138		17° 43' 81" N	83° 19' 60" E
210	RWHS 139	Examination Block	17° 43' 81" N	83° 19' 59" E
211	RWHS 140	Arts College	17° 43' 31" N	83° 19' 27" E

The rainwater harvesting well structures during construction phase are shown in Figure 9. Typical RWH wells in the campus are shown in Figure 10. The check dams constructed for RWH are shown in Figure 11.

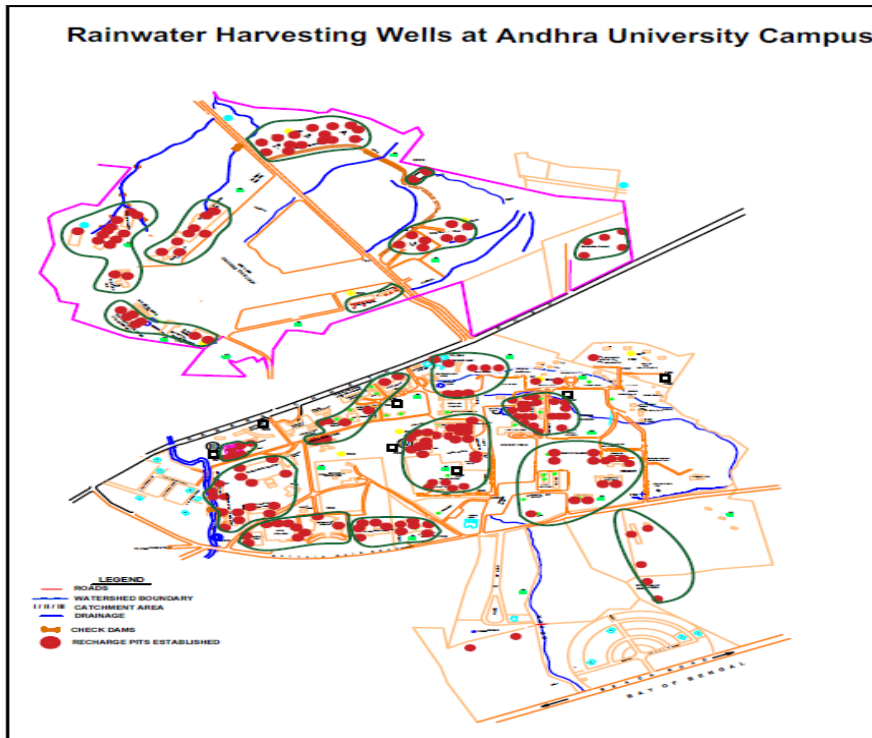


Figure 8: Rainwater Harvesting Wells at Andhra University Campus



Figure 9 (a): RWH Well and Laying of Pipelines for Rainwater Harvesting at Department of Instrument Technology.



Figure 9 (b): Laying of Rings and Connecting the Wells with the Roof Top Rainwater Collection System.

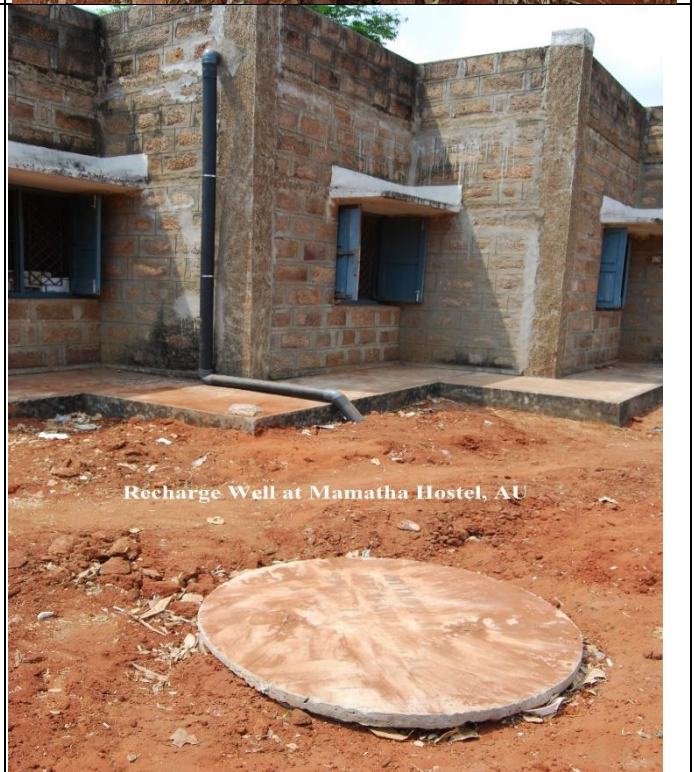
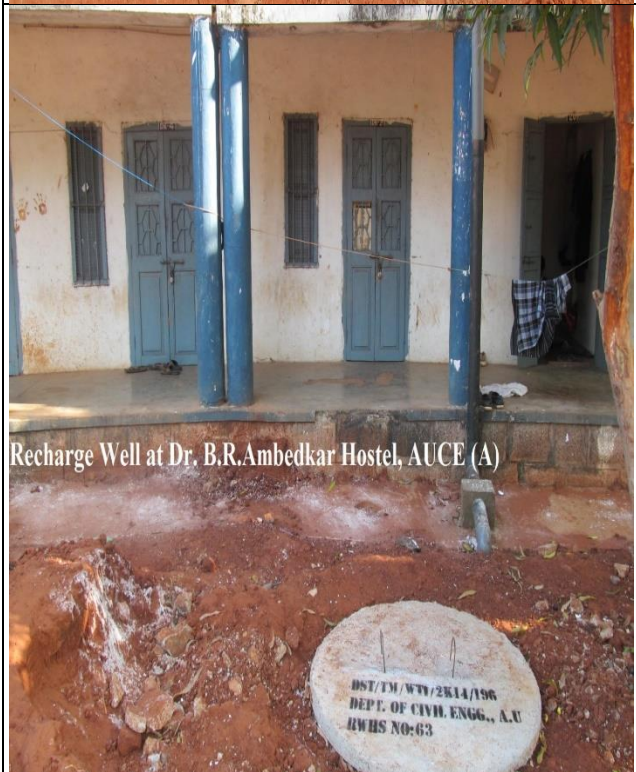
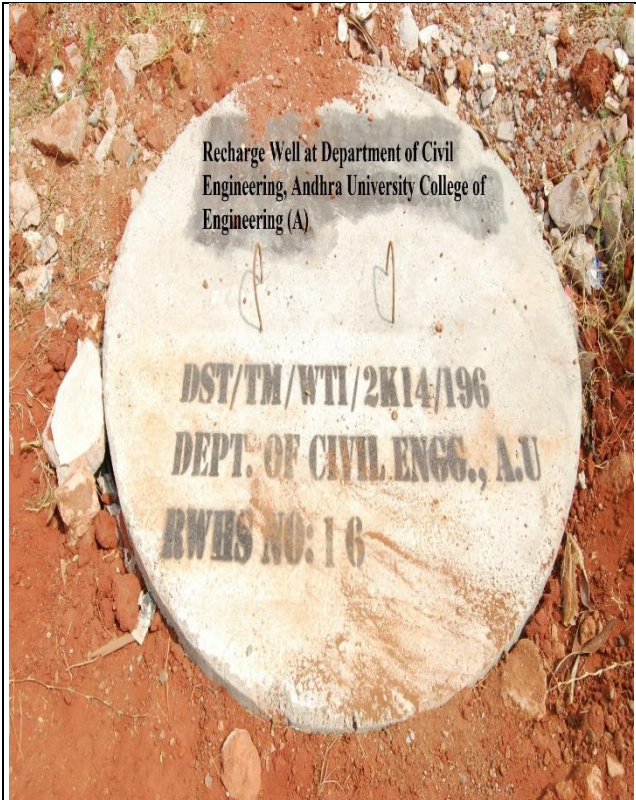


Figure 10(a): Typical RWH Wells in the Andhra University Campus

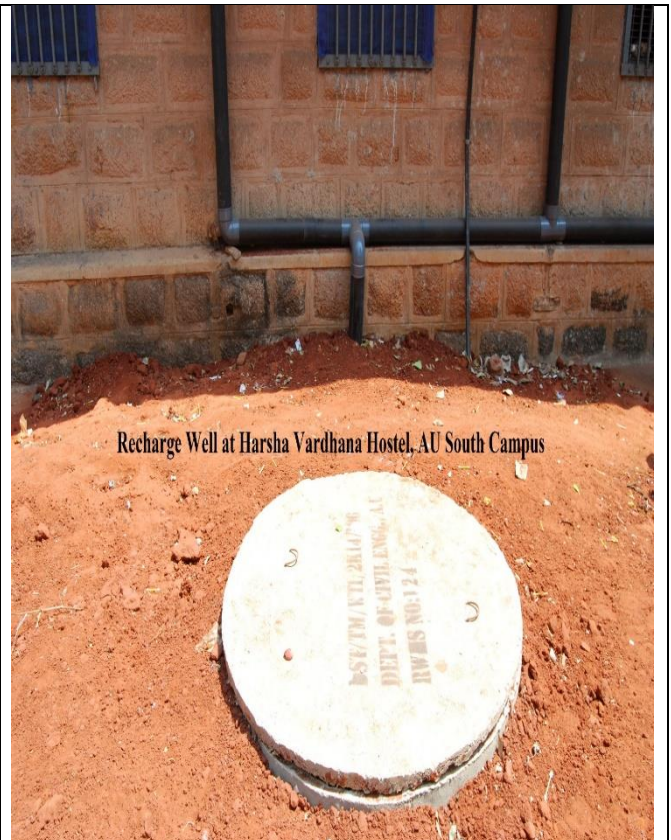
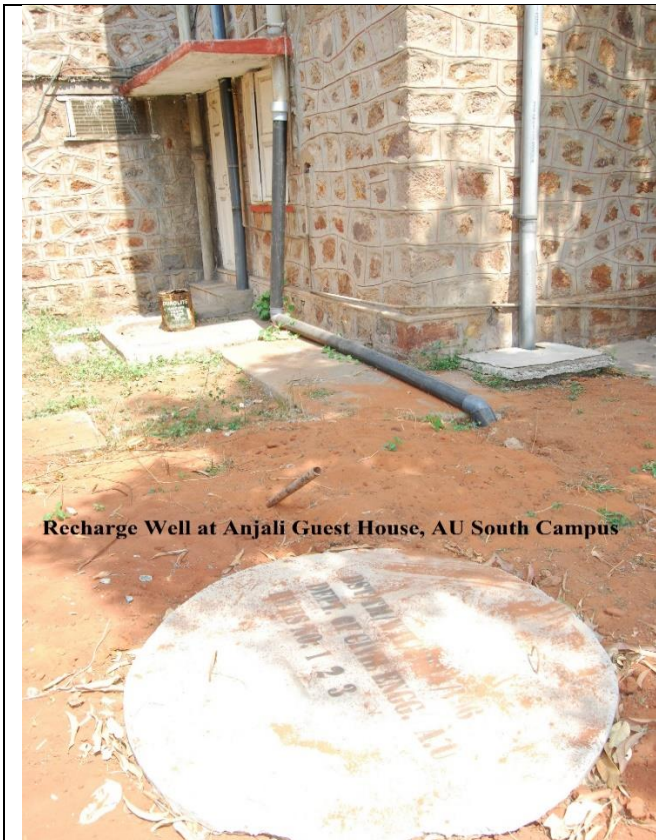


Figure 10(b): Typical RWH Wells in the Andhra University Campus



Figure 11: Check Dams Constructed in the Andhra University Campus as part of the RWH Program



Figure 12: The Weather Station in the Andhra University North Campus



CONSTRUCTION OF PIEZOMETRIC WELLS

As a part of the RWH program, five piezometric wells are constructed to monitor the water table fluctuations to monitor the impact of rainwater harvesting structures in the university campus and its surroundings. These wells are established taking into consideration the slope direction of the topography and groundwater table. In order to know the subsurface lithology and aquifer depth and to decide the depth of the bore well, Vertical Electrical Soundings (VES) tests are conducted at selected locations as mentioned in earlier chapters. The location details of Piezometric wells are given in Table 8 and Figure 13. The geological strata along with the observaiton wells is shown in Figure 14. Typical monitoring wells are shown in Figure 15.

Table 8: Locations of the Piezometric Well used for Monitoring of the GWT

S.No	Piezometric Well Number	Latitude	Longitude	Location
1	Piezometric Well Number 1	17° 43' 10" N	83° 19' 22" E	Near NCC Office building
2	Piezometric Well Number 2	17° 43' 79" N	83° 19' 05" E	Near CSE Department, AUCE
3	Piezometric Well Number 3	17° 43' 86" N	83° 19' 60" E	Near Samatha Hostel, AU
4	Piezometric Well Number 4	17° 43' 52" N	83° 19' 70" E	Near South Campus Dispensary
5	Piezometric Well Number 5	17° 43' 28" N	83° 19' 24" E	Near Assembly Hall

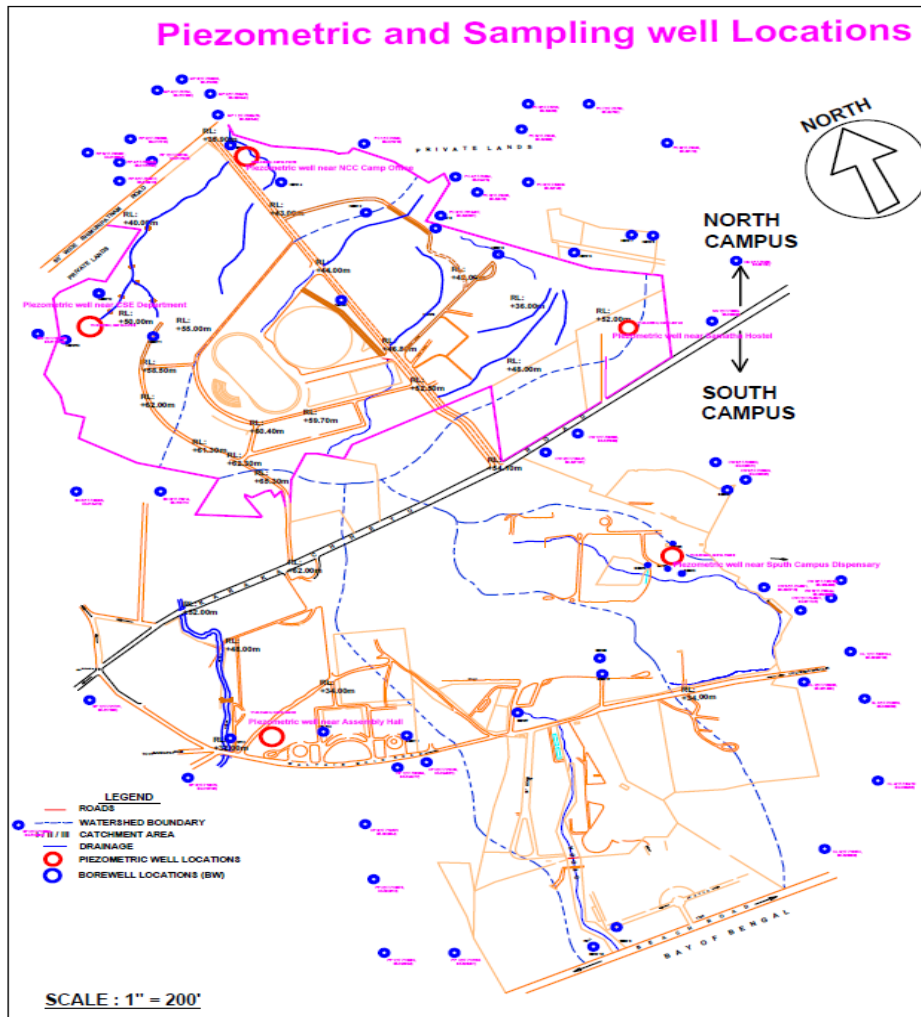


Figure 13: Locations of Piezometric Wells and Sampling Wells in Andhra University Campus.

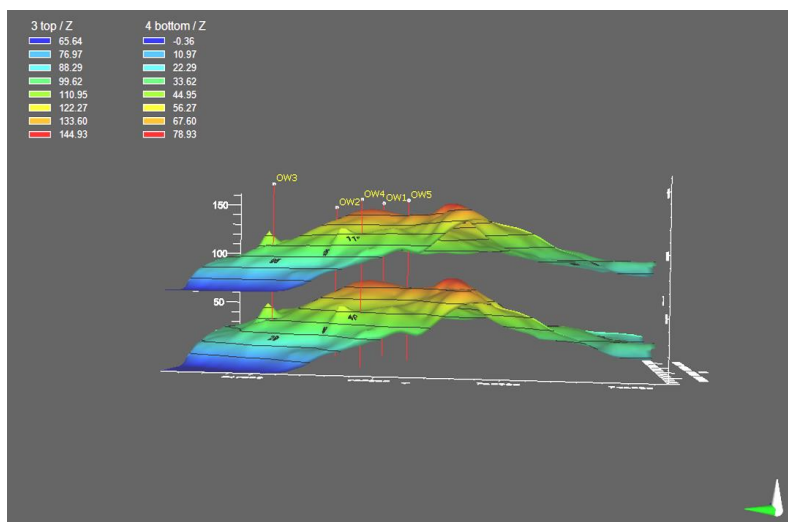


Figure 14: Geological Strata of Study Area with Observation Wells in Andhra University Campus



Figure 15: Typical RWH Monitoring Wells in the Andhra University Campus.

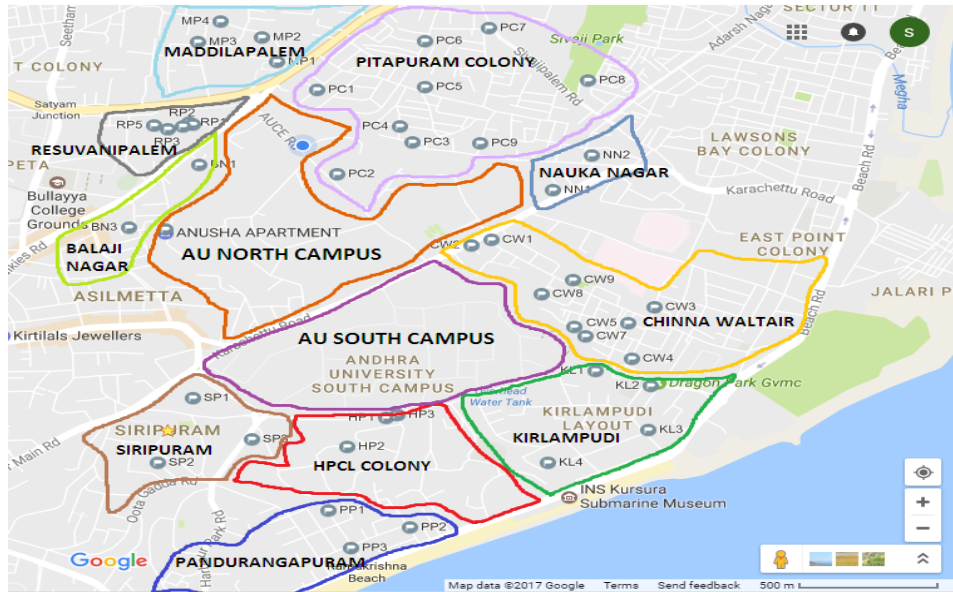


Figure 10: Area of Influence of the Rain Water harvesting Activities in Andhra University, Visakhapatnam.

EPILOGUE

The Andhra University is probably the first university to take up a comprehensive Rain Water Harvesting (RWH) program in its campus. The geophysical investigations and the Vertical Electrical Sounding (VES) tests conducted in the study area covering a depth of 300 ft have shown that the lithology of the study area comprises of Gravel, Red loamy, Liptinite, Khondalite, Charnockite in varying proportions of depths, at different locations of the study area. The thickness of different geo-electric layers ranged from 0.392 m to 2.24 m (first layer), 0.713 m to 29.9 m (second layer), 1.91 m to 24.3 m (third layer) and 9.34 m to 49.1m (fourth layer) at different VES locations. These layers are categorized as the red sandy soil, gravel, weathered/highly weathered rock, fractured/ highly fractured rock and bed rock. The aquifer is found to be present in the fractured rock zone i.e., in the fourth layer at different places of the study area.

The university campus area is delineated in to 8 micro-watersheds consisting of 84 first order, 21 second order, 6 third order and 2 fourth order streams. The drainage networks and the flow directions observed in the above cited 8 micro-watersheds enabled the identification of potential recharge sites. The infiltration rates are observed to vary from 2.06 cm/hr to 17.43 cm/hr at various places in the campus. It is further observed that, the soil at the university is permeable permitting infiltration. As part of the RWH program, 211 rainwater harvesting structures covering 62 major buildings of the university and two check dams were constructed within the campus. Five piezometric wells with automatic water level recorders for continuous monitoring of groundwater levels are established in the university campus. The continuous monitoring of groundwater levels from the above cited piezometric wells has shown that the groundwater levels varied from a minimum of 12.26 m below ground level (bgl) to a maximum of 33.08 m bgl. The extents of water bearing zones are varying from season to season and are observed to be overlapped during the monsoon season. Around 18 flow paths are identified through which the groundwater flows from the university campus in to the surrounding colonies.

It is estimated that 2233.62 ML of water is joining into the groundwater flow in the university campus per year through natural as well as artificial recharging out of which 657

ML per year is being withdrawn from the 25 bore wells located in the campus for its usage. The RWH program has shown that 1547.237 ML of groundwater 69.27% of the recharged amount from the university area is flowing out through head-dependent boundaries in to the surrounding colonies enriching their groundwater resources. It is an effective recharging system for groundwater recharge in the university campus and the major portion of which flows into the surrounding residential colonies benefitting two to three lakhs of people residing there.