Analysis in accordance with IS 2911 Part 1 sec 2 - 2010

BH-7

Pile Type		=	Bored Cast in Situ	
Pile Cross-section		=	Circle	
Pile Dia	(D)	=	1.00	m
Pile Length below GL	L	=	20.00	m
Unsupported length of Pile	L1	=	0.00	m
Taking Unit Weight of Concrete		=	25	KN/mm^3
Self Weight of the Pile, Wp		=	Ap.L.γp	
Area of the Pile	Ap	=	0.7850	
Length of the Pile		=	20.00	m
	Wp		392.50	kN
	Qu	=	Qs+Wp	
	Qs	=	929.65	kN
		=	1322.15	
Factor Of Safty	FOS	=	**2.50**	
		=	528.86	kN
Uplift capacity of Piles @20.0m		=	**78.28**	Tonnes
Uplift capacity of Piles @25.00 m		=	**117.42**	Tonnes
Uplift capacity of Piles @30.0m		=	**165.70**	Tonnes
Uplift capacity of Piles @35.0m		=	**213.99**	Tonnes

Pile Depth Below GL(m)	**20.00**	**25.00**	**30.00**	**35.00**	**40.00**
Uplift Capacity(Ton)	**52.89**	**78.28**	**117.42**	**165.70**	**213.99**

Analysis in accordance with IS 2911 Part 1 sec 2 - 2010

BH-8

Pile Type		=	Bored Cast in Situ	
Pile Cross-section		=	Circle	
Pile Dia	(D)	=	1.00	m
Pile Length below GL	L	=	20.00	m
Unsupported length of Pile	L1	=	0.00	m
Taking Unit Weight of Concrete		=	25	KN/mm^3
Self Weight of the Pile, Wp		=	Ap.L.γp	
Area of the Pile	Ap	=	0.7850	
Length of the Pile		=	20.00	m
	Wp		392.50	kN
	Qu	=	Qs+Wp	
	Qs	=	973.76	kN
		=	1366.26	
Factor Of Safty	FOS	=	**2.50**	
		=	546.50	kN
Uplift capacity of Piles @20.0m		=	**80.89**	Tonnes
Uplift capacity of Piles @25.00 m		=	**119.63**	Tonnes
Uplift capacity of Piles @30.0m		=	**166.70**	Tonnes
Uplift capacity of Piles @35.0m		=	**213.77**	Tonnes

Pile Depth Below GL(m)	**20.00**	**25.00**	**30.00**	**35.00**	**40.00**
Uplift Capacity(Ton)	**54.65**	**80.89**	**119.63**	**166.70**	**213.77**

Analysis in accordance with IS 2911 Part 1 sec 2 - 2010

BH-9

Pile Type		=	Bored Cast in Situ	
Pile Cross-section		=	Circle	
Pile Dia	(D)	=	1.00	m
Pile Length below GL	L	=	20.00	m
Unsupported length of Pile	L1	=	0.00	m
Taking Unit Weight of Concrete		=	25	KN/mm^3
Self Weight of the Pile, Wp		=	$Ap.L.\gamma p$	
Area of the Pile	Ap	=	0.7850	
Length of the Pile		=	20.00	m
	Wp		392.50	kN
	Qu	=	Qs+Wp	
	Qs	=	813.41	kN
		=	1205.91	
Factor Of Safty	FOS	=	**2.50**	
		=	482.36	kN
Uplift capacity of Piles @20.0m		=	**99.26**	Tonnes
Uplift capacity of Piles @25.00 m		=	**150.29**	Tonnes
Uplift capacity of Piles @30.0m		=	**201.31**	Tonnes
Uplift capacity of Piles @35.0m		=	**252.34**	Tonnes

Pile Depth Below GL(m)	**20.00**	**25.00**	**30.00**	**35.00**	**40.00**
Uplift Capacity(Ton)	**48.24**	**99.26**	**150.29**	**201.31**	**252.34**

ANNEXURE - XI

LATERAL CAPACITY OF PILE

Pile Type		:	Bore Cast in Situ RCC Pile	
Pile Cross -section		:	Circle	
Pile Dia		:	600	mm
Pile Cut-off-Level below GL		:	10.00	m
Pile Length		:	40.00	m
Pile Head		:	Fixed Head Condition	
Grade of Concrete		:	M 35	
Modulus of Elasticity	E	:	29580	Mpa
Moment of Inertia	I	:	6.365E+09	M^4
Soil Classification		:	Granular soil with medium Dense	
Design SPT N Value of soil Strate		:	75	
Saturation		:	Submerged	

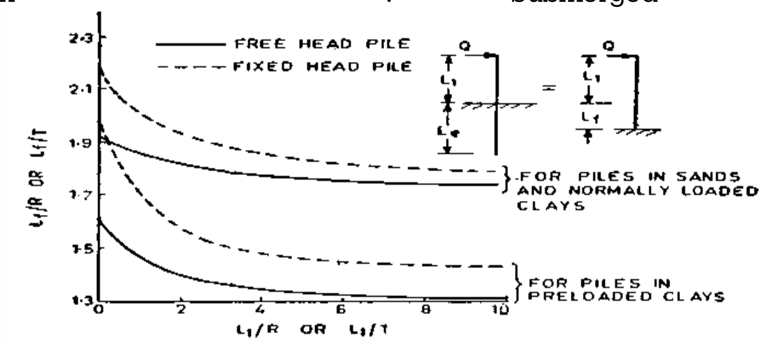

FIG. 2 DETERMINATION OF DEPTH FIXITY

T = (EI/nh)1/5. for Granular Soils and NC Clays. R = (EI /K1) 1/4 for Preconsolidated Clays

(As per "Table 3 in ANNEX C (Clause 6.5.2), Second Revision of IS:2911(Part I/Sec 2) - 2010")

Modulus of Subgrade Reaction Cohesive soil(K_1): 0.525

T : 356.21 cms

Free Standing Length of Pile or Length of pile below cut-off-level not contributing substantially to lateral capacity (L1) : 0.00 m

L1/T : 0.00

Lf/T : 2.19 Reading off from Graph

Depth of Fixity, Zf : 780.10 cms

L1+Lf : 780.10 cms

$$\text{Deflection, } y = \frac{H(e + z_f)^3}{3\,EI} x10^3 \quad \text{.... for free-head pile}$$

$$\text{Deflection, } y = \frac{H(e + z_f)^3}{12\,EI} x10^3 \quad \text{.... for fixed-head pile}$$

where : y = Lateral deflection at pile top; e = Free-standing length of pile
H = Lateral load applied; z_f = Depth of fixity

Permissible Horizontal Deflection at top of pile = 5.00 mm

Computed Lateral Capacity of Pile, H = 381.3 kN **38.91 T**

Pile Type		:	Bore Cast in Situ RCC Pile
Pile Cross -section		:	Circle
Pile Dia		:	600 mm
Pile Cut-off-Level below GL		:	10.00 m
Pile Length		:	40.00 m
Pile Head		:	Free Head Condition
Grade of Concrete		:	M 35
Modulus of Elasticity	E	:	29580 Mpa
Moment of Inertia	I	:	6.365E+09 M^4
Soil Classification		:	Granular soil with medium Dense
Design SPT N Value of soil Strate		:	75
Saturation		:	Submerged

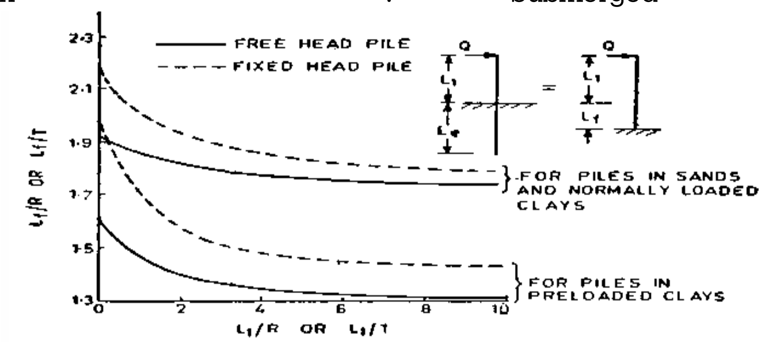

FIG. 2 DETERMINATION OF DEPTH FIXITY

T = (EI/nh)1/5. for Granular Soils and NC Clays. R = (EI /K1) 1/4 for Preconsolidated Clays

(As per "Table 3 in ANNEX C (Clause 6.5.2), Second Revision of IS:2911(Part I/Sec 2) - 2010")

Modulus of Subgrade Reaction Cohesive soil(K_1): 0.525

T : 356.21 cms

Free Standing Length of Pile or Length of pile below cut-off-level not contributing substantially to lateral capacity (L1) : 0.00 m

L1/T : 0.00

Lf/T : 1.93 Reading off from Graph

Depth of Fixity, Zf : 687.49 cms

e+Zf : 687.49 cms

Deflection, $y = \frac{H(e+z_f)^3}{3EI} x10^3$ .... *for free-head pile*

Deflection, $y = \frac{H(e+z_f)^3}{12\ EI} x10^3$ .... *for fixed-head pile*

where : y = Lateral deflection at pile top; e = Free-standing length of pile

H = Lateral load applied; z_f = Depth of fixity

Permissible Horizontal Deflection at top of pile = 5.00 mm

Computed Lateral Capacity of Pile, H = 184.3 kN | **18.81 T** |

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LATERAL CAPACITY OF PILES

Pile Type		:	Bore Cast in Situ RCC Pile	
Pile Cross -section		:	Circle	
Pile Dia		:	1000	mm
Pile Cut-off-Level below GL		:	10.00	m
Pile Length		:	40.00	m
Pile Head		:	Fixed Head Condition	
Grade of Concrete		:	M 35	
Modulus of Elasticity	E	:	29580	Mpa
Moment of Inertia	I	:	4.911E+10	M^4
Soil Classification		:	Granular soil with medium Dense	
Design SPT N Value of soil Strate		:	75	
Saturation		:	Submerged	

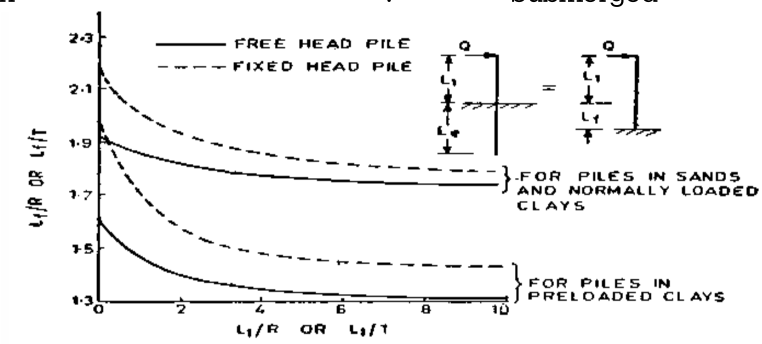

FIG. 2 DETERMINATION OF DEPTH FIXITY

T = (EI/nh)1/5. for Granular Soils and NC Clays. R = (EI /K1) 1/4 for Preconsolidated Clays

(As per "Table 3 in ANNEX C (Clause 6.5.2), Second Revision of IS:2911(Part I/Sec 2) - 2010")

Modulus of Subgrade Reaction Cohesive soil(K_1): 0.525

T : 425.83 cms

Free Standing Length of Pile or Length of pile below cut-off-level not contributing substantially to lateral capacity (L1) : 0.00 m

L1/T : 0.00

Lf/T : 2.19 Reading off from Graph

Depth of Fixity, Zf : 932.57 cms

L1+Lf : 932.57 cms

Deflection, $y = \dfrac{H(e+z_f)^3}{3EI} x10^3$ .... *for free-head pile*

Deflection, $y = \dfrac{H(e+z_f)^3}{12\ EI} x10^3$ .... *for fixed-head pile*

where : y = Lateral deflection at pile top; e = Free-standing length of pile
H = Lateral load applied; z_f = Depth of fixity

Permissible Horizontal Deflection at top of pile = 5.00 mm

Computed Lateral Capacity of Pile, H = 544.0 kN | **55.51 T** |

LATERAL CAPACITY OF PILES

Pile Type		:	Bore Cast in Situ RCC Pile	
Pile Cross -section		:	Circle	
Pile Dia		:	1000	mm
Pile Cut-off-Level below GL		:	10.00	m
Pile Length		:	40.00	m
Pile Head		:	Free Head Condition	
Grade of Concrete		:	M 35	
Modulus of Elasticity	E	:	29580	Mpa
Moment of Inertia	I	:	4.911E+10	M^4
Soil Classification		:	Granular soil with medium Dense	
Design SPT N Value of soil Strate		:	75	
Saturation		:	Submerged	

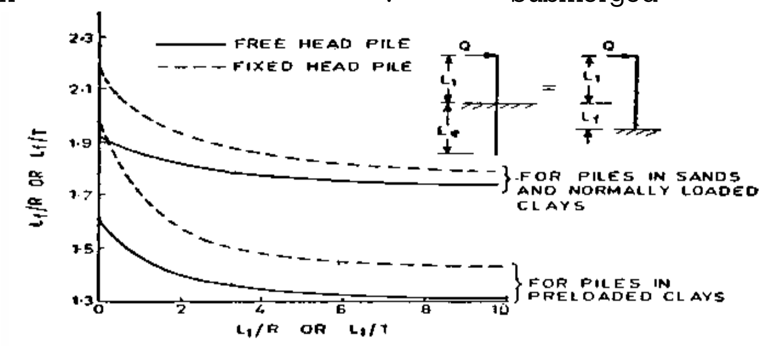

FIG. 2 DETERMINATION OF DEPTH FIXITY

T = (EI/nh)1/5. for Granular Soils and NC Clays. R = (EI /K1) 1/4 for Preconsolidated Clays

(As per "Table 3 in ANNEX C (Clause 6.5.2), Second Revision of IS:2911(Part I/Sec 2) - 2010")

Modulus of Subgrade Reaction Cohesive soil(K_1): 0.525

T : 425.83 cms

Free Standing Length of Pile or Length of pile below cut-off-level not contributing substantially to lateral capacity (L1) : 0.00 m

L1/T : 0.00

Lf/T : 1.93 Reading off from Graph

Depth of Fixity, Zf : 821.85 cms

e+Zf : 821.85 cms

$$\text{Deflection, } y = \frac{H(e+z_f)^3}{3EI} x10^3 \quad \text{.... for free-head pile}$$

$$\text{Deflection, } y = \frac{H(e+z_f)^3}{12\ EI} x10^3 \quad \text{.... for fixed-head pile}$$

where : y = Lateral deflection at pile top; e = Free-standing length of pile
H = Lateral load applied; z_f = Depth of fixity

Permissible Horizontal Deflection at top of pile = 5.00 mm

Computed Lateral Capacity of Pile, H = 213.5 kN | **21.79 T** |

ANNEXURE - XII

PHOTOGRAPHS

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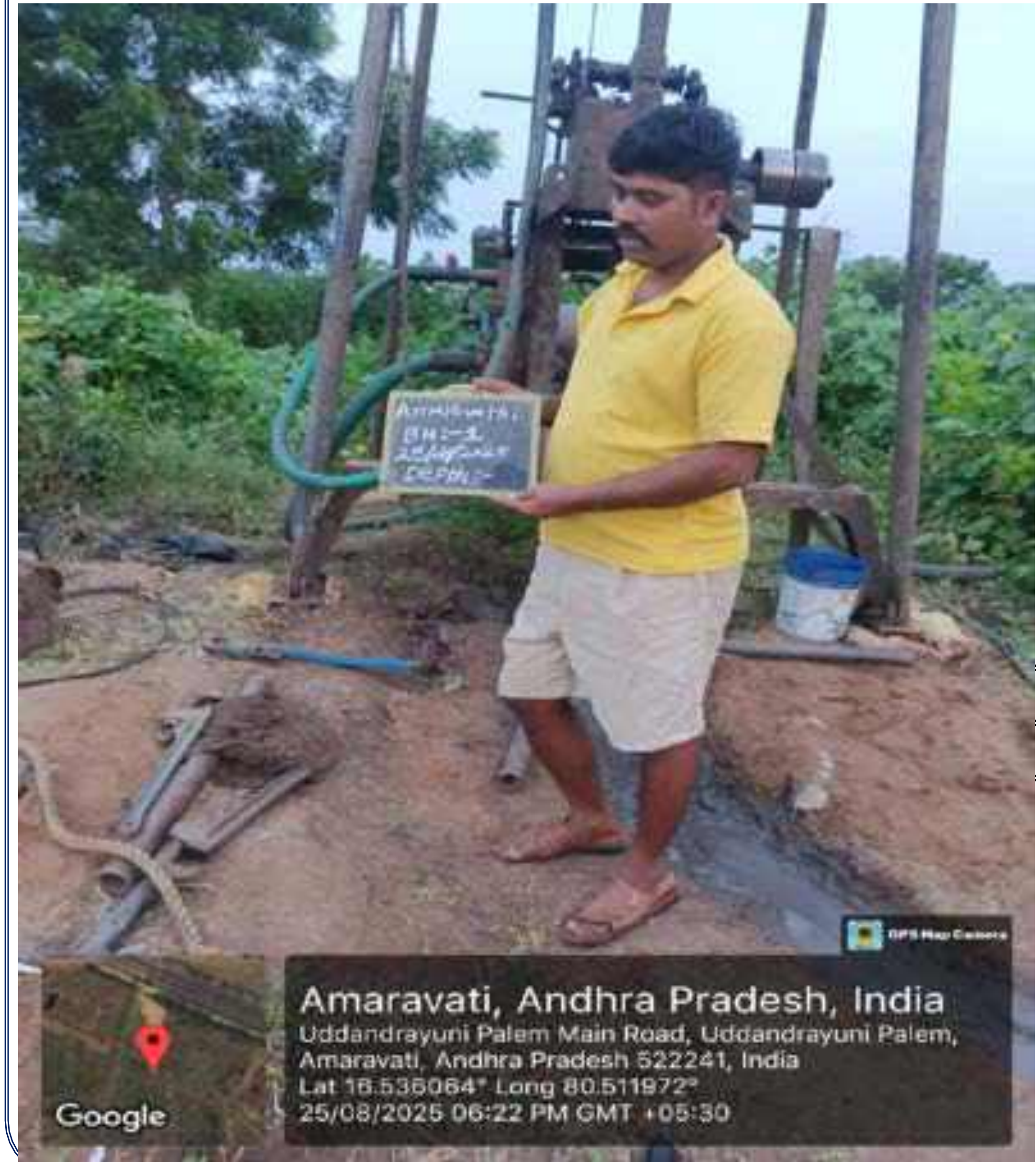
FIELD PHOTOGRAPHS



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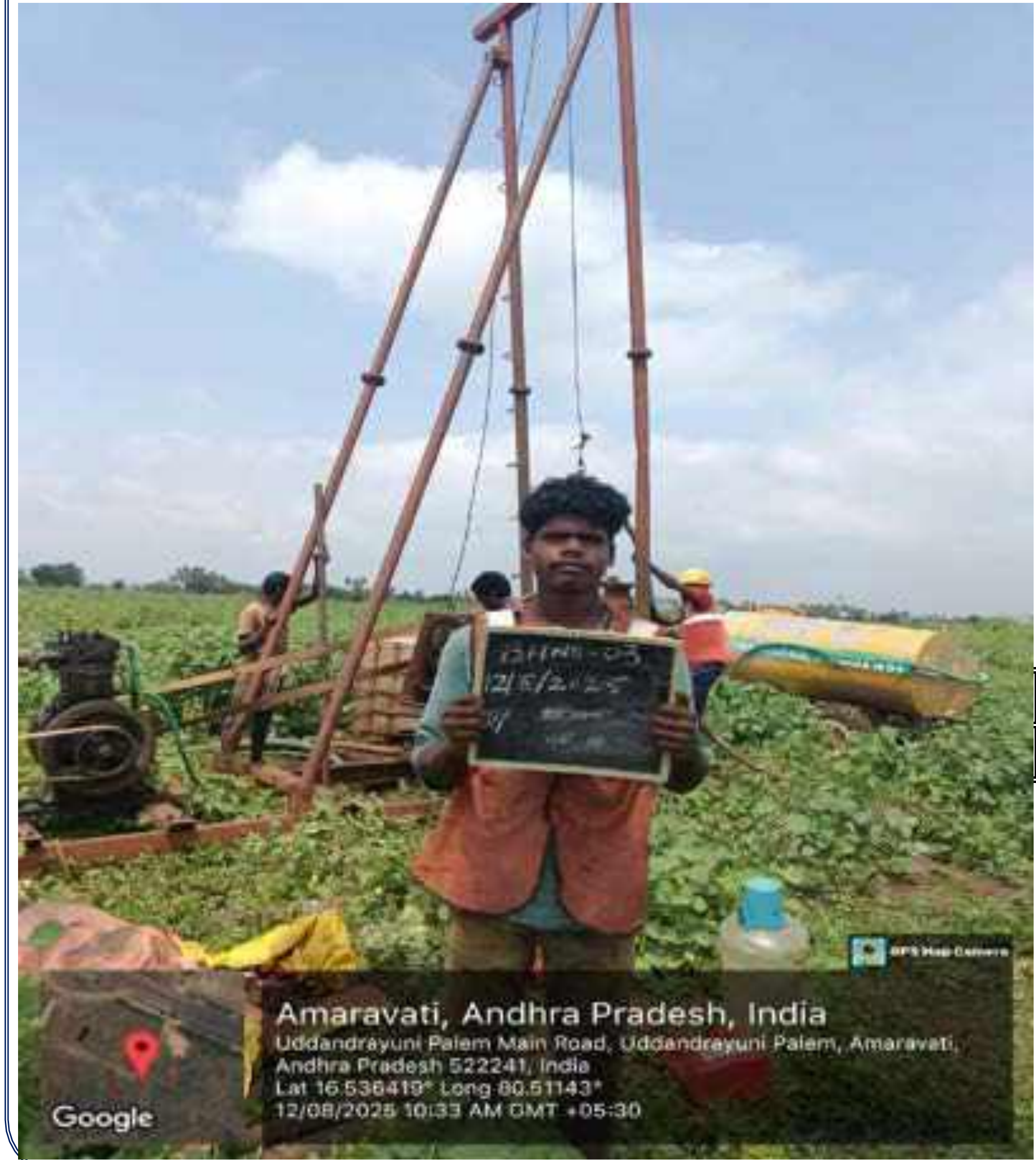
FIELD PHOTOGRAPHS



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FIELD PHOTOGRAPHS

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FIELD PHOTOGRAPHS

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FIELD PHOTOGRAPHS

GEO-PHYSICAL
& HYDROGEOLOGY REPORT

CONTENT

1.0 INTRODUCTION

M/s STATE BANK OF INDIA. is planning to Construct of building for Amaravati Local Head Office and other outfits at Amaravati, Andhra Pradesh. **M/s STATE BANK OF INDIA.** have entrusted the work of Geotechnical Investigation to **M/s MEDINI GEO ENGINEERING SERVICES** Hyderabad. The current investigation is at Uddandrayanpallem, Amaravathi. Andhra Pradesh.

The investigation aims to delineate subsurface layers and identify potential groundwater-bearing zones (aquifers) to inform the design of a bore well and a Rainwater Harvesting (RWH) recharge well. For this purpose, **M/s MEDINI GEO ENGINEERING SERVICES**. has conducted a geo-physical and geo-hydrological survey at the site.

This report presents the results of the survey conducted together with our observations at site.

1.1 SCOPE OF WORK

The main purpose of the study was to assess the groundwater conditions to meet the water requirement of the project. The geophysical survey was carried out on 16.08.2025 after a review of the literature available on the area and earlier work done.

1.2 TECHNICAL BACKGROUND

Hydrogeology is a scientific discipline that requires the appreciation of physiography, meteorological parameters, hydrology, geology and structure of the region in which the particular site is situated along with local details, for a quantitative evaluation of the ground water potential and for a continued development of the water resources.

This report presents the relevant technical background together with our recommendations on expected yield and water quality.

2.0 GENERAL SITE CONDITIONS

2.1 LOCATION

The site surveyed is located at Uddanrayanpallem Village, Amaravati, Andhra Pradesh. The site under study is situated about 10 km southwest of Vijayawada. It lies between coordinates latitudes 16°53' 58.44" and longitudes E 80°51' 21.28''.

2.2 PHYSIOGRAPHY & CLIMATE

The site surveyed is a plain land, sloping downwards towards north. It comes under Aravali hill range. Locally the ridges have a Northeast - Southwest trends. The area is at about 296 to 308 m above mean sea level the area is covered by thick alluvium bed, the area having extremes of climate in summer and winter.

The area falls in a semi-arid zone, with extremes of climate in summer and winter. Its climate is generally hot and humid, with summers extending from March to June, high moisture levels, and increasing exposure to risks like intense rainfall, floods, heatwaves, cyclones, and droughts.

The Southwest monsoon period between June and September is the main rainy season of the area when about 63% of the annual precipitation occurs. The mean annual rainfall is about 724 mm. The coefficient of variation is fairly low at 15 mm and the corresponding dispersion of mean rainfall is 20% with a 90 mm standard deviation. The air over this area is generally dry for most part of the year. The soils are sandy clays and fairly well drained.

2.3 GEOLOGY

The geology of the Amaravati region consists primarily of gneisses, charnockite-khondalite complexes, and alluvium-sand sediments, with charnockite being dominant in the central areas and the complex more prevalent in the surrounding zones. These rocks form diverse lithologies across the capital region, influencing its geomorphology and soil types.

Lithology:

The region's geology is characterized by three main groups:

- Gneisses A significant component of the region's rock formations.
- **Charnockite-Khondalite Complex**: This complex is a major geological feature, especially in the south-southeast and western areas of Amaravati.
- **Alluvium-Sand Sediments:** Modern deposits that contribute to the diversity of soil types in the area.
- **Dominant Formations:** The Charnockite series is particularly dominant in the central portion of the Amaravati region, contributing to its distinct geological character.

2.4 HYDROGEOLOGY

The study area, covering parts of Vijayawada, Guntur, and Amaravathi Urban Agglomerate, falls under a hard rock (crystalline) terrain (gneisses, Khondalites, Charnockites).

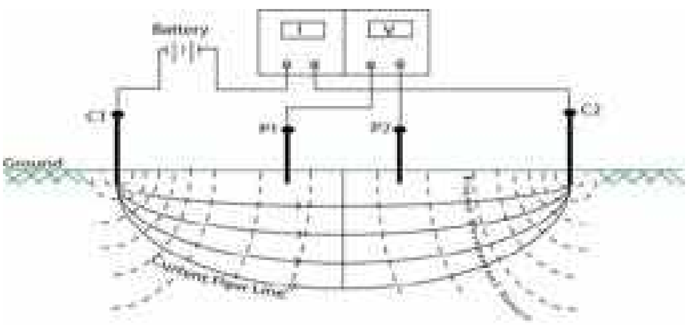
- Aquifer Type: Groundwater occurrence is primarily governed by secondary porosity—the network of fractures, joints, and faults in the hard rock.
- Key Zones: Water-bearing zones typically include the highly weathered mantle and deeper fracture zones.
- Weathering Depth: Generally ranges from 8 to 15 meters below ground level (m bgl).
- Fracture Depth: Potential water-yielding fractures are often encountered between 40 and 120 m bgl.

- Well Yield: Bore well yields in the region typically range from 1 to 5 Litres per Second (lps).
- Major Drainage: The Krishna River is the major, perennial river draining the area, with most other streams being seasonal.
- Geology & Aquifer Type: The area is predominantly underlain by crystalline formations (Archaean age rocks like gneisses, Khondalites, Charnockites, and dolerite dykes).
- These formations naturally lack primary porosity.
- Groundwater storage relies on Secondary porosity developed through fractures, joints, faults, and the subsequent formation of a weathered zone/soil.
- Rainfall: The average annual rainfall is 864 mm, with 63% of this rainfall occurring during the southwest monsoon (June-September).

3.0 RESISTIVITY SURVEY

3.1 GENERAL PRINCIPALS

When electricity passes through the earth, it encounters resistance to the flow from the soil / rock-materials. The impedance is dependent on the elemental constitution, granular arrangement, and fluid content of the underlying earth layers. A four electrode Werner array, as illustrated below, with a maximum current electrode separation of 20.0 m was used to obtain the vertical sequence of materials at several specific locations. The apparent resistivity offered by these layers is calculated using the relationship between the distances of potential and current electrodes and the amperage used to generate the measured voltage difference after nullifying, if any,



the natural potential of such materials. Based on parametric soundings at locations where the subsurface lithology is known and by curve matching techniques the thickness and nature of formations in a given area are obtained by interpretation.

The investigation is planned to obtain the Electrical Resistance of soil in the proposed project site and collect field data to determine the Apparent Soil Resistivity of soil for design of earthing parameters. In this proposed project site we are applied Vertical Electrical Sound using Werner Method with DDR-1 model.

3.2 VERTICAL ELECTRICAL SOUNDING

To obtain a total coverage of the area and to probe the conditions at greater depths, electrical soundings have been carried out. Electrical soundings were made to probe the subsurface conditions prevailing, to the depths of 120.0 m using extrapolation techniques. The data obtained were analysed by empirical methods.

A total of Four (04) Vertical Electric Soundings (VES) were conducted at site. The VES locations are illustrated on Fig. 1 and marked on the master plan.

The data was plotted as measured resistivity values versus the current electrode spacing (AB/2). The measured apparent resistivity values are tabulated on Table 1. Graphical plots of the results are presented on Annexures-1

4.0 GROUND WATER ASSESSMENT & RECOMMENDATION

4.1 SITE ASSESSMENT

The data obtained has been evaluated to assess the general trend of groundwater conditions across the site. Keeping in view various hydro-geological and geophysical aspects of the study area, our assessment of site conditions is as follows:

a. The area surveyed is part of north sloping Aravali hill range with sand, gravel kankar and weathered rock forming the potential aquifers.
b. Groundwater occurs under phreatic conditions at shallow depths and under semi-confined conditions at greater depths.
c. Resistivity data indicates that the surveyed area has uniform underground conditions with minor changes at specific locations. In general, the trend of groundwater conditions is uniform and no substantial variations are expected.
d. The survey indicated hard rock formations comes at depth of 40 m below ground level.

4.2 GROUND WATER POTENTIAL AND QUALITY

There are no exact methods of calculating yields from tube-wells using VES data. However, a good and reliable estimate can be made on the basis of resistivity values, interpreted stratigraphy, hydrological information and local site conditions. Broadly the assessment of yield is made after careful review of the following:

a) Thickness of sand zones,
b) Presence of fractured / jointed rock,
c) Groundwater conditions in the area,
d) Geology of the area,
e) Actual yield from the existing wells in vicinity,
f) Presence of water bodies in the surrounding areas.
g) Rainfall in the project area and expected recharge of the groundwater sources,
h) Assessment of hydraulic gradient and ground water flow.

Based on review of various parameters as explained above, the interpreted stratigraphy and expected water quality at each of the 5 VES locations is presented on Tables 2 to 6. Our assessment of groundwater potential is as follows:

a. Resistivity data indicates that the surveyed area has uniform underground conditions with minor changes at specific locations.
b. The quality of groundwater is potable and fit for any use. There may be minor variations in the actual quantity that can be drawn depending upon various seasonal and hydrological factors.
c. Overall study indicated that the site has good ground water potential.
d. Whereas yields will be higher in coarse sand, the yield will be lesser in fine sand and strata containing silts and clays.

Tube-wells for the project should be installed to about 130 140 m depth. As per our assessment, each well in the area can yield about 15,000 litres per hour (1,50,000 litres per day for maximum 10 hours of pumping). The recharge of groundwater is good; however, it is likely that the yield could decrease over a period of time.

We anticipate that the estimated yield is likely to be available for a period of at least 10-15 years.

The yield and quality of groundwater will be influenced by the urbanization and industrialization in the area and the number of tube-wells that may be installed within the site area and in the surrounding area in the future and quantum of water extracted from the aquifer.

4.3 RECOMMENDED TUBE-WELLS

Tube-well drilled to a depth of 90 m to 140 m using DTH technique with an efficient pumping system may be installed under an expert guidance. The study confirms that the underground formations are fairly uniform.

Hence tube-well may be drilled at any five locations (Refer Fig. 1). Our suggested order of preference is as follows:

1. VES- 3
2. VES- 2
3. VES- 4
4. VES- 1

Our recommended tubewell design is given in Fig.13. It shows the depths of the blank and slotted casings. The actual location of the well screen should be decided during drilling. The gap between the hole and casing should be filled with pea gravel.

To avoid interference, we suggest that a minimum distance of not less than 100 m be kept between adjacent tube-wells.

The quality of underground water is potable. Testing of water to ascertain quality is essential.

5.0 RAINWATER HARVESTING

To conserve water as a runoff from the surface of open areas and building roof, rainwater harvesting is recommended to recharge the shallow aquifer through a recharge structure.

Rainwater harvesting is likely to be beneficial in the long run for sustained yield from the wells and also to limit further increase in salinity. At least two structures may be provided at the project site. For successful rainwater harvesting, all water from storm-water drains should flow into the recharge structure. Also, the ground slopes should be such that all water from open areas flow into the water harvesting structure.

There is a nallah passing through the site. We understand that it runs full during the monsoons. The water in this nallah may be intercepted in the higher reaches and fed into a recharge well installed specifically for this purpose. It should be ensured that the recharge well can absorb the peak-monsoon discharge of the nallah. This will enhance the groundwater scenario in the area and ensure long life of the wells.

6.0 LIMITATIONS

All projections and recommendations are subject to the inherent limitations of the technique employed. There could be variations as the underground conditions are not always amenable to physical interpretations. In case any major variations are observed, we request to be informed so that our hydrogeologists may review the site conditions in light of these variations.

7.0 SUMMARY OF PRINCIPAL FINDINGS & RECOMMENDATIONS

M/s MEDINI GEO ENGINEERING SERVICES assessed the ground water potential at the proposed Amaravati Local Head Office Building at Amaravati. He purpose is to establish the reliability and adequacy of source to meet its water requirement. The results from the hydro-geological and geophysical investigations reveal good groundwater potential and good quality.

A general assessment of the site indicates that the current groundwater potential can be about 12,000 to 15,000 litres per hour from one tube-well. In case two or more tube-wells are installed they should be spaced 100 m apart. For long term performance of the wells, rainwater harvesting is suggested.

8.0 CLOSURE

We appreciate the opportunity to perform this investigation for you and have pleasure in submitting this report. Please contact us when we can be of further service to you.

For MEDINI GEO ENGINEERING SERVICES

APPARENT RESISTIVITY VERSUS ELECTRODE SPACING

ESP in m(AB/2)	Apparent Resistivity in ohm-meters			
	VES-1	VES-2	VES-3	VES-4
1.50	7.98	5.52	7.09	5.27
2.00	7.51	5.32	6.11	-
5.00	5.79	6.13	4.85	7.49
10.00	6.35	6.94	5.98	7.32
13.00	6.79	7.71	5.99	6.34
16.00	7.29	10.01	6.36	6.00
20.00	8.14	7.59	6.32	6.89
30.00	8.59	8.00	7.00	7.04
40.00	-	-	7.81	7.75
50.00	-	-	8.23	8.60
80.00	-	-	10.86	10.90
90.00	-	-	13.08	13.10

VES: Vertical Electrical Sounding (Schlumberger Array)
ESP: Electrode Separation in m

Values in table are measured apparent resistivity values (ohm-m) for corresponding electrode separation.

Expected Formation and Water Quality at VES - 1:

Depth, m	App. Resistivity ohm-m	Expected Litho-Log	Expected Quality
1.242	**8.556**	Topsoil/Laterite/Moist Clay (Moderately Low Resistivity)	
5.247	**4.613**	Clay/Saturated Zone (Low Resistivity)	
∞	**10.30**	Weathered/Fractured Rock (Moderately Low Resistivity, potentially the beginning of the basement)	

Expected Formation and Water Quality at VES - 2:

Depth, m	App. Resistivity ohm-m	Expected Litho-Log	Expected Quality
0.75	**7.137**	Topsoil/Laterite/Moist Clay (Moderately Low Resistivity)	
1.10	**2.023**	Clay/Saturated Zone (Low Resistivity)	
∞	**10.30**	Weathered/Fractured Rock (Moderately Low Resistivity, potentially the beginning of the basement)	

Expected Formation and Water Quality at VES - 3:

Depth, m	App. Resistivity ohm-m	Expected Litho-Log	Expected Quality
0.92	10.0	Topsoil/Laterite/Moist Clay (Moderately Low Resistivity)	
2.38	3.49	Clay/Highly Saturated Zone (Very Low Resistivity, often a highly conductive zone)	
63.0	7.93	Weathered/Fractured Rock (Low Resistivity, a thick zone)	
∞	2120	Fresh/Competent Bedrock (Very High Resistivity, the basement)	

Expected Formation and Water Quality at VES - 4:

Depth, m	App. Resistivity ohm-m	Expected Litho-Log	Expected Quality
1.35	4.57	Topsoil/Laterite/Moist Clay (Moderately Low Resistivity)	
3.75	13.60	Clay/Highly Saturated Zone (Very Low Resistivity, often a highly conductive zone)	
6.65	2.33	Weathered/Fractured Rock (Low Resistivity, a thick zone)	
58.9	8.29	Fresh/Competent Bedrock (Very High Resistivity, the basement)	

COMPRESSION OF VES 1,2 AND VES 3,4

The VES data provides Apparent Resistivity (ρa) values up to an AB/2 spacing of 30m (VES 1) and 70m (VES 2). Resistivity values are interpreted qualitatively to infer lithology and water saturation.

Location	AB/2 Max (m)	Resistivity Range (ρa in Ω·m)	Qualitative Trend	Hydrogeological/Lithological Inference
VES 1,2	30.0	5.79 to 8.59	Starts low, decreases slightly, then shows a gradual increase.	**Very Low Resistivity (~ 5-8 Ω·m)**: Indicates highly weathered rock, clayey formation, or saline/brackish water-saturated zones. The **low-resistivity zone extends at least up to 30m** bgl, suggesting a thick weathered layer or highly fractured upper bedrock.
VSE 3,4	70.0	4.85 to 15.22	Starts low, decreases to minimum at 5m, then shows a consistent, **gradual increase** with depth.	**Shallow Zone (≤10m):** Very low ρa (4.85 to 5.37 Ω·m), representing the topsoil/highly saturated, clayey weathered mantle. **Deeper Zone (~30m to 70m):** Resistivity gradually increases (7.82 to 15.22 Ω·m), indicating a transition to moderately fractured/fresh hard rock. The increasing trend suggests **better quality rock at depth**, which may host a less-conductive (less saline) water-bearing fracture system.

CONCLUSION ON GROUNDWATER POTENTIAL:

Poor Shallow Potential: The uniformly very low resistivity (~5–8Ω·m) in the upper 30-40 meters suggests that the groundwater stored in the shallow weathered zone may be of poor quality (possibly brackish/saline) or is highly saturated with clay.

Recommendation for Deep Drilling: The gradual increase in resistivity at VES 2 below 30 meters (up to 70 meters) is the most favorable indication. The primary target for a productive bore well should be the deep, confined fracture zone within the hard rock, likely between 80 m and 120 m bgl,

2. Recommendations for Bore well VES 3 Location- (latitude 16.535844° & longitude 80.512128°)

Drilling Recommendation

The VES 3 model identifies two potential water-bearing zones:

Layer 2: Lowest resistivity (3.49 Ω·m).

Layer 3: Low resistivity (7.93 Ω·m) and **extremely thick** (60.6 m).

The best target is the highly permeable **fractured/weathered bedrock of Layer 3**.

- **Target Layer:** Layer 3.
- **Target Depth:** Layer 3 begins at **2.38 m** and extends to **63 m**. This layer likely represents a massive zone of weathered or fractured rock, which is a classic, high-potential aquifer in basement terrains.
- **Drilling Strategy:** Drill through the top two layers and fully penetrate the upper, more highly fractured part of Layer 3 to maximize water interception. A high-resistivity $\rho 4=2120$ Ω·m is encountered at 63 m, which is the massive, fresh bedrock (aquifer base).
- **Recommended Drill Depth:** Between **20 to 40 meters** to tap into the most productive weathered/fractured zone of Layer 3, while avoiding the massive, non-water-bearing bedrock below 63 m.

Estimated Yield Capacity

- **Yield Prospect: High.**
- **Flow Rate Expectation:** The combination of vast thickness and an intermediate-low resistivity (indicative of a productive weathered/fractured rock aquifer) suggests a **high and sustainable yield**.
- **Approximate Capacity:** 2.0 to 8.0 **liters per second (L/s)**, or approximately 7,200 to 28,800 **liters per hour (L/h)**, suitable for community water supply or large-scale irrigation.

Summary of Best Location for High Yield

Location- (latitude 16.535844° & longitude 80.512128°) (VES 3) offers a **significantly higher** water yield potential due to the presence of a deep, extremely thick, and low-resistivity layer (Layer 3) that is characteristic of a highly productive weathered bedrock aquifer

Parameter	Details
VES Curve Type	H-type ($\rho1 > \rho2 < \rho3$), followed by high-resistivity layer ($\rho4$)
Water-Bearing Zones	Layer 2 (ρ = 3.49 Ω·m), Layer 3 (ρ = 7.93 Ω·m, thickness = 60.6 m)
Best Target Layer	Layer 3 – weathered/fractured bedrock
Target Depth	Begins at 2.38 m, extends to 150 m
Aquifer Base	Fresh bedrock with high resistivity ($\rho4$ = 2120 Ω·m) at 63 m

Parameter	Details
Recommended Drill Depth	20–40 m (to intercept the most productive weathered/fractured portion of Layer 3)
Drilling Strategy	Drill through top layers, fully penetrate fractured/weathered zone of Layer 3
Yield Prospect	High
Expected Flow Rate	2.0 – 8.0 L/s (≈ 7,200 – 28,800 L/h)
Suitability	Community water supply, large-scale irrigation

Bore Well Design Suggestion (as per CGWB)

Based on the interpretation of hard rock terrain with deep fracture aquifers, the bore well must penetrate the weathered mantle and target the productive fractured zones.

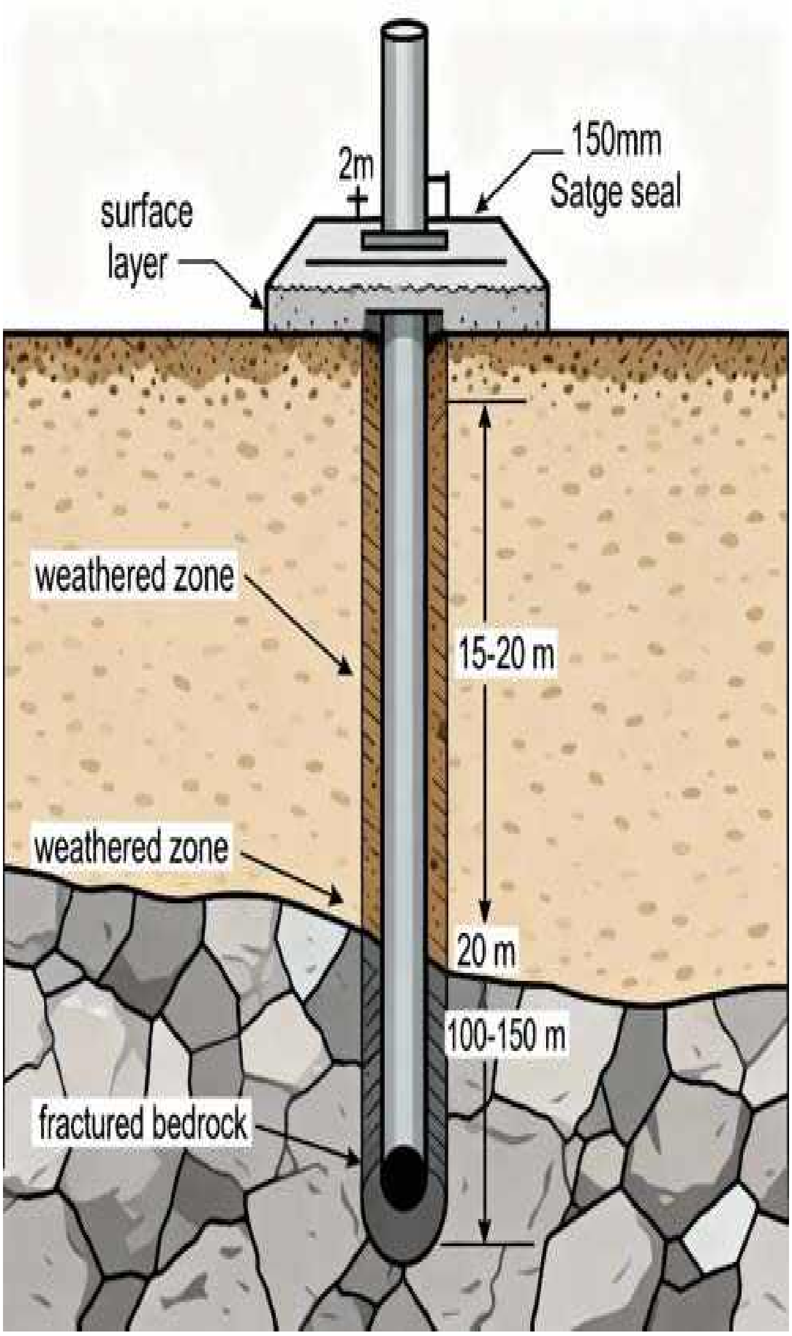
Bore Well Specifications

Parameter	Recommended Specification	Justification (Hard Rock/CGWB)
Target Depth	**100 – 150 m bgl**	To intercept deeper, confined fracture zones which are the reliable aquifers in this geology.
Drilling Diameter	6.5" or 8" diameter (165 mm or 203 mm)	Standard size for hard rock drilling rigs. 6.5" is common and economical.
Bore Casing Pipe (Surface)	**150 mm (6") MS or PVC Casing Pipe**	To seal off the unstable, low-resistivity (clayey/weathered) top soil/mantle and prevent the entry of contaminated shallow water into the main aquifer.

Parameter	Recommended Specification	Justification (Hard Rock/CGWB)
Casing Depth	15 – 20 m bgl	Should extend into the massive rock below the highly weathered zone (which is typically 8-15 m deep).
Well Section below Casing	Open Hole (Un-cased)	Standard practice in hard rock: the rest of the bore hole is left uncased, as the rock itself is stable, and water enters directly through the intercepted fractures.
Yield	Expected to be **1–5 lps** (Litres per second)	The final pump design (HP) must match the actual tested yield.

Bore Well Construction Diagram (Conceptual)

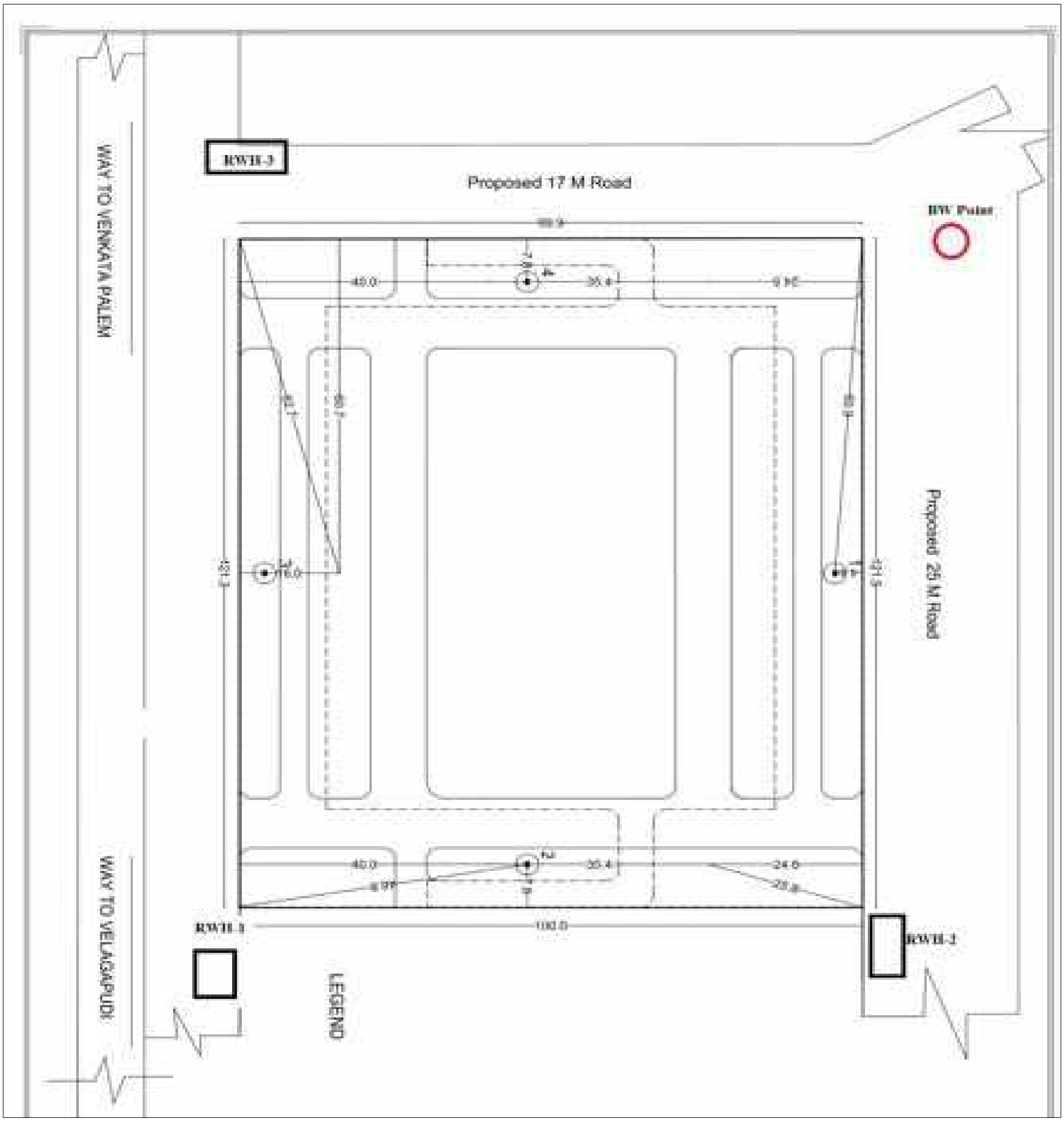
1. **Start:** Drill large diameter (e.g., 10") up to 2m and install a **cement platform** (sanitary seal).
2. **Casing:** Drill the final diameter (6.5"/8") and install **150 mm casing pipe** up to the required depth (15–20 m) to ensure stability and seal the weathered zone.
3. **Open Hole:** Continue drilling as an open hole until the target depth (100–150 m) to intercept deep fractures.


150mm
Satge seal
2m
surface
layer
weathered zone
15-20 m
weathered zone
20 m
100-150 m
fractured bedrock

3. Recommendations for Rainwater Harvesting (RWH) Recharge VES 1,2,4

Location proposed RWH-

- RWH 1 (VES 1) (Latitude 16.536813°, Longitude 80.511803°)
- RWH 2 (VES 4) (Latitude 16.536329°, Longitude 80.512325°)
- RWH 3 (VES 2) (Latitude 16.536340°, Longitude 80.511285°)



Recommended Rainwater Injection Well Placement

Place rainwater injection wells at sites corresponding to VES 1 and VES 4 with well screens targeted at depths of about 5–20 m, where moderate resistivity values indicate the likely presence of permeable and water-bearing layers.

Avoid placing screens in very high-resistivity layers (which may indicate compact rocks or clay), and position the bottom of the screen just above any massive hard rock zones detected at greater depth.

In summary: Focus recharge well construction near the VES points, targeting the 5–20 m depth intervals with moderate resistivity, for maximized injection and aquifer recharge effectiveness

Given the primary aquifer is a deeper, fractured zone sealed by a low-permeability weathered/clayey layer (low resistivity in VES data), the most appropriate CGWB structure is a Recharge Well (Injection Well) or Recharge Shaft to bypass the impervious layer and inject water directly into the confined aquifer.

3.1 Design Components and Specifications

Component	Specification	Function (CGWB Guideline)
Structure Type	Recharge Well / Injection Well	Most suitable when the top soil/clay layer is impervious, and the aquifer is deep (25-30m or more). This is the case in this hard rock area.
Catchment Area	Rooftop Area (For the proposed SBI buildings)	Source of clean, filtered runoff for recharge.
First Flush Arrangement	Mandatory	A device to ensure that the initial runoff (which carries dust/pollutants) is flushed out and does not enter the recharge system.

Component	Specification	Function (CGWB Guideline)
Filtration Unit / Pit (Pre-treatment)	**Required** (e.g., 2m x 2m x 2m pit)	To remove suspended solids (silt, leaves, debris) before water is injected.
Filter Media Layers	**Graded Layers (from top to bottom):** Coarse Sand/Morang, Gravel (5-10 mm), and Boulders (50-200 mm)	The filtration chamber should have graded media, with fine material on top for easy cleaning and maintenance.
Recharge Well (Borehole)	**100-150 mm (4"-6") diameter, extending to 30-40 m bgl**	The well is drilled to a depth where the highly permeable fractured zone or the water table is intercepted, ensuring water enters the main aquifer. Must be fully screened and/or filter-packed.
Safety Measure	**Injection Head above ground level**	To prevent backflow of groundwater or contaminants into the surface system.

RAINWATER MANAGEMENT PLAN

Calculation of Annual Recharge:

Sr. No.	Details	Area (m^2)	Annual Rainfall (m)	Run-off coeff.	Total Runoff (m3/annum)
1	Roof top Area	12140	0.864	0.85	8915.6

Calculation of Hourly Recharge:

Sr. No.	Details	Area (m^2)	Hourly Rainfall (m)	Run-off coeff.	Total Runoff (m3/hr.)
1	Roof top Area	12140	0.045	0.85	464.4

(Source- Manual of Artificial Recharge of Ground Water, (CGWB,2007))

Calculation of No. of Structure.

The data also includes calculations for hourly and 20-minute runoff quantities.

Total Runoff per Hour: The total runoff water quantity per hour is **464.4 m^{3}**.

Total Runoff per 20 Minutes: The total quantum of water available at 20 minutes is **154.8 m3**.

Rainwater Harvesting Structure Design

The plan involves constructing a two-pit system.

1. First Pit - Filter Chamber: This pit is designed to filter the rainwater.

   Dimensions: It is **4 m** long, **2 m** wide, and has a filter media depth of **0.75 m**.

   Filter Media Volume: The volume of the filter media is 1.58m3.

   Porosity: The filter media has a porosity of 35.0%.

   Volume: 2.1 **m^3**

2. **Second Pit - Storage Chamber:** This pit is for storing the filtered water.

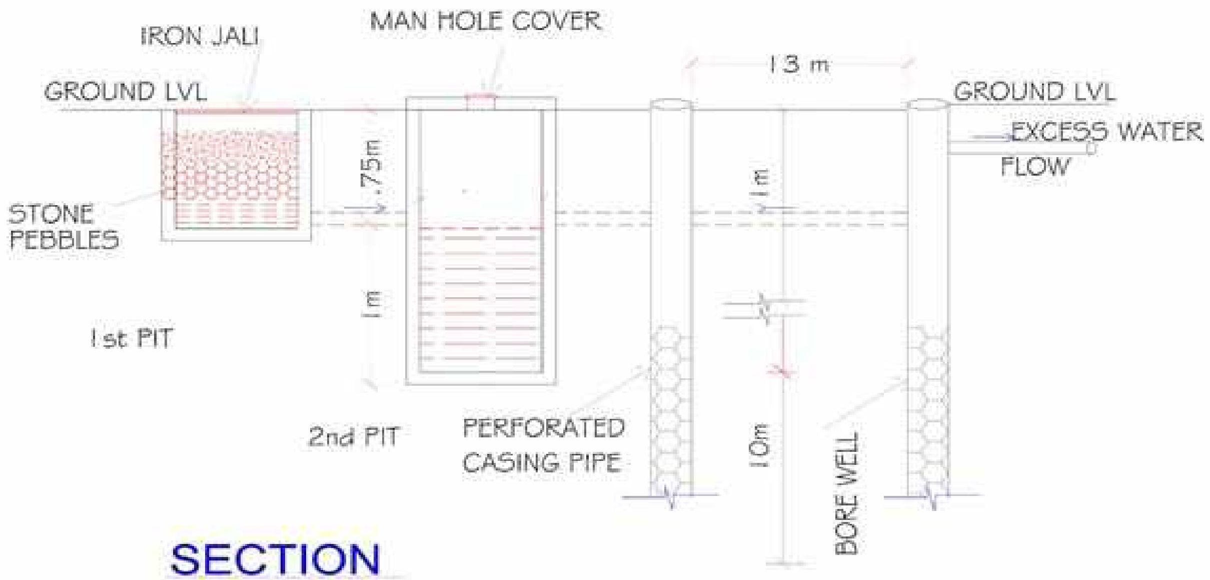
   Dimensions: It is **4 m** long and **2 m** wide, with a free board depth of **1.75 m**.

   Volume: The total volume of this pit is **14 m^3**.

3. **The plan also includes two intake wells with a capacity of 5 LPS** (18m^3/hr)

   Total Capacity of RWH Each pit is 52.1 m^3

   The total required volume for the RWH pits is **155/52.1 m3 = 2.9 Say 03 pits** are needed.



SECTION

HARVESTING STRUCTURE

ANNEXURE - I

ERT DATA

ERT.NO : **1**

CO-ORDINATE

Easting : 80°51'18.03"E

Northing : 16°53'68.13"N

VES.NO : **1**

MN/2	Electrode Spacing AB/2(m)	V	I	R	Multiplier	Apparent Resistivity (P=2PaR)
0.50	1.50	641.00	506.00	1.27	6.30	7.98
0.50	2.00	324.00	509.00	0.64	11.80	7.51
0.50	5.00	36.00	484.00	0.07	77.78	5.79
0.50	10.00	20.00	987.00	0.02	313.50	6.35
2.00	10.00	82.00	987.00	0.08	75.50	6.27
2.00	13.00	52.00	995.00	0.05	130.00	6.79
2.00	16.00	36.00	978.00	0.04	198.00	7.29
2.00	20.00	19.00	728.00	0.03	312.00	8.14
2.00	30.00	10.00	820.00	0.01	704.00	8.59

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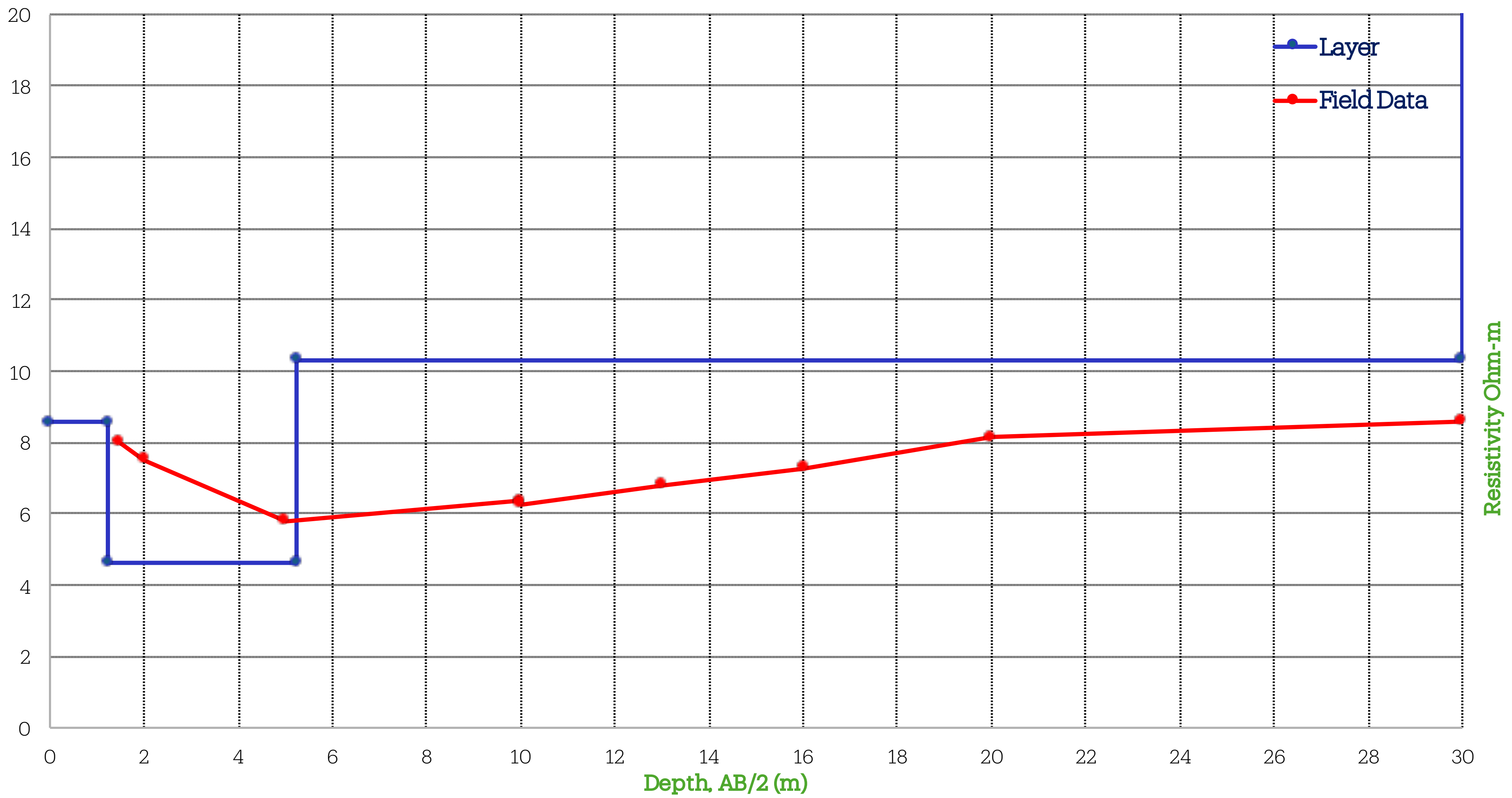
ELECTRICAL RESISTIVITY TEST

ERT.NO : 1



ERT.NO : 2

CO-ORDINATE

Easting : 80°51'23.25"E

Northing : 16°53'63.29"N

VES.NO : 2

MN/2	Electrode Spacing AB/2(m)	V	I	R	Multiplier	Apparent Resistivity (P=2PaR)
0.50	1.50	536.00	612.00	0.88	6.30	5.52
0.50	2.00	281.00	623.00	0.45	11.80	5.32
0.50	5.00	45.00	571.00	0.08	77.78	6.13
0.50	10.00	10.00	452.00	0.02	313.50	6.94
2.00	10.00	45.00	452.00	0.10	75.50	7.52
2.00	13.00	27.00	455.00	0.06	130.00	7.71
2.00	16.00	22.00	435.00	0.05	198.00	10.01
2.00	20.00	12.00	493.00	0.02	312.00	7.59
2.00	30.00	5.00	440.00	0.01	704.00	8.00

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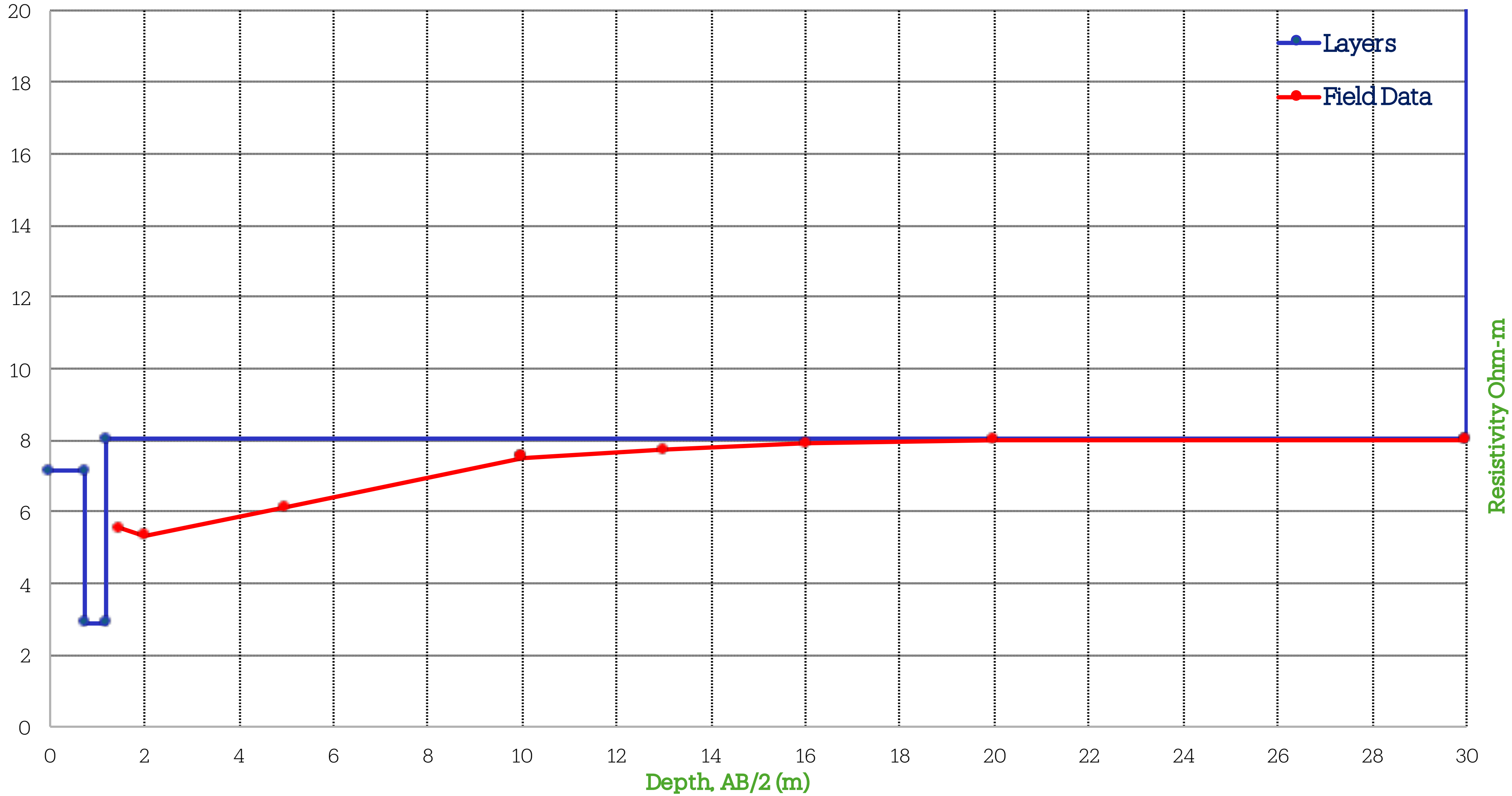
ELECTRICAL RESISTIVITY TEST

ERT.NO : 2



ERT.NO : 3

CO-ORDINATE

Easting : 80°51'21.28"E

Northing : 16°53'54.44"N

VES.NO : 3

MN/2	Electrode Spacing AB/2(m)	V	I	R	Multiplier	Apparent Resistivity (P=2PaR)
0.50	1.50	550.00	489.00	1.12	6.30	7.09
0.50	2.00	257.00	496.00	0.52	11.80	6.11
0.50	5.00	28.00	449.00	0.06	77.78	4.85
0.50	10.00	18.00	934.00	0.02	313.50	6.04
2.00	10.00	74.00	934.00	0.08	75.50	5.98
2.00	13.00	46.00	998.00	0.05	130.00	5.99
2.00	16.00	32.00	996.00	0.03	198.00	6.36
2.00	16.00	20.00	999.00	0.02	312.00	6.25
2.00	20.00	9.00	1003.00	0.01	704.00	6.32
2.00	30.00	5.60	1003.00	0.01	1254.00	7.00
2.00	40.00	4.00	1004.00	0.00	1961.00	7.81
2.00	50.00	19.00	1003.00	0.02	377.00	7.14
10.00	50.00	15.00	1003.00	0.01	550.00	8.23
2.00	80.00	11.00	1003.00	0.01	990.00	10.86
10.00	100.00	9.00	1070.00	0.01	1555.00	13.08

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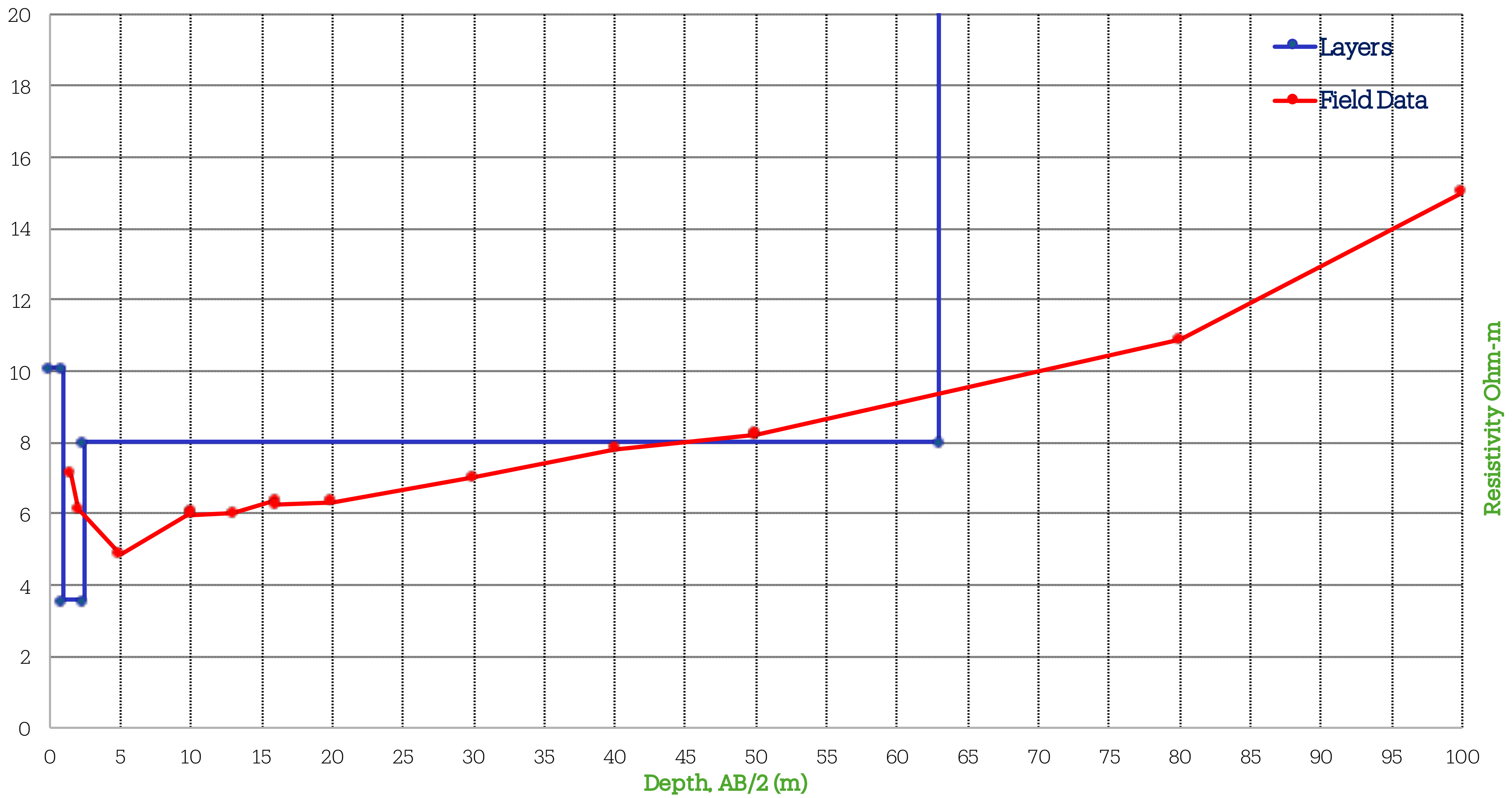
ELECTRICAL RESISTIVITY TEST

ERT.NO : 3



ERT.NO : 4

CO-ORDINATE

Easting : 80°51'23.25"E

Northing : 16°53'63.29"N

VES.NO : 4

MN/2	Electrode Spacing AB/2(m)	V	I	R	Multiplier	Apparent Resistivity (P=2PaR)
0.50	1.50	418.00	500.00	0.84	6.30	5.27
0.50	5.00	49.00	509.00	0.10	77.78	7.49
0.50	10.00	13.00	557.00	0.02	313.50	7.32
2.00	10.00	54.00	557.00	0.10	75.50	7.32
2.00	13.00	28.00	574.00	0.05	130.00	6.34
2.00	16.00	14.00	462.00	0.03	198.00	6.00
2.00	20.00	22.00	996.00	0.02	312.00	6.89
2.00	30.00	10.00	1000.00	0.01	704.00	7.04
2.00	40.00	6.20	1003.00	0.01	1254.00	7.75
2.00	50.00	4.40	1003.00	0.00	1961.00	8.60
5.00	50.00	22.00	1002.00	0.02	377.00	8.28
10.00	50.00	16.00	550.00	0.03	550.00	16.00
10.00	80.00	11.00	999.00	0.01	990.00	10.90
10.00	90.00	10.00	1190.00	0.01	1550.00	13.03

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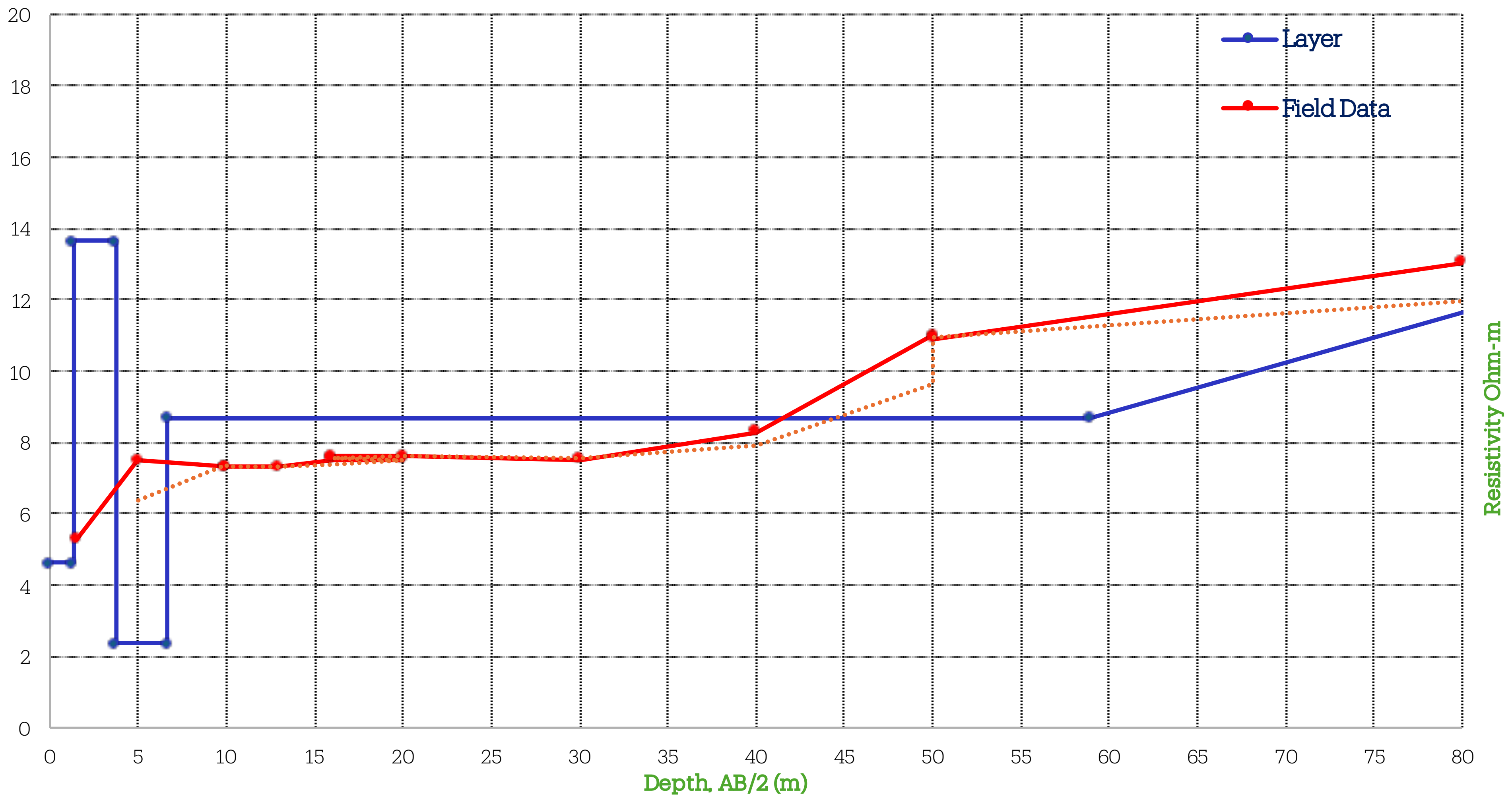
ELECTRICAL RESISTIVITY TEST

ERT.NO : 4



ANNEXURE - XII

PHOTOGRAPHS

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GEOTECHNICAL INVESTIGATION FOR PROPOSED CONSTRUCTION OF BUILDINGS FOR AMARAVATI LOCAL HEAD OFFICE AND OTHER OUTFITS AT AMARAVATI, ANDHRAPRADESH.

GEOTECHNICAL INVESTIGATION FOR PROPOSED CONSTRUCTION OF BUILDINGS FOR AMARAVATI LOCAL HEAD OFFICE AND OTHER OUTFITS AT AMARAVATI, ANDHRAPRADESH.

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