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Identification of Ground water Potential Zones Using Electrical Resistivity and VLF-EM Methods in Gaarakuntapalem Village, Maadugulapally Mandal, Nalgonda District, Telangana State, India

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ABSTRACT

A geophysical investigation involving the VLF-EM(very low frequency electromagnetic) and the vertical electrical sounding (VES) electrical resistivity methods was carried out Gaarakuntapalem village, Maadugulapally mandal, Nalgonda district, Telangana state. The study was carried out with a view to determine the subsurface layer parameters (velocities, resistivity's, and thicknesses) and use same to categorise the ground-water potential of the area. Very low frequency electromagnetic (VLF-EM) and vertical electrical sounding (VES) method were used to delineate fracture zones for groundwater exploration within the permanent site of some gaarakuntapalem village. The VLF-EM survey was made at 5 meters interval along traverses at East - West direction ranging from 230 - 500 meters in length. The plot of filtered real and filtered imaginary identified prominent fracture zones close to the surface or sub surface which was further delineated by VES method. VES soundings were carried out at locations of prominent VLF anomalies presumably typical of basement fracture using AB/2 of 100m. the results Table 4 distinctive geo-electric interpreted layers of sandy top soil, (0.6m to 8.6m, 107.8Ωm to 662.72Ω m), underlain by sandy clay/ clayey sand (5.7m to 43.5m, 34.7Ωm to 346.8Ωm) which is underlain by fractured/fresh basement (484Ωm to 5651Ωm). The basement fractures identified from VLF-EM anomaly curves were confirmed by geo-electric interpretation of the VES, therefore, the use of the two methods help in identification and delineation of prominent prospective groundwater areas.

Keywords: Fracture Zones, Geoelectric Sections, Potential Zones, Traverse and Resistivity Values, VES and VLF-EM.

1. INTRODUCTION

This work focused on the use of Very Low Frequency – Electromagnetic (VLF– EM) and Electrical Resistivity – Vertical Electrical Sounding (VES) methods of geophysical survey in a typical crystalline basement complex terrain. The Electromagnetic (EM) method has been found useful in groundwater development, most especially in basement complex areas. In Hard rock terrain, in addition to weathered layer, the deep saturated fractures in bedrock are also potential target of groundwater exploration. The VLF – EM offers a relatively fast approach to delineate the fractures compared to many other geophysical methods. This method has therefore been the most popular electromagnetic tools for quickly mapping near – surface geologic structures in geophysical survey as a reconnaissance tool for weathered layer investigation and the method has proved successful in identifying deep water – bearing fractures in bedrock.

Electrical resistivity methods can give information of locations where neither gravity nor magnetic anomalies can exist for horizontal bedding, it can be used where structures is not too complicated (Telford et al., 1976). Electrical resistivity method is commonly used in engineering site investigation. its relevance is in depth to bedrock determination, structural mapping, and usually determination of the nature of the superficial deposit. It serves as a major tool in groundwater exploration.

Studies of the relationship between resistivity and other rock characteristics such as; porosity, texture, salinity and content of ore minerals has provided a basic for evaluating the condition and nature of geological formation. This method has been usefully applied in groundwater prospecting, and also use to determine the depths to saturated zones and to obtain the total thickness of the overburden including weathered basement in order to reveal the nature of the fresh basement.

The electromagnetic and resistivity methods are both responsive to water-bearing basement fracture columns due to the relatively high bulk electric conductivities, both methods were therefore found relevant and were hence integrated in the geophysical investigation, the VLF – EM method was adopted as a fast reconnaissance tool to map possible linear features such as; fault, and fracture zones while the electrical resistivity method was used investigate prominent electromagnetic anomalies and provide a geo-electric image or section of the subsurface sequence (Benson et al., 1997).

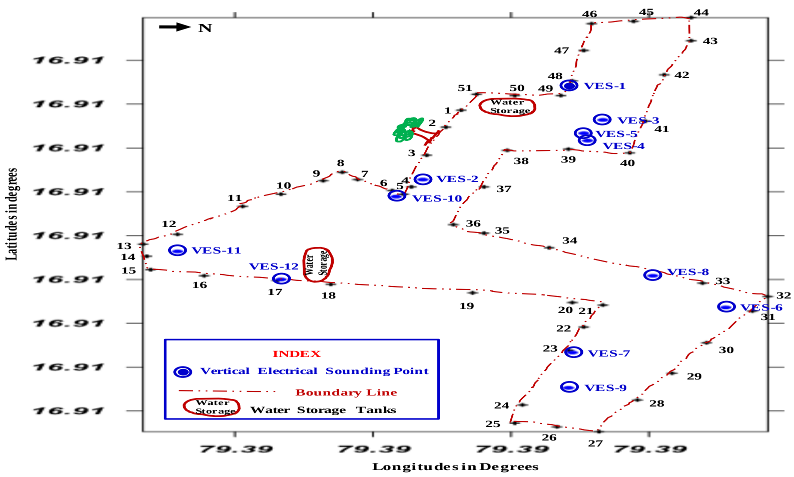
2. LOCATION AND GEOLOGY OF THE STUDY AREA

The site Study Area is situated roughly in the western direction of the Gaarakuntapalem village at a distance of about 0.5km. The area of about 15 acres boundary was marked in latitudes and longitudes at a distance of about 30m as study area by Global Positioning System (GPS), the area is completely covered by red soil, partly elevated platform in the S-W portion.

The site where the Geophysical methods (VLF and Electrical Resistivity Methods) were conducted is situated Eastern direction of the Gaarakuntapalem village, Maadugulapally mandal, Nalgonda district. The surface is covered with red soil, underlain by morum with sand and gravel, hard morum and then weathered granite and basement rock as seen from surface exposed western and Northern portion of the site.

3. METHODOLOGY

Two methods of geophysical surveys were used for this work: Very Low Frequency – Electromagnetic (VLF - EM) method which literarily serves as reconnaissance survey tool for the subsurface geophysical delineation and electrical resistivity (VES) method.



The VLF – EM measurements were made at 5m interval traverses of approximate east-west direction with each traverse ranging from 230m – 500m The EM response was measured using the ABEM WADI VLF – EM for data collection. The equipment measured the real (in-phase) and quadrature or imaginary (out-of-phase) component of the vertical to horizontal magnetic field ratio. The VLF WADI instrument displays the filtered real anomaly on the screen, and this anomaly can be roughly interpreted on site.

The VLF-EM geophysical method is a quick and powerful tool for the study of shallow conducting lineament features in the near-surface earth (Telford et al., 1977). The method is based on measurement of the secondary magnetic field induced in local conductors by primary electromagnetic fields generated by the powerful military radio transmitter in the very low-frequency range (15 – 30 KHz). The entire ABEM WADI system is portable equipment mounted on a belt worn by the user.

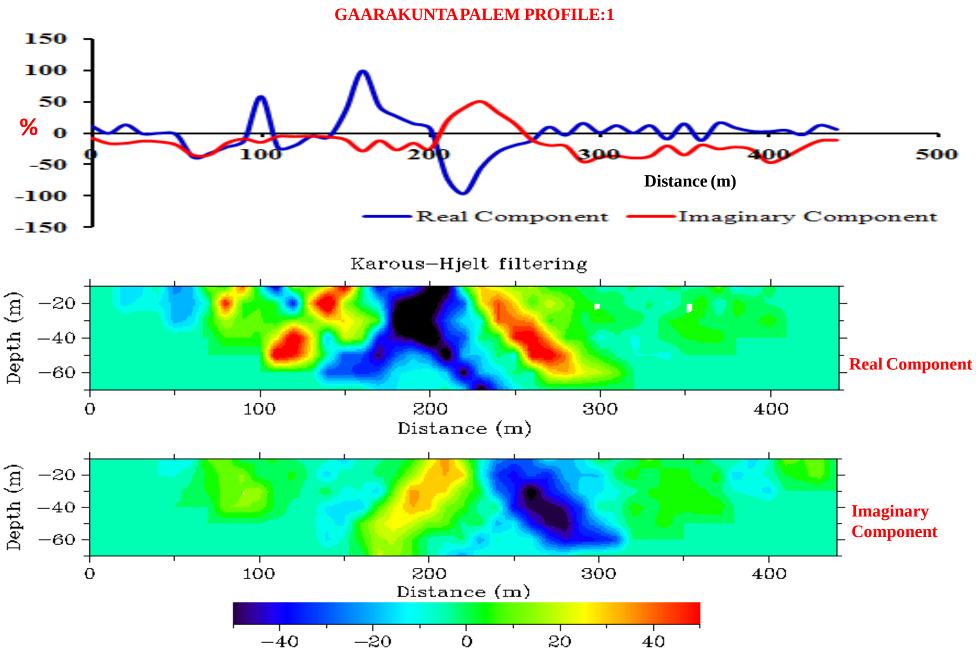
The hand-held controller unit contains a microcomputer, keyboard and screen where measurements are displayed and stored. The measuring unit contains the radio receiver with amplifier and another electronic circuitry from where one can send information to a printer or computer. The antenna are kept upright (vertical) or almost while the measurements are being taken, less a warning signal appear on the screen.

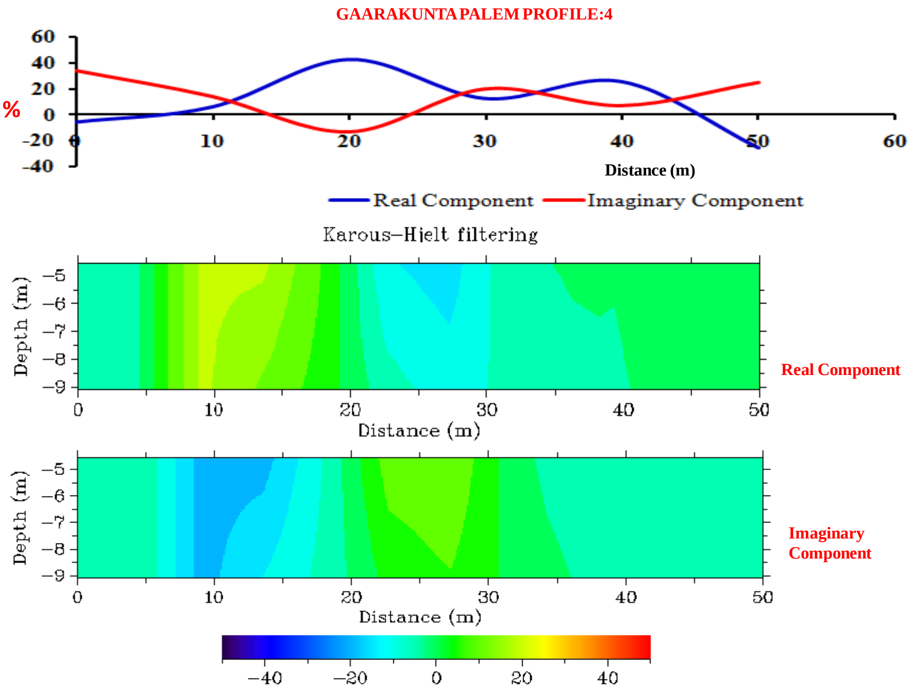
The equipment called ABEM WADI utilizes the negative component of the electromagnetic field generated by military radio transmitter with very low frequency (VLF) range between 15-30 kHz. ABEM WADI sends primary field waves into the subsurface which in returns; send out a weak secondary magnetic field that had been built around conductive geological structures aligns in concentric lines around the transmitting antenna. The WADI measures the field strength and phase displacement around geologic structure such as fault or shear zone in the bedrock.

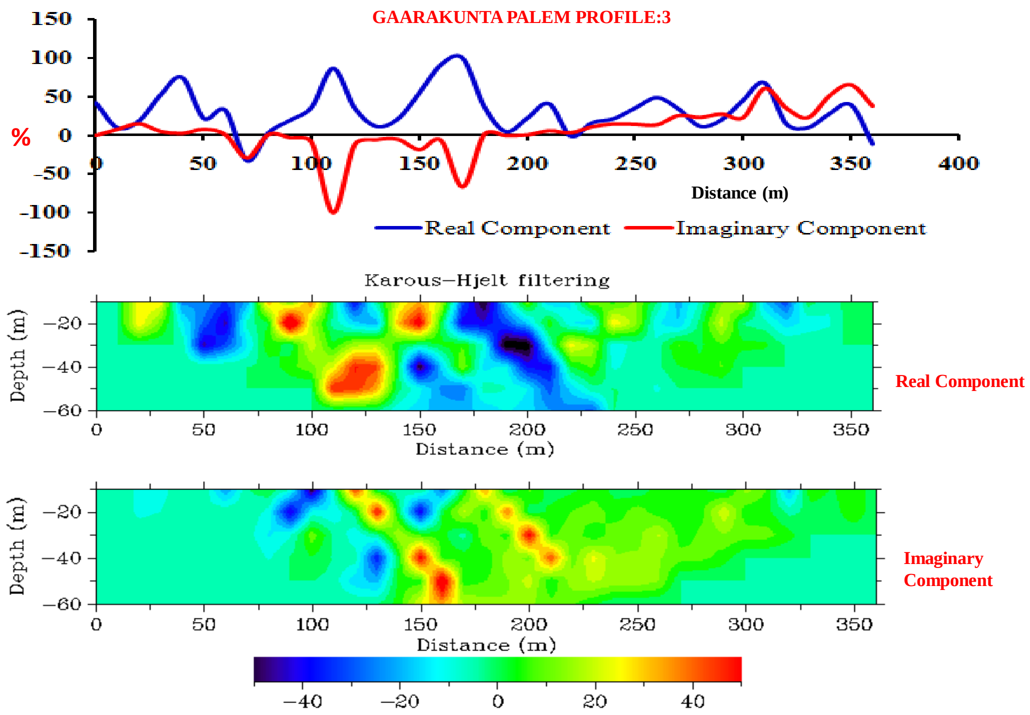
4. RESULTS AND DISCUSSION

The results of the VLF-EM plots along each traverse are presented in figures and showed varied anomalies with narrow, sharp or broad peaks with varying width extent. The curves with maximum positive peak of filtered real with corresponding low filtered imaginary curves were delineated and identified as area with high conductivity which is the characteristic of water-filled fractures or faults and therefore can serve as a good auriferous zones.

Mullern and Erickson, (1983) indicated that the strength of the in-phase component expressed in percentage is directly proportional to the yield of the water, further the strength of the VLF anomaly depend on the contrast between the electrical conductivity in water–bearing fracture zone that gives rise to the anomaly in an electrical conductivity of the surrounding bedrock. Similarly the variation between the in-phase component and the yield of water exist in the present study. The high – resistivity contrasts between the bedrock is proportional to the strength of the VLF signal which in –turn is related to the yield. VLF can detect fracture zones if the weathered layers is not too thick or conductive, the tilt angle method i.e (measurement of in-phase and quadrature component) can be a tool for detailed ground water exploration because of its rapid data acquisition and lower cost, particularly in hard rock terrain, a more reliable result is achieved by VLF when combine with other method. Geological interfaces (F1-F12) were delineated using characteristic features of coincident inflection on real component anomaly curves (ABEM, 1990, Olorunfemi et al., 1997). These interfaces are near- surface/subsurface fracture in the basement complex rock, when such linear features are water saturated, they constitute good aquifers.






GAARAKUNTA PALEM PROFILE:3
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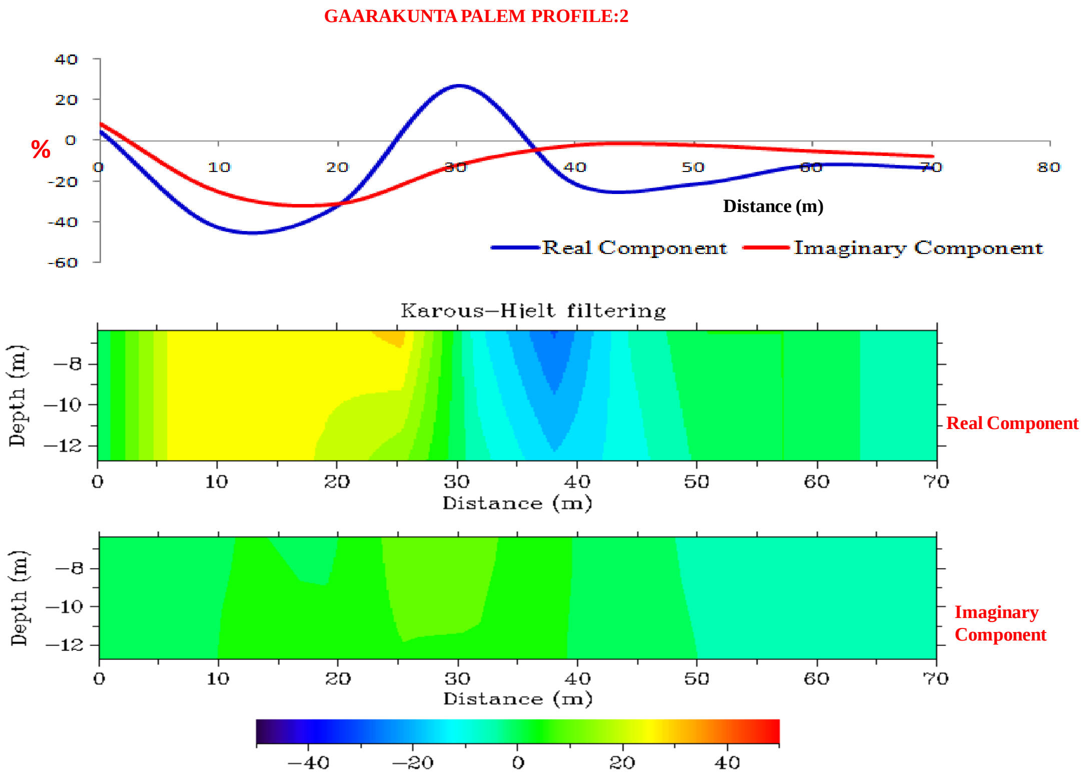
Distance (m)
Real Component
Imaginary Component
Karous–Hjelt filtering
Depth (m)
Distance (m)
Real Component
Depth (m)
Distance (m)
Imaginary Component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Distance (m)
Real Component
Imaginary Component
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Depth (m)
Distance (m)
Real Component
Depth (m)
Distance (m)
Imaginary Component

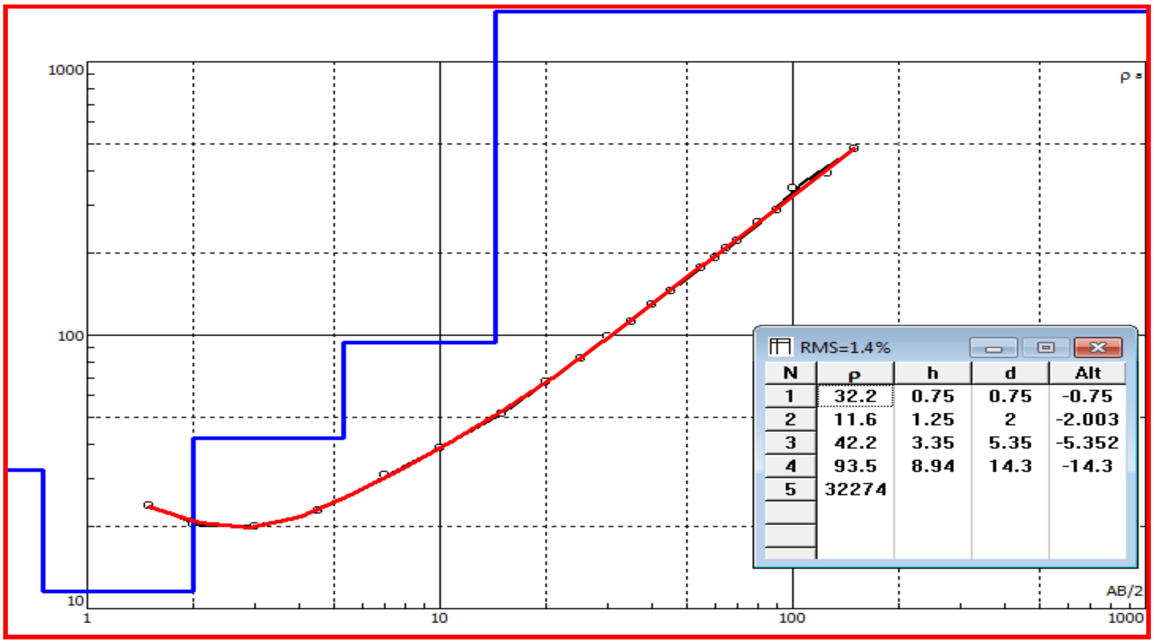
Table: 1 Layout map coordinates Cultivated Land (Gaarakuntapalem Village, Maadugulapally Mandal, Nalgonda District)

Sl. No.	AB/2 (m)	MN/2 (m)	K (m)	Ves-1 ρa (Ωm)	Ves-2 ρa (Ωm)	Ves-3 ρa (Ωm)	Ves-4 ρa (Ωm)	Ves-5 ρa (Ωm)	Ves-6 ρa (Ωm)
1	1.5	0.5	6.3	19.5	76.3	16.8	15.8	10.9	47.7
2	2	0.5	11.8	21.7	74.8	18.8	12.7	09.6	48.2
3	3	0.5	27.5	19.2	75.9	24.2	14.5	11.1	55.5
4	4.5	0.5	63	25.5	71.8	29.9	18.5	11.9	62.6
5	7	0.5	153	33.6	73.4	37.4	26.0	16.0	70.3
6	10	0.5	313.5	48.5	65.8	42.2	34.4	23.4	78.3
7	10	2.0	75.4	34.6	76.1	45.9	35.0	22.9	85.2
8	15	0.5	706	74.1	56.4	56.4	52.9	38.8	95.2
9	15	2.0	175	48.1	71.7	58.6	49.0	39.3	105.0
10	20	2.0	311	60.6	80.8	73.0	60.6	54.3	124.4
11	25	2.0	487.7	73.1	92.6	90.1	70.6	65.8	134.0
12	30	2.0	703.8	91.4	105.5	109.0	84.4	73.8	147.7
13	35	2.0	959.09	105.4	124.6	129.4	91.1	86.3	148.6
14	40	5.0	494.86	123.7	148.4	165.7	96.4	94.0	185.5
15	45	5.0	628.40	144.5	166.4	188.5	97.3	97.3	201.0
16	45	10	302.5	139.1	190.5	190.5	114.9	101.3	190.5
17	55	5.0	942.60	179.0	207.3	216.7	117.8	103.6	245.0
18	55	10	459.51	176.9	229.7	222.8	130.9	107.9	232.0
19	60	10	549.85	192.4	252.9	230.9	142.9	115.4	255.6
20	65	10	648.03	213.8	272.1	249.4	155.5	126.3	281.8
21	70	5.0	1531.7	237.3	260.3	252.6	137.8	130.1	321.6
22	70	10	754	237.4	301.6	263.9	162.0	135.7	312.8
23	80	10	989.7	277.1	336.4	301.8	183.0	148.4	361.1
24	90	10	1256.8	314.2	377.0	345.6	201.0	163.3	408.4
25	100	10	1556	357.8	404.5	381.2	225.6	186.7	474.5
26	125	10	2226.9	400.8	467.6	423.1	267.2	211.5	545.5
27	150	10	3520	528.0	563.2	545.6	334.4	281.6	686.4
28	200	10	6270	-----	752.4	721.0	344.8	282.1	815.1

Table: 2 Layout map coordinates Cultivated Land (Gaarakuntapalem Village, Maadugulapally Mandal, Nalgonda District)

Sl. No.	AB/2 (m)	MN/2 (m)	K (m)	Ves-7 ρa (Ωm)	Ves-8 ρa (Ωm)	Ves-9 ρa (Ωm)	Ves-10 ρa (Ωm)	Ves-11 ρa (Ωm)	Ves-12 ρa (Ωm)
1	1.5	0.5	6.3	50.9	28.5	23.8	83.9	63.6	24.4
2	2	0.5	11.8	47.4	28.2	27.4	74.4	54.2	25.1
3	3	0.5	27.5	51.1	34.6	30.8	75.9	51.4	25.4
4	4.5	0.5	63	56.3	40.3	32.7	74.3	44.7	26.1
5	7	0.5	153	63.4	48.1	35.1	76.5	45.0	34.3
6	10	0.5	313.5	67.3	53.2	40.7	84.6	----	45.4
7	10	2.0	75.4	41.8	50.5	47.8	76.9	----	45.2
8	15	0.5	706	77.6	74.1	56.4	----	----	70.6
9	15	2.0	175	81.3	65.6	67.3	----	----	69.1
10	20	2.0	311	96.4	76.1	83.9	----	----	93.3
11	25	2.0	487.7	112.1	85.3	102.4	----	----	114.5
12	30	2.0	703.8	133.7	98.5	119.6	----	----	133.7
13	35	2.0	959.09	153.4	105.4	134.2	----	----	153.4
14	40	5.0	494.86	178.1	128.6	150.9	----	----	173.2
15	45	5.0	628.40	194.8	144.5	169.6	----	----	191.6
16	45	10	302.5	196.6	145.2	175.4	----	----	184.5
17	55	5.0	942.60	230.9	174.3	197.9	----	----	235.6
18	55	10	459.51	234.3	179.2	211.3	----	----	225.1
19	60	10	549.85	255.6	192.4	225.4	----	----	244.6
20	65	10	648.03	278.6	207.3	239.7	----	----	262.4
21	70	5.0	1531.7	291.0	214.4	229.7	----	----	298.6
22	70	10	754	297.8	222.4	248.8	----	----	286.5
23	80	10	989.7	336.4	252.3	291.9	----	----	336.4
24	90	10	1256.8	370.7	270.1	314.2	----	----	383.3
25	100	10	1556	427.8	287.8	342.3	----	----	435.6
26	125	10	2226.9	501.0	300.5	389.6	----	----	523.2
27	150	10	3520	651.2	404.8	510.4	----	----	686.4
28	200	10	6270	846.4	501.6	658.3	----	----	877.8

VES-1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N ρ h d Alt
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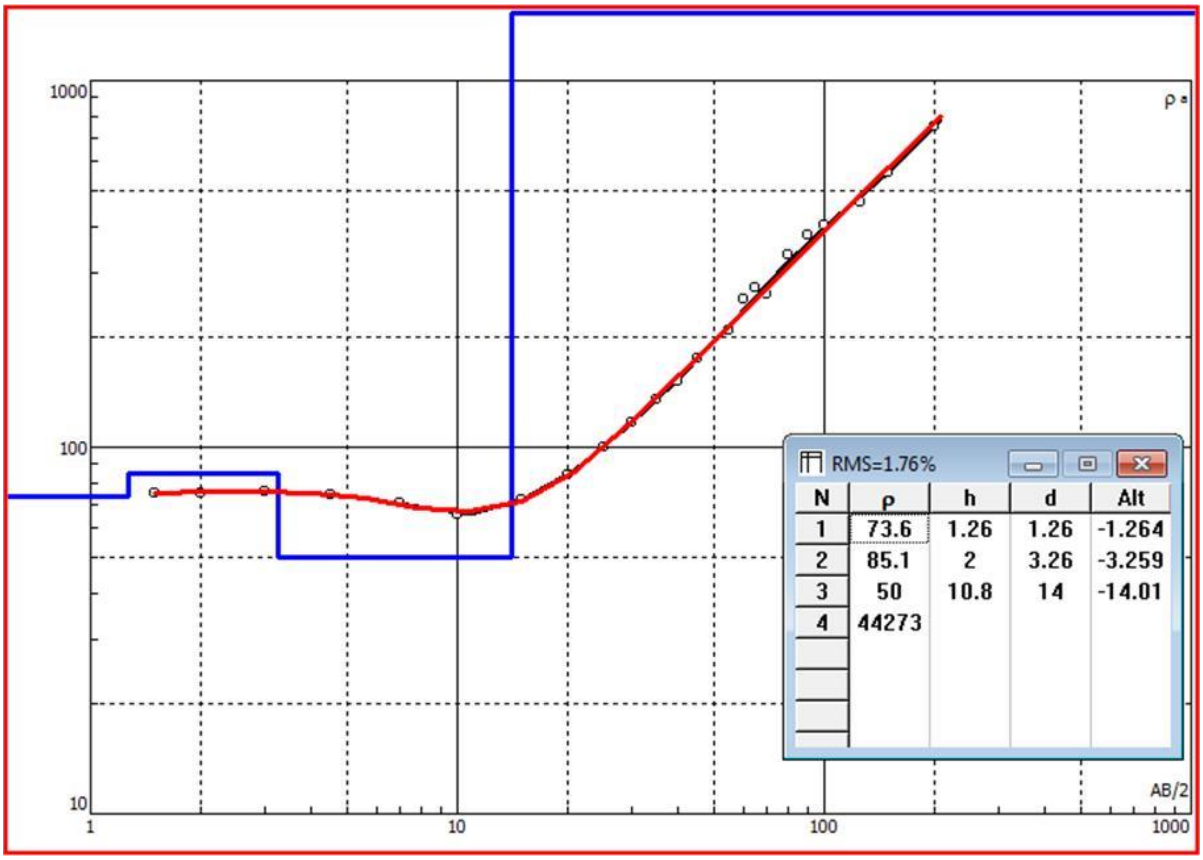
2 11.6 1.25 2 -2.003
3 42.2 3.35 5.35 -5.352
4 93.5 8.94 14.3 -14.3
5 32274
AB/2
1000
100
10
1

VES-2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1 73.6 1.26 1.26 -1.264
2 85.1 2 3.26 -3.259
3 50 10.8 14 -14.01
4 44273
AB/2
1000
100
10
1

Table: 3:- Interpreted layer Resistivity and thickness from VES

Sl. No.	VES No.	VES Type	ρ_1 (Ωm)	ρ_2 (Ωm)	ρ_3 (Ωm)	ρ_4 (Ωm)	ρ_5 (Ωm)	ρ_6 (Ωm)	h_1 (m)	h_2 (m)	h_3 (m)	h_4 (m)	h_5 (m)	h_6 (m)	H (m)
1	1	HA	32.2	11.6	42.2	93.5	32274	---	0.75	1.25	3.35	8.94	---	---	14.3
2	2	H	73.6	85.1	50	44273	---	---	1.26	2	10.8	---	---	---	14
3	3	HA	11.1	76.5	16.4	6257	7146	---	0.88	1.32	2.58	12.2	---	---	17
4	4	HA	20.3	6.84	241	71.9	1451	---	0.75	1.37	3.88	11	---	---	17
5	5	HA	13.1	5.65	17.7	475	5701	---	0.88	1.01	2.76	148	---	---	153
6	6	AA	45.9	70	145	157	8352	---	1.59	3.43	17.4	1.77	---	---	24.2
7	7	AA	49.1	60	95.8	2382	112104	---	2.12	3.88	11	31.1	---	---	48.1
8	8	AA	24	34.8	65.6	5930	1181	---	0.75	1.5	14.6	7.8	---	---	24.7
9	9	HA	19	42.7	25	891	6827	---	0.75	1.37	3.88	50.8	---	---	56.8
10	10	---	---	---	---	---	---	---	---	---	---	---	---	---	---
11	11	---	---	---	---	---	---	---	---	---	---	---	---	---	---
12	12	HA	25	13.2	88.7	1477	44116	---	2.27	1.55	0.43	26.6	---	---	.8

Table: 4:- List of Recommended Borewell Points

Sl. No.	VES No.	Longitude	Latitude	Total Thickness H (m)	Maximum Depth to be drilled (m)	Expected Yield (in inches)
1	2	$78^0 48'55.0''$	$17^0 30'55.3''$	35.9	200	$1\frac{1}{2}$ & Above
2	7	$78^0 48'54.6''$	$17^0 30'56.3''$	136	200	2 & Above

Note: - * Casing should be placed up to loose soil.

5. CONCLUSION

Geological features suspected to be basement fracture identified from VLF-EM anomaly were confirmed by geo-electric sub-surfaces images develop from interpretation results of VES. Studies in similar basement terrain (Bala and Ike, 2001; Omosuyi et. al., 2003) have identified areas with thick overburden cover as high groundwater potential zones. Consequently, areas with overburden thickness of 15m and above are priority areas for groundwater development, and majority of the areas identified from VLF-EM plot have thickness greater than this values. This work however shows the effectiveness of the combination of VLF-EM and VES survey in accurately delineating an area for groundwater occurrence and exploitation.

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