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Groundwater Potential Evaluation of Ultra Modern Guest House, Afe Babalola University, Ado-Ekiti, Southwestern Nigeria

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ABSTRACT

Geophysical study of the Ultra Modern Guest House, Afe Babalola University, Ado-Ekiti was conducted to investigate its groundwater potential and challenges. Profiling and Vertical electrical sounding methods were employed using Dipole - Dipole and Schlumberger configuration respectively. Eleven points were sounded along three traverses and three profiles were occupied. Five different subsurface lithologic units were established namely; lateritic topsoil, sandy-clay, weathered basement, fractured basement and, fresh basement. The curve types range between simple K, H to complex HA, and HK. The topsoil, sandy-clay and weathered basement materials are characterised with relatively low resistivity values while the fresh basement materials are characterized with high resistivity values. The average resistivity and thickness values for the topsoil are 180Ωm and 3.0m respectively. Sandy-clay was encountered in all the locations with average resistivity and thickness values of 37Ωm and 10.0m respectively. Weathered basement was encountered in seven locations with average resistivity and thickness values of 121Ωm and 9.0m respectively. Fractured basement was encountered in two locations with average resistivity and depth to the top of fracture values of 25Ωm and 20.0m respectively. Basement is relatively shallow in the study area, it was encountered in six locations and the average resistivity and depth values to the top of basement are 294Ωm, and 13.0m respectively. Overburden thickness was established in all the locations with an average resistivity and thickness values of 113Ωm and 22.0m respectively. The combination of overburden materials with the fractured basement constitutes aquiferous units within the study area. The groundwater potential of the area is moderate. VES 3 and 8 could be drilled to a total depth of 50m provided there is no drop in volume of water as drilling progresses.

KEYWORDS: *Profiling, Vertical electrical sounding, Lithologic units, Fractured basement, Aquiferous unit.*

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I. INTRODUCTION

Afe Babalola University Ado-Ekiti is indisputably one of the fastest growing private university in Nigeria.. The enviable pace of infrastructural development among other factors is attracting more and more people into the university and the population keeps increasing at a steady rate. Also notable is the influx of visitors from all spheres of life across the globe on regular basis. The university community has hosted the "who is who" in Nigeria and beyond from time to time since inception. Expectedly, the University will continue to witness this influx of guest perhaps on a larger scale. The choice of most guest to reside within the campus while their visit last is remarkable but, the existing University Guest House is barely large enough to cater for such cadre and number of guests as frequently witnessed. In order to meet up with the anticipated cadre and large number of expected visiting guests in the University and in keeping pace with the leading role in reforming education, the management has embarked on construction of a 158 bedded ultra modern guest house. On completion, the structure will no doubt adequately accommodate the anticipated frequent and large numbers of guest on the campus. For maintenance and service, water is an essential amenity for the Ultra Modern Guest House, more so, in a complex basement terrain with low groundwater potential like Ado_Ekiti where the structure is located.

The existing number of boreholes, storage and reticulation facilities on campus are barely sufficient to meet the water requirement of the University community. There is need to look inward rather than leaning on the over-stressed water supply network on campus. Several workers such as Dutcher and Garret (1965), Clerk (1985), Olorunfemi and Olorunniwo (1985), Olorunfemi (1990), Olayinka and Olorunfemi (1992)Olorunfemi and Olayinka (1992), Olorunfemi and Fasuyi (1993), Oladipo et al, (2005) Olayinka and Weller (1993), Rehil and Birk (2010), Ojo et al, (2011), Talabi (2013) have carried research in various aspect of groundwater exploration/investigation, evaluation and structural delineation using geophysical methods in several location within the basement complex terrain around the world. Afe Babalola University located in Ado Ekiti is not exempted from the challenge of low groundwater availability resulting from complex geology of this area, hence, the need to source for additional means to complement the existing water supply for the ever-increasing population of the University community. There is need to investigate and evaluate the groundwater potential of the newly constructed college of engineering within the campus for improved water supply. The university has spent fortunes in sinking boreholes to ensure that the daily demand for potable water on the campus is met, but the ever increasing population growth of the university community with the attendant increase in water requirement suggest the need for further groundwater potential evaluation of the campus. The Ultra Modern Guest House under construction will require additional water supply.However, groundwater exploration in the basement aquifers posed a serious challenge resulting from complexity of rocks and minerals and their attendant heterogeneous grain size distribution. Olayinka and Olorunfemi (1992) emphasized the need to conduct a surface geophysical survey such as Vertical Electrical Resistivity Sounding in identifying the localized aquiferous zones before siting boreholes. Electrical resistivity method has been used extensively in groundwater investigation especially in the basement complex terrains (Grant and West, 1965, Olorunfemi and Olorunniwo, 1985. Olorunfemi, 1990. Olorunfemi and Olayinka, 1992). This study therefore aims at assessing the groundwater potential of the guest house and environs with attention on the delineation of the fracture system, overburden thickness and lithological variation across the terrain.

II. LOCATION AND GEOLOGY OF THE STUDY AREA

2.1 Location

Afe Babalola University is located in Ado-Ekiti along Ijan road, opposite The Federal Polytechnics. The study guest house is located at the south-western part of the University campus adjacent to the campus main gate. It lies at longitudes $5^{0}18'05.78''$E and latitudes $7^{0}36'09.59''$N (Figure 1). The terrain in the study area is gently undulating, with topographic elevation ranging from 345m to 370m above sea level. Ado Ekiti is underlain by crystalline rocks made of Older granite, Migmatite and Charnockites with little or no fracture in most location and shallow overburden.

2.2 Climate, Geology and Hydrogeology of The Area

The area is situated within the tropical rain forest region, with a climate characterized by dry and wet seasons. Average annual rainfall in this area is 1300 mm, with average wet days of about 100. The annual temperature varies between 18^{0}C to 34^{0}C. The study area lies within the basement complex of south-western Nigeria and is made up of; older granite, Migmatite and Charnockites. The overburden is relatively shallow within the study area with average of 22m. The groundwater is found within the overburden and fractured basement while the area is drained by the river Ogbese which flow SW-NE direction. The basement complex rocks are poor aquifers as they are characterized by low porosity and negligible permeability, resulting from their crystalline nature, thus availability of groundwater resource in such areas can only be attributed to the development of secondary porosity and permeability resulting from weathering and fracturing.

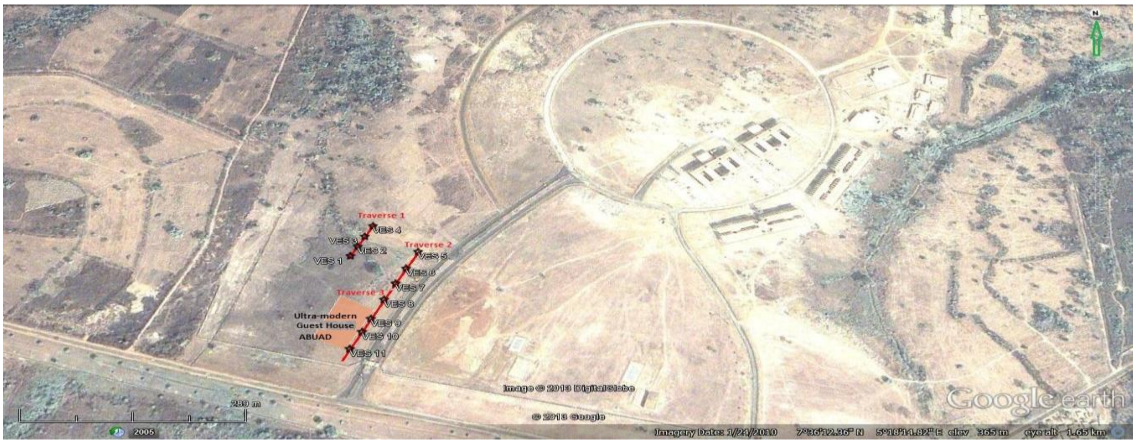


Fig.1. Aerial Photo of the Study Location

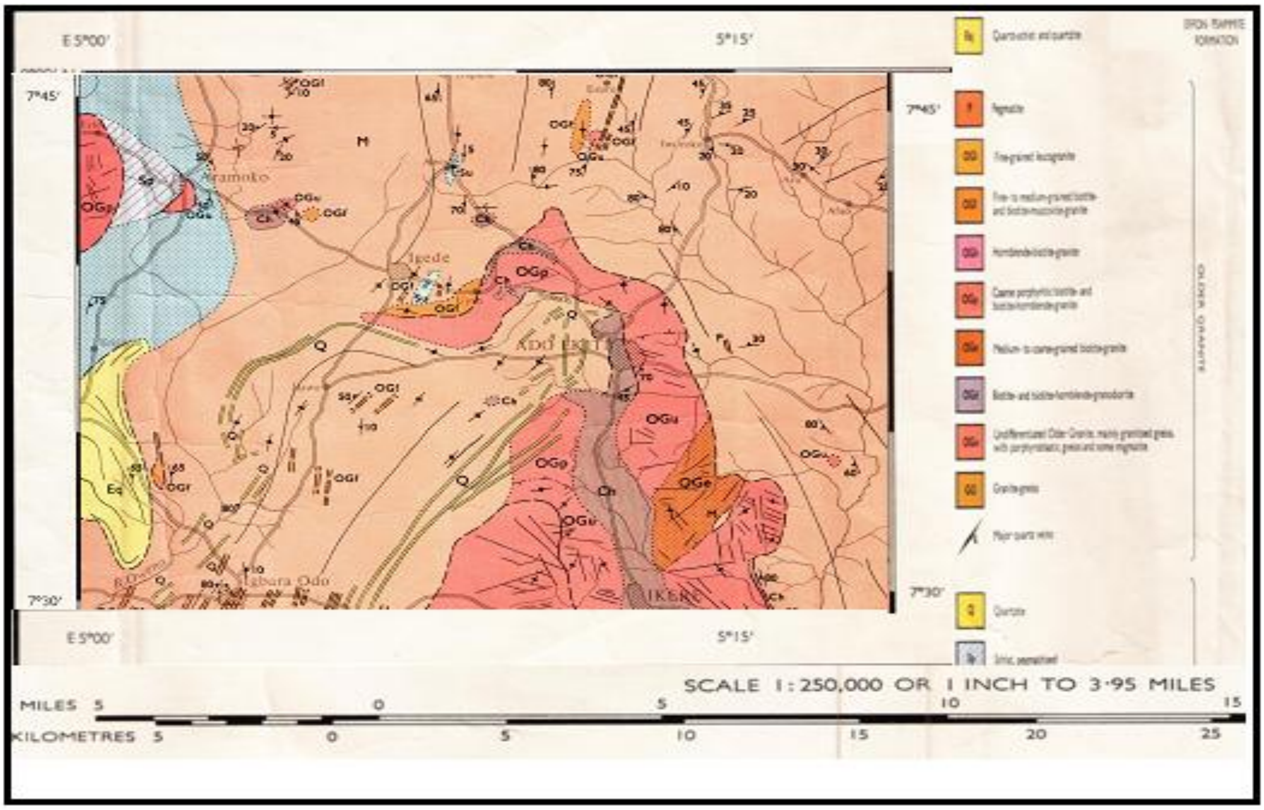


Fig. 2. Geology Map Of The Study area

III. Methodology, Data acquisition and Interpretation

A reconnaissance survey of study college was carried out for site familiarization and planning. This was followed with geophysical investigation of the college and environs. Geophysical methods are indirect site investigation techniques and predominantly non-intrusive. Two methods namely Resistivity Sounding and Resistivity Profiling were adopted. Soil resistivity meter (PASI) was used for the geophysical tests. It is highly reliable and reproducible. Resistivity sounding was adopted in resolving resistivity variation with depth, thus sounding helped in delineating the various subsurface lithological units, hydrogeological significance and the protective capacity or vulnerability of the subsurface layers to possible pollution.

Resistivity profiling was adopted in resolving horizontal resistivity variation in this study, hence profiling helped in establishing the lateral continuity of the various subsurface lithological units.

IV. RESULTS AND DISCUSSIONS

4.1 Vertical Electrical Sounding

A total of 11 VES locations across 3 traverses were spread over the study area (Figure 1). The processed data were interpreted, resulting curve types were assessed, existing subsurface lithologic units were established, and the geoelectric properties of the various subsurface layers were used in delineating the aquiferous units in the study area. The results are presented in the form of table (Table 1), geoelectric curves (Figure 3) and sections (Figure 4a,b & c). Five different subsurface lithologic sequences were established namely; lateritic topsoil, sandy-clay, weathered basement, fractured basement and, basement. The curve types range between simple H, K, HA, and HK. The topsoil, sandy-clay and weathered basement materials are characterised with relatively low resistivity values while the basement materials are typified with high resistivity values. A summary of the results of interpretation, on which the following findings were hinged, is shown in

Table 1.

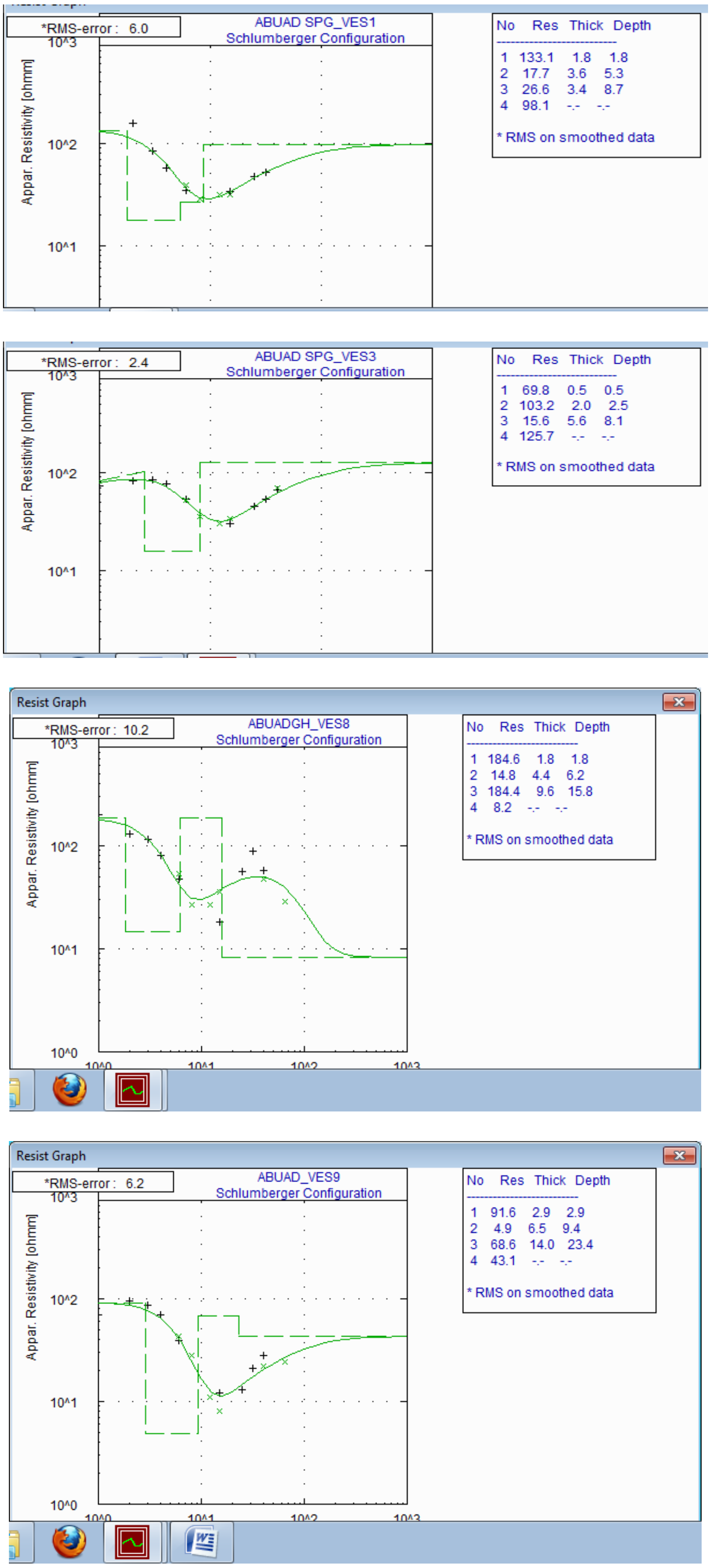


Fig. 3. Typical Geoelectric curves from data interpretations

Table 1: Correlation Table

VES POINT		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
CURVE TYPE		**H**	**HA**	**HA**	**HA**	**H**	**HA**	**H**	**HK**	**H**	**H**	**K**
LITHOLOGY												
TOP SOIL	TOP	0	0	0	0	0	0	0	0	0	0	0
	BASE	2	2	3	1	1	4	2	6	2	3	6
	THICKNESS	2	2	3	1	1	4	2	6	2	3	6
	Ωm	138	163	103	207	139	272	249	171	200	92	241
SANDY-CLAY	TOP	2	2	3	1	1	4	2	6	2	3	6
	BASE	9	8	8	7	15	11	19	24	7	23	14
	THICKNESS	7	6	5	6	14	7	17	18	5	20	8
	Ωm	27	36	16	23	29	10	29	72	45	61	63
WEATHERED BASEMENT	TOP	9	8	8	-	15	-	-	24	7	-	14
	BASE	-	16	-	-	-	-	-	-	16	-	-
	THICKNESS	-	8	-	-	-	-	-	-	9	-	-
	Ωm	98	139	126	-	156	-	-	77	189	-	65
FRACTURED BASEMENT	TOP	-	-	-	-	-	-	-	-	16	23	-
	BASE	-	-	-	-	-	-	-	-	-	-	-
	THICKNESS	-	-	-	-	-	-	-	-	-	-	-
	Ωm	-	-	-	-	-	-	-	-	6	43	-
BASEMENT	TOP	-	16	-	7	-	11	19	-	-	-	-
	BASE	-	-	-	-	-	-	-	-	-	-	-
	THICKNESS	-	-	-	-	-	-	-	-	-	-	-
	Ωm	-	369	-	279	-	277	249	-	-	-	-

4.1.1 Geoelectric Units

The geoelectric sections (Figures 4a,b & c) show the variations of resistivity and thickness values of layers within the depth penetrated in the study area. Three traverses were taken along the N-S direction. Five subsurface layers were revealed: Lateritic Topsoil, Sandy-clay, Weathered basement, Fractured basement and presumed Fresh basement.

Topsoil

The topsoil is relatively thin along these traverses. The average resistivity and thickness values for the topsoil are 180Ωm and 3.0m respectively.

Sandy-clay

Sandy-clay was encountered at shallow depths of 3.0meters on the average in all locations and the average resistivity and thickness values for the Sandy-clay are 37Ωm and 10.0m respectively.

Weathered-basement

Weathered-basement was encountered in seven locations and the average resistivity and thickness values of the weathered-basement are 121Ωm and 9.0m respectively.

Fractured-basement

Fractured basement was encountered in two locations and the average resistivity and depth values to the top of fractured basement are 25Ωm and 20.0m respectively.

Basement

The basement is the fresh bedrock and is the last layer. It is relatively shallow in the study area, it was encountered in six locations and the average resistivity and depth values to the top of basement are 294Ωm and 13.0m respectively.

Overburden

The overburden in assumed to include all materials above the presumably fresh basement. The depth to the bedrock varies from 7.0 to 19.0m and the average depth to the bedrock is 13.0m (Table 1 and Figure 4a,b & c). Overburden thickness was established in all locations and the average resistivity and thickness values are 113Ωm and 22.0m. The relatively moderate overburden thickness has potentials for groundwater saturation, however, the clayey nature and poor permeability of the materials will pose a challenge for water abstraction.

4.2 Horizontal Profiling

Result of the three profiles carried out in N-S direction are presented in the sections below. The traverses are 55, 60 and 180meters long respectively. Four continuous subsurface lithologic units namely; Lateritic topsoil (blue), sandy-clay (green), weathered basement (yellowish-brown) and fresh basement (reddish purple) were established by the profile section. The results are presented in form of 2-D resistivity structures (Figure 5a, b & c). The 2-D resistivity plot revealed a relatively thin overburden and shallow basement across the study area.

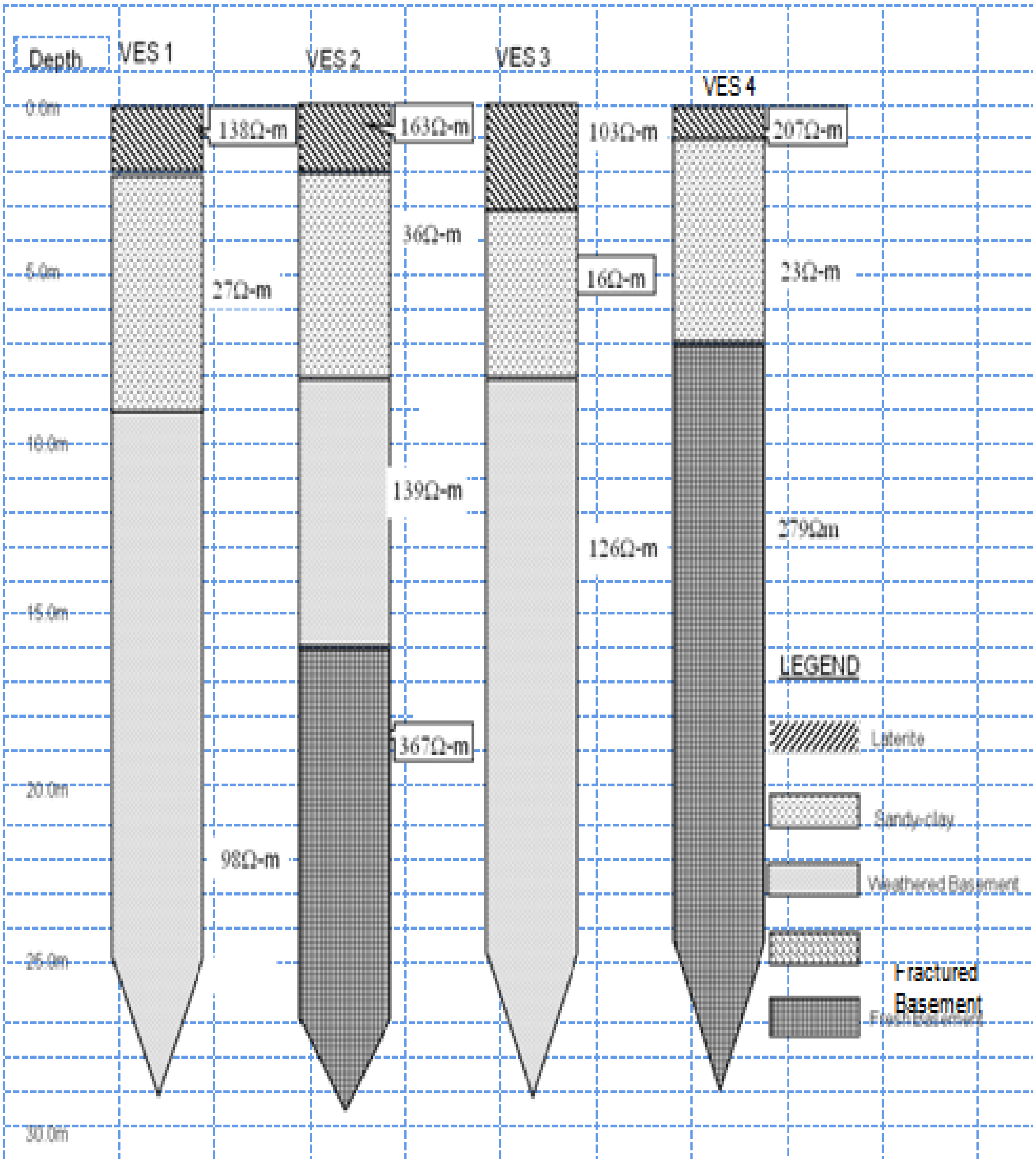


FIG. 4a: GEOELECTRIC SECTIONS OF VES 1, 2, 3 & 4 OF ULTRA MODERN GUEST HOUSE, ABUAD

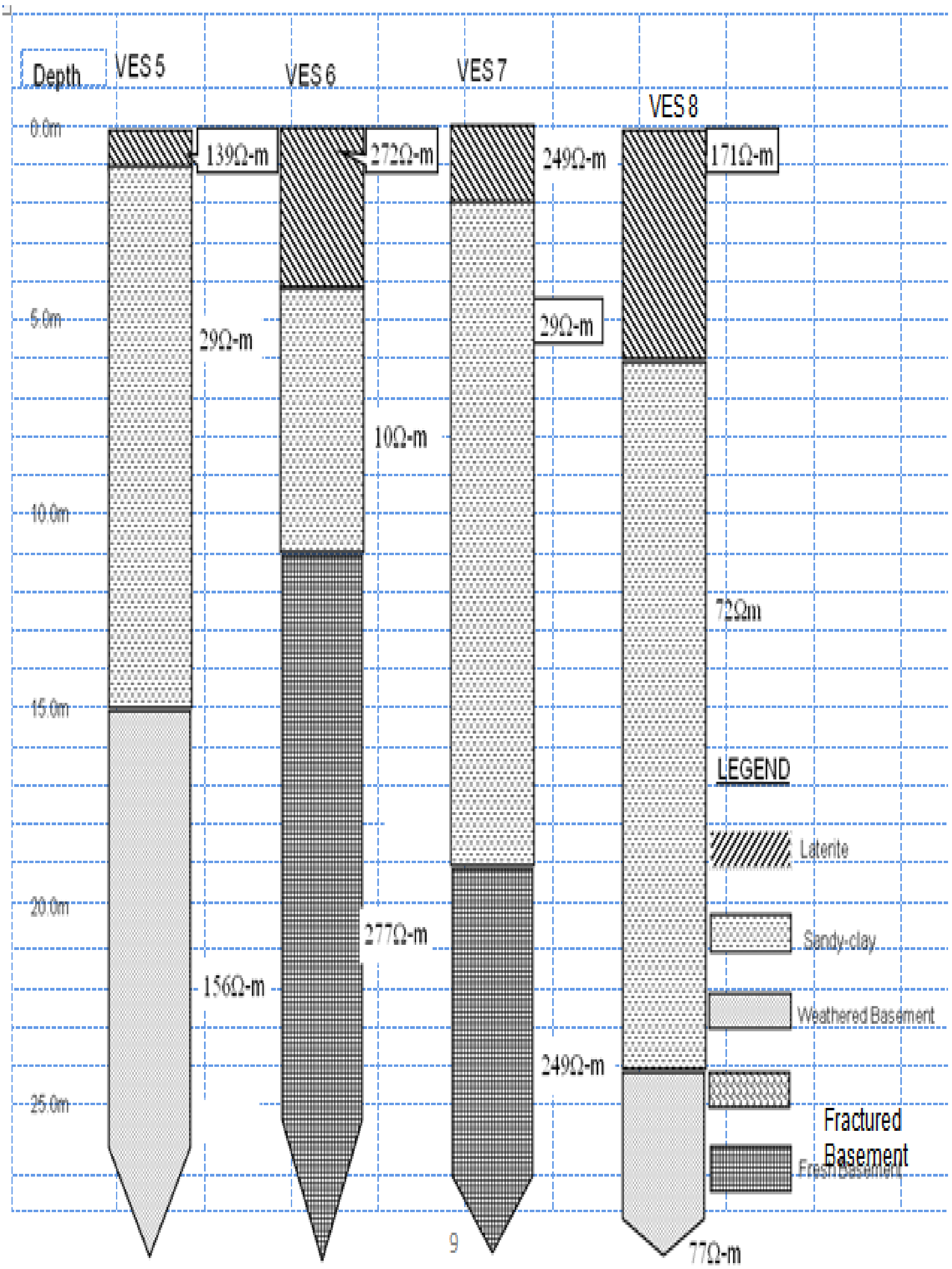


FIG. 4b: GEOELECTRIC SECTIONS OF VES 5, 6, 7 & 8 OF ULTRA MODERN GUEST HOUSE, ABUAD

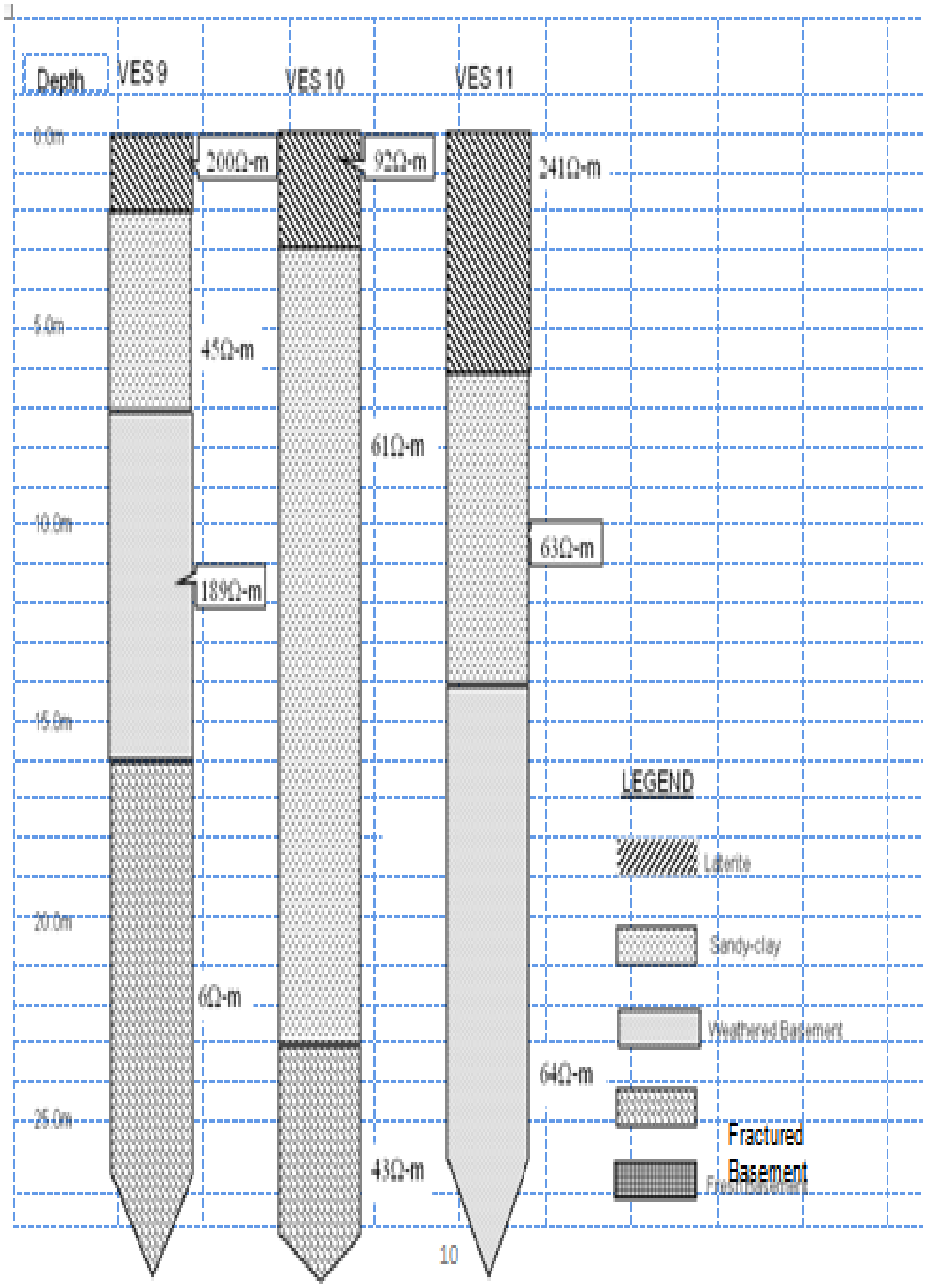
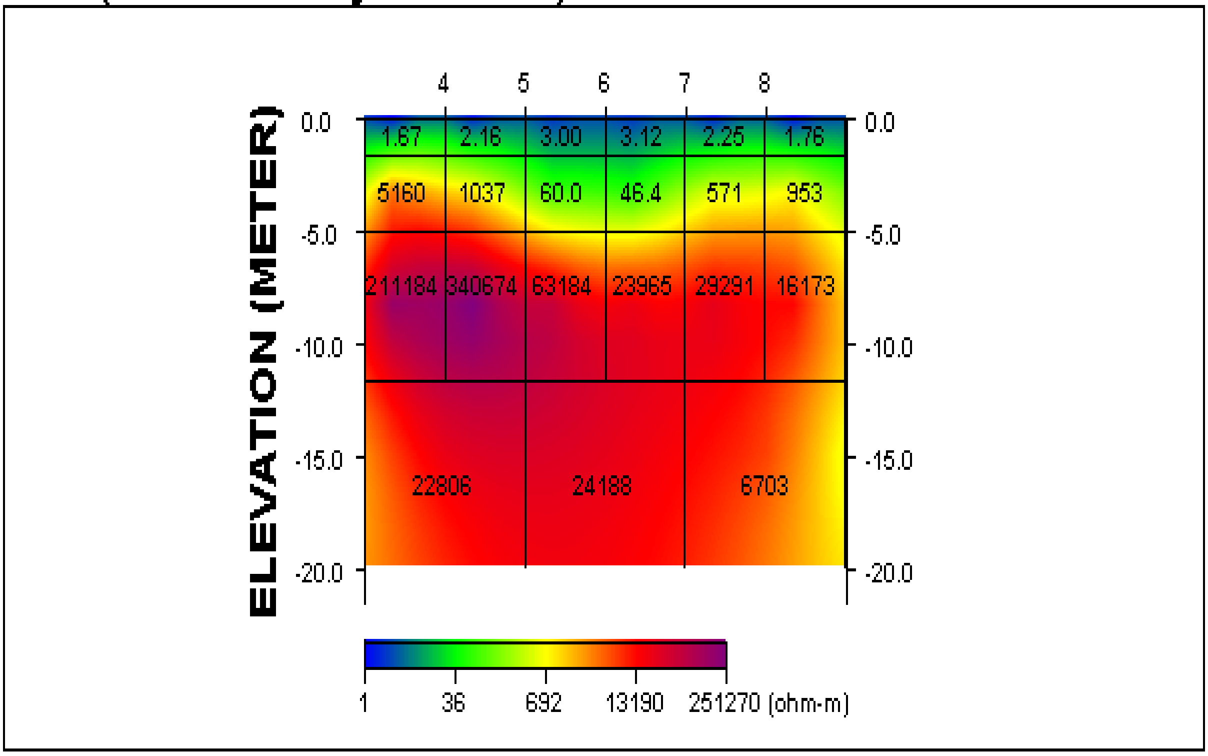


FIG. 4c: GEOELECTRIC SECTIONS OF VES 9, 10 & 11 OF ULTRA MODERN GUEST HOUSE, ABUAD

TR 1 (2-D Resistivity Structure)



TR 1 (2-D Resistivity Structure)

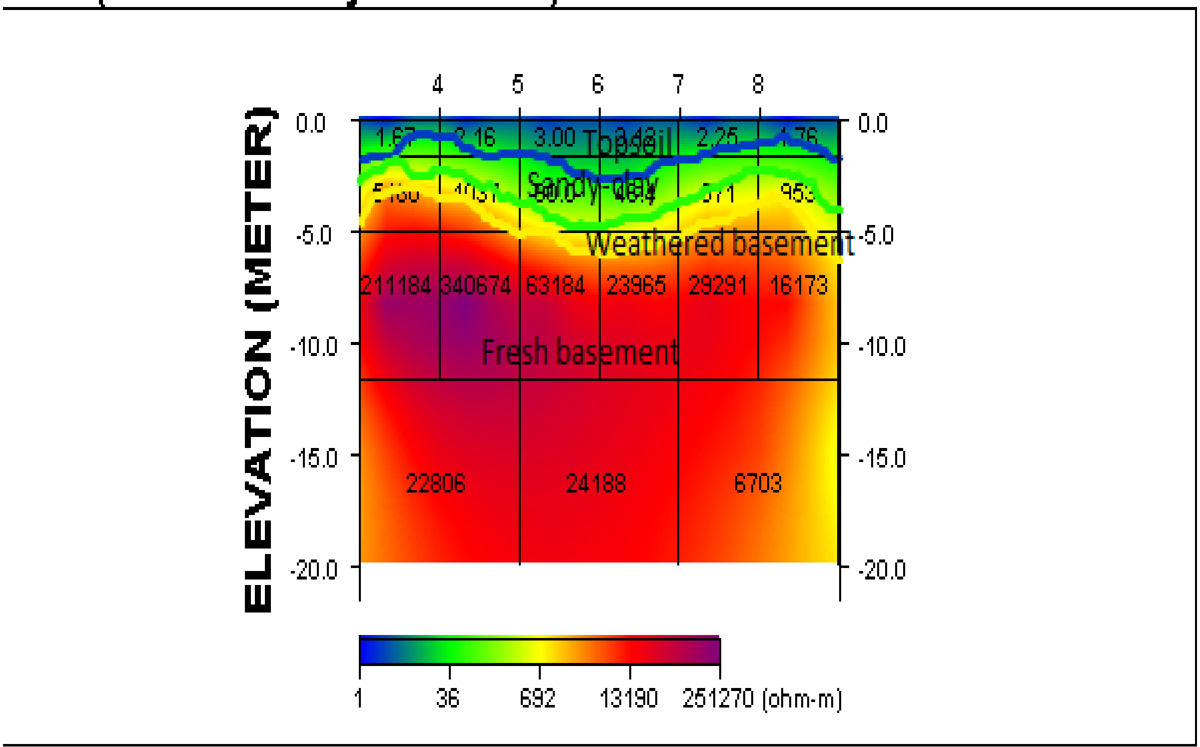
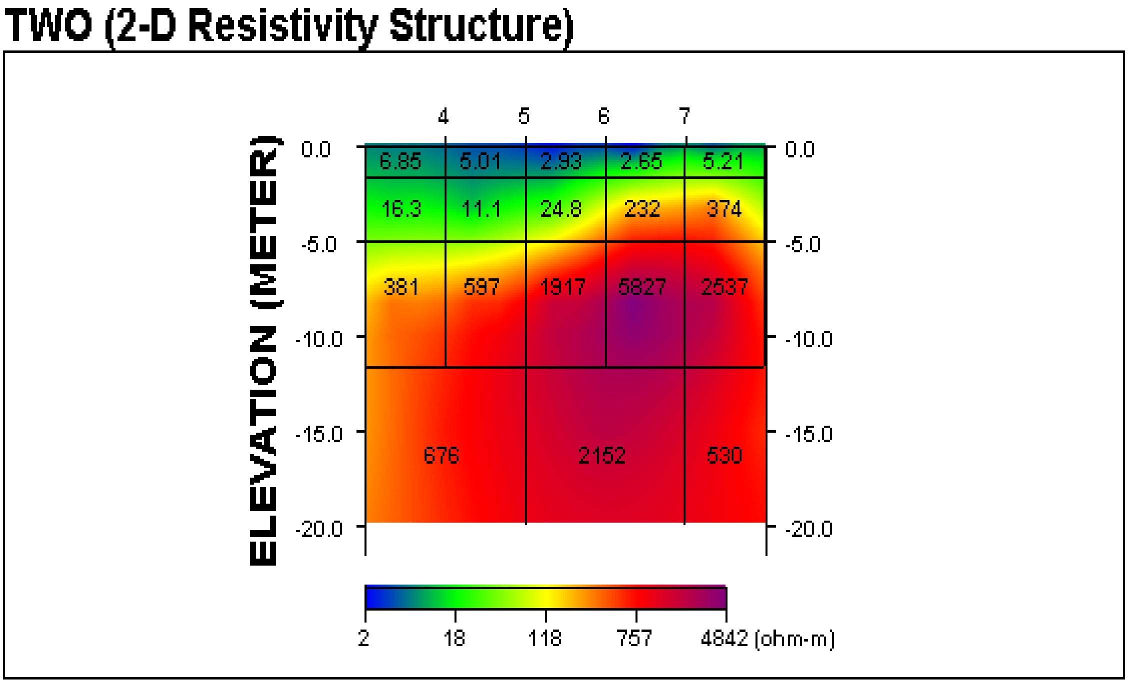


Fig. 5a. 2-D resistivity structures of Profile 1



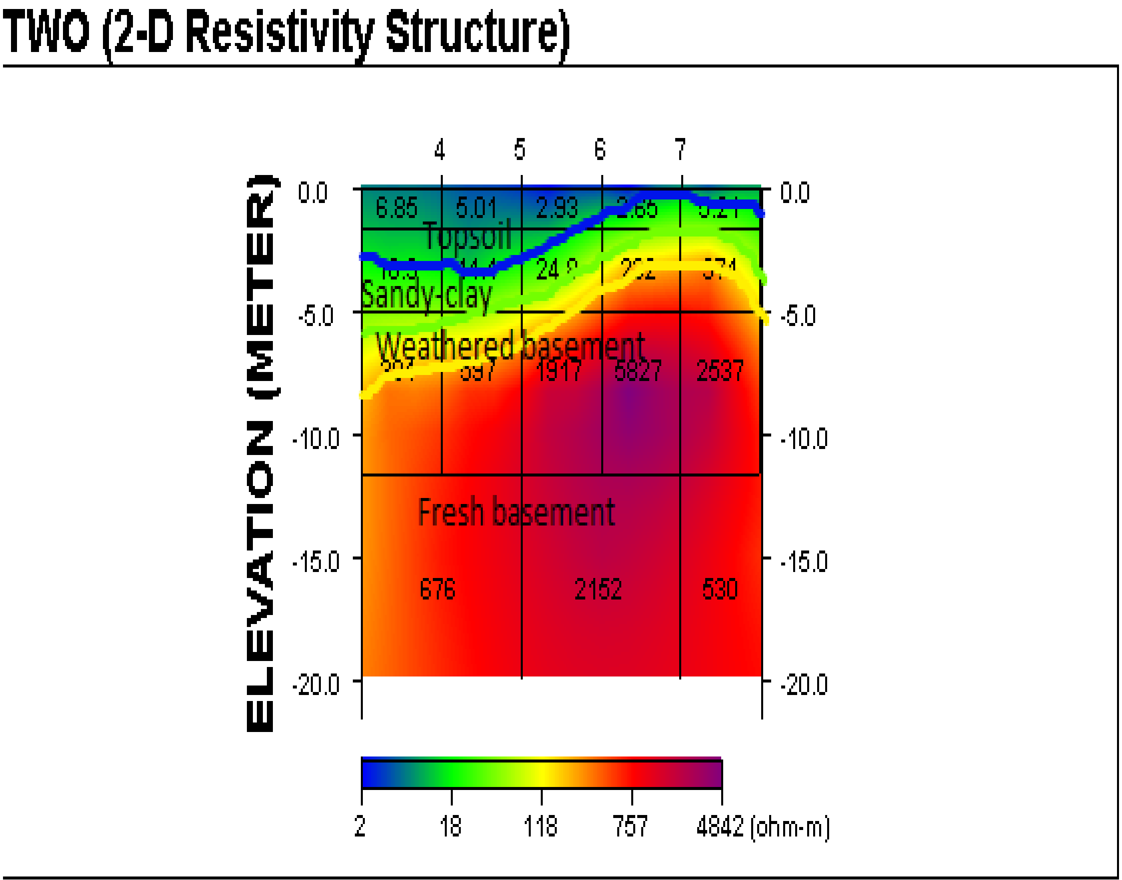


Fig. 5b. 2-D resistivity structures of Profile 2

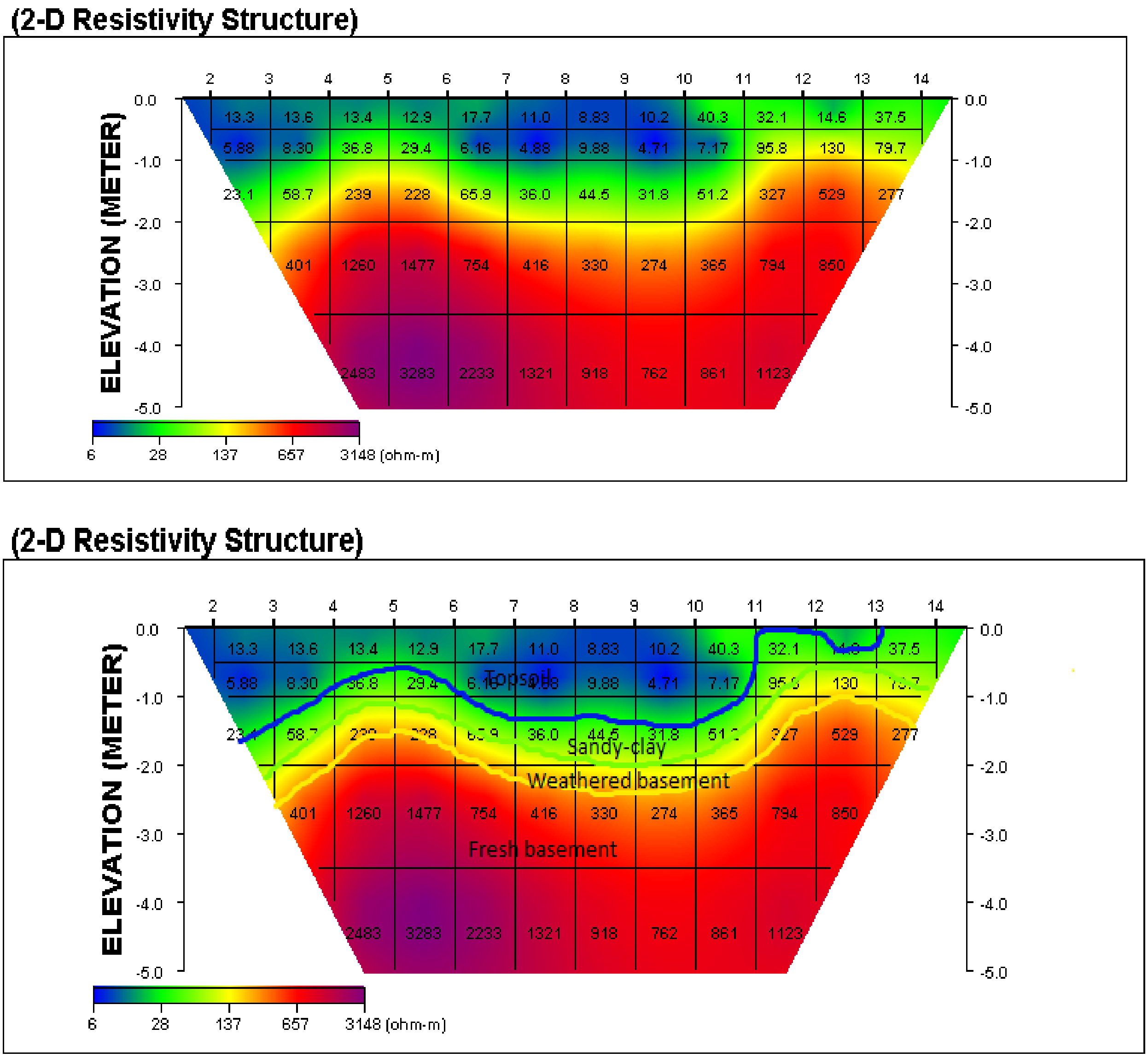


Fig. 5c. 2-D resistivity structures of Profile 3

V. EVALUATION OF GROUNDWATER POTENTIAL

Given the average resistivity values and thicknesses of the sandy-clay, weathered and fractured basement layers and the overburden thickness, (Table 1 and Figure 4 & 5), the study area is moderate. The combination of overburden materials with the fractured basement constitutes aquiferous units within the study area although the sand and weathered/fractured basement units are largely responsible for the groundwater potential. Observed thickness and nature of the weathered layer are important parameters in the groundwater potential evaluation of a basement complex terrain (Clerk, 1985; Bala and Ike, 2001). Horizon is regarded as a significant water-bearing layer (Bala and Ike 2001) if significantly thick and the resistivity parameters suggest saturated conditions. An average thickness value of 22m and resisitivity of 113Ωm of aquiferous unit and of low clay content is suggestive of a medium/moderate groundwater potential.

VI. CONCLUSIONS

In this study, the groundwater potential of Ultra Modern Guest House, Afe Babalola University, Ado-Ekiti, southwestern Nigeria was evaluated using three profiles and eleven Schlumberger vertical electrical soundings (VES).

The curve types ranges between simple K, H to complex HA and HK. The computer assisted profiling and sounding interpretation revealed five different subsurface lithologic sequences namely; lateritic topsoil, sandy-clay, weathered basement, fractured basement and, fresh basement. The topsoil, sandy-clay and weathered basement materials are characterised with relatively low resistivity values while the fresh basement materials are typified with high resistivity values. The combination of overburden materials with the fractured basement constitutes aquiferous units within the study area although the weathered basement and fractured basement units are largely responsible for the groundwater potential. The yield of the weathered basement material is dependent on the amount of the clay content. The higher the clay content, the lower the groundwater yield. The topsoil has limited hydrologic significance. The groundwater potential rating of the area is considered to be moderate. Existing number of boreholes, storage facilities and reticulation network are inadequate for the ever-growing population of the university. There is need for proper completion and maintenance of borehole(s) and expansion of storage and reticulation facilities. An average depth of 40m to 50m is recommended for boreholes in this area. VES 1, 3, 8 & 9 could be considered for drilling,

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