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Full Length Research Paper

Groundwater Exploration of Lokpaukwu, Abia State Southeastern Nigeria, Using Electrical Resistivity Method

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ABSTRACT

Groundwater investigations of Lokpaukwu in Abia State, Southeastern Nigeria has been carried out. Ten (10) Vertical Electrical Sounding (VES) was acquired within the study area, using the Schlumberger Array Configuration. Data acquired were processed and interpreted using INTERPEX resistivity software. Six geoelectric layers were obtained showing a sequence of shale/clay-sand. The H-curve type predominates with a water table depth of 40meters. Contour maps of Iso-resistivity, Isopach, Traverse resistance, Longitudinal Conductance and Aquifer depth were constructed. Variations of these data show a possibility of groundwater occurrence at Lokpaukwu at a depth of 100meters. The yield is expected to be low in areas with no incidence of fractures. The use of Electrical Resistivity method has proved useful in evaluating the groundwater potentials within and around Lokpaukwu.

Keywords: Groundwater, Geoelectric layers, Contour maps, Curve type.

INTRODUCTION

The study area is located at Lokpaukwu in Umunneochi Local Government Area in Abia State, Nigeria (Figure 1). The project site lies between latitude 5^0 51^I and 5^0 56^IN and Longitude 7^0 21^I and 7^0 26^IE with an area extent of about $90km^2$. A high population of the rural dwellers in Lokpaukwu and neighbouring villages depends on groundwater for day-to-day domestic, industrial and commercial water supply. The successful exploitation of basement terrain groundwater requires a proper understanding of its hydrogeophysical characteristics (Choudhury *et al.*, 2001). This is particularly important in view of the discontinuous nature of basement aquifers (Satpathy and Kanungo, 1976). Lokpaukwu and environs suffer from acute shortage of water in season and out of season. At the peak of the rainy season, most of the area becomes marshy due to the impermeable nature of the shale. Because of the nature of the country rock owing to the catchment's area, the yield from springs is little and vanishes during the dry season. Hence, drilling programme for groundwater development in areas like Lokpaukwu is generally proceeded by detailed geophysical investigations. The Vertical Electrical Sounding (VES) had been used to delineate the different sub-surface layers (Ezeh, 2012); aquifers unit and their characteristics, the sub-surface units and their characteristics, the sub-surface structure and the depth to water table (Okonkwo and Ujam, 2013). This study was aim at delineating suitable sites for groundwater development in Lokpaukwu and environs.

PHYSIOGRAPHY

In the area, the dominant physiographic feature is the isolated hills with intrusion of rocks; break the monotonous of the low-lying shally terrain (Figure 2).

GEOLOGY AND HYDROGEOLOGY

The study area is situated at the Southeastern part of the Lower Benue Trough. The area is underlain by two main geologic formations. The Asu River Group and Nkporo Formation, (Reyment, 1965; Murat, 1972). The Asu River

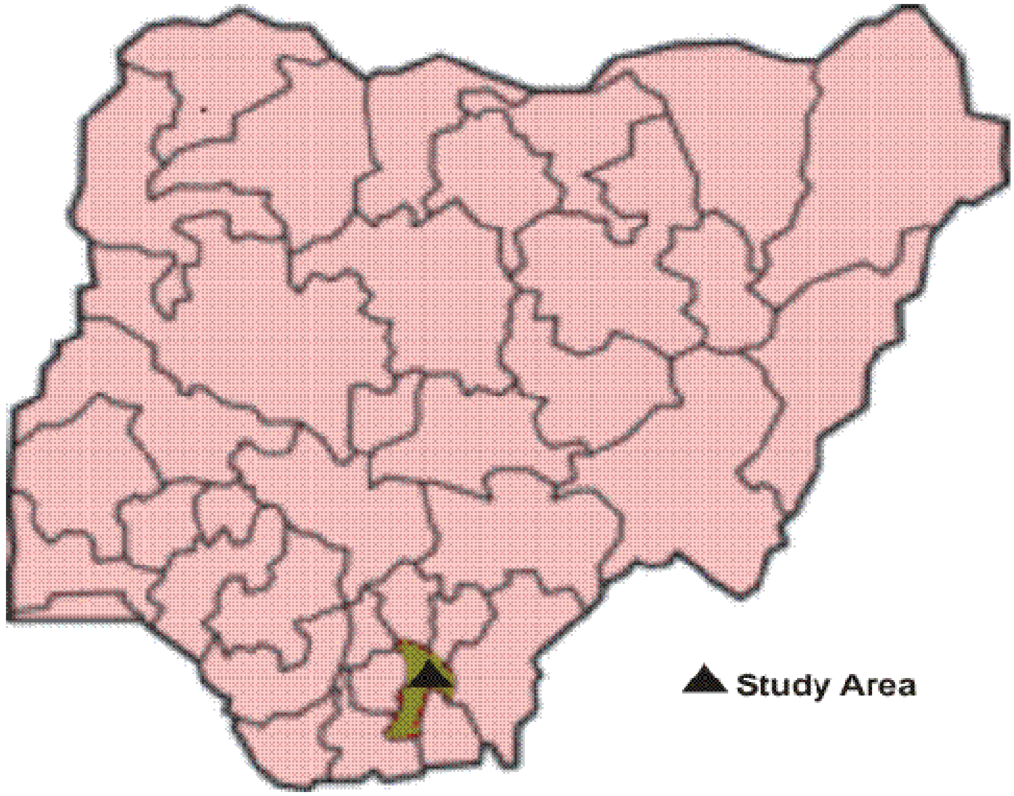


Figure1. Map of Nigeria showing the study area.

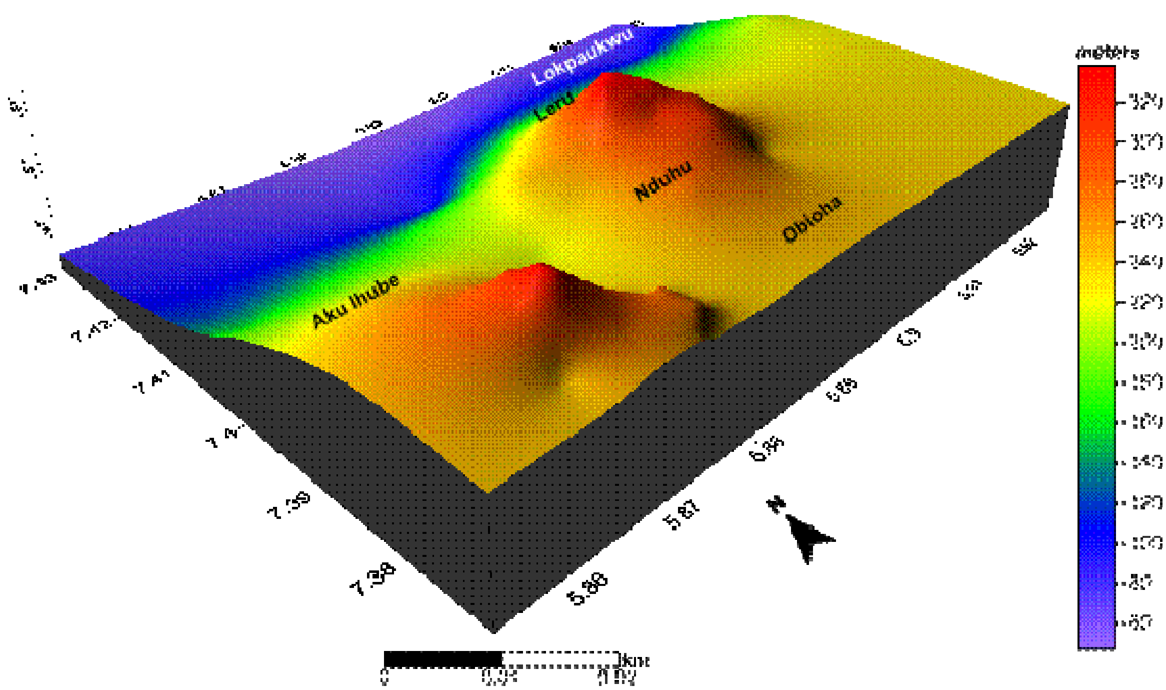


Figure 2. Surface map of the study area.

Table 1. Interpreted model geoelectric and curve types from the study area

S/N	LOCATIONS	VES NO.	NL	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	T_1	T_2	T_3	T_4	T_5	T_6	CURVE TYPE
1.	LOKPAUKWU	1	5	142.68	6771.2	232.57	33.900	2619.8	-	0.94926	0.23347	17.647	43.980	-	-	HQK
2.	UMUEZEGEM	2	5	67.562	578.89	5.8474	50.242	0.40976	-	1.9440	5.1201	8.9316	74.149	-	-	KK
3.	UMUANYI	3	4	374.05	98.549	304.81	79.255	-	-	1.6983	6.4592	58.199	-	-	-	HK
4.	OBIOHA	4	5	932.34	100.61	139.49	62.157	226.41	-	1.7967	1.4229	17.135	65.731	-	-	HH
5.	OKIGWE	5	4	37.497	3712.2	54.175	15.010	-	-	3.9019	10.254	98.472	-	-	-	KQ
6.	LERU	6	5	34.982	58.670	82.257	18.036	10.170	-	1.4699	1.4053	2.3410	86.856	-	-	HQ
7.	NDUHU	7	6	54.622	8.8040	0.70736	22.852	1.5512	148.96	0.95147	6.1274	5.5871	16.572	90.598	-	QKH
8.	ELUAMA	8	5	430.41	366.07	3322.5	244.87	2181.7	-	0.48662	3.7338	34.526	46.681	-	-	HH
9.	AKU IHUBE	9	5	82.011	6.4353	35.110	22.999	0.23232	-	0.90880	3.2182	1.03339	75.530	-	-	HH
10.	ISUOCHI	10	5	201.62	2349.3	121.32	51.882	98.810	-	1.7478	2.0223	20.693	85.009	-	-	KH

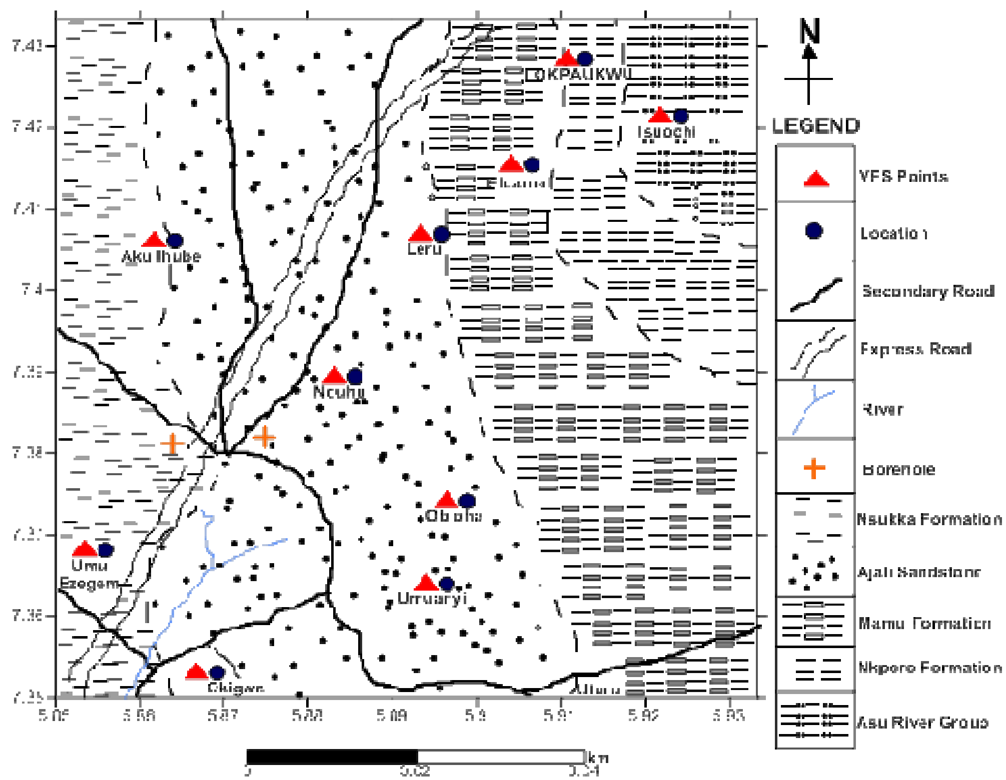


Figure 3. Geologic map of the study area showing VES and Borehole points.

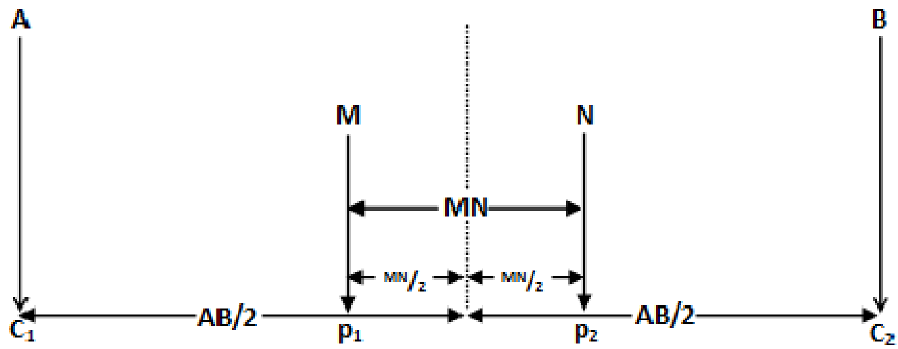


Figure 4. Schlumberger array configuration.

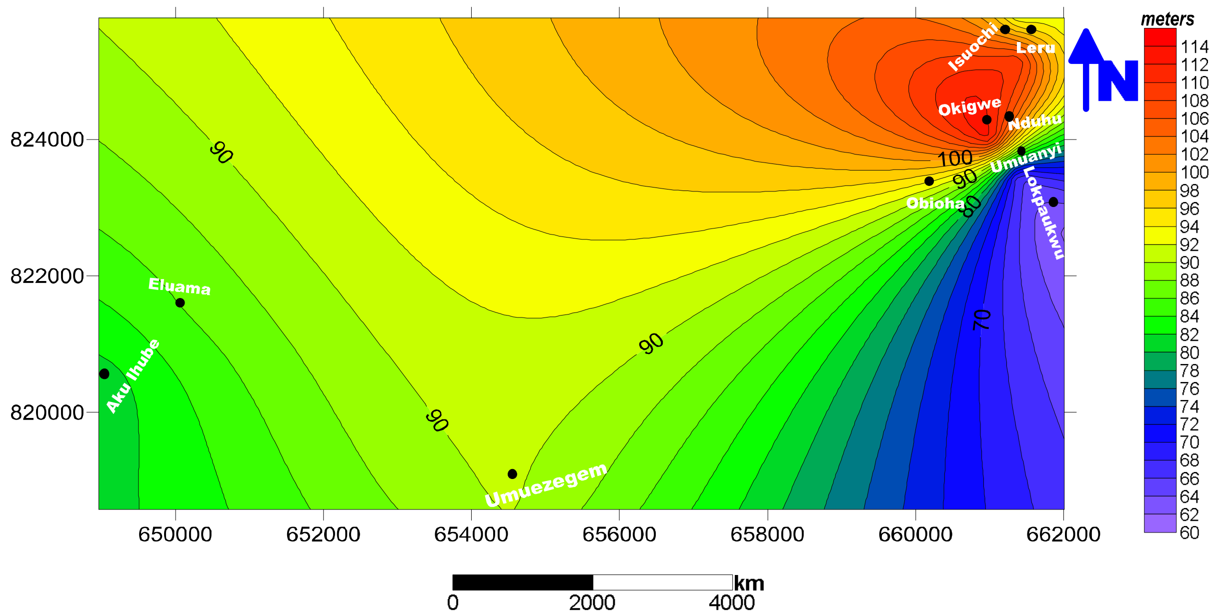


Figure 5. Aquifer Depth Map of the study area.

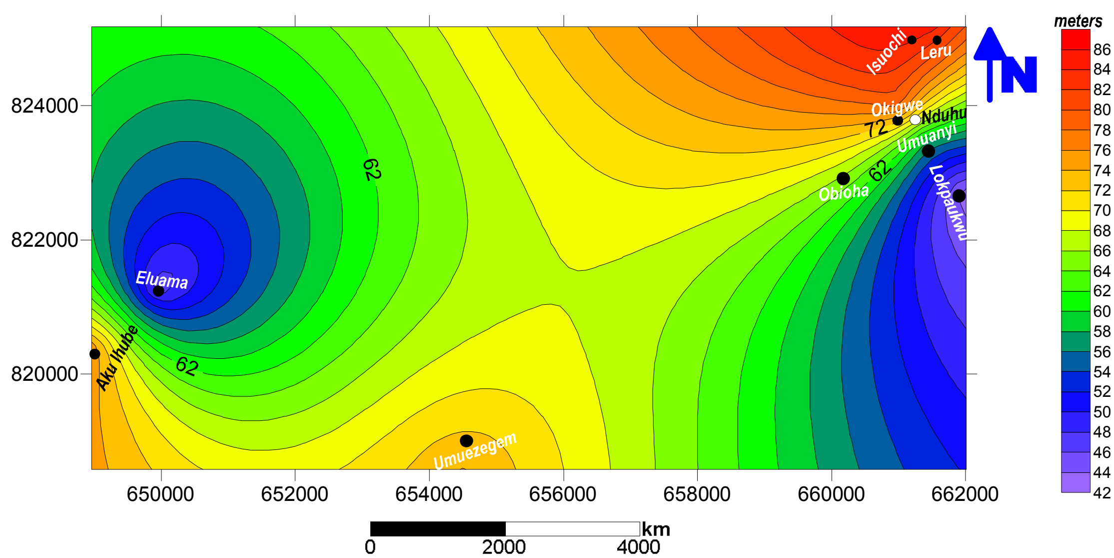


Figure 6. Aquifer Thickness Map of the study area.

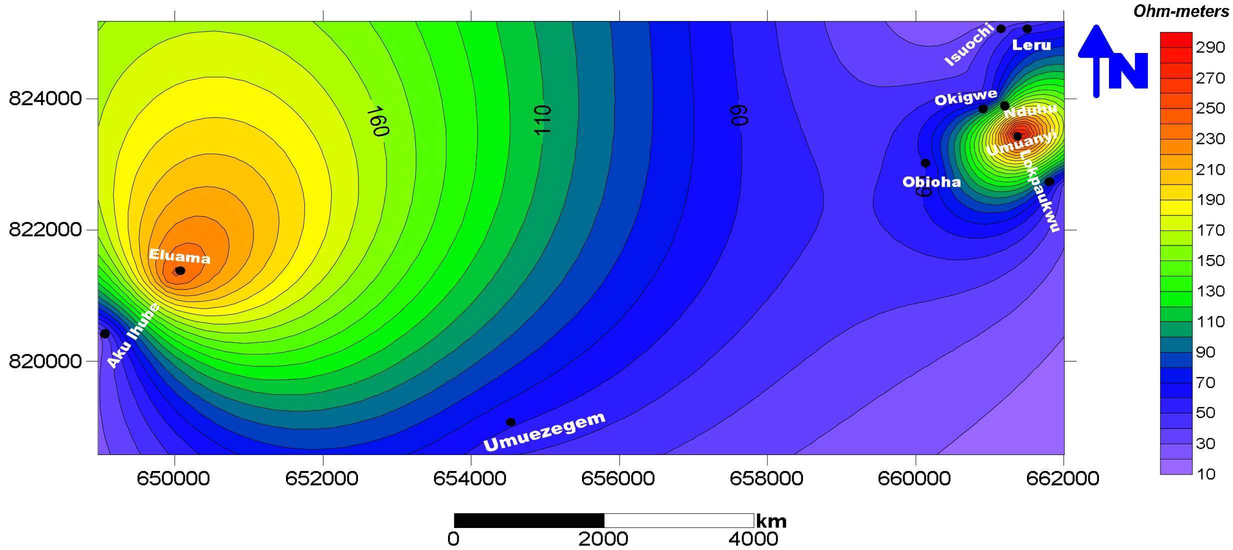


Figure 7.Aquifer Resistivity Map of the study area.

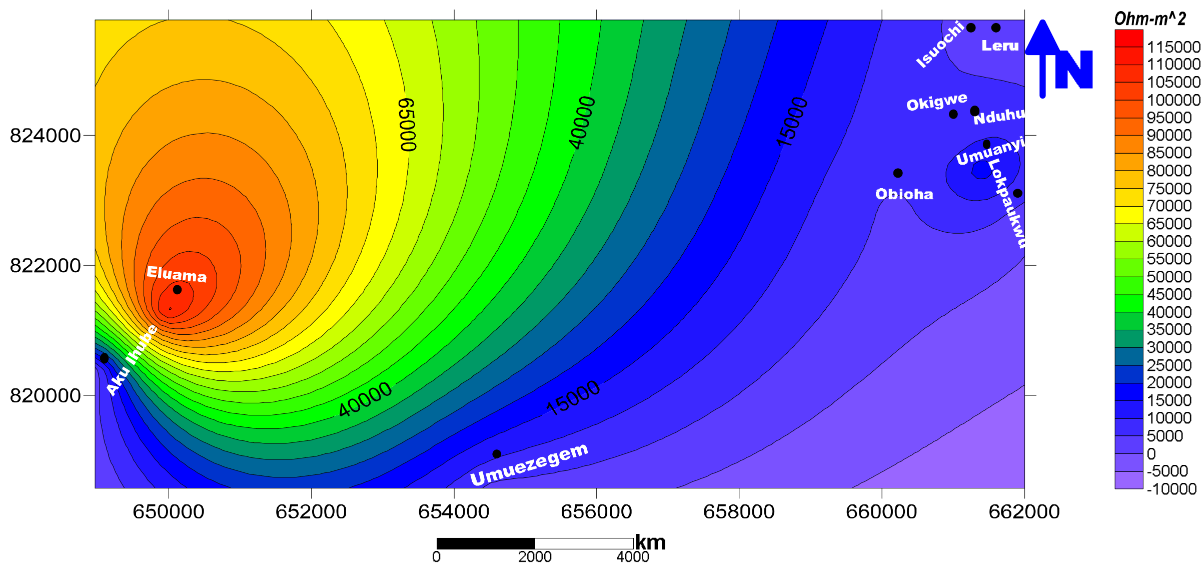


Figure 8.Traverse Resistance Map of the study area.

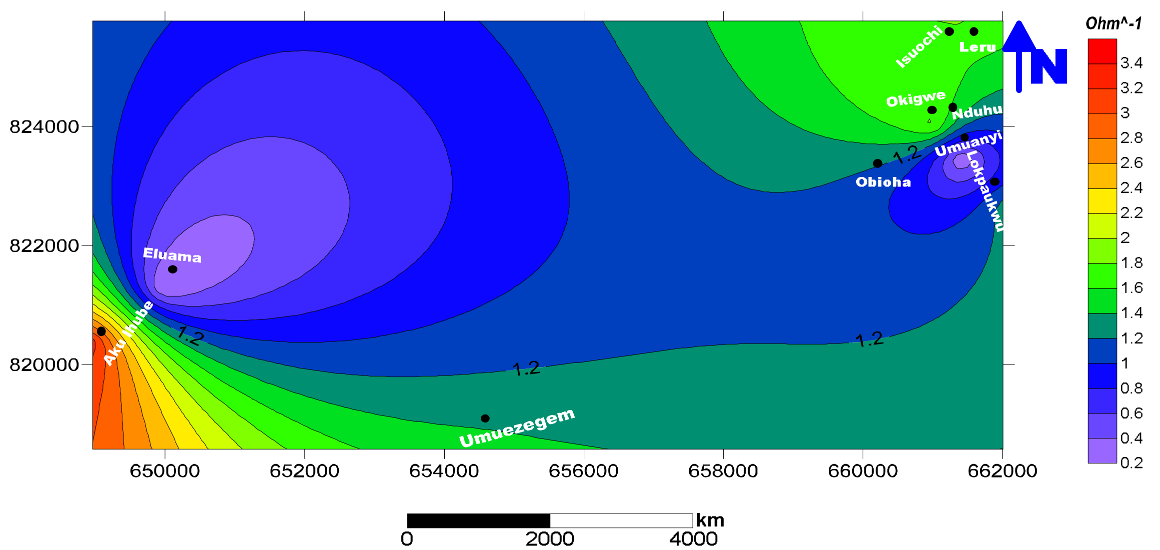
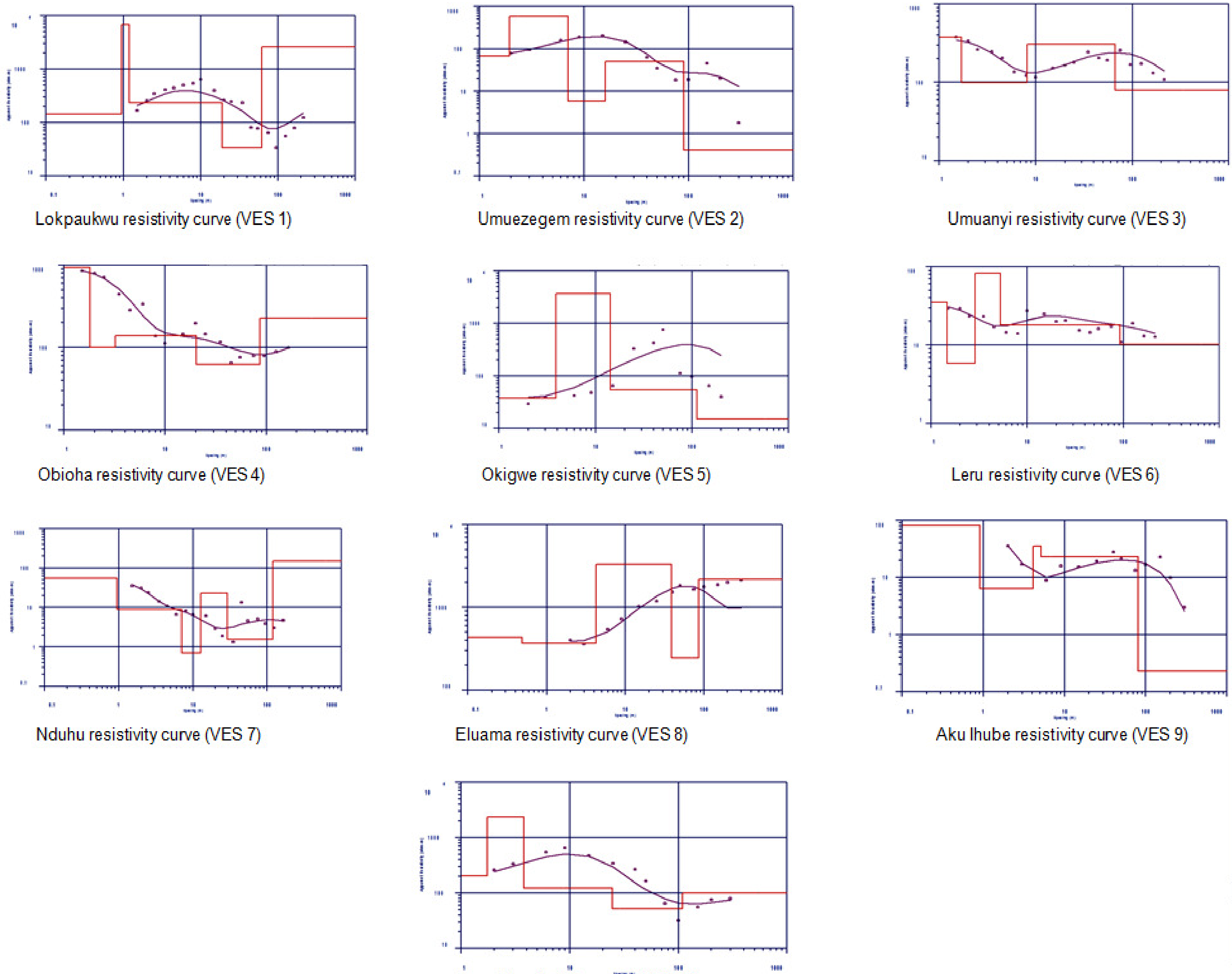


Figure 9.Longitudinal Conductance Map of the study are



Lokpaukwu resistivity curve (VES 1)

Umuezegem resistivity curve (VES 2)

Umuanyi resistivity curve (VES 3)

Obioha resistivity curve (VES 4)

Okigwe resistivity curve (VES 5)

Leru resistivity curve (VES 6)

Nduhu resistivity curve (VES 7)

Eluama resistivity curve (VES 8)

Aku Ihube resistivity curve (VES 9)

Isouchi resistivity curve (VES 10)

Figure10. Depth Sounding Resistivity Curves

Group is an alternating succession of dark shale with sandstone and ironstone. The sandstone is whitist to yellowish in colour in which the shale is highly fissile. The shales of the Asu River group (Lower Cretaceous) are the oldest sediments in the area (Figure 3). Overlying the Asu River Group sediments are the Upper Cretaceous sediments. The Nkporo Formation consists of dark fissile shale with intercalated siderite and occasionally occurring shally limestone, they are Campanian Maastrichtian in age. Lokpaukwu and environs suffer from acute shortage of water due to the nature of the country rock owing to the catchment's area; the yield from springs is little and vanishes during the dry season. Hydrogeologically, the shales of the Nkporo Formation are the producing aquiferous units as a result of the secondary porosity developed by the intrusion action forming cross-cutting and linear fractures.

METHODOLOGY

Data Acquisition

Electrical Resistivity method was used because of its flexibility and qualitative interpretation which is straight forward (Frohlich and Urish, 2002). Of the possible electrode configuration, the Schlumberger Array was also employed (Figure 4), with ABEM Terrameter SAS 1000. The potential electrodes remain fixed and the current electrodes are expanded simultaneously about the center

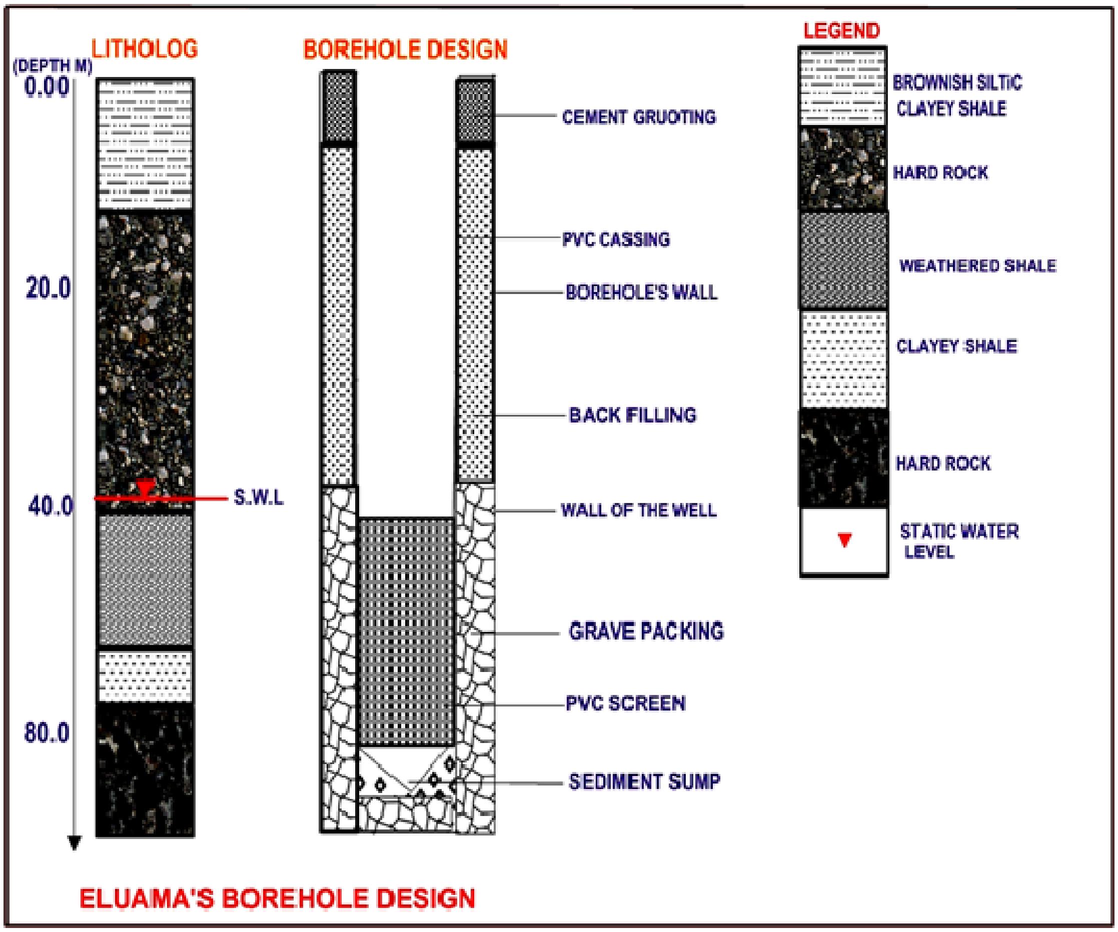


Figure 11. Eluama Borehole Log and Design.

of the spread. The maximum electrode separation used was 100-150m which are normally arranged in a straight line, with the potential electrode placed in between the current electrodes. This configuration is mostly used as it would provide sub-surface information considering the depth of penetration which ranges $^{1}/_{3}$ and ¼ of the total separation (David and Ofrey, 1989; Osemiekhain and Asokhia, 1994; Mallam and Ajayi, 2000).

A total of Ten (10) Vertical Electrical Sounding (VES) stations were acquired within the study area (Figure 3). These stations were chosen at different locations within the area. The resistivity sounding curves were interpreted quantitatively; this is done by partial curve matching technique and computer iteration of the interpreted resistivity curves.

Data Processing

The field data were converted to apparent resistivity (ρa) in ohm-meter by multiplying with Schlumberger geometric factor (k).

$$a = \pi \left(\frac{a^2}{b} - \frac{b}{4} \right)$$

Where a: half current electrode spacing
b: potential electrode spacing

The sounding curve for each point was obtained by plotting the apparent resistivity on the ordinate against half electrode spacing on a bi-logarithmic transparent paper. Parameters such as apparent resistivity and thickness obtained from both partial curve matching and the method of asymptotes were used as input data for computer interactive modelling.

Data Interpretation

From the sounding acquired in all locations, in which data was inputted and analyzed with a suitable computer resistivity software (INTERPEX). And result shows that VES 1-10 has curves like HQK, KK, HK, HH, KQ, HQ, QKH, HH, HH, and KH respectively (Table 1) in which Eight (8) out of the Ten (10) resistivity curves obtained from the study area shows 3-layers H-types curve while the remaining shows igneous extrusive rocks, which contains a low resistivity intermediate layer underlain and overlain by more resistant materials (Olayinka and Mbachi, 1992).The H-type curve has an intermediate of high resistivity value that is recognized as the aquifer unit at these VES locations. The extent to which the rocks have been weathered or fractured determines the amount of water to be found and these in turn govern the electrical resistivity values (Nwankwo, et al., 2004).

RESULT AND DISCUSSION

The Vertical Electrical Sounding (VES) data are presented as depth sounding curve (Figure 10) which is obtained by plotting apparent resistivity values against electrode spacing on a log-log or bi-log graph paper. Eight (8) of the Ten (10) sounding resistivity curves acquired shows H-type curve (Table 1). Layer 1 and 2 are respectively the low resistance top soil and high resistance lateritic/sandy clay. In basement complex terrains, the intermediate layer H-type is commonly water saturated and it's often characterized by high resistivity, high porosity, low specific yield and permeability (Jones, 1985).

In order to have good understanding of the sub-surface geology of the study area, geoelectric sections was also drawn for each of the location in the study area. The geoelectric sections reveal the sub-surface variation in electrical resistivity and attempts to correlate the geoelectric sequence across the profiles. Water does not conduct electricity except its constituent. Based on these facts, we can conclude that water can/would be gotten from the study area of high resistivity. Previous study shows that Eluama's borehole design (Figure 11), groundwater occurred at the depth of 40-80m with resistivity value of 3322.5ohm-meter which is the weathered shale zone. Correlating these with other VES curves like VES curve 1, 5 and 10 (Figure 10). The resistivities at these points are very high and display the KH-type curves at the second layers. A similar study (Bala and Ike, 2001) reveals that areas with thick overburden cover have high potential for groundwater. Consequently, areas with overburden thickness of 10m and above are good for groundwater development. Contour plot of Longitudinal Conductance, Aquifer Resistivity, Aquifer Depth, Aquifer Thickness and Traverse Resistance were constructed. In Aquifer resistivity (Figure 7) the resistivity value is very high at Eluama area with value of 230-250ohm-meter and low resistivity occurs at Aku Ihube area with value of 10-30ohm-meter. In Aquifer Depth contour plot (Figure 5) Eluama ranges from 80-90m and lowest thickness 42m and highest at Okigwe, Isuochi and Leru Areas. Lokpaukwu has the lowest depth of 60m and thickness of 42m (Figure 6). Therefore, based on the analysis above, that is overburden thickness, curve types and resistivity values. VES 1, 5, 8 and 10 will be suitable for groundwater development in which drilling is recommended at a depth of 40-100meters in the study area. Because of the shale in VES 1 and 8, the water is also recommended for treatment before use.

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