IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 3, Issue 5 Ver. I (Sep. - Oct. 2015), PP 75-82
www.iosrjournals.org

1-D Electrical Resistivity Survey For Groundwater In Ketu-Adie Owe, Ogun State, Nigeria.

Usifo A.G.[1], Adeola A.J.[1], Babafemi E. M.[2] , and Akinnawo O. O.[1]
[1]*(Department of Physical and Earth Sciences, College of Natural and Applied Sciences, Crawford University, Nigeria)*
[2] *(Skangix Development Limited, Chevy View Estate, Lekki, Lagos, Nigeria)*

Abstract: *This research involved the use of 1-D electrical resistivity survey method for groundwater investigation in Ketu-Adie Owe, Ogun State. Seven (7) vertical electrical resistivity soundings (VES) using Schlumberger array were carried out at different locations. The Schlumberger resistivity soundings were executed with half-spacing in the range of 1.00 – 100.00 metres. The curve types are AAK, AAK, KHAK, AKQ, KQH, AK. The study shows that viable aquifer is within 17.30 – 52.90 metres square.*

Keywords: *Aquifer, Curves types, Electrical resistivity, Groundwater, Vertical Electrical Sounding.*

I. Introduction

Groundwater is one of the most important natural resources. It is normally used to augment the supplies from surface sources and sometimes it is the main source of water supplies [1]. To harness groundwater for domestic and industrial usage usually require the drilling of boreholes which is quite expensive and is prone to failure when there is no prior knowledge of the sub surface geology, hence the need for thorough geophysical stu dies.

The VES method is a depth sounding galvanic method and has proved very useful in groundwater studies due to simplicity and reliability of the method. The electrical resistivity of rock is a property which depends on lithology and fluid contents. The ultimate objective of VES at some locality is to obtain a true resistivity log similar to the induction log of a well at the locality, without actually drilling the well [2]. In this study, the electrical resistivity method, i.e. the VES technique was used to delineate the different subsurface geoelectric layers, the aquifer units and their hydrogeologic properties.

11. HEADINGS
1. Introduction
2. Indentations and Equations
2.1. Physical and geological setting of the study area
2.2 Methodology
3. Figures and Tables
4. Conclusion
5. Acknowledgements

II. Identations And Equations

2.1. Physical and geological setting of the study area

Ketu-Adie Owe, Ogun State is situated within longitudes N06^0 30$^/$ 00 and N06^0 70$^/$ 00 and latitudes E003^{0}04$^/$00.00$^{//}$ and E003^0 04$^/$51.00$^{//}$. In Adodo/Ota local Government Area, Ogun State, Nigeria (Figure1).The study area forms part of the Dahomey (Benin) basin, a very extensive sedimentary basin on the continental margin of the Gulf of Guinea, which extends from the Volta River Delta. South-eastern Ghana in the West, to the western flank of the Niger Delta [3, 4]. This formation known as coastal plain sand is made of poorly sorted sands which are in parts cross-bedded and shows transitional to continental characteristics like Ilaro and Abeokuta formations. The thickness of the coastal plain sand ranges from 10m to 100m while the ages fall under Pleistocene and Oligocene [5]. Despite several published works on the stratigraphic units particularly in the Palaeogene of South-western Nigeria.

The sedimentary basin in the Southern Nigeria is particularly divided into Western and Eastern portions by the Okitipupa ridge a submarine basement whose outcrop approaches 40km of the coast at about 4^{0}30$^/$E. In the Western part of the basin, sedimentation did not begin until the terminal stages of the cretaceous whereas; the earliest transgression in the Eastern part was during the Albian. Tertiary sediments accumulated in the eastern half of an extensive Mesozoic-cenozoic coastal basin which extends from Ghana in the west to Cameroun in the east. Marked variations existed in the texture and thickness of about 10,000 to 12, 000
metres beneath the shelf of the Niger Delta [6].

The Paleocene sea covers the Southern Nigeria extending entire westward to Republics of Benin and Togo. The Palaocene deposits are characterized by extremely rapid lateral faces changes. In the eastern Nigeria, the strata are large, composed of dark grey, thinly laminated friable Imo shale with occasional admixture of clay ironstone and sandstone beds. To the west, biogenic limestone of the Ewekoro formation are found in the lower part of the Palaeocene section [5]. The Palaeocene deposits in Western Nigeria were attended by local crustal elevation which resulted in extensive erosion of the upper units of limestone. Glauconitic shale and Phosphatic materials accumulated on the surface of the limestone.

III. Methodology

Vertical Electrical Soundings (VES) were carried out in the study area with an ABEM TERRAMETER SAS (Signal Averaging System) 300B with booster SAS 2000 manufactured in Sweden was used for taking surface resistivity readings. The equipment is light and powerful for deep penetrations. When the distance between the two current electrodes is finite (Fig. 2), the potential at any nearby surface point will be affected by both current electrodes.

As before, the potential due to C_1 at P_1 is

$$V_1 = \frac{-A_1}{r_1} \quad where \;\; A_1 = \frac{-I\rho_a}{2\Pi}$$

Because the currents at the two electrodes are equal and opposite in direction, the potential due to C_2 at P_1 is

$$V_2 = \frac{-A_2}{r_2} \quad where \;\; A_2 = \frac{I\rho_a}{2\Pi} = -A_1$$

Thus, we have

$$V_1 + V_2 = \frac{I\rho_a}{2\Pi}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

Finally, by introducing a second potential electrode at P_2 we can measure the difference in potential between P_1 and P_2 which will be

$$\Delta V = \frac{I\rho_a}{2\Pi}\left\{\left(\frac{1}{r_1} - \frac{1}{r_2}\right) - \left(\frac{1}{r_3} - \frac{1}{r_4}\right)\right\}. \qquad (1)$$

Such an arrangement corresponds to the four electrode spreads normally used in resistivity field work. The end result of the field measurement is the computation of the apparent resistivity, using the equation

$$\rho_a = \frac{KV}{I} = KR \qquad (2)$$

where

$$K = \frac{\frac{\Pi}{2}\left[\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2\right]}{\left(\frac{MN}{2}\right)} \qquad (3)$$

and

ρ_a = Apparent Resistivity
K = Geometric factor
V = Volt; I = Current;
R = Resistance
AB = Current Electrodes Separation
MN = Potential Electrodes Separation.

IV. Figures And Tables

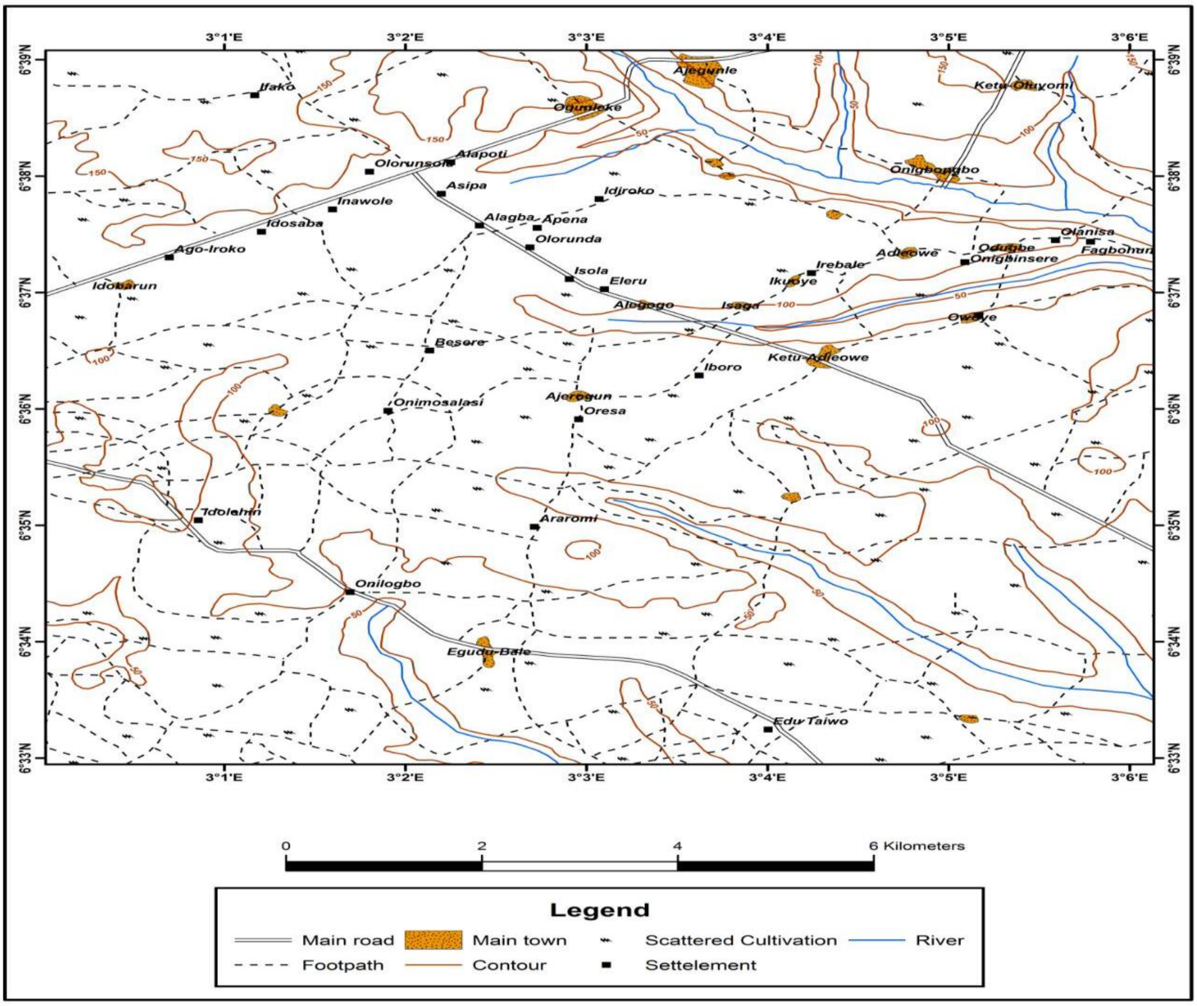


Figure 1: map of ketu - adie owe and environs.

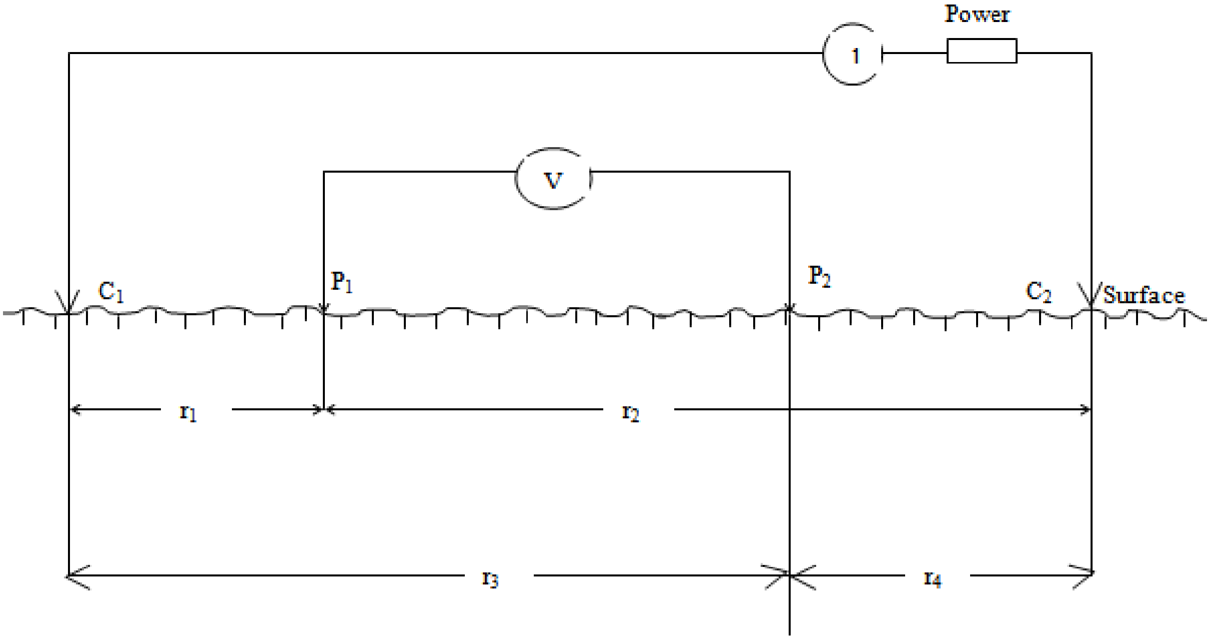
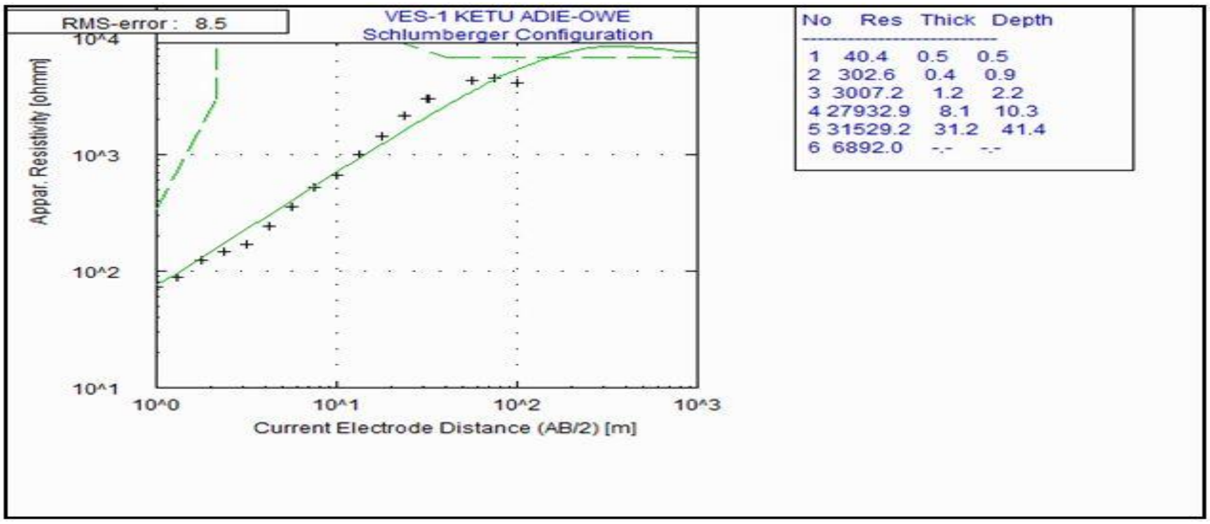


Figure 2: two current and two potential electrodes on the surface of heterogeneous ground of app. resistivity ρ_a

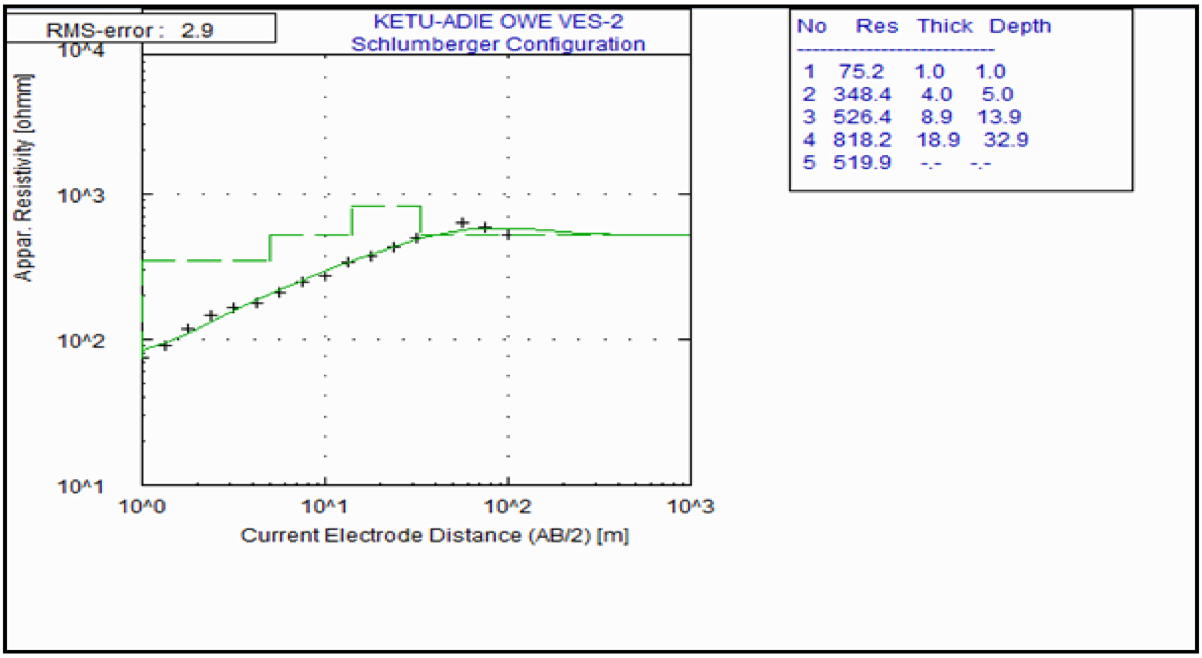


```
No   Res    Thick  Depth
-------------------------
1   40.4    0.5    0.5
2  302.6    0.4    0.9
3 3007.2    1.2    2.2
4 27932.9   8.1   10.3
5 31529.2  31.2   41.4
6 6892.0   -.-    -.-
```

Figure 3: field and theoretical curves for VES 1

Table 1: Geoelectric layer parameter analysis of VES No. 1

Geoelectric layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Lithology
1	40.40	0.5	0.5	Top soil
2	302.60	0.4	0.9	Clayey sand
3	3007.20	1.2	**2.20**	Sand
4	27932.90	8.1	10.30	Sand (very dry)
5	31529.20	31.20	41.40	Sand (very dry)
6	6892.00	-	-	Lateritic sand



```
No   Res   Thick  Depth
------------------------
1   75.2   1.0    1.0
2  348.4   4.0    5.0
3  526.4   8.9   13.9
4  818.2  18.9   32.9
5  519.9   -.-    -.-
```

Figure 4: field and theoretical curves for VES 2

Table 2: Geoelectric layer parameter analysis of VES No. 2

Geoelectric layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Lithology
1	75.20	1.00	1.00	Top soil
2	348.40	4.00	5.00	Clayey sand
3	526.40	8.90	13.00	Sand
4	818.20	18.90	32.90	Sand (very dry)
5	519.90	-	-	Sand (wet)

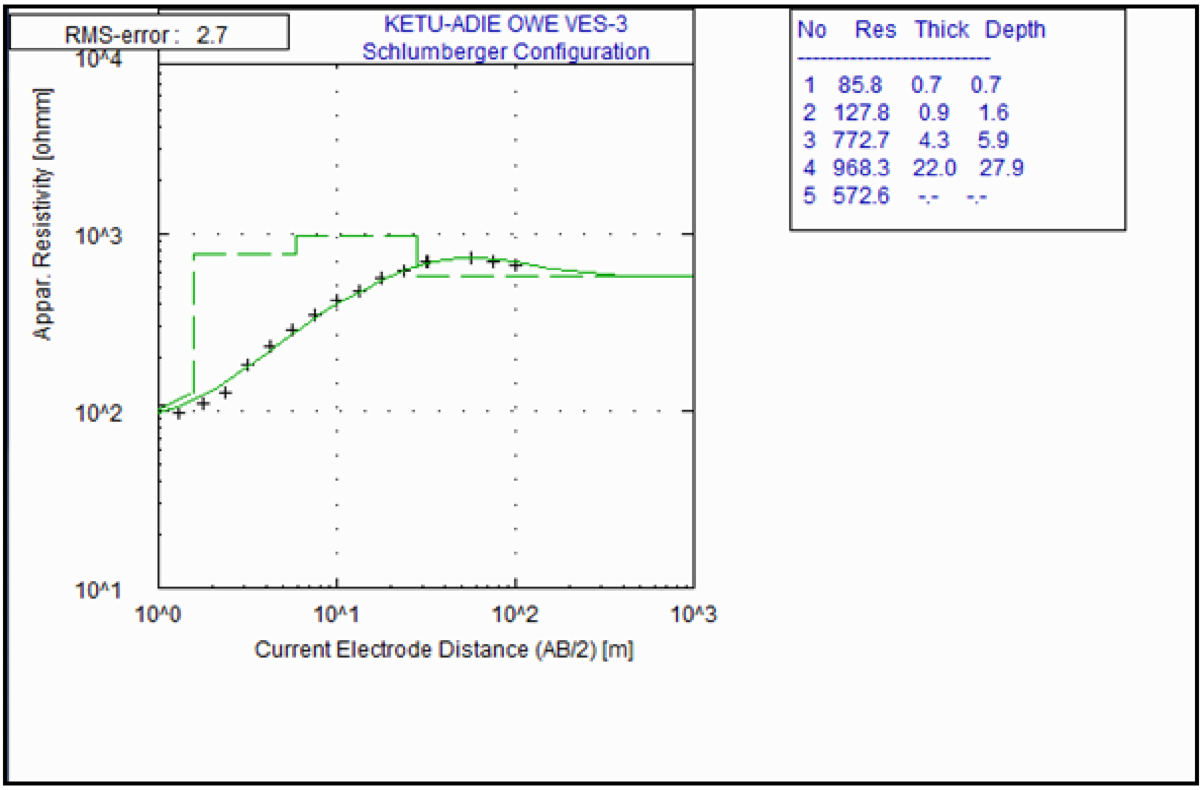


Figure 5: field and theoretical curves for VES 3

Table 3: Geoelectric layer parameter analysis of VES No. 3

Geoelectric layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Lithology
1	85.80	0.70	0.70	Top soil
2	127.80	0.90	1.60	Clayey sand
3	772.70	4.30	5.90	Sand
4	968.30	22.00	27.90	Sand (dry)
5	572.60	---	---	Sand (wet)

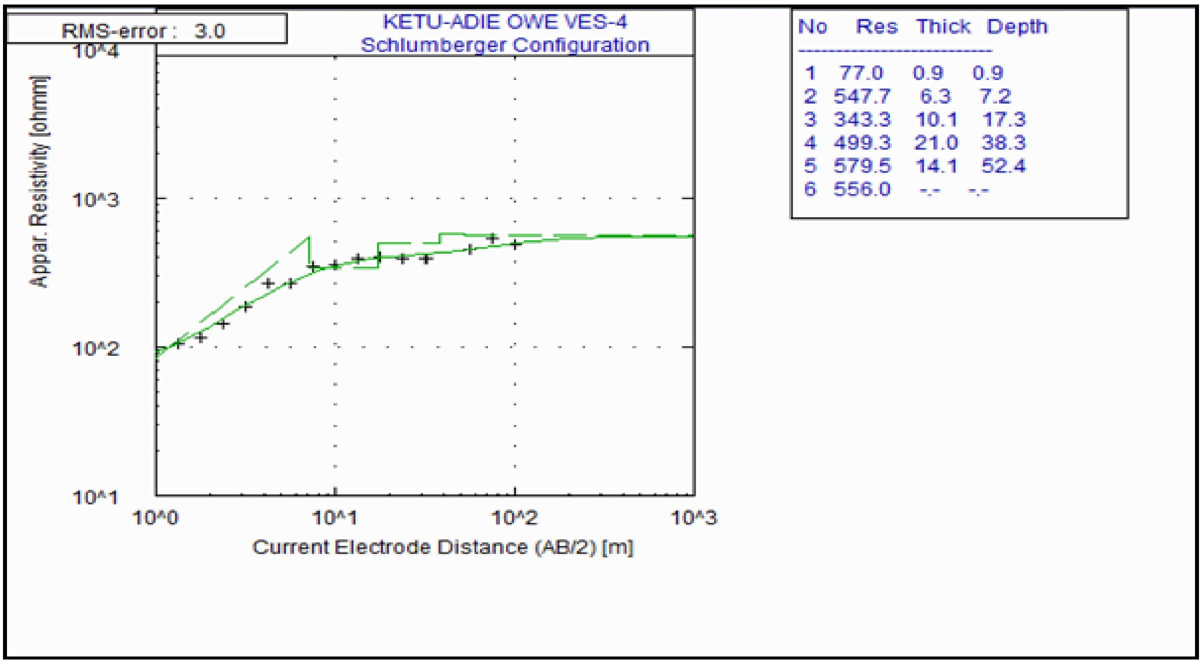


Figure 6: field and theoretical curves for VES 4

Table 4: Geoelectric layer parameter analysis of VES No. 4

Geoelectric layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Lithology
1	77.00	0.90	0.90	Top soil
2	547.70	6.30	7.20	Sand
3	343.30	10.10	17.30	Sand (wet)
4	499.30	21.00	38.30	Sand
5	579.50	14.10	52.40	Sand (dry)
6	556.00	-	-	Sand (wet)

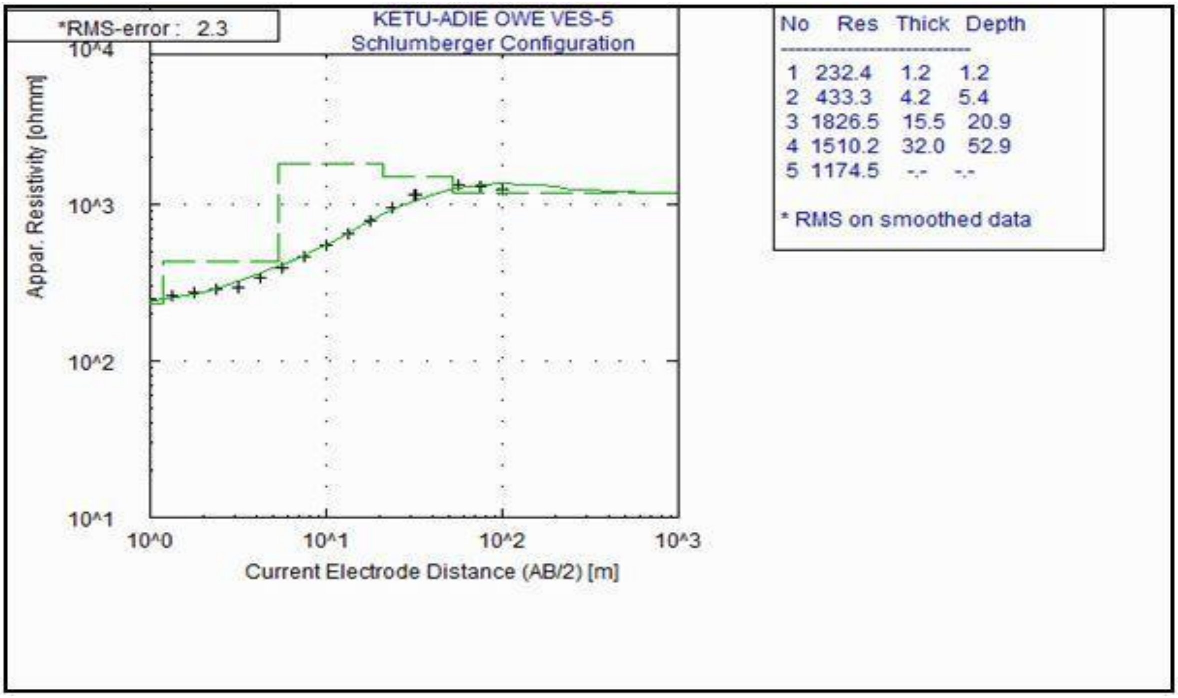


Figure 7: field and theoretical curves for VES 5

Table 5: Geoelectric layer parameter analysis of VES No. 5

Geoelectric layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Lithology
1	232.40	1.20	1.20	Top soil
2	433.30	4.20	5.40	Sand
3	1826.50	15.50	20.90	Sand (very dry)
4	1510.20	32.00	52.90	Sand (dry)
5	1174.50	-	-	Lateritic sand

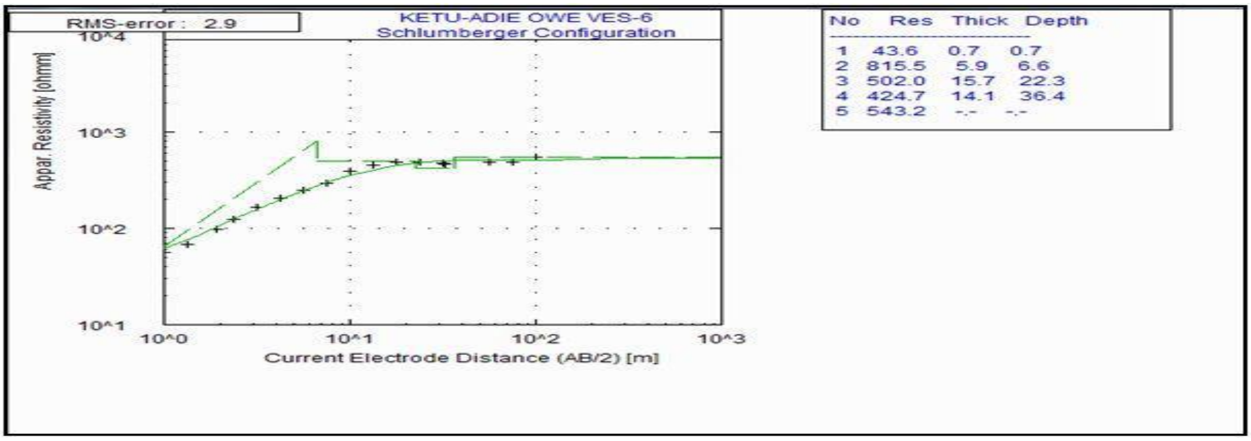


Figure 8: field and theoretical curves for VES 6

Table 6: Geoelectric layer parameter analysis of VES No. 6

Geoelectric layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Lithology
1	43.60	0.70	0.70	Top soil
2	815.50	5.90	6.60	Sand (dry)
3	502.00	15.70	22.30	Sand (wet)
4	424.70	14.10	36.40	Sand
5	2148.10	28.30	52.00	Sand (dry)

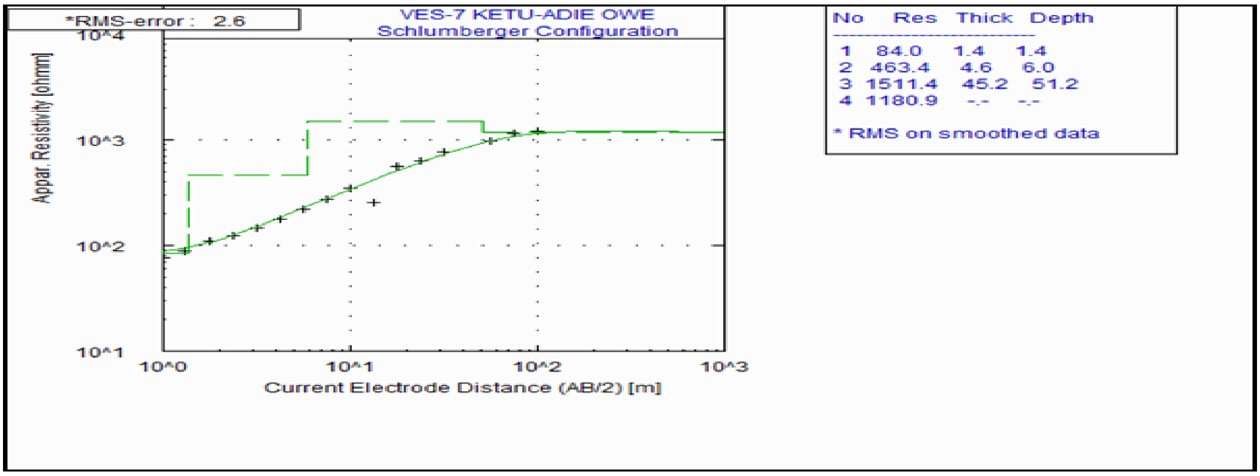


Figure 9: field and theoretical curves for VES 7

Table 7: Geoelectric layer parameter analysis of VES No. 7

Geoelectric layer	Resistivity (Ωm)	Thickness (m)	Depth (m)	Lithology
1	84.00	1.40	1.40	Top soil
2	463.40	4.60	6.00	Sand
3	1511.40	45.20	51.20	Lateritic sand
4	1180.90	.	.	Sand (dry)

Table 8: Summary of results

Geoelectric layer	Curve shape	Depth to Aquifer (m)	Latitude	Longitude	Elevation (m)
1	AAAK	Below 41.30	E003^{0}04'23.00''	N06^{0}35’53.00''	43.00
2	AAK	Below 32.90	E003^{0}04'00.00''	N06^{0}32’00.00''	42.00
3	AAK	Below 27.90	E003^{0}04'03.70''	N06^{0}36’04.50''	36.00
4	KHAK	Below 17.30	E003^{0}04'46.50''	N06^{0}35’33.90''	38.90
5	AKQ	Below 52.90	E003^{0}04'50.80''	N06^{0}35’28.60''	37.90
6	KQH	Below 22.30	E003^{0}04'17.90''	N06^{0}36’02.40''	41.70
7	AK	Not penetrated	E003^{0}04'05.60''	N06^{0}35’45.80''	39.00

V. Conclusion

The Geoelectric section of VES 1 shows geoelectric layers and its apparent resistivity curve is the AAAK-type with $\rho_1 < \rho_2 < \rho_3 < \rho_4 < \rho_5 > \rho_6$. The first layer with a resistivity value of 40.40 Ω m and a thickness of 0.50m is the top soil. The second layer suspected to be sandy clay has a resistivity value of 302.60 Ω m and a thickness of 1.20m indicating the presence of sand. The fourth and fifth layers contain very dry sand. They have thicknesses of 8.10m and 31.20m respectively. The sixth layer with a resistivity value of 6892.00 Ω m; suspected to contain lateritic sand, and lying below a depth of 41.30m is the aquifer.

The geoelectric section of VES 2 shows geoelectric layers and its apparent resistivity curve is the AAK-type, with $\rho_1 < \rho_2 < \rho_3 < \rho_4 > \rho_5$.The first layer has a resistivity value of 75.20 Ω m and a thickness of 1.00m indicating the top soil. The second layer has a resistivity of 348.40 Ω m with a thickness of 4.00m and it is composed of clayey sand. The third layer has a resistivity value of 526.20 Ω m with a thickness of 8.90m, and they are made of sand. The fourth layer has a resistivity value of 818.20 Ω m with a thickness of 18.90m and it is suspected to be dry sand. The fifth layer with a resistivity value of 519.90m and below a depth of 32.90m is the aquifer.

The geoelectric section of VES 3 shows geoelectric layers and its apparent resistivity curve is the AAK-type with $\rho_1 < \rho_2 < \rho_3 < \rho_4 > \rho_5$. The first and second layers have resistivity values of 85.80 Ω m and 127.80 Ω m . They also have thicknesses of 0.70m and 1.60m, and these indicate the top soil and the clayey sand respectively. The third layer is suspected to be sand. It has a resistivity value of 772.70 Ω m and a thickness of 4.30m. The fourth layer resistivity value of 968.30 Ω m with a corresponding thickness of 22.00m shows the presence of dry sand. The fifth layer has a resistivity value of 572.60 Ω m and its indicate the presence of wet sand. The later with a depth below 27.90m is the aquifer.

The geoelectric section of VES 4 shows geoelectric layer and its apparent resistivity curve is the KHAK – type, with $\rho_1 < \rho_2 > \rho_3 < \rho_4 < \rho_5 > \rho_6$. The first layer with a resistivity value of 77.00 Ω m and a thickness of 0.90m is the top soil. The second layer has a resistivity value of 547.70 Ω m and a thickness of6.30m and it is made up of sand. The third and fourth layers have resistivity values of 343.30 Ω m and 499.30 Ω m with thickness of 10.10 and 21.00 metres respectively. The earlier contains wet sand while the later contain ordinary sand. The fifth layer has a thickness of 14.10 metres and a resistivity value of 579.50 Ω m. It contain dry sand. The sixth layer with a resistivity value of 556.00 Ω m and having a depth below 52.40 metres is a shallow aquifer while the third layer of depth below 17.30 metres is a deep aquifer.

The geoelectric section of VES 5 shows geoelectric layers and its apparent resistivity curve is the AKQ – type with $\rho_1 < \rho_2 < \rho_3 > \rho_4 > \rho_5$. The first layer with a resistivity value of 232.40 Ω m and a thickness of 120m is the top soil. The second layer is suspected to be sand and it contains a resistivity value of 433.30 Ω m and a thickness of 4.20m. The third and fourth layers have resistivity values of 1826.50 Ω m and 1510.20 Ω m with thicknesses of 15.50 and 32.00 metres respectively. They both contain dry sand (but the third layer is dryer). The fifth layer is believed to contain lateritic sand. It has a resistivity value of 1174.50 Ω m. The fourth layer with a depth of 52.90m is the aquifer.

The geoelectric section of VES 6 shows geoelectric layers and its apparent resistivity curve is the KQH – type with $\rho_1 < \rho_2 > \rho_3 > \rho_4 < \rho_5$. The first layer is the top soil with a resistivity value of 43.60 Ω m and a thickness of 0.70m. The second layer has a resistivity value of 815.50 Ω m with a thickness of 5.90m and it contains dry sand. The third layer has a resistivity value of 502.00 Ω m with a thickness of 15.70m and it shows the presence of wet sand. The fourth and fifth layers contain sand. They have resistivity values of 424.70 Ω m and 543.20 Ω m respectively with the earlier having a thickness of 14.10m. The third layer with a depth of 22.30 metres is the aquifer.

The geoelectric section of VES 7 shows geoelectric layers and its apparent resistivity curve is the AK – type with $\rho_1 < \rho_2 < \rho_3 > \rho_4$. The first layer with a thickness of 1.40m and a resistivity value of 84.00 is the top soil. The second layer with resistivity value of 463.40 Ω m and thickness of 4.60m indicates the presence of sand. The third layer suspected to be lateritic sand has a resistivity value of 1511.40 Ω m and a thickness of 45.20m. The fourth layer with a resistivity value of 1180.90 Ω m contains dry sand.

The electrical resistivity method of prospecting for groundwater is cost effective compared to other methods. My recommendation is that anyone that wants to do the same work in this same environment should ensure the length of electrode spread for the vertical electrical sounding (VES) extend beyond 200 metres (used in this research work) for the depth of groundwater resolution.

References

[1]. Francis A. Dawodu (2013). Geoelectric investigation of Groundwater conditions: A case study of Ogwashi – Uku in Delta State, Nigeria. Journal of the Nigerian Association of Mathematical Physics,25(2), November, 2013, 81 -88.

[2]. Hamil, L. And Bell, (1986). Groundwater resources development britain library cataloguing in publication data london, 151 – 158.

[3]. Omotasola M. E. and Adegoke O. S. (1981). Tectonic evolution and cretaceous stratigraphy of the Dahomey Basin. Journal of Mining and Geology, 18 (1), 130 – 137.

[4]. Jones H. A. And Hockey R.D. (1964). The Geology of parts of South-western Nigeria. Bulletin of the Geological survey of Nigeria, 31, 86 – 88.

[5]. Gbadebo A.M., Taiwo a.m., Ayedun H. And Adeola A.J. (2012). Geochemical Analysis of Groundwater Quality in Agbara and Environs. Journal of Applied Ecology and Environmental Research, 2-3.

[6]. Allen J.R.L. and Wells J.W. (1962): Holocene coral banks and subsidence in the Niger Delta. Journal of Geology, 70 (4), 381 – 397.

Corresponding author: Usifo A.G.
E- mail: abel.giwa.usifo@gmail.com