# GEOELECTRICAL INVESTIGATION FOR GROUNDWATER AT DAY SECONDARY SCHOOL, KAMPALA, MINNA, NIGER STATE, NIGERIA

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***Abstract***

*Geoelectrical investigation of groundwater has been carried out at Day Secondary School, Kampala, Minna, Niger state, Nigeria. The area is situated on Latitude 9°40'37.11'' to 9°41'37.1''N and longitude 6°29'52.64'' to 6°30'51.56'' E. The survey was carried out with the aim of delineating the potential area for groundwater development and locating possible and suitable sites for productive boreholes, via overburden thickness and depth to the groundwater within the study area. A total of 500 m x 500 m was covered with VES points at 100 m interval and inter profile space of 100 m giving a total of thirty six (36) VES points. The schlumberger configuration was used for data collection with half-current electrode (AB/2) ranging from 1 to 100 m. WinResist computer software package was used to produce the VES curves. The quantitative interpretation of the VES curves made use of curve matching and computer aided approach. The depth sounding interpretation results were used to generate geoelectric section. The corresponding geologic section were also generated which revealed the existence of three subsurface layers. These layers comprises the topsoil, weathered/fractured basement and fresh basement The depth to basement map was also produced to further indicate depth to basement from the ground surface with VES $A_2$, B5, $D_2$ and $E_1$ to be relatively deeper with depth values range between 25 to 35 m while the shallower region of the area has a depth range values between 10 to 20 m. Hence, VES $A_2$, $A_5$, $B_4$, $B_5$, $C_2$, $C_4$, $D_4$, $D_5$, $E_1$, $E_3$, and $F_4$ are high conductive zone which are prolific for ground water potential. The depth range of the aquifer potential zones is between 22.7 m to 50.4 m. Correlations of the geologic sections extracted from the geoelectric section with the interpreted nearby borehole log were in agreement.*

***Keywords**: Lithology, Aquifer, Geoelectric, Iso-Resistivity, Basement, Vertical Electrical Sounding (VES)*

## INTRODUCTION TO THE STUDY

Water is considered an important necessity in the sustenance of life. The approach of innovation has made the mission for water in life to float from conventional search for surface water to prospecting for enduring and dependable subsurface water from boreholes. Throughout the years, and in recent time, particularly in Nigeria, boreholes have safeguarded natives from intense deficiency of water. Subsurface or underground water is portrayed by a specific number of parameters which are dictated by geophysical techniques such as gravity method, magnetic method, scenic methods, electrical resistivity method, and so on. Groundwater is thus, a huge major monetary asset, especially in many urban areas of Nigeria where compact water is rare. Resistivity of rocks is immovably affected by the closeness of groundwater, which goes about as an electrolyte. The minerals that shape the framework of a rock are for the most part great resistors than groundwater, so the resistivity of silt declines with the measure of groundwater it contains.

This relies on upon the portion of the rock that comprises of pore spaces and the part of this pore volume that is water filled (Lowrie, 1997).The typical parameters incorporate: the porosity, penetrability and conductivity. Electrical resistivity survey in geophysical investigation has proven reliable (Emenike, 2001). Records have demonstrated that the depths of aquifers vary from place to place due to variation in Geo-thermal and Geo-structural event (Ekine and Osobonye, 1996; Okwueze, 1996). Among the geophysical survey techniques, vertical electrical sounding (VES) method has been as often as possible embraced in hydro-geophysical survey for groundwater in both permeable and fissured media (Onuoha and Mbazi, 1988; Mbonu et al., 1991; Franjo et al., 2003). This method depends on the reaction of the earth to the stream of regulated current source. This method was adopted for Kampala study area since it has ended up being reliable, and is a successful method of solving groundwater problem in various part of the world (Bruse, 1963; Zohdy and Jackson, 1969 and Frohlich, 1974).

This study attempts to explore the use of geoelectrical survey technique to investigate the water bearing zones within the study area.

## LOCATION OF THE STUDY AREA

The survey site is Day Secondary School, Kampala, Minna, Niger State. The area is situated on Latitude $9^{o}$40'37.11"to $9^{o}$41'37.13"N and longitude $6^{o}$29'52.64" to $6^{o}$30'51.56" E. The site consists of building that housed the administrative block of the school, which occupy about 5% of the land mass. Behind the compound is a large vast of land mass that is not fenced and the topography is fairly flat. The area is characterized by dry and wet season which lies within southern part of Minna and accessible through Minna-Zungeru-Kontagora road. The site has a typical Guinea Savannah Climate. The dry season usually last from December to April and accompanied by rainy season that last from May to October.

## GEOLOGY OF THE STUDY AREA

The geology of the study area is part of Minna Sheet 164 and falls within the Basement Complex Terrain of Nigeria. The Nigerian Basement Complex forms part of the ancient African shield, bordered to the west by West African Cratonic Plate and underlies about 61% of Nigeria's land mass. The rock types found in the study area consists predominantly of coarse-grained biotite granite and granodiorite.

The granite types and the granodiorite together form part of the older Granite.

The study area is underlain by Precambrian rocks of the Nigerian Basement complex and consists of crystalline rocks mainly of older granite series formed during the Pan Africa Orogeny. The older granite consisting pegmatite, quartz veins, porphrics granites, gneisses' are present.

The hydrogeology of the study area is controlled by the vegetation rainfall, vegetation cover and evapotranspiration and the general geology of the area. The geology of the area serves as the ground water reservoir while rainfall is the dominant source of the ground water. These factors are responsible for the number of aquifers to be encountered and the means of recharging them.

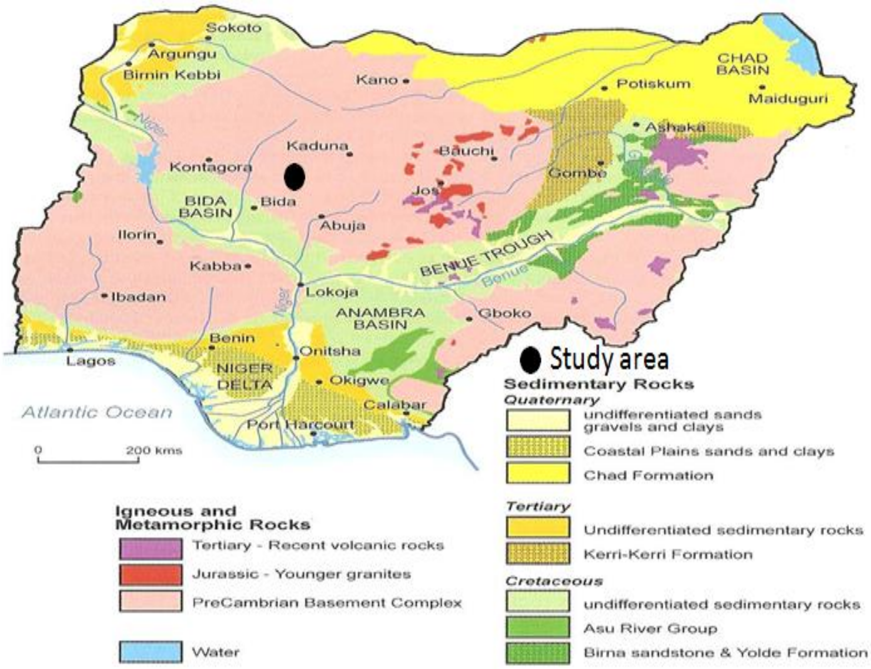



Figure 1: Generalized Geological Map of Nigeria (Olasehinde and Amadi, 2009)

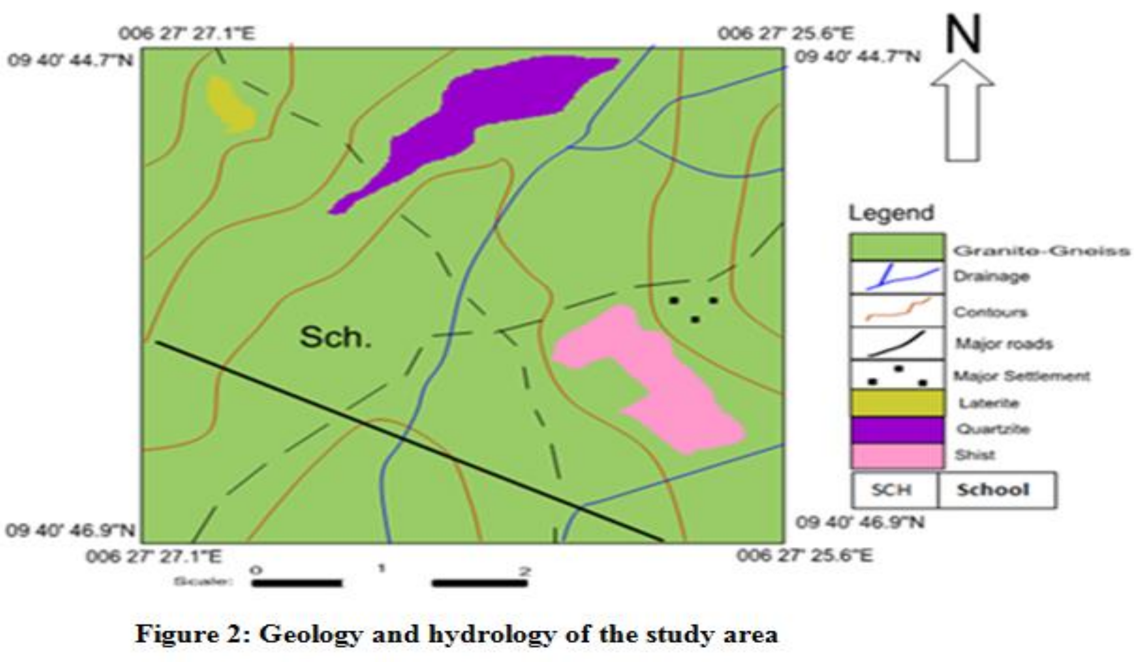



**Figure 2: Geology and hydrology of the study area**

## MATERIALS AND METHODS

The procedure employed in this research is as follows:

- Profile laying
- data analysis
- interpretations
- and conclusions

An extensive preliminary field survey was carried out to ascertain the total area coverage and also to clear off rugged terrains in the site. This is to ease the survey processes. The procedure started by pegging at equal distance of 100 m along each profile. The gridding strings were used to ensure the profiles were straight; the tape was used to aid the measurement. The inter profile space was 100 m and a total of 500 by 500 meter was covered given a total of thirty six (36) VES points. After the pegging was done, an array of four non-polarizable electrodes consisting of two potential electrodes flanked on the extremes by two current electrodes traversed each profile measuring 100m long.

In order to accurately locate the VES points even after the field survey, GPS was used to collect the coordinate and topography readings for each VES point.

Finally, the terrameter was set up by inserting both the current and potential electrode into the ground while ensuring tight connections of the terminal

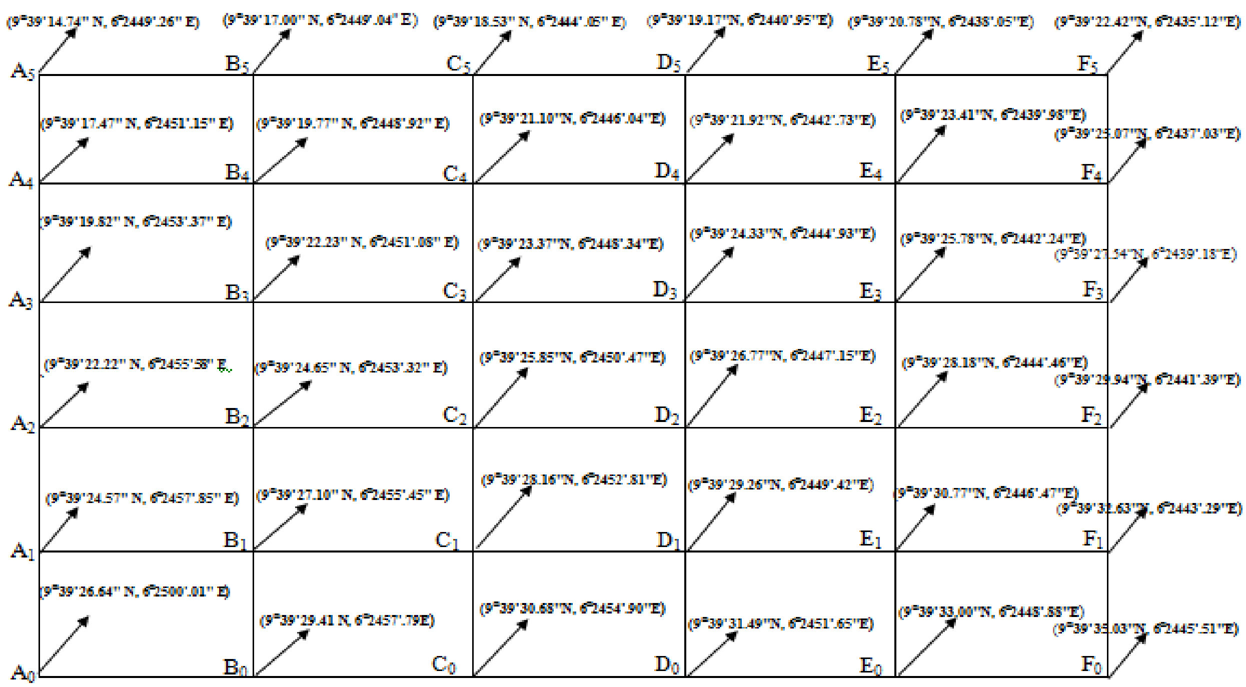



**Figure 3:** Profile Layout for VES **Collection**

## THEORY OF RESISTIVITY METHOD

Resistivity is expressed in ohm-meters and is an estimate of the earth resistivity calculated using relationship between resistivity, an electric field, and current density (Ohm's Law), and the geometric constant, spacing of the current and potential electrodes. The fundamental equation for resistivity surface is derived from ohm's law (Grant and west, 1965; Dobrin and Savit, 1988). Given by:

$$\rho = \frac{1}{\delta} = \frac{RA}{L} \qquad (1)$$

Where $\rho$ is resistivity, R is electrical resistivity, L the length, A the cross sectional Area and $\delta$ the conductivity.

Fractures enhance the conductivity of the earth when an electrical current, I, passed through it, thus making the rock a semi-conductor. Since the earth is not like a straight wire and it is anisotropic, then equation (1) is thus customized to:

$$\rho_a = \frac{\Delta V}{I} . 2\pi r \qquad (2)$$

Where 2rπ is defined as a geometrical factor (G) fixed for a given electrode configuration. The Schlumberger configuration was used in this work. The geometric factor G is thus given as

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

Where AB is (current electrode spacing) and MN is (spacing between potential electrodes).

**Electrode Configuration**

**Wenner Arrangement**

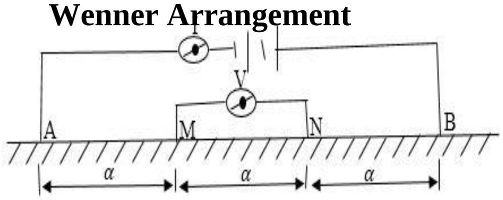



**Figure 5:** Wenner Array

Named after Wenner (1916).The four electrodes A, M, N, and B are equally spaced along a straight line. The distance between adjacent electrodes is called "a" spacing.

So AM=MN=NB= ⅓ AB = a=$\boldsymbol{\alpha}$.

$$\rho_a = 2\ \pi\ a\ V / I \qquad (4)$$

The Wenner array is widely used in the western Hemisphere. This array is sensitive to horizontal variations.

**Schlumberger Arrangement**

This array is the most widely used in the electrical prospecting. Four electrodes are placed along a straight line in the same order AMNB, but with AB ≥ 5 MN

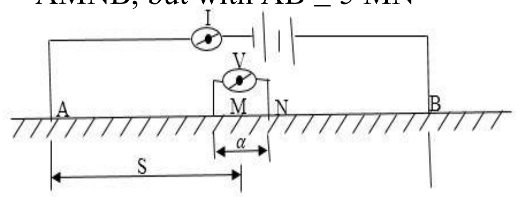



**Figure 4:** Schlumberger Array

$$\rho_a = \pi X \frac{V}{I}\ \text{X} \left[\frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN}\right] \qquad (5)$$

This array is less sensitive to lateral variations and faster to use as only the current electrodes are moved

**RESULTS AND DISCUSSIONS**

Ohm's law (V = IR) was used to estimate the resistance value and later multiplied by the geometric factor to obtain the apparent resistivity.

The VES interpretation was carried out using a computer program, called WinResist software. The curve gives the equivalent n-layered model from the apparent resistivity of each sounding point. Surfer 11 computer software was used to produce Iso-Resistivity and Geoelectric vertical section contour maps of data deduced from the WinResist. This gives more information about the sub-surface structure.

## INTERPRETATION OF GEOELECTRIC VERTICAL SECTION ALONG PROFILE

**Deduction from profile A**

The subsurface vertical geoelectric section is as shown in Figure (6a). The map was deduced from Table (1a). The resistivity range varies from 200 Ωm and 5000 Ωm. The weathering basement is seen to dominate the central region of the contour map. The layer resistivity values spread across the profile at different depths. An isolated structure of high resistivity about 2 m to 10 m is seen to intrude on VES $A_2$.

**Deduction from profile B**

The geoelectric section through profile B (Figure 7a) was generated from Table (1a). The north and western region of the map are characterized by low resistivity structures such as clay, weathered laterite and fadama loam. The weathered basement appeared on VES $B_2$, $B_3$ and extended downward to a depth of 25 m on VES $B_4$.

**Deduction from profile C**

The vertical section though profile C (Figure 8a) was produced from (Table 1a). The resistivity variation is between 100 Ωm and 1600 Ωm. The map is completely weathered as seen from the central region .That is, the weathered basement except the western edge that shows a very high resistive intrusive structure at VES $C_0$ from 5 m up to a depth 25 m which represent the fresh basement.

**Deduction from profile D**

Table 1b was used to generate the vertical section of figure 9b. A completely weathered basement is seen to dominate the entire contour map except the north corner edge that shows an intrusion of fresh basement on VES $D_0$. The intrusion covers about 2 m up to 13 m depth on VES $D_0$.

**Deduction from profile E**

Profile E (Figure 10a), was produced using (Table 1b). The weathered zones include VES $E_1$ and $E_3$ which are bright sports for aquifer potential with appreciable overburden thickness of 41.2 m and 22.7 m. The fresh basement appeared to dominate VES $E_2$, $E_4$ and $E_5$ at a depth of about 7 m up to 30 m on VES $E_5$.

**Deduction from profile F**

Figure 11a shows the vertical section of profile E which was produced using (Table 1b). It has resistivity variation between 500 Ωm and 8000 Ωm. The map is characterized by completely weathered basement/ fractured basement. VES $F_0$, $F_1$, $F_2$, $F_3$ and $F_4$ are under completely weathered basement and are viable points for groundwater potential except at the eastern region of the map that shows a characteristics fresh basement.

**Table 1a: Resistivity values for VES on profile A, B and C**

| Profile A | | | Profile B | | | Profile C | | |
|---|---|---|---|---|---|---|---|---|
| **X (m) x 10** | **Y(m)** | **Z (Ωm)** | **X (m) x 10** | **Y (m)** | **Z (Ωm)** | **X (m) x 10** | **Y (m)** | **Z(Ωm)** |
| **0** | -30 | | 0 | -30 | | 0 | -30 | 514.5 |
| **0** | -25 | 224.4 | 0 | -25 | 224.4 | 0 | -25 | |
| **0** | -20 | | 0 | -20 | | 0 | -20 | |
| **0** | -15 | | 0 | -15 | | 0 | -15 | 1574.3 |
| **0** | -10 | 431.4 | 0 | -10 | 431.4 | 0 | -10 | |
| **0** | -5 | 746.6 | 0 | -5 | 746.6 | 0 | -5 | 858.7 |
| **0** | 0 | 56.1 | 0 | 0 | 56.1 | 0 | 0 | 14.6 |
| **10** | -30 | | 10 | -30 | | 10 | -30 | |
| **10** | -25 | | 10 | -25 | | 10 | -25 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **10** | -20 | 33.7 | 10 | -20 | 33.7 | 10 | -20 | 231.1 |
| **10** | -15 | | 10 | -15 | | 10 | -15 | |
| **10** | -10 | | 10 | -10 | | 10 | -10 | |
| **10** | -5 | 80 | 10 | -5 | 80 | 10 | -5 | 325.8 |
| **10** | 0 | 45.7 | 10 | 0 | 45.7 | 10 | 0 | 151.7 |
| **20** | -30 | | 20 | -30 | | 20 | -30 | |
| **20** | -25 | 161.1 | 20 | -25 | 161.1 | 20 | -25 | |
| **20** | -20 | | 20 | -20 | | 20 | -20 | 332 |
| **20** | -15 | | 20 | -15 | | 20 | -15 | |
| **20** | -10 | 340.6 | 20 | -10 | 340.6 | 20 | -10 | 47.3 |
| **20** | -5 | 684.3 | 20 | -5 | 684.3 | 20 | -5 | 416.4 |
| **20** | 0 | 60.7 | 20 | 0 | 60.7 | 20 | 0 | 60.2 |
| **30** | -30 | | 30 | -30 | | 30 | -30 | |
| **30** | -25 | 130.7 | 30 | -25 | 130.7 | 30 | -25 | |
| **30** | -20 | | 30 | -20 | | 30 | -20 | |
| **30** | -15 | 45.9 | 30 | -15 | 45.9 | 30 | -15 | 323.6 |
| **30** | -10 | | 30 | -10 | | 30 | -10 | 325.7 |
| **30** | -5 | 499.4 | 30 | -5 | 499.4 | 30 | -5 | 286.4 |
| **30** | 0 | 40.2 | 30 | 0 | 40.2 | 30 | 0 | 56.2 |
| **40** | -30 | | 40 | -30 | | 40 | -30 | |
| **40** | -25 | | 40 | -25 | | 40 | -25 | 327.5 |
| **40** | -20 | 497.9 | 40 | -20 | 497.9 | 40 | -20 | |
| **40** | -15 | 346.7 | 40 | -15 | 346.7 | 40 | -15 | |
| **40** | -10 | | 40 | -10 | | 40 | -10 | 69.8 |
| **40** | -5 | | 40 | -5 | | 40 | -5 | 496.5 |
| **40** | 0 | 180.6 | 40 | 0 | 180.6 | 40 | 0 | 51.6 |
| **50** | -30 | | 50 | -30 | | 50 | -30 | |
| **50** | -25 | 193.5 | 50 | -25 | 193.5 | 50 | -25 | |
| **50** | -20 | | 50 | -20 | | 50 | -20 | |
| **50** | -15 | 57.7 | 50 | -15 | 57.7 | 50 | -15 | 261 |
| **50** | -10 | 69.2 | 50 | -10 | 69.2 | 50 | -10 | 47.9 |
| **50** | -5 | | 50 | -5 | | 50 | -5 | |
| **50** | 0 | | 50 | 0 | | | | |

**Table 1b: Resistivity values for VES on profile D, E and F**

**Profile D** **profile E** **Profile F**

| X (m) x10 | Y (m) | Z (Ωm) | X (m) X 10 | Y (m) | Z (Ωm) | X (m) x 10 | Y (m) | Z (Ωm) |
|---|---|---|---|---|---|---|---|---|
| **0** | -30 | | 0 | -30 | | 0 | -30 | |
| **0** | -25 | | 0 | -25 | | 0 | -25 | |
| **0** | -20 | | 0 | -20 | | 0 | -20 | |
| **0** | -15 | 623.4 | 0 | -15 | 340.5 | 0 | -15 | |
| **0** | -10 | 2798.8 | 0 | -10 | 300.8 | 0 | -10 | |
| **0** | -5 | 4710.8 | 0 | -5 | 994.1 | 0 | -5 | |
| **0** | 0 | 258.3 | 0 | 0 | 159.9 | 0 | 0 | |
| **10** | -30 | | 10 | -30 | 377.7 | 10 | -30 | 666.6 |
| **10** | -25 | | 10 | -25 | | 10 | -25 | |
| **10** | -20 | 209.9 | 10 | -20 | | 10 | -20 | |
| **10** | -15 | 78.6 | 10 | -15 | | 10 | -15 | 178.3 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **10** | -10 | | 10 | -10 | 335.5 | 10 | -10 | |
| **10** | -5 | 654.3 | 10 | -5 | | 10 | -5 | 181.9 |
| **10** | 0 | 66.6 | 10 | 0 | 54.4 | 10 | 0 | 31.6 |
| **20** | -30 | | 20 | -30 | | 20 | -30 | |
| **20** | -25 | | 20 | -25 | | 20 | -25 | |
| **20** | -20 | | 20 | -20 | | 20 | -20 | 1743.3 |
| **20** | -15 | 168.6 | 20 | -15 | 2224.6 | 20 | -15 | |
| **20** | -10 | | 20 | -10 | | 20 | -10 | 680.4 |
| **20** | -5 | 563.5 | 20 | -5 | 591.8 | 20 | -5 | 243.9 |
| **20** | 0 | 90.1 | 20 | 0 | 9.3 | 20 | 0 | 17.6 |
| **30** | -30 | 478.8 | 30 | -30 | | 30 | -30 | |
| **30** | -25 | | 30 | -25 | 489.6 | 30 | -25 | |
| **30** | -20 | | 30 | -20 | | 30 | -20 | |
| **30** | -15 | 206.2 | 30 | -15 | 298.5 | 30 | -15 | 2483.1 |
| **30** | -10 | | 30 | -10 | 118.9 | 30 | -10 | |
| **30** | -5 | 315.7 | 30 | -5 | | 30 | -5 | 626.1 |
| **30** | 0 | 60.7 | 30 | 0 | 38.9 | 30 | 0 | 7.7 |
| **40** | -30 | | 40 | -30 | | 40 | -30 | |
| **40** | -25 | | 40 | -25 | | 40 | -25 | 393.5 |
| **40** | -20 | 242.5 | 40 | -20 | | 40 | -20 | |
| **40** | -15 | | 40 | -15 | 1796.6 | 40 | -15 | 72.5 |
| **40** | -10 | 306.5 | 40 | -10 | | 40 | -10 | |
| **40** | -5 | | 40 | -5 | 693.5 | 40 | -5 | 358.1 |
| **40** | 0 | 45.9 | 40 | 0 | 7.2 | 40 | 0 | 37.3 |
| **50** | -30 | | 50 | -30 | | 50 | -30 | |
| **50** | -25 | 179.7 | 50 | -25 | | 50 | -25 | |
| **50** | -20 | | 50 | -20 | 1287.2 | 50 | -20 | |
| **50** | -15 | | 50 | -15 | | 50 | -15 | 7984.3 |
| **50** | -10 | 249.3 | 50 | -10 | | 50 | -10 | |
| **50** | -5 | 346.4 | 50 | -5 | 696 | 50 | -5 | 1803.6 |
| **50** | 0 | 50.2 | 50 | 0 | 11.6 | 50 | 0 | 21.2 |

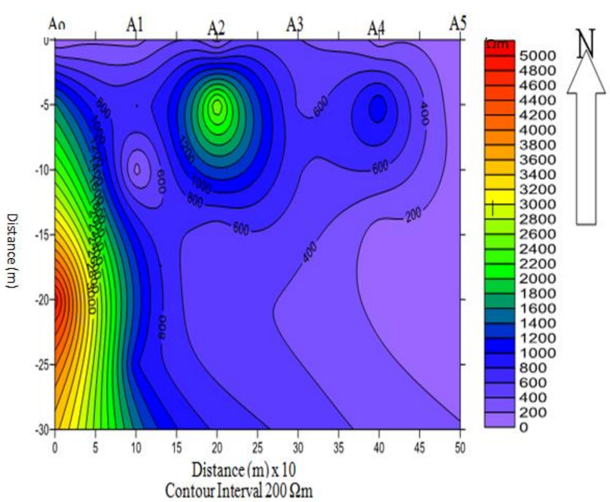



**Figure 6a:** Vertical section (Geoelectric) map profile A

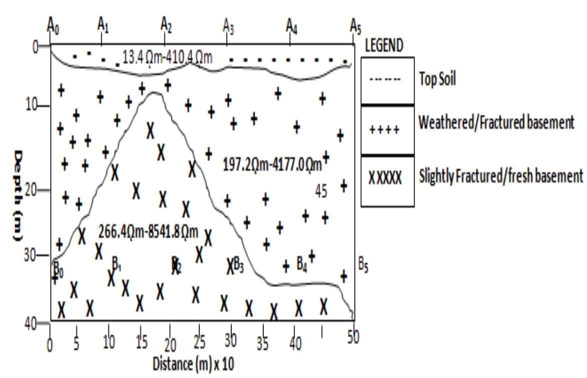



**Figure 6b:** Geologic section through profile

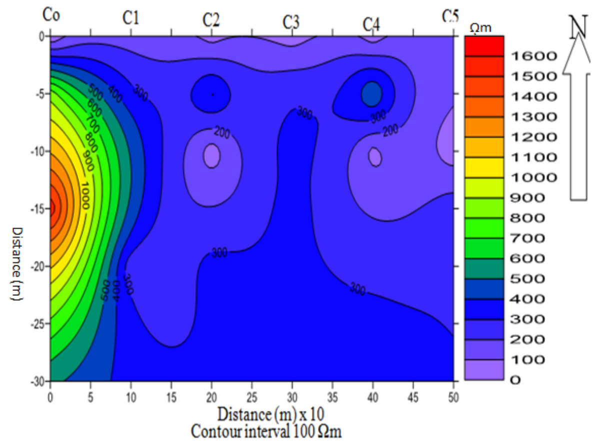



**Figure 8a:** Vertical section (Geoelectric) map profile C

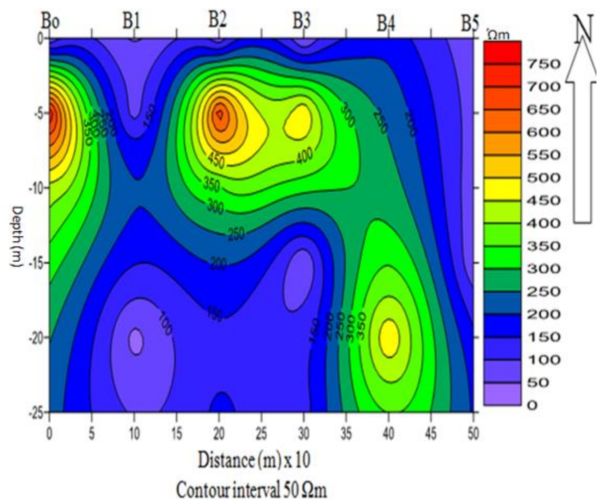



**Figure 7a:** Vertical section (Geoelectric) map profile B

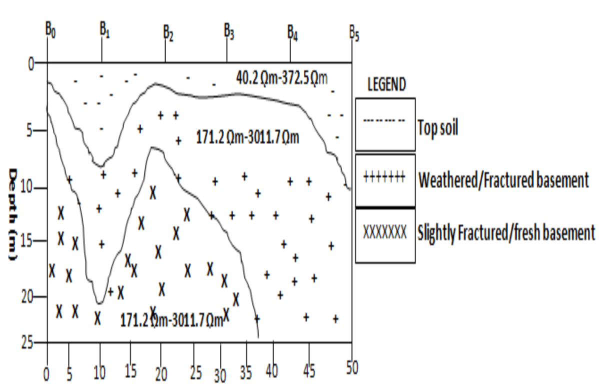



**Figure 7b:** Geologic section through profile B

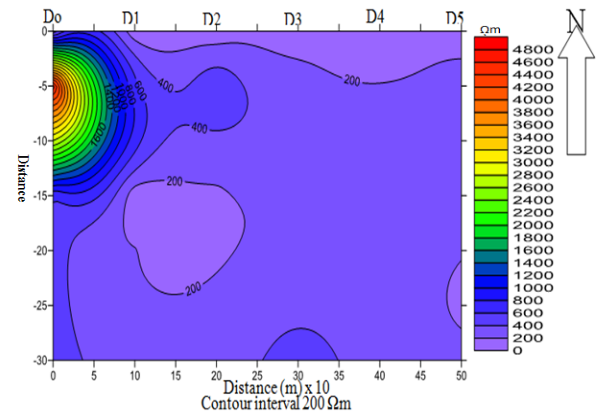
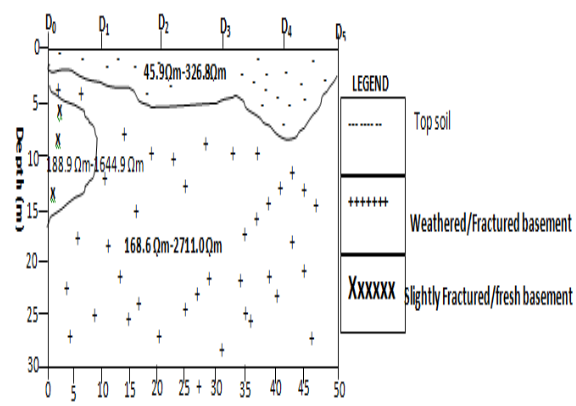



**Figure 9a:** Vertical section (Geoelectric) map profile D



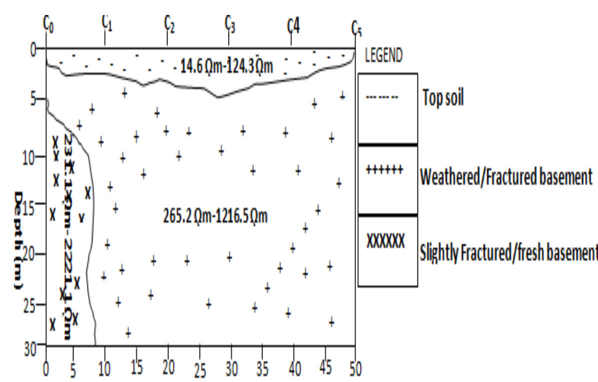




**Figure 8b:** Geologic section through profile C

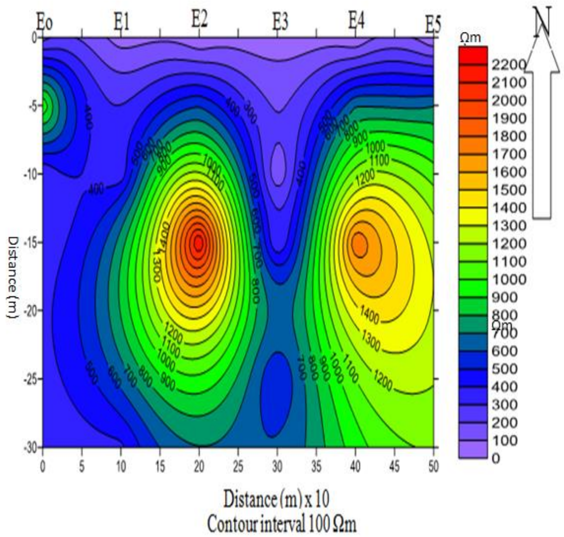
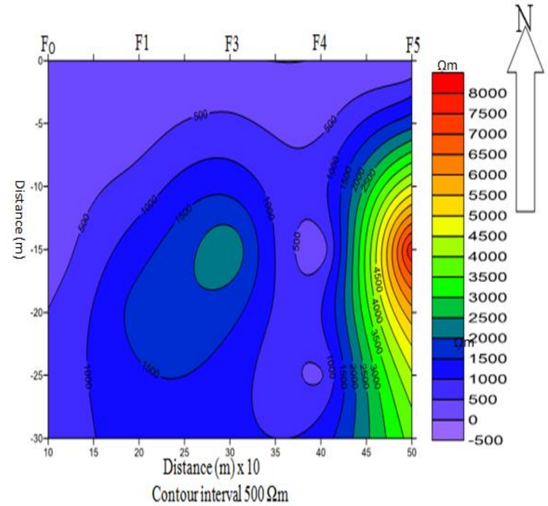



**Figure 10a:** Vertical section (Geoelectric) map profile E

**Figure 9b:** Geologic section through profile




D

**Figure 11a:** Vertical section (Geoelectric) map profile E

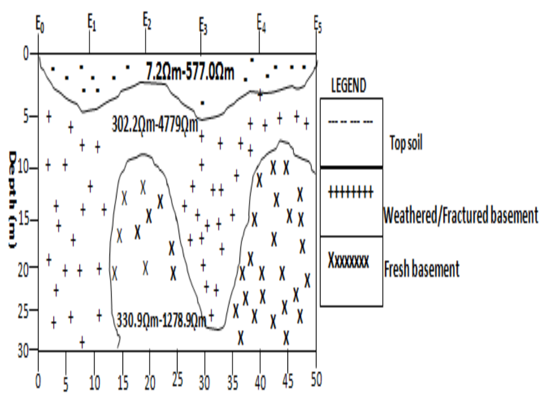



**Figure 10b:** Geologic section through profile E

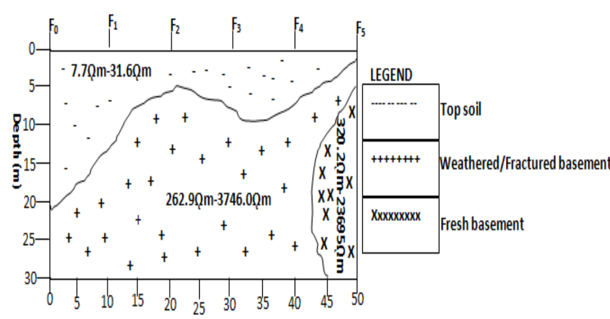



**Figure 11b:** Geologic section through profile F

**Interpretation of Geologic sections and its correlation with nearby geologic sections of borehole log samples**

Geologic section provides help to understand the geologic conditions that occur in specific areas of the section. In an attempt to further analyze the geological formation of the study area; geologic sections were extracted from the geoelectric map (Figure 6a-11a) and were correlated with nearby geologic sections and borehole log sample located at the Barrister Dattis Commercial Centre and the other located at the Dr. Isah Niger Insurance residence, Bosso.

**Table 2: Nearby borehole log (Niger State Rural Water Supply and Sanitation) some few kilometres away from the study area**

| Depth Range (M) | Lithology/Observation/Description | Time Of Penetration (Min) | Interpretation And Justification |
|---|---|---|---|
| 0 – 7 | Lateritic Top soil | 3 | Topsoil |
| 7 – 14 | Highly weathered basement | 4 | Wet sand/clay |
| 14 – 21 | Weathered basement | 4 | Low water bearing |
| 21 – 28 | Fractured pegmatite | 4 | High water bearing |
| 28 – 35 | Weathered basement | 5 | Low water bearing |
| 35 – 42 | Weathered basement | 5 | Low water bearing |
| 42 – 49 | Highly fractured pegmatite (Pink) | 4 | High water bearing |
| 49 – 56 | Fractured pegmatite (Pink) | 4 | High water bearing |
| 56 – 63 | Weathered basement | 8 | High water bearing |

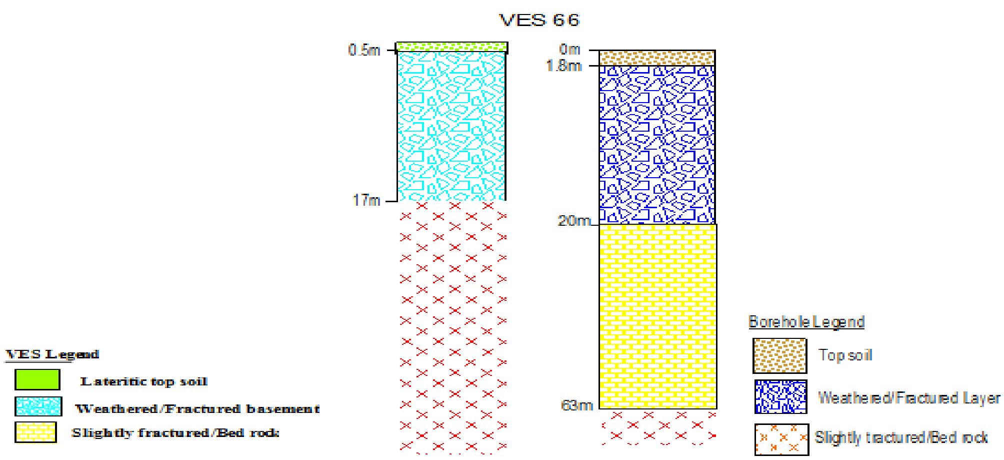



**Figure 12:** (a) VES 66 for borehole log 7 (b) The geologic section of the VES data interpreted and the litho log based on borehole drilling. (Niger State Rural Water Supply and Sanitation*)*

**Geologic section through profile A**

The geologic section through profile A, shown in Figure 6b was extracted from Figure 6a. The nearby borehole log sample is as shown in table 2 and its geologic section in Figure 12. The geologic section though profile A has three sections and in correlation with the geologic section of the nearby borehole log sample which also has three sections (Figure 12). The first section (Figure 6b) has thickness/depth range between 0.6 m and 1.8 m while the first section of the nearby geologic section of borehole log sample (Figure 12) has depth variation between 0 m and 1.8 m. The second section (Figure 6b) has depth variation between 20.2 m and 38.5 m while the second section of the nearby geologic section (Figure 12) has depth variation between 1.8 m and 20 m. The third layer (Figure 6b) has depth variation between 20.8 m and 39.4 m which correlate with the depth range of the third layer of the nearby borehole sample log (Figure 12) which has 20 m and 63 m as depth range. Though there is some little variation in depth between the three geologic sections and the correlated. nearby geologic section of the borehole log sample are within correlation range.

**Geologic section through profile B**

Figure 7b; represent the geologic section of profile B, extracted from Figure 7a. Table 2 shows the nearby borehole log sample and its geologic section in Figure 12. The geologic section though profile B has three sections while the geologic section of the nearby borehole log sample has three sections. The first section (Figure 7b) has thickness/depth range between 0.6 m and 8.7 m while the first section of the nearby geologic section (Figure 12) has depth variation between 0 m and 1.6 m. The second section (Figure 7b) has depth range between 6.6 m and 41.7 m while the second section of the nearby geologic section (Figure 12) has depth variation between 1.6 m and 15 m. The third section (Figure 7b) has depth range between 7.2 m and 50.4 m while (Figure 12) has depth range between 20 m and 63 m. The geologic section Figure (7b) agrees with the borehole log sample (Figure 12).

**Geologic section through profile C**

The geologic section of profile C, shown in Figure 8b is an extraction from Figure 8a. The nearby borehole log sample is shown in table 2 and its geologic section in figure 12. Both Figures 8b and 12 have three geologic layers. The first layer of Figure 8b has thickness/depth variation between 0.6 m and 1.2 m while the first layer of Figure 12 has depth variation between 0 m and 1.8 m. The second layer (Figure 8b) has depth range between 12.3 m and 24.4 m while the second layer (Figure 12) has depth range between 1.8 m and 20 m. The third layer/section (Figure 8b) has depth range between 12.9 m and 25.1 m while the third section of Figure 12 has depth range between 20 m and 63 m.

**Geologic section through profile D**

The geologic section of profile D is as shown in Figure 9b, extracted from Figure 9a. Figure 12 shows nearby geologic layer of borehole litho log sample (Table 2). The geologic section though profile D has three layers while the geologic section of the nearby borehole log sample (Figure 12) also has three layers. The first layer (Figure 9b) has thickness/depth variation between 0.7 m and 5.8 m while the first layer of the nearby geologic section of borehole litho log sample (Figure 12) has depth variation between 0 m and 1.6 m. The second layer (Figure 9b) has depth variation between 11.5 m and 30.1 m while the second layer of the nearby geologic section Figure 12 has depth variation between 1.6 m and 15 m. The third layer (Figure 9b) has depth range between 16.5 m and 40.5 m while Figure 12 has depth range between 20 m and 63 m. The geologic section

(Figure 9b) agrees with the geologic section of the borehole log sample (Figure 12).

**Geologic section through profile E**

The geologic section through profile E shown in Figure 10b is an extraction from Figure 10a. The nearby geologic section of the borehole log sample is shown in Figure 12c and the log sample in table 2. Both Figures (10b) and Figure (12) have three geologic sections. The first section of Figure (10b) has thickness/depth variation between 0.6 m and 4.7 m while the First section of Figure 12 has depth between 0 m and 1.8 m. The second section (Figure 10b) has depth variation between 4.1 m and 41.2 m while the second section (Figure 12) has depth variation between 1.8 m and 20 m. The third layer/section (Figure 10b) has depth range between 4.7 m and 42.2 m while the third section of Figure 12 has depth range between 20 m and 63 m. The geologic section (Figure 10b) is in correlation with (Figure 12).

**Geologic section through profile F**

Profile F geologic section is shown in Figure 11b. The section was extracted from Figure 11a. The nearby borehole litho log sample is shown in (Table 2) and its corresponding geologic section (figure 12). The geologic section though of profile F has three layers while three layers also exist for the borehole log sample (Figure 12). The first layer (Figure11b) has thickness/depth variation between 0.6 m and 0.9 m while the first layer of the nearby geologic section of borehole log (Figure 12) has depth variation between 0 m and 1.6 m The second layer (Figure 11b) has depth variation between 1.8 m and 23.7 m while the second layer of the nearby geologic section (Figure 12) has depth variation between 1.6 m and 15 m.The third layer (Figure 11b) has depth range between 2.5 m and 24.3 m while (Figure 12) has depth range between 20 m and 63 m. The geologic section Figure (11b) agrees with the geologic section of the borehole log sample (Figure 12).

## CONCLUSION

In this research work, one technique was used; the horizontal profiling and the vertical electrical sounding (VES) were used and a total of thirty six (36) VES points were sounded. As of the VES data analysis, three geologic units exist beneath the VES points, which revealed different lithological composition. The electrical resistivity technique used in this work entails locating a favourable borehole spots within the study area, which revealed three geoelectrical layers. These layers consist of the topsoil, weathered and fractured basement and the fresh basement.

## RECOMMENDATION

In an attempt to investigate groundwater potential, geoelectrical technique is by far the most efficient means of exploration. Other geophysical technique such as seismic refraction could also be used to investigate the nature of the subsurface material and in determining the depth to bed rock.

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