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Depth of Groundwater Investigation in Creek Town, Cross River State, Nigeria

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Abstract: *Electrical resistivity survey was employed for geophysical investigation, aimed at depth of ground water in Creek Town. Vertical Electrical Sounding approach was adopted and Schlumberger configuration employed to aid in estimating the thickness and resistivity of assumed horizontal layers. Abem Terrameter (SAS) 4000 was the equipment used for field survey. The analysis of data and interpretation by Resist Inversion program shows that the water is about 52.2m deep with a thickness of 46.1m. Drilling at this location is expected to reach a depth of 52.2m to enable the entire thickness of the layer be penetrated. The thickness of the weathered/ fracture basement beneath the region was found to be considerably large indicating a higher and possible ground water aquifer.*

***Keywords**: Depth, Groundwater, Potential and Current Electrodes, Vertical Electrical Sounding, Schlumberger Configuration, Resistivity and Terrameter.*

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I. Introduction

According to the United Nation's World Health Organization (WHO), more than one billion people in low and middle income countries lack access to safe water for drinking which represents more than 20 percent of the people in the world (Mendie, 2001). Contaminated drinking water leads to serious hazards to all customers, but children, elderly and the sick are more at risk (Mendie, 2005). Water quality standards are created from different types of water bodies and water body locations per desired uses (Morash et al., 2004). A better understanding of the depth of borehole water would help private owners of boreholes to site one after a proper investigation has been carried out by a Geophysicist (Eni et al., 2011) which is an expert in the field.

Groundwater is described as the water formed beneath the surface of the earth in underground steams and aquifers (Anomohanram, 2011). It is the largest available reservoir of fresh water. Observation shows that groundwater comes from rain, snow, sheet and hail that soak into the ground and becomes the groundwater responsible for the springs well and bore holes (Oseji et al., 2005). Groundwater is often withdrawn for agricultural, municipal and industrial use by constructing and operating extraction wells.

Electrical geophysical prospecting methods detect the surface effects produced by electric current flow in the ground. In Electrical Resistivity method, electric current is introduced into the ground and the resulting potential difference is measured at the surface. Two main procedures are involved, Vertical Electrical Sounding (VES) and Constant Separation Traversing (CST). They are used to know the electrical properties of the subsurface in homogeneities and to solve problems related to ground water assessment investigation exploration and salinity. VES is called electrical drilling or expanding probe, used to study horizontal or near horizontal interfaces. The current and potential electrodes are maintained at the same relative spacing and the spacing is progressively or gradually expanded about a fixed central point. Readings are taken as the current reaches progressively greater depths. CST is known as electrical profiling used to determine lateral variations of resistivity. Current and Potential electrodes are maintained at a fixed separation and the whole spread moved along a profile. It is used in mineral prospecting to locate faults. It also provides a means of determining interval variation in the resistivity of the ground (Olayinka and Mbachi, 1992; Oluruniwo and Olurunfemi, 1987). The method has been recognized to be more suitable for hydro geological survey of sedimentary basin (Kelly and Stanislav, 1993). The method is chosen for this because it has capability to distinguish between saturated and unsaturated layers.

The electrical resistivity method can be best employed to estimate the thickness of overburden, the thickness of weathered/fractured zones with reasonable accuracy and others (Soupious et al., 2007; Choudh'ury et al., 2001; Park et al., 2007; Arshad et al., 2002 and Kaya, 2001). Arrays or configurations include: Wener array, Schlumberger array, Pole – Pole array, Gradient array, Dipole - Dipole array, Pole – Dipole array and Multi – Electrode array. By measuring the resulting variations in electrical potential at other pairs of planted electrodes, it is possible to determine the variations in resistivity (Dobrin, 1988; Ozcep et. al., 2009; Alile et al., 2011, Umoren, et al., 2017).

In carrying out resistivity sounding survey, electrodes are distributed along a line centered about a midpoint that is considered the location of the sounding. The electrode arrangement used in data acquisition is the Schlumberger array of electrodes. The Schlumberger survey involves the use of two current electrodes labeled A and B, and two potential electrodes M and N placed in line with one another and centered on some location. It is worthy to state that the potential and current electrodes are not placed equidistant from one another. The geometric arrangement for this array is shown in Figure 2.0.

Table 1.0 shows some typical ranges of resistivity values for man-made materials and natural minerals and rocks, similar to numerous tables found in the literature (Telford et al., 1976). The ranges of values shown are those commonly encountered but do not represent extreme values. It may be inferred from the value listed that the user would expect to find in a typical resistivity survey rock producing higher resistivity. Usually, this will be the case, but the particular conditions of a site may change the resistivity relationships. For example, coarse sand or gravel, if it is dry, may have a resistivity like that of igneous rocks, while a layer of weathered rock may be more conductive than the soil types or lithology consideration should be given to the various factors that affect resistivity (Kearey and Brooks, 2000).

Table 1.0: Electrical Resistivity of Some Earth Materials (Telford et al., 1976)

Material	Resistivity (Ωm)
Clay	1 – 20
Sand, wet to moist	20-200
Shale	1-500
Porous limestone	100-1,000
Dense limestone	1,000 – 1,000,000
Metamorphic rocks	50-1,000,000
Igneous rocks	100 – 1,000,000

II. Site Location And Geology

Creek town is a class P – populated place in Odukpani, Cross River State, Nigeria, Africa with the region font code of Africa/middle east. It is located at an elevation of 99m above sea level and its population amounts to 171,672 from the result of 2006 census. Its coordinates are $4^0 58^1 60^{11}$ N and $8^0 16^1 60^{11}$ E in DMS (Degrees Minutes Seconds) or 4.98333 and 8.28333 (in decimal degrees). Its UTM position is ML25 and its joint operation Graphic reference is NB 32 – 114. The sun rises at 09:02 and sets at 21:09 local time (Africa/Lagos UTC/GMT +1). The standard time zone for Creek Town is UTC/GMT +1 (www.getamap.net/maps/nigeria/nigeria_(general)/-creektown/).

It is located in Cross River State which is the state that contains the largest amount of tropical High Forest in remaining in Nigeria and the largest remaining rainforest in west Africa (0.85 million hectares), although its quality and density varies across the state's three agro-ecological zones. Cross River State also contains 1,000sq.kilometres of mangrove and swamp forest. The main tree species found here include gmelina, albizia, iroko, ebony, mahogany, cedar, ukong, brachystegia and obeche. Cross River State due to her rich biodiversity and ecology remains an ideal biometry resource data base for tropical plant and animal research. The State is tagged peoples paradise, situated in Niger Delta region, in the tropical rainforest belt. It lies between latitudes $5^0 32^1$ and $4^0 27^1$ North and longitudes $7^0 50^1$ and $9^0 28^1$ East (figure 1.0), bounded in the North by Benue state, in the south – west by Akwa Ibom state, in the west by Ebonyi and Abia states. The state shares an internal frontier to the East with the United Republic of Cameroon and its Atlantic coastline is to the south where the Calabar River meets the sea.

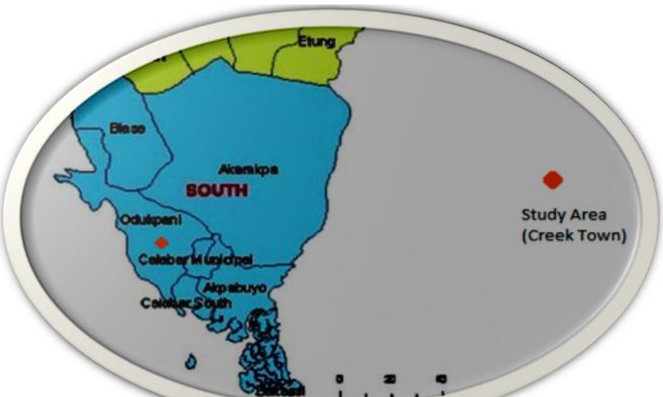

Figure 1.0: A section of Cross River State Map

(www.nigerianmuse.com/20100527092749zg/sections/pictures-maps-cartoons/maps-of-various-states-and-their-local-governments-in-nigeria/).

III. Mathematical Relations

Theoretical Basis in Resistivity Method is based on ohm's law

$$V = IR \quad 1.0$$

$$R = \frac{V}{I} \quad 2.0$$

V is the potential difference
I is the current
R is the resistance
The relation of these parameters with apparent resistivity ρ_a is given in equation 3.0

$$\rho_a = K\frac{\Delta V}{I} = KR \quad 3.0$$

K is geometric factor and is defined in Schlumberger Configuration (equation 4.0)

$$K = \pi\left[\frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN}\right] \quad 4.0$$

Thus,

$$\rho_a = \pi\left[\frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN}\right]R \quad 5.0$$

(George et al., 2017).

Figure 2.0 illustrates the electric field around the two electrodes in terms of equipotentials and current lines. The equipotentials represent imagery shells, or bowls, surrounding the current electrodes, and on any one of which the electrical potential is everywhere equal. The current lines represent a sampling of the infinitely many paths followed by the current, paths that are defined by the condition that they must be everywhere normal to the equipotential surfaces.

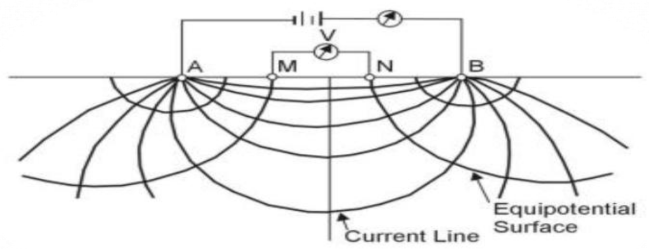

Figure 2.0: Schlumberger array (Wightman, et al., 2003).

In addition to current electrodes A and B, figure 2.0 shows a pair of electrodes M and N, which carry no current, but between which the potential difference V may be measured.

IV. Materials And Method

The equipment used for the survey is ABEM terrameter (SAS) 4000. Other materials used include: Measuring tapes, Current and Potential cables with crocodile clips, Current and Potential electrodes, Hammers, Global Positioning System, 12 Volt Battery and recording sheet.

Electric current was introduced into the ground by means of two current electrodes and voltage between two potential electrodes was measured. The physical quantities measured are the current and potential difference but displayed as resistance on the Terrameter and the distances between the various electrodes using measuring tape. VES was adopted and Schlumberger configuration (Figure 2.0) employed to aid in estimating the thickness and resistivity of assumed horizontal layers. The results were recorded on the recording sheet. Potential and current electrodes spacing is stated in Table 2.0.

V. Result, Data Analysis And Discussion

The summary of the resistivity result is shown in Table 2.0. Computer iteration using Win Resist Program yielded the sounding curve shown in Figure 3.0. The interpreted field resistivity data showed the depths and thicknesses beneath the subsurface and the different layers it comprises.

Table 2.0: Summary of Measured and Calculated Parameters of the Soil

S/N	Current Electrode $\frac{AB}{2}(m)$	Potential Electrode $\frac{MN}{2}(m)$	R (Ω)	Geometrical Factor (K)	ρ (Ωm)
1	1.0	0.25	424.131	5.89	2500.00
2	1.5	0.25	152.768	13.74	2100.00
3	2.0	0.25	88.913	24.74	2200.00
4	3.0	0.25	35.610	56.16	2000.00
5	4.0	0.50	40.475	49.48	2003.00
6	5.0	0.50	27.160	77.76	2111.96
7	6.0	0.50	20.752	112.32	2330.64
8	8.0	0.50	12.185	200.30	2439.65
9	10.0	1.00	14.700	155.52	2286.14
10	15.0	1.00	4.534	351.90	1594.10
11	20.0	1.00	1.772	626.97	1111.00
12	30.0	1.00	0.637	1412.87	900.80
13	40.0	2.50	1.041	1001.92	1043.00
14	50.0	2.50	0.638	1568.96	1001.00
15	60.0	2.50	0.354	2259.88	800.00
16	80.0	2.50	0.236	4025.42	950.00
17	100.0	10.00	0.774	1555.55	1204.00
18	130.0	10.00	0.493	2643.00	1303.00

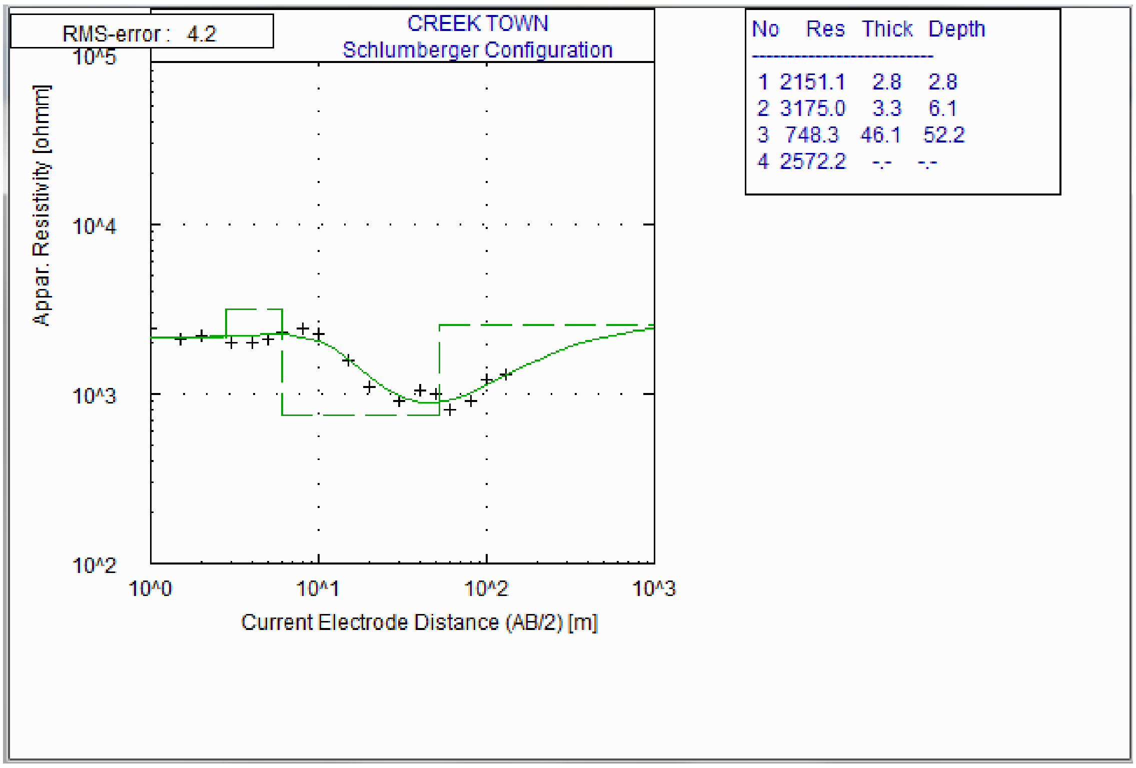

Figure 3.0: A Curve (Graph) of Apparent Resistivity against Current Electrode Separation

The apparent resistivity calculated are present as sounding curves for all the VES points using Resist Inversion Program, software designed for interpreting vertical electrical sounding data. The measured parameter is the resistance, calculated parameter is resistivity. Equation 4.0 and equation 5.0 were used to compute calculated parameters in Table 2.0. We ensure the readings were not affected by poor electrical contact at the surface. Four subsurface lithological layers are distinguished, this comprises of top soil, weathered layer, partly weathered/ fractured basement and fresh basement. The top soil has resistivity of 2151.1 Ωm with thickness of 2.8m at the depth of 2.8m. Underlying the top soil is weathered layer with resistivity of 3175.0Ωm and thickness of 3.3m at a depth of 6.1m. The third layer is partly weathered/

fracture basement; it is has a resistivity of $748.3\Omega m$ with the thickness of $46.1m$ and $52.2m$ deep. It indicates a high degree of saturation and shows that the layer corresponds to aquiferous zone in the study area. Figure 3.0 shows the thickness of overburden, the depth to the weathered layer and partly weathered/ fracture basement and the fresh basement.

VI. Conclusion

Electrical resistivity surveys have been employed for many years in geophysical investigation aimed at ground water exploration. These surveys have successfully delineated aquifers in places where significant resistivity differences exist between them and their surrounding formations. The information obtained from the geoelectric section such as: depth to basement, aquifer thickness led to conclusion that VES approach is recommendable. The analysis of data and interpretation by Resist Inversion program has shown that the water table in the area is about $52.2m$ deep with a thickness of $46.1m$. Drilling at this point is expected to reach a depth of $52.2m$ to enable the penetration of entire thickness of the layer. The thickness of the weathered/ fracture basement beneath the region was found to be considerably large indicating a higher and possible ground water potential.

References

[1]. Alile, O. M., Ujuanbi, O. and Evbuomwan, I. A. (2011). Geoelectric Investigation of Groundwater in Obaretin-Iyan Onnon Locality, Edo State, Nigeria. *Journal of Geology and Mineral Research*, 3(1): 13 – 20.
[2]. Anomohanran, O. (2011). Determination of Groundwater in Asaba, Nigeria Using Surface Geoelectric Sounding. *International Journal of the Physical Science*, 6(33): 7651-7656.
[3]. Arshad, M., Sikandar, P., Baksh, A. and Pana, T. (2002). The Use of Low Salinity Ground Water for Irrigation in Chaj and Rachna Doabs. *Journal of Environmental Earth Science*, 16: 1113 – 1129.
[4]. Chondh'ury, K., Saha, O. and Chakraborty, P. (2001). Geophysicaal Study of Saline Water Intrusion in a Coastal Alluvial Terrain. *Journal of Applied Geophysics*, 46: 189 – 200.
[5]. Dobrin, (1988). *Introduction to Geophysical prospecting*. Forth Edition.
[6]. Eni, D., Joel, E., Oko, L. and Ekwok, I. (2011). Flood and Its Impact on Farmlands in Itigidi, Abi Local Government Area, Cross River State, Nigeria. *International Journal of Humanities and Social Science*, 1(9): 98 – 104.
[7]. George, N., Atat, J., Umoren, E. and Etebong, I. (2017). Geophysical Exploration to Estimate the Surface Conductivity of Residual Argillaceous Bands in the Groundwater Repositories of Coastal Sediments of EOLGA, Nigeria. *NRIAG Journal of Astronomy and Geophysics*. 1 – 10.
[8]. Kaya, G. K. (2001). An Investigation of Ground Water Contamination using Electric and Electromagnetic Methods at an Open Waste – Disposal Site: A Case Study of Isparta. *Turkey Environmental Geology*, 40: 725 – 731.
[9]. Keary, P. and Brooks, M. (2000). *An Introduction to Geophysical Exploration.* Oxford: Blackwell Scientific Publication, P. 254.
[10]. Mendie, U. (2001). Health Implication of Drinking Contaminated Water. Workshop on Package Water, Fruit Juice and other Water Based Drink Organized by NAFSDAC.
[11]. Mendie, U. (2005). *The Theory and Practice of Clean Water Production for Domestic and Industrial Uses*. Lagos: Lacto-Medals Publishers. Pp. 2 – 9.
[12]. Morash, K. R., Thornthon, R. D. and Saunders C. H. (2004). Measurement of Resistivity of Ultrapure Water at Elevated Temperature. *Journal of Ultrapure Water*, 11 (4): 11 – 19.
[13]. Olayinka, A. I. and Mbachi, C. N. (1992). A Technique for the Interpretation of Electrical Sounding from Crystalline Basement Areas of Nigeria. *Journal of Mining Geology*, 27: 63-69.
[14]. Oloruniwo, M. A. and Olorunfemi, M. O. (1987). Geophysical Investigation for Groundwater in Precambrian Terrain: A case History from Ikare, Southern West Nigeria. *Journal of African Earth Sciences*, 6: 787-796.
[15]. Oseji, J. O., Atakpo, E. A. and Okolie, E. C. (2005). Geo-electric Investigation of the Aquifer Characteristics and Groundwater in Kwale, Delta State, Nigeria. *Journal of Applied Science and Environmental Management*, 9: 157-160.
[16]. Ozcep, F., Tezel, O. and Asci, M. (2009). Correlation between Electrical Resistivity and Soil-Water Content, Istanbul and Glocuk, Turkey. *Internal Journal of Physical Sciences*, 4(6): 362-365.
[17]. Park, H. Y., Doh, S. J. and Yun, S. T. (2007). Geoelectric Resistivity Sounding of Riverside Alluvial Aquifer in an Agricultural Area at Buyeu, Geum River Water Shed, Korea: An Application to Ground Water Contamination Study. *Environmental Geology*, 53: 849 – 859.
[18]. Soupious, P., Kouli, M., Villiantos, A. and Starroulakis, G. (2007). Estimation of Aquifer Hydraulic Parameters from Surficial Geophysical Methods: A Case Study of Keritis Basin in Chania (Crete – Greece). *Journal of Hydrology*, 338: 122 – 131.
[19]. Telford, W. M., Geldert, L. P., Sheriff, R. E. and Keys, K. A. (1976). *Applied Geophysics*. New York: Cambridge University Press. P. 860.
[20]. Umoren, E. B., Agbasi, O. E. and Emmanuel, E. O. (2017). Evaluation of Ground Water Potential in Ekpri – Ikang, Bakassi Local Government Area, Cross River State, Nigeria. "A Case Study of Open Bible Standard Church Premises'. *International Journal of Advanced Geosciences*, 5(1): 26 – 30.
[21]. Wightman, W. E., Jalinoos, F., Sirles, P., and Hanna, K. (2003). Application of Geophysical Methods to Highway Related Problems. *United States Environmental Protection Agency*. FHWA – IF – 04 – 021.
[22]. www.getamap.net/maps/nigeria/nigeria_(general)/-creektown/.
[23]. www.nigerianmuse.com/20100527092749zg/sections/pictures-maps-cartoons/maps-of- various-states-and-their-local-governments-in-nigeria/.

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