

Evaluation of Groundwater Potential in Takum Metropolis, North East Nigeria, Using the Electrical Resistivity Method.

Samuel Saleh^{1*}, Ayuni N.K.¹, Yusuf S.¹, Aboche E.F.¹, Ndom B.N.², Sa'adu B.A.¹, Osaro A.J.¹, Okeke D.V.¹, Achimugu A.¹, Kozak A.A.³ Moshud K. Musa⁴

¹Department of Pure and Applied Physics, Federal University Wukari, Taraba State, Nigeria.

²GSD Department, Air force Institute of Technology, Mando Kaduna.

³Department of Physics, University of Jos, Plateau state Nigeria.

⁴Federal university Wukari.

*Correspondence: Samuel Saleh

The authors declare that no funding was received for this work.



Received: 26-January-2026

Accepted: 20-February-2026

Published: 25-February-2026

Copyright © 2026, Authors retain copyright. Licensed under the Creative Commons Attribution 4.0 International License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. <https://creativecommons.org/licenses/by/4.0/> (CC BY 4.0 deed)

This article is published in the **MSI Journal of Multidisciplinary Research (MSIJMR)** ISSN 3049-0669 (Online)

The journal is managed and published by MSI Publishers.

Volume: 3, Issue: 2 (February-2026)

ABSTRACT: Vertical electrical sounding (VES) were taken at twelve (12) electrode equipped stations using the Schlumberger design, with spacing of $\frac{AB}{2} = 100\text{m}$. The aim of the study is obtaining the geophysical parameters and hydrological conditions of the subsurface of the study area. Electrical resistivity was used to measure the depth dependent resistivity variations of the subsurface in groundwater investigation. Software programs Interpex IX1-D and surfer 12 were used to examine the data. Two unique curve types can be seen in the examined result which are Q- type 8.3% and H-type have 91.7%. Iso-resistivity maps of $\frac{AB}{2} = 70\text{m}$ and 100m were produced. The anomaly was seen at Akpela in the northwest, Awuhe in the southwest and two minor anomalies are found in the southeast and northeast, hard resistive rocks are indicated in the research areas portion that corresponds to the 3-D model. The area is underlain by three to four geologic

sequences, consisting of top soil, fractured/weathered basement, and fresh basement, according to a geo-electric section. Sand and silty minerals make up the topsoil, and they have resistivity and thickness values that range from 391 – 617 Ωm and 1.5 – 6.8 m. The second layer which is basically silty materials and fractured weathered granite consist of highly fracture/weathered basement with resistivity measurements between 15 – 189 Ωm and a thickness of 4 – 37 m. This layer has an appreciable thickness and can be consider to be water bearing zones. Fresh basement has resistivity values of 1878 – 7463 Ωm with infinite depth. Longitudinal conductance for twelve (12) VES points were utilized to determine the capacity to defend against overburden. Two VES points have excellent capabilities, six (6) have moderate, three (3) have weak and two (2) have poor protective capacity. Transverse resistance values range from 1373.90-6397.08 Ωm^2 with an average value of 3712.08 Ωm^2 .

Key words: *Groundwater potential, Iso-resistivity, Geo-electric section, Protective capacity and Takum*

1.0 Introduction

Water in very necessary for human existence and lack of it will greatly affect human daily activity. Lack of water is a problem in most developing countries such as Nigeria and most states in North-East Nigeria is challenging. The research area (Takum metropolis) is situated in the North eastern region of Nigeria in Taraba state which is located within the Latitude $7^{\circ}23'00''\text{N}$ to $7^{\circ}27'00''\text{N}$ and Longitude $10^{\circ}0'00''\text{E}$ to $10^{\circ}4'00''\text{E}$. It covers an area of about 53.78 km^2 as shown in Figure 1. Twelve (12) VES stations were used to conduct vertical electrical soundings using the Schlumberger setup. The research used a potential electrode with a spacing of $\frac{AB}{2} = 1 - 100$ m and $\frac{MN}{2} = 0.5-15$ m. Computer iteration software (Interpex), which provides an automatic interpretation of the apparent resistivity, was used to evaluate and interpret the resulting data from the twelve (12) VES stations. On the surface of the earth as well as underground in the pore spaces of the planet's geologic components, water is a highly mobile and variable resource (C.K. Mbah, A. Nur, 2022). The success of groundwater supply and its quality depends on the borehole sitting, water supply should be the priority of every responsible government in other

to provide a less stressful living condition for mankind. Domestic water supply comes largely from the groundwater, much of which is obtained from overburden and fractured rock. On the surface of the earth as well as underground in the pore spaces of the earths geologic sections water is a highly mobile and variable resources. Aquifers are water bearing porous and permeable rocks that are found beneath the subsurface. Water resources are thought to be abundantly blessed in Nigeria. However, Aquifers can also be described as worn or fractured basement rocks. A significant improvement in water supply is essential for sustainable environment Programme. The capacity to access water is a prerequisite for both the production of food and other socioeconomic activities (Ozegin et al., 2011). Water has had a significant role in growth of settlements (Amadi et al., 2010). Precipitation that has seeped into the earth is the source of almost all of the water in the soil. Observations have revealed that extra rainfall merely flows off the grounds surface some infiltrates and springs, lakes, and wells are the result of groundwater that seeps through the earth (Oseji et al.,2011). According to Nur (2012), electrical resistivity method has been very useful for groundwater exploration in Sub-Sahara African. It has been used by researchers for groundwater exploration and environmental studies in Hong, Bauchi, Fufore, Michica, Takum and Jalingo metropolis with high degree of success. Understanding the hydrogeological properties of groundwater is necessary for the successful use of geophysics to its exploration (Samuel, et.al; 2020). Therefore, this research will help in understanding the regions geological and hydrogeological features and those in the utilization of the knowledge to locate safe and highly productive regions for sustainable water development by determining depth to aquifer and stratigraphic order of the research field.

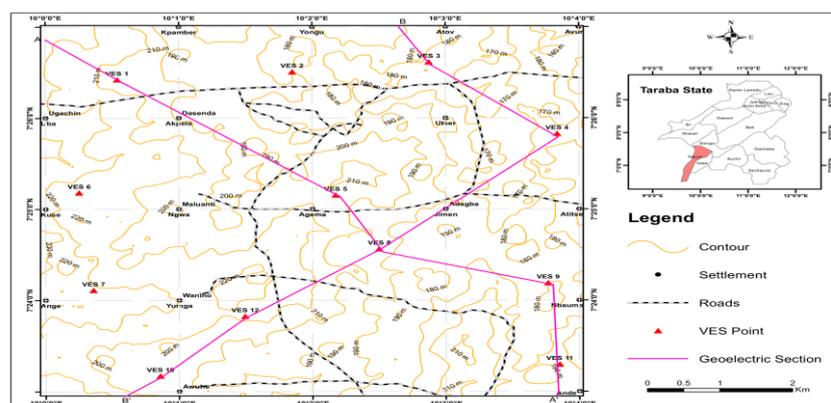


Figure 1: The VES locations on a topographic Map of the Study Area

1.1 Geology and Hydrogeology of the Study Area

The research field lies under the basement complex rocks of the Precambrian and upper Paleozoic age. The rocks consist of diorite, granite, Undifferentiated Metasediment, and Alluvium (Carter et al., 1963). The granitic rocks and diorite are basically found in the region to the north of the research area. They have undergone weathering and laterization, which has led to unconsolidated silty-sand, clay and gravel. Quartzite's are also commonly found inter-bedded with biotite-gneiss, they are frequently feldspar with highly kaolinised plagioclase and microcline in finely granular quartz matrix. The undifferentiated Metasediment rocks have been metamorphosed into migmatities and granite gneiss. They are located in the research areas northern and southern regions as showed in Figure 2. Alluvium deposits are derived from the weathered basement rocks transported and deposited along the riverbanks at the study areas north-west, west, and south-west portions and consist mainly fine to medium grained silty materials.

There are two types of water resources in the research area: surface water and groundwater. Rainfall is one of the main seasonal sources of surface water in the region. The months of August and September have the highest river discharge, while January and February experience the lowest. The weathered/fractured basement mostly makes up the aquifer unit in the studied area. Due to the low permeability of these rocks, poor penetration of surface water during the rainy season leads to shallow water table conditions.

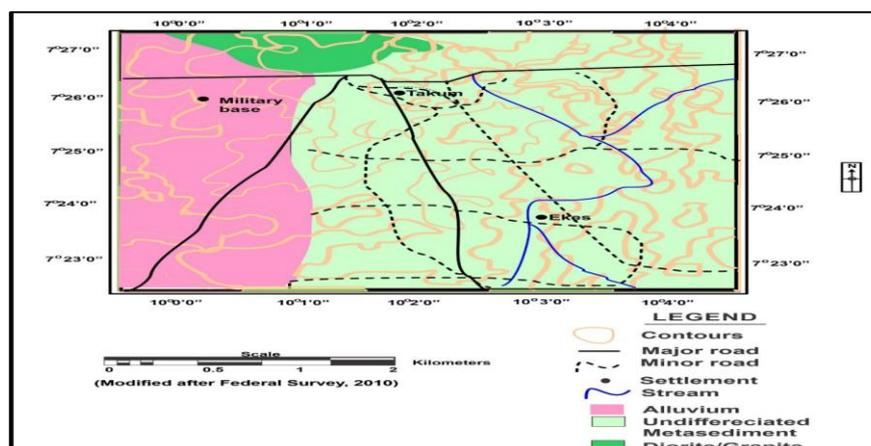


Figure 2: Geological Map of the Study Area (Modified after Federal Survey, 2010)

2.0 Materials and Technique

2.1 Data collection

The ABEM Terrameter SAS 300 was used to carry out the geophysical field survey with its accessories. Global Positioning System (GPS) was used to determine coordinates and elevations. With a half current electrode spread of $\frac{AB}{2}$ between 1 and 100 m and a half potential electrode spread of 0.5 to 15 m, 12 vertical electrical soundings (VES) using Schlumberger setup were conducted. To determine the apparent resistivity, the electrical resistances were multiplied by the relevant geometric factor (k) for each electrode separation. Apparent resistivity was calculated using (Equation 1) below. The Schlumberger sounding curves the n -layer model curve was then obtained using IX1D Interpex program. The Schlumberger sounding curves are automatically interpreted by this software. The presented curves automatically identify each layers, thickness, depth, and average resistivity at various VES locations.

Plotting apparent resistivity against $\frac{AB}{2}$ produced sounding curves, which represented the sounding data, this was done using a computer program known as IX1D software to obtain resistivity of different layers and thickness (Equation 1).

$$\rho_a = KR \quad 1$$

where ρ_a represent apparent resistivity and (R) the earth resistance

$$R = \frac{\Delta V}{I} \quad 2$$

Therefore, the geometric factor G , is express in Equation 3

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

Where AB and MN represent, respectively, the separation between the current and potential electrodes. Because the earth media serves as a natural filter for percolating fluids, it is possible to assess an area overburden protection capacity using the total longitudinal conductance (Dar-Zarrouk) values. Its capacity for protection is gauged by how well it can filter and delay percolating fluid. Protection from the underlying materials is provided by the entire overburden thickness. Additionally, the second overburden layer will obstruct fluid flow through it. The values of the longitudinal unit conductance of the overburden rock serve as the foundation for the

characterization of the aquifers protective capacity. The overburdens longitudinal layer conductance (S) and transverse resistance at each VES locations were acquired from Equation (4 and 5). According to Ogungbemi et al., (2013) Table 1 shows the resistivity range for each subsurface earth material, and Table 2 shows the protective capacity rating, where h is the saturated thickness of each layer and ρ is the layer resistivity.

$$S_L = \sum_{i=1}^n \frac{h_i}{\rho_i} \quad 4$$

$$R_T = \sum_{i=1}^n h_i \cdot \rho_i \quad 5$$

Where ρ_a and h_i are the overburden layer resistivity and thickness respectively.

3.0 Findings and Discussion

3.1 Iso-resistivity and Geo-electric section

The research areas iso-resistivity maps were created using information from the geoelectric sounding showing variation of apparent resistivity for different locations within the study area. The variations may be a good indicator of areas of low or high resistivity which may help to evaluate locations that have aquifers or not. For a deeper understanding of the earth, iso-resistivity and 3-D maps were generated with the surfer 12 software. The contouring of their resistivity value was done for, $\frac{AB}{2} = 70\text{m}$, and $\frac{AB}{2} = 100\text{ m}$ which are shown in Fig. (3a, and 4a) respectively with their corresponding 3-D maps which revealed the depth of penetration of 18-33mand resistivity values of 132 - 542 Ωm . The areas with low resistivity values indicate relatively good conductors which signifying highly fracture/weathered granite while fresh basement with high resistivity values indicate poor conductors. The anomaly has seen at Akpela in the northwest, at Awuhe in the southwest and two minor anomalies are found in the southeast and northeastern part of the research area Figures 3a and 4a. Table 1, displays the results of the resistivity data analysis and interpretation. Giving information on the resistivity of each layer, depth, thickness and curve types.

Table 1: Results of computer interpretation of the 12 VES locations

VES No.	Coordinate	No. of layers	Thickness (m)	Depth (m)	Resistivity (ohm-m)	Longitudinal conductance (seimens)	Transvers resistance (ohm-m ²)	Curve type	Lithology
1	7°26'25.343"N 10°0'32.272"E	1	1.7841	1.7841	406.94	0.0043	726.02	Q	Top lateritic soil Silty material Fracture/weathered granite
		2	6.2116	7.9957	189.11	0.0422	1512.1		
		3	-	-	91.695	-	-		
2	7°26'30.404"N 10°1'50.931"E	1	3.2024	3.2024	477.85	0.0067	1530.3	H	Top lateritic soil Silty materials Weathered fractured granite
		2	11.134	14.336	170.59	0.0840	2445.6		
		3	-	-	70.573	-	-		
3	7°26'36.804"N 10°2'52.532"E	1	3.0076	3.0076	554.54	0.0054	1667.8	H	Top lateritic soil Fractured/weathered granite Fresh Basement
		2	37.337	40.345	117.22	0.3442	4729.2		
		3	-	-	4878.6	-	-		
4	7°25'49.554"N 10°3'50.091"E	1	2.2366	2.2366	391.83	0.0057	876.37	H	Top lateritic soil Fracture/weathered granite Fresh Basement
		2	10.443	12.680	118.03	0.1074	1496.6		
		3	-	-	805.96	-	-		
5	7°25'9.253"N 10°2'10.378"E	1	5.8959	5.8959	397.26	0.0148	2342.2	H	Top lateritic soil Fracture/weather granite Fresh Basement
		2	3.9191	9.815	15.998	0.6135	157.02		
		3	-	-	7463	-	-		

6	7°25'10.82"N 10°0'15.075"E	1	4.2459	4.2459	554.31	0.0076	2353.5	H	Top lateritic soil Highly weathered Fracture/weathered granite Fresh Basement
		2	1.5828	5.8287	4.7208	1.2348	27.511		
		3	-	-	7463.9	-	-		
7	7°24'6.695"N 10°0'21.453"E	1	0.9467	0.9467	398.23	0.0023	377.05	H	Topsoil Partially weathered granite Fracture/weathered Basement
		2	2.8341	3.7808	263.66	0.0143	996.84		
		3	-	-	99.072	-	-		
8	7°24'33.88"N 10°2'29.963"E	1	4.0577	4.0577	412.61	0.0098	1674.2	H	Topsoil Fracture/weathered Basement Fresh Basement
		2	24.100	28.158	86.586	0.3252	2438.1		
		3	-	-	31827	-	-		
9	7°24'11.462"N 10°3'45.941"E	1	1.5742	1.5742	459.25	0.0034	722.95	H	Lateritic soil weathered Basement Fresh Basement
		2	31.528	33.102	149.43	0.2215	4946.4		
		3	-	-	2321.0	-	-		
10	7°23'10.363"N 10°0'51.495"E	1	2.4738	2.4738	460.78	0.0053	1139.8	H	Topsoil weathered Basement Fresh Basement
		2	25.885	28.359	109.29	0.2594	3099.4		
		3	-	-	2241.3	-	-		
11	7°23'17.792"N 10°3'51.031"E	1	4.6070	4.6070	617.52	0.0074	2844.9	H	Top lateritic soil Weathered granite Fresh Basement
		2	16.781	21.388	131.06	0.1632	2803.1		
		3	-	-	1544.3	-	-		
12	7°23'49.543"N 10°1'29.583"E	1	6.8230	6.8230	487.61	0.0139	3326.9	H	Top lateritic soil Highly weathered granite Fresh Basement
		2	7.7070	14.53	21.399	0.6790	310.92		
		3	-	-	33112	-	-		

Three to four geo-electric stratigraphic strata define the study region by curve types Q (VES 1) and with dominant of H curve types (VES 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12). Figure (5 and 6), are the geo-electric section displaying the difference of resistivity with depths and geologic sediments are exposed.

The modeling of Vertical Electrical Sounding done at twelve (12) VES locations was utilized calculate the geo-electric sections for a number of profiles which shows that the study area has primarily three geologic strata. This comprises of Top lateritic soil, fracture/weathered Basement, partly Fracture/weathered Basement and Fresh Basement.

Profile A – A¹ (VES 1,5,8,9 and 11) layer one indicates top lateritic soil with resistivity value range between 397 – 617 Ωm with thickness 1.5 – 5.8m, depth range from and 1.5 – 5.8 m, respectively. The resistivity values for the second layer comprises of 15 – 189 Ωm , having a thickness of 3.9 – 31.5 m and depth of 7.9 – 33 m. Basement is indicated by the third layers resistivity of 2321 – 7463 Ωm (Fig. 5)

Profile B – B¹ (VES 3, 4, 8, 12, and 10) indicate top soil which compose mainly of laterite material with resistivity values range from 391 – 554 Ωm and the thickness and depth range from 2.2 – 6.8 m and 2.2 – 6.8 m respectively for layer one. The second layer resistivity values range from 21 – 118 Ωm with thickness of 7.7 – 37.3m and depth of 14.5 – 40.3 m. The third layer fourth layer has an unlimited thickness and depth with a resistivity value of 1878 – 3311 Ωm (Figure 6).

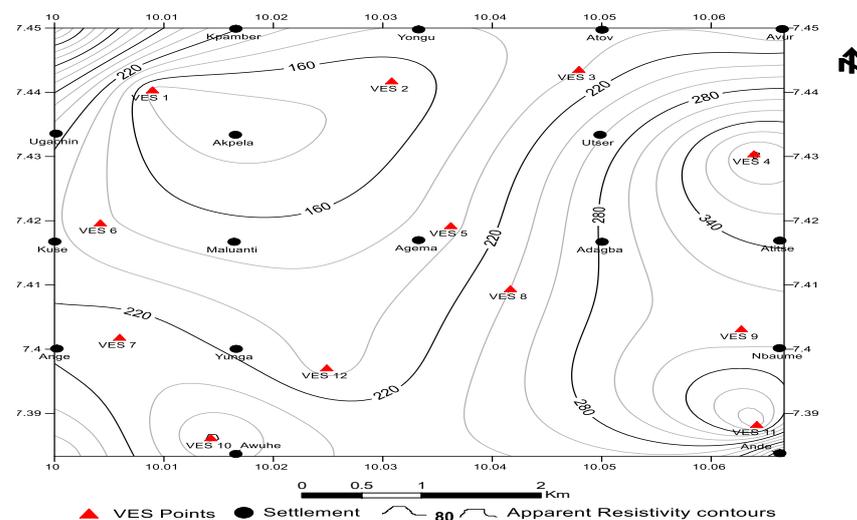


Figure 3a: Iso-resistivity contour

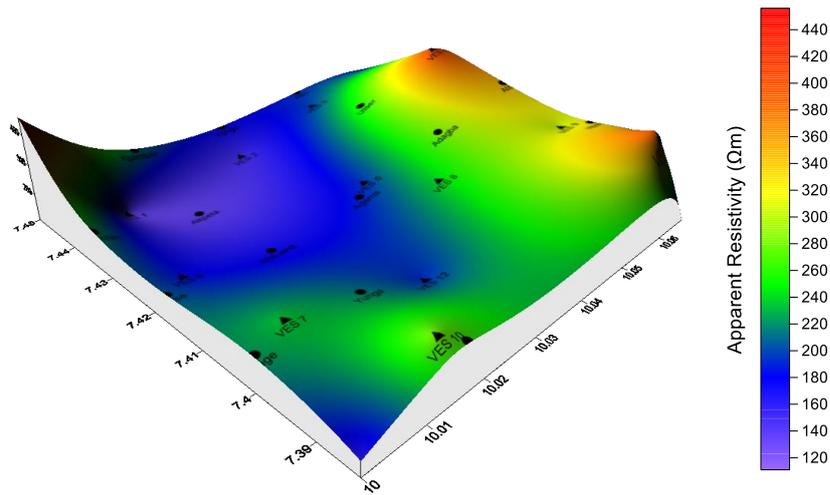


Figure 3b: the 3D map for $\frac{AB}{2} = 70\text{m}$ (Contour interval = $20\Omega\text{m}$)

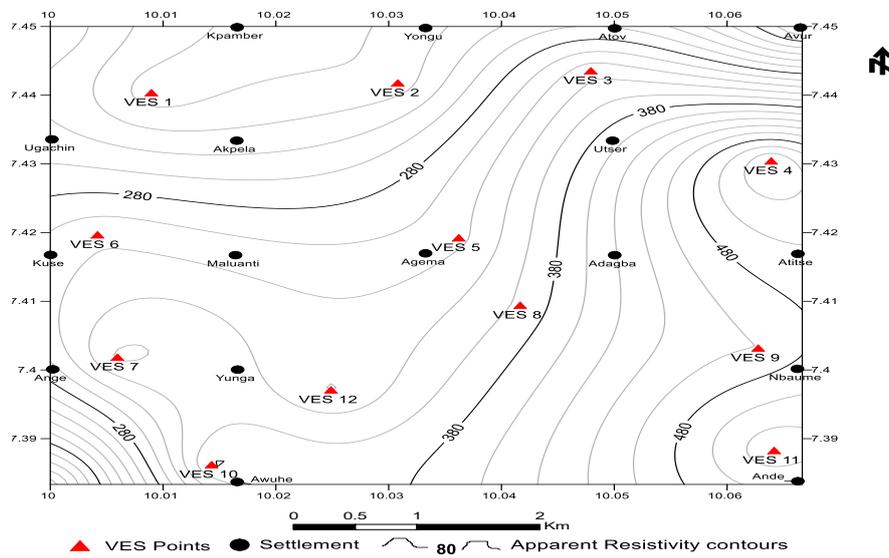


Figure 4a: Iso-resistivity contour

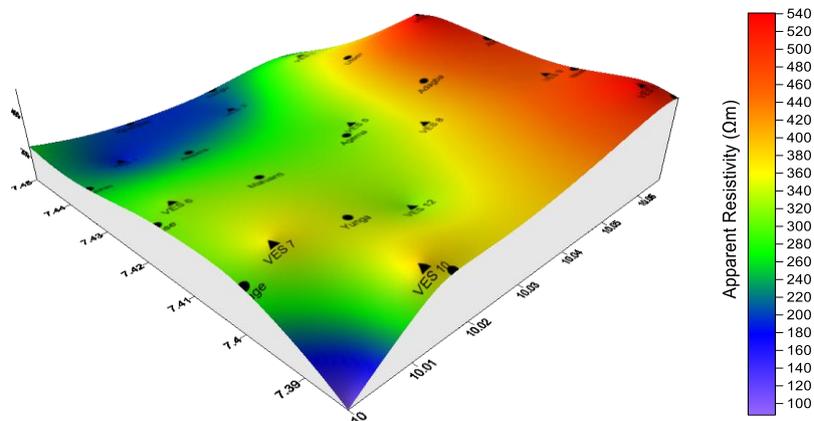


Figure: 4b: 3D map for $\frac{AB}{2} = 100\text{m}$ (Contour interval = $20\Omega\text{m}$)

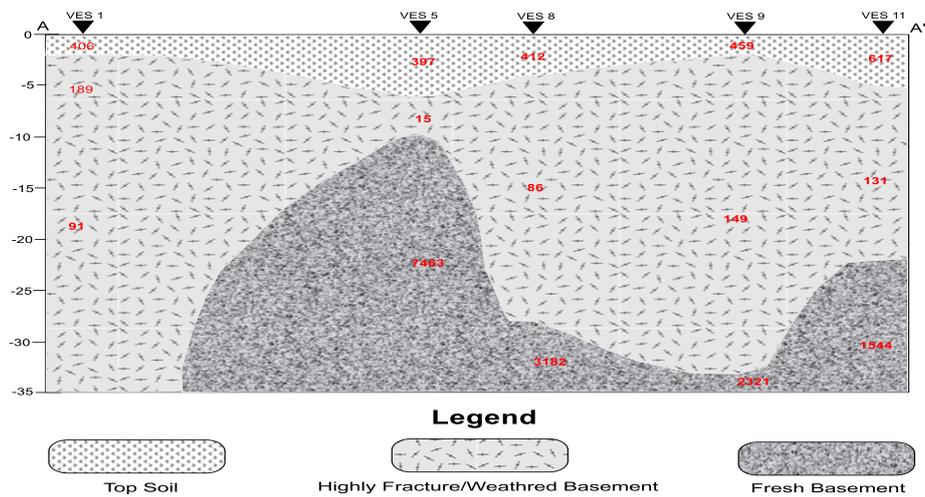


Figure 5: Geo-electric Section (A-A¹)

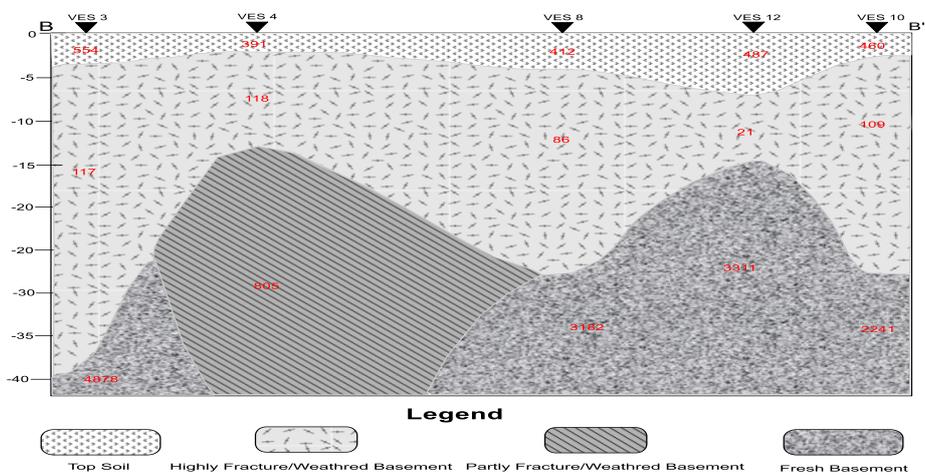


Figure 6: Geo-electric Section (B-B¹)

3.2 Evaluation of Aquifer protective capacity

Aquifer protective capacity is a measurement of the aquifers resistivity and the thickness of the subsurface soil layers that surround it. The water-bearing unit should be covered by an acceptable subsurface layer thickness and low hydraulic conductivity for the soil layer to safeguard groundwater reservoirs. This is so because current research has revealed that the earths subsoil acts as a natural filter for the contaminating fluid, and that how well it can withstand fluid is an indicator of how well it can protect. (Ameiza *et al.*, 2018, Alao *et al.*, 2022, Oladapo *et al.*, 2007, Dogara *et al.*, 2017). Hence, a measurement of a substances protective capacity is its power to delay and filter percolating ground surface contaminating fluids (Olorunfemi *et al.*, 1999). The geologic components that cover an aquifer may function as a seal, preventing it. The overburden protection capacity rating of the

study area was determined using the longitudinal unit conductance map (Fig. 7), which was calculated from equation (4) for all of the VES stations. The underlying aquifer is shielded by the impermeable clayey overburden, which exhibits relatively high longitudinal conductivity. The highly impervious clayey overburden, which is characterized by relatively high longitudinal conductance, offers protection to the underlying aquifer (Abiola *et al.*, 2009). The protective capacity in the study region has been rated as low, weak, and moderate by (Olusegun *et al.*, 2016 and Aina *et al.*, 2019). This research has shown that the overburden materials in the vicinity of the study areas northwestern and southeastern regions have good to moderate protection capacity. Good to moderate aquifer capacity constitutes about 58.1% and weak/poor capacity have about 41.7% aquifer protective capacity rating Table 2. Areas that are weak and poor are suggestive areas and are therefore susceptible to leachate and other surface contaminants penetration. (Nggada and Nur 2017). The transverse resistance values computed from equation (5) were contoured and plotted to generate the transverse resistance map of the research locations (Fig. 8). The transverse resistance values in the research areas from the VES results ranges from 1373.90 to 6397.08 Ωm^2 with average value of 3712.08 Ωm^2 . High transverse resistance values are located in the research areas at the north and southeastern portion. The transverse resistance rating for VES 7 is the lowest in the southwestern part. Fig. 8, below shows the transverse resistance contour map indicating the variation of this parameter.

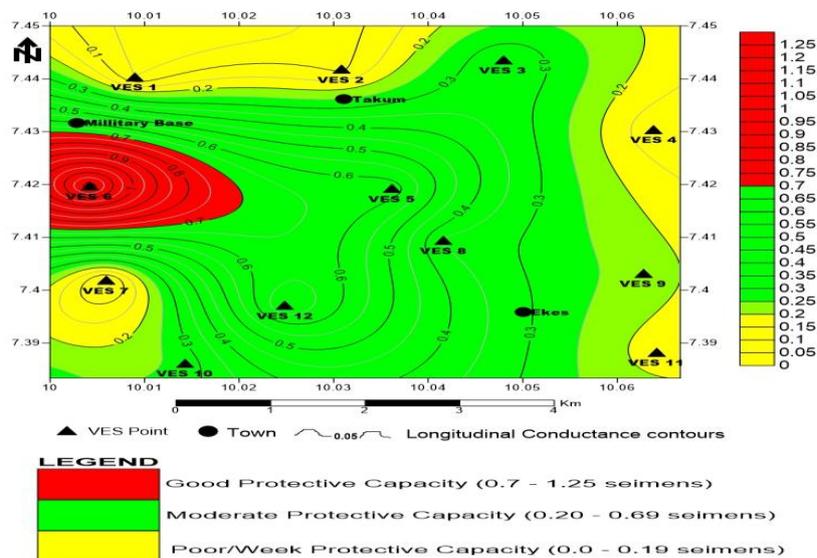


Figure 8: Protective capacity contour map of the research area (contour interval 0.05 Seimens)

Table 2: Present Aquifer Protective Capacity Rating (Ogungbemi, et al. 2013)

Rating	Remarks
Greater than 10	Excellent
5-10	Very good
0.7-4.9	Good
0.2-0.69	Moderate
0.1-0.19	Weak
Less than 0.1	Poor

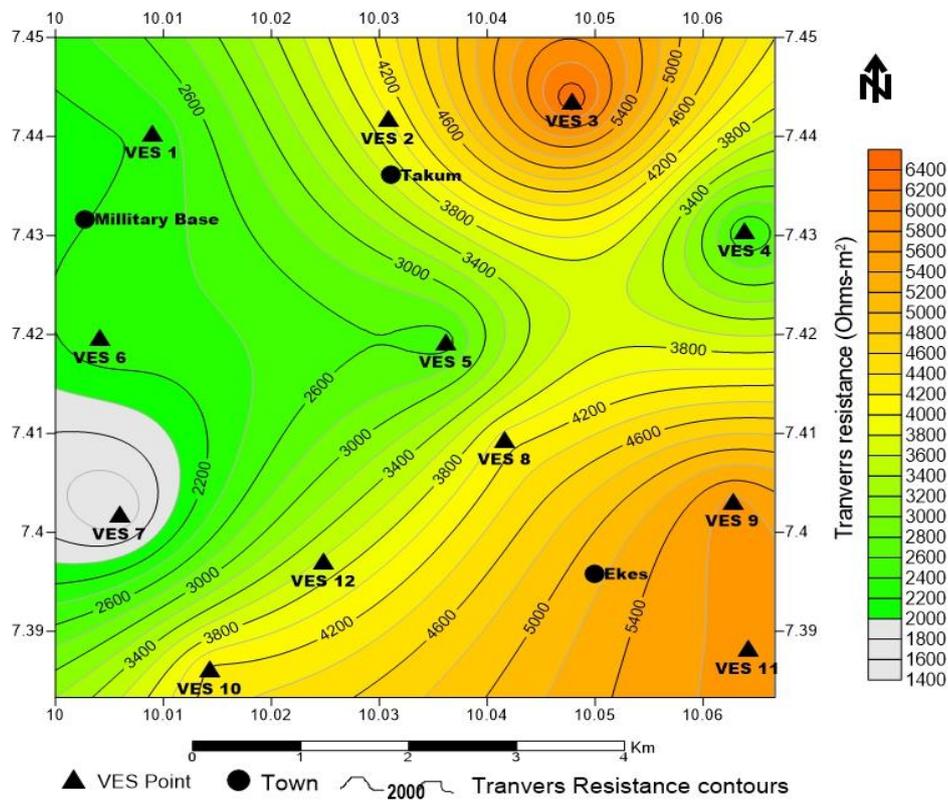


Figure 8: Total transverse resistance map of the research area (contour interval of 400 Ωm^2)

4.0 Conclusion

The study concluded that to define the groundwater potential in Takum Metropolis, twelve (12) VES were studied. The VES curve obtained exhibited mostly three geoelectric layers and with Q and H curve types. The values of topsoil resistivity vary between 391 – 617 Ωm with thickness of 1.5 – 6.8m. The second layer has a resistivity

between 15 – 189 Ωm and is 4 – 37m thick. This layer has an appreciable thickness and can be considered to be water bearing zones referred to as an aquifer. Fresh basement has resistivity values of 1878 – 7463 Ωm with infinite depth. Longitudinal conductance for the twelve (12) VES points were used to assess its capacity for overburden protection. Two VES points have good protective capacity, six (6) have moderate, three (3) have weak and two (2) have poor protective capacity. Transverse resistance values range from 1373.90 – 6397.08 Ωm^2 with an average value of 3712.08 Ωm^2 . Therefore, the findings showed that groundwater exploration can be achieved in the studied area.

Competing interest

All the authors declare that there is no conflicting interest

References

1. Abiola O., P. A. Enikanselu & M. I. Oladapo (2009). Groundwater potential and aquifer protective capacity of overburden units in Ado-Ekiti, southwestern Nigeria. *International Journal of Physical Sciences*, 4(3), 120-132.
2. Adeeko, T. & Damilola, S. (2018). Application of Electrical Resistivity in Mapping Subsurface Characteristics. *Asian Journal of Environment & Ecology*. 6. 1-12.
3. Aina, J.O., Adeleke O.O., Makinde V., Egunjobi H.A. & Biere P.E. (2019) Assessment of Hydrogeological Potential and Aquifer Protective Capacity of Odeda, Southwestern Nigeria. *RMZ – M and G Vol. 66pp. 199-210*
4. Amadi, A. N., Olasehinde, P. I., Okosun, E. A. and Yisa, J., (2010). Assessment of the water quality index of Ota miri and Oramiriukwa Rivers. *Physics International*, 1 (2), pp. 116-123
5. Alao J.O., Ahmad M.S., Danjumo T.T., Ango A. & Emmanuel J. (2022). Assessment of aquifer protective capacity, against the surface contamination a case study of Kaduna industrial village Nigeria. *PhysSciInt J.* 26(1):43–51. <https://doi.org/10.9734/PSIJ/2022/v26i130306>

6. Carter, D. J., Barber, W. & Tait, E. A., (1963). The Geology of part of Adamawa, Bauchi and Borno Provinces in the Northern Nigeria. *Geol. Surv. Bulletin* No.30
7. Mbah C.K. & Nur A. (2022). Geo-Electrical Study for Groundwater Potential of Gude and Environs, Adamawa State, Nigeria”, *European Journal of Environment and Earth Sciences* 3(2) 24-30 <https://doi.org/10.24018/ejgeo>.
8. Dogara M.D., Alao J., Abdullahi H., Ezekiel J. & George J. (2017). Delineation of the geotechnical parameters within the Kaduna refining and petrochemical corporation layout. *World J ApplPhys* 2(3):36–42. <https://doi.org/10.11648/j.wjap.20170203.11>
9. Nggada I.S. & Nur A. (2017). Geo-electrical Survey for Groundwater Potential of Biu and Environs, North Eastern Nigeria. *World Journal of Applied Physics* 2(5): 59-70
10. Nur A. & Kujir A.S. (2006). Hydro geo-electrical study in the Northeastern part of Adamawa State, Nigeria. *J. Environ. Hydrol.*, p.14.
11. Ogungbemi O.S., Badmus G.O. & Idowu K.A. (2013). Geoelectric and electromagnetic methods for post foundation studies in a typical basement terrain. *Journal of Engineering Trends in Engineering and Applied Science* 4(6):863–868
12. Oladapo M. I. & Akintorinwa O. J. (2007). Hydro-geophysical study of Ogbese Southwestern, Nigeria. *Global J. Pure and App. Sci.* 13(1): 55-61.
13. Olusegun O.A., Adeolu O.O. & Dolapo F.A. (2016). Geophysical investigation for groundwater potential and aquifer protective capacity around Osun State University (UNIOSUN) College of Health Sciences. *Am j Water Resour* 4(6):137-143.
14. Olurunfemi M.O., Ojo J.S. & Akintunde O.M. (1999). Hydrogeophysical evaluation of the groundwater potential of Akure metropolis, southwestern Nigeria. *International Research Journal of Geology and Mining* 35(2) 207-228.
15. Omeiza J.A. & Dary M.D. (2018). Aquifer vulnerability to surface contamination: a case of the new millennium city, Kaduna, Kaduna State Nigeria. *World J ApplPhys* 3(1):1–11. <https://doi.org/10.11648/j.wjap.20180301.11>

16. Oseji, J.O., Atakpo E.A. & Okolie, E.C. (2005). Geoelectric investigation of the aquifer characteristics and groundwater potential in Kwale, Delta state, Nigeria. *J. Applied Sci. Environ. Mgt.*, 9: 157-160. pp. 1/8.
17. Ozegin, K.O., Oseghale A., Okolie E.C. & Ujuanbi O. (2011). Integration of very low frequency electromagnetic (vlf-em) and electrical resistivity methods in mapping subsurface geologic structures favourable to road failures. *International Journal of Water Resources and Environmental Engineering*.3 (6), 126-131.
18. Samuel S., Nur A., Ayuni N.K & Yusuf S. (2020). Geo-electrical Investigation for Groundwater Potential of Kaltungo and Environs, Northeast Nigeria. *Applied Journal of Physical Science*, vol 2(3), pp 55-67.
19. Uma, K. O., Egboka, B.C.E. & Onuoha, K. M., (1989). New statistical grain-size method of evaluating the Hydraulic conductivity of sandy aquifers. *Jour. of Hydrogeology* 108, 343-266.