

# Hydro-geophysical Mapping of Borehole Yield using Geophysical Method in Vandeikya Local Government Area, Benue State, Nigeria

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## ABSTRACT

*This study presents an integrated hydro-geophysical investigation of groundwater potential and borehole yield in Vandeikya Local Government Area, Benue State, Nigeria, using the Vertical Electrical Sounding (VES) technique with the Schlumberger array. Eighteen (18) VES stations were systematically distributed to ensure adequate spatial coverage of both upland and lowland terrains, characterized by moderately undulating topography that influences groundwater recharge and flow dynamics. Apparent resistivity values range from less than 50  $\Omega m$  to greater than 8000  $\Omega m$ , reflecting significant subsurface heterogeneity controlled by lithology, weathering, and moisture distribution. Low resistivity zones (<200  $\Omega m$ ) indicate clay-rich or water-saturated formations, while high resistivity values (>1000  $\Omega m$ ) suggest resistive materials such as fresh basement rocks. Geoelectrical interpretation reveals seven to nine subsurface layers, grouped into topsoil, weathered basement, fractured basement, and fresh basement. The weathered and fractured basement units form the principal aquifer system, with resistivity values of 46.5–749  $\Omega m$  and thicknesses ranging from 0.6 to 46.0 m. Areas such as Akar, Mbayongo, Achwa, and Ishan exhibit relatively thick overburden and enhanced groundwater storage potential. Dar-Zarrouk parameters show longitudinal conductance values of 0.001–0.731 mhos and transverse resistance values of 111 to >12,000  $\Omega m^2$ . High conductance values indicate moderate to good aquifer protective capacity, while high transverse resistance reflects significant transmissivity and groundwater yield potential. The results demonstrate that aquifer thickness, resistivity, and transmissivity are the primary controls on borehole productivity, confirming the effectiveness of the Schlumberger VES method for groundwater exploration in Basement Complex terrains.*

## KEYWORDS

*Vertical Electrical Sounding (VES), Groundwater Potential, Basement Complex Terrain, Dar-Zarrouk Parameters and Aquifer Characterization*

## I. INTRODUCTION

Water is an indispensable natural resource that underpins human survival, agricultural productivity, industrial development, and environmental sustainability. In recent decades, increasing population pressure, rapid urbanization, climate variability, and widespread

contamination of surface water bodies have significantly intensified reliance on groundwater resources, particularly in developing countries such as Nigeria (Offodile, 2002; Todd and Mays, 2005; Adelana & MacDonald, 2008; MacDonald et al., 2012; Ahmed et al., 2020). Groundwater is generally regarded as a more reliable and resilient source; however, its availability and sustainability are strongly controlled by subsurface geological and hydrogeological conditions (Taylor et al., 2013; Cuthbert et al., 2019).

In Basement Complex terrains, which underlie large parts of Nigeria, groundwater occurrence is inherently limited due to the negligible primary porosity of crystalline rocks. Consequently, groundwater is largely confined to zones of secondary porosity developed through weathering and fracturing processes (Olorunfemi and Fasuyi, 1993; Oseji et al., 2005; Wright et al., 2016). The spatial variability and discontinuity of these aquifer units often result in unpredictable borehole yields and high failure rates, especially where borehole siting is conducted without adequate subsurface investigation (Ako and Olorunfemi, 1989; MacDonald et al., 2021). This challenge is evident in many parts of Benue State, including Vandeikya Local Government Area, where numerous boreholes exhibit inconsistent performance. To mitigate these challenges, geophysical methods, particularly electrical resistivity techniques—have been widely adopted for groundwater exploration. The Vertical Electrical Sounding (VES) method using the Schlumberger array has proven to be highly effective due to its cost-efficiency, operational simplicity, and ability to provide reliable information on subsurface layering and aquifer characteristics (Zohdy et al., 1974; Telford et al., 1990; Niwas & Singhal, 1981; Soupios et al., 2007; Emenike, 2018). Recent advances in hydrogeophysics further demonstrate the integration of resistivity data with hydrogeological parameters for improved aquifer characterization and yield prediction (Binley et al., 2015; Aizebeokhai & Oyeyemi, 2018).

Previous studies have demonstrated the applicability of VES in delineating aquifer zones and estimating hydrogeological parameters in Basement Complex environments (Olorunfemi and Fasuyi, 1993; Oseji and Okolie, 2011; Akinlalu et al., 2017). However, most existing studies focus primarily on qualitative aquifer delineation, with limited integration of quantitative parameters such as longitudinal conductance and transverse resistance for direct borehole yield prediction (Niwas & Singhal, 1981; Ekanem et al., 2020). Furthermore, there remains a significant gap in the spatial mapping of borehole yield potential based on integrated hydro-geophysical parameters within Vandeikya and similar terrains. Many groundwater investigations do not adequately link resistivity-derived parameters with aquifer productivity indicators, resulting in suboptimal decision-making for borehole development (Oladapo et al., 2019; Olayinka & Olorunfemi, 2021). This underscores the need for a more robust, data-driven approach that combines geoelectrical interpretation with quantitative aquifer evaluation.

This study addresses these gaps by integrating detailed VES data with computed aquifer parameters to map borehole yield potential across Vandeikya LGA. The innovation of this research lies in the combined use of resistivity interpretation, aquifer thickness analysis, longitudinal conductance (protective capacity), and transverse resistance (transmissivity proxy) to delineate high yield groundwater zones. By establishing a clear relationship between these parameters and borehole productivity, the study advances beyond conventional groundwater exploration approaches and provides a more reliable framework for sustainable borehole siting in Basement Complex terrains. The specific objectives are to: characterize the subsurface lithology using VES data, determine aquifer parameters controlling groundwater occurrence, and develop a spatial framework for mapping borehole

yield potential within the study area. The outcomes of this study are expected to significantly improve groundwater exploration success rates and contribute to sustainable water resource management in Vandeikya and similar geological settings.

**II. MATERIALS AND METHODS**

*A. Study Area Description*

The study was conducted in Vandeikya Local Government Area (LGA), located in the south-eastern part of Benue State, Nigeria, between latitudes 6°48'–7°12'N and longitudes 8°42'–9°06'E, covering an approximate area of 591 km<sup>2</sup>. The area is predominantly agrarian, with major crops including yam, cassava, and rice. Geologically, the area is underlain by Precambrian Basement Complex rocks, mainly granite, gneiss, and migmatite, which are characterized by negligible primary porosity. Groundwater occurrence is therefore controlled by secondary porosity resulting from weathering and fracturing (Olorunfemi and Fasuyi, 1993; Offodile, 2002) as presented in figure 1. The climate is tropical wet-and-dry, with annual rainfall ranging from 1200 to 1800 mm and temperatures between 24°C and 35°C, necessitating a high dependence on groundwater resources.

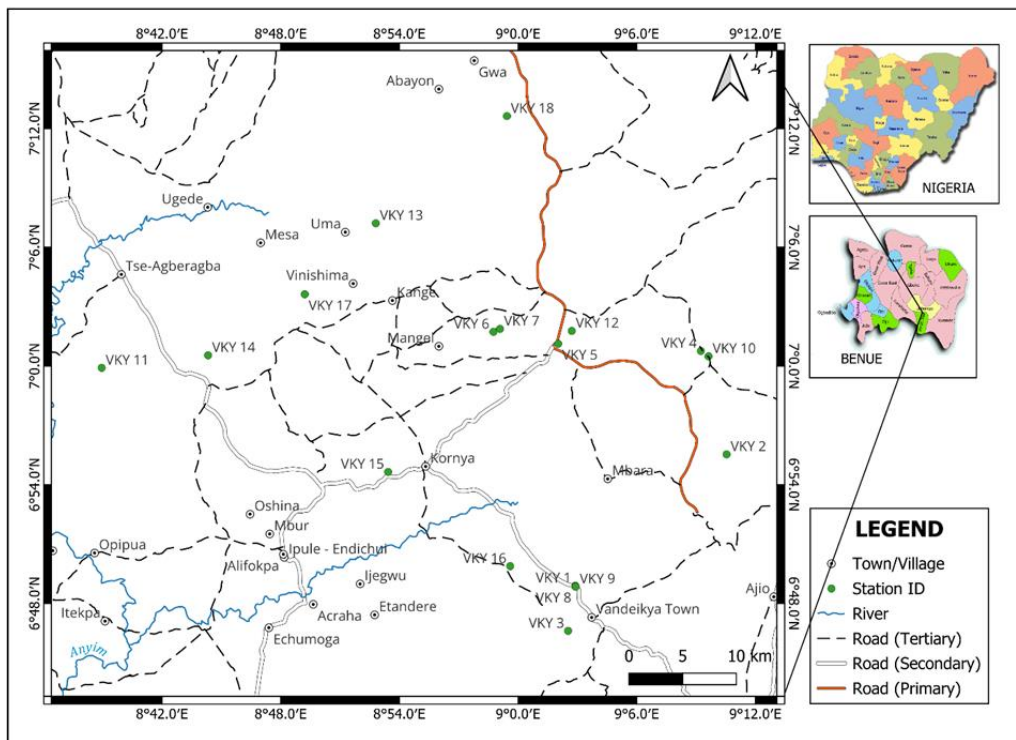


Figure 1: Location map of the study area

**III. THEORETICAL BACKGROUND**

*A. Electrical Resistivity Method*

The electrical resistivity method is based on the principle that subsurface materials exhibit varying resistance to the flow of electrical current depending on their composition, porosity, and fluid content (Telford et al., 1990). The method is governed by Ohm’s Law, expressed as presented in equation (1).

$$V = IR \quad (1)$$

where  $V$  is the potential difference (V),  $I$  is the current (A), and  $R$  is the resistance ( $\Omega$ ). For a homogeneous medium, the resistivity ( $\rho$ ) is given by equation (2).

$$\rho = K \frac{\Delta V}{I} \quad (2)$$

where  $K$  is the geometric factor dependent on electrode configuration.

For the Schlumberger array, the geometric factor is defined as presented in equation (3)

$$K = \frac{\pi(AB)^2}{4MN} \quad (3)$$

where  $AB$  is the current electrode spacing and  $MN$  is the potential electrode spacing (Zohdy et al., 1974). The apparent resistivity ( $\rho_a$ ) obtained represents an average resistivity of subsurface layers.

#### B. Groundwater Flow Theory

Groundwater movement in porous media is governed by Darcy's Law as presented in equation (4)

$$Q = -KA \frac{dh}{dl} \quad (4)$$

where  $Q$  is the discharge,  $K$  is the hydraulic conductivity,  $A$  is the cross-sectional area, and  $\frac{dh}{dl}$  is the hydraulic gradient (Fetter, 2001; Todd and Mays, 2005).

In Basement Complex terrains, groundwater occurs mainly within weathered and fractured zones, which serve as aquifers due to enhanced permeability and storage capacity (Olorunfemi and Fasuyi, 1993).

#### C. Dar-Zarrouk Parameters

Aquifer properties were further evaluated using Dar-Zarrouk parameters (Maillet, 1947; Henriot, 1976) as shown in equation (5) and (6).

$$S = \sum_{i=1}^n \frac{h_i}{\rho_i} \quad (5)$$

$$T = \sum_{i=1}^n h_i \rho_i \quad (6)$$

where  $h_i$  and  $\rho_i$  are the thickness and resistivity of the  $i^{th}$  layer, respectively.

Longitudinal conductance (S) is an indicator of aquifer protective capacity, while transverse resistance (T) correlates with transmissivity and groundwater yield potential (Henriet, 1976; Olorunfemi and Fasuyi, 1993).

#### D. Survey Design and Data Acquisition

A total of eighteen (18) VES stations were strategically established across the study area to capture geological variability, including upland and lowland regions as well as areas near existing boreholes. The survey design ensured adequate spatial coverage for reliable hydro geophysical interpretation.

Field measurements were conducted using a resistivity meter (e.g., ABEM Terrameter) with the Schlumberger electrode configuration. Four electrodes were used: two current electrodes (C1 and C2) and two potential electrodes (P1 and P2).

The current electrode spacing ( $AB/2$ ) was progressively increased from 1 m to a maximum of approximately 300–500 m to probe deeper subsurface layers. At each spacing, the injected current and resulting potential difference were measured, and the apparent resistivity was computed. Quality control measures included repeat measurements at selected spacing, identification of noisy data, and documentation of possible sources of error such as cultural interference (power lines, metallic objects) and near-surface in homogeneities.

#### *E. Data Processing and Interpretation*

The acquired data were plotted as sounding curves of apparent resistivity versus electrode spacing on a log–log scale. Curve types (A, H, K, Q) were identified to provide preliminary insight into subsurface layering (Zohdy et al., 1974).

Quantitative interpretation was carried out using iterative curve matching and computer-based inversion software such as IPI2Win and Win Resist. This process yielded layer resistivity's and thicknesses, which were used to construct geo electric sections and identify aquifer units. Aquifer zones were delineated based on resistivity contrasts and thickness. Moderate resistivity values (typically 100–400  $\Omega\text{m}$ ) with significant thickness were interpreted as water-bearing formations, while very low resistivity indicated clay-rich zones and high resistivity corresponded to fresh basement rocks.

#### *F. Estimation of Aquifer Parameters and Borehole Yield*

Aquifer resistivity and thickness derived from VES interpretation were used to compute Dar-Zarrouk parameters (S and T). These parameters were employed as proxies for aquifer protective capacity and transmissivity, respectively (Henriet, 1976; Oseji and Okolie, 2011).

Borehole yield potential was estimated indirectly based on the relationship between resistivity, thickness, and transmissivity. Zones with moderate resistivity and high transverse resistance were classified as high-yield areas, while zones with low thickness and high resistivity were classified as low-yield areas.

Where available, existing borehole and pumping test data were used for calibration to improve the reliability of yield predictions. Yield classes were defined as low, moderate, and high based on inferred transmissivity and aquifer characteristics.

#### *I. Hydro-geophysical Mapping*

All interpreted VES parameters, including aquifer depth, thickness, resistivity, longitudinal conductance, and transverse resistance, were integrated with geographic coordinates using GIS-based interpolation techniques.

Hydro-geophysical maps were generated to depict spatial variations in groundwater potential and borehole yield across the study area. These maps provide a basis for identifying suitable locations for sustainable groundwater development.

#### IV. RESULTS AND DISCUSSION

##### A. Spatial Distribution of VES Stations

The spatial distribution of the Vertical Electrical Sounding (VES) stations (Table 1) indicates adequate coverage of the study area, encompassing both upland and lowland geomorphic units. Elevation ranges from approximately 137 m (Ihugh) to 270 m (Tsambe), reflecting a moderately undulating terrain. Such topographic variation plays a significant role in groundwater recharge and subsurface flow dynamics, as higher elevations typically serve as recharge zones while lower act as discharge or accumulation zones (Todd and Mays, 2005). The relatively uniform spread of stations enhances the reliability of spatial interpolation used in generating resistivity and hydro geophysical maps (Figures 2-7). Table 1 presents the geographical distribution of the VES stations across the study area.

Table 1. Description of VES Stations in the Study Area

Station ID	Location	Latitude (N)	Longitude (E)	Elevation (m)
VKY 1	Vandeikya HQ	5.74500	7.52000	180
VKY 2	Gbagbongom	5.76550	7.48520	210
VKY 3	Mbakaange	5.75580	7.51040	165
VKY 4	Hemde	5.76155	7.46685	255
VKY 5	Ihugh	5.75040	7.53525	137
VKY 6	Unde	5.74607	7.51130	152
VKY 7	Kaanga	5.72225	7.52792	170
VKY 8	Mbayongo	5.77023	7.47132	204
VKY 9	Mbayongo II	5.77920	7.50312	148
VKY 10	Tsambe	5.77185	7.45642	270
VKY 11	Abwa	5.76928	7.49707	148
VKY 12	Ishan	5.74345	7.50350	170
VKY 13	Akar	5.74963	7.54063	125
VKY 14	Aginde	5.73445	7.47153	251
VKY 15	Agirgba	5.71735	7.53594	162
VKY 16	Bako	5.83278	7.43394	156
VKY 17	Achwa	5.83653	7.41399	201
VKY 18	Agbile	5.73505	7.48444	228

##### B. Apparent Resistivity Characteristics

The apparent resistivity values (Table 2) exhibit significant lateral variation across the study area, ranging from less than 50  $\Omega\text{m}$  to values exceeding 8000  $\Omega\text{m}$ . This wide range reflects strong heterogeneity in subsurface lithology and hydrogeological conditions. Low resistivity zones (<200  $\Omega\text{m}$ ), observed in locations such as Gbagbongom, Abwa, and Mbayongo, are indicative of clay-rich materials and/or water-saturated formations. These materials typically possess low permeability but may act as protective layers against contamination. Conversely, high resistivity values (>1000  $\Omega\text{m}$ ), recorded in Tsambe, Akar, and Agbile,

suggest the presence of resistive formations such as fresh basement rocks or dry, compacted sands. The spatial distribution of resistivity (Figure 2) highlights distinct conductive and resistive zones, confirming the heterogeneous nature of the Basement Complex terrain. These findings are consistent with established studies, where resistivity is primarily controlled by lithology, porosity, degree of weathering, and fluid saturation.

Table 2: Apparent Resistivity Data

Station ID	Min $\rho_a$ ( $\Omega m$ )	Max $\rho_a$ ( $\Omega m$ )	Mean $\rho_a$ ( $\Omega m$ )	Resistivity Class
VKY 1	<100	>8000	2005	Very High Range
VKY 2	50	500	200	Low-Moderate
VKY 3	200	1200	600	Moderate
VKY 4	180	950	400	Moderate
VKY 5	150	700	350	Moderate
VKY 6	200	800	420	Moderate
VKY 7	120	600	300	Moderate
VKY 8	46	500	220	Low
VKY 9	60	650	280	Low-Moderate
VKY 10	500	>8000	2000	High
VKY 11	70	500	250	Low
VKY 12	60	450	230	Low
VKY 13	100	1200	450	Moderate
VKY 14	400	2000	900	High
VKY 15	200	900	500	Moderate
VKY 16	80	600	300	Low-Moderate
VKY 17	110	1000	420	Moderate
VKY 18	600	>8000	2500	Very High

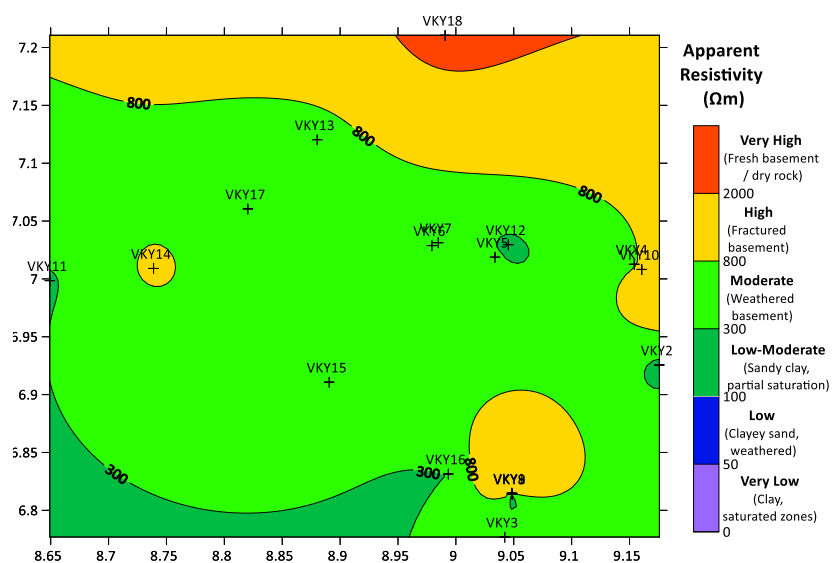


Figure 2. Apparent resistivity map of the study area

### C. Geo electric Layering and Aquifer Geometry

Interpretation of the VES data (Table 3) reveals a multilayered subsurface structure comprising between seven and nine geoelectric layers. These layers are broadly classified into topsoil, weathered basement, fractured basement, and fresh basement. The weathered and fractured basement units constitute the principal aquifer horizons. Aquifer resistivity values range from 46.5  $\Omega\text{m}$  to 749  $\Omega\text{m}$ , while aquifer thickness varies significantly from 0.6 m to 46.0 m. Areas such as Akar (46.0 m), Achwa (28.6 m), Mbayongo (34.0 m), and Ishan (24.0 m) are characterized by relatively thick overburden, suggesting enhanced groundwater storage capacity.

In contrast, locations including Vandeikya HQ, Kaanga, and Aginde exhibit very thin overburden (<1 m), indicating limited groundwater potential. The depth to basement ranges from 70 m to 180 m, with deeper basement zones generally associated with better-developed weathering profiles. The spatial patterns observed in the aquifer resistivity (Figure 3), aquifer thickness (Figure 4), and depth-to-basement maps (Figure 5) further corroborate these interpretations. The variability in aquifer geometry reflects differential weathering and fracturing processes, which are key controls on groundwater occurrence in crystalline basement terrains (Oseji et al., 2005).

Table 3: Geo-electric Layer & Aquifer Geometry

Station ID	No. of Layers	Aquifer Resistivity ( $\Omega\text{m}$ )	Aquifer Thickness (m)	Depth to Basement (m)	Lithology Interpretation
VKY 1	7	582	0.7	75	Thin weathered layer
VKY 2	8	49.1	5.1	90	Clayey/weathered
VKY 3	7	223	0.5	80	Sandy/weathered
VKY 4	8	232	0.6	85	Weathered basement
VKY 5	7	180	1.2	95	Sandy clay
VKY 6	8	251	12.6	110	Fractured basement
VKY 7	7	163	0.7	70	Thin overburden
VKY 8	9	46.5	34.0	150	Thick weathered zone
VKY 9	8	60	18.0	130	Weathered/fractured
VKY 10	8	749	16.1	140	Fractured basement
VKY 11	7	76.7	20.2	120	Clayey aquifer
VKY 12	8	63.6	24.0	135	Saturated zone
VKY 13	9	114	46.0	180	Highly fractured
VKY 14	7	546	0.6	80	Fresh basement
VKY 15	8	200	3.0	100	Weathered layer
VKY 16	7	74.4	6.4	95	Clayey sand
VKY 17	9	118	28.6	160	Productive aquifer
VKY 18	8	601	14.0	140	Fractured basement

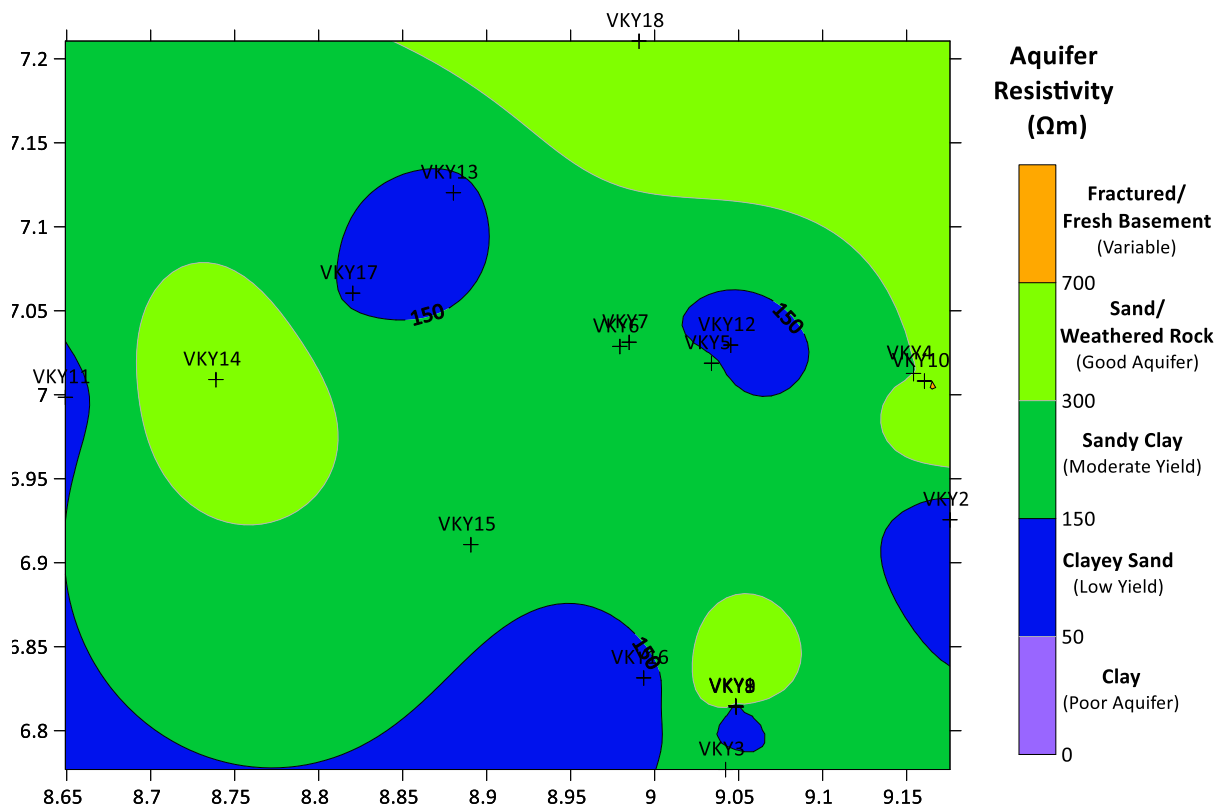


Figure 3. Aquifer resistivity map of the study area

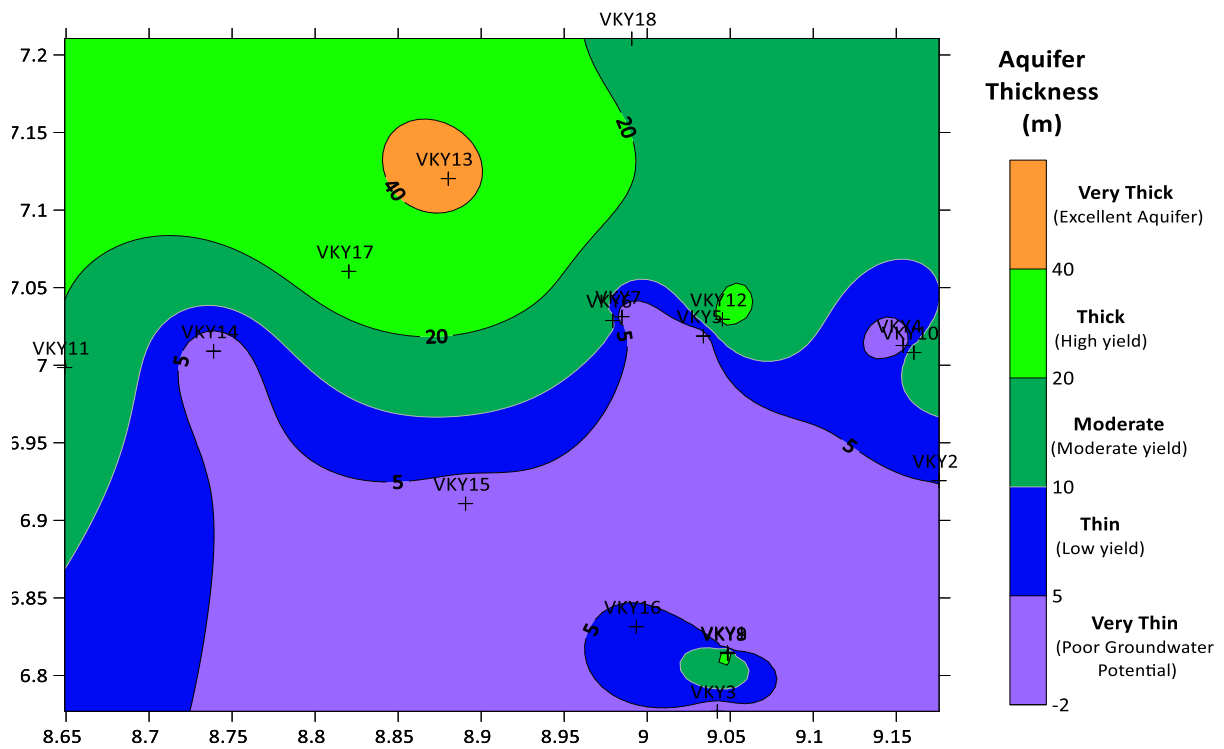


Figure 4: Aquifer thickness map of the study area

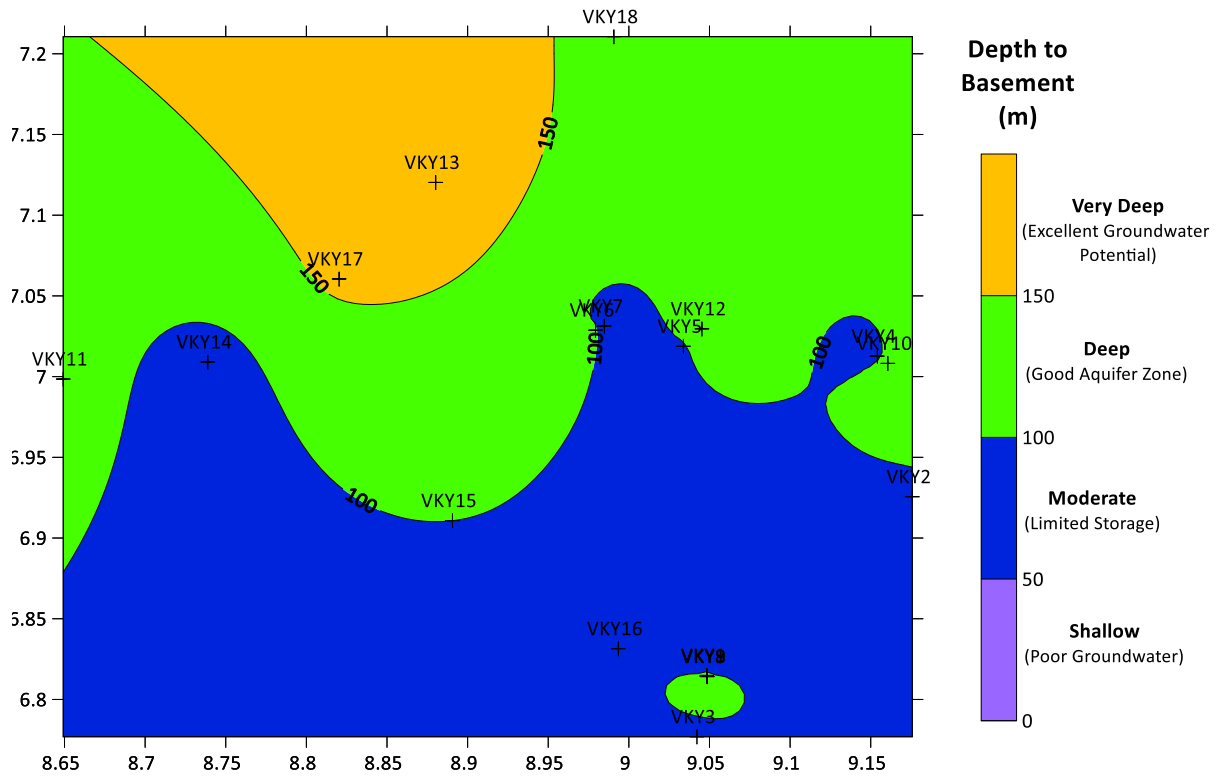


Figure 5: Depth to basement map of the study area

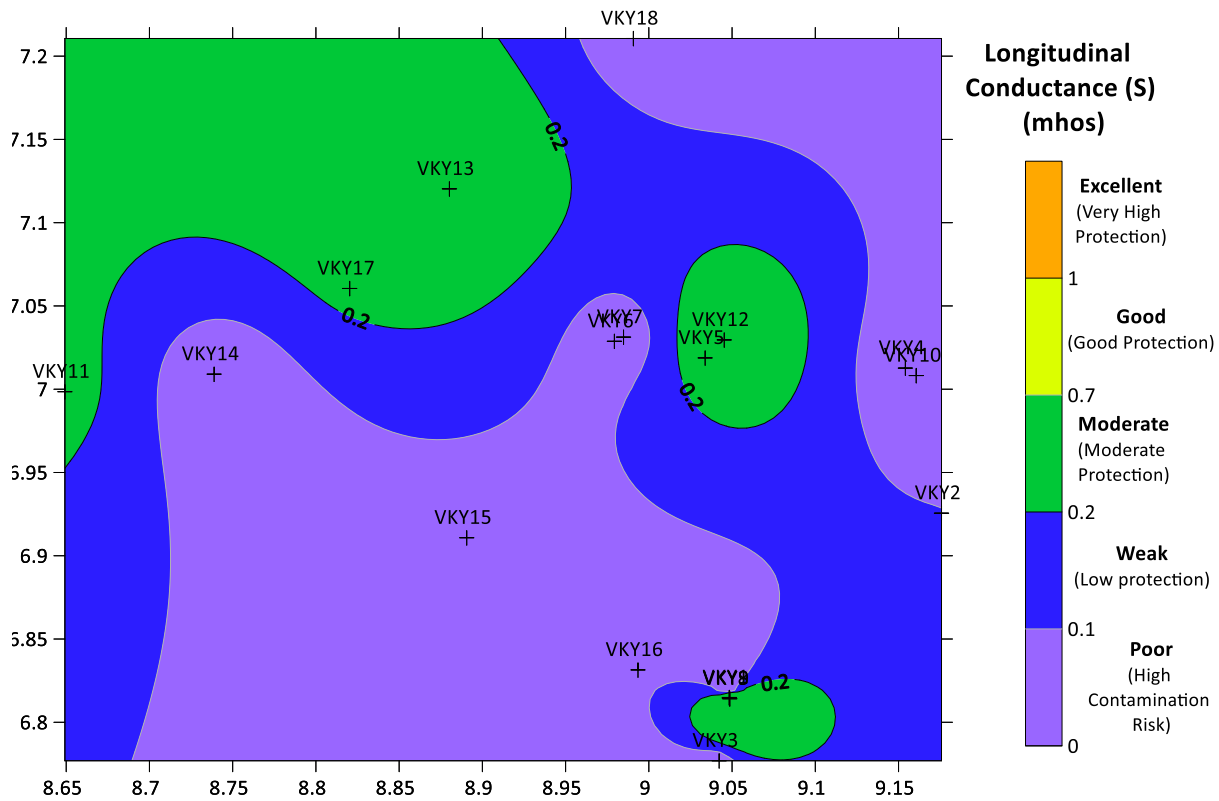


Figure 6: Longitudinal conductance map of the study area

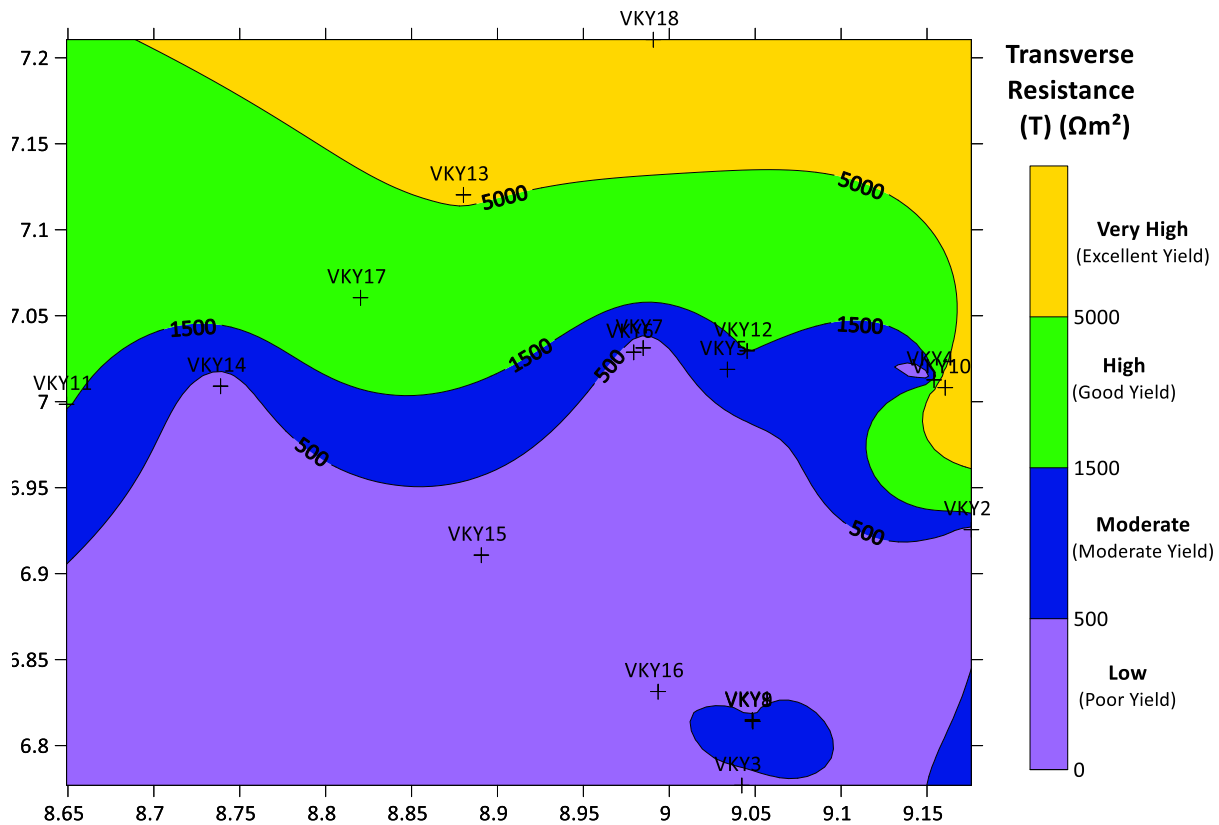


Figure 7: Transverse resistance map of the study area

*D. Dar-Zarrouk Parameters and Aquifer Protective Capacity*

The computed Dar-Zarrouk parameters (Table 4) provide further insight into aquifer characteristics and groundwater potential.

Longitudinal conductance (S), which reflects the protective capacity of overburden materials, ranges from 0.001 to 0.731 mhos. High S values recorded in Mbayongo, Ishan, Abwa, and Akar indicate moderate to high protective capacity, suggesting reduced vulnerability to surface contamination. Conversely, low S values in Vandeikya HQ and Aginde indicate poor protective cover and increased susceptibility to contamination (Henriet, 1976). Transverse resistance (T), a proxy for transmissivity, varies widely from 111  $\Omega\text{m}^2$  to over 12,000  $\Omega\text{m}^2$ . High T values observed in Tsambe, Agbile, and Akar indicate zones of high transmissivity and significant groundwater yield potential. These results are consistent with previous findings that associate high transverse resistance with productive aquifer systems (Oseji and Okolie, 2011).

The spatial distribution of longitudinal conductance (Figure 6) and transverse resistance (Figure 7) clearly delineates zones of varying groundwater potential and aquifer protection.

Table 4: Dar-Zarrouk Parameters

Station ID	Location	$\rho$ ( $\Omega\text{m}$ )	$h$ (m)	$S$ (mhos)	$T$ ( $\Omega\text{m}^2$ )	Protective Capacity	Transmissivity Class
VKY 1	Vandeikya HQ	582	0.7	0.001	407	Poor	Low
VKY 2	Gbagbongom	49.1	5.1	0.103	250	Moderate	Low
VKY 3	Mbakaange	223	0.5	0.002	111	Poor	Low
VKY 4	Hemde	232	0.6	0.003	139	Poor	Low
VKY 6	Unde	251	12.6	0.050	308	Moderate	Moderate
VKY 7	Kaanga	163	0.7	0.004	114	Poor	Low
VKY 8	Mbayongo	46.5	34.0	0.731	1581	High	High
VKY 10	Tsambe	749	16.1	0.021	12058	Moderate	Very High
VKY 11	Abwa	76.7	20.2	0.263	1550	High	High
VKY 12	Ishan	63.6	24.0	0.377	1526	High	High
VKY 13	Akar	114	46.0	0.403	5244	High	Very High
VKY 14	Aginde	546	0.6	0.001	164	Poor	Low
VKY 16	Bako	74.4	6.4	0.086	474	Moderate	Moderate
VKY 17	Achwa	118	28.6	0.242	3374	High	High
VKY 18	Agbile	601	14.0	0.023	8414	Moderate	Very High

#### E. *Integrated Hydro-geophysical Interpretation*

The integration of resistivity data, geoelectric parameters, and Dar-Zarrouk indices reveals that groundwater potential in the study area is highly variable and structurally controlled.

Areas such as Akar, Tsambe, Achwa, Ishan, and Abwa are characterized by: moderate resistivity values (indicative of saturated weathered/fractured zones), significant aquifer thickness, high transverse resistance, and moderate to high longitudinal conductance.

These conditions collectively indicate high transmissivity, good aquifer protection, and strong potential for sustainable groundwater development. In contrast, areas such as Vandeikya HQ, Kaanga, and Aginde exhibit: Thin overburden, low longitudinal conductance, and low transverse resistance. Such conditions are indicative of poor aquifer development and low borehole success rates.

#### F. *Implications for Borehole Development*

The borehole yield classification (Table 5) confirms that aquifer productivity is primarily controlled by the thickness and hydraulic properties of the weathered/fractured basement. Zones classified as having excellent to high groundwater potential (e.g., Akar, Tsambe, Agbile, Achwa, and Ishan) are recommended for borehole development due to their high transmissivity and storage capacity. Conversely, areas with thin overburden and low transmissivity (e.g., Vandeikya HQ and Aginde) are less suitable for groundwater exploitation and may require alternative water supply strategies. These findings align with previous studies in Basement Complex terrains, which emphasize the importance of secondary porosity (fracturing and weathering) in controlling groundwater occurrence (Olorunfemi and Fasuyi, 1993; Offodile, 2002).

Table 5: Borehole Yield Potential

Station ID	Location	Aquifer Thickness (m)	Resistivity ( $\Omega\text{m}$ )	T ( $\Omega\text{m}^2$ )	Yield Class	Groundwater Potential
VKY 1	Vandeikya HQ	0.7	582	407	Low	Poor
VKY 2	Gbagbongom	5.1	49.1	250	Low	Low
VKY 6	Unde	12.6	251	308	Moderate	Moderate
VKY 8	Mbayongo	34.0	46.5	1581	High	High
VKY 10	Tsambe	16.1	749	12058	Very High	Excellent
VKY 11	Abwa	20.2	76.7	1550	High	High
VKY 12	Ishan	24.0	63.6	1526	High	High
VKY 13	Akar	46.0	114	5244	Very High	Excellent
VKY 14	Aginde	0.6	546	164	Low	Poor
VKY 17	Achwa	28.6	118	3374	High	High
VKY 18	Agbile	14.0	601	8414	Very High	Excellent

## V. CONCLUSION

This study employed the Vertical Electrical Sounding (VES) method using the Schlumberger array to evaluate groundwater potential in Vandeikya Local Government Area, Benue State. The results reveal a highly heterogeneous subsurface typical of Basement Complex environments, with resistivity variations reflecting differences in lithology, degree of weathering, and saturation conditions.

Geoelectrical interpretation identified between seven and nine subsurface layers, grouped into topsoil, weathered/fractured basement, and fresh basement. The weathered and fractured basement units constitute the principal aquifer system, with resistivity values ranging from 46.5 to 749  $\Omega\text{m}$  and thicknesses between 0.6 m and 46.0 m. Aquifer zones characterized by moderate resistivity and significant thickness were identified as the most productive.

The analysis of Dar-Zarrouk parameters further highlighted variations in aquifer protective capacity and transmissivity. High longitudinal conductance values indicate zones of good protective cover, while elevated transverse resistance values correspond to high groundwater yield potential. Notably, locations such as Akar, Tsambe, Achwa, and Agbile exhibit favourable hydro-geophysical conditions for sustainable groundwater development.

Spatial analysis shows that the central and northwestern parts of the study area are the most promising for groundwater exploration due to thicker overburden and well-developed weathered/fractured zones. In contrast, areas with thin overburden and high resistivity

values correspond to poor groundwater potential. Overall, the study demonstrates that aquifer thickness, resistivity, and transmissivity are the primary controls on groundwater occurrence and borehole yield in the area. It also confirms the effectiveness of the Schlumberger VES technique as a reliable tool for groundwater exploration and hydro geophysical characterization in Basement Complex terrains.

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