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Hydrogeological and Geophysical Investigation of Ground Water Potentials in Basement Terrain of Ado Ekiti, Southwestern Nigeria

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Abstract: *Hydrogeological survey of Ado Ekiti a Precambrian basement terrain consisting of migmatite-Gneiss, Quartzite complex was carried out using electrical resistivity survey method. One hundred and four Vertical Electrical Sounding (VES) were conducted with Ohmega campus terrameter while WINRESIT Software was used to process the field data and analyzed with surfer 13 mapping software. The result revealed lithological sequence of Top soil, clay soil, lateritic soil, weathered layer, fractured basement and fresh basement with KH-curve type (25%) as most dominant in the study area. Dar Zarouk parameters of longitudinal resistance, transverse resistance were used to estimate hydraulic conductivities (K) (m/day), transmissivity(m^2/day) and coefficient of anisotropy(λ).These were analyzed and used to map high, medium and low aquifer potentials. The result revealed high longitudinal conductance and transmissivity rate at Adebayo, Bamigboye street, Adehun, Okeila, Afao road, part of Olaoluwa and Egbewa with transmissivity value from 501.12m^2/day to 780.67m^2/day, However 61.5% have moderate transmissivity value. Good and moderate aquifer potentials occupy 52.8% of the area assuming a thickness of 13m and taking resistivity from 10Ωm to 208Ωm. Also 50% of the study area have good (11.5%) and moderate (38.5%) Aquifer protective rating, these area are Owode, Olaoluwa, Fagbohun, Fajuyi housing estate, Adebayo, Ago Aduloju, Igirigiri and part of ABUAD and EKSU. 65.3% of the study area have coefficient of anisotropy less than 1.2, evident of good groundwater potential within the weathered/ fractured zone. Based on the localized nature of aquifer found in the study area, it is recommended that pre-drilling geophysical investigation of well site should be carried out before drilling. Bore Hole should be sited where there is enough thickness (30m) of aquifer this will guarantee maximum yield.*

Keywords*-Aquifer, Lithology, porosity, conductance, Transmissivity, Vertical Electrical Sounding, Groundwater*

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I. Introduction

Water is necessary and requires for human activities, it is require for domestic use, for drinking, for agriculture and industrial use. The use of water depends on the quality and quantity of water needed for such purpose. Streams, ponds, rivers and stored rain water from surface source are the sources of water in the study area, also ground sources from springs and wells can be seen in the metropolis. Most of the water from these sources is only good for Agriculture and domestic purposes.

The nearest dam is Ero Dam in Ikun Ekiti; it is about 42 km from Ado- Ekiti. The dam supplied water to three nearby local Government areas in the state for only four years after commissioning. The present Government is planning to complement Ureje dam by extending the water from Ero Dam to the study area and even if it is done it might not serve the increase population of the city. Ado Ekiti: the study area, is Ekiti state capital, home to a fast growing private University (Afe Babalola University), the State University and a Federal Polytechnic. Block molding small scale industry exists in every community in the metropolis, it has been said that the growing demand for potable water supply has been the major problem of most urban centre [1] and it is estimated that about 100litre/day of potable water is the required minimum amount of water per person [2].

Numerous hand dug shallow wells exist in the town as source of ground water, it is difficult to source out water in Ado-Ekiti because of the nature of the topography and bed rock that surround the city. Depth to aquifer is reachable at low cost in valley and low land area but then the geological formation of the bed rock is a constraint to underground water exploitation. The study area lies within Precambrian basement complex of southwestern region which consist of migmatite- Gneiss, Quartzite complex and known to be associated with faults, joints and lithological contracts. Fresh water exists within these joints, and fractured and faulty zones, thus sourcing out water from these zones require geological investigation and monitoring of the existent and direction. In this study, geo electrical method of geophysical survey was employed. [3] used the combination of geo electrical resistivity and electromagnetic (VLF) methods for ground water exploration in the Precambrian terrain of Ikare, southern Nigeria. [4] carried out the study of ground water potential and aquifer protective capacity in Ado – Ekiti in 2009. [5] using Afe Babalola University Ado Ekiti as case study postulated that sustainable groundwater exploitation is achievable in Ado Ekiti if boreholes are located and constructed based on standard best practices. [6] also carried out a work on groundwater potential in Ado Ekiti in 2012 using vertical electrical sounding method.

The study is aimed at investigating the hydrogeological conditions of Ado metropolis by assessing its ground water potentials using Vertical electrical sounding method and estimation of Dar-Zarouk parameters of longitudinal conductance (S), transverse resistance (R), Hydraulic conductivity (K) and transmissivity (T).Contour map of depth to aquifers, vector map of ground water flow and transmissivity spatial map are provided using suffer 13 mapping software.

1.1 Study Area

The study area covers Ado Ekiti metropolis, Ado local Government area, part of Irepodun/Ifelodun and Ikere Local government within 734000mE to 761000mE and 835100mN to 851600mN southern Nigeria as shown in figure 1.1. The VES stations are marked with doted yellow points; the population of Ado Ekiti is about 427,700 according to 2016 population censor.

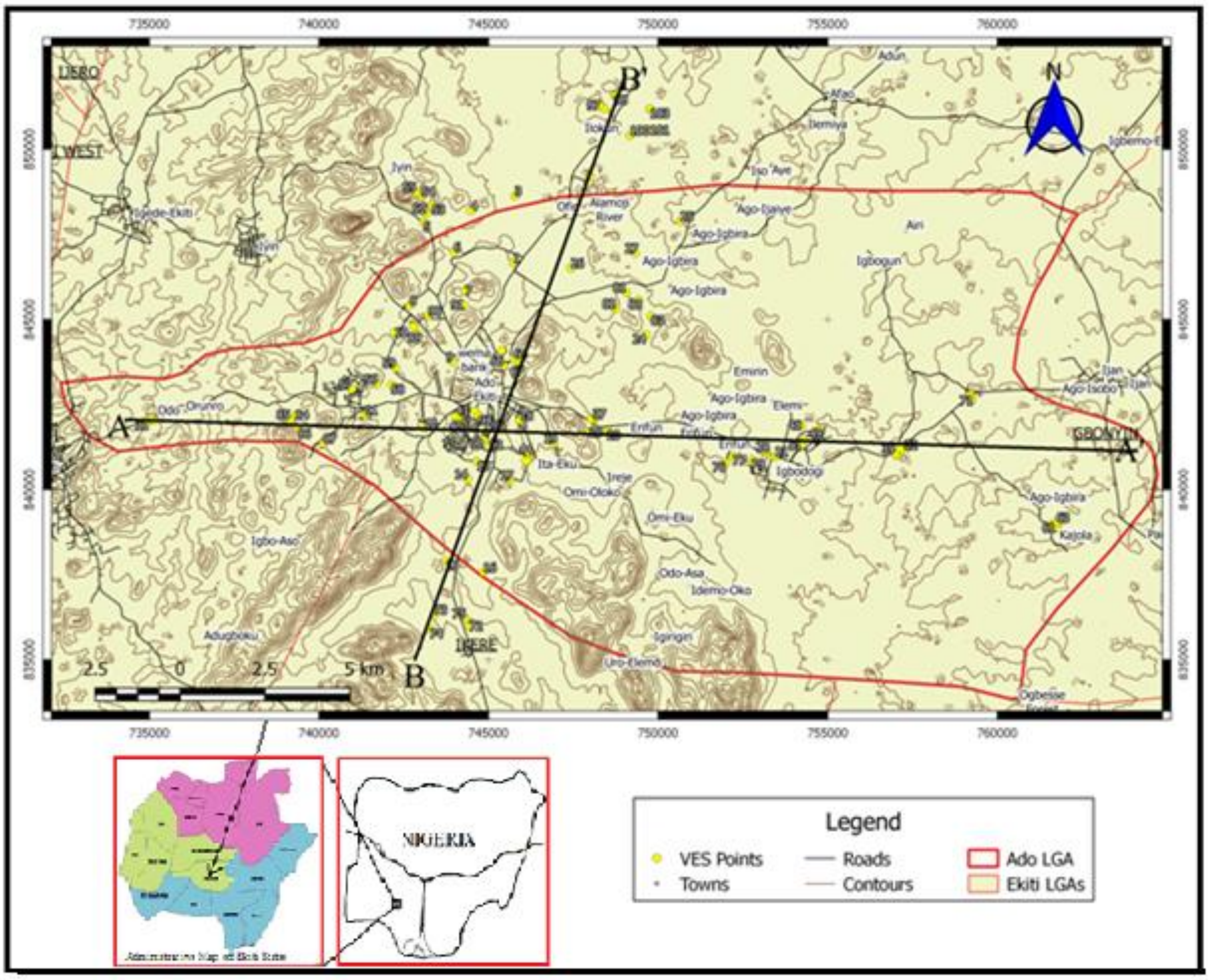


Figure 1.1: Map of the Study Area (Source: Agbemuko 2021)

1.2 Geological Setting of the study Area

Ado Ekiti is underlain by crystalline rocks made of older granite migmatite and Charnokites [7] of southwestern Nigeria, it is a city surrounded by hills and inselbergs of different shapes in ridges, a rugged topography with rivers and streams meandering through the valleys. The major River is Ireje, Omisanjana and Elemi that flow to River Ose and Owena in Ondo State at the southern part of Ekiti, The rock specimen constitutes the Precambrian Basement complex of South Western Nigeria (Figure1.2).

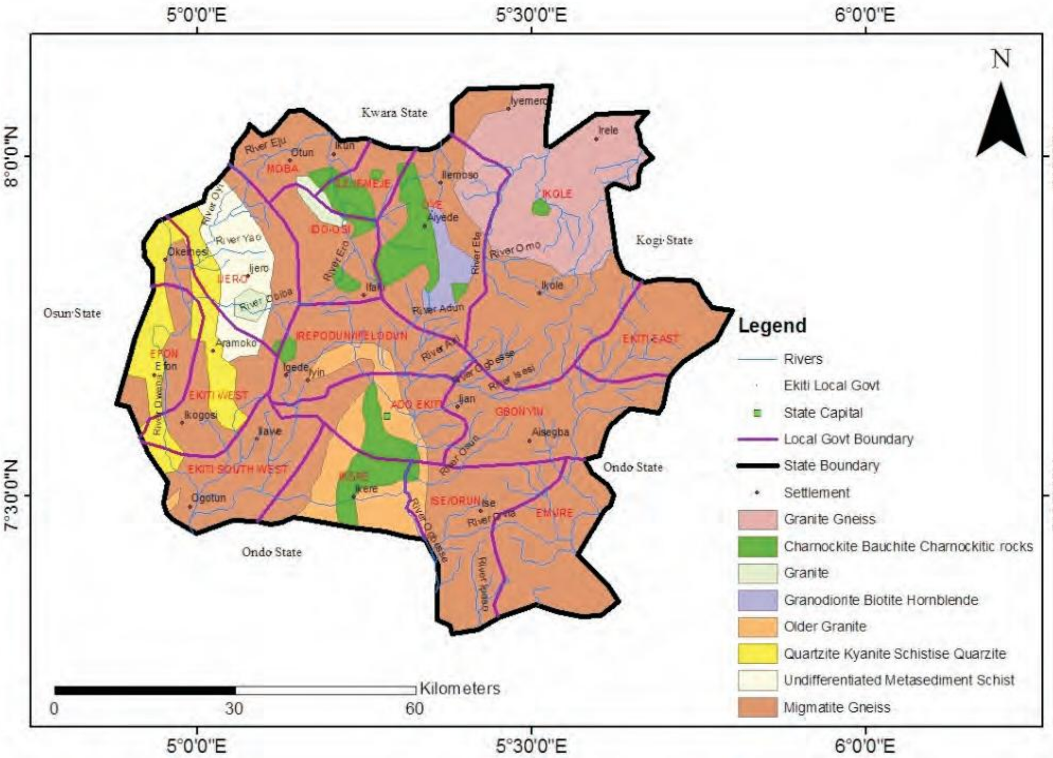


Figure 1.2: Geologic Map of Ekiti-State (Ademilua, 1997)

1.3 Geography, Climate and Vegetation

Ado- Ekiti is a city surrounded with hills and ridges a basement complex environment; it lies on the tropical part of western Nigeria with average rainfall of 1400mm per annual and relative Humidity of 50% to 80%. It rain heavily between the months of April to October, during this Period the ground water is recharged and bedrock saturated through surface run off and infiltration. The period of November to March is a period of drought, water table is low, and the soil / Rock pores become hard.

II. Material and Methods

2.1 Materials

The equipment used for the study is the Ohmega Campus Resistivity meter with sets of four standard realms of cables, Electrodes and modern micro-processor, Hand held Garmin GPS equipment for spatial geo-reference of all the VES points. 2 Hammers, four set of 50metres tapes, reflective Aprons for traffic, Hand held compass for orientation of the traverse line, wire clips and one field vehicle. Ohmega campus is a high quality portable earth resistance meter capable of accurate measurement over a wide range of condition. All the internal controls together with the liquid crystal display are situated on the top front panel of the Instrument [8].

2.2 Field Procedure

Two current electrodes A and B were spaciously positioned at a predetermined distance with two potential electrodes M and N sandwiched between the two current electrodes at a known distance (figure 2.1), current was introduced into the current electrode through a 12 volts motor battery plugged into the ohmega terrameter, the potential different developed is measured and attendant resistance displayed and recorded from the terrameter with minimum error less than 1% in three circles. The resistance is a function of the configuration of the electrodes and electrical parameters of the ground. The two potential electrodes M and N were kept constant for some spread of current electrodes readings thereafter, the potential electrode distance increased and kept constant for another three to four sets of current of electrode separation, The VES stations were spread out of Ado local Government and its environment due to the expansion of Ado municipality. A total of 104 vertical electrical soundings were executed in the study area. At every field station, check on observations were made through manual computation of apparent resistivity on the data sheet this is to guide against gross error that might arise from cables, electrodes connections and miss booking. The principle is based on ohm's law on current flowing through a material.

Current 'I' flowing through a wire is proportional to the potential difference across it.

$$R = \frac{V}{I} \qquad 2.1$$

Where R is resistance in ohms (Ω),

In a material medium resistance is giving as R= $\rho \frac{L}{A}$ 2.2

Hence $\rho = R\frac{A}{L}$ or $K\frac{\Delta V}{I}$ 2.3

Where ρ is the resistivity of the medium,

L = the length,

A = the area of the material

R= Resistance

In schlumberger arrangement as in figure 2.1, apparent resistivity is given as

$\rho_a = \frac{\Delta V}{I}\pi\left[\frac{s2}{a} - \frac{a}{4}\right]$ 2.4

Where K = the arrangement of electrodes spacing given as $\pi\left[\frac{s2}{a} - \frac{a}{4}\right]$ 2.5

Hence resistivity ($\rho_{a)}$ = $\frac{\Delta V}{I}$k, or RK 2.6

Where R =$\frac{\Delta V}{I}$ measured 2.7

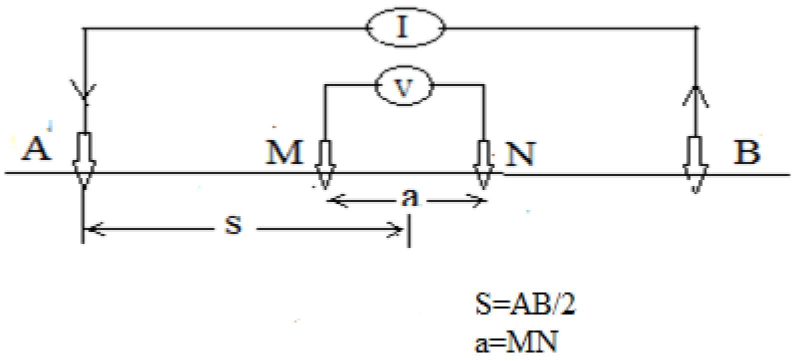


Figure 2:1. Schlumberger configuration

2.3 Data Interpretation

The resistance values were keyed into excel program designed to compute the resistivity of each recorded AB/2 with the corresponding K factor. The results were processed with WIN RESIST; a geophysical computer iteration software[9]. The program re-modeled the layers and display result after one to six iterations. The layers number, thickness, depth, resistivity parameters and resistivity curve are displayed assuming that earth is made up of horizontal layer with differing resistivity.VES determined depth to geologic interface could be accurate to within +-10%. All VES points achieve this accuracy. The field data were presented as depth sounding curves.

The geometrical arrangement of interstices in rock has pronounced effect on their electrical conductivity but make the resistivity anisotropic[10], this is due to influence of water or fluid that filled these interstices thus resistivity of rocks varies with the movement, concentration and degree of dissociation of ions. Anisotropy is a measure of degree of inhomogeneity[11]; hence it is important in defining degree of fractures in basement topography, transverse resistance (T) and longitudinal conductance (S) play important role in resistivity sounding these were computed from the VES result, other parameters considered are longitudinal resistivity (P_L), transverse resistivity (P_T), coefficient of anisotropy (λ), transmisivity(Tr) and resistivity of formation they are calculated base on the formulae below.

$S= \sum h_i / \rho_i + h_{ii} / \rho_{ii} + \text{--------} \sum h_n / \rho_n$ 2.8

$T= \sum h_i \rho_i + h_{ii} \rho_{ii} + \text{--------} \sum h_n \rho_n$

2.9

Longitudinal Resistivity: $P_L = \frac{H}{S}$ 2.10

Transverse Resistivity: $P_T = \frac{T}{H}$ 2.11

Coefficient of anisotropy (λ) which is always 1 is given as $\sqrt{(P_T/P_L)}$ 2.12

Mean Resistivity given as $\sqrt{(P_T P_L)}$ 2.13

H= Total thickness of all layers $\sum h_i + h_{ii} + \text{--------} h_n$

$T_c = K_c b$ 2.14

Where T_c = calculated transmissivity (m^2 /day) from VES data

Kc calculated hydraulic conductivity m/day from VES

b = thickness of saturated layer
The value of Kc used for this study is given as $386.4R_w^{-0.93283}$
Where R_w is aquifer resistivity.

III. Field Result, Discussion and Interpretation

Table 3.1 is the interpretation of the rock lithology why figure 3.1 show samples of VES curves found in the study area. 20 types of curves ranges from A, H, Q, AA, AK, HA, HK, KH ,KQ, QH, AKQ, HKH, HAA, KHA, KHK,HAK, QAA, QHK, QHA to KQQ were discovered in the study and KH-curve type is most dominant in the study area.

3.1 Geo Electric Section

The goal of geophysical surveys is to image rocks below the shallow subsurface and determines deeper structure that might represent permeability in a geothermal system [12], five layers are visible in the study area these are: Top soil, clayed soil /lateritic soil, weathered layer, fracture layer and Basement layer.

3.2 Top soil

The profile taken from West to East section AA^1 of the study area in figure 3.2a revealed a thin layer of top soil of which the resistivity ranges from 13.1 Ωm to 86.1 Ωm with thickness of 0.7m to 2.4m, the highest thickness is 2.4m which occurred in VES 12 Ifelere area. Profile B^1 B along South – North revealed high resistivity in the top soil, ranges from 13.1 Ωm to 337.8 Ωm with thickness from 0.6m to 2.2m.The top soil consists of black humour soil, sandy clay and lateritic clay. The high resistivity value recorded in area like EKSU 178.4Ωm, Egbewa with 136. Ωm and Olorusogo of 305.7 Ωm are due to the lateritic mix.

3.3 Clayed Soil

Clayed soil in some area is next to the top soil while in some places it is sandwich between lateritic and weathered layer, generally the resistivity is low. In West-East profile it ranges from 16.5 Ω m to 33.4 Ωm with thickness of 2.4m to 4.6m. Also on the South- North profile, clayed soil was detected in all the profile except VES 67 where weathered layer intercepted the continuation. Resistivity range is between 13.7 Ωm to 54.2 Ωm and thickness between 2.5m to 21.6m. Clayed soil was discovered in about forty (40) VES stations.

3.4 Lateritic Soil

Lateritic soil occurred between top soil and weathered layer. It appeared in about forty one (41) VES stations in the study area. Also its resistivity ranges from 63 Ωm to 422.2 Ωm and thickness of 0.8m to 34m.

3.5 Weathered Layers

Weathered layer occupy the third layer in sequential presence of geological layers in the study area, it resistivity ranges from 29.5 Ωm – 423.5Ω m along the East to West profile. The thickness is between 2.5m to 75.7 meters. However, along profile section on South- North axis, resistivity ranges from 7.6 Ωm to 423.6Ωm and thickness of 12m to 82.9m. The low resistivity is due to the present of substantiate volume of clay content. [13] and [14] had observed that the layer resistivity would often be less than 600 Ωm and that weathered basement layer that is saturated is characterized by a moderately lower resistivity layer (with value ranges from 100 Ω m to 340 Ω m). Partially weathered zone of 323ohm-m runs to infinity in VES 98 along south-North profile. In the study area, majority of the aquifer zone falls within weathered layer. [15] Reported that weathered layer in Akure, a similar basement comprise of sandy clay- clayed sandy and sand have resistivity ranges from 6Ωm to 659Ωm.Weathered resistivity in this study area ranges from 7.7Ωm to 545.6Ωm.

3.6 Fractured Basement / Fresh Basement

Basement layer is the last observable layer in the study area exception is in VES 64, 65, 71, 83, 87 and 98 that have no record of basement layer. The presence of cracks or fracture serve as conduit and pores for water or fluid passage in basement environment this result into fracture zone .This zone have lower resistivity value than fresh basement, hence it constitutes aquifer zone in basement layer.

In the West -East profile, the fractured basement have resistivity ranges from 9.5 Ωm to 404.1 Ωm. at VES 86, it occupied the third layer after weathered zone, the thickness also ranges from 16.5 meters to infinity in VES 31. There is no trace of fracture along the profile until VES 39 at 222.4 Ωm and 49.1m thick. However, on the South-North profile, fracture basement occupied the last layer into infinity from the beginning to the end excluding VES 15, VES 21 and VES 98. The resistivity range is between 29.7 Ω m to 112.2 Ω m. The low resistivity recorded in VES 68 (Ayegunle) and VES 86 (Olaoluwa) is a result of their topography which lie on plain sediment, hence a potential for groundwater. Fractured resistivity ranges from 9.44ohms meters to 1902.6 ohms meters in the study area. Fresh basement is visible from VES 86 to the East of profile E/W from VES 31, 86, 12, 95, 39, 50 and 33 in that order having resistivity ranging from 96.2 Ω m to 700.3 Ωm with infinite thickness. However on South to North profile, fresh basement is identified in VES 15 and VES 21, the resistivity is 1338.8 Ω m and 2590.4Ωm respectively. Basement resistivity values ranges from 142.6ohm-m to 27326.2 ohm-m.

Table 3.1: Geological Interpretation of some typical VES in the Study Area

VES No	Location	No. Of Layers	App. Resistivity (Ωm)	Thickness	Depth	Lithographic Layer	Curve Type
1	Adebayo Area	1	112.9	0.6	0.6	Top Soil	
		2	47.4	3.9	4.5	clayed sand soil	
		3	48.2	6.3	10.8	weathered layer	HKH
		4	12.4	17.3	28.1	Fractured layer	
		5	955.6	0	0	basement	
2	Behind Fm Off	1	92.7	1.2	1.2	Top Soil	HAA
	Iworoko Rd	2	21.3	4.8	6	clayed sand soil	
		3	148.8	4.7	10.7	Lateritic soil	
		4	237.9	6.1	16.8	Weathered layer	
		5	2590.4	0	0	Fresh basement	
3	Olorunsogo	1	305.7	0.8	0.8	Top Soil	
		2	55.9	4.4	5.2	clayed sand soil	
		3	86.8	13.7	18.9	weathered layer	HA
		4	750.4	0	0	basement	
4	Olorunda	1	173.4	1	1	Top Soil	
	Keji	2	102.2	3.6	4.6	weathered layer	HK
		3	1554.2	34.4	39	basement	
		4	640.5	0	0	Fractured Basement	
5	Police Pry.	1	227.7	0.9	0.9	Top Soil	
	Iyin Road	2	286.5	4	4.9	Lateritic soil	
		3	191.7	7.5	12.5	weathered layer	KHA
		4	352.5	8.7	21.1	Partly weathered	
		5	946.5	0	0	Fresh basement	
6	Owode	1	155.3	1	1	Top Soil	
	off nova	2	143.1	4.9	5.9	Lateritic soil	QH
	Road	3	128.3	6	11.9	weathered layer	
		4	1729.9	0	0	Fresh basement	
7	Oluwatuyi	1	191.6	1	1	Top Soil	
	Quarters	2	149.1	3.1	4.1	Lateritic soil	HAA
		3	222.4	9.3	13.4	weathered layer	
		4	336.8	33.1	46.5	Fractured Basement	
		5	3493.6	0	0	Fresh basement	
8	ILAMOYE	1	80.9	1.4	1.4	Top Soil	
		2	154.8	9.2	10.5	Lateritic soil	
		3	73.2	12.4	22.9	weathered layer	KHK
		4	422.8	32.6	55.6	Partly weathered	

	5	63	0	Fractured Basement

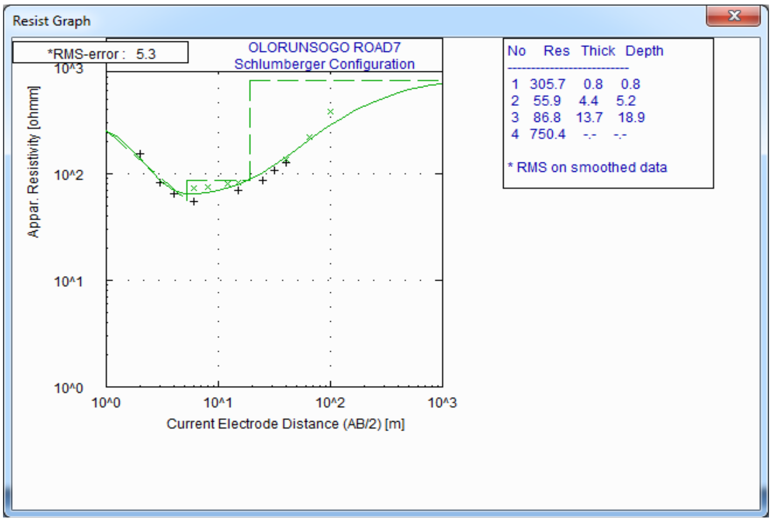


Figure 3.1a. Typical Curve HA-TYPE

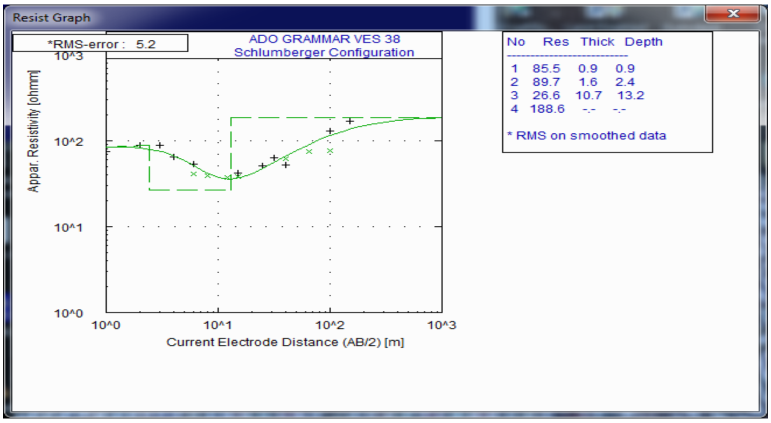


Figure 3.1b .Typical curve KH-TYPE

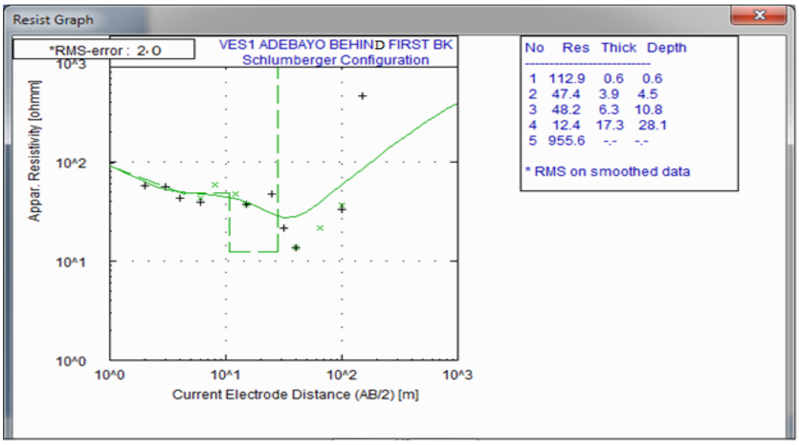
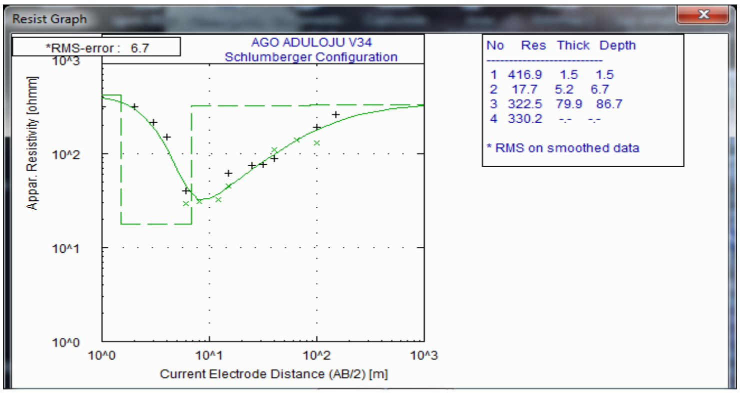


Figure 3.1d. Typical Curve HKH -TYPE



A Figure 3.1e Typical Curve HAA-TYPE

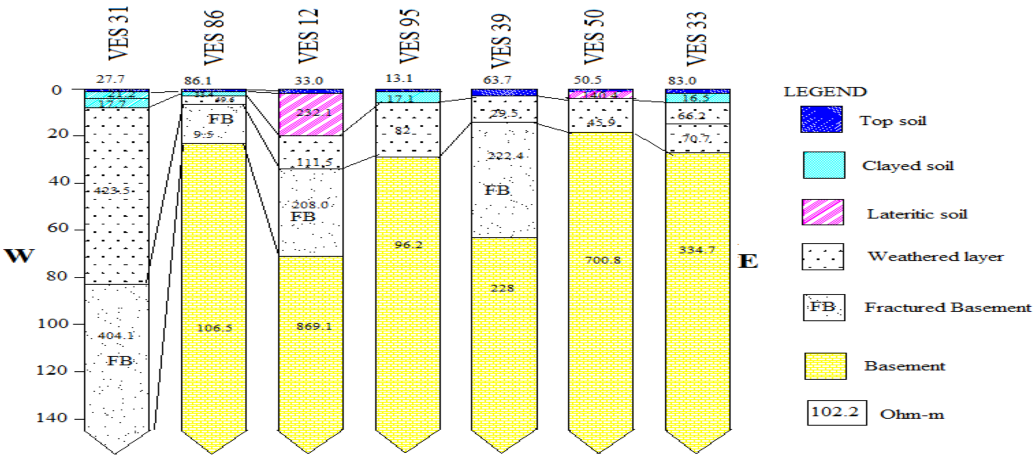


Figure 3.2a Geoelectrical section of West-East profile in the study area

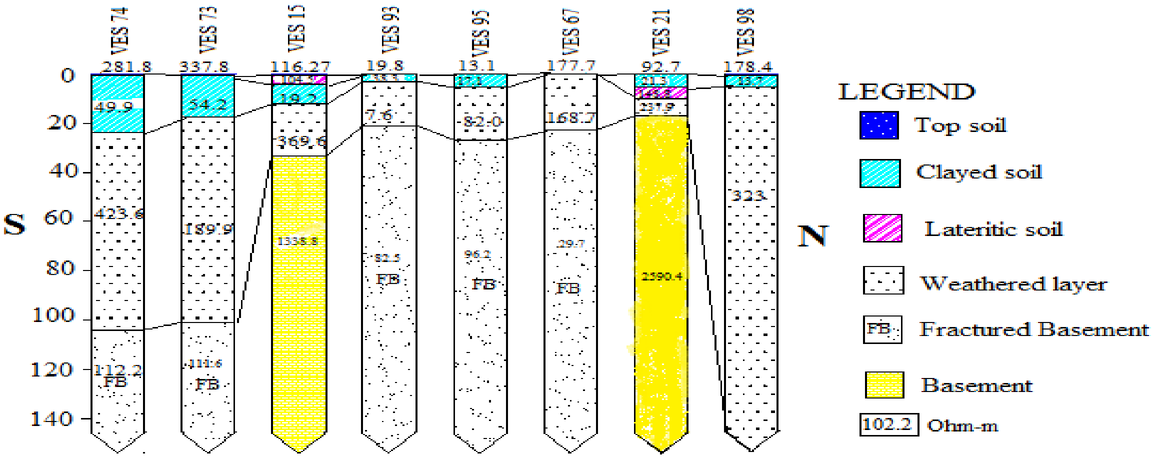


Figure 3.2b Geoelectrical section of South-North profile in the study area

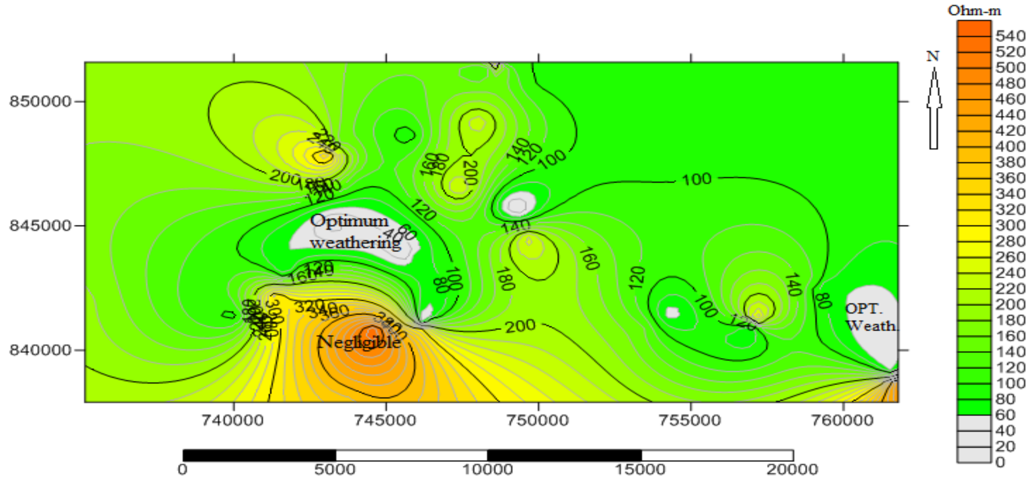


Figure 3.3. Map of the study area showing weathered zone distribution

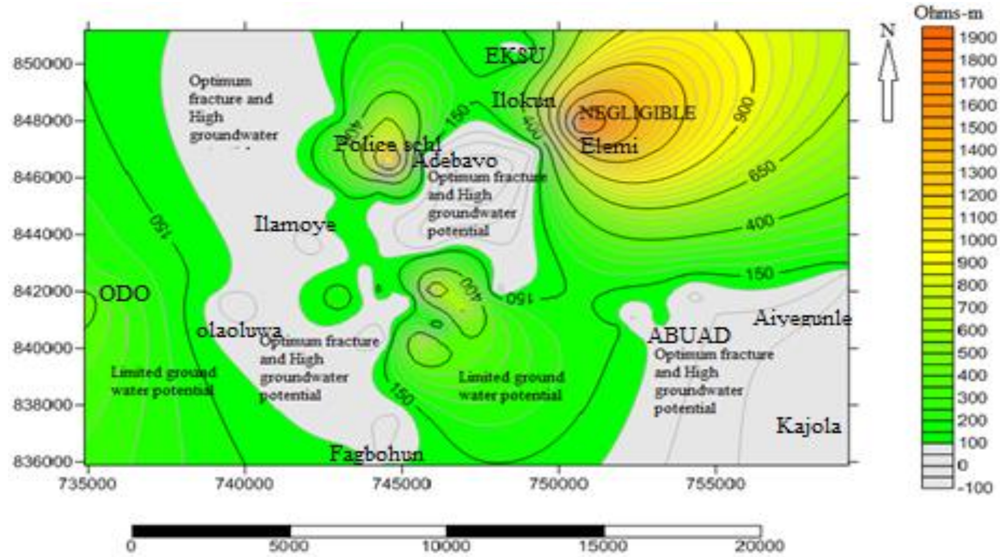


Figure 3.4 Map of the study area showing Fracture zone

Optimum

3.7 Dar Zarouk Parameters

Aquifer parameter such as longitudinal conductance, transverse resistance, hydraulic conductivity and transmissivity were determined from the resistivity and thickness. The value of longitudinal conductance in the study area ranges from 0.0105 Ω to 1.736 Ω with mean value of 0.3498Ω which can generally be admitted to be moderate. The transverse resistance varies from 57.34 Ω m^2 to 103,040 Ωm^2 with mean value of 5638. 79 Ωm^2, it means adequate aquifer thickness. [16] Reported that a transverse resistance from 235.2 Ω m^2 to 6317.87 Ωm^2 with average value of 1789.50 Ω m^2 is classed as low ground water development class. However, the result of the computed transmissivity shows that the higher the longitudinal conductance value the higher the transmissivity so also the lower the longitudinal conductance the lower the transmissivity. Area with high transmissivity and high longitudinal conductance have been adjudged as area of good water this also correlates with high hydraulic conductivity as shown in table 3.3. [17] said that transmissivity is a function of the properties of the liquid, the porous media and the thickness of the porous media, hence it is good for underground water modeling. From the study high longitudinal conductance and transmissivity occurred in Nine VES stations these are in Adebayo area, Bamigboye Street, Adehun, Okeila , Okeila Afao road (VES 81& 82) and Egbewa VES 89, it formed 8.7% of the study area. Moderate area is 61.5% while low potential occupied 29.8% of the area investigated.

Figure 3.5 is the transmissivity map. North West and South East have low transmissivity value (ash color area) while South West to North East have moderate transmissivity value. The dotted red is the highest value area. The higher potential area have Transmissivity ranges from 501.12m^2/ day to 780.67m^2/day, moderate is between 56.13m^2/day to 474.8m^2/day and low is between 6.74m^2/day to49.6m^2/day. The hydraulic conductivity value of the area ranges from 0.337m/day to 57.556m/day with mean value of 8.436m/day typical of weathered basement (figure 3.6). [16] Suggested that area with high hydraulic conductivity would be highly permeable to fluid flow. The hydraulic conductivity map shows that high conductivity appears in the South West to the North central and moderately high conductivity in green colour extend from South West towards the North and Eastern part of the study area, this map almost correlates with transmissivity map of figure 3.5.

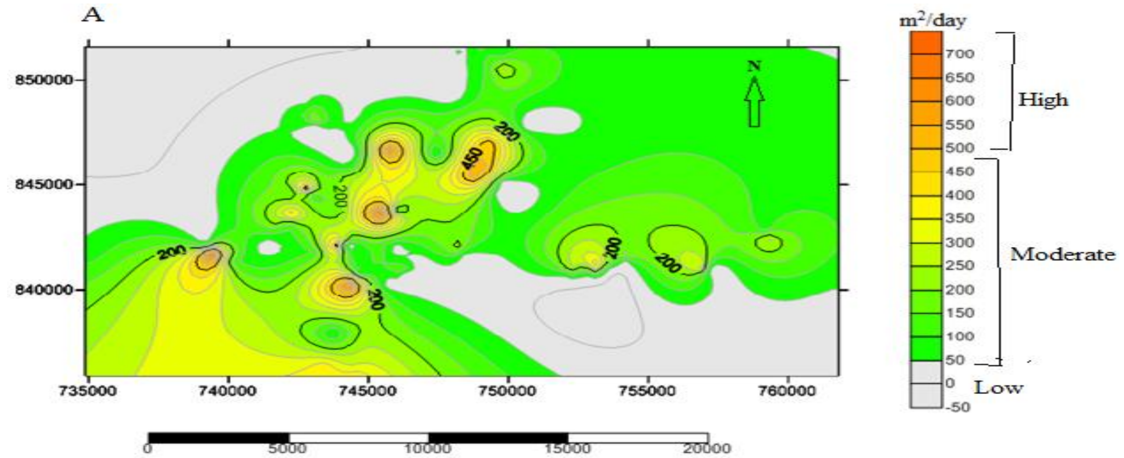


Figure 3.5: Map of the study area showing variation in Transmissivity

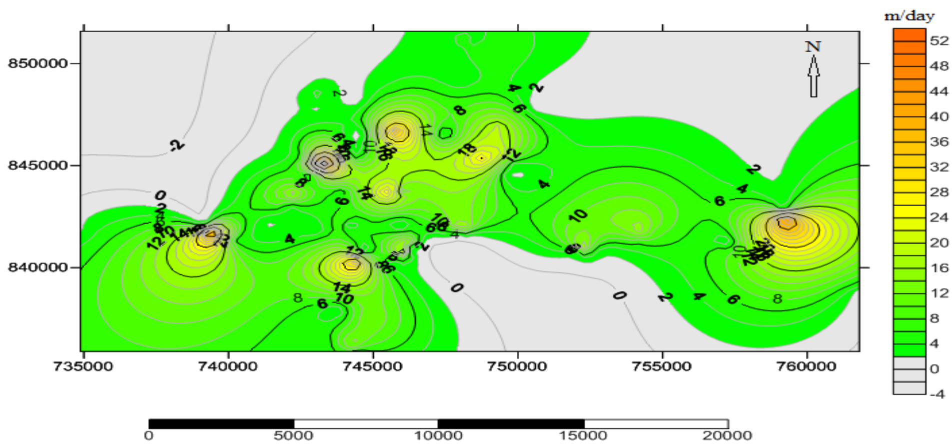


Figure 3.6: Map of the study area showing variation in Hydraulic conductivity

3:8 Aquifer depths/Ground water flow pattern

Figure 3.7 is a contour map showing the depth of aquifer. The blue colour indicates shallow area; the map shows the flow pattern of ground water, the arrows indicate the direction of water flow underground from higher elevation to lower elevation areas. Water converges into lower depth area with blue colour. The converging zones are discharge zones these are high groundwater potential zones.

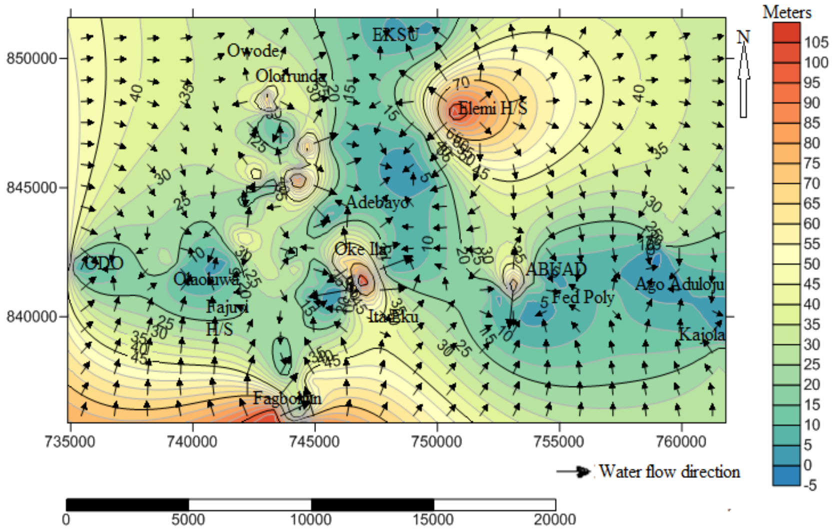


Figure 3.7 Groundwater flow vector map of Aquifer of the study area

Table 3.2: Aquifer classification based on Transmissivity values (Offodile 1983)

Transmissivity (m^2/day)l	Classification of well
>500	High Potentials
50-500	Moderate Potential
5- 50	Low Potential
0.5- 5	Very low Potential
<0.5	Negligible Potential

3.9 Correlation Analyses

The primary parameters: resistivity and thickness were subjected to correlation analysis. In high potential zone “r” value is 1 while medium and low potential area correlation value ’r’ are 0.174 and 0.5 respectively. It means there is strong relationship between thickness and resistivity value in High potential zone while in medium and low potential there is no strong association between resistivity and thickness in this area. This does not mean that they are independent but there is no strong association which can influence high productivity rate.

3.10 Coefficient of Anisotropy

The coefficient of anisotropy (λ) provides insight to the nature of aquifer in a basement environment. It is good in investigating aquifer potential in bedrock environment, The value of ‘λ’ computed in this study area is within 1 but VES 18- Olope is 3.6, VES 19 at Ita- Eku road is 7.7 while Egbewa VES 90 is 2.4 this is due to impact of fresh basement and lateritic soil found in them. This area cannot be considered for ground water exploitation.

Table 3.3a: Aquifer parameters of the study area (Dar-zarrouk parameter)

Ves No	Location	Layer Resistivity	Thickness (Metres)	Aquifer Conductivity	Longitudinal Conductance	Transverse Resistance	Hydraulick Conductivity (m/day)	Transmi-ssivity m^2/Day
1	Adebayo Area	12.4	17.3	0.080645161	1.39516129	214.52	36.90290602	638.4202741
2	Iworoko Rd/Fm	237.9	6.1	0.004203447	0.025641026	1451.19	2.345660153	14.30852694
3	Olorunsogo	86.8	13.7	0.011520737	0.157834101	1189.16	6.007970098	82.30919035
4	Olorunda Keji	640.5	35	0.00156128	0.054644809	22417.5	0.931176214	32.5911675
5	Police Pry Schl Iyin Rd	352.5	8.7	0.002836879	0.024680851	3066.75	1.625438996	14.14131926
6	Owode Off Nover Rd	128.3	6	0.007794232	0.046765394	769.8	4.17272771	25.03636626
7	Oluwatuyi Quarters	336.8	33.1	0.002969121	0.09827791	11148.08	1.696010817	56.13795803
8	Ilamoye	63	30	0.015873016	0.476190476	1890	8.101366373	243.0409912
9	Eksu Guest House	119.6	33.3	0.008361204	0.278428094	3982.68	4.455199349	148.3581383
10	Model Estate	74.5	20	0.013422819	0.268456376	1490	6.928410032	138.5682006
11	Fajuyi Housing Estate	330.6	11.5	0.003024803	0.034785239	3801.9	1.725662418	19.8451178
12	Ifelere Omisanjana	208	36.9	0.004807692	0.177403846	7675.2	2.658753637	98.1080092
13	Ekute	545.6	18.4	0.001832845	0.03372434	10039.04	1.081430483	19.89832088
14	Bamigboye Street	13.6	20	0.073529412	1.470588235	272	33.8561849	677.123698
15	Ajebandele Area	369.6	20.9	0.002705628	0.056547619	7724.64	1.555176593	32.5031908
16	Covenant Avenue	41.2	20	0.024271845	0.485436893	824	12.03961357	240.7922714
17	Moferere Quarters	648.8	16.3	0.001541307	0.025123305	10575.44	0.920059178	14.99696459
18	Olope Idofin Keji	812.9	15	0.001230164	0.018452454	12193.5	0.745533543	11.18300314
19	Ita Eku Road	681.4	30	0.001467567	0.044027003	20442	0.87893065	26.36791951
20	Mother/Child Estate	167.3	8.9	0.005977286	0.053197848	1488.97	3.257567317	28.99234912
21	Ado Federal Poly Ist	141.6	12.2	0.007062147	0.086158192	1727.52	3.805929884	46.43234459
22	Irona Okebola	103.7	20	0.009643202	0.192864031	2074	5.089301973	101.7860395
23	Mary Hill Oke Ila	64.7	6.2	0.015455951	0.095826893	401.14	7.902623245	48.99626412
24	Wonder City	254	11.6	0.003937008	0.045669291	2946.4	2.20666335	25.59729485
25	Elemi Housing Estate	1902.6	20	0.000525597	0.010511931	38052	0.337258882	6.745177646

Table 3.3a: Aquifer parameters of the study area (Dar-zarrouk parameter) continuation

Ves No	Location	Layer Resistivity	Thickness (Metres)	Aquifer Conductivity	Longitudinal Conductance	Transverse Resistance	Hydraulic Conductivity	Transmisivity m^2/Day
26	Onola Quarters	247.6	7.6	0.004038772	0.030694669	1881.76	2.259824475	17.17466601
27	Moses Faluyi Street Adehun	25.7	26.8	0.038910506	1.042801556	688.76	18.69860478	501.1226081
28	Odo Community	479.2	15	0.002086811	0.03130217	7188	1.22059229	18.30888435
33	Ago Aduloju	70.7	11.8	0.014144272	0.166902405	834.26	7.275171005	85.84701785
44	Agric Trainning Centre	348.4	141	0.002870264	0.404707233	49124.4	1.643275425	231.7018349
48	Abuad	31.4	9.2	0.031847134	0.292993631	288.88	15.51158704	142.7066008
52	OWODE	128.7	56.5	0.007770008	0.439005439	7271.55	4.160628713	235.0755223
56	Ilawe Road	59.5	24.5	0.016806723	0.411764706	1457.75	8.545047016	209.3536519
60	Kajola Community	221	10.7	0.004524887	0.04841629	2364.7	2.512567125	26.88446824
64	Okeila Road	19.7	22.1	0.050761421	1.121827411	435.37	23.96184133	529.5566933

68	Aiyegunle	9.4	6.1	0.106382979	0.64893617	57.34	47.78309342	291.4768699
72	Fagbohun	109.6	82.2	0.009124088	0.750000000	9009.12	4.833265346	397.2944114
76	Ikare Road	157.3	18.3	0.006357279	0.116338207	2878.59	3.450346121	63.14133401
81	Afao Road	23.3	26.9	0.042918455	1.154506438	626.77	20.4892704	551.1613738
84	Olaoluwa/Ileabiye	107.4	17.9	0.009310987	0.166666667	1922.46	4.925557507	88.16747938
90	Egbewa	7.7	3.1	0.12987013	0.402597403	23.87	57.55618165	178.4241631
95	Igirigiri	96.2	23.1	0.01039501	0.24012474	2222.22	5.458482412	126.0909437
97	Eksu	106.9	11.9	0.009354537	0.11131899	1272.11	4.947044819	58.86983335
100	Ilokun	89	15	0.011235955	0.168539326	1335	5.869317967	88.03976951
104	Aiyedun Quarters	1288.7	80	0.000776395	0.062111801	103040	0.48530443	8.82435865

Table 3.3b: Aquifer potential rating using Transmissivity values.

Ves No	Location	Longitudinal Conductance	Transmissivity m^2/Day	Aquifer Potentials
1	ADEBAYO AREA	1.39516129	638.4202741	High
2	BEHIND FM IWOROKO RD	0.025641026	14.30852694	Low
3	OLORUNSOGO	0.157834101	82.30919035	Moderate
4	OLORUNDA KEJI	0.054644809	32.5911675	Low
5	POLICE PRY SCHL IYIN	0.024680851	14.14131926	Low
6	OWODE OFF NOVER ROAD	0.046765394	25.03636626	Low
7	OLUWATUYI QUARTERS	0.09827791	56.13795803	Moderate
8	ILAMOYE	0.476190476	243.0409912	Moderate
9	EKSU GUEST HOUSE	0.278428094	148.3581383	Moderate
10	MODEL ESTATE	0.268456376	138.5682006	Moderate
11	FAJUYI H/ESTATE	0.034785239	19.8451178	Low
12	IFELERE	0.177403846	98.1080092	Moderate
13	EKUTE	0.03372434	19.89832088	Low
14	BAMIGBOYE ST	1.470588235	677.123698	High
15	AJEBANDELE	0.056547619	32.5031908	Low
16	COVENANT AVENUE	0.485436893	240.7922714	Moderate
17	MOFERERE QUARTERS	0.025123305	14.99696459	Low
18	OLOPE IDOFIN KEJI	0.018452454	11.18300314	Low
19	ITA EKU ROAD	0.044027003	26.36791951	Low
20	Mother And Child Estate	0.053197848	28.99234912	Low
21	ADO FED POLY IST GATE	0.086158192	46.43234459	Low
22	IRONA OKEBOLA	0.192864031	101.7860395	Moderate
23	MARY HILL OKE ILA	0.095826893	48.99626412	Low
24	WONDER CITY	0.045669291	25.59729485	Low
25	ELEMI HOUSING ESTATE	0.010511931	6.745177646	Low
26	ONOLA QUARTERS	0.030694669	17.17466601	Low
27	MOSES FALUYI STREET	1.042801556	501.1226081	High
28	ODO COMMUNITY	0.03130217	18.30888435	Low

33	AGO ADULOJU	0.166902405	85.84701785	Moderate
36	Ado Grammar School	0.523206751	250.0646503	Moderate
40	ADO COMMUNITY SCHOOL	0.215550423	115.4933888	Moderate
44	AGRIC TRAINNING CENTRE	0.404707233	231.7018349	Moderate
48	ABUAD	0.292993631	142.7066008	Moderate

Table 3.3b: Aquifer potential rating using Transmissivity values (continued).

Ves No	Location	Longitudinal Conductance	Transmissivity M2/Day	Aquifer Potentials
52	OWODE	0.439005439	235.0755223	Moderate
56	ILAWE ROAD	0.411764706	209.3536519	Moderate
60	KAJOLA COMMUNITY	0.04841629	26.88446824	Low
64	OKEILA ROAD	1.121827411	529.5566933	High
68	AIYEGUNLE	0.64893617	291.4768699	Moderate
72	FAGBOHUN	0.750000000	397.2944114	Moderate
76	IKARE ROAD	0.116338207	63.14133401	Moderate
81	AFAO ROAD	1.154506438	551.1613738	High
84	OLAOLUWA/ILEABIYE	0.166666667	88.16747938	Moderate
90	EGBEWA	0.402597403	178.4241631	Moderate
95	IGIRIGIRI	0.24012474	126.0909437	Moderate
97	EKSU	0.11131899	58.86983335	Moderate
100	ILOKUN	0.168539326	88.03976951	Moderate
104	AIYEDUN QUARTERS	0.062111801	38.82435865	Low

IV. Conclusion

The result of the study revealed that a sequential layer of Top soil , clayed soil, lateritic soil, weathered layer, fractured and fresh basement consisting of varying degree in resistivity and thickness values exist in the study area. 20 various types of curves were discovered with KH- curve type found predominant in the study area.The geo-electric section revealed that the aquifer zone lies within weathered layer and fractured basement of varying resistivity and thickness. The fracture basement resistivity ranges from 9.4ohm-m to 1902.6ohm-m with thickness between 3.4m to 100m while weathered layer resistivity and thickness ranges from 7.7ohm-m to 545.6ohm-m and 3.1m to 67.7m respectively. 52.8percent of the study area is adjudging to be good and moderate ground water potential when resistivity between 10Ωm to 208Ωm and thickness from 13m are considered.

The result of longitudinal conductance revealed that 50% of the study area has adequate protection from underground water contamination. These areas are Owode, Olaoluwa, Ile abiye, Ilawe road, Fagbohun, Fajuyi housing Estate, Adebayo part of EKSU and ABUAD, Ago Aduloju and Igirigiri.

The coefficient of anisotropy is generally within 1 which confirms good water potential within the weathered and fractured zone, area characterized by higher anisotropy value are associated with low porosity and permeability hence low ground water potential such area are at Olope Idofin keji (3.6), Ita Eku road(7.7)Elemi Housing Estate (2.9), Egbewa VES90(2.5), Aiyedun Qtrs-Apata Nathaniel(1.7) and Olaoluwa VES84 (1.9). 79.8% of the study area have coefficient of anisotropy less than 1.5. But the aquifer depth is low, 70% of the study area fell within low aquifer depth.

The ground water potential of Ado Ekiti and its environs can be classified as high, medium and low from this study. The result from aquifer transmissivity indicated that 8.7% of the study area is high, 61.5% is considered moderate water potential while low potential occupied 29.8% of the area of investigation.

The transmissivity range for high potential zone is within 501.12m^2/day to 780.67m^2/day and are found in Adebayo area, Bamigboye street, Adehun, Okeila, Afao and Egbewa these communities are located in different part of Ado Ekiti far from each other. VES 96,97,98 and 99 are located on Ekiti state university campus while VES 100,101,102 and 103 are located at Ilokun in the neighborhood of Ado Ekiti university these stations have different aquifer depth and thickness ranges from 2m to 88m hence a generalized depth for drilling will be a failure in the two neighborhoods.

The degree of relationship between resistivity and thickness determine the ground water potential of the aquifer. This study revealed that where there is strong linear association between resistivity and thickness of a body of water there will be good potential of underground water for exploitation. Strong linearity must exist between the two parameters. It also discovered those areas of good, moderate and poor overburden capacity in entire Ado Ekiti and its environment; it is therefore useful in management of waste generation and disposal. Sitting of dump sites in weak zone will expose the underground water to contaminants. The study revealed the usefulness of vertical electrical sounding for detailed hydro-geophysical investigation in basement complex, the reliability of the method in the revelation of thickness and depth of subsurface lithology, its deeper penetrating power make the method reliable in hydro-geophysical survey.

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