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DELINEATION OF SHALLOW FLOODPLAIN AQUIFERS FOR IRRIGATION PURPOSES OVER A FLOODPLAIN AT AULE, AKURE SOUTHWESTERN NIGERIA

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ABSTRACT

Geophysical investigation involving the use of Electrical Resistivity method using Modified Wenner Array Configuration has been adopted for shallow groundwater potential evaluation over a floodplain at AULE, Akure southwestern Nigeria for irrigation purposes. The research presents the result from the quantitative interpretation of forty eight vertical electrical sounding (VES) obtained from the survey area which has helped in the identification of aquiferous units and has provided an understanding of aquifer characteristics especially the thickness and depth to fractured zones which are required for locating points with high potentials for groundwater occurrence. The Vertical Electrical Sounding technique result delineated three to six (3-6) subsurface geologic layers (top soil, clay, clay, weathered layer, partly weathered layer and bedrock) with different depth ranges (0.04m to 10.0m). The lithology of the subsurface strata is mainly clay (expansive clay) which justifies the dominance of low resistivity values and explains why the runoff water via flood doesn't infiltrate the soil. The overburden thickness and aquifer resistivity were used in classifying the groundwater potential of the study area. Areas having moderate overburden with thickness between 5m and 10m with weathered layer above 4 Ωm such as VES 1, 3, 13, 28, 32, 39, 40, 41, 43 and 44 are delineated to be promising sites for shallow wells.

Keywords: Aule, Floodplain, Overburden thickness, Fadama, Agriculture, Irrigation, Weathered layer

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1. INTRODUCTION

The global food demand is ever on the increase given the ever increasing rate of population. In Africa it is a worrisome development, with the local food supply not been able to keep phase with the population explosion. It is also noted that the effect of the steady rise in population density generally has necessitated the need for intensification of agricultural production and/or expansion of agricultural lands to support the growing food demands, the resultant effects of which has resulted into acute competition and land scarcity [1]; [2].

Given the unprecedented population increase in the last ten years in Nigeria, the attendant consequences of shortage of land for agricultural purpose, in the face of the demand for land for the purpose of industrial and infrastructural developments, especially in the urban centres, it then became very expedient to look inwards to other areas where land could be assessed for agricultural purposes without the constrain of industrial and infrastructural needs. Hence it became imperative that efforts should be directed at assessment of areas such as swamp forest, old river paths and flood zones, which are normally not considered for development for the purpose of agricultural development [2]. A typical example of such an area is the floodplain at Aule, the study area.

Food security has been a perennial problem in Africa and Nigeria in particular. Even though the increase in global food production has outpaced that of population growth over the last 50 years. Food insecurity remains a major issue globally as food production and demand are not spatially balanced. With a population of about 177.5 million inhabitants and Nigeria being Africa's most populous country, agriculture remains the largest sector of the country's economy, in terms of domestic product and employment provision [3]. Notwithstanding, Nigeria still suffers from poverty and food insufficiency.

Agriculture plays a dominant role in the economies of both developed and developing countries. The production of food is important to everyone and producing food in a cost-effective manner is the goal of every farmer as well as large-scale farm managers and regional agricultural institutions. A farmer needs to be informed to be efficient, and that includes having the knowledge and information products to forge a viable strategy for farming operations for it is believed that growth in the sector will impact directly in growth of economy as well as employment ([4], [5]).

In order to boost food production, Government of Nigeria came up with series of Agricultural programmes that can ensure food sufficiency and circulation, a typical example of such programme is FADAMA. Fadama is a Hausa word meaning the seasonally flooded or floodable plains along major rivers and or depressions or adjacent to seasonally or perennially flowing

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streams and rivers ([6]; [3], [7]). Such lands are noticeable to be highly suitable for irrigated agricultural production. A typical example of such lands is a floodplain at Aule, Akure, southwestern Nigeria. Globally flooding occurs along major rivers and small streams, in coastal areas, and along the margins of some lakes. Other flood prone areas include alluvial fans and other types of unstable and meandering channels, ground failure areas and areas influenced by structural measures. Flooding may also be due to surface runoff and locally inadequate drainage particularly in rapidly urbanizing areas as the case in Aule floodplain under investigation [8].

Human interactions with floodplain date backs thousands of years. Originally human inhabitants utilized the biological resources of these floodplains, but later due to development and modernization, they often altered floodplains to suit the needs of an agriculture society. Humans always valued floodplains for their tangible benefits to human society, e.g. food and water, hence floodplains are now becoming the “food basket” because they serve as the main source for growing crops for man and food supply to livestock all year round[8]. Floodplains are found scattered in and around Akure, the study area and other parts of Nigeria.

In the context of food insecurity, the increasing food shortage as against the increasing population in Nigeria calls for less dependence on rain fed production to irrigation practices. This will ensure all year round food production. [9], describes food security as a situation where all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life [9]; [10]; [7]. The Fadama Development project was established to guarantee all-year round growing of crops and promotion of simple and low cost improved irrigation under World Bank financing. Food crops grown on the Fadama includes rice, leafy vegetables, okra, maize and other crops including root and tuber [7];[3]).

Successful agriculture is dependent upon farmers having sufficient access to water, but agriculture in Nigeria has largely been dependent on rain fall; and, given the erratic and extremely unreliable nature of rainfall, probably due to climate variability, irrigation development is seen as an obvious and alternative strategy to increase agricultural production. As a result of this, surface water cannot be dependable throughout the year, hence the need to look for other alternatives to supplement surface water ([11]; [12]; [13]).

Farmers are increasingly using groundwater as a source of irrigation water due to the unavailability of surface water during the dry season but there is need to investigate its availability and suitability in order to ensure sustainability in the application and possible expansion of groundwater irrigation in many areas. Groundwater development for irrigation should therefore be really looked at.

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Irrigation is defined as “Artificially supplying and systematically dividing of water for agriculture and horticulture in order to obtain higher or qualitatively better production [11].

Water is essential to plant growth and for millenniums. Water plays a crucial role in the origin of life and it has an essential role in maintaining plant and animal life. Plant depends on water for the transport of nutrients and photosynthesis; an adequate supply of safe water for maintaining ecosystem which supports all life and for achieving sustainable development[11]. Successful farmers have used different methods to apply water to their crops. This artificial addition of water is called irrigation. Irrigation is essentially the artificial allocation of water to overcome deficiencies in rainfall for growing crops. Irrigation is also seen as the application of controlled amounts of water to plants at needed intervals. It helps to grow agricultural crops, maintain landscapes, and revegetate disturbed soils in dry areas and during periods of less than average rainfall. It also has other uses in crop production, including frost protection suppressing weed growth in grain fields and preventing soil consolidation. Irrigation systems are also used for cooling livestock, dust suppression and disposal of sewage, Increases crop yield, protects from famine, helps in economic development, improve conditions in the soil, dissolves nutrients and make them available to plants.

There are several methods of irrigation which vary in how the water is supplied to the plants. The various methods are surface irrigation, micro-irrigation, drip irrigation, sprinkler irrigation, center pivot irrigation, etc.

The importance and practice of the shallow ground water irrigation actually increases along the dryer river areas, since in these areas, the importance of dry season agriculture for increasing food production is a priority for agricultural development. The floodplain at Aule is now intensively being used for arable crop farming like maize, vegetables, rice, etc. (Fig. 1) under FADAMA III programme, in Ondo state thereby providing a means of survival for some set of people in terms of food and economic means. Therefore for all the year round farming activities, there is a need for the development of shallow groundwater to be used for irrigation during the dry season, especially between the month of December and March.

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Figure 1: Maize and rice plantation at the study area

Groundwater is defined as water beneath the earth surface in soil pore spaces and in fracture of rock formations [14], [15]. It is a hidden treasure stored in subsurface void spaces and moves slowly through geologic formations of soil and rocks called aquifers. Groundwater has always been considered to be a readily available source of water for domestic purposes, agriculture as well as industries. Water might not be evenly distributed within the subsurface including the study area for many reasons, hence the need for geophysical survey to delineate a viable location for shallow wells for irrigation, hence showing how geophysical methods are becoming an increasingly valuable tool for application within a wide range of agro ecosystems[16]; [17]).

Several geophysical methods can be used to investigate groundwater resources and the success of each method depends on the geological and hydrological system. Geoelectrical prospecting has attained the greatest importance in groundwater investigations. Electrical resistivity methods were developed in early 1900's and they have been used extensively for ground water investigation by many workers [18]). Vertical electrical sounding (VES) survey has been widely employed for demarcation of different geological contacts and water-bearing formations [19]; [20]; [21], [22]; [23].

[24]) noted that electrical technique is the most popular geophysical method used in shallow groundwater exploration due to the close relationship between electrical conductivity and the hydro geological properties of the aquifer. Therefore for the purpose of this study, electrical

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resistivity method involving Vertical Electrical Sounding using Modified Wenner array configuration shall be employed.

2. LOCATION, CLIMATE AND GEOLOGY OF THE STUDY AREA

The study area (Fig.2) is located at Third National Fadama Development Project Additional Financing. It occupies a total of 22 hectares of land beside road D4, Aule GRA, in Akure South Local Government Area of Ondo state (Fig. 2).It falls between latitude 804964 to 805250, and longitude 737818.8 to 738131 Universal Traverse Mercator (UTM). The study area is accessible via tarred roads, untarred roads and footpaths. The climatic condition of Akure is that of the South Western-Nigeria with wet season between April and October and Dry season between November and March [15], [22]). The study area is usually becomes completely flooded and water logged between the month of May and October every year and becomes completely dry from December to April, when farmers cultivate only arable crops like maize, vegetables, rice etc (Fig. 1).

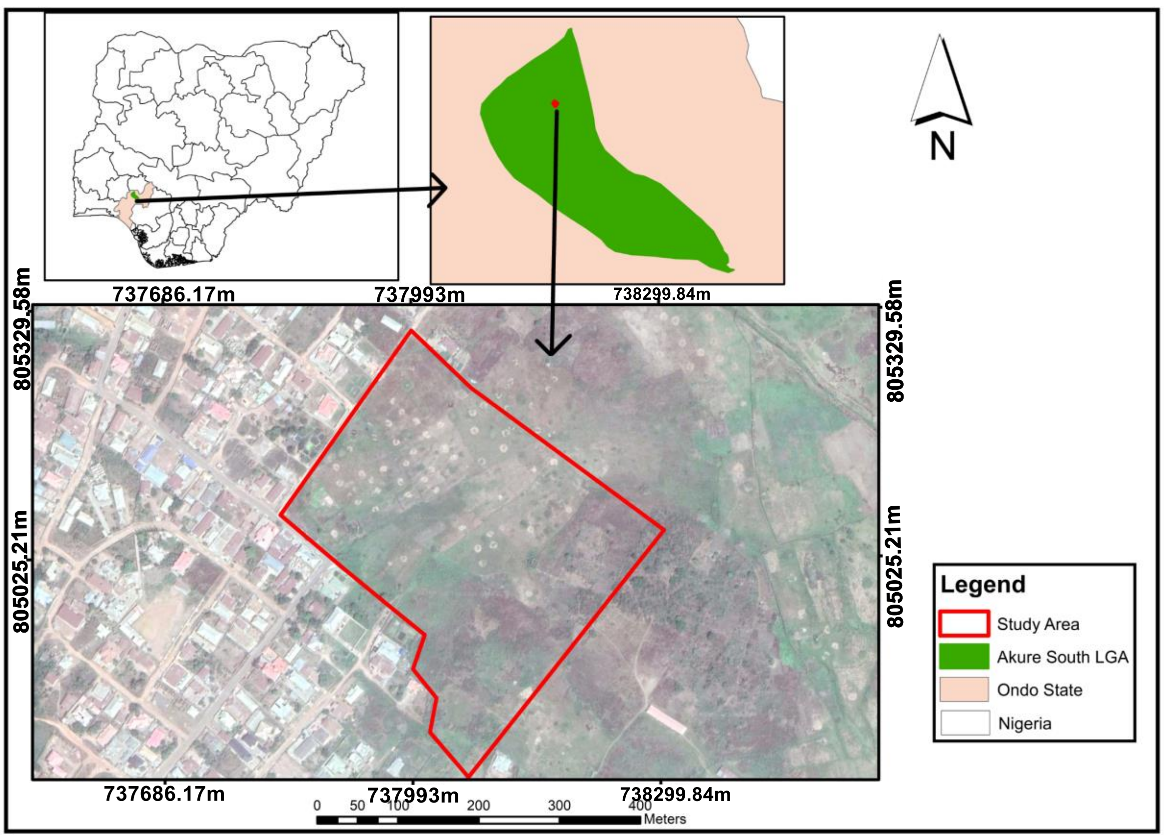

Figure 2: Map of Nigeria showing Ondo State and the Study Area

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Geologically, Aule area is underlined by crystalline rock of the Precambrian basement complex of Southwestern Nigeria [25]. The lithological units include migmatite gneiss, granitic and gneiss charnokite[15], [22]. Outcrops of biotite granitic gneiss occur in some locations around the western part of the study area likewise some other boulders of granite and charnokites occur at the western part of the study area. The hydro geological setting of the area is such that various rock types of both igneous and metamorphic origin occur but they are in general, impermeable except in cleaved, sheared, jointed and fissured areas [26] as in the case of the study area where the fractured basement of gneiss and charnokite serves as the aquifers that boreholes and the wells tap their water from [27]).

Aule flooding is a recurring natural disturbance, and a flooding due to surface run off and inadequate drainage which are normally a major problem, particularly in rapidly urbanizing areas, and this is actually the case of Aule floodplain under investigation.

Locally, heavy precipitation may produce flooding in areas other than delineated floodplain. If local drainage conditions are inadequate to accommodate the precipitation through a combination of infiltration and surface runoff, water may accumulate in areas that may cause flooding problems (Floodplain Management in the United States. The study area exhibits a unique landscape that is characterized as bowl or saucer-shaped tectonic depression (Figure 3).

Figure 3: An overview of the study area

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3. MATERIALS AND METHODOLOGY

In this research work, electrical resistivity method involving Wenner arrays with specialized engineering spread was used. A total of 48 VES were established along seven traverses (each of length 150m) in West to East direction in the study area (Fig. 4). A maximum of 30m (i.e. maximum of AB/2 of 30m) spread was used starting with “a” as small as 0.5m, so as to monitor subsurface soil properties to the minimum grain size possible.

The data obtained from VES were processed and presented as sounding curves using a commercial computer software program called IP2WIN (version 3.0.1). The geoelectric parameters (resistivity, thickness and depth) obtained were appropriately iterated with the aid of the software. The program modifies the iteration by inversion mode until a good fit is acquired. Interpretation of the VES data entails the assessment of the curve types in the study area which quantitatively determines the geoelectric parameters of the subsurface layers in terms of resistivity and thickness (depth), on the basis of which promising zones were delineated. The aquiferous zones are expected to have low resistivity values, thick overburden and where the overburden is not thick enough we look for where the basement rock is fractured especially in the basement complex like the study area.

The basic equipment for the electrical resistivity method is the resistivity meter, which displays apparent resistivity values digitally as computed from Ohm’s law

$$V = IR \qquad 1$$

$$R = \frac{V}{I} \qquad 2$$

From the current (I) and voltage (V) values, an apparent resistivity (ρ_a) value was calculated

$$\rho_a = K\frac{V}{I} \qquad 3$$

where K is the geometric factor which depends on the arrangement of the four electrodes.

For the engineering spread, using Wenner configuration, the apparent resistivity of the subsurface was computed using,

$$\rho_a = 2\pi a R \qquad 4$$

where ‘a’ is the electrode spacing and R is the resistance. Other accessories to the resistivity meter includes, four metal electrodes, cables for current and potential electrodes, harmmers, measuring tapes, writing pads etc.

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Modified Wenner array (engineering spread) was used for VES purpose of determining vertical variation of resistivity at shallow depth. The survey was carried out in the month of March, 2019, at the peak of dry season, so this will enable true determination of depth to aquiferous layer.

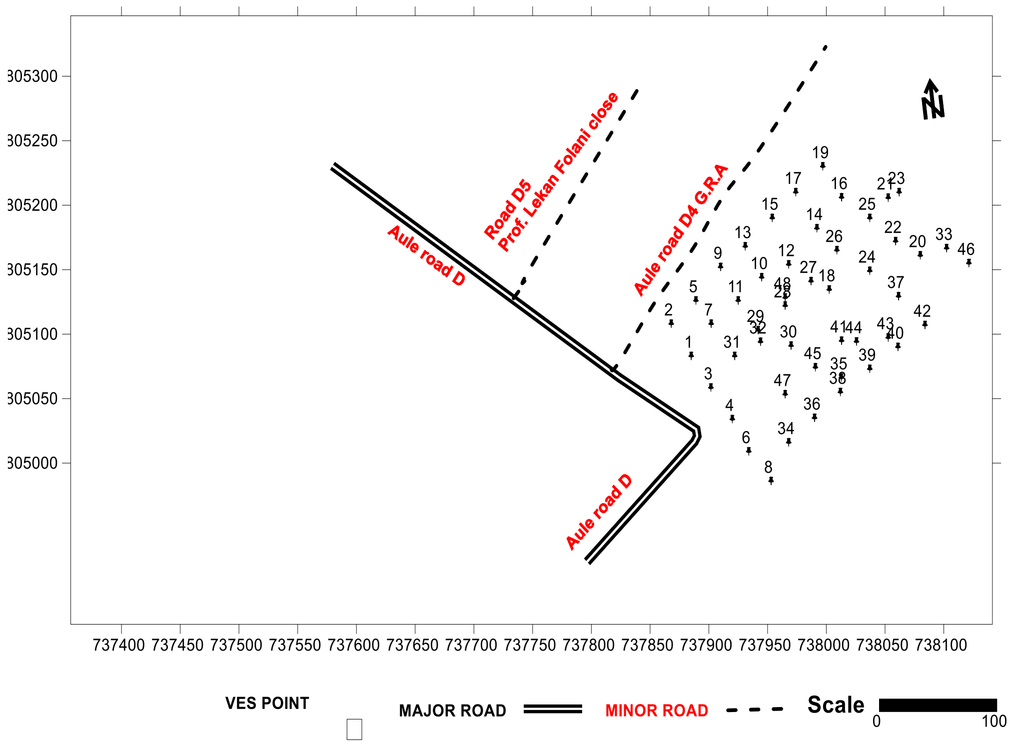

Figure 4: Base Map of the Study Area

4. RESULTS AND DISCUSSION

4.1 Vertical Electrical Sounding

The results of the sounding curves from the computer iteration showed that the area under investigation exhibit a 3 to 6 geoelectric layers down to the depth investigated by the maximum current electrode used.

The interpretation of the VES curves involves grouping of the curves on the basis of the relationship between resistivity of the layers. The field curves vary from simple A and H curves to a more complex QH, QA, KH, HK, KHA, QHA, HKA, and KHKA types. Based on the relationship between resistivities of the layers, the VES curves were grouped into nine (9) distinct groups.

Group 1: A-type

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Table 1: Group 1. A - Type (3layer): Conductive – Resistive – Resistive [$P_1 < P_2 < P_3$]

VES	P_1(Ωm)	d_1(m)	P_2(Ωm)	d_2(m)	P_3(Ωm)
28	6.40	1.17	19.14	10.00	321.2
38	7.57	0.31	10	2.94	69.4

This comprises of VES curves 28 and 38 (Table 1). They are three-layer earth model (Fig. 5) characteriesed by layering sequence; Conductive – Resistive – Resistive. That is resistivity increases from topsoil down to the third or last layer. The resistivities of the topsoil is 6.40Ωm and 7.57 Ωm, with depth range of 1.17m and 0.31m respectively, while the middle layer has resistivity values 19.4 Ωm and 10.0 Ωm with depth range of 10.0m and 2.94m. The last layer in the group (i.e. assumed basement) has the resistivity values of 321.2 Ωm and 64.9 Ωm, with the depth extending to infinity.

The geologic formation below the two VES points showed that it consists of an expansive clay formation which might be a setback for meaningful groundwater development. But VES 28 appears to be promising in the sense that its third layer seems to contain weathered clay or clayey material and the depth seems reasonable for a shallow groundwater development. VES 38 is not in any way suitable for groundwater development both in terms of resistivity values (7.57 Ωm to 69.4 Ωm) and depth (0.39m to 2.94m). This suggests it to be a clay formation with thin overburden.

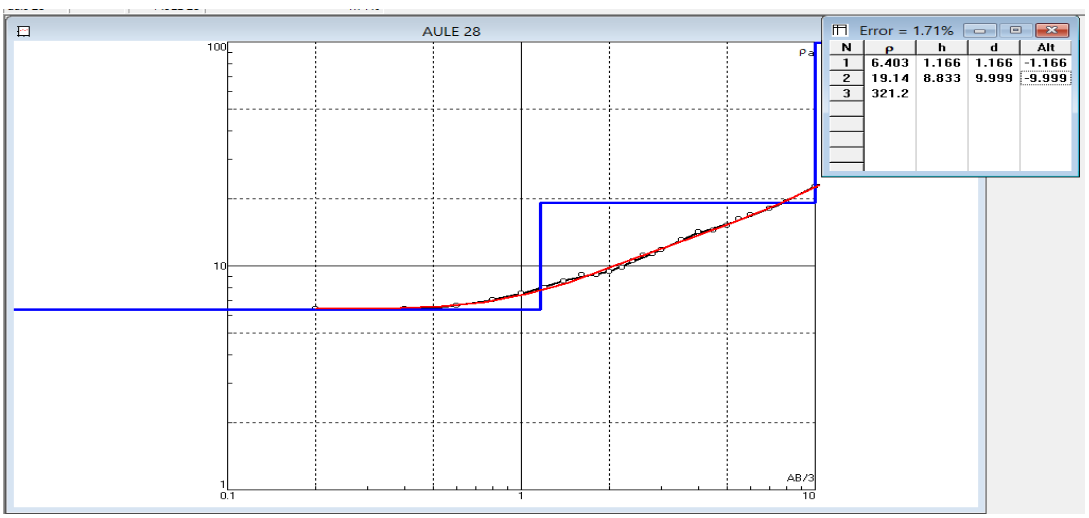

Figure 5: A Sample of Group A-Type

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Group 2: H-type

Table 2: Group 2. H - Type (3layers): Resistive – Conductive – Resistive [$P_1 > P_2 < P_3$]

VES	$P_1(\Omega m)$	$d_1(m)$	$P_2(\Omega m)$	$d_2(m)$	$P_3(\Omega m)$
6	21.05	1.19	1.76	2.48	1530
7	2511	0.24	7.15	2.2	37.8
9	17.19	0.42	7.37	2.30	45
10	83.48	0.12	9.81	3.97	37.15
15	20.18	0.40	7.39	3.48	35
16	16.98	0.69	8.83	2.89	85
18	43.61	0.32	5.16	1.89	108.8
22	15.89	0.25	9.49	2.38	60.03
25	13.5	0.67	8.55	3.82	120.4
29	17.01	0.16	7.83	2.27	49.79
31	98.91	0.42	2.18	0.93	23.72
33	13.82	0.25	8.48	2.92	55.06
48	80.66	0.09	9.51	2.98	62.96

This group comprises of VES curves 6, 7, 9, 10, 13, 15, 16, 18, 22, 25, 29, 31, 33 and 48 (Table 2).

They are three-layer earth model section characterized by layering sequence; Resistive – Conductive – Resistive (Fig. 6). The resistivity values of the topsoil for the group ranged

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between 13.5 Ωm to 98.91 Ωm with depth ranging between 0.12m to 1.19m. The abnormally high resistivity value of the topsoil on VES 7 is suggested to be as a result of the electrode being placed on a bolder or shallow buried organic matter from the runoff. The middle layer (second layer) has resistivity values ranged between1.76Ωm to 9.81 Ωm with depth values ranging between 0.93m to 3.97m. The third layer (assumed basement) has the resistivity values ranging between 23.72 Ωm to 1530 Ωm. None of these VES points (under H-type) appears to be promising and suitable for groundwater development. The resistivity lows suggest the formation under these VES points to be clay; couple with the very thin overburden will definitely be a draw back for groundwater development.

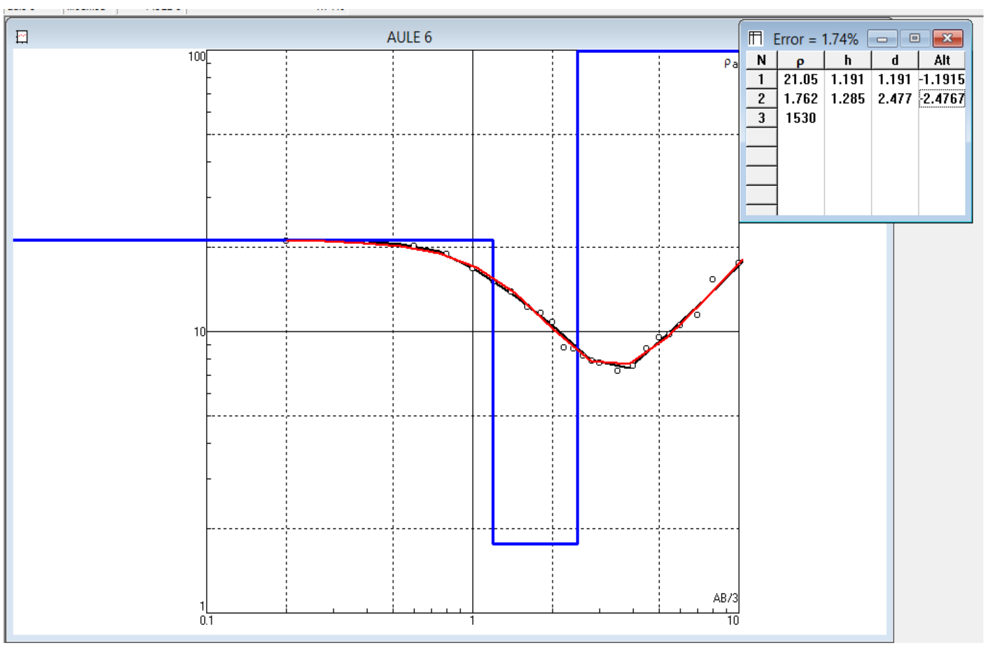

Figure 6: A Sample of Group H-Type

Group 3: HA-type

Table 3: Group 3. HA –Types (4 layers): Resistive – Conductive – Resistive – resistive [$P_1 > P_2 < P_3 < P_4$]

VES	P_1 (Ωm)	d_1 (m)	P_2 (Ωm)	d_2 (m)	P_3 (Ωm)	d_3 (m)	P_4 (Ωm)
32	13.71	0.24	7.55	1.56	14.96	7.60	190.8
41	16.97	0.12	7.59	1.48	24.04	8.0	259.4

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The group comprises of VES 32 and 41 (Table 3). They are four-layer earth model section characterized by layering sequence; Resistive – Conductive – Resistive - Resistive (Fig. 7). The resistivity values of the topsoil for the group ranged between 13.5 Ωm to 16.97Ωm with depth ranging between 0.12m to 0.24m. The second layer has resistivity values ranged between 7.55Ωm to 7.59Ωm with depth values ranging between 1.48m to 1.56m. The third layer has the resistivity values ranging between 14.96Ωm to 24.04Ωm with depth ranged between 7.60m to 8.0m. The fourth layer (assumed basement) has the resistivity values ranging between 190.8 Ωm to 259.4 Ωm. These two VES points (under HA-type) appears to be promising and suitable for groundwater (especially for hand-dug well) development. The third and the fourth layer appeared to be weathered and the overburden reasonable enough to favour hand-dug well(s).

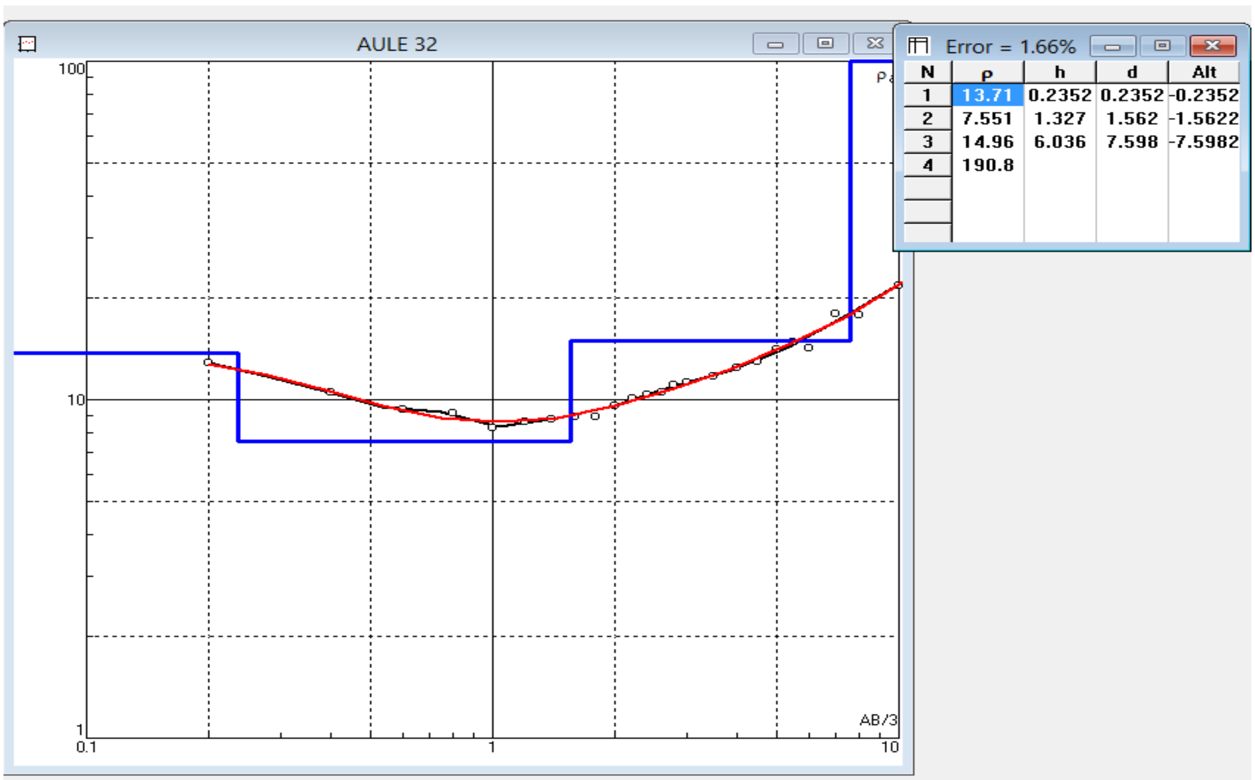

Figure 7: A Sample of Group HA-Type

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Group 4: HK-type

Table 4: Gro.4. HK – (4 layers): Resistive – conductive – Resistive – Conductive [$P_1 > P_2 < P_3 > P_4$]

VES	P_1 (Ωm)	d_1 (m)	P_2 (Ωm)	d_2 (m)	P_3 (Ωm)	d_3 (m)	P_4 (Ωm)
11	17.83	0.29	6.97	1.89	87.85	4.27	0.17
12	42.82	2.19	7.73	2.19	98.92	4.48	4.00

The group comprises of VES 11and 12 (Table 4). They are four-layer earth model section characterized by layering sequence; Resistive – Conductive – Resistive - Conductive (Fig. 8). The resistivity values of the topsoil for the group ranged between 17.83Ωm to 42.82Ωm with depth ranging between 0.29m to 2.19m. The second layer has resistivity values ranged between 6.97Ωm to 7.73Ωm with depth values ranging between 1.89m to 2.19m. The third layer has the resistivity values ranging between 87.85Ωm to 98.92Ωm with depth ranged between 4.27m to 4.48m. The fourth layer (assumed basement) has the resistivity values ranging between 0.17Ωm to 4.00Ωm. None of these VES points (under HK-type) appears to be promising and suitable for groundwater development. The resistivity lows suggest the formation under these VES points to be clay; couple with the very thin overburden will definitely be a draw back for groundwater development.

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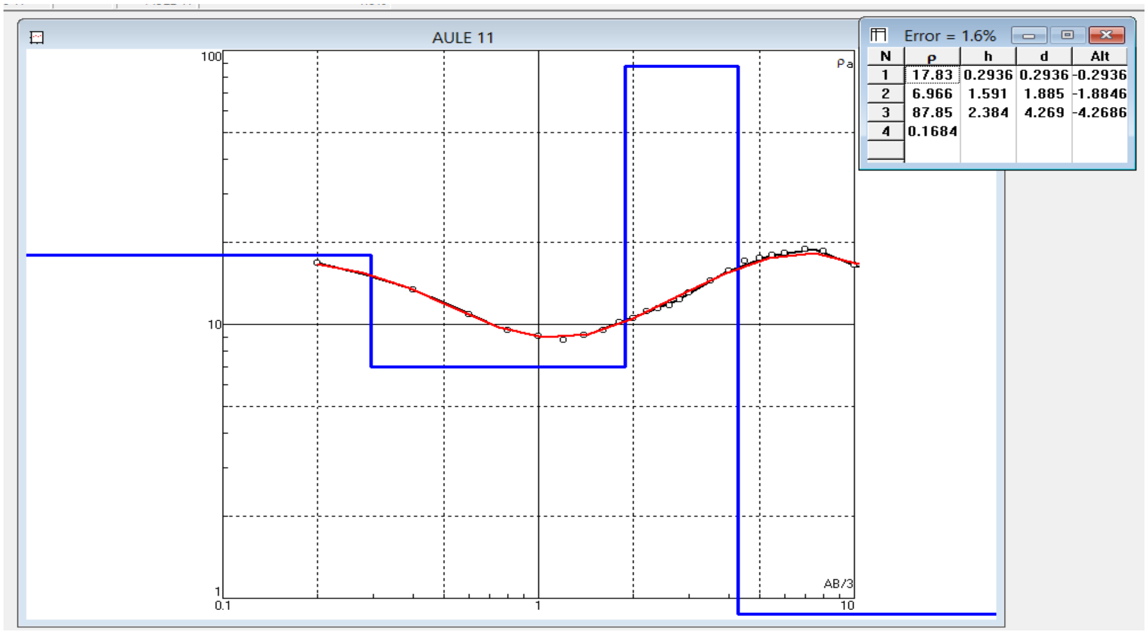

Figure 8: A Sample of Group HK-Type

Group 5: KH - type

Table 5: Group 5. KH – (4 layers): Conductive – Resistive – conductive – Resistive [$P_1<P_2>P_3<P_4$]

VES	P_1 (Ωm)	d_1 (m)	P_2 (Ωm)	d_2 (m)	P_3 (Ωm)	d_3 (m)	P_4 (Ωm)
1	99.18	0.11	344.5	0.24	12.73	8.54	205.9
2	226	0.41	405	1.11	4.68	3.04	63.1
4	17.16	0.26	67.1	0.54	6.90	2.38	23.91
5	84.4	0.10	531	0.24	4.47	1.38	44.1
8	8.95	0.42	17.8	0.84	4.13	1.75	19.09
21	27.74	0.25	64.02	0.53	2.27	1.13	65.01
23	6.92	0.12	11.48	0.53	6.5	2.37	352
34	15.17	0.12	105.2	0.26	7.63	2.65	34.3
36	9.30	0.12	15.26	0.54	7.19	2.38	35.59

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37	6.80	0.12	23.34	0.25	6.32	2.40	105
42	8.87	0.12	38.61	0.25	7.11	2.38	15.65
45	6.06	0.12	52.65	0.25	4.77	1.23	38.33

The group comprises of 12 VES points (Table 5). They are four-layer earth model section characterized by layering sequence; Conductive – Resistive – Conductive - Resistive (Fig. 9). The resistivity values of the topsoil for the group ranged between 6.06Ωm to 226Ωm with depth ranging between 0.10m to 0.42m. The second layer has resistivity values ranged between 15.26Ωm to 344.5Ωm with depth values ranging between 0.24m to 1.11m. The third layer has the resistivity values ranging between 2.27Ωm to 12.73Ωm with depth ranged between 1.13m to 8.4m. The fourth layer (assumed basement) has the resistivity values ranging between 15.65Ωm to 352Ωm. None of these VES points appears to be promising and suitable for groundwater development exceptVES1 whose third and fourth layers appeared weathered and so could be considered for groundwater development especially for hand-dug well. The resistivity lows suggesting clay; couple with the very thin overburden will definitely be a draw back for groundwater development for other VES points.

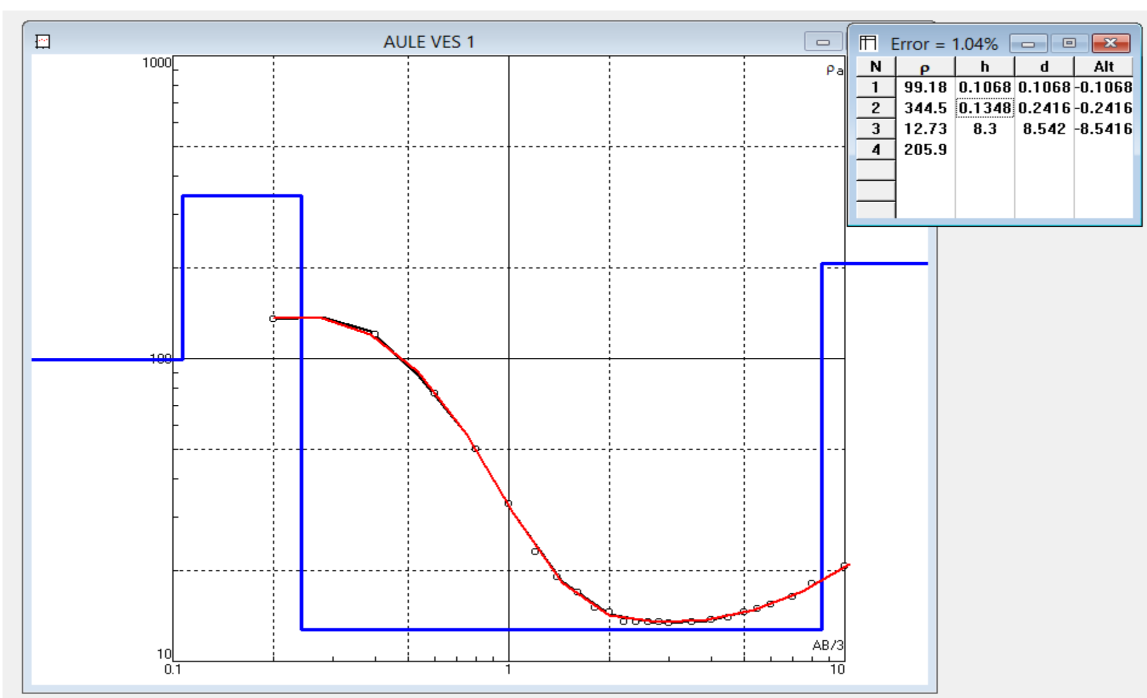

Figure 9: A Sample of Group KH-Type

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Group 6: QH - type

Table 6: Group 6. QH – (4 layers): Resistive – Conductive – Conductive – Resistive [$P_1>P_2>P_3<P_4$]

VES	P_1 (Ωm)	d_1 (m)	P_2 (Ωm)	d_2 (m)	P_3 (Ωm)	d_3 (m)	P_4 (Ωm)
2	41.56	0.16	12.57	0.53	6.36	2.35	36.87
13	52.7	0.12	12	0.53	7.74	5.0	2430
20	21.91	0.12	13.2	0.53	5.43	2.37	159
24	41.66	0.16	12.57	0.53	6.36	2.35	36.89
26	58.55	0.08	11.09	0.48	7.55	2.45	35.61
27	77.24	0.42	8.16	0.73	6.19	3.74	19.03
30	132	0.09	32.5	0.40	6.79	2.38	44.23
46	25.39	0.17	13.74	0.79	6.37	2.42	55.67

The group comprises of 8 VES points (Table 6). They are four-layer earth model section characterized by layering sequence; Resistive – Conductive – Conductive - Resistive (Fig. 10). The resistivity values of the topsoil for the group ranged between 21.91Ωm to 132Ωm with depth ranging between 0.08m to 0.42m. The second layer has resistivity values ranged between 8.16Ωm to 32.5Ωm with depth values ranging between 0.40m to 0.79m. The third layer has the resistivity values ranging between 5.43Ωm to 7.74Ωmwith depth ranged between 2.35m to 5.0m. The fourth layer (assumed basement) has the resistivity values ranging between 19.03Ωm to 2430Ωm. None of these VES points appears to be promising and suitable for groundwater development exceptVES13whose third and fourth layers appeared weathered with reasonable overburden and so could be considered for groundwater development especially for hand-dug well. The resistivity lows suggesting clay; couple with the very thin overburden will definitely be a drawback for groundwater development for other VES points.

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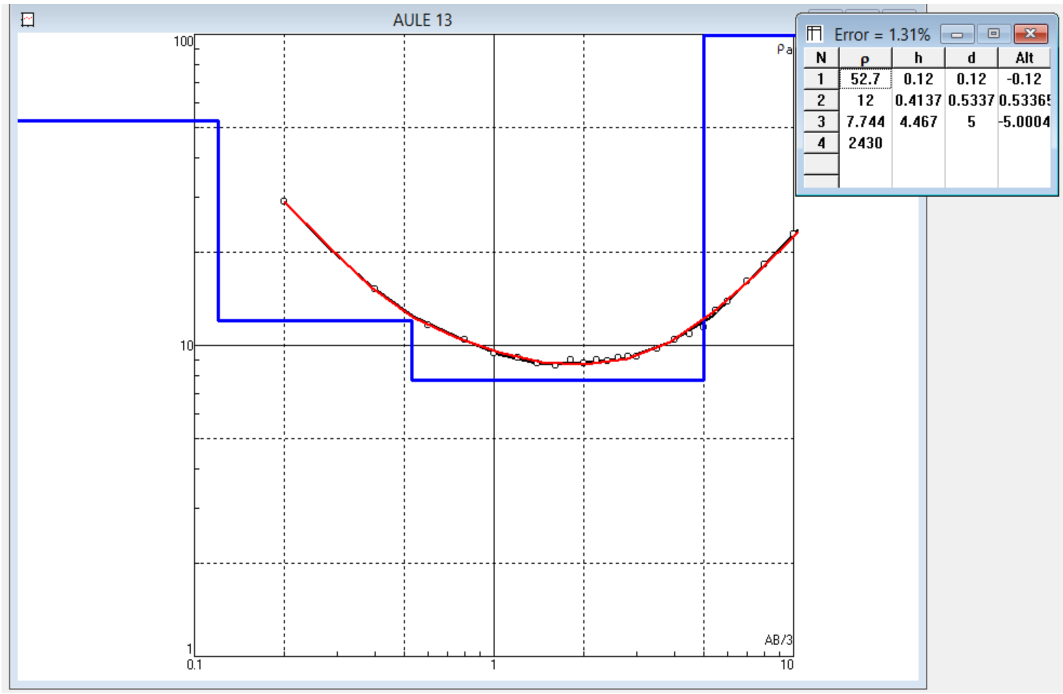

Figure 10: A Sample of Group QH-Type

Group 7: HKH - type

Table 7: Group 7. HKH (5layers): Resistive – Conductive – Resistive – Conductive – Resistive [$P_1 > P_2 < P_3 > P_4 < P_5$]

VES	P_1 (Ωm)	d_1 (m)	P_2 (Ωm)	d_2 (m)	P_3 (Ωm)	d_3 (m)	P_4 (Ωm)	d_4 (m)	P_5 (Ωm)
14	19.4	0.12	3.94	0.25	28.5	0.53	3.29	1.12	27.8
35	35.02	0.11	4.12	0.22	23.62	0.54	5.40	2.035	56.28

The group comprises of VES 14 and 35 (Table 7). They are five-layer earth model section characterized by layering sequence; Resistive – Conductive – Resistive – Conductive - Resistive (Fig. 11). The resistivity values of the topsoil for the group ranged between 19.4Ωm to 35.02Ωm with depth ranging between 0.11m to 0.12m. The second layer has resistivity values ranged between 3.94Ωm to 4.12Ωm with depth values ranging between 0.22m to 0.25m. The third layer has the resistivity values ranging between 23.62Ωm to 28.5Ωm with depth ranged between 0.53m to 0.54m. The fourth layer has the resistivity values ranging between 3.29 Ωm to 5.40

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Ωm with depth ranged between1.12m to 2.04m.While the fifth layer (assumed basement) has resistivity values ranging between 27.8 Ωm to 56.28 Ωm. None of these VES points appears to be promising and suitable for groundwater development The resistivity lows suggesting clay; couple with the very thin overburden will definitely be a draw back for groundwater development for the VES points.

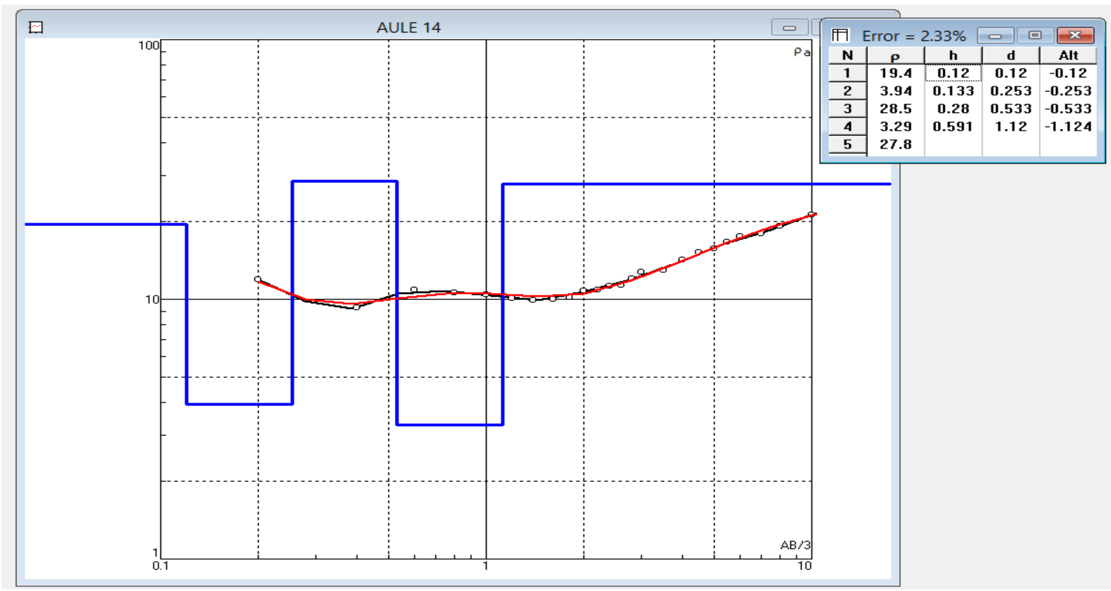

Figure 11: A Sample of Group HKH-Type

Group 8: KQH - type

Table 8: Group 8. KQH (5layers): Conductive – Resistive – Conductive – Conductive – Resistive [$P_1<P_2>P_3>P_4<P_5$]

VES	P_1 (Ωm)	d_1(m)	P_2 (Ωm)	d_2 (m)	P_3 (Ωm)	d_3 (m)	P_4 (Ωm)	d_4 (m)	P_5 (Ωm)
3	32.49	0.17	126.1	0.32	8.63	2.80	3.95	5.41	920.7
17	38.11	0.12	203.1	0.25	5.88	1.13	13.44	2.37	41.08
19	36.59	0.25	48.86	0.53	5.93	1.13	11.04	2.37	22.13
40	19.3	0.13	60.17	0.37	4.43	0.91	30.8	10	157.8

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43	8.37	0.98	57.88	0.24	4.91	0.88	17.95	7.97	1478
44	7.41	0.12	56.1	0.25	5.32	1.14	13.9	5.05	295
47	24.22	0.25	44.16	0.53	2.61	1.13	69.17	2.37	19.09

The group comprises of 7 VES points (Table 8). They are five-layer earth model section characterized by layering sequence; Conductive – Resistive – Conductive – Conductive - Resistive (Fig. 12). The resistivity values of the topsoil for the group ranged between 7.41Ωm to 38.11Ωm with depth ranging between 0.12m to 0.98m. The second layer has resistivity values ranged between 44.16Ωm to 203.1Ωm with depth values ranging between 0.24m to 0.53m. The third layer has the resistivity values ranging between 2.61Ωm to 8.63Ωm with depth ranged between 0.88m to 2.80m. The fourth layer has the resistivity values ranging between 3.95Ωm to 30.8Ωm with depth ranged between 2.37m to 10.0m. While the fifth layer (assumed basement) has resistivity values ranging between 19.09Ωm to 1478Ωm. VES points 3, 40, 43 and 44 appears to be promising and suitable for groundwater (especially for hand-dug well) development in view of their reasonable overburden thickness especially when the fifth layer is penetrated.

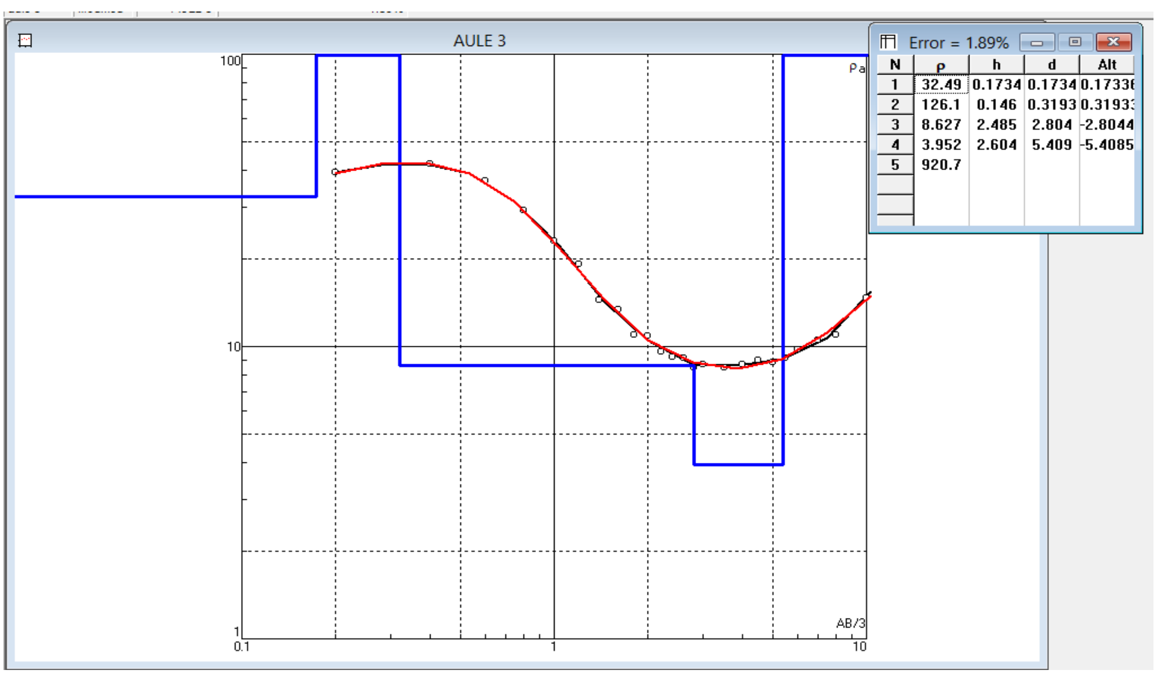

Figure 12: A Sample of Group KQH-Type

Group 9: KHKH - type

Table 9: Group 9. KHKH (6layers): Conductive – Resistive – Conductive – resistive – Conductive – Resistive [$P_1<P_2>P_3<P_4>P_5<P_6$]

VES	P_1(Ωm)	d_1(m)	P_2(Ωm)	d_2(m)	P_3(Ωm)	d_3(m)	P_4(Ωm)	d_4(m)	P_5(Ωm)	d_5(m)	P_6(Ωm)
39	14.7	0.12	65.94	0.25	5.45	1.15	28.7	2.40	3.28	5.028	104.2

The group comprises of only VES 39 (Table 9). It is a six-layer earth model section characterized by layering sequence; Conductive – Resistive – Conductive – Resistive – Conductive - Resistive (Fig. 13). The resistivity value of the topsoil is 14.7Ωm with depth of 0.12m. The second layer has resistivity value of 65.94Ωm with depth value of 0.25m, the third layer has the resistivity value of5.45Ωm with depth of 1.15m. The fourth layer has the resistivity value of 28.7Ωm with depth of 2.40m, the fifth layer is with a resistivity value of 3.28 Ωm and depth of 5.03m. While the sixth layer (assumed basement) has resistivity value of 104.2Ωm.This VES point appears to be promising and suitable for groundwater (especially for hand-dug well) development in view of its reasonable overburden thickness especially when the sixth layer is penetrated.

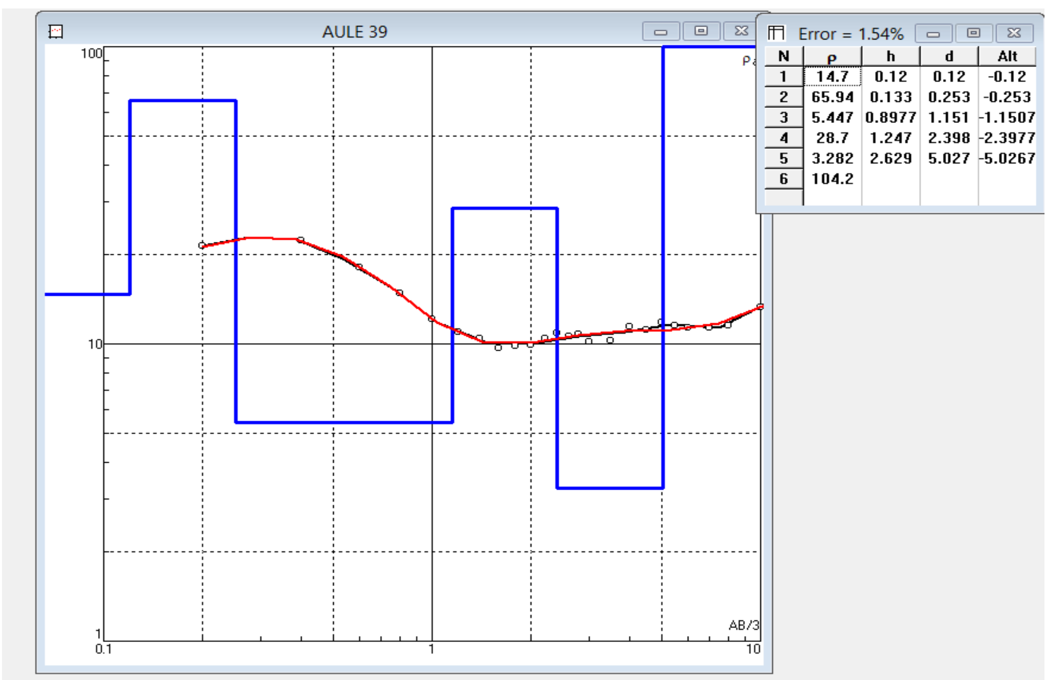

Figure 13: A Sample of Group KHKH-Type

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Table 10: Summary of the Geoelectric Parameters and their Hydrogeological Significance

VES Station	Curve Characteristics	Curve Type	No. of layers	Resistivity (Ωm)	Thickness (m)	Depth (m)	Inferred lithology	Hydrogeological Significant
1	$P_1<\rho_2>\rho_3<\rho_4$	KH	1	99.18	0.11	0.11	Topsoil	-
			2	344.4	0.13	0.24	Weathered layer	- Poor aquifer potential
			3	12.73	8.3	8.54	Fractured layer	Good aquifer potential
			4	205.9	-	-	Fractured basement	Good aquifer potential
2	$P_1<\rho_2>\rho_3<\rho_4$	KH	1	226	0.41	0.41	Topsoil	-
			2	405	0.70	1.11	Weathered layer	Poor aquifer potential
			3	4.68	1.93	3.04	Clay	Poor aquifer potential
			4	63.1	-	-	Basement	-
3	$P_1>\rho_2>\rho_3<\rho_4$	QH	1	32.49	0.17	0.17	Topsoil	-
			2	126.1	0.14	0.31	Weathered layer	Poor aquifer potential
			3	8.63	2.49	2.80	Clay	Poor aquifer potential
			4	3.95	2.60	5.40	Clay	Poor aquifer potential

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			5	920.7	-	-	Fractured basement	Fair aquifer
4	$P_1<\rho_2>\rho_3<\rho_4$	KH	1	17.16	0.26	0.26	Topsoil	-
			2	67.1	0.28	0.54	Clay	Poor aquifer potential
			3	6.90	1.84	2.38	Clay	Poor aquifer potential
			4	23.91	-	-	Clayey	-
5	$P_1<\rho_2>\rho_3<\rho_4$	KH	1	84.4	0.10	0.10	Topsoil	-
			2	531.0	0.14	0.24	Clayey	Poor aquifer potential
			3	4.47	1.14	1.38	Clay	Poor aquifer potential
			4	44.1	-	-	Clayey	-
6	$P_1>\rho_2<\rho_3$	H	1	21.05	1.19	1.19	Topsoil	-
			2	1.76	1.29	2.48	Clay	Poor aquifer potential
			3	1530	-	-	Basement	-
7	$P_1>\rho_2<\rho_3$	H	1	2511	0.24	0.24	Topsoil	-
			2	7.15	2.0	2.24	Clay	Poor aquifer potential
								Poor aquifer

			3	37.8	-	-	Clay	potential
8	$P_1<\rho_2>\rho_3<\rho_4$	KH	1	8.95	0.43	0.43	Topsoil	-
			2	17.8	0.41	0.84	Clay	Poor aquifer potential
			3	4.13	0.92	1.76	Clay	Poor aquifer potential
			4	19.09	-	-		-
9	$P_1>\rho_2<\rho_3$	H	1	17.19	0.42	0.42	Topsoil	-
			2	7.37	1.88	2.30	Clay	Poor aquifer potential
			3	45.4	-	-	Clayey	-
10	$P_1>\rho_2<\rho_3$	H	1	83.48	0.12	0.12	Topsoil	-
			2	9.81	3.85	3.97	Clay	Poor aquifer potential
			3	37.15	-	-	clayey	-
11	$P_1>\rho_2<\rho_3>\rho_4$	HK	1	17.83	0.29	0.29	Topsoil	-
			2	7.0	1.59	1.88	Clay	Poor aquifer potential
			3	87.85	2.38	4.26	Clayey	Poor aquifer potential
			4	0.17	-	-	Peat	-
12	$P_1>\rho_2<\rho_3>\rho_4$	HK	1	42.82	0.68	0.68	Topsoil	-
			2	7.73	1.51	2.19	Clay	Poor aquifer potential

			3	98.92	2.29	4.48	Weathered layer	Fair aquifer
			4	4.00	-	-	Clay	Poor aquifer potential
13	$P_1>\rho_2>\rho_3<\rho_4$	QH	1	52.7	0.12	0.12	Topsoil	-
			2	12.0	0.41	0.53	Clay	Poor aquifer potential
			3	7.74	4.47	5.00	Clay	Poor aquifer potential
			4	2430	-	-	Basement	-
14	$P_1>\rho_2>\rho_3<\rho_4<\rho_5$	HKH	1	19.4	0.12	0.12	Topsoil	-
			2	3.94	0.13	0.25	Clay	Poor aquifer potential
			3	28.5	0.28	0.53	Clay	Poor aquifer potential
			4	3.29	0.59	1.12	Clay	Poor aquifer potential
			5	27.8	-	-	Clay	-
15	$P_1>\rho_2<\rho_3$	H	1	20.18	0.40	0.40	Topsoil	-
			2	7.39	3.08	3.84	Clay	Poor aquifer potential
			3	35.07	-	-	Clayey	-
16	$P_1>\rho_2<\rho_3$	H	1	16.98	0.07	0.07	Topsoil	-
			2	8.83	2.82	2.89	Clay	Poor aquifer potential

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			3	85.76	-	-	Clayey	-
17	$P_1>\rho_2>\rho_3<\rho_4<\rho_5$	KQH	1	38.11	0.12	0.12	Topsoil	-
			2	203.1	0.13	0.25	Weathered layer	Poor aquifer potential
			3	5.88	0.87	1.12	Clay	Poor aquifer potential
			4	13.44	1.25	2.37	Clay	Poor aquifer potential
			5	41.08	-	-	Clayey	-
18	$P_1>\rho_2<\rho_3$	H	1	43.61	0.32	0.32	Topsoil	-
			2	5.16	1.56	1.88	Clay	Poor aquifer potential
			3	108.8	-	-	Fractured Basement	-
19	$P_1<\rho_2>\rho_3>\rho_4<\rho_5$	KQH	1	36.59	0.25	0.25	Topsoil	-
			2	48.86	0.28	0.53	Weathered layer	Poor aquifer potential
			3	5.93	0.59	1.12	Clay	Poor aquifer potential
			4	11.04	1.25	2.40	Clay	Poor aquifer potential
			5	22.13	-	-	Clay	-

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20	$P_1>\rho_2>\rho_3<\rho_4$	QH	1	21.91	0.12	0.12	Topsoil	-
			2	13.2	0.41	0.53	Clay	Poor aquifer potential
			3	5.43	1.83	2.36	Clay	Poor aquifer potential
			4	159.1	-	-	Weathered layer	Poor aquifer potential
21	$P_1<\rho_2>\rho_3<\rho_4$	KH	1	27.74	0.25	0.25	Topsoil	-
			2	64.02	0.28	0.53	Weathered layer	Poor aquifer potential
			3	2.27	0.59	1.12	Clay	Poor aquifer potential
			4	65.81	-	-	-	-
22	$P_1>\rho_2<\rho_3$	H	1	15.89	0.25	0.25	Topsoil	-
			2	9.49	2.13	2.38	Clay	Poor aquifer potential
			3	60.03	-	-	-	
23	$P_1<\rho_2>\rho_3<\rho_4$	KH	1	6.92	0.12	0.12	Topsoil	-
			2	11.48	0.41	0.53	Clayey	Poor aquifer potential
			3	6.5	1.84	2.37	Clay	Poor aquifer potential
			4	352	-	-	-	-
24	$P_1>\rho_2>\rho_3<\rho_4$	QH	1	41.66	0.157	0.16	Topsoil	

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			2	12.57	0.37	0.53	Clay	Poor aquifer potential
			3	6.36	1.82	2.35	Clay	Poor aquifer potential
			4	36.89	-	-	-	-
25	$P_1>\rho_2<\rho_3$	H	1	13.5	0.67	0.67	Topsoil	_
			2	8.55	3.15	3.82	Clay	Poor aquifer potential
			3	120.4	-	-	-	_
26	$P_1>\rho_2>\rho_3<\rho_4$	QH	1	58.55	0.08	0.08	Topsoil	-
			2	11.09	0.40	0.48	Clay	Poor aquifer potential
			3	7.55	1.96	2.44	Clay	Poor aquifer potential
			4	35.61	-	-	-	-
27	$P_1>\rho_2>\rho_3<\rho_4$	QH	1	77.24	0.04	0.04	Topsoil	-
			2	8.16	0.69	0.73	Clay	Poor aquifer potential
			3	6.19	3.01	3.74	Clay	Poor aquifer potential
			4	19.03	-	-	-	-

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28	$P_1<\rho_2<\rho_3$	A	1	6.40	1.17	1.17	Topsoil	-
			2	19.14	8.83	10.00	Weathered layer	Fair aquifer potential
			3	321.2	-	-	Fractured basement	Good aquifer potential
29	$P_1>\rho_2<\rho_3$	H	1	17.01	0.16	0.16	Topsoil	-
			2	7.83	2.11	2.27	Clay	Poor aquifer potential
			3	49.79	-	-	Weathered basement	Poor aquifer potential
30	$P_1>\rho_2>\rho_3<\rho_4$	QH	1	132	0.09	0.09	Topsoil	-
			2	32.5	0.31	0.40	Weathered layer	Poor aquifer potential
			3	6.79	1.98	2.28	Clay	Poor aquifer potential
			4	44.23	-	-	Weathered basement	Poor aquifer potential
31	$P_1>\rho_2<\rho_3$	H	1	98.91	0.43	0.43	Topsoil	-
			2	2.18	0.50	0.93	Clay	Poor aquifer potential
			3	23.72	-	-	-	-
32	$P_1>\rho_2<\rho_3<\rho_4$	HA	1	13.71	0.24	0.24	Topsoil	-
			2	7.55	1.33	1.57	Clay	Poor aquifer

								potential
			3	14.96	6.04	7.61	Weathered layer	Fair aquifer potential
			4	190.8	-	-	Fractured basement	Fair aquifer potential
33	$P_1>\rho_2<\rho_3$	H	1	13.82	0.25	0.25	Topsoil	-
			2	8.48	2.67	2.92	Clay	Poor aquifer potential
			3	55.06	-	-	-	-
34	$P_1<\rho_2>\rho_3<\rho_4$	KH	1	15.17	0.12	0.12	Topsoil	-
			2	105.2	0.14	0.26	Weathered layer	Poor aquifer potential
			3	7.63	2.39	2.65	Clay	Poor aquifer potential
			4	34.3	-	-	clayey	Poor aquifer potential
35	$P_1>\rho_2<\rho_3>\rho_4<\rho_5$	HKH	1	35.02	0.11	0.11	Topsoil	-
			2	4.12	0.11	0.22	Clay	Poor aquifer potential
			3	23.62	0.31	0.53	Clay	Poor aquifer potential
			4	5.40	1.50	2.03	Clay	Poor aquifer potential
			5	56.28	-	-	Weathered	Poor aquifer potential

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							layer	
36	$P_1<\rho_2>\rho_3<\rho_4$	KH	1 2 3 4	9.30 15.26 7.19 35.59	0.12 0.42 1.84 -	0.12 0.54 2.38 -	Topsoil Clay Clay -	- Poor aquifer potential Poor aquifer potential -
37	$P_1<\rho_2>\rho_3<\rho_4$	KH	1 2 3 4	6.80 23.34 6.37 105	0.12 0.13 2.15 -	0.12 0.25 2.40 -	Topsoil Weathered layer Clay -	- Poor aquifer potential Poor aquifer potential -
38	$P_1<\rho_2<\rho_3$	A	1 2 3	7.57 10 69.4	0.31 2.63 -	0.31 2.94 -	Topsoil Clay -	- Poor aquifer potential -

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39	$P_1<\rho_2>\rho_3<\rho_4>\rho_5<\rho_6$	KHKH	1	14.7	0.12	0.12	Topsoil	-
			2	65.94	0.13	0.25	Weathered layer	Poor aquifer potential
			3	5.45	0.90	1.15	Clay	Poor aquifer potential
			4	28.7	1.25	2.40	Clayey	Poor aquifer potential
			5	3.28	2.63	5.03	Fractured layer	Fair aquifer potential
			6	104.2	-	-	Fractured basement	Fair aquifer potential
40	$P_1<\rho_2>\rho_3>\rho_4<\rho_5$	KQH	1	19.3	0.13	0.13	Topsoil	-
			2	60.17	0.24	0.37	Weathered layer	Poor aquifer potential
			3	4.43	0.54	0.91	Clay	Poor aquifer potential
			4	30.8	9.09	10	Weathered layer	Fair aquifer potential
			5	157.8	-	-	Fractured basement	Good aquifer potential
41	$P_1>\rho_2<\rho_3<\rho_4$	HA	1	16.97	0.12	0.12	Topsoil	Topsoil
			2	7.60	1.35	1.47	Clay	Poor aquifer potential
			3	24.04	6.52	7.99	Weathered	Fair aquifer potential

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							layer	Good aquifer potential
			4	259.4	-	-	Fractured basement	
42	$P_1<\rho_2>\rho_3<\rho_4$	KH	1	8.87	0.12	0.12	Topsoil	-
			2	38.61	0.13	0.25	Weathered layer	Poor aquifer potential
			3	7.11	2.13	2.38	Clay	Poor aquifer potential
			4	15.65	-	-	-	-
43	$P_1<\rho_2>\rho_3>\rho_4<\rho_5$	KQH	1	8.37	0.10	0.10	Topsoil	-
			2	57.88	0.14	0.24	Weathered layer	Poor aquifer potential
			3	4.91	0.64	0.88	Clay	Poor aquifer potential
			4	17.95	7.10	7.98	Weathered layer	Fair aquifer potential
			5	295	-	-	Fractured basement	Fair aquifer potential
44	$P_1<\rho_2>\rho_3>\rho_4<\rho_5$	KQH	1	7.41	0.12	0.12	Topsoil	-
			2	56.1	0.13	0.25	Weathered layer	Poor aquifer potential
			3	5.32	0.89	1.14	Clay	Poor aquifer potential
			4	13.9	3.91	5.05	Weathered layer	fair aquifer potential
							Fractured	Fair aquifer potential

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			5	295	-	-	basement	
45	$P_1<\rho_2>\rho_3<\rho_4$	KH	1	6.06	0.12	0.12	Topsoil	-
			2	52.65	0.13	0.25	Weathered layer	Poor aquifer potential
			3	4.77	0.98	1.23	Clay	Poor aquifer potential
			4	38.33	-	-	clayey	Poor aquifer potential
46	$P_1<\rho_2>\rho_3<\rho_4$	QH	1	25.39	0.17	0.17	Topsoil	-
			2	13.74	0.62	0.79	Clay	Poor aquifer potential
			3	6.37	1.63	2.42	Clay	Poor aquifer potential
			4	55.67	-	-	Weathered layer	Poor aquifer potential
47	$P_1<\rho_2>\rho_3>\rho_4<\rho_5$	KQH	1	24.22	0.25	0.25	Topsoil	-
			2	44.16	0.28	0.53	Weathered layer	Poor aquifer potential
			3	2.61	0.59	1.12	Clay	Poor aquifer potential
			4	69.17	1.25	2.37	Weathered layer	Poor aquifer potential
							Fractured	Poor aquifer potential

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			5	19.09	-	-	layer	
48	$P_1>\rho_2<\rho_3$	H	1	80.66	0.09	0.09	Topsoil	-
			2	9.51	2.89	2.98	Clay	Poor aquifer potential
			3	62.96	-	-	Weathered layer	Poor aquifer potential

4.2 Maps

4.2.1 The elevation map

The elevation ranges between 320m to 375m (Fig. 14). The northern part is of high elevation ranged between 350m to 375m, while the eastern, western and southern part is of low elevation which ranged between 320m to 350m. The areas with low elevation are adjudged good for groundwater accumulation. So the eastern, western and southern part of the study area is expected to be viable for groundwater accumulation.

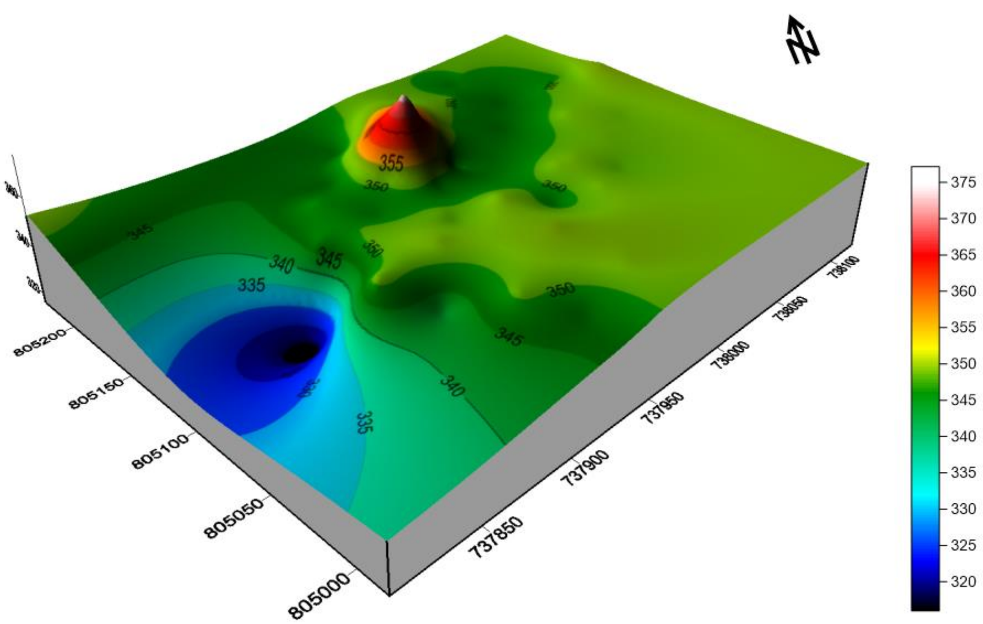

Figure 14: Elevation map of the study area (measured in metre m)

4.2.2 Isoresistivity map of the study area

The isoresistivity map of the study area (Fig. 15)was generated to determine the overview resistivity across all the VES stations in the study area. The map was generated by contouring the average resistivity of each VES station using surfer 12 Microsoft software, and superposed on base map. The northern, eastern and southeastern parts (blue/navy blue colour coded) of the study area is observed to be having low resistivity value (between 0 Ωm to 100 Ωm), while the northwestern trending southwestern parts (green/yellow/red colour coded) are of high resistivity zones (between 100 Ωm to 825 Ωm). The isoresistivity map showed the northern, eastern, southwestern parts appearing to be promising zones for groundwater development.

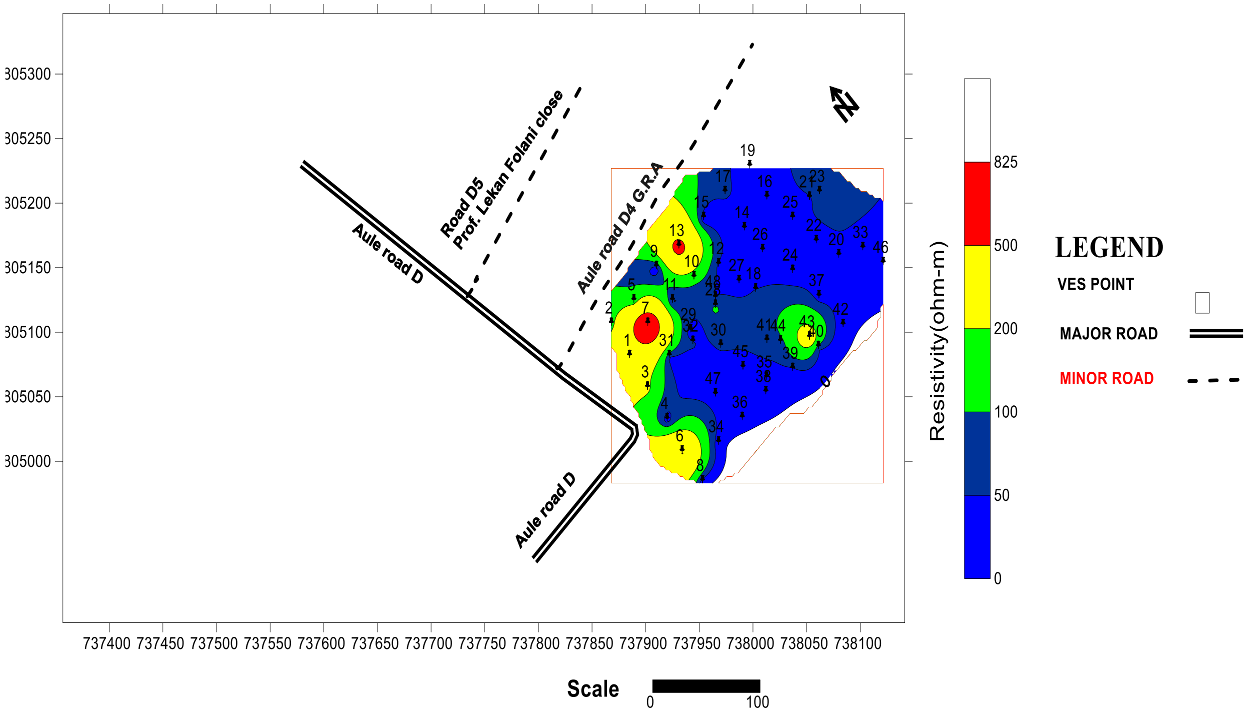

Fig 15: Isoresistivity map of the study area

4.2.3 Overburden Thickness map

The overburden thickness map of the study area (Fig. 16) was generated to determine the overview overburden thickness across all the VES stations in the study area. The western part trending eastern part with some southwestern part, including an isolated zone in the northern part (green/red colour coded) showed reasonable overburden thickness ranged between 3m to

10m.According to [22], [28], the highest groundwater yields are found in areas where thick overburden overlie fracture/weathered zones. Therefore, the zones with overburden thickness between 3.5m to 5m are recommended for shallow well development while those zones with thickness greater than 5m recommended for deep-wells and boreholes especially when it is underlained by fractured basement. So the western part trending eastern part are better and recommended zones for ground water development in the study area in view of the reasonable overburden thickness.

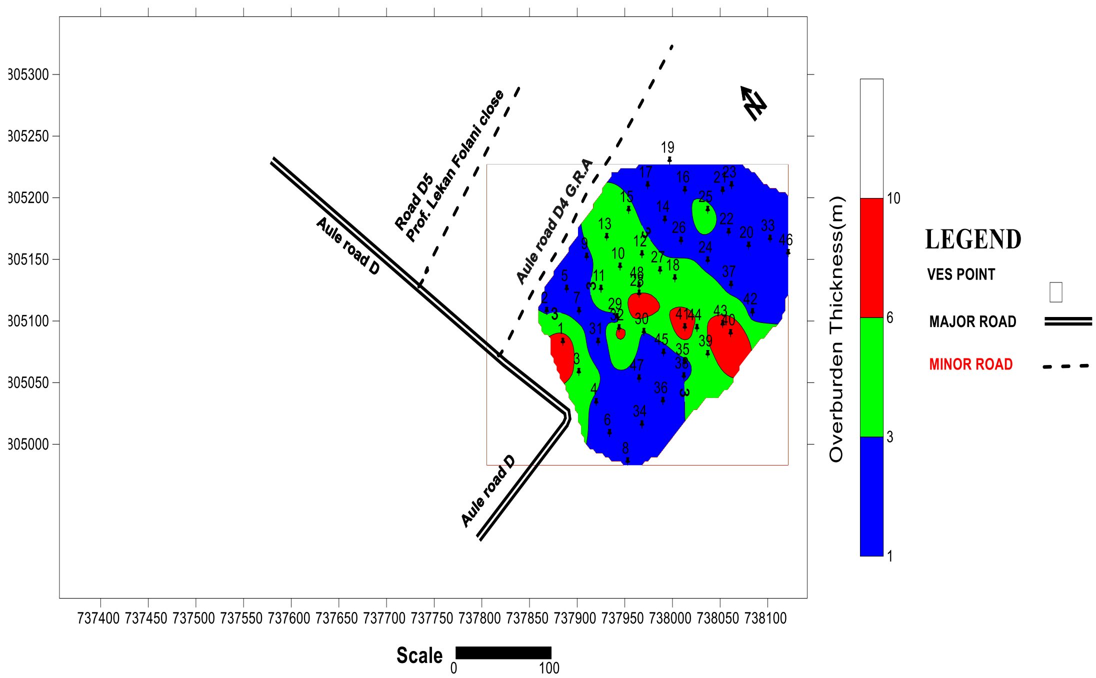

Figure 16: Overburden Thickness Map of the study area

4.2.4 Aquifer Resistivity Map of the Study Area

Figure 17, Showed the resistivity map of the viable aquifers recommended for shallow wells in the study area. The low resistivity values are attributed to clay and peat in the study area. The areas with no aquifer potentials in terms of resistivity are distributed on the map with ash colour coded while other areas with observed aquifer potential are colour coded with blue (3 Ωm to 20 Ωm),green (20 Ωm to 30 Ωm),yellow (3 Ωm to 70 Ωm). This result showed that the western parts trending east appear to be viable for groundwater development.

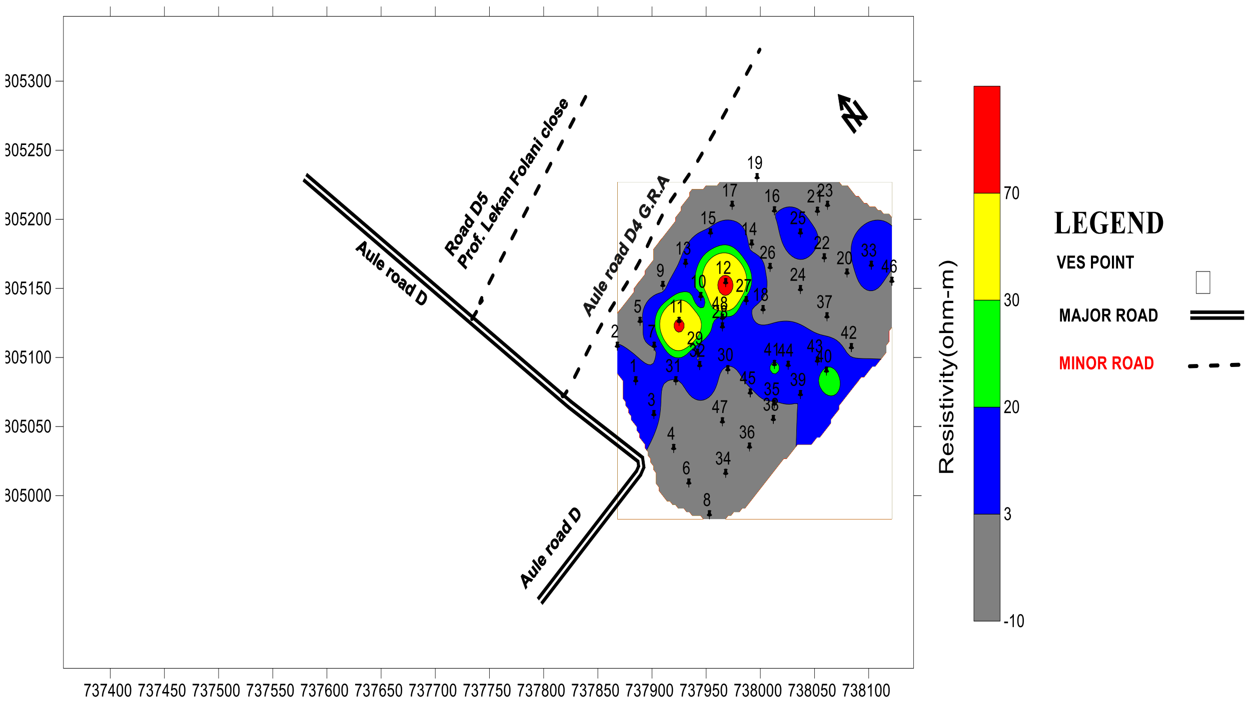

Figure 17: Aquifer Resistivity Map of the Study Area

4.2.5 Aquifer Thickness Map

The aquifer thickness map of the study area (Fig. 18) was generated to determine the overall thickness of the suspected and delineated aquifers across the VES stations in study area. The map showed the thickness of the aquifer with values ranged between 1.9m to 9.1m. For the study area the promising aquifers thickness ranged between 3m to 9.1m, hence, the northwest trending southeast, southwest and two isolated zones in the northern part of the study area (colour coded, green, blue and red) appears to be suitable for shallow well groundwater development. The green and red colour coded zones are adjudged suitable for shallow groundwater development.

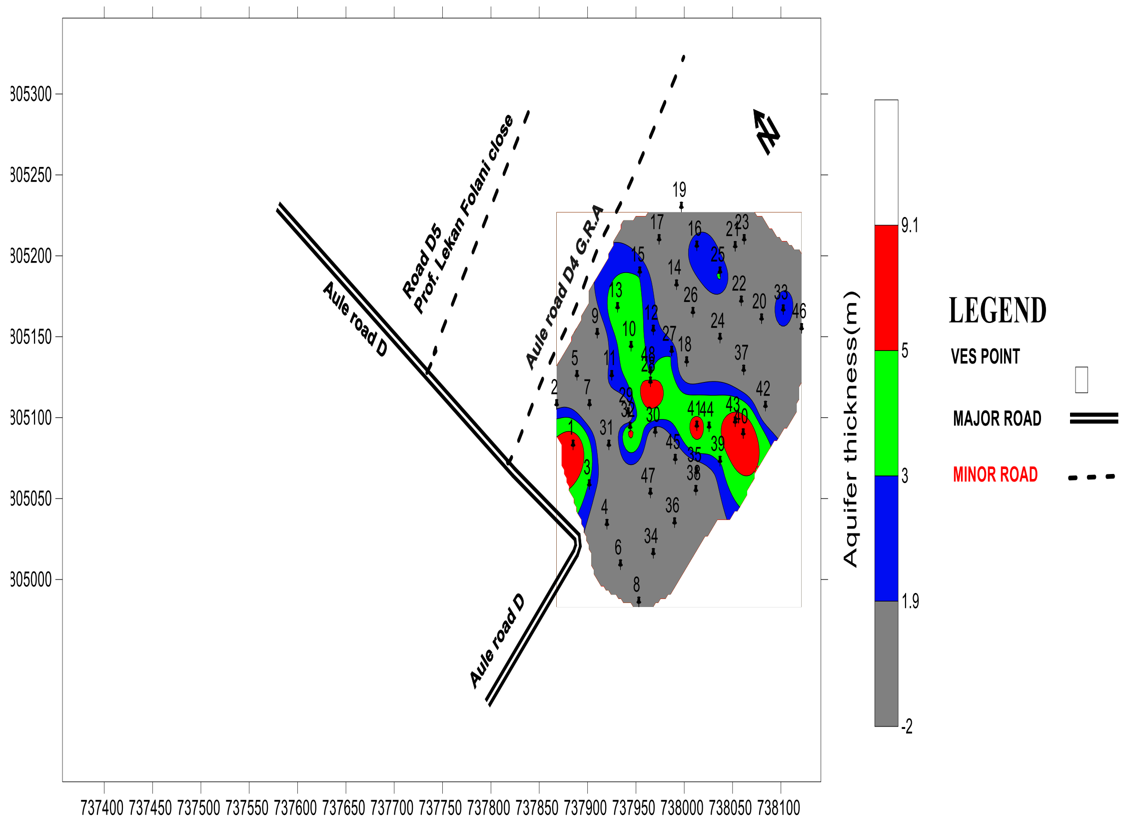

Figure 18: Aquifer Thickness Map of the Study Area

5. CONCLUSION

Geophysical investigation involving the use of Electrical Resistivity method using Modified Wenner Array Configuration has been adopted for shallow groundwater potential evaluation over a floodplain at AULE, Akure southwestern Nigeria for irrigation purposes. This project presents the result from the quantitative interpretation of forty eight VES obtained from the survey area which has helped in the identification of aquiferous units and has provided an understanding of aquifer characteristics especially the thickness and depth to fractured zones which are required for locating points with high potentials for groundwater occurrence.

The Vertical Electrical Sounding technique result delineated three to six (3-6) subsurface geologic layers (top soil, clay, clay, weathered layer, partly weathered layer and bedrock). The lithology of the subsurface strata is mainly clay (expansive clay) which justifies the dominance of low resistivity values and explains why the runoff water via flood doesn't infiltrate the soil. The overburden thickness and aquifer resistivity were used in classifying the groundwater potential of the study area. Areas having moderate overburden with thickness between 5m and

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10m with weathered layer above 4 Ωm such as VES 1, 3, 13, 28, 32, 39, 40, 41, 43 and 44 are delineated to be promising sites for shallow wells.

REFERENCES

[1] Ogunjimi, L.A.O. and Adekalu, K.O. (2007): Problems and Constraints of Small-scale Irrigation (FADAMA) in Nigeria. Food Reviews International, vol.18, issue 4, PP295-304

[2] Alagbe, O.A. and Faleye, E. O. (2020): 2D Electrical Resistivity Imaging (ERI) for Subsurface Evaluation of a Pre-engineering Construction Site in Akure, Southwestern Nigeria. International Journal of Environmental Monitoring and analysis, Vol. 8, No. 2, PP 33-44.

[3] Matanmi, M.M.; Falola, A.; Animashaun, J.O. and Atanda, T.O. (2017): Effect of Fadama III program on dry-season vegitable growers in Kwarastate , Nigeria. Kasetsart Journal of Social Sciences, PP 164-167.

[4] Henning B., Andre V. R. and Richard S. (2016): Profitability and Productivity barriers and Opportunities in small-scale irrigation Schemes. International Journal of Water Resources Development, 33:5, 690-704.

[5] Babatunde M. M., Abraham F., Jubril O. A. and Temitope O. A. (2017): Effect of Fadama iii program on dry-season vegetable growers inKwara State, Nigeria. Kasetsart Journal of Social Sciences, PP163-167.

[6] World Bank (2008): Agriculture for development. In: World development report. The World Bank, Washington DC.

[7] Ekenta, C.M.; Usman, K. and Ojeleye, O.A. (2015): Impact of Fadama III project on the Food security status of beneficiary and non-beneficiary farmers in Kabba/Bunu LGA, Kogi. Journal of Biology, Agriculture and Healthcare, vol.5, No.24, PP 22- 28

[8] Federal Emergency Management Agency (1992):Floodplain Management in the United State: An assessment report volume 2.

[9] FAO (1996): Report of the World Food Summit, Rome, Italy

[10] Tanyeri-Abur, A. (2015): Food security in Southern Meditarranean/North Africa. The Sustainability of Agro-Food and Natural Resource Systems in the Mediterranean Basin. Springer Cham Heidelberg New York Dordrecht London, PP1-14

[11] Adeeko, T.O. and Buba, A.A. (2016): Using Geo-Electrical Method of Estimation In Groundwater For Irrigation potentials of Kiyi Community, Kuje Area Council, Abuja, Nigeria. European Journal of Academic Essays, vol.3 (4), PP 156-168

[12] Adanu, E.A. (1994): Groundwater Development and Management in the Basement Complex Terrain in Zaria, Kaduna Area. Water Resources Bulletin, 4 (1&2), PP 64-68.

ISSN: 2455-6939

Volume: 08, Issue: 02 "March-April 2022"

[13] Omotoso, O.A.; Ojo, O.J.; Morakinyo, E.P. and Alao, D.A. (2012) :Hydro-Geophysical Study of River Niger Floodplain at Jebba-North, Nigeria. Journal of Emerging Trends in Engineering and Applied Sciences, 3(1), PP 152-158

[14] Muchingami, I., Hlatywayo, D.J., Nel, J.M., Chuma, C. (2012): Electrical resistivity survey for groundwater investigations and shallow subsurface evaluation of the basaltic-greenstone formation of the urban Bulawayo aquifer. Physics and Chemistry of the Earth, 50–52, pp.44–51.

[15] Alagbe, O.A. (2018): 2D Geoelectrical Resistivity Imaging for the Assessment of subsurfacesoil corrosivity zones at a proposed filling station site in Akure Southwestern Nigeria. International Advanced Research Journal in Science Engineering and Technology, vol. 5, Issue 11.

[16] Kitchen, N.R.; Sudduth, K.A.; Kremer, R.J. and Myers, D.B. (2010): Mapping the soil Health of Agricultural fields via soil electrical conductivity. FastTimes, vol.15, no. 4, PP 41-47.

[17] Barry, J.A and Robbert, S.F. (2010): Application of Geophysical Methods to Agriculture: An Overview.FastTimes, vol.15, no. 4 , PP 13-25.

[18] Olorunfemi M. O. and Fasuyi S. A. (1993): Aquifer types and the Geoelectric/Hydrogeologiccharacteristics of part of the central basement terrain of Nigeria (Niger state). Journal of African Earth Sciences 16, 309-317.

[19] Ballukraya PN, Jagadeeshesan MS, Rukmangandar Reddy B (1988): Delineation of geological contacts by electrical resistivity soundings. J AssocExplGeophys 9(1):31–36.

[20] Appa Rao S, Nageswara Rao PV, Satyanarayana KVV (2009): Groundwater potential zones in Tanuku area of West Godavari district, Andhra Pradesh. Acharya Nagarjuna Univ J Nat Sci 1(1):53–57

[21] Narasimha Prasad NB (2011): Geophysical investigation for groundwater exploration in Lakshadweep Island- a case study. J IndianGeophys Union 15(4):221–227

[22] Alagbe. O.A., Sanusi S.O, Bamigboye A.A, (2019): 2D Electrical Resistivity Prospecting for Groundwater at the premises of the staff Quarters of Elizade University, Ilara Mokin, Ondo state. World Journal of Innovative Research (WJIR), vol.6, Issue 2 pg. 100-108.

[23] Bawallah, M.A., Adebayo, A., Ilugbo, S.O.,Alagbe, O.A. and Olasunkanmi, K.N. (2018): Evaluation of Groundwater prospect in a Clay Dominated. International Journal of Advanced Engineering Research and Science, Vol.,5, issue 6, Pp45-56.

[24] Goldman, M. and Neubauer F.M. (1994): Ground water exploration using integrated geophysical techniques. Surveys in Geophysics 15(3): 331-361.

[25] Rahaman, M.A. (1988):Recent Advances in study of the Basement Complex of Nigeria Precambrian geology of Nigeria. In:Oluyide, P.O. et al., (eds) Precambrian Geology of Nigeria. Geology Survey of Nigeria Publication, Kaduna, 11-43.

[26] Olayinka, A.I. (1972): Bulletin of the International Association of Hydrogeological Sciences, XVII, 1 4/1972.

[27] Akinlalu, A.A., Adelusi, A.O., and Adebayo S.S. (2013):Geophysical and Hydrochemistry Methods for mapping Groundwater around Aule area, Akure, Southwestern Nigeria. International Journal of Water Resources and Environmental Engineering vol.5 (7), pp.442-451.

[28] Alagbe, O.A., Sunmonu, L.A. and Adabanija, M.A. (2013): Fracture Distribution Within Bowen University Permanent Site and Its Hydrogeologic Implication. Journal of Physical Sciences, Vol. 1(3) Pp 1-5.

