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Geotechnical Competence Assessment and Groundwater Prospect Deductions from Geoelectrical Sounding around Idanre Local Government Area of Ondo State, Southwestern Nigeria

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Sixty vertical electrical soundings with maximum electrode spacing of 100 m; and seventy static water level measurements were undertaken in Idanre Local Government Area of Ondo State, Nigeria with the aim of assessing the engineering competence of the soil material to host civil engineering structures; and also establish notable point/location with groundwater prospect for borehole drilling and development. Typical sounding curves from the area include H, A, HA, KH, QH, and AA reflecting diverse lithological variations. The H, A, and HA curve types are the most preponderant constituting 30%, 15% and 25% respectively. The A (15%) and AA (7%) curve types suggest subsurface geoelectric configurations apparently favourable for foundation construction, as they showed an increase in resistivity (competence) with a corresponding increase in depth. The QH, KH, HA and H curve types constituting about 78% are favourable for groundwater

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accumulation and development. The topsoil is generally composed of sandy clay which is moderately competent soil material to harbour civil structures such as road, buildings. Although some degree of settlement is expected especially along traverses where the weathered layer is clayey. The study shows that 70% of the area in the upper 10 m is moderately suitable for civil engineering shallow foundation construction. The weathered layer is generally clay/sandy clay with resistivity less than 200 Ω-m, therefore can serve as earth medium for electrical material. The major aquifer units in the area are combined weathered layer and fractured basement (common in Aponmu and Jimgbe); a weathered layer (prominent in Imolumu, Ayefemi, Onipanu and Ajegunle) and fractured basement aquifer (found in Ajegunle and Odode). The maximum probable drilling depth to these aquifers varies between 15 m to 30 m. Areas with high static water level are characterized by thin overburden thickness (shallow depth to basement rocks). Also, areas with low static water level have corresponding thick overburden thickness (deep depth to basement rock/high depth of weathering). However substantial settlement may occur in areas with high static water level which could exceed the tolerable limit and threatens the integrity of structures during the raining season, coupled with the clayey nature of the weathered layer in many places.

Keywords: Resistivity; competence; groundwater; electrical sounding; prospect; foundation design.

1. INTRODUCTION

In the light of incessant failing civil engineering structures such as road, buildings, dams etc. which could be precipitated by design error, construction, lack of supervision, both in the sedimentary and basement terrains of Nigeria. Therefore it's now imperative to conduct adequately site investigation so as to determine hosting bearing capacity and strength of the intended foundation material to host such structures [1]. Most problems of structural failures can be associated to the failure of the builders to adequately have the knowledge of the physical parameters governing competency of the soil material for building development. Therefore, the nature of the soil or rocks supporting the substructures becomes an extremely important issue for safety, structural integrity and durability.

In addition, the alarming increase in both population and infrastructure development in Idanre local Government Area of Ondo State has necessitated the need for proper structural planning and groundwater development [2]. However, poor planning and inability to carry out pre-developmental geophysical studies have led to a lot of structural problems which resulted in the scarcity of water, dilapidation of building, loss of resources and death during the collapse of buildings. It is believed this study would provide information on near surface geologic structures/sequence and invariably assist in proper planning and implementation of an appropriate foundation for building development and groundwater projects in the study area.

Therefore in order to emphasize the importance of pre-developmental geophysical survey in geotechnical foundation studies and groundwater assessments, the geophysical investigation has been carried out to investigate the groundwater potential and subsurface structural integrity/competence using geoelectrical soundings in Idanre Local Government area of Ondo state. The geophysical investigation of the earth involves taking a set of measurements, usually by a systematic pattern near or at the surface that is influenced by the internal distribution of physical properties either by land, sea or air or vertically in borehole [3,4]. Geophysical methods are therefore helpful in delineating and evaluating the subsurface geological structures or bodies (anomalies) and their geometries [5]. Geophysics offers a fast, cheap and cost effective method of evaluating the competency of soils for building foundations and groundwater investigation [6-11]. Thus, in engineering foundation studies, geophysics plays significant roles in the investigation of subsurface material and structures which are likely to have significant engineering implication and hydrogeological significance.

2. DESCRIPTION OF THE STUDY AREA

2.1 Geographic Location, Physiographic Features and Drainage

Idanre Area is situated in Idanre Local Government area of Ondo State. The study area is located within approximately 20 km away from Akure, along Akure – Idanre highway. It is one of the major towns that bordered Akure, Owo, and

Ondo East local government areas of Ondo State (Fig. 1). The Idanre Local Government lies within Latitudes 06°32' and 07°18'N and Longitudes 04°48' and 05°32'E. The topography of the area is highly undulation with high gradient. Areas around Odode, Opa-Idanre, Ajebandele, Kajola-Asoko have high mountain/hill ranges with topographical elevation varying from 270 m to above 450 m above sea level, whereas the intervening topographic lows are about 300 m.

The main rain bearing system affecting Idanre area is embedded in the basic easterly wind current. The available rainfall data of the area show that rain falls throughout the whole year but the onset is during the month of March and cessation (sharp decrease in amount) is during the month of November. During June through September, rainfall is critical and the amount is usually high, thus leading to the high probability of soil erosion and flooding. July and September, are the first and second peak months. These two months are very significant because of sporadic, heavy downpours [12]. At times, rainfall in excess of 40 mm is recorded on a single day while the average annual rainfall is 1333 mm. The annual mean temperature is 33°C while the mean minimum is 18°C. Evaporation is usually low from June through September, ranging from 3.3 mm to 4.0 mm per day. Vegetation in the study area is of rainforest type and it has a vegetation of grasses, scattered trees and extensive widespread cocoa farmland. The area is well drained by Ogbese river. The directions of flow of the streams are toward the Northern parts of the town.

2.2 Geology and Structures

Field observations revealed exposures of rocks underlying the area along the stream channels and on the slopes bordering the channels. The rocks are mainly migmatites, porphyritic biotite granite and granite gneiss classified by Geological Survey Department as undifferentiated Basement rocks of Nigeria (Fig. 2). The migmatite consists of biotite gneiss, granite, and gneiss as members. The granite is weakly foliated and appears to have resulted from granitization of biotite gneiss and gneiss members. The gneiss in the migmatite has well developed leucocratic/melanocratic banding. The major structural elements in the rocks are foliation, fractures, lineation, microfolds, veins and microdykes. Fractures on migmatite and gneiss in the study area trend mostly in Northeastern – Southwestern and East-West directions. Also, geological structures such as joint and fault, which can serve as voids for subsurface groundwater accumulation were also observed.

3. METHODOLOGY

Preliminary visitations were done many times to ascertain the general geology, drainages and its patterns, topographical elevations. Measurements of resistivity were made using D.C. resistivity meter model R-50. This equipment has accuracy in reading up to a depth of over 180 m. The Schlumberger configuration was adopted for the vertical electrical sounding (VES). The voltmeter was used in measuring the potential difference between the non-polarizing potential electrodes. The current electrode separation ($^{AB}/_{2}$) used varied from 1-100 m while the potentials of electrode separation did not exceed 4 m. The first step undertaken was the reconnaissance study of the area with the use of VLF-EM study to know places/points to be investigated. Having established these points, VES with Schlumberger array was carried out with a total number of sixty (60) sounding stations in the study area. A total of 9 traverses were established in the study area (Fig. 3).

The VES using Schlumberger configuration in which the potential electrodes remain fixed and the current electrodes were expanded symmetrically about the centre of the spread. A global positioning system (GPS) was used to acquire coordinate of sounded points using the North American Datum of 1983 and Zone 31 N - 0°E to 6°E. Data generated from the VES using Schlumberger configuration were presented as geoelectric sounding curves.

These are field curves obtained by plotting the apparent resistivity values against the electrode spacing on tracing paper superpose on log-log, graph sheet. All of which were iterated thereafter on the computer with the software program called Resist Version 1.0. The interpretation of VES data was quantitative and the method employed was partial curve matching; where each curve generated was matched segment by segment while this is progress, the axes of both the field curves and the model resistivity curve (Schlumberger) must be in parallel. This interpretation is based on the separation or replacement resistivity. The partial curve matching can be regarded as the preliminary interpretation of the field curves; which produced the parameters (each layer resistivity and

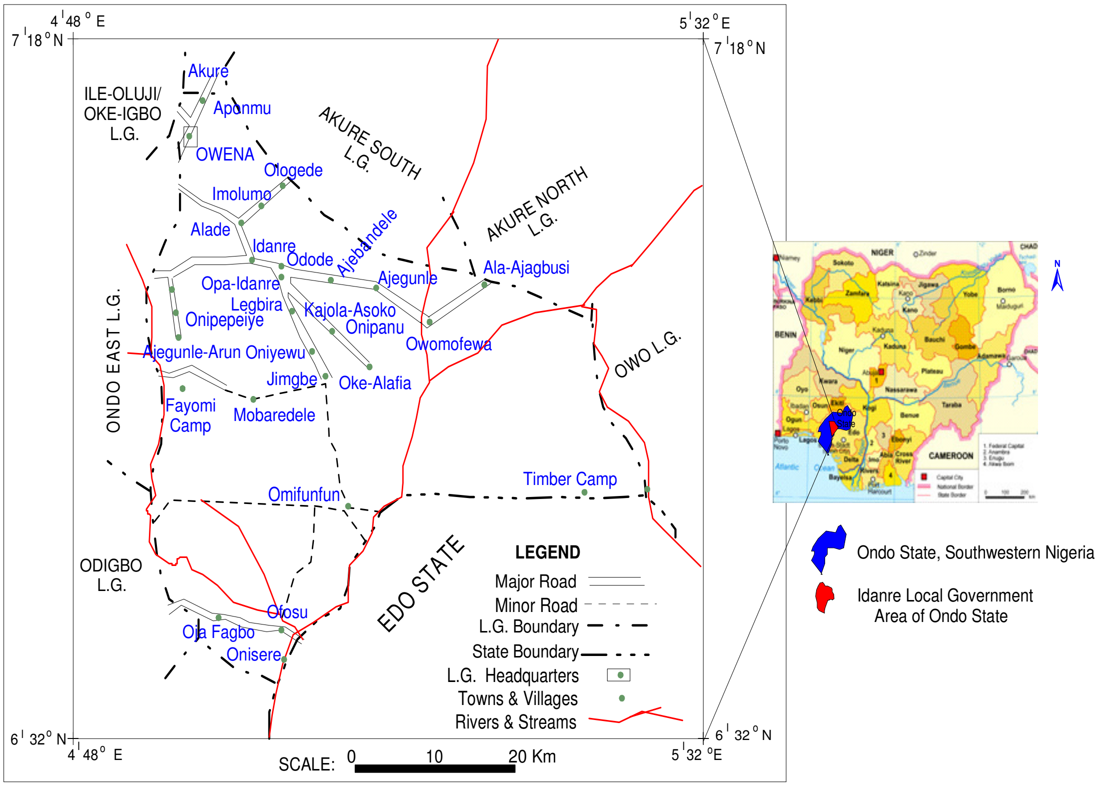

Fig. 1. Location map of the study area. Inset: Location of the study area on map of Nigeria

thickness values) for computer iteration. The field data and the obtained parameters were input into the system for computer iteration using Resist package [13], which in turn displayed the resultant theoretical curves. Therefore, the parameters were subsequently varied until what was considered the best possible fit between the field and the theoretical curve was obtained each VES station. The parameters of the final models give the layer resistivity and thickness for the VES points.

The generalized geoelectric parameters of the subsurface layers (are shown in Table 1) was used in interpreting resistivity data, while resistivity in the range of 0-100 Ω-m, 100-350 Ω-m, 350-750 Ω-m, 750 to infinity Ω-m were used to determine the engineering competence of soil as clay (incompetent), sandy clay (moderately competent), clayey sand (competent) and sand/laterite/bedrock (highly competent) respectively. The static water level was measured in the study area so as to determine general groundwater direction and appropriate depth of foundation placement to prevent dampness on buildings, dissolution of basement/foundation footing. With the aid of meter rule and tape, the depth to the water levels was measured and recorded at seventy (70) hand dug wells proximate to established traverses.

The surface elevation at different points vary due to topographic variation, the true water level was obtained by subtracting the measured depth to the water level in the hand-dug wells from the surface elevation to get uniform water levels otherwise known as the elevation of the water level.

Mathematically, $S_{wl} = E - D_{wl}$

Where: S_{wl} is the true or uniform water level otherwise known as the static water level in the case of unconfined aquifer

E is the surface elevation with respect to the mean sea level

D_{wl} is the depth from the surface of the earth to the water level (Well Head) in the hand -dug wells (Direct borehole logging).

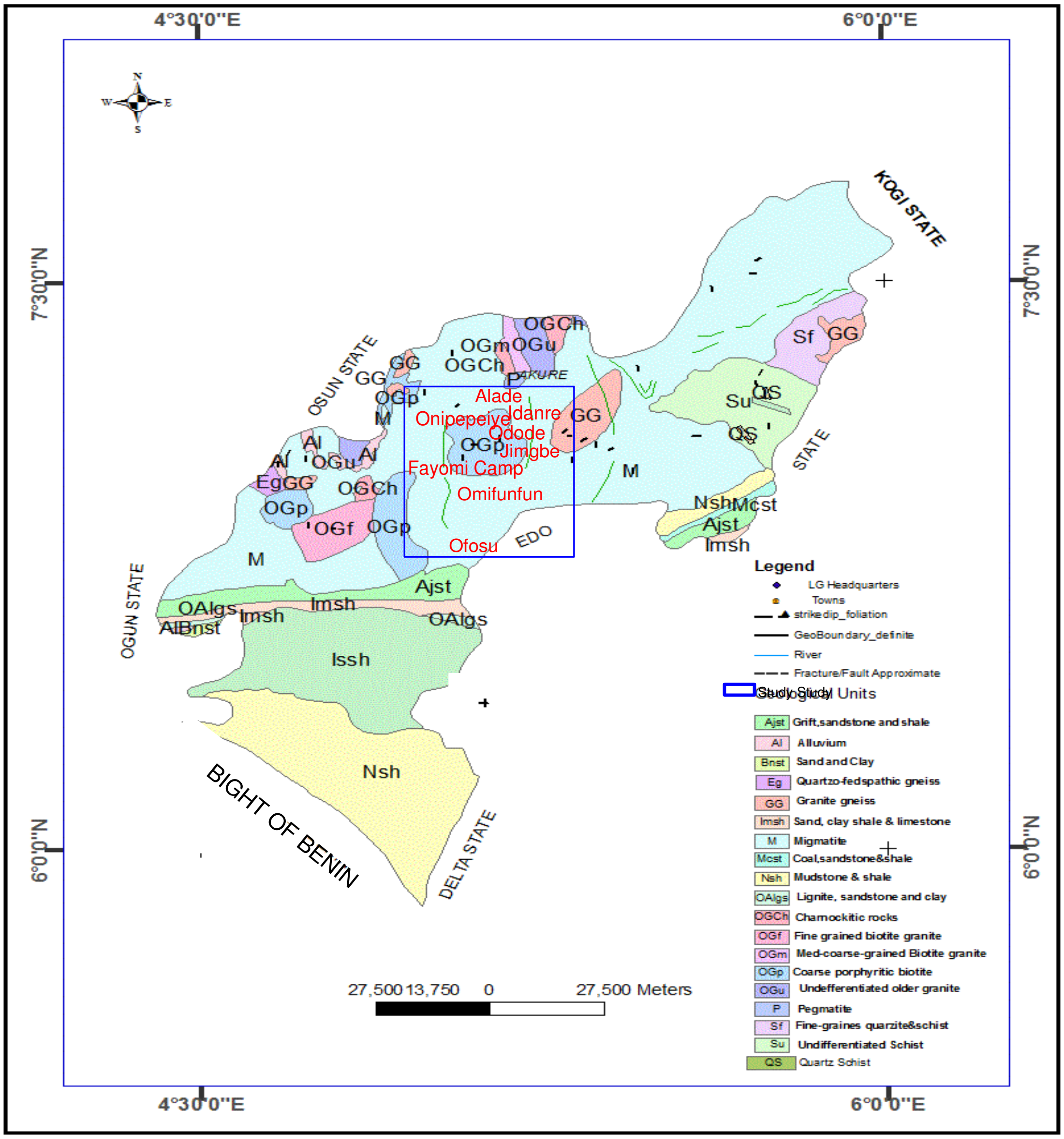

Fig. 2. Geology map of the study area

Table 1. Geoelectric parameters of a typical basement complex area [6]

Subsurface Layer	Resistivity (Ohm-m)	Thickness (m)
Topsoil/Laterite	Very variable 1 – 10,000	Generally < 1.0 m but could be as thick as 5.0 m in places
Weathered Basement Layer	Generally < 100 but could be as high as 500	Generally < 30.0 m but could be as thick as 60.0 m in schist
Partly Weathered/ Fractured Basement	Generally < 1000	Generally < 20 m but could be as thick as 40 m
Fresh Basement	Generally > 1000 - ∞	Not Determined

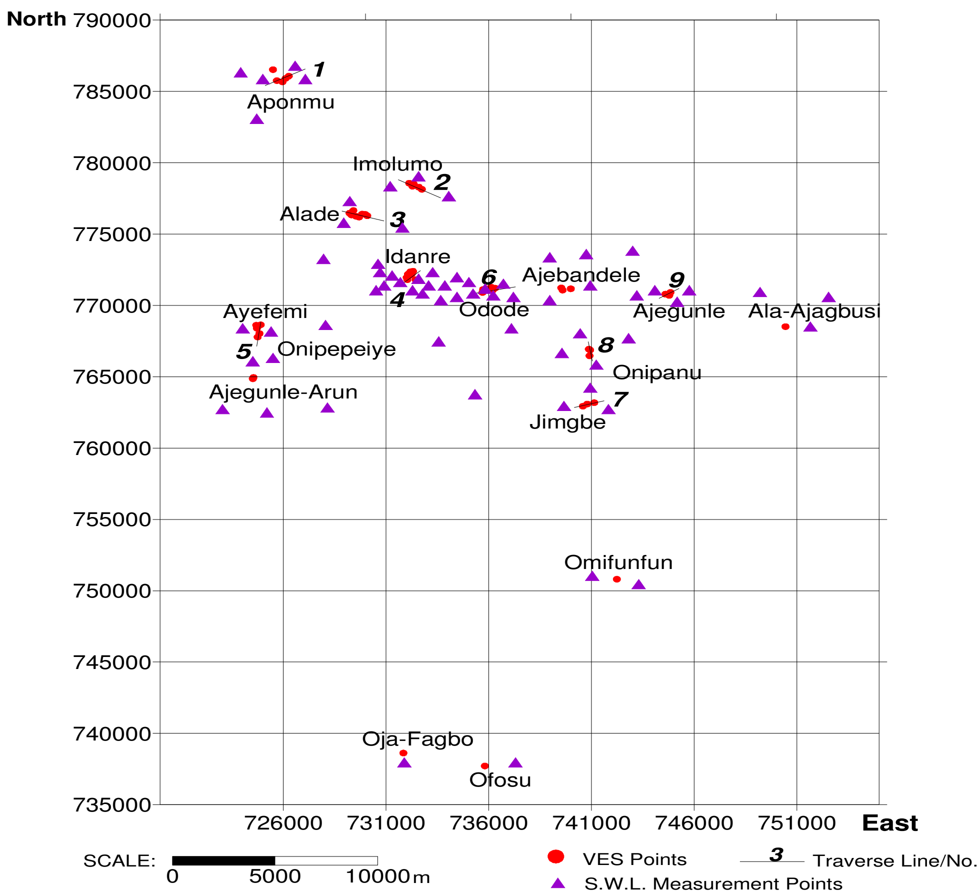

Fig. 3. Base map of the study showing VES points, established traverse lines and well locations from which static water level measurement was taken

4. RESULTS AND DISCUSSION

The geoelectric curve types identified from the study area include H, A, HA, KH, QH, and AA reflecting lithological variations. The H and HA curve types are the most preponderant constituting 30% and 25% respectively (Fig. 4 and Table 2). The A and AA curve types constituting about 15% and 7% respectively are characterized by an increase in resistivity (competence) with depth. These curve types suggest subsurface geoelectric configurations apparently favourable for foundation construction, while HA (25%) has fair competence due to low resistivity topsoil. The electrical methods of geophysical prospecting reflect variations in ground resistivity and used to identify the degree of competence in foundation design in terms of resistivity/conductivity values. The combined KH, QH, and H curve types constituting about 54% are favourable for groundwater accumulation and development.

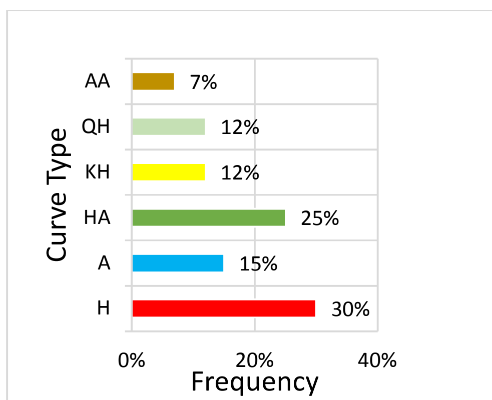

Fig. 4. Percentage distribution of the curve types identified in the study area

Along Traverse 1 (Fig. 5), the geologic units comprise topsoil, weathered layer, partly weathered/fractured basement. The topsoil is predominantly sandy clay and sand material with resistivity range of 84–522 Ω-m. The underlying material is a fairly competent sandy clay material under VES 1-3 with resistivity variation of 123 to 199 Ω-m. The weathered layer is made of thickness above 5 m and shows some degree of competence for foundation construction (except VES 1 and 2, but can be graded with competent sand/gravel) as it composes clay, sandy clay, and sand. The partly weathered/fractured basement is only recorded under VES 3 and 4. These VES points have good groundwater prospects in view of the combination of weathered layer and fractured basement aquifer systems.

In Imolumo representing Traverse 2 (Fig. 6), the topsoil resistivity ranges between 229 - 660 Ω-m with the composition of moderately competent sandy clay, clayey sand and sand. Immediately under the topsoil is heterogeneous layer composing clay, sandy clay, clayey sand, and sand. The resistivity of the weathered layer varies from 42 to 477 Ω-m which indicates clay and clayey sand composition. However, some level of settlement for structure(s) is expected under VES 8, 9 and 10 with thickness above 5 m. In other words, VES 10 is recommended for drilling due to its potential for groundwater accumulation.

At Alade-Idanre i.e. Traverse 3, the topsoil is predominantly sand material with resistivity in the range of 200 – 800 Ω-m. This resistivity range makes the topsoil very competent material (Fig. 7). Below the topsoil is a layer with a high degree of inhomogeneity and composed of clay, sandy clay, clayey sand and sand; however clay is the most dominant resistivity values. The weathered layer is generally clay sand with resistivity above 200 Ω-m, while the thickness is between 3 m and 10 m especially under VES 12. The partly weathered layer/fractured basement was only recorded under VES 17 and 18; the degree of fracturing is presumably of low density as reflected in their resistivity values. The resistivity of the fresh basement varies from 987 to 5279 Ω-m. VES 12, 17, and 18 are recommended groundwater development points a due combination of weathered layer and fractured basement aquifer system.

Fig. 8 shows the geoelectric section at Idanre (Traverse 4). The topsoil is composed of fairly competent clayey sand material, with no distinction between it and the underlying layer, which is thicker under VES 26. The weathered layer is of appreciable thickness ranging from 3 m to 15 m and resistivity predominantly in the range of 0 - 100 Ω-m suggestive of clay material. The partly weathered layer/fractured basement is localized within the basement rock under VES 25. However, VES 24 and 25 showed good prospect for groundwater development.

In Odode-Idanre represented by Traverse 5 (Fig. 9), the topsoil is made up of moderately competent sand clay material with a thickness less than 2 m. This thickness can still accommodate highway foundation and shallow foundation for buildings. The weathered layer is predominantly clayey with thickness above 5 m except under VES 31. Hence it can accommodate electrical earthling material. Although there is a need to improve the subsurface conductivity of this layer most especially within the areas where the electrode for the earthling system will be buried. The partly weathered layer/fractured basement occurred under all VES stations except VES 32. This shows that the basement rock has been degraded. This observation must be put into consideration. Also, an assessment of the degree of fracturing should be conducted, if possible it can be grouted. However, the fractured basement is the main aquifer unit along this traverse.

Along Traverse 6 (Fig. 10), the resistivity of the topsoil varies from 46 to 291 Ω-m and predominantly incompetent clay soil with a thickness less than 3 m. The weathered layer showed relatively high resistivity values in the range of sandy clay – sand material with resistivity above 100 Ω-m and thickness between 8 and 17 m. The thickness and resistivity of this layer suggest a moderate degree of competence to harbour civil engineering foundation structure. The basement rock resistivity varies from 778 to 3334 Ω-m with no evidence of fracturing. The low resistivity value recorded under VES 40 is due to the screening effect of the overlying conductive weathered material. The weathered layer is the main aquifer unit in this area with the recommendable depth of drilling not above 25 m.

In Jimgbe (Fig. 11) represented by Traverse 7, the topsoil is generally made up of moderately competent sand clay with a resistivity range of 74 to 214 Ω-m. The weathered layer resistivity ranges between 26 and 199 Ω-m. The resistivity values recorded under VES 55 and 56 are substantially above 100 Ω-m depicting sandy clay. The basement rock showed evidence of fracturing under VES 55 and 56 which could be the main aquifer system along this traverse, with the drillable depth of about 30 m.

Table 2. VES data and static water level obtained in the study area

North (m)	East (m)	S.W.L. (m)	VES No.	Thickness (m)										
				ρ_1	ρ_2	ρ_3	ρ_4	h_1	h_2	h_3	d_1	d_2	d_3	
785918	726114	301	1	201	123	188	991	1.2	2.0	15.3	1.2	3.2	18.5	HA
785671	725961	304	2	522	199	85	1799	0.6	2.3	18.2	0.6	2.9	13.5	QH
786529	725497	298	3	152	189	42	889	0.7	0.9	12.6	0.7	1.6	14.2	KH
785762	725685	299	4	84	104	773		3.2	10.8		3.2	14.0		A
786072	726266	307	5	154	1002	1255	1317	0.8	13.5	15.8	0.8	14.3	30.1	AA
778295	732594	399	6	323	458	477	3265	1.0	1.5	4.7	1.0	2.5	7.2	AA
778355	732287	388	7	229	280	2587		0.9	1.8		0.9	2.7		A
778509	732347	398	8	660	176	85	3524	1.9	1.3	5.1	1.9	3.2	8.3	QH
778142	732748	390	9	271	55	42	3002	0.5	1.5	7.7	0.5	2.0	9.7	QH
778570	732132	391	10	283	69	145	1287	1.0	3.6	12.5	1.0	4.6	17.1	HA
776254	729533	296	11	410	58	319	5279	0.7	1.1	3.4	0.7	1.8	5.2	HA
776409	729839	297	12	365	197	249	1362	0.8	1.1	10.8	0.8	1.9	12.7	HA
776652	729408	290	13	69	89	84	1299	0.9	2.5	3.2	0.9	3.4	6.6	KH
776193	729687	299	14	466	88	253	987	0.4	2.0	4.2	0.4	2.4	6.6	HA
776379	729993	283	15	855	120	138	1222	0.8	1.7	4.6	0.8	2.5	7.1	HA
776345	729318	295	16	155	112	226	1833	0.7	1.5	4.9	1.6	3.1	8.0	HA
776287	730086	303	17	175	48	465		0.8	4.5		0.8	5.3		H
776467	729225	291	18	407	48	241	882	1.1	1.2	2.9	1.1	2.3	5.2	HA
771809	732040	415	19	66	58	2147		0.8	1.2		0.8	2.0		H
771963	732008	418	20	88	18	72	1234	0.7	2.0	3.8	0.7	2.7	6.5	HA
772117	732161	405	21	92	40	59	966	0.5	0.9	4.5	0.5	1.4	5.9	HA
772178	732069	399	22	332	78	58	3255	1.0	1.3	5.8	1.0	2.3	9.1	QH
772240	732130	419	23	1888	66	92	2201	0.7	1.0	11.2	0.7	1.7	12.9	HA
772178	732099	432	24	75	520	2822		0.4	10.2		0.4	10.6		A
772363	732191	435	25	480	140	126	884	0.7	1.6	12	0.7	2.3	14.3	QH
772210	732253	438	26	131	30	1222		1.2	7.5		1.2	8.7		H
772394	732313	431	27	227	62	2259		1.2	9.2		1.2	10.4		H
771811	732439	402	28	555	250	229	716	0.7	0.4	9.5	0.7	1.1	9.9	QH
771214	736310	406	29	146	38	945		1.6	10.9		1.6	12.5		H
771274	736126	405	30	188	44	669		0.9	16.5		0.9	17.4		H
771151	735942	401	31	291	132	910		1.5	3.9		1.5	5.4		H

771060	736188	426	32	52	111	1547		0.7	10.6		0.7	11.3		A
770904	735697	427	33	98	57	304	4552	1.0	5.4	15.5	1.0	6.4	21.9	HA
771119	735727	423	34	217	55	986		1.4	16.5		1.4	17.9		H
771181	735850	425	35	39	92	4172		0.9	14.8		0.9	15.7		A
771089	735881	430	36	802	151	146	1332	0.8	2.8	17.9	0.8	3.6	21.5	QH
768397	724716	289	37	60	323	1122		1.9	8.6		1.9	10.5		A
768550	724777	290	38	46	225	3334		0.9	16.3		0.9	17.2		A
768612	724685	291	39	95	369	3216		1.0	19.1		1.0	20.1		A
768644	724899	297	40	56	291	104	778	0.8	1.6	18.4	0.8	2.4	20.8	KH
767783	724750	293	41	85	177	98	1211	1.6	6.6	15.3	1.6	8.2	23.5	KH
768029	724841	295	42	79	38	995		1.6	6.7		1.6	8.3		H
764955	724547	301	43	99	53	499		1.1	0.5		1.1	1.6		H
764863	724517	301	44	74	154	715	1922	0.6	6.3	18.1	0.6	6.9	25.0	AA
771229	739534	392	45	238	487	4172		0.6	16.2		0.6	16.8		A
771169	739995	391	46	142	102	1265		1.1	15.4		1.1	16.5		H
771075	739596	394	47	112	53	3225		0.9	3.9		0.9	4.8		H
770791	744602	385	48	35	217	602	1573	0.6	1.2	19.5	0.6	1.8	21.3	AA
770700	744787	380	49	55	25	442		1.2	12.1		1.2	13.3		H
770915	744847	384	50	269	99	141	987	1.1	4.7	10.2	1.1	5.8	16.0	HA
766932	740874	370	51	92	78	789		3.6	15.1		3.6	18.7		H
766472	740907	375	52	56	39	1020		1.3	12.4		1.3	13.7		H
766871	740936	372	53	144	98	159	897	0.9	1.8	8.9	0.9	2.7	11.6	HA
763091	740799	292	54	74	26	1533		1.0	6.4		1.0	7.4		H
763185	741137	291	55	79	167	60	2361	1.1	9.0	14.2	1.1	10.1	24.3	KH
762936	740585	289	56	214	199	535	965	1.0	4.4	13.3	1.0	5.4	18.7	HA
768514	750448	290	57	45	19	1212		1.2	16.1		1.2	17.3		H
750806	742238	287	58	445	66	1120		1.0	16.8		1.0	17.8		H
737717	735813	279	59	120	222	55	1880	0.8	5.5	19.8	0.8	6.3	26.1	KH
738622	731846	274	60	136	298	88	1698	1.5	6.8	20.3	1.5	8.3	28.6	KH

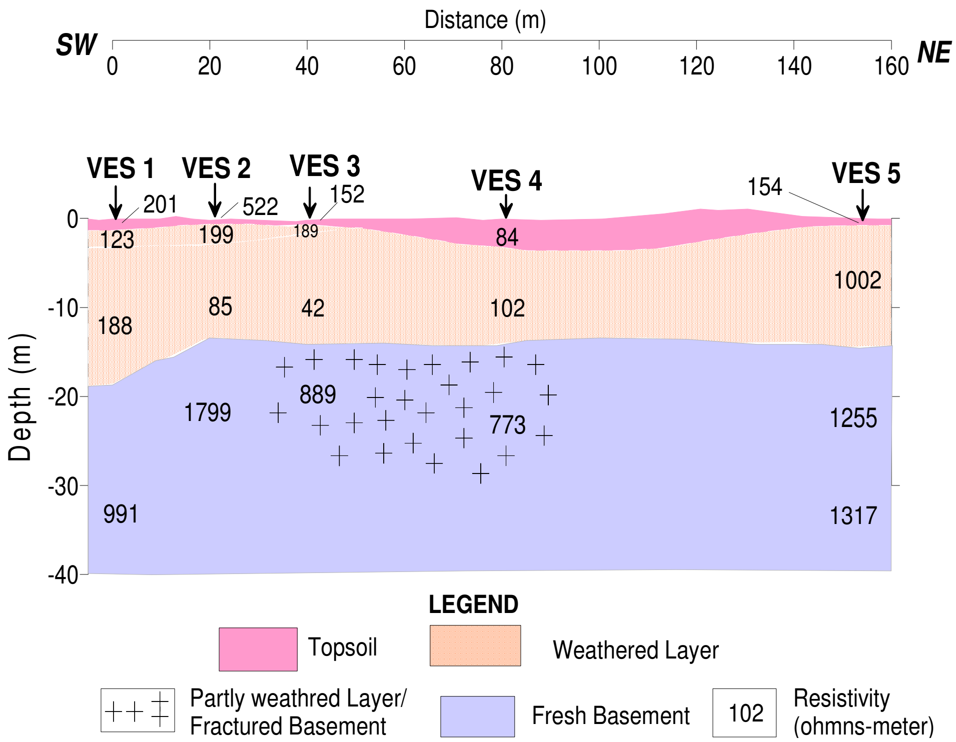

Fig. 5. Geoelectric section along traverse 1

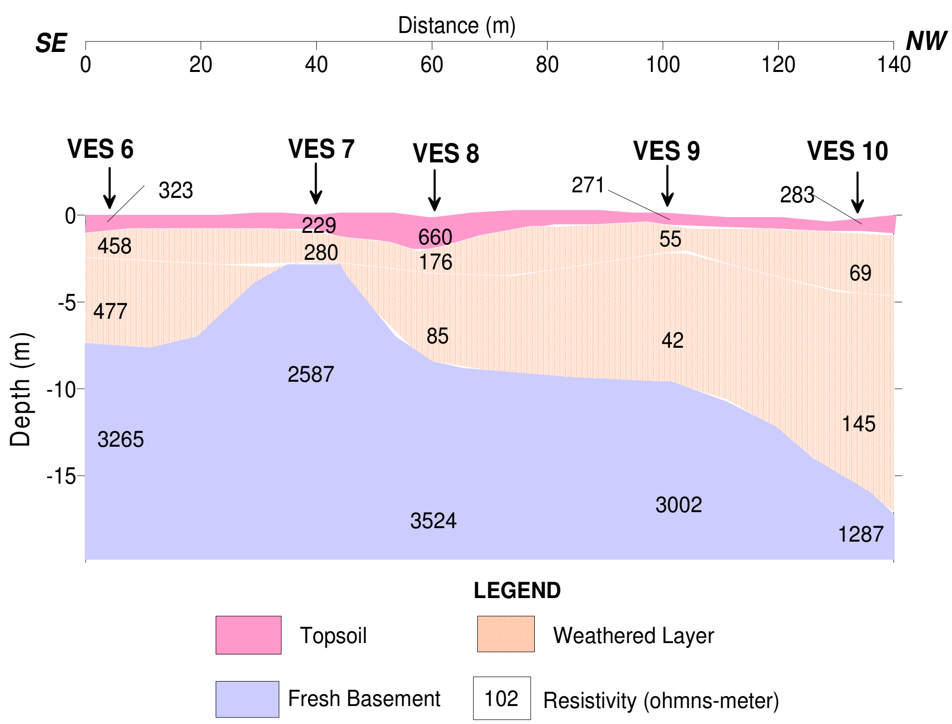

Fig. 6. Geoelectric section along traverse 2

At Onipanu (Fig. 12), the topsoil is clay except under VES 53 (sandy clay) with a resistivity of 114 Ω-m. The weathered layer showed the same lithological unit as the topsoil with resistivity ranging from 39 to 159 Ω-m. The fresh basement showed a degree of fracturing under VES 51 and 53 which can serve as secondary aquifer system for weathered layer water bearing geological unit.

Also, the thickness of the weathered layer suggests that they can also accommodate electrical earthling appliances and installation. In view of the geologic sequence, the combination of weathered layer and fractured basement aquifer system are the major aquifer units with depth extent greater than 20 m.

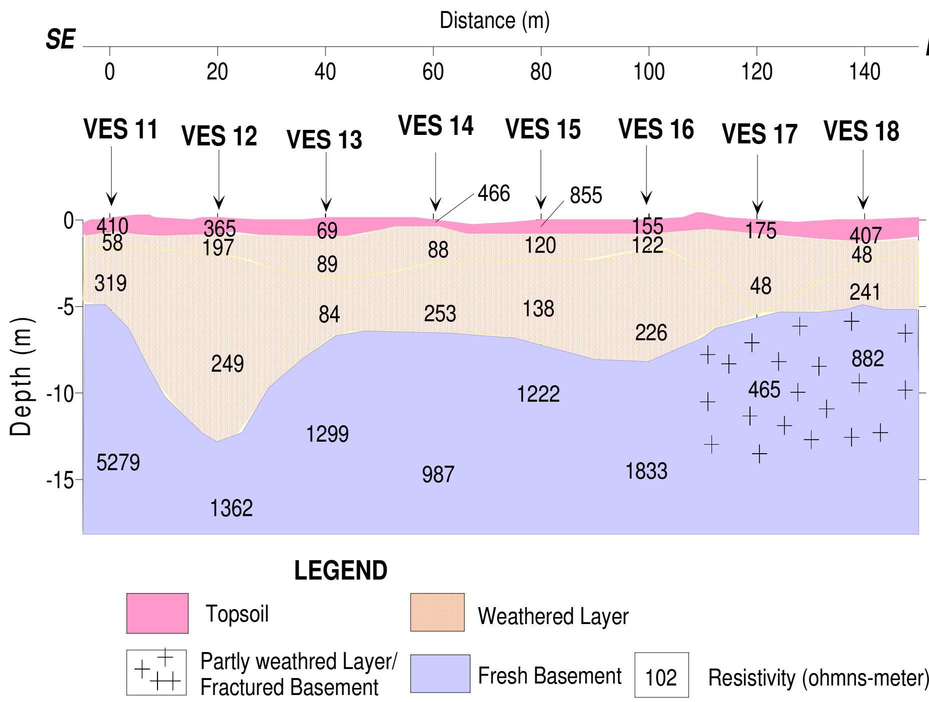

Fig. 7. Geoelectric section along traverse 3

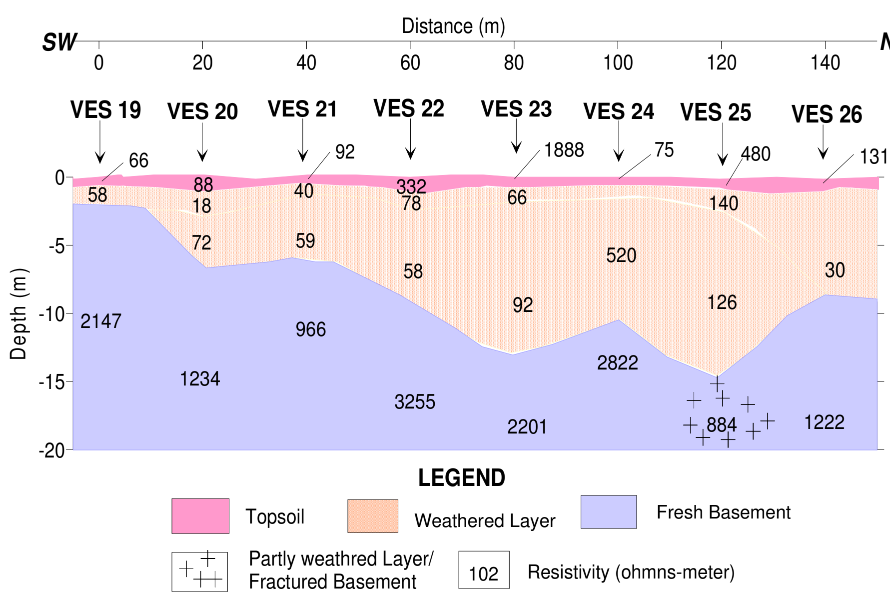

Fig. 8. Geoelectric section along traverse 4

Along Traverse 9 (Fig. 13), the topsoil showed a high degree of heterogeneity as the resistivity ranges from 32 to 269 Ω-m and thickness between 2 and 7 m (VES 50). The topsoil is generally clayey. The weathered layer is sand under VES 48, clay under VES 49, and sandy clay under VES 50. The fresh basement showed some degree of fracturing under VES 49. It can be deduced that VES 48 and 49 are the only promising points for groundwater accumulation with the drillable depth of about 20 m.

4.1 Geoelectrical Maps

The generated competence map at upper 5 m and between 5 -10 m (Figs. 14 and 15) showed no substantial distinction as they are made up of the moderately competent soil of about 70%, the incompetent area of about 20%, while competent area is about 10%. At upper 5 m the competent and incompetent areas include Omifunfun and Onipanu respectively. At 10 m, competent areas include Jimgbe, Ala-Ajagbusi, Idanre, Aponmu etc., while incompetent areas are Ajegunle-Arun, Ajebandele, Alade, Onipanu etc. Fig. 16 shows that area with high static water level is characterized by thin overburden thickness/shallow depth to basement rocks. Also, areas with low static water level have corresponding thick overburden thickness/deep depth to basement. However substantial settlement may occur around the area of high static water level which could exceed the tolerable limit and threatens the integrity of structures during the raining season and coupled with the clayey nature of the weathered layer in many places. Consequently, this additional settlement should be taken into consideration. Areas with thick overburden above 18 m are feasible places for groundwater accumulation and development, which embraced Omifunfun, Imolumo, and Aponmu, while the central part of the study area (with overburden thickness between 8 m – 13 m) can still rely on shallow wells for their sustenance.

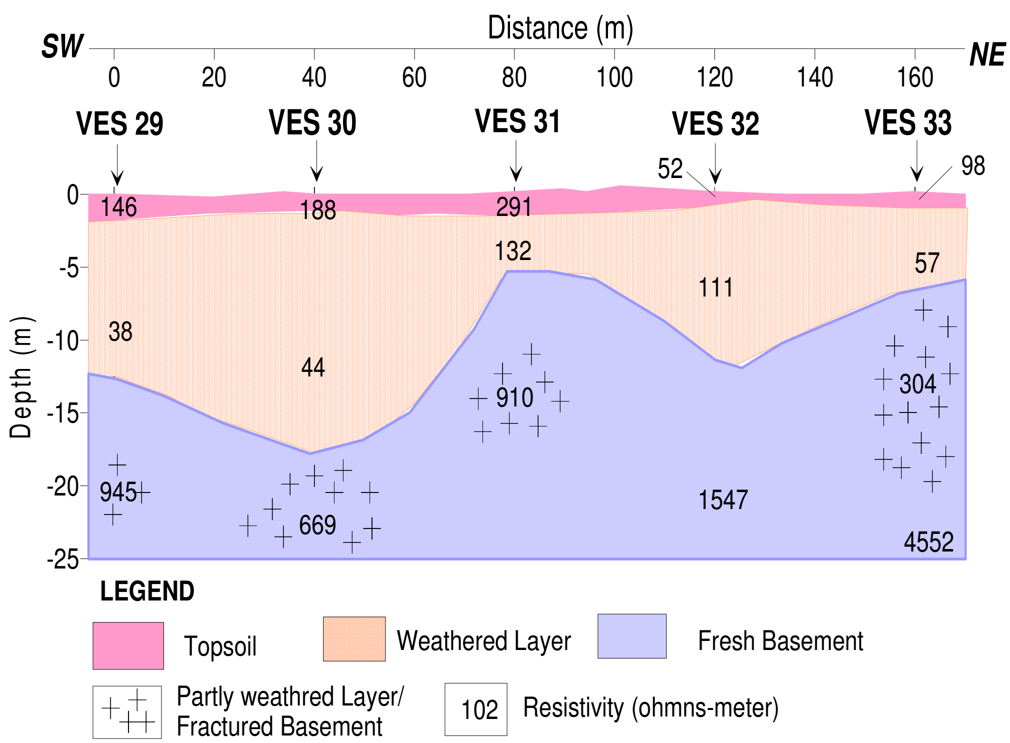

Fig. 9. Geoelectric section along traverse 5

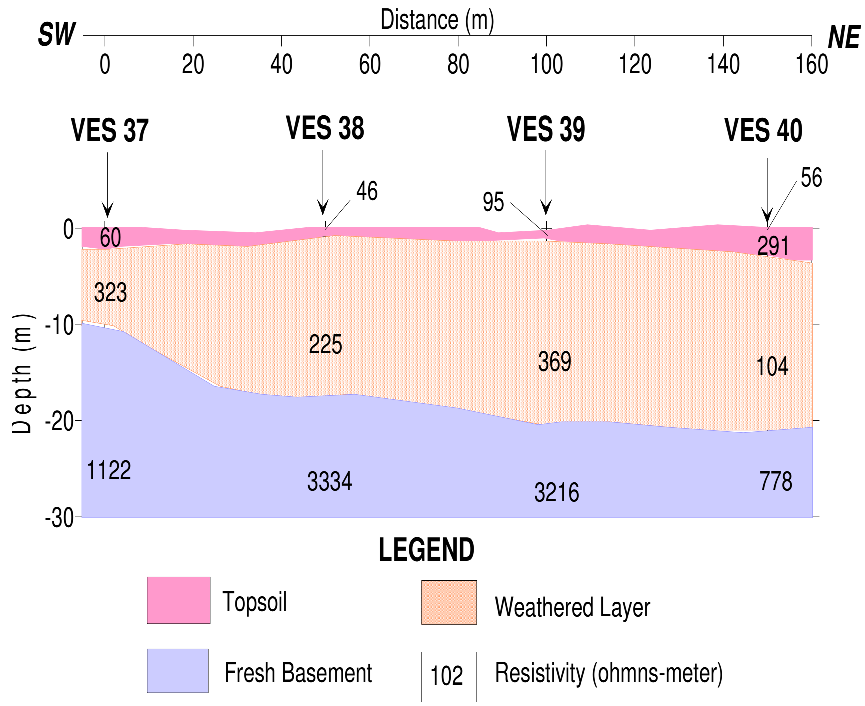

Fig. 10. Geoelectric section along traverse 6

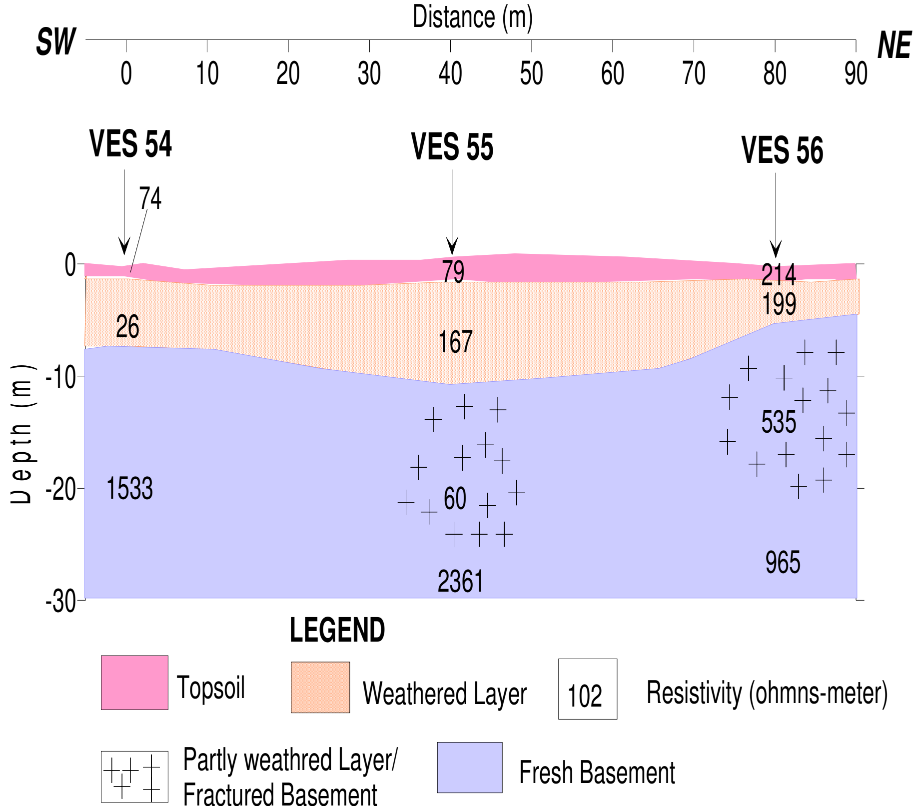

Fig. 11. Geoelectric section along traverse 7

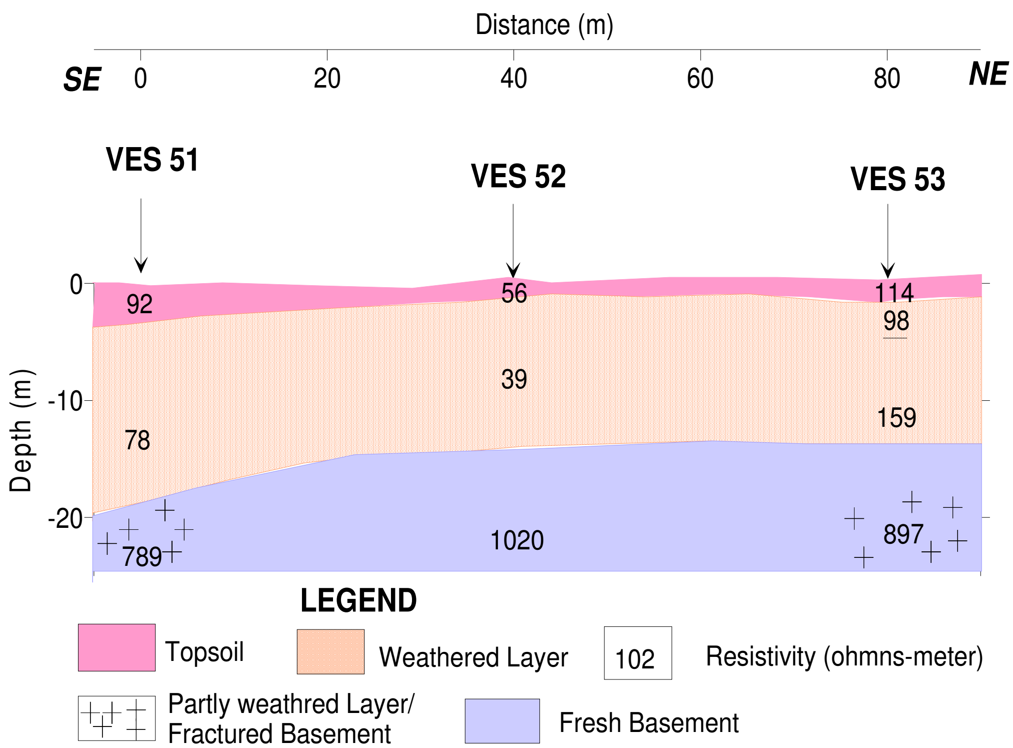

Fig. 12. Geoelectric section along traverse 8

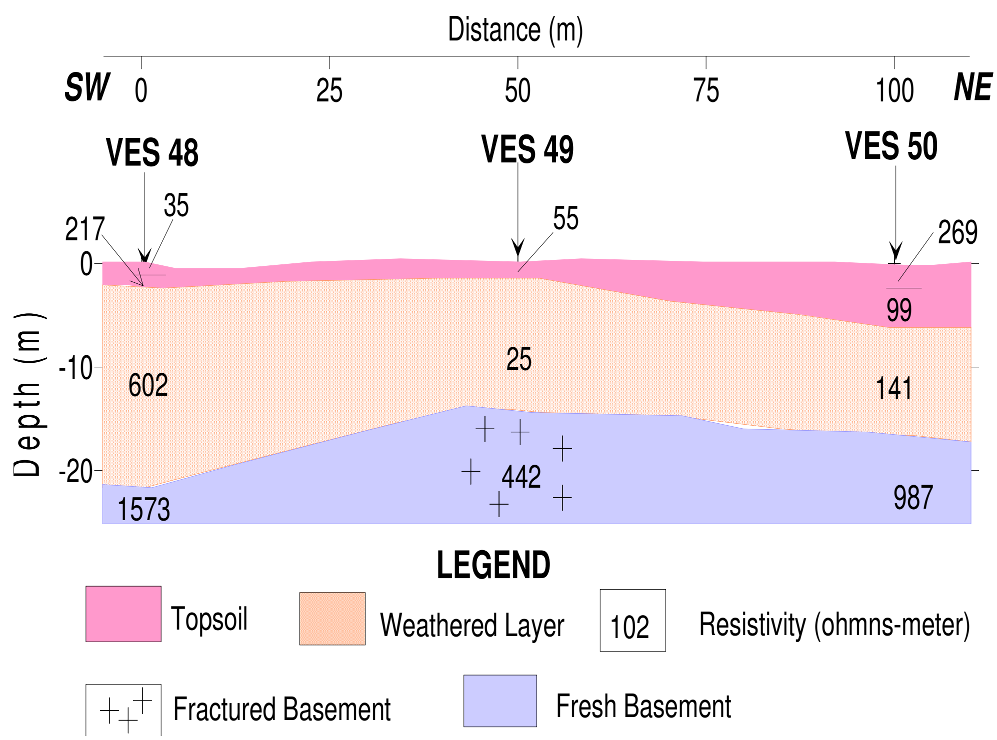

Fig. 13. Geoelectric section along traverse 9

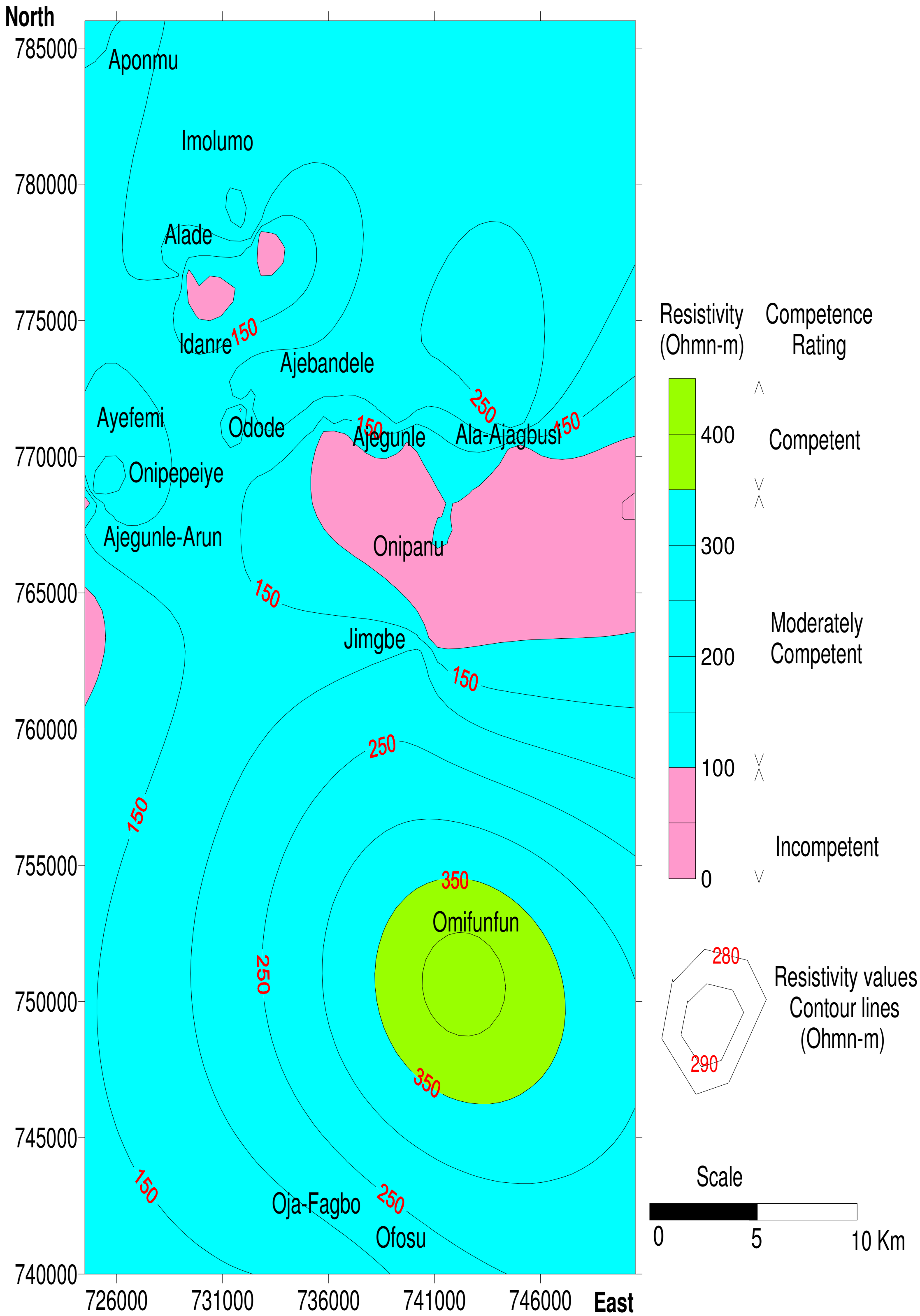

Fig. 14. Subsoil competence map of the upper 5 m

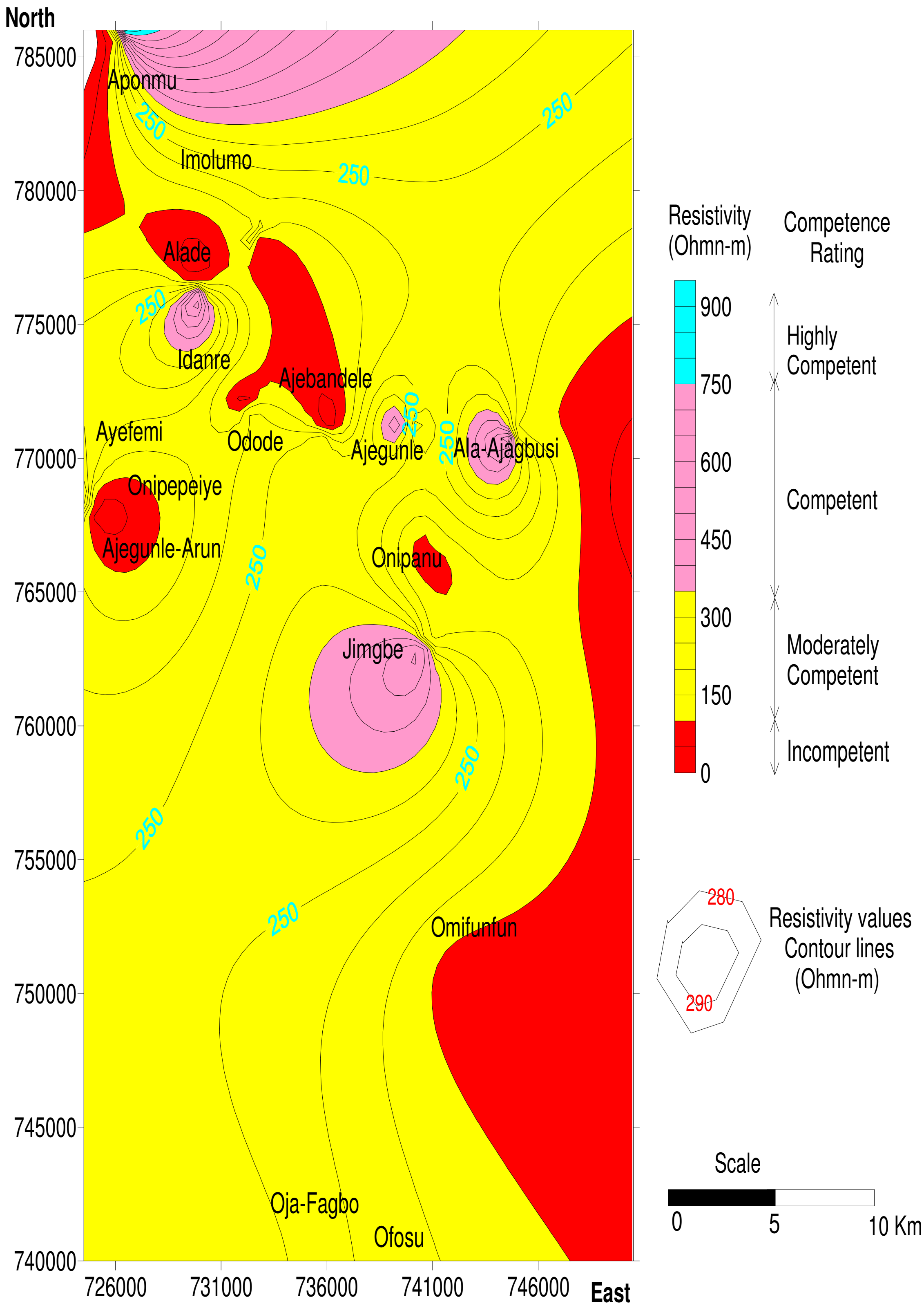

Fig. 15. Competence map of the subsoil between depths of 5 - 10 m

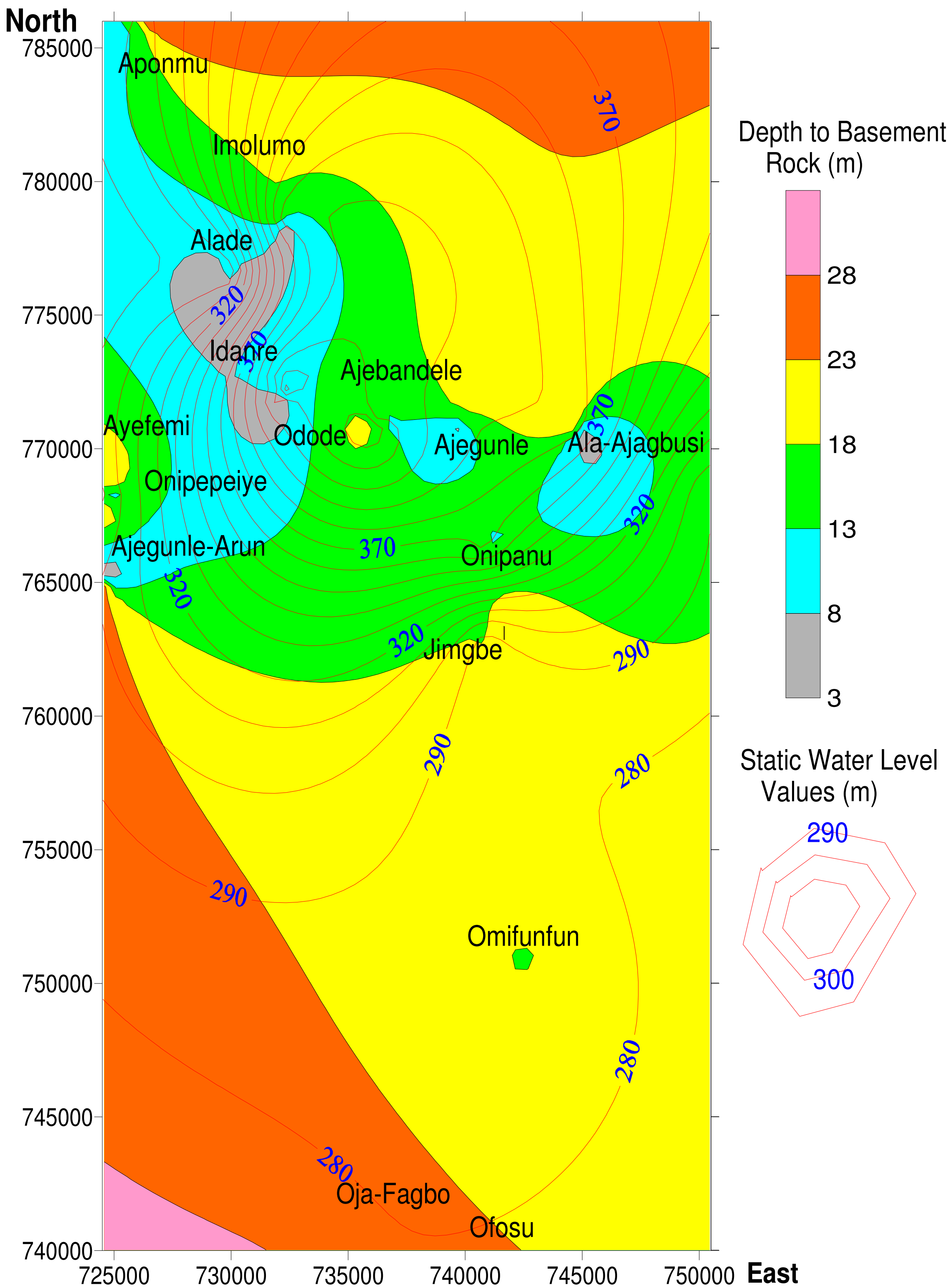

Fig. 16. Static water level generated for the study area

5. CONCLUSION

The major findings of the study are:

1. The topsoil is generally composed of sandy clay with a resistivity of 100 – 350 Ω-m, which are moderately competent soil material. Although some degree of settlement is expected especially along traverses where the weathered layer is clayey. The study shows that 70% of the subsoil between the depths of 5 - 10 m is clayey. Therefore excavation will be needed at the weaker zones within the overburden and be refilled with competent sand/laterite before the soil will be able to host civil engineering structures.
2. The weathered layer is generally clay /sandy clay with resistivity less than 200 Ω-m, which can serve as earth medium for electrical material. This soil material can be classified as slightly corrosive material. Any metal or steel structures would be slightly exposed to chemical corrosion.
3. The major aquifer units in the area are combined weathered layer and fractured basement (common in Aponmu and Jimgbe); a weathered layer (prominent in Imolumu, Ayefemi, Onipanu and Ajegunle) and fractured basement aquifer (found in Ajegunle and Odode).
4. The maximum drilling depth to these aquifers varies between 15 m to 30 m.
5. Areas with high static water level are characterized by thin overburden thickness (shallow depth to basement rocks). Also, areas with low static water level have corresponding thick overburden thickness (deep depth to basement rock/high depth of weathering). However substantial settlement may occur around the area of high static water level which could exceed the tolerable limit and threatens the integrity of structures during the raining season.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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