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ELECTRICAL RESISTIVITY INVESTIGATION OF THE GROUNDWATER POTENTIAL IN PARTS OF KWARA STATE POLYTECHNIC, ILORIN, NIGERIA

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ABSTRACT

Vertical Electrical Soundings (VES) were carried out within the premises of the Institute of Technology, Kwara State Polytechnic Campus, Ilorin Kwara State, Nigeria, with the aim of determining viable aquiferous zones within the institute to alleviate the problems of well failure in the area. The study area is about 1.5kmsqures and is underlain by the Precambrian basement rocks comprising migmatite gneiss. Fifteen (15) VES were carried out using Schlumberger electrode arrayconfiguration with AB/2 equal to 70m. The VES data generated were processed and interpreted using partial curve matching method and computer iteration techniques. The interpreted data revealed three to four geo-electric sections with varied thicknesses and resistivity. The lateritic clay layer ranges from 53.1 to 302Ωm, the weathered horizon resistivity ranges from 22.7 to474.2Ωm while the competent rock has resistivity values greater than 220.3Ωm. The lateritic clay layer resistivity and thickness range from 53.1 to 302Ωm and 1.9 to 8.0m respectively, the weathered horizon resistivity ranges from 22.7 to 474.2Ωm and 4.4 to 11.7m respectively while the competent rock has resistivity values greater than 220.3Ωm and 6.1 to ∞m respectively. The third geoelectric layer constitutes the aquiferous zone in the 4-layer geoelectric section while the second geoelectric layer is the aquiferous zone in all the 3-layer geoelectric sections. Only VES station 9 out of the 15 VES stations shows good groundwater potential as revealed by the thick overburden and weathered layer with low resistivity value. VES stations 3, 4, and 13 show poor groundwater potentials while the others are non-aquifereous in nature.

KEYWORD: Basement, Parched Aquifer, Groundwater, Ilorin, Hydrogeology.

INTRODUCTION

Access to safe drinking water is a key ingredient for better health and reducing poverty (MacDonald *et al.* 2005). Reliable groundwater potential data is very significant and fundamental for the development of groundwater (Singh 1984). Groundwater occurrence in Precambrian basement terrain is hosted within zones of weathering and fracturing which often are not continuous in vertical and lateral extent (Jeff, 2008). Most groundwater projects recorded in basement complex aquifers have revealed geophysical survey as a compulsory perquisite to any successful water well drilling project (Dan Hassan and Olorunfemi 1999). The electrical resistivity method involving the vertical electrical sounding, (VES) technique is extensively gaining application in environmental, groundwater and engineering geophysical investigations (Afolayan and Olorunfemi 2004, Abubakar and Auwal 2012, Adepelumi et al., 2013, Ochuko 2013, Okogbue and Omonona 2013, Oladunjoye et al., 2013, Akande et al., 2016, Bienibuor et al., 2016, Kumar et al., 2016, Nicholas et al., 2016). In the Institute of Technology campus, Ilorin, groundwater abstraction is mainly from shallow hand dug wells which are perched in nature and dry out during the dry season. Aside drying out during the dry season, the water supply from these shallow wells have not been able to meet the growing population of the institute community. Several deep wells (boreholes) drilled and development within the institute have failed because of poor siting of the boreholes emanating from poor understanding of the geology and groundwater occurrence in the area. The objective of this work is to demonstrate the effectiveness of the use of vertical electrical sounding, a technique of electrical resistivity method in identifying viable spots or locations of great groundwater potentials for borehole drilling and development.

Study area

The study area is located within latitude $8^0$28'58.3''N, $4^0$31'35(Figure1). The area is accessible through major and minor roads. The climate of the area is made up of two major and distinct seasons: a wet season, which usually lasts from March to October, and a dry season which lasts from November to February. Occasionally there are rainfalls in the months of January and February. The mean annual rainfall is about 1333.66mm. The mean annual minimum temperature is 21.6^{o}C and the mean annual maximum temperature is 33.3^{o}C while the mean annual evaporation is about 4.76mm. The mean annual evapotranspiration falls between 1,500 mm and 1,750 mm Isolines (Olasehinde, 1999b).

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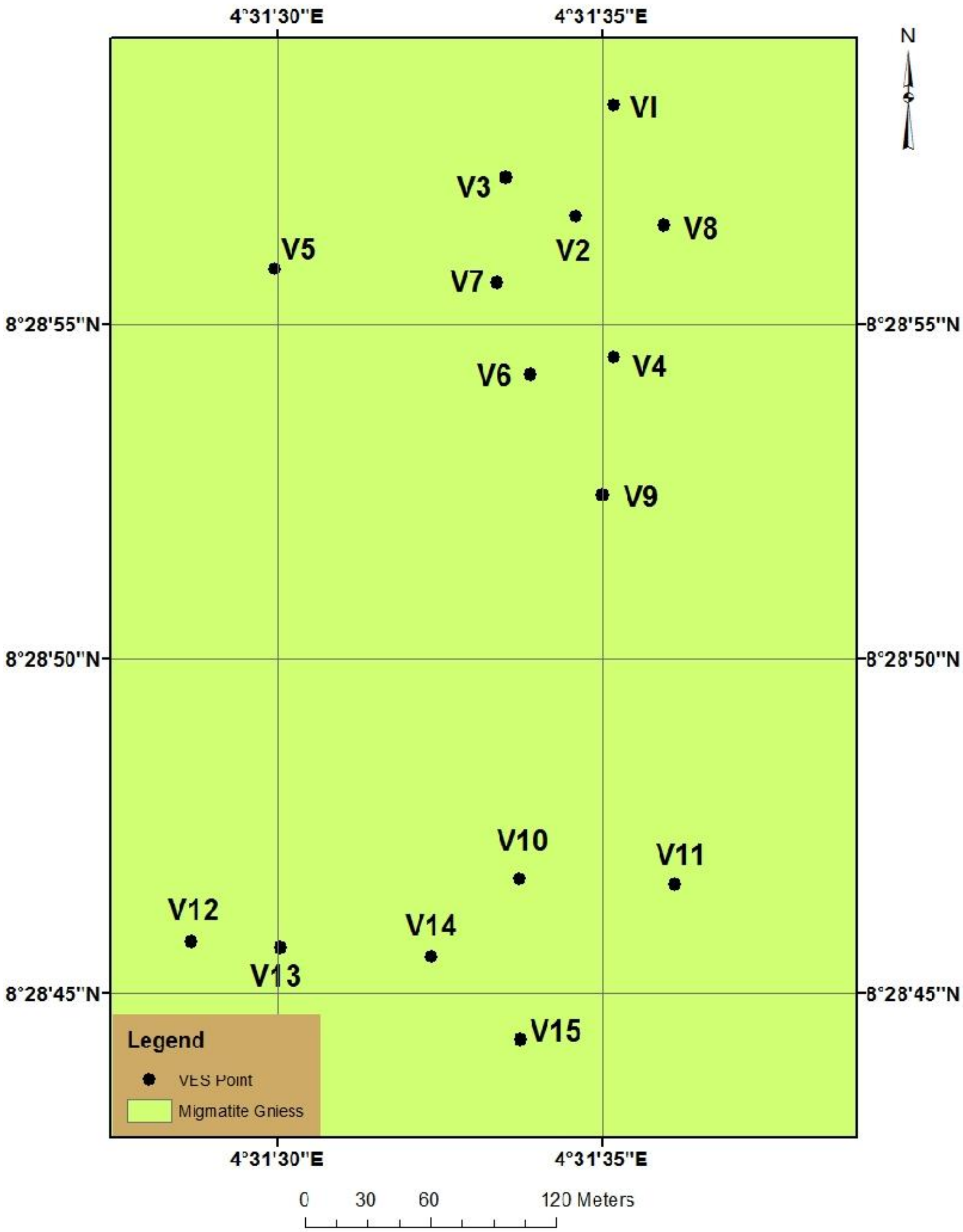


Figure 1: Geological Map of the study area showing VES Points

The vegetation is basically Savannah (Guinea) interspersed with tropical forest remnants (Esan, 1999).
Geologically, the area belongs to the southwestern Nigeria Precambrian basement complex. Locally, the study area is underlain by migmatite gneiss complex Figure 1. These rocks were emplaced in Precambrian times and have been subjected to tectonic activities characterized by large changes in temperature and the pressure resulting in features like joints, faults and folds. Such fractures are those that influence the ground water in crystalline rocks especially, if they exist at depth and are over laid by a thick superficial cover (overburden).

MATERIALS AND METHODS

Geophysical investigations were carried out in order to locate areas of high groundwater potential characterized with thick weathered and fractures zones. The electrical resistivity survey involved vertical electrical sounding (VES) within the IOT campus using Allied Omega digital Resistivity equipment. The Schlumberger electrode configuration was used, with maximum current electrode separation (AB/2) of 50m. The instrument, in this array measures vertical changes in ground resistivity with depth. This is the preferred way to locate vertical layers and aquifers thicknesses. The principle of the resistivity methods is that an electric current is passed into the ground through two current electrodes and the resulting potential difference is measured across two potential electrodes. The resulting potential difference to the current is displayed by the digital resistivity equipment as a resistance. The electrode spacing is progressively increased, keeping the center point of the electrode array fixed. At small electrode spacing, the apparent resistivity is nearly the resistivity of the surface material, but as the current electrodes spacing increase the current penetrates deeper within the subsurface and so the apparent resistivity reflects the resistivity of the deeper layers as well. The apparent resistivity values are obtained by multiplying the measured resistance with an appropriate geometric factor. Different factors affect the resistivity in the subsurface (Telford *et al*, 1990). The generated resistivity curves from the field measurements were first interpreted manually using curve matching and then using relevant computer software (WIN Resist).

RESULTS AND DISCUSSION

The summary of the results of the VES data are presented in Table 1. This table comprises the coordinates and the elevation above mean sea level of each VES points. Also, the thickness and the resistivity of the observed layers and the curve type of each VES point is presented. Some of the interpreted data curves with their root mean square (RMS) values < 5.0 are presented in Figures 2 to 5.

Table 1: Summary of the results of interpresfed VES data

VES	Lat. /Long.	Elev. (m)	Ist layer*	Ist layer**	2nd layer*	2nd layer**	3rd layer*	3rd layer**	4th layer*	4th layer**	Curve type
1	82857.2N 43133.5E	323	6.4	53.1	8.6	474.2	∞	155.5	Nil	Nil	K
2	82855.9N 43130.0E	323	4.7	302	11.7	71.1	∞	39575	Nil	Nil	H
3	82855.9N 43130.0E	325	3.3	284	6.9	39	∞	2265	Nil	Nil	H
4	82845.7N 43128.8E	335	3.2	140.3	5.4	47.5	6.1	234.9	∞	1235	HA
5	82845.8N 43128.7E	335	1.9	122.6	5.7	60.6	∞	613.5	Nil	Nil	H
6	82843.5N 43133.7E	340	2.2	194.4	8.8	59.1	∞	2911.7	Nil	Nil	H
7	82846.8N 43133.7E	338	6.7	61.2	4.9	22.7	∞	2967.8	Nil	Nil	H
8	82846.7N 43136.0E	344	2.6	106.9	5.5	28.4	∞	4577.1	Nil	Nil	H
9	82852.5N 43135.0E	346	3.9	141.9	7.0	35.1	∞	1055	Nil	Nil	H
10	82856.9N 43133.4E	296	8.0	66.1	5.8	26.9	∞	905.0	Nil	Nil	H
11	82855.5N 43133.4E	327	8.0	61.1	5.8	26.6	∞	905.2	Nil	Nil	H
12	82854.2N 43133.9E	336	7.1	57.4	4.4	125.5	∞	467.4	Nil	Nil	H
13	82856.6N 43135.9E	330	3.6	128.4	11.2	62.5	∞	426.2	Nil	Nil	H
14	82854.5N 43135.2E	329	3.9	113.6	7.9	55.3		518.7	Nil	Nil	H
15	82858.3N 43135.2E	332	2.4	228.2	11.1	125.5	∞	522.8	Nil	Nil	H

Lat.-latitude; long.-longitude; elev.-elevation above mean sea level; *- layer thickness; **-layer resistivity

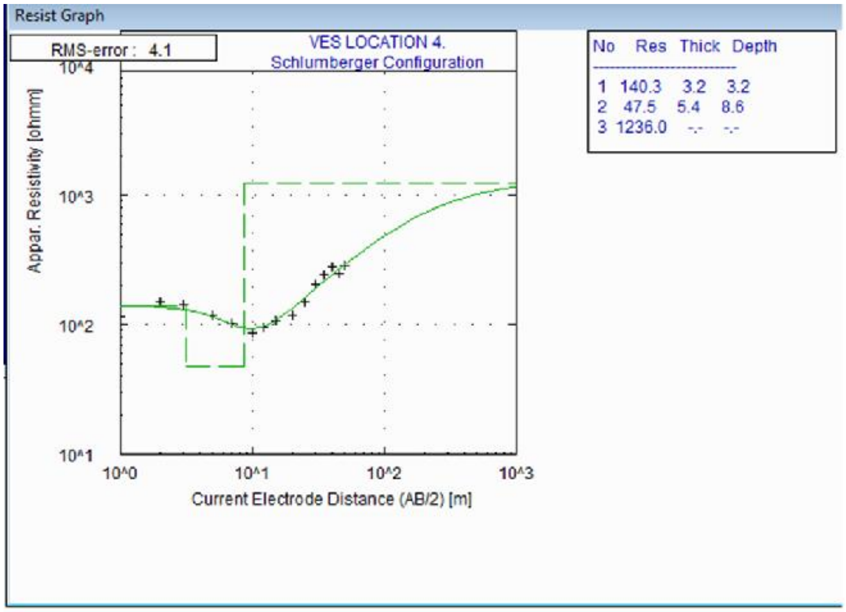
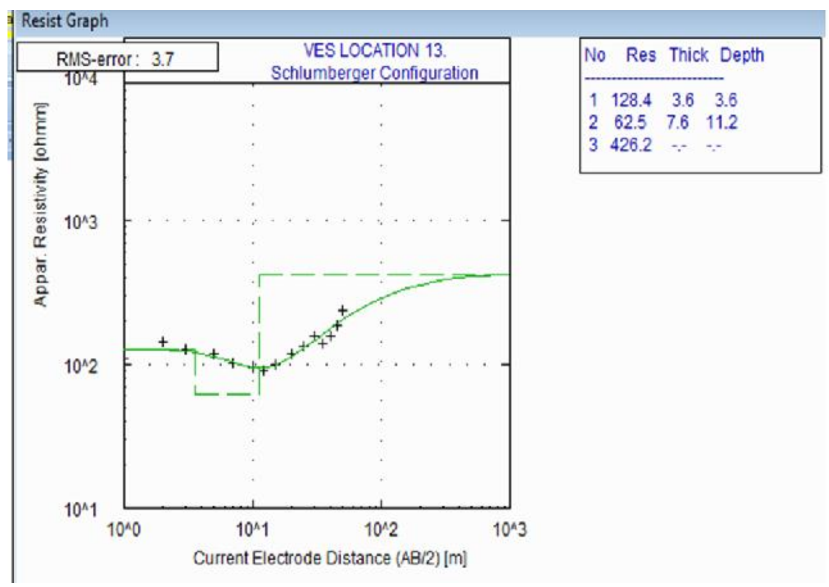


Figure 2:



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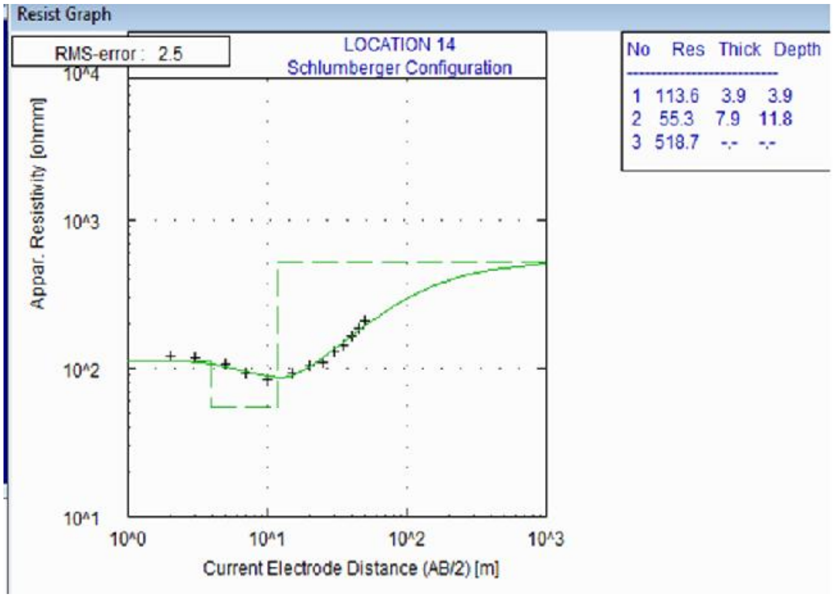

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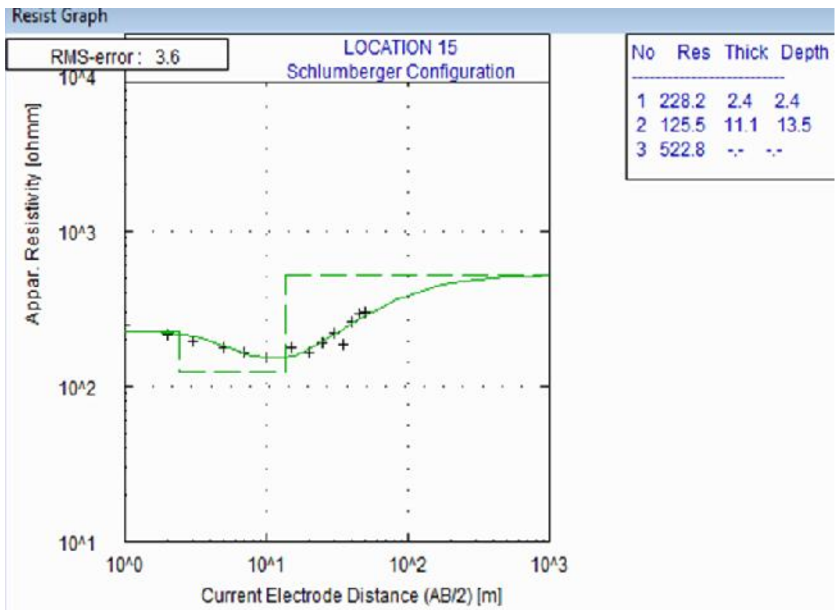

Figure 5:

The interpreted VES data revealed that the area is characterised by mostly three geoelectric layers with varied thickness and resistivity values (Figure 6, Figure 7 and Figure 8). The lithology of the subsurface were inferred from the geoelectric sections bearing in mind the surficial geology and the subsurface geology obtained from nearby boreholes and wells. The inferred lithologies from top to bottom are lateritic clay soil, weathered basement rock and fresh competent basement rock. Groundwater potential was evaluated based on the thickness of the overburden, the thickness and the resistivity of the weathered layer. From Table 1, the overburden thickness ranges from 1.9 to 8m (Figure 9), the weathered layer thickness ranges from 4.4 to stations 1, 2, 5, 6, 7, 8, 10, 11, 14, and 15 are non aquiferous as there is no indication of weathering or fracturing that will serve as conduit for water storage and its passage. VES stations 3, 4, and 13 revealed low groundwater conditions. The weathered layers and overburden thicknesses are high but they are characterised with low degree of weathering and fracturing. VES 9 revealed a prolific aquifer potential as are indication of productive fracturing within the weathered basement and the very thick overburden which is most likely to store water (Figure 10). Groundwater extraction can be achieved by drilling to a depth of about 45 to 52m based on the interpretation of the acquired hydrogeophysical data and hydrogeological

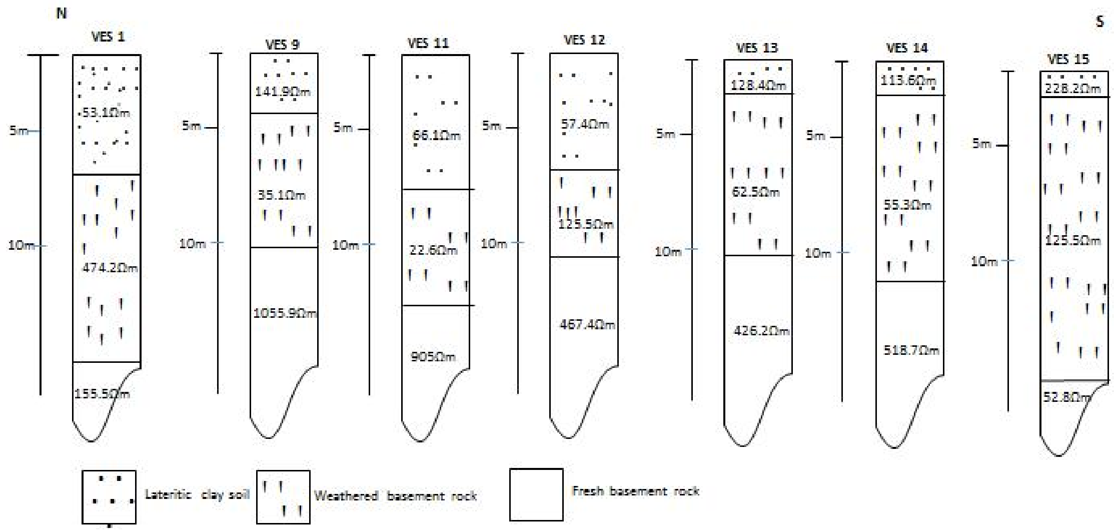

Figure 6: Geo-electric sections along the N-S transverse

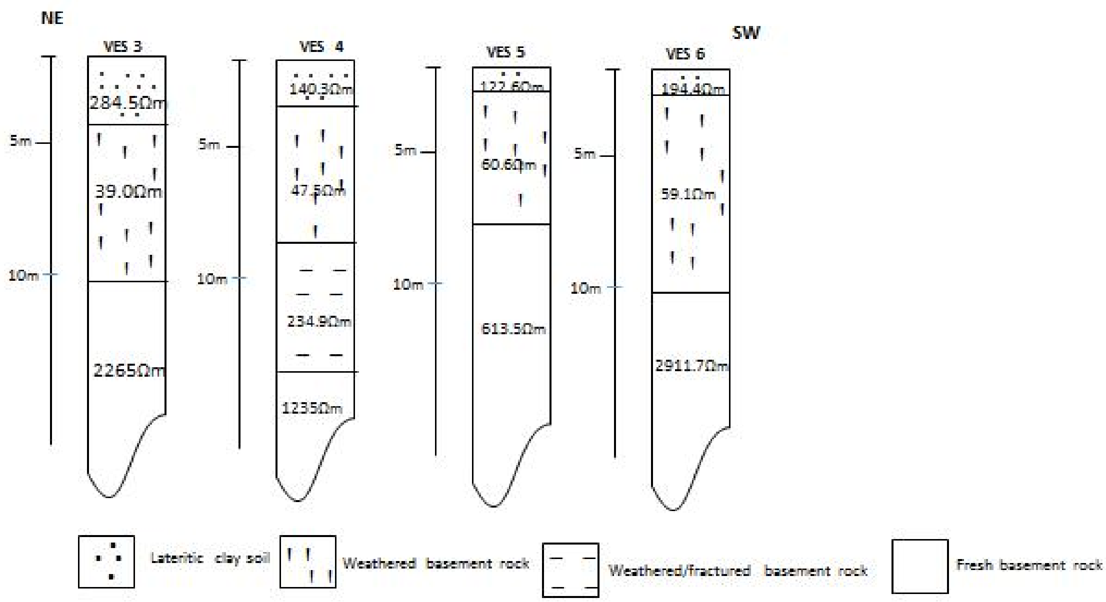

Figure 7: Geo-electric sections along the NE-SW transverse

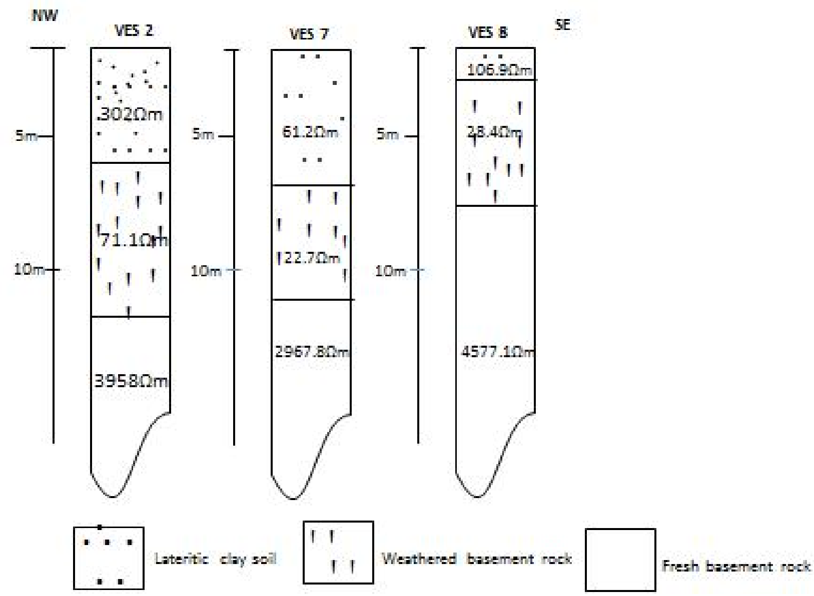

Figure 8: Geo-electric sections along the NW-SE transverse

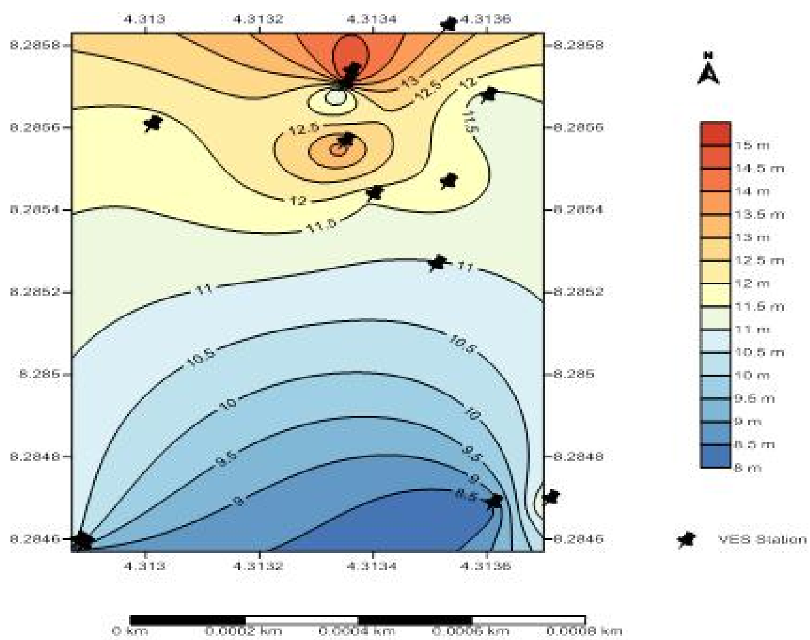

Figure 9: Overburden thickness isopach map

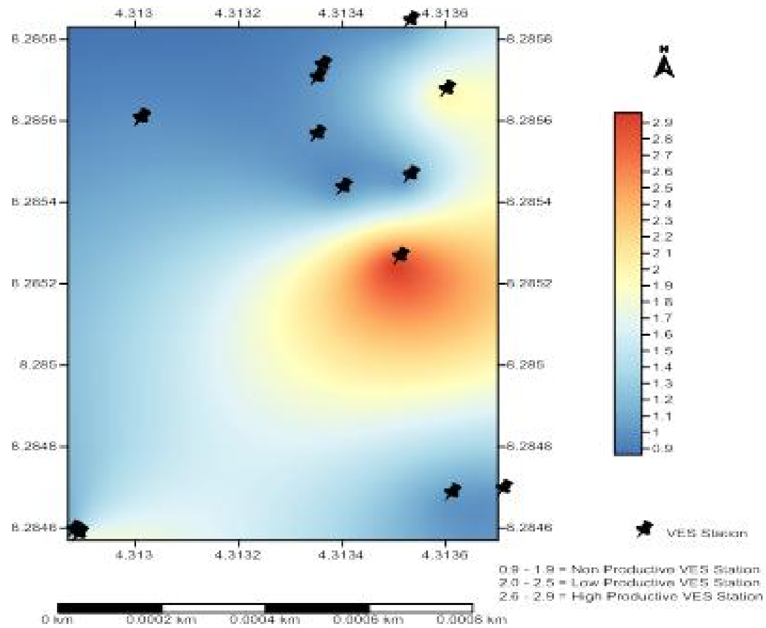

Figure 10: Groundwater potential map of the study area.

CONCLUSIONS

The groundwater condition of the Kwara State Polytechnic, Institute of Technology Campus has been assessed using electrical resistivity technique. 15 vertical electrical soundings were conducted using Allied Omega digital resistivity equipment. The surveyed area revealed basically three to four geoelectric sections with varied thickness and resistivity values. VES stations 3, 4, and 13 revealed a poor groundwater condition while location 1, 2, 5, 6, 7, 8, 10, 11, 14, 15 lack productive fractures which serves as conduit for water passage. VES station 9 revealed a productive fracture within the basement and also water in both the overburden and weathered rock. The quantity and quality of this borehole could not be predicted until after drilling has been done and testing pumping carried out.

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