Hydrogeological and Geophysical Surveys for Groundwater at Designated Premises of the Main Campus of the Federal University of Technology, Minna

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Abstract

The resistivity prospecting method was applied to determine groundwater potential and to identify suitable sites for exploitation of groundwater through drilling of boreholes around developed areas such as the SET complex and students' hostels. The hydrogeological and geophysical data analysis indicated a low prospect for underground water in the area prospected due to lack of fractures and thick unconsolidated layer. However, the VES 3 and VES 4 that are hydrogeologically below the watershed are good candidates for drilling.

Keywords: Resistivity, VES, Overburden, Fracture, Basement.

Introduction

The objective of this study was to determine the groundwater potential and to identify suitable sites for exploitation of groundwater through drilling of boreholes, around the developed areas, particularly the School of Environmental Technology Complex and the students' hostel, of the main campus of the Federal University of Technology, Minna. The developed area covers the east-central part of the permanent site, and the present study was focused on this sector. However, a general overview of the entire site has been given to provide background information about the area.

Location of Permanent Site

The Federal University of Technology, Minna, permanent site that is the proposed main campus is located along the new Minna-Kateregi-Bida road. The site is about 10,600 hectares in areal extent and it lies between latitude 9°26' 15" and 9°37'30"N and longitude 6°21'15" and 6°28'45"E. It has the shape of a bow, bulging out from the centre towards the east and stretching the upper arm towards the north-west at about 45° and the lower arm to the southwest at about the same angle.

Method of investigation

Field studies involved mapping of the area to identify the rock types, structural fabric and the hydrogeological framework. There were no existing wells in the area, and it was therefore impossible to map out the groundwater configuration.

Relief

The relief of the area rises steadily from 150m above sea level in the southern part of the main campus to about 340m above sea level in the northern part. The central part is about 230m above sea level. In the southern and central parts, the topography is generally flat with very few rock outcrops mainly along the stream valleys. In the northern parts the monotonous landscape is broken by a chain of ridges and low-lying hills. The rocks are well exposed in this part.

Vegetation

The vegetation is the woodland savannah type, characterized by moderate height trees of about 12m tall with perennial foliage interspersesd with stunted shrubs and fairly tall grasses.

Drainage

The area is drained in the western part by tributaries of River Gbako and on the eastern part by tributaries of River Chanchaga. The major tributaries include River Dagga, River Weminafia, River Grambuku, and River Leghedna. They exhibit dendritic pattern, indicating that they are controlled by tectonic features. The major tributaries are classified as semi-perennial streams, because they break up into isolated ponds after about three months of cessation of rainfall. In the developed area, which is the focus of this study, several ephemeral streams arise and radiate out of the site in virtually all directions as watersheds. All the streams were dry at the time of investigation which occur in the months of November and December. Some of their courses were identified only as patches of fadama land.

Rock Types

The area is underlain by Basement complex rocks consisting of medium-grained biotite granite interbanded with coarse-grained leucocratic granite and intruded in places by quartzo-feldspathic pegmatite dykes. The dykes strike parallel to the strike of the foliation, and they range from 0.5 to about 3.5 meters in diameter. In the developed area, the rocks are poorly exposed. Good outcrops are found along the river valleys as flat-lying bodies. They range in sizes from 3 x 5 m to about 8 x 15 m. Pinkish feldspar (potassium feldspar) is the dominant mineral in the granite gneiss and the pegmatite. This implies that its weathered product will be rich in clay.

Structure

There are two main sets of fractures. The major fractures strike between 290° and 020°, while the other set strikes between 075° and 085°. Both the major and the minor sets are either vertically dipping or very steeply dipping. Wrench faults are found in few places. The displacement was generally dextral with a heave of about 14cm. The aperture of some fractures is about 10cm in diameter, while others are just about a few millimeters wide. Most of the rocks are fairly well foliated. Two major foliation directions were observed. The foliation of rocks on the northern and southern parts of the Environmental Complex strikes in the range of 340° to 010°, and dips between 60° and 70° E, while outcropping on the western and eastern sides of the Complex strikes at about 280° and dips at between 60° NE and 68° NE.

Weathered Profile

Exposures along the streams indicate very thin weathered zone of about 0.3 to 1.0 m, overlain by a thin cover of superficial deposit or top soil of 0.3 to 0.5 meters thick. It is expected that the geophysical survey will identify points of reasonably thick weathered zone in the area.

The Geophysical Survey

Project Location

The geophysical survey covered an area of 500m by 500m with the School of Environmental Technology (SET) lying almost centrally in it. The area is bounded to the west by the Library and the Administrative Blocks. To the south, it extends about 100m beyond the School of Agriculture and Agricultural Technology (SAAT), and it also covers the entire School of Engineering and Engineering Technology (SEET). The area is bounded to the east by the tarred road immediately after SEET. To the north, the geophysical survey area is bounded by a tarred road that connects to SET and SEET through the Main Campus main entrance.

The Geophysical Methods Employed

The geophysical work carried out here is based on electrical resistivity survey using Horizontal Profiling and Vertical Electrical Sounding (Parasnis, 1986; Kearey and Brooks, 1988; Lowrie, 1997). These were done by determining the depth to basement rock (overburden thickness) and the fissure/fracture systems in the basement rocks. The resistivity method involves the artificial introduction of current into the ground through point electrodes. Potentials are subsequently measured at other electrodes in the vicinity of the current flow. By this means, it is then possible to measure or determine an effective or apparent resistivity of the subsurface. Low resistivity in a given area is a likely indicator of groundwater presence (Ako and Olorunfemi, 1982; Gana, 1995; Bonde, 1997; Dangana, 2002; Offor, 2001; Nasir, 2002). The Wenner array was applied in the electrical profiling of the area. A total of six profiles were established with a 20m electrode spacing, Fig.1. This method was employed so as to delineate zones of low resistivity within the survey area. Overall, seven zones of low resistivity were delineated.

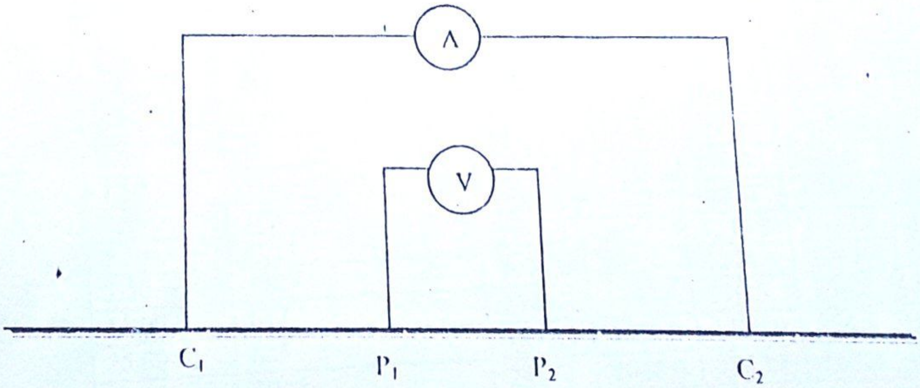

Fig. 1: Wenner Array (C_1 and C_2 are current electrodes while P_1 and P_2 are potential electrodes).

The Schlumberger array was employed in the Vertical Electrical Sounding (VES) of the seven zones of low resistivity. The VES determines the vertical sequence of the underlying strata (Olorunfemi and Okhue, 1972; Okwueze et al, 1981; Okwueze and Ezeanyi, 1985; Olorunfemi and Fasuyi, 1993; Shuaibu et al, 2004). The Schlumberger array is shown in Fig. 2. The data is shown in Table 1.

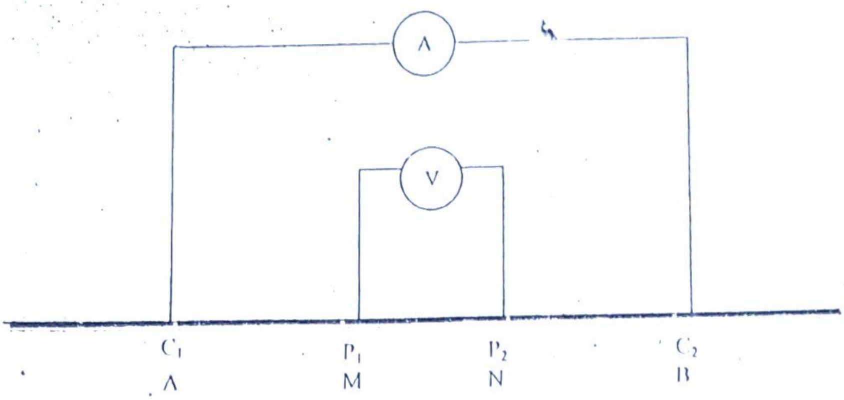

Fig. 2: The Schlumberger Array (the maximum depth probe was AB/2 = 100m).

Table1: Field Data (Schlumberger Array)

MN/2 (M)	Geometric factor (k)	VES 1	VES 2	VES 3	VES 4	VES 5	VES 6	VES 7
.50	2.36	146.3	15.6	193.5	118.0	37.3	23.6	136.9
..50	11.8	94.4	14.2	141.6	56.6	53.1	106.2	106.2
.50	27.8	94.5	22.2	105.6	30.9	52.8	55.6	52.8
.50	77.8	147.8	15.6	93.4	70.0	116.7	155.6	62.2
.50	112	190.4	16.8	100.8	67.2	190.4	156.8	89.6
1.00	55	99.0	38.5	143.0	49.5	22.0	99.0	22.0
1.00	99	79.2	99.0	217.8	131.7	35.6	376.2	118.8
1.00	156	93.6	171.6	280.8	93.6	56.2	405.6	234.0
2.50	58.9	70.7	123.7	23.6	82.5	21.2	141.4	117.8
2.50	137	137.0	301.4	52.1	137.0	150.7	342.5	239.8
2.50	245	245.0	56.4	137.2	220.5	343.0	588.0	343.0
2.50	562	505.8	196.7	505.8	449.6	843.0	1967.0	618.2
2.50	1001	700.7	2002.0	1001.0	700.7	1501.5	4304.3	1001.0
7.50	323	581.4	155.0	516.8	96.9	872.1	1227.4	1227.4
7.50	512	1228.8	184.3	716.8	665.6	870.4	2048.0	240.6
7.50	742	1780.8	215.2	981.9	1113.0	816.2	2968.0	348.7
7.50	1014	2332.2	263.6	1216.8	1622.4	1318.2	4157.4	466.4
7.50	1329	7974.0	292.4	1594.8	3548.4	1727.7	5581.8	598.1
15.00	647	2329.2	1164.6	970.5	258.8	970.5	1552.8	1488.1
15.00	825	1897.5	1650.0	1320.0	354.8	1320.0	1155.0	2334.8
15.00	1024	2457.6	2048.0	1740.8	143.4	1638.4	1024.0	1638.4

Qualitative Interpretation

The results of the electrical profiling using the Wenner array were contoured, and this is shown in Fig.3. From the contour, there is a low region around SAAT to the south of the map. This low region appears to extend southeastward into areas not investigated. The value of the resistivity within the contour closure in this area is 0.1ohm-m and thus this area was marked for VES investigation. Three VES points were sited here. The second low resistivity region occurs at the lower half of the map. It extends from the northeast of the map and covers part of SET and almost all of SEET area. The low resistivity area changes trend at SEET from where it extends northeastward. The value of the closure within this area is 0.4 ohm-m. Two VES points are sited within the closure and one at the southeastern end. The seventh VES point is sited at the south part of SEET

Fig. 3 Contour Map of Wenner Array Data.

Fig. 4 - VES Curve for Site 2

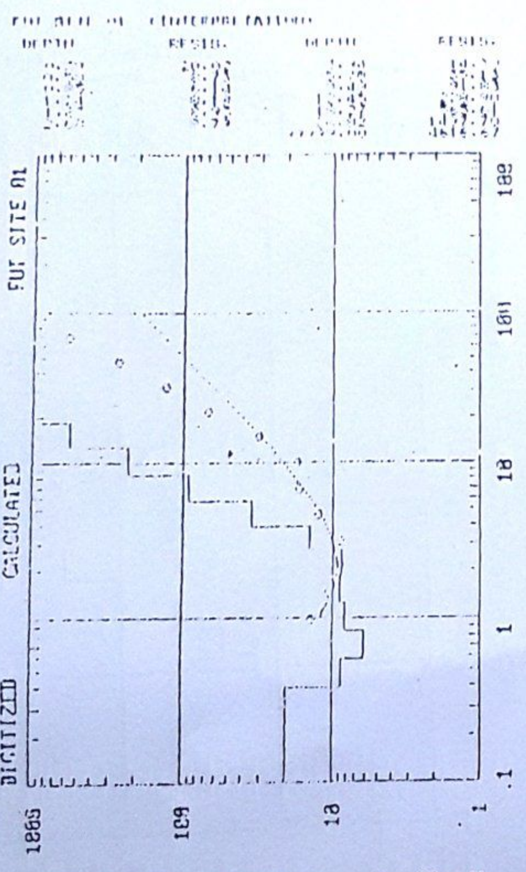

Fig. 5 - VES Curve for Site 1

Fig. 6 - VES Curve for Site 3

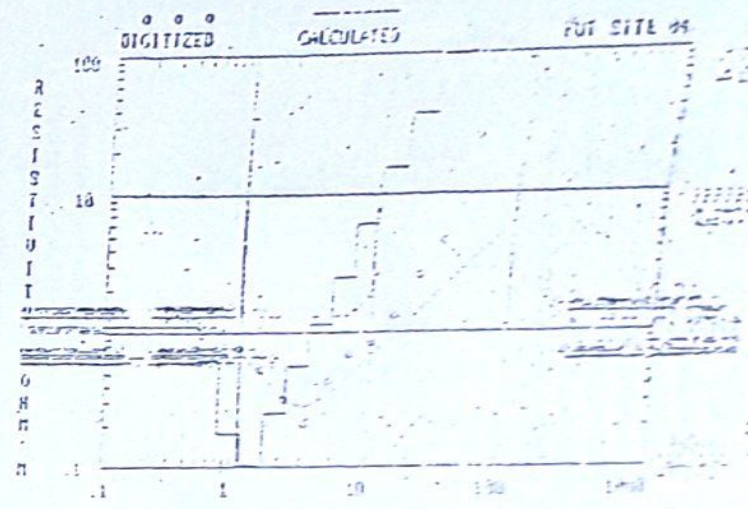

Fig. 7 - VES Curve for Site 4

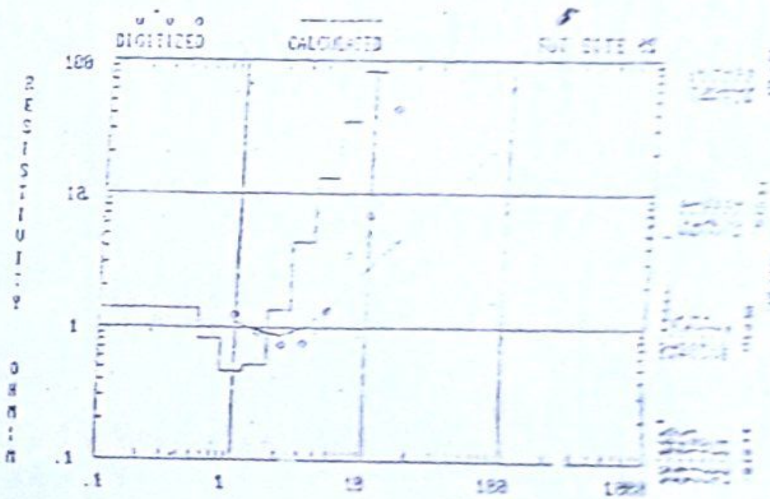

Fig. 8 - VES Curve for Site 5

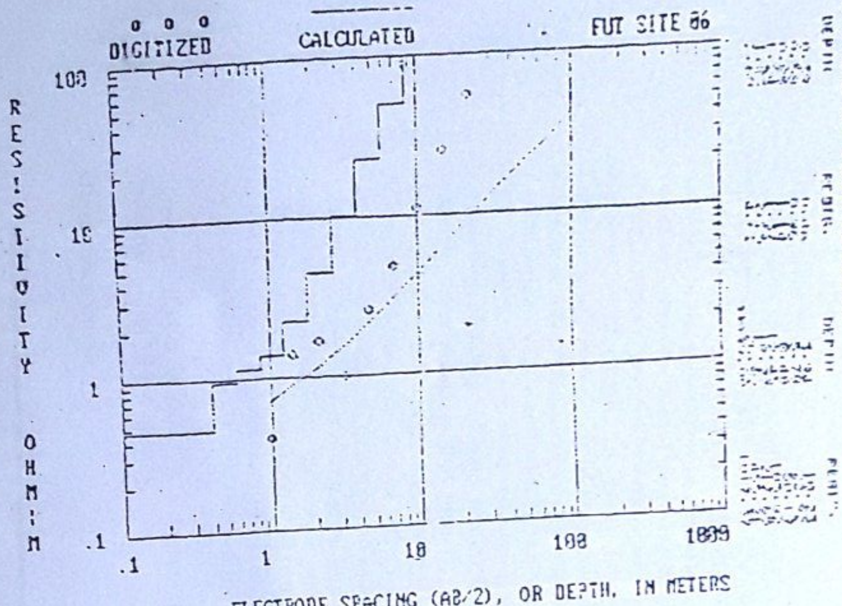

Fig. 9 - VES Curve for Site 5

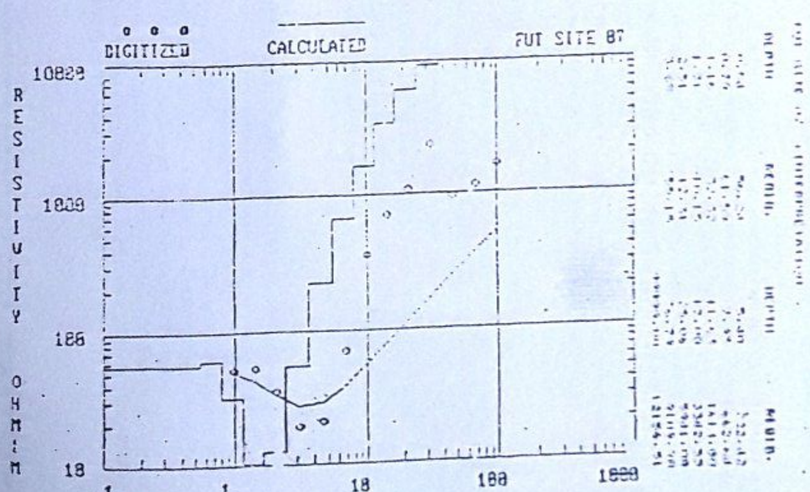

Fig. 10 - VES Curve for Site 7

where the trend of the contour suddenly turned northeast ward. It is sited here because a fresh low resistivity area trending northeastward began to develop at the area. The resistivty here (0.7ohm-m) is however not as low as the other VES points. Generally, the resistivity lows are of average value in terms of groundwater expectation.

Quantitative Interpretation

The data from the VES were interpreted using a two-dimensional computer program developed by Zohdy (1989). The results are shown in Figs 4 to 10. From the computer plotting, three-layered formations were inferred. Table 2 shows the estimations of the thicknesses and resistivities of the layers.

Table 2: Data Analysis

	No of layers	Layer 1 Resist. Ohm-m	Thickness (m)	Layer 2 Resist. Ohm-m	Thickness (m)	Layer 3 Average Resistivity	Thickness (m)
VES 1	3	20.02	0.39	9.18	3.55	>100	∞
VES 2	3	8.04	1.71	32.01	15.37	>100	∞
VES 3	3	7.43	0.79	4.31	4.61	>100	∞
VES 4	3	1.13	0.49	1.60	3.73	>50	∞
VES 5	3	1.39	0.54	0.79	1.97	>100	∞
VES 6	3	0.71	0.58	1.59	1.25	>50	∞
VES 7	3	61.59	0.79	18.26	1.72	>100	∞

Curves 3, 4 and 5 look promising for they show average resistivity values for the second layer in the order of 4.3 ohm-m, 1.6ohm-m and 0.79 ohm-m respectively. Therefore, the interpretation could infer the fresh basement within the three points to have range of resistivity from 50 ohm-m to 100 ohm-m. Curves 2 and 6 show the effect of wet clay at lower depths, that is, low resistivities. The evidences of these are small fadama areas very close to these points.

Discussion

The hydrogeological investigation has shown that VES 3 is below the watershed in the south, and that VES 4 and VES 5 are below the watershed in the central part of the surveyed area. Therefore, within the low of the resistivity contour, at the southern part of surveyed area (SAAT premises), VES shows a good three-layered formation and the thickness of the second layer in the order of 4.6m. This infers a better water-bearing formation than VES 1 and VES 2. The VES 4 and VES 5 are within the same enclosure and they present high possibility of water bearing formations than any other points in that vicinity. Table 2.1 shows that the fresh basement in VES 4 (field data) is less consolidated than that in VES 5. This may imply a better storage of underground water at VES 4 vicinity. The VES 7 is also a good three-layered formation but the fresh basement shows high resistivity value (range of 1000 - 10,000 ohm-m). In this area, there is possibility of a fracture in the x-y direction (figure 2.1). The trend of this fracture may be inferred along VES 4 - VES 5 - VES 7 direction. If this is so, it is a booster to water potential within VES 4 vicinity.

Recommendation

The hydrogeological and geophysical data analysis has indicated a low prospect for underground water in this area due to lack of fractures and the unconsolidated layer is not so thick. However, the VES 3 and VES 4, which are hydrogeological below the watershed, are recommended for drilling. The underground water prospects here are believed to be higher than any other points in this area. In any borehole where low yield is expected, it is advisable to adequately determine the borehole characteristics to select the most suitable pump in order to avoid over pumping.

From the hydrogeological set up of the entire area of Main Campus, it is recommended that another area of ½km x ½km to the south of this present area be surveyed comprehensively. This area will enclose the staff quarters. After that, another portion of ½km x ½km to the east of this area be surveyed and this will be toward the students hostels. Therefore, the complete set up of underground water trend would be apparent.

Conclusion

The drilling operation must be very carefully done so as not to miss or block with the drilling dust the minor fractures that might supplement water from the overburden. The drilling campaign may commence with pneumatic drilling, therefore avoiding the use of mud drilling for the overburden.

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