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Groundwater Potential Investigation Using Electrical Resistivity Method in BASUG New Site Main Campus Gadau, Bauchi State, Nigeria

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ABSTRACT

The study examined the use of vertical electrical sounding (VES) method for groundwater potential investigation in BASUG New Site Faculty of Science Main Campus Gadau, Itas/Gadau L.G.A, Bauchi State. The 12 VES points were carried out across the study area using the Schlumberger electrodes arrays with current electrodes separation from 0 to 200 m to each profile of VES points to identify the depths and resistivity value of the identified geo-electric layers. Through analysis using interpex software, the apparent resistivity; depth and thicknesses of the aquifer were generated. The Interpreted geo-electric layers show a sequence of lateritic topsoil, coarse sand, silty sand, clay sand and clayey. Result of the VES curve analysis reveals that the sub-surface is underlained by three to four lithological layers namely; topsoil, coarse sand, silty sand, and clay sand 0-50m, each VES point is 50m that is one profile is 200m.

Keywords: Vertical electrical sounding (VES), Groundwater, Apparent resistivity geo-electric, Aquifer.

INTRODUCTION

Water is one of the natural resources which are found in an adequate amount. It is an essential source for the existence of the life on the planet earth. It is widely used for various purpose such as drinking, washing, bathing, cleaning, cooking and other industrial and domestic uses. This resource is distributed on the Earth's surface and below the earth surface, there are a lot of variation in terms of both quantity and quality of natural water whether surface or underground. Yet people and animals need clean potable water to survive. The major sources of clean water are tap, borehole, open wells, streams and rivers. In the absence of available good water, people use unsafe sources and this leads to so many health problems (Pimental et al, 1997).

Groundwater is a large source of fresh water available on earth; water is widely distributed and plays a vital role in both environment and human life. Groundwater is water that exists underground in saturated Zone beneath the land surface. It fills the pores and fracture in underground materials such as sand, grave, and other rock where it is stored in and moves slowly through geologic formation like porous and permeable rocks called aquifers like sandstones. Groundwater is the water present beneath Earth’s surface in rock and soil pore spaced and in fractures of rock formation. Groundwater investigation can be generally divided into two types; investigation of water quantity and water quality; nevertheless, investigation depends on project requirements and objectives.

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Ground water investigation can be carried out at a regional scale, local scale or site scale (Schwartz and Zhang, 2003). Regional scale investigation is the largest scale for groundwater investigations, which typically encompasses hundreds or thousands of squares kilometer. It provides somewhat an overall evaluation of groundwater conditions. Local scale investigation covers an area of a few tens or hundreds of square kilometers. On the other hand, site-scale investigation is the smallest scale for groundwater investigation, where in a particular site is involved such as a well field, mining site, waste disposal site, industrial site etc. Site-scale groundwater investigation provides in-depth field investigation at the site under study.

Groundwater can be explored and investigated using different methods. The four major groundwater exploration methods are the areal method, surface methods, subsurface method and esoteric methods which is not based on science, mostly based on traditional indicators (Shishaye, 2016). Geophysical survey is therefore one of the sub methods under the surface method of groundwater exploration. It's applications for groundwater exploration purposes have increased over the years due to the rapid evidence in its computer and numerical modeling solutions. Various methods have been employed successfully these includes electrical resistivity, gravity, magnetic etc. (Karami, 2009). The choice of the methods depends on largely and sometime cost (Majundar and Dass, 2012).

The electrical resistivity method is the most popular of all the geophysical methods used in ground water investigations in the area (Afolayan, 2014). Electrical resistivity of the surface involved determination of the distribution of the ground resistivity based on its response to the flow of electric current injected during surface measurement (Oladunjoye, 2013).

MATERIALS AND METHODS

The Study Area

The study area is located in main campus, Gadau town, Itas/Gadau local government area. It falls between latitude 11.8278° N, and longitude 10.1638° E (Figure 1)

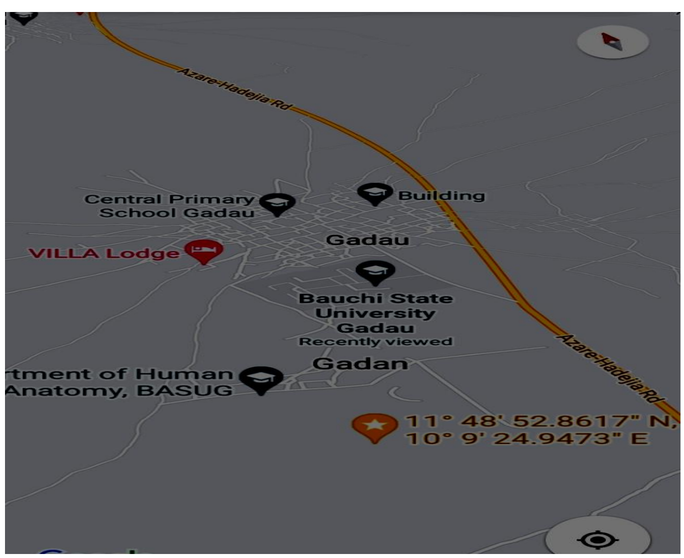

Figure 1: Geology Map of BASUG (Google Map, 2022)

Resistivity Survey Measurement

The resistivity survey measurement was carryout by using an Ohmeger resistivity meter. The Terrameter is a potable microprocessor controlled integrated receiver and transmitter which provides a direct digital read out of resistance. Power is supplied by rechargeable battery pack and provision is made for higher current requirements by means of an internal electronic circuitry. The measurement system employs signal filtering, rejection of self-potential and current transient enabling accurate discrimination of the signal even in high noise environments. Several self-diagnostic checks for instrument, cable and electrodes faults are also inbuilt.

Other instruments that are needed include: Hammer crocodile Chips, measuring tapes, GPS (global positioning system), an umbrella, steel electrodes, field note book and log-log graphs. The global positioning system GPS was used to take the co-ordinate of each sounding point. The usual practice in earth resistance measurement is to pass current into the ground by means of two electrodes and to measure the potential difference between a second pair placed in line between them.

The Vertical electrical sounding (VES) or Depth Sounding method was employed for this investigation. The Schlumberger configuration method was adopted for the investigation. This involves placing the electrodes in a straight line at a certain distance, and for each measurement, the distance between the electrodes is increased. By multiplying the resistance obtained from each measurement by a factor appropriate to the electrodes' configuration and separation, series of apparent resistivities are obtained.

$$I = \frac{V}{R} \qquad (1)$$

Where V is the potential difference between the ends of a conductor, R is the resistance and I is the current of the conductor, R is directly proportional to the length L of the conductor and inversely proportional to the cross-sectional area A (m^2) so that;

$$R = \rho\frac{L}{A} \qquad (2)$$

These resistance values are converted to apparent resistivity values using the formula: $\rho_a = k\frac{v}{i}$ where ρ_a=apparent resistivity and K =geometric factor. The geometric factor varies based on the geometry of each electrode spacing setup.

RESULTS AND DISCUSSION

A total of three (3) profiles VES points were surveyed and each profiles having four (4) VES points that is a total of 12 VES points, the result of these sounding points are presented in Table 1. Each profile have 200m that is, each profile have 4 VES points and each VES point having 50m and interval of 50m from each profile.

The study revealed that the area indicates the presence of mostly four (4) geologic layers which comprise of topsoil (Lateritic), coarse sand, clayed sand, silty clay which have been identified from VES 1, 2, 6, 7, 8, 10 and 11. Other geologic layers having three (3) layers that indicates topsoil, clay and clay sand as identified from VES 4, 5, and 9 and also other geologic layers having three (3) layers that indicates topsoil, silty clay and clayed as identified from VES 3 and 12 respectively.

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Table 1: Resistivity Survey Data around the study area (VES 1-3)

AB/2	MN/2	K	R1(Ω)	R2(Ω)	R3(Ω)	VES 01 (Ω-m)	VES 02 (Ω-M)	VES 03 (Ω-M)
1.5	0.5	6.28	127.3	86.9	41.6	799	546	261
2.5	0.5	18.8	46.1	21.9	13.56	867	412	255
4	0.5	49.5	18.04	5.19	2.92	893	257	145
6	0.5	112	7.76	1.938	0.60	869	217	67
8	0.5	200	4.01	0.848	0.19	802	170	38
10	0.5	313	1.909	0.447	0.09	598	140	28
15	0.5	706	0.427	0.156	0.02	301	110	14
15	2.5	137	1.771	0.628	0.17	243	86	23
20	2.5	247	0.515	0.170	0.06	127	42	15
20	2.5	389	0.189	0.075	0.04	74	31	16
25	2.5	639	0.075	0.045	0.07	48	29	45
40	2.5	1001	0.034	0.01	0.01	34	10	10

Table 2: Resistivity Survey Data around the study area (VES 4-6)

AB/2	MN/2	K	R1(Ω)	R2(Ω)	R3(Ω)	VES 04 (Ω-M)	VES 05 (Ω-M)	VES 06 (Ω-M)
1.5	0.5	6.28	35.3	116.1	25.5	222	229	160
2.5	0.5	18.8	9.12	28.6	3.59	171	538	67
4	0.5	49.5	1.32	5.14	1.350	65	254	67
6	0.5	112	0.233	0.694	0.539	26	78	60
8	0.5	200	0.044	0.166	0.278	19	33	56
10	0.5	313	0.054	0.085	0.189	17	27	59
15	0.5	706	0.023	0.046	0.100	16	32	71
15	2.5	137	0.158	0.125	0.556	22	17	76
20	2.5	247	0.066	0.129	0.296	16	32	73
25	2.5	389	0.031	0.073	0.123	12	36	48
32	2.5	639	0.012	0.061	0.055	8	39	35
40	2.5	1001	0.008	0.042	0.025	8	42	25

Table 3: Resistivity Survey Data around the study area (VES 7-9)

AB/2	MN/2	K	R1 (Ω)	R2 (Ω)	R3 (Ω)	VES 07 (Ω-M)	VES 08 (Ω-M)	VES 09 (Ω-M)
1.5	0.5	6.28	102.3	45.1	20.2	642	283	127
2.5	0.5	18.8	22.2	7.42	5.41	417	137	102
4	0.5	49.5	6.35	2.47	1.76	314	122	87
6	0.5	112	0.445	0.557	0.489	50	62	55
8	0.5	200	0.153	0.187	0.158	31	37	32
10	0.5	313	0.074	0.069	0.055	23	22	17
15	0.5	706	0.036	0.033	0.028	25	23	20
15	2.5	137	0.098	0.158	0.139	13	22	19
20	2.5	247	0.074	0.067	0.055	18	17	14
25	2.5	389	0.053	0.061	0.038	20	24	15
32	2.5	639	0.058	0.045	0.029	37	29	19
40	2.5	1001	0.037	0.030	0.020	37	30	20

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Table 4: Resistivity survey Data around the Study area (VES 10-12)

AB/2	MN/2	K	R1 (Ω)	R2 (Ω)	R3 (Ω)	VES 10 (Ω-M)	VES 11 (Ω-M)	VES 12 (Ω-M)
1.5	0.5	6.28	25.2	21.4	26.7	158	134	168
2.5	0.5	18.8	4.88	5.42	6.21	92	102	117
4	0.5	49.5	1.621	1.472	1.748	80	73	87
6	0.5	112	0.456	0.441	0.547	51	49	61
8	0.5	200	0.246	0.147	0.257	49	39	51
10	0.5	313	0.124	0.129	0.134	39	40	42
15	0.5	706	0.046	0.055	0.064	32	39	45
15	2.5	137	0.245	0.201	0.231	34	28	32
20	2.5	247	0.147	0.0725	0.132	36	18	33
25	2.5	389	0.089	0.058	0.067	35	23	26
32	2.5	639	0.0478	0.061	0.045	31	39	29
40	2.5	1001	0.044	0.053	0.031	44	53	31

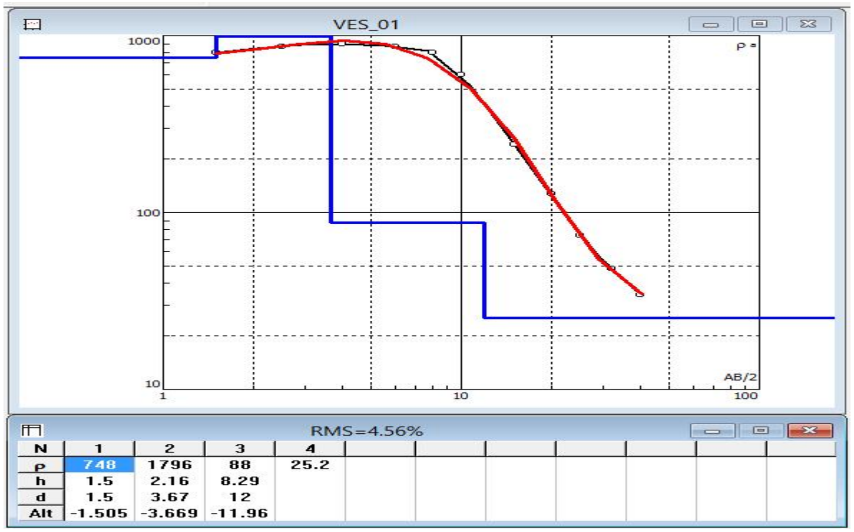

Figure 2: Interpretation curve for VES 01 (Type K)

Figure 3: Interpretation curve for VES 02 (Type K)

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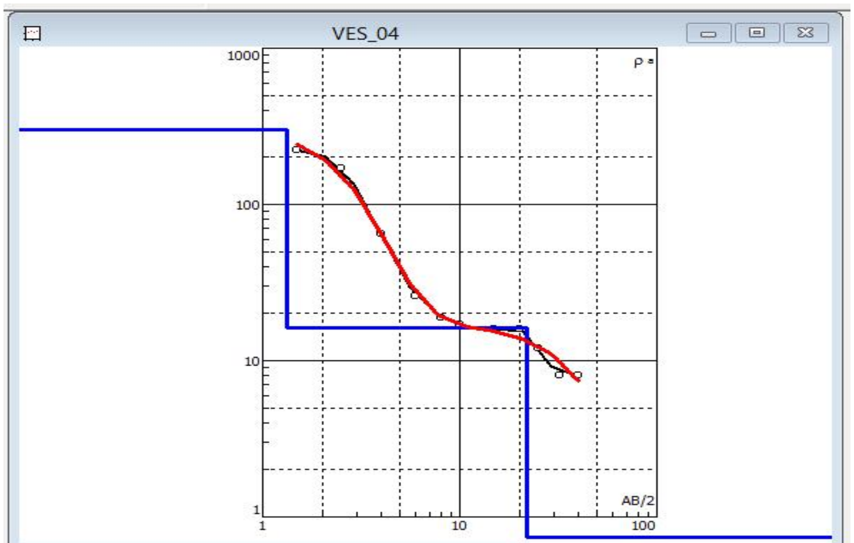
RMS=24.6%

N	1	2	3
ρ	315	22.8	0.144
h	1.88	23.2	
d	1.88	25.1	
Alt	-1.885	-25.06	

Figure 4: Interpretation Curve for VES 03 (Type Q)



RMS=8.31%

N	1	2	3
ρ	299	16.1	0.123
h	1.33	20.6	
d	1.33	22	
Alt	-1.329	-21.96	

Figure 5: Interpretation curve for VES 04 (Type Q)

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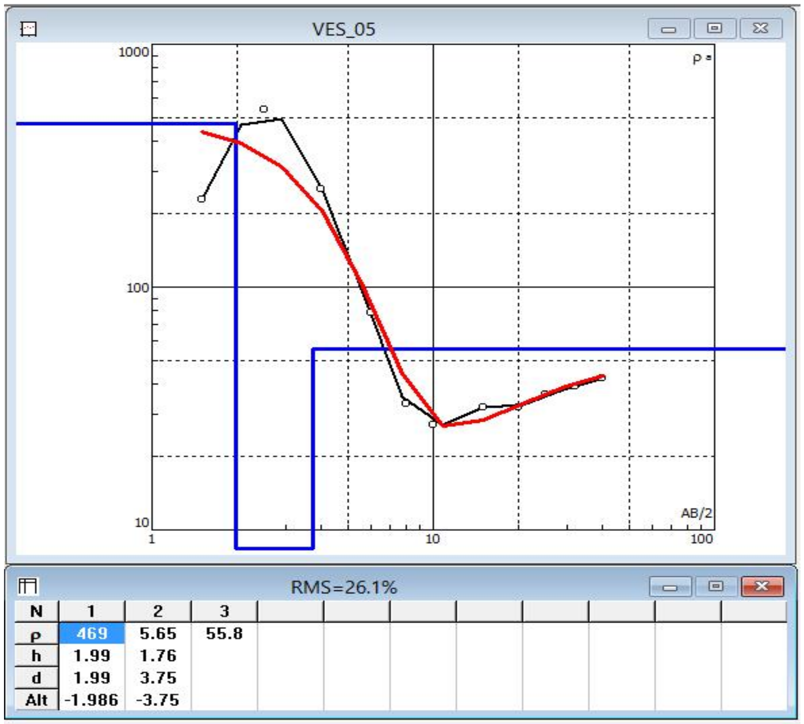

Figure 6: Interpretation curve for VES 05(Type H)

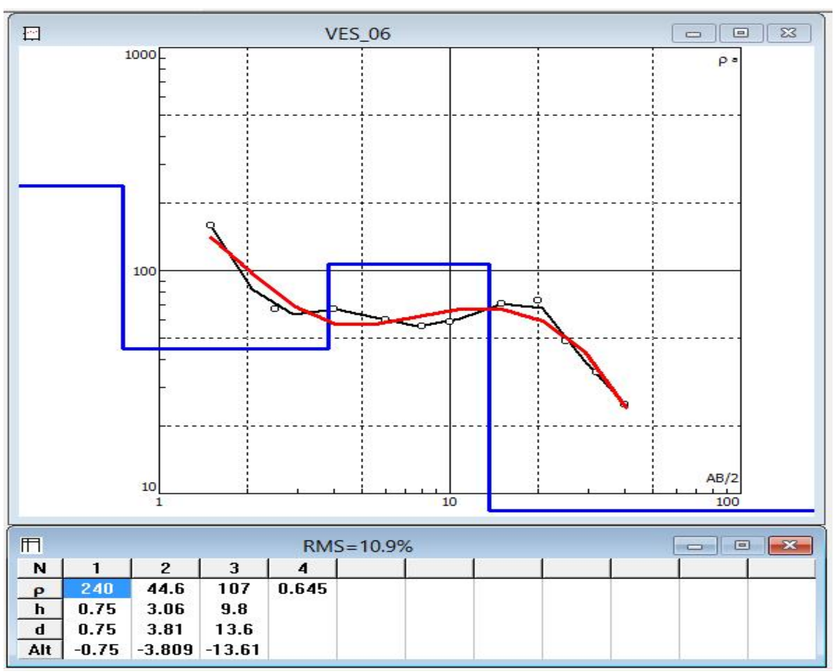

Figure 7: Interpretation curve for VES 06 (Type Q)

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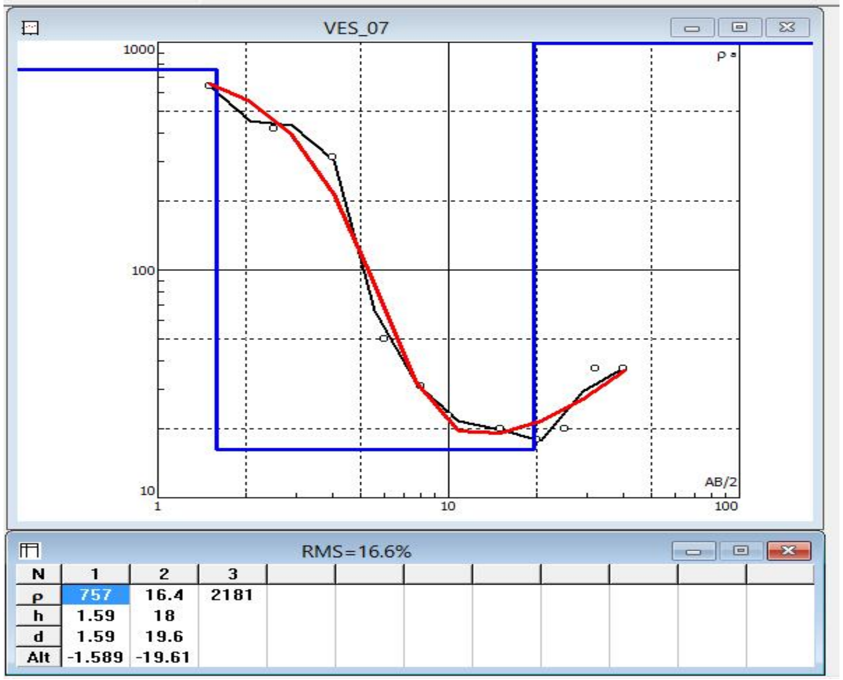
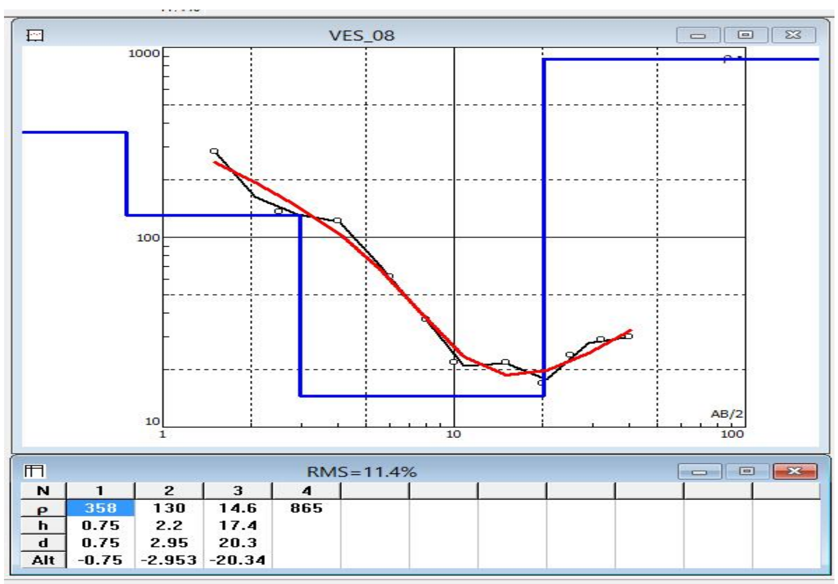


N	1	2	3
ρ	757	16.4	2181
h	1.59	18	
d	1.59	19.6	
Alt	-1.589	-19.61	

Figure 8: Interpretation curve for VES 07 (Type H)



N	1	2	3	4
ρ	358	130	14.6	865
h	0.75	2.2	17.4	
d	0.75	2.95	20.3	
Alt	-0.75	-2.953	-20.34	

Figure 9: Interpretation curve for VES 08 (Type H)

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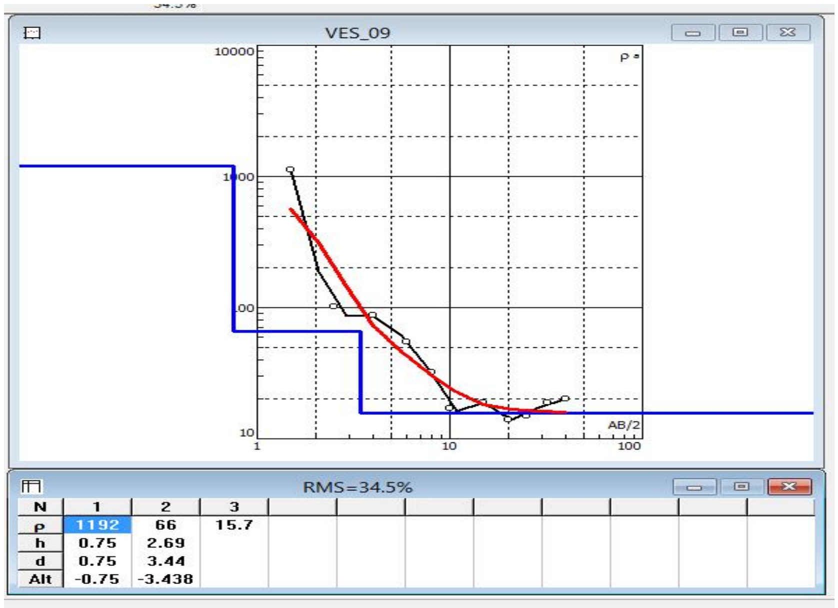

Figure 10: Interpretation Curve for VES09 (Type Q)

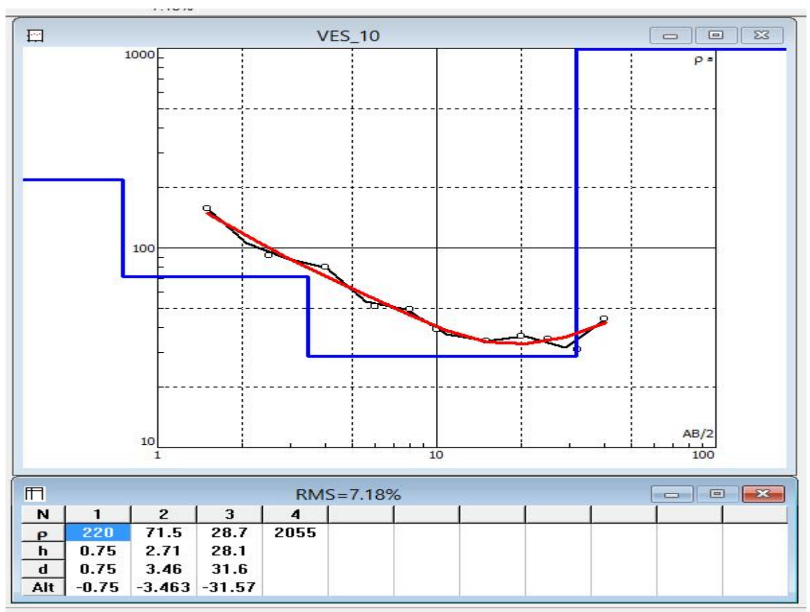

Figure 11: Interpretation curve for VES 10 (Type H)

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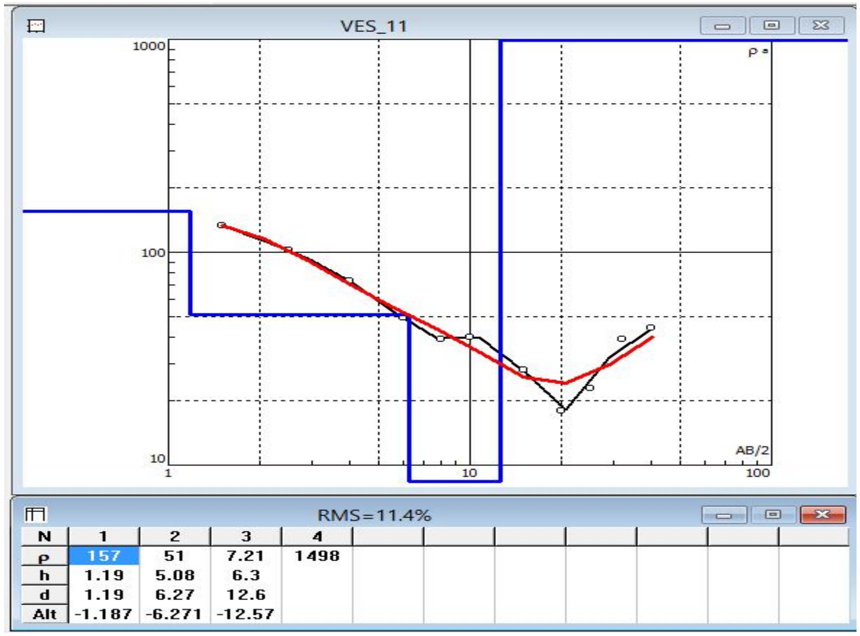
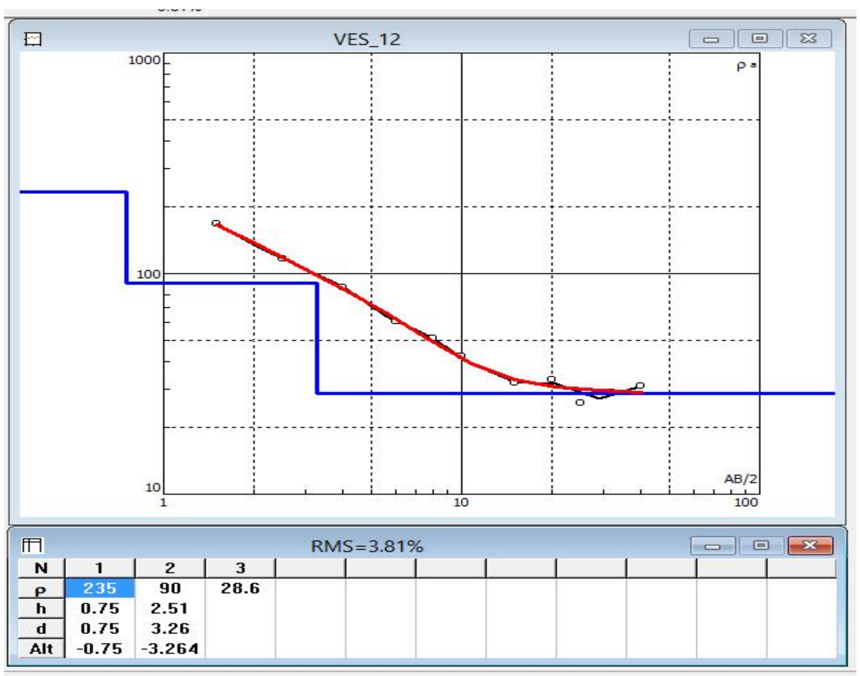


N	1	2	3	4
ρ	157	51	7.21	1498
h	1.19	5.08	6.3	
d	1.19	6.27	12.6	
Alt	-1.187	-6.271	-12.57	

Figure 12: Interpretation curve for VES 11 (Type H)



N	1	2	3
ρ	235	90	28.6
h	0.75	2.51	
d	0.75	3.26	
Alt	-0.75	-3.264	

Figure 13: Interpretation curve for VES 12 (Type Q)

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Table 5: Resistivity values and thicknesses of the VES points.

LOCATION	VES COORDINATES	LAYER NO.	RESISTIVTY (Ᵽ)	LAYER THICKNESS (m)	INFERED LITHOLOGIC FORMATION
Gadau 1	11.81997 N	1	742	1.5	Top soil (lateritic)
	10.15962 E	2	1,796	3.7 6	Coarse sand
		3	88	12	Clayey Sand
		4	25.2	ꝏ	Silty clay
Gadau 3	11.82017 N	1	738	0.922	Top soil (Lateritic)
	10.15955 E	2	235	5.23	Coarse sand
		3	51.2	17.3	Clay sand
		4	0.302	ꝏ	Clayey
Gadau 4	11.82002 N	1	315	1.88	Top soil (Lateritic)
	10.15998 E	2	22.8	25.1	Silty Clay
		3	0.144	ꝏ	Clayey
Gadau 5	11.82016 N	1	299	1.33	Top soil (Lateritic)
	10.16007 E	2	16.1	22	Clayey sand
		3	0.123	ꝏ	Clay
Gadau 6	11.8045 N	1	469	1.99	Top soil (Lateritic)
	10.16004 E	2	5.65	3.75	Clay
		3	55.8	ꝏ	Clayey Sand
Gadau 7	11.82082 N	1	240	0.75	Top soil (Lateritic)
	10.15989 E	2	44.6	3.81	Clayey sand
		3	107	13.6	Coarse Sand
		4	0.645	ꝏ	Clayey
Gadau 8	11.82042 N	1	757	159	Top soil (Lateritic)
	10.15975 E	2	16.4	19.6	Clayey
		3	2,181	ꝏ	Coarse Sand
Gadau 9	11.82066 N	1	358	0.75	Top soil (Lateritic)
	10.15977 E	2	130	295	Coarse Sand
		3	14.6	20.3	Clay
		4	865	ꝏ	Coarse Sand
Gadau 10	11.82046 N	1	1192	0.75	Top soil (Lateritic)
	10.1598 E	2	66	3.44	Clay Sand
		3	15.7	ꝏ	Clay
Gadau 11	11.82048 N	1	220	0.75	Top soil (Lateritic)
	10.16014 E	2	71.5	3.46	Sand
		3	28.9	31.6	Silty Clay
		4	2055	ꝏ	Coarse Sand
Gadau 12	11.82024 N	1	157	1.19	Top soil (Lateritic)
	10.16003 E	2	51	6.27	Clayey Sand
		3	7.21	12.6	clayey
		4	1498	ꝏ	Coarse Sand
Gadau 13	11.82046 N	1	235	0.75	Top soil (Lateritic)
	11.16008 E	2	90	3.26	Clay Sand
		3	28.6	ꝏ	Silty Clay

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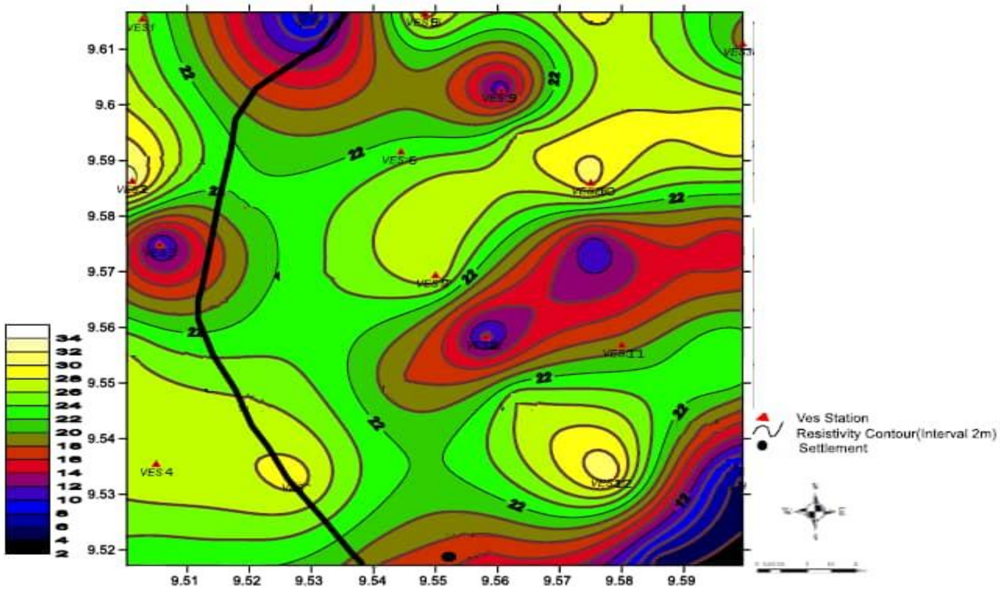

Figure 14: Iso- resistivity contour map of the aquifer layer of the study area

Iso-resistivity analysis gives the qualitative interpretation that represents the variations in resistivity at a designated depth and indicates the general lateral changes in the electrical properties around the area (Mohammed et al., 2014). Figure 13 and 14 show the iso-resistivity and iso-depth contour maps of the aquifer layer. The depth contour maps support claim of which points may have high groundwater yield due to the appreciable values of overburden thickness.

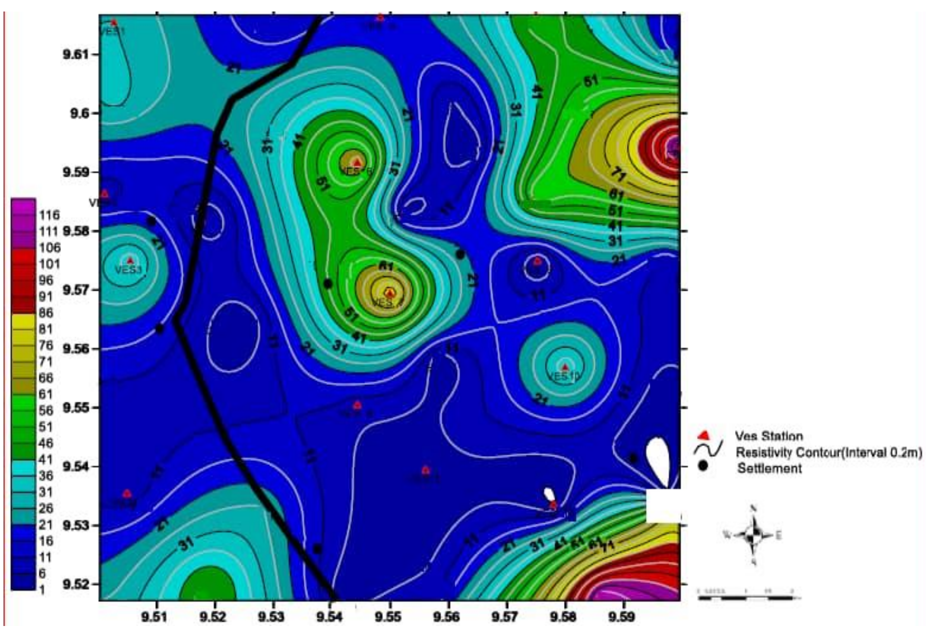

Figure 15: Iso-depth contour map of the aquifer layer of the study area

The result obtained from the Vertical Electrical Sounding was documented in Table 5 showing the coordinates of 12 VES points with the estimated thickness of the aquifer and its associated resistivity values. The interpreted VES data and their results are in

Tables 1 to 4 and Figure 2 to 13. The Vertical Electrical Sounding results gave dominantly 4 geoelectric layers, corresponding underlying rocks comprising of weathered top soil, sand, silty clay and coarse sand. The VES points probed within the horizon, at all the delineated area is prolific. The aquifer exists at different depth within 40m horizon. The values of the resistivity of the aquifer range from 20.55Ωm to 427.8Ωm at shallow layers.

CONCLUSION

The study was carried out to investigate the geophysical electrical properties of the subsurface, geological information that would yield aquifer layers and groundwater quality was also analyzed from BASUG New Site, Main Campus Area, using electrical resistivity method.

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