Vertical Electrical Sounding for Groundwater study In Khanakai Returnee and internal displacement people Settlement, Bihsud district of Nangarhar Province

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Table of Contents

Table of Table

Table of Figure

ABSTRACT

Vertical Electrical Sounding (VES) investigation were carried out in Khanakai Returnees and Internal Displacement People (IDPs) Settlement in Bihsud District of Nangarhar Province, in order to study the aquifer characteristic with a view of determining the depth and thickness of sediments layers and recommend suitable site to drill wells for safe drinking water . Five VES profile were conducted in this area and the Schlumberger electrodes configuration was used for the field data acquisition.

The length of current electrode spacing (AB/2) ranged from 350-500 m and total lengths of VESs profile was 4.1 Km. The field data obtained was analyzed using IX1D computer software which gives an automatic interpretation of the apparent resistivity.

Interpretation of VESs profile data results confirm the similarities of the subsurface Geologic sequence (litho-logic layers). The subsurface Geology lies within the Quaternary-Neogene clastic sedimentary deposits (clay, silt clay, silt sand, sand, gravel, people, coble, boulder, conglomerate and sandstone) and it is underlain by fundamental Rocks (early Proterozoic gneiss, schist, amphibolites and quartzite). The maximum depth of study range is between 140 m and 200m. The aquifers average apparent resistivity range is between 6.87 and 471 Ohom.m and the groundwater characterized by fresh water. The depth of water table is prospected between 75 and 95 m. This area is problematic for well drilling due to having deep water table and hard strata.

Key word: VES, Groundwater, Geo-electrical characteristic of sediments and Schlumberger array.

List of Abbreviation and Technical Terms

Roh:	Apparent Resistivity (ohm.m)
Sp:	Self Potential (mV)
Vp:	Voltage Potential (mV)
In:	Current (m A)
VES:	Vertical Electrical Sounding
DACAAR:	Danish Committee for Aid to Afghan Refugee
WASH:	Water Sanitation and Hygiene

1. Introduction

On 15-16 November 2016, the geo-electrical survey (Vertical Electrical Sounding) was carried out in Khanakai Returnees and Internal Displacement People (IDPs) Settlement in Bihsud District of Nangarhar Province, which was requested by Kabul UN Habitat. The Khanakai Returnee camp is located in Bihsud district of Nangarhar province. This is dissert without any settlement.
Vertical Electrical Sounding (VES) using Schlumberger array [1] was carried out at five VES line. SYSCAL Pro Standard & *Switch* (48 - 72 or 96) Version [2] was used for the data acquisition.

Vertical Electric Sounding (VES) employs collinear arrays designed to output a 1-D vertical apparent resistivity versus depth model of the subsurface at a specific observation point [3]. In this method a series of potential differences are acquired at successively greater electrode spacing while maintaining a fixed central reference point. The induced current passes through progressively deeper layers at greater electrode spacing [4]. The potential difference measurements are directly proportional to the changes in the deeper subsurface. Apparent resistivity values calculated from measured potential differences can be interpreted in terms of overburden thickness, water table depth, and the depths and thicknesses of subsurface strata.
In this study, the resistivity measurements were made by injecting current into the ground through two current electrodes (C1 and C2), and measuring the resulting voltage difference at two potential electrodes (P1 and P2).

2. Objectives of the survey

The overall objective of this study was to assess availability of ground water and adjustment of Geological-Technical condition for the drilling of wells in the target area. The following are the specific objectives of the study:

- Determine depth and thickness of sediments layers.
- Identify the depth of groundwater table of the area.
- Identify aquifers qualitative status of aquifers

3. Rationale to carry out investigation

In the Khanakai area has planned to settle Returnee and Internal displacement families, but this area has groundwater development problem due to unknown availability of groundwater. Therefore, there is a need to perform geophysical study (VES) for determining groundwater availability and hydro-geological condition for adjustment of drilling technology.

4. Surface Geological setting of area

The surface geological formations of the area are:

- Recent: Loess, clay, sand and gravel.
- Early Quaternary: red clay, loam, sand and gravel.
- Middle Quaternary: clay, silt clay and conglomerate.
- Early Miocene: sandstone, siltstone, conglomerate and limestone.
- Eocene: clay, shale and conglomerate.
- Paleocene: siltstone, conglomerate and limestone.
- Late Cretaceous: limestone and marl.

- Early Cretaceous: limestone, dolomite and gypsum.

The surface Geology of the study area is shown in the Figure 1.

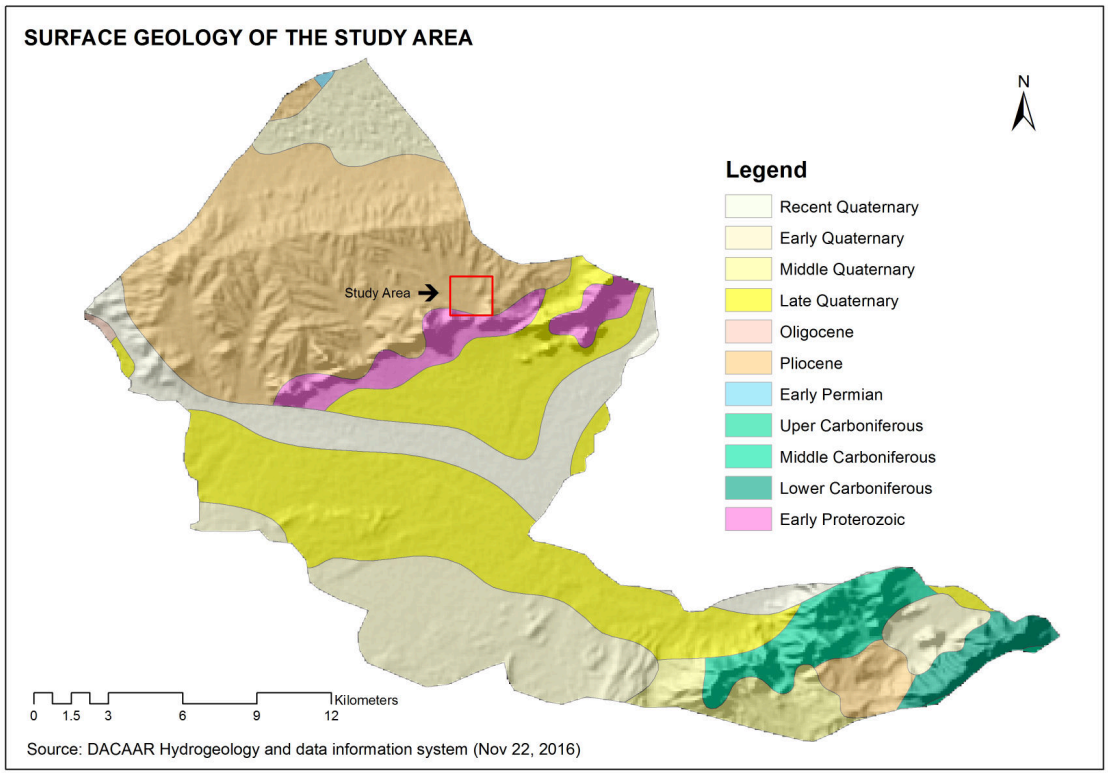

Figure 1.Surface Geological Setting of the Area

5. Materials and method

5.1 Description of the area

The study areas are located about 12 Km in the North direction of Jalalabad city of Nangrahar province and positioned at latitude of 34.485572 to 34.491456 and a longitude of 70.496714 to 70.493959. It has semi- arid climate with major fluctuation in day- and night-time fluctuations. The winter is characterized by low temperatures of less than -4 ºC while the summer is dominated by high temperatures of more than 45 ºC. The rainfall and snowfall are the main source of groundwater and surface water, and the area receives an average 150 mm rainfall. There are number of seasonal rivers and abandoned channels which are flowing water in rainy seasons. The study area is shown in the figure 2.

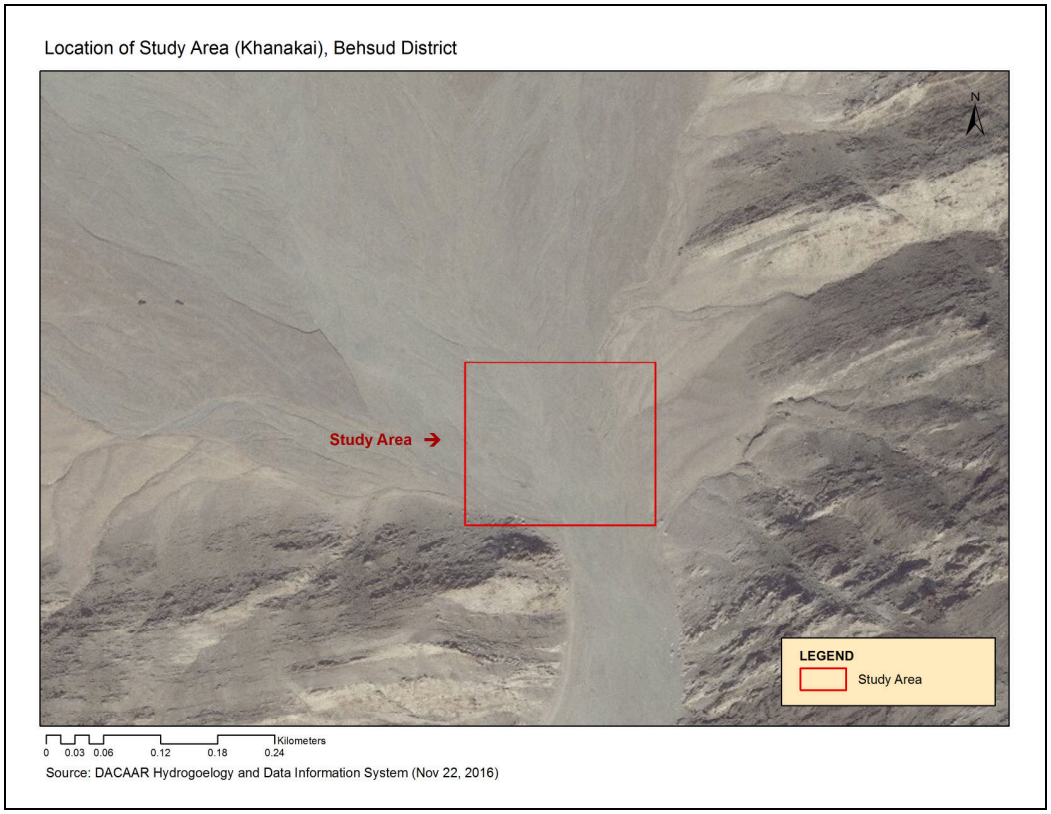

Figure 2.Location of Study Arae

5.2 Data Acquisition

Vertical Electrical Sounding (VES) using Schlumberger array was carried out at five VESs profile of the study area. SYSCAL Pro Standard & *Switch* (48 - 72 or 96) Version was used for the data acquisition. Figure 3 is shown the field data acquisition processes onsite.

Figure 3.Measured Field Data

The Applied Schlumberger Techniques was used by transmitting electrical current into the ground from DC (direct current) or low frequency sources by two electrodes (A and B). The potential difference between a second pair of electrodes (M and N) was measured (Figure 4)

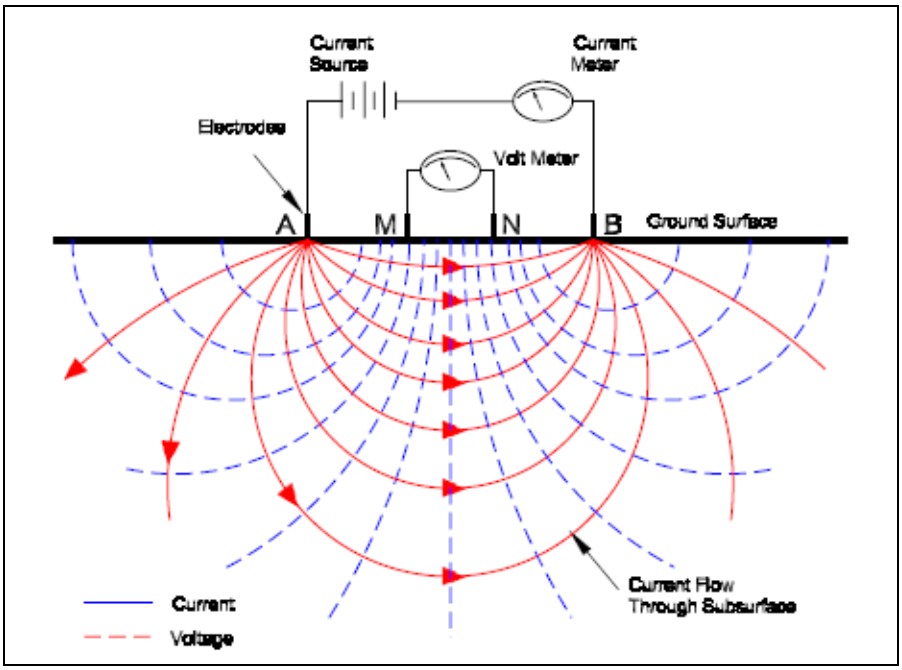

Figure 4.Schlumberger Applied Techniques Method

The field data were analyzed using IX1D software which gives an automatic interpretation of the apparent resistivity.

5.3 Location of VES stations

Five VES lines were performed in the study area. The VES lines location were georefrenced. and shown in table 1and the VES lines is shown in the Figure 5

Table 1.Location and Length of VES Stations

NO	VES Stations	Latitude	Longitude	Elevation (m)	VES Length (m)
1	VES1	34.48690	70.49968	625	700
2	VES2	34.48696	70.49963	625	700
3	VES3	34.48797	70.49893	627	1000
4	VES4	34.49044	70.49730	634	1000
5	VES5	34.48779	70.49873	633	700

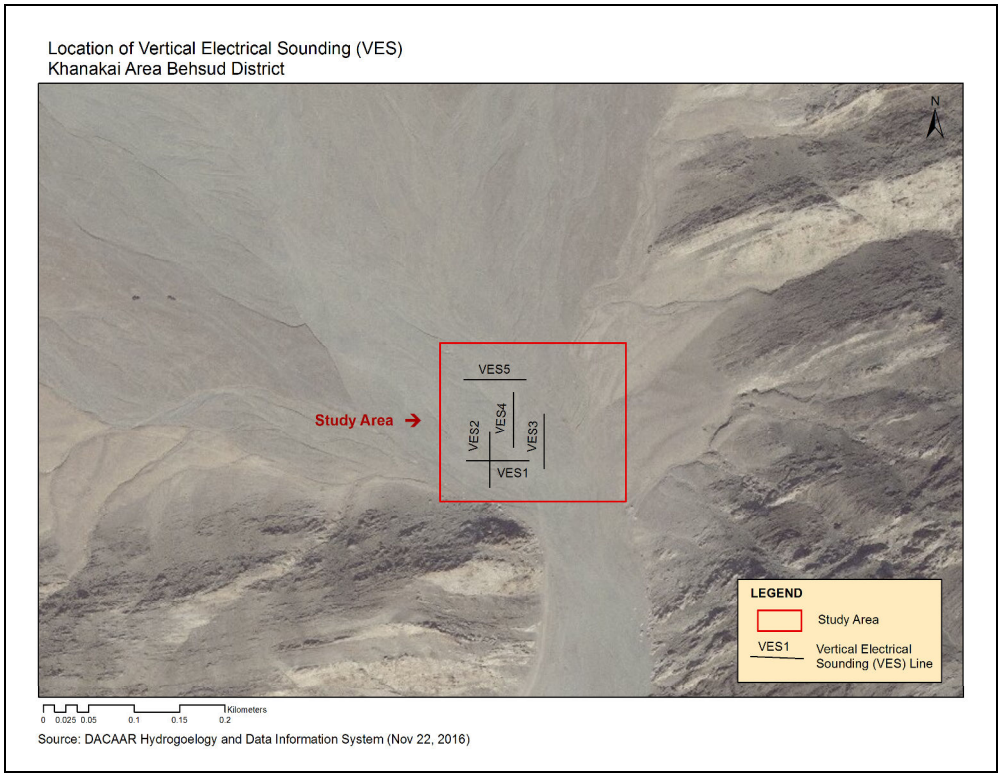

Figure 5.Location of VES lines

5.4 Measured VES stations data

The field measured data from VES lines are shown in Table 2, 3, 4, 5 and Table 6.

Table 2.VES 1 measured Field Data

VES_1 Latitude: 34.48690 Longitude:70.49968 Elevation (m):625					
AB/2	MN/2	Pa (Ωm)	ΔV (mV)	I (mA)	K
1	0.5	3.4370	943.698	645.231	2.35
2	0.5	568.0269	171.082	3.554	11.8
3	0.5	291.2639	21.956	2.073	27.5
4	0.5	152.2768	12.499	4.063	49.5
5	0.5	178.4241	10.795	4.701	77.7
6	0.5	103.6840	1.945	2.101	112
8	0.5	33.3696	0.614	3.68	200
10	0.5	23.7985	1.69	22.227	313
15	0.5	18.3188	0.87	33.482	705
15	5	22.1303	12.061	34.226	62.8
20	5	16.7402	8.424	59.38	118
20	0.5	18.6098	0.888	59.646	1250
25	0.5	47.1768	2.365	98.256	1960
25	5	16.8217	8.89	99.355	188
30	5	17.0446	8.686	140.141	275
35	5	18.4432	3.935	80.436	377
40	5	22.8769	3.669	79.388	495
50	5	13.1907	1.357	80.243	780
60	5	25.2989	0.861	38.117	1120
70	5	16.0010	0.467	44.654	1530

80	5	54.2096	1.375	50.729	2000
80	30	22.8746	4.082	51.394	288
100	30	31.7311	2.002	29.969	475
100	5	114.3831	1.178	32.235	3130
125	5	133.5364	1.226	44.987	4900
125	30	35.9862	2.186	46.774	770
150	30	42.8652	0.716	18.875	1130
175	30	80.8317	1.54	29.721	1560
200	30	20.3772	0.938	93.905	2040
250	30	11.7366	0.145	39.905	3230
300	30	62.9884	0.276	20.419	4660
350	30	409.6007	0.421	6.537	6360

Table 3VES2 Measured Field Data

VES_2 Latitude: 34.48696 Longitude:70.49963 Elevation (m): 626					
AB/2	MN/2	Pa (Ωm)	ΔV (mV)	I (mA)	K
1	0.5	1088.3585	6036.916	13.035	2.35
2	0.5	594.5482	816.748	16.21	11.8
3	0.5	264.3851	111.907	11.64	27.5
4	0.5	136.8535	40.81	14.761	49.5
5	0.5	89.0845	27.466	23.956	77.7
6	0.5	64.6230	12.684	21.983	112
8	0.5	42.8306	4.267	19.925	200
10	0.5	34.0859	1.998	18.347	313
15	0.5	49.9616	1.624	22.916	705
15	5	23.0760	8.537	23.233	62.8
20	5	23.3918	3.978	20.067	118
20	0.5	109.3400	1.756	20.075	1250
25	0.5	34.2528	0.167	9.556	1960
25	5	11.3488	0.571	9.459	188
30	5	7.5383	0.799	29.148	275
35	5	21.1967	2.656	47.239	377
40	5	17.0557	1.422	41.27	495
50	5	15.4135	0.901	45.595	780
60	5	12.6730	2.029	179.316	1120
70	5	21.0753	0.856	62.143	1530
80	5	11.2379	0.458	81.51	2000
80	30	19.5868	5.567	81.856	288
100	30	21.3735	1.984	44.092	475
100	5	48.1441	0.757	49.215	3130
125	5	36.0347	0.251	34.131	4900
125	30	22.1897	1.133	39.316	770
150	30	31.6730	1.44	51.375	1130
175	30	30.6546	0.915	46.564	1560
200	30	39.2012	0.893	46.471	2040
250	30	62.0569	2.406	125.23	3230
300	30	53.9426	0.791	68.333	4660
350	30	140.9938	0.406	18.314	6360

Table 4.VES 3 Measured Field Data.

VES_3 Latitude: 34.48797 Longitude:70.49893 Elevation (m): 627					
AB/2	MN/2	Pa (Ωm)	ΔV (mV)	I (mA)	K
1	0.5	415.8397	15019.42	84.878	2.35
2	0.5	768.2498	3490.328	53.61	11.8
3	0.5	472.5785	938.558	54.616	27.5
4	0.5	303.4802	448.697	73.186	49.5
5	0.5	239.2278	241.577	78.463	77.7
6	0.5	199.7818	133.11	74.623	112
8	0.5	150.0105	35.779	47.702	200
10	0.5	122.2439	19.659	50.336	313
15	0.5	68.5541	3.072	31.592	705
15	5	76.7595	38.744	31.698	62.8
20	5	43.2774	13.16	35.882	118
20	0.5	43.1339	1.271	36.833	1250
25	0.5	29.5170	1.67	110.892	1960
25	5	28.0701	16.709	111.909	188
30	5	17.2005	4.809	76.886	275
35	5	19.9720	4.523	85.378	377
40	5	17.5292	1.425	40.24	495
50	5	18.4937	1.586	66.892	780
60	5	19.5288	0.732	41.981	1120
70	5	26.1863	0.868	50.715	1530
80	5	17.1837	0.616	71.696	2000
80	30	22.4914	5.674	72.655	288
100	30	24.3496	3.452	67.34	475
100	5	33.3312	0.723	67.894	3130
125	5	22.0871	0.437	96.948	4900
125	30	25.0924	3.203	98.289	770
150	30	29.0683	1.658	64.453	1130
175	30	31.3344	1.511	75.226	1560
200	30	37.5466	1.459	79.271	2040
250	30	46.1461	0.813	56.906	3230
300	30	53.5801	0.584	50.792	4660
350	30	119.2151	0.748	39.905	6360
350	100	103.6078	2.353	40.107	1766
400	100	142.9254	2.064	34.081	2360
400	30	156.5851	0.634	33.606	8300
450	30	249.8997	0.593	24.916	10500
450	100	199.9466	1.747	26.212	3000
500	100	79.8990	0.505	23.765	3760

Table 5.VES4 Measured Field Data

VES_4 Latitude: 34.49044 Longitude:70.49730 Elevation (m): 634					
AB/2	MN/2	Pa (Ωm)	ΔV (mV)	I (mA)	K
1	0.5	810.826	12237.26	35.467	2.35
2	0.5	111.650	627.965	66.368	11.8

3	0.5	34.530	71.088	56.615	27.5
4	0.5	22.713	29.53	64.357	49.5
5	0.5	22.502	12.256	42.321	77.7
6	0.5	27.425	10.925	44.616	112
8	0.5	31.522	6.909	43.836	200
10	0.5	30.253	8.197	84.807	313
15	0.5	37.415	2.517	47.427	705
15	5	35.760	27.258	47.869	62.8
20	5	39.140	17.763	53.552	118
20	0.5	45.701	1.955	53.472	1250
25	0.5	22.249	0.756	66.6	1960
25	5	40.054	14.254	66.904	188
30	5	43.210	7.883	50.17	275
35	5	43.485	4.623	40.08	377
40	5	47.496	4.823	50.265	495
50	5	46.867	2.623	43.654	780
60	5	51.971	2.014	43.403	1120
70	5	35.350	0.625	27.051	1530
80	5	46.487	0.648	27.879	2000
80	30	56.019	5.534	28.451	288
100	30	43.344	3.33	36.493	475
100	5	37.761	0.619	51.309	3130
125	5	61.928	0.508	40.195	4900
125	30	53.713	2.852	40.885	770
150	30	47.066	4.875	117.043	1130
175	30	59.158	1.687	44.486	1560
200	30	50.564	1.243	50.149	2040
250	30	129.673	1.239	30.862	3230
300	30	237.695	1.701	33.348	4660
350	30	102.325	1.69	105.042	6360
350	100	64.432	4.664	127.834	1766
400	100	181.591	1.336	17.363	2360
400	30	439.128	0.91	17.2	8300
450	30	81.116	0.372	48.153	10500
450	100	22.879	0.36	47.204	3000
500	100	29.023	0.29	37.57	3760

Table 6.VES5 Measured Field Data

VES_5 Latitude: 34.48779 Longitude:70.49873 Elevation (m): 633					
AB/2	MN/2	Pa (Ωm)	ΔV (mV)	I (mA)	K
AB/2	MN/2	R	V	I	K
1	0.5	785.779	15019.42	44.918	2.35
2	0.5	636.098	5224.956	96.926	11.8
3	0.5	381.081	675.04	48.713	27.5
4	0.5	193.815	213.647	54.565	49.5
5	0.5	97.556	54.679	43.55	77.7
6	0.5	51.119	8.012	17.554	112
8	0.5	33.535	5.907	35.229	200

10	0.5	28.101	4.797	53.43	313
15	0.5	4.549	0.956	148.157	705
15	5	22.947	17.733	48.53	62.8
20	5	17.983	6.748	44.278	118
20	0.5	7.212	0.258	44.719	1250
25	0.5	12.863	0.276	42.056	1960
25	5	12.335	2.777	42.325	188
30	5	18.890	4.179	60.839	275
35	5	16.218	2.299	53.442	377
40	5	18.205	3.278	89.13	495
50	5	18.653	2.585	108.095	780
60	5	14.612	1.064	81.555	1120
70	5	26.955	1.289	73.164	1530
80	5	22.487	0.539	47.938	2000
80	30	22.179	3.758	48.799	288
100	30	21.344	2.686	59.775	475
100	5	13.446	0.32	74.489	3130
125	5	5.972	0.086	70.559	4900
125	30	20.087	1.844	70.685	770
150	30	20.629	1.137	62.281	1130
175	30	18.289	0.528	45.037	1560
200	30	54.588	2.546	95.147	2040
250	30	29.364	1.445	158.947	3230
300	30	32.117	0.299	43.383	4660
350	30	46.552	0.643	87.848	6360

6. Results and discussion

6.1 VES Profile data interpretation

The VES lines field geo-electrical data versus electrode spacing (AB/2) were plotted on log-log scale to obtain VES Curves and layered model using IX1D software [5]. The 1D (one dimensional) VESs profile Curve illustrates number of layers, computed and modeled apparent resistivity, thicknesses and depth of layers.

6.1.1 VES 1 Curves

The VES1 Curve (Figure 6 and Figure 7) shows the following geo-electrical layers:

- Top layer characterized by apparent resistivity values of 384.7 m with 0.25 m thickness and the deposits made of dry sand and gravels, pebbles, cobbles and boulders.
- The second layer characterized by average apparent resistivity values of 378.42 Ohm.m with 2.0665m thickness. The expected litho-logy of layer made of dry sand, gravel, pebbles.
- The third layer characterized by average apparent resistivity values of 14.43 Ohm.m with 29.11m thickness. The expected litho-logy of layer probably made of sand, sand clay, sand and gravel. The depth of this layer is expected 119m.

The VES1 curve layers show availability of groundwater. The water level expected ranges between 75 m to 85m. The depth versus Resistivity Curve (layered model) is shown in the

Figure 6 and the apparent resistivity versus spacing curve (layered model) is shown in the Figure 7.

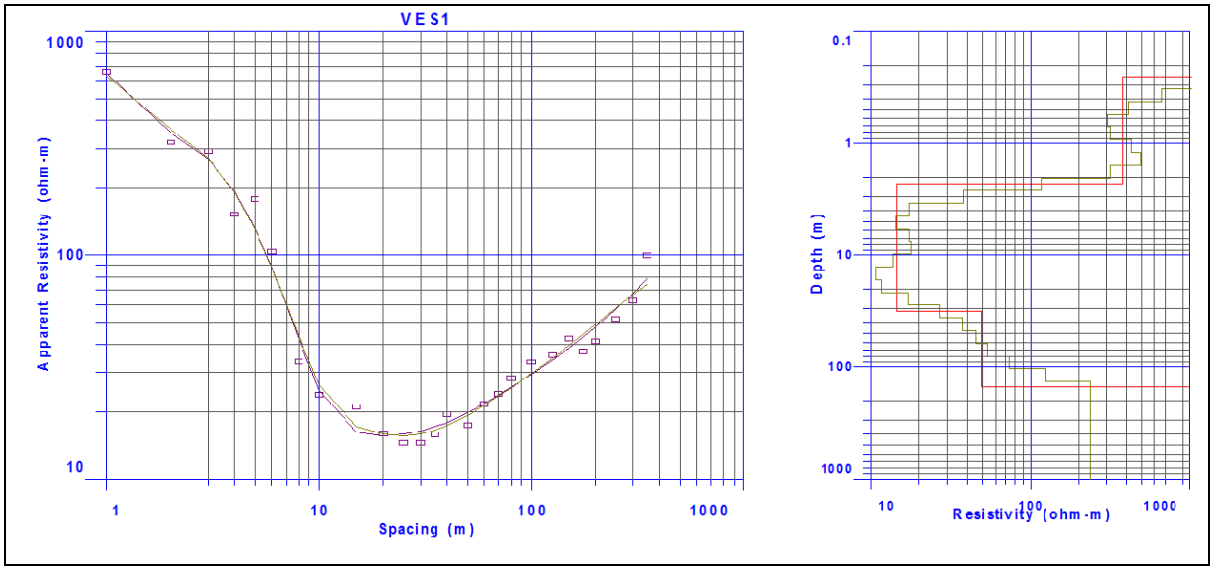

Figure 6.VES 1 Depth of Layers versus Resistivity Curve

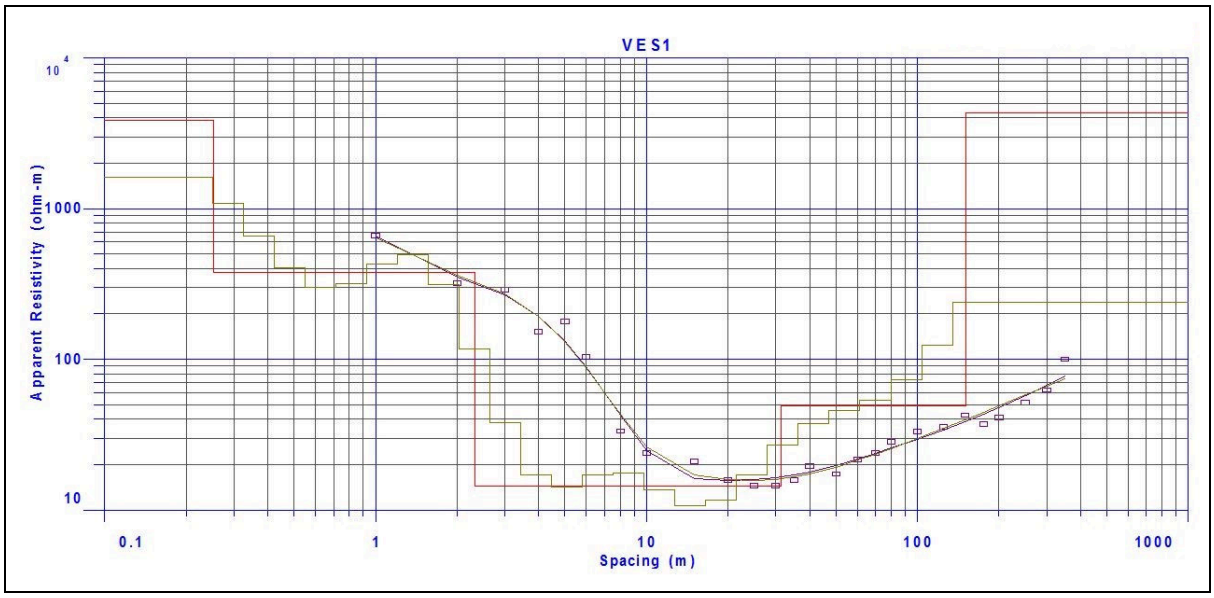

Figure 7.VES 1 apparent resistivity versus spacing curve

6.1.2 VES2 Curves

The VES2 Curve (Figure 8 and Figure 9) shows the following geo-electrical layers:

- Top layer characterized by average resistivity values of 360.83 Ohm.m with 1.6486 m thickness and the expected deposits made of sand silt, gravels, pebbles, cobbles and boulders.
- The second layer characterized by apparent resistivity values of 30.752 Ohm.m with 7.7076 m thickness. The expected litho-logy of layer made of clay with sand and gravel.
- The third layer characterized by average apparent resistivity values of 17.736 Ohm.m with 81.034 m thickness. The expected litho-logy of layer probably made of dry sand clay, sand silt and gravel.

- The fourth layer characterized by apparent resistivity value of 2398.1 Ohm.m with unknown thickness. The expected litho-logy of layer made of fundamental Rocks.

The expected depth of water table ranges from 75 m and 95 m. In this VES profile, the groundwater is suitable for drinking. The depth versus Resistivity Curve (layered model) is shown in the Figure 8 and the apparent resistivity versus spacing curve (layered model) is shown in the Figure 9.

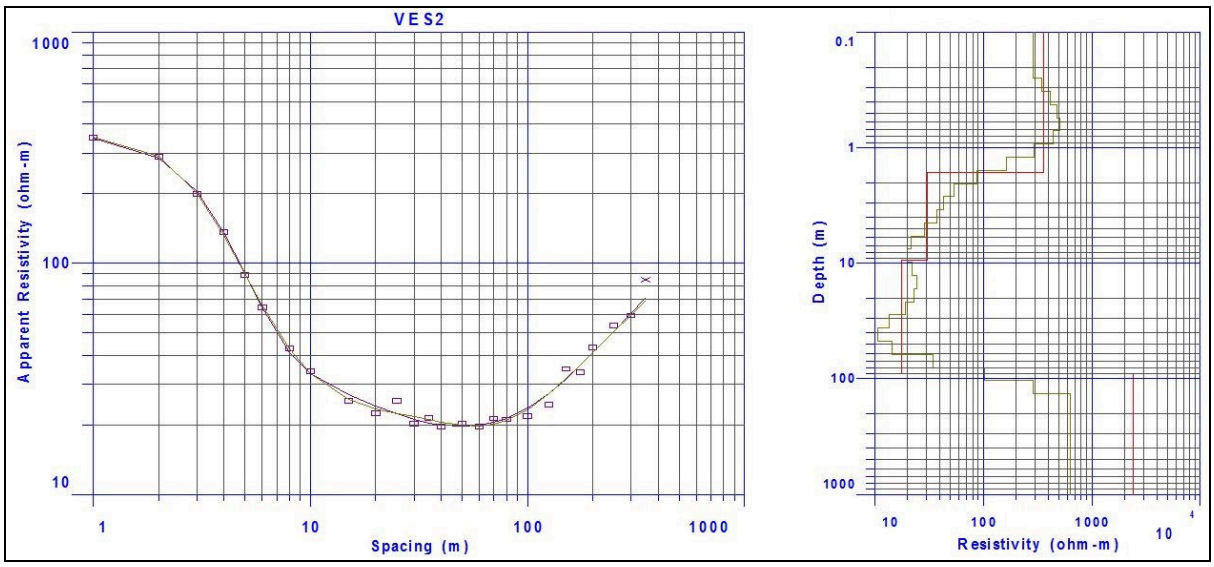

Figure 8.VES 2 Depth versus Resistivity Curve

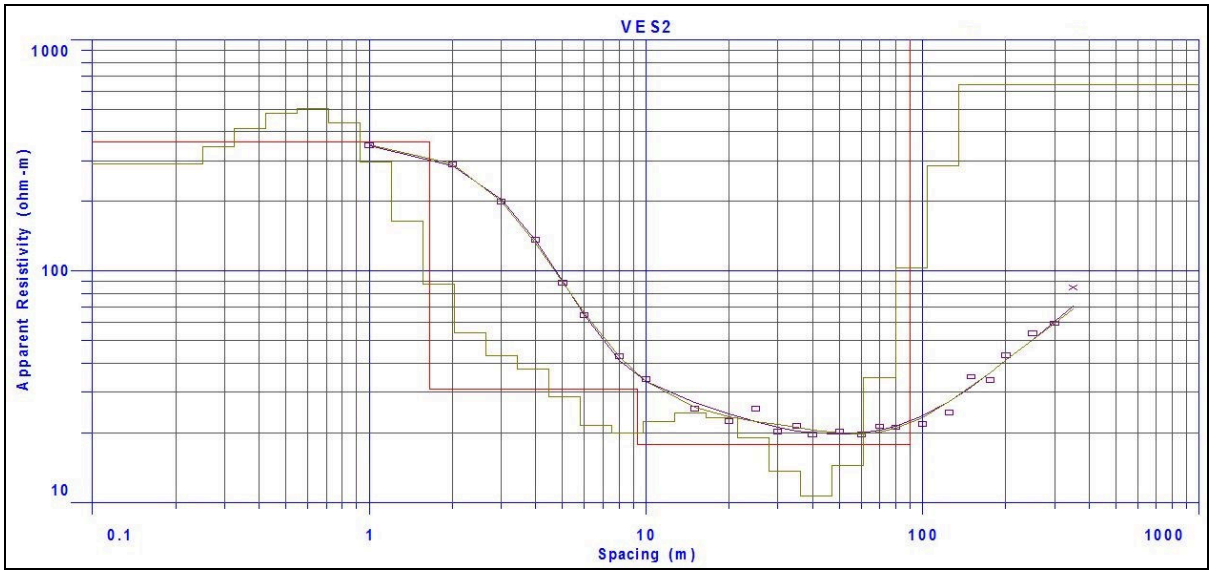

Figure 9.VES 2 Apparent Resistivity versus Spacing Curve

6.1.3 VES 3 Curve

The VES3 Curve (Figure 10 and Figure 11) shows the following geo-electrical layers:

- Top layer characterized by average apparent resistivity values of 646.61 Ohm.m with 1.4831 m thickness and the expected deposits made of dry sand silt, gravels, pebbles, cobbles and boulders.

- The second layer characterized by apparent resistivity values of 162.92Ohm.m with 5.72 m thickness. The expected litho-logy made of silt and silt clay, sand and gravel.
- The third layer characterized by apparent resistivity values of 16.434Ohm.m with 81.512 m thicknesses. The expected litho-logy of layer probably consist of sand clay, clay and sand.
- Fourth layer described by apparent resistivity value of 309.29 Ohm.m with unknown thickness. The expected litho-logy of layer made of fundamental Rocks.

The expected water table ranges between75 m and 90 m. The depth versus Resistivity Curve (layered model) is shown in the Figure 10 and the apparent resistivity versus spacing curve (layered model) is shown in the Figure 11.

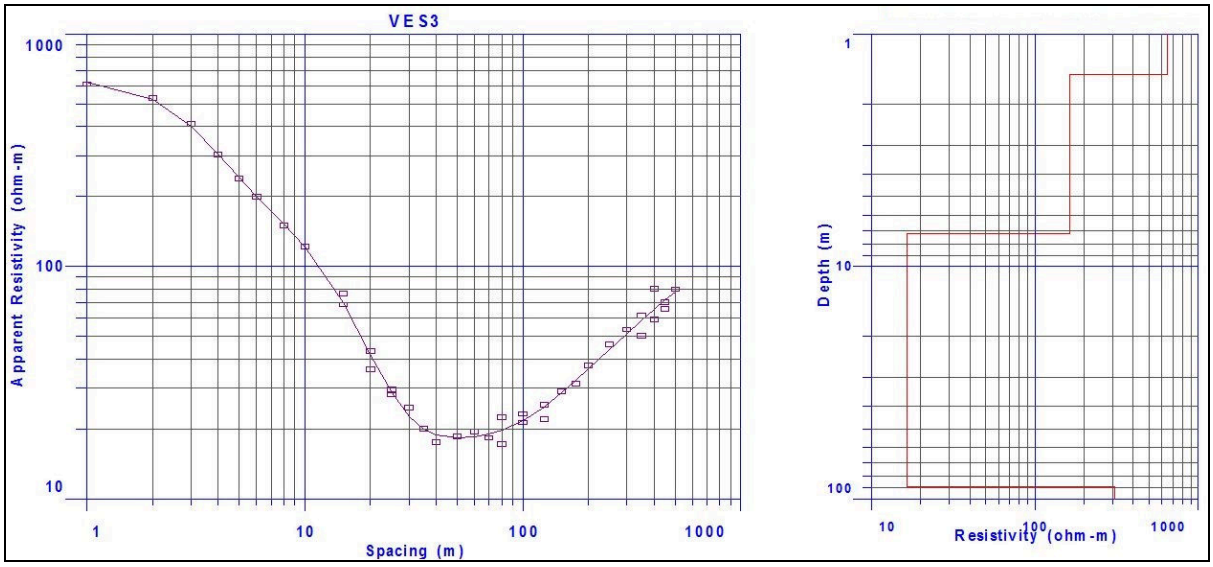

Figure 10.VES 3 Depth of Layers versus Resistivity Curve

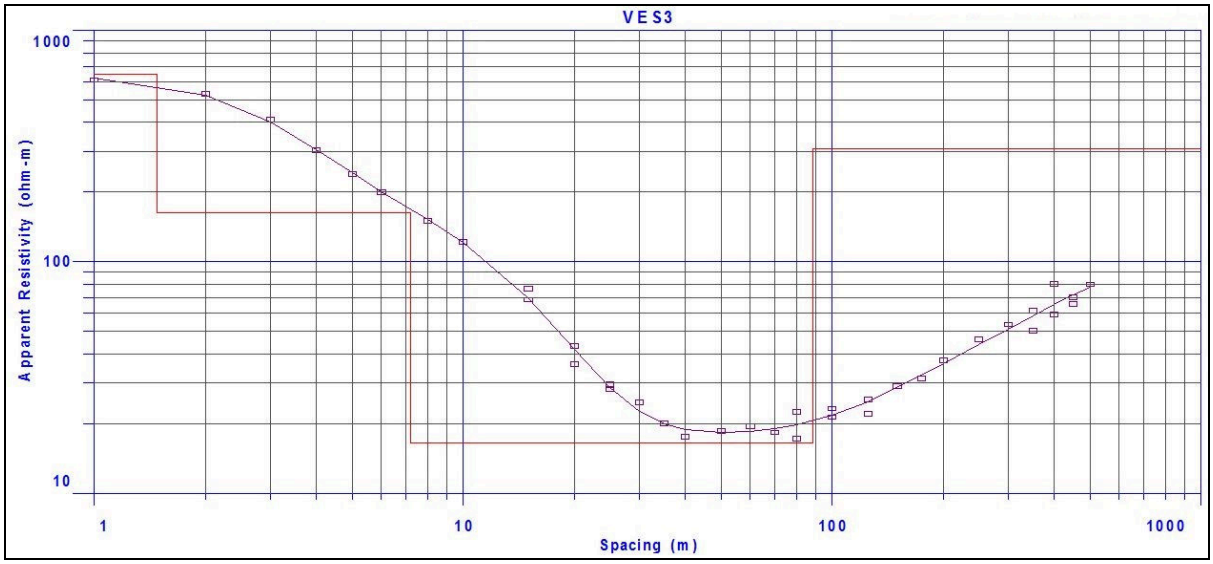

Figure 11.VES 3 Apparent Resistivity versus Spacing Curve

6.1.4 VES 4 Curve

The VES1 Curves (Figure 12 and Figure 13) show the following geo-electrical layers:

- Top layer characterized by average apparent resistivity values of 166.65Ohm.m with 0.90 m thickness and the expected deposits made of dry sand silt, gravels, pebbles, cobbles and boulders.
- The second layer characterized by average apparent resistivity values of 6.8 Ohm.m with 1.06m thickness. The expected litho-logy of layer probably made of silt clay and clay.
- The third layer characterized by average apparent resistivity values of 68.667Ohm.m with 4.5746 m thickness. The expected litho-logy of layer probably made of sand and gravel.
- Fourth layer described by average apparent resistivity values of 31.37 Ohm.m with 112.92 m thickness. The expected litho-logy of layer may be consisting of sandy clay sand silt and sand. The depth of this layer is expected 119.4m.
- The fifth layer characterized by apparent resistivity value of 757.6Ohm.m with the unknown thickness.

The expected water table ranges between 75 m and 90 m. The depth of layers versus Resistivity Curve (layered model) is shown in the Figure 12 and the apparent resistivity versus spacing curve (layered model) is shown in the Figure 13.

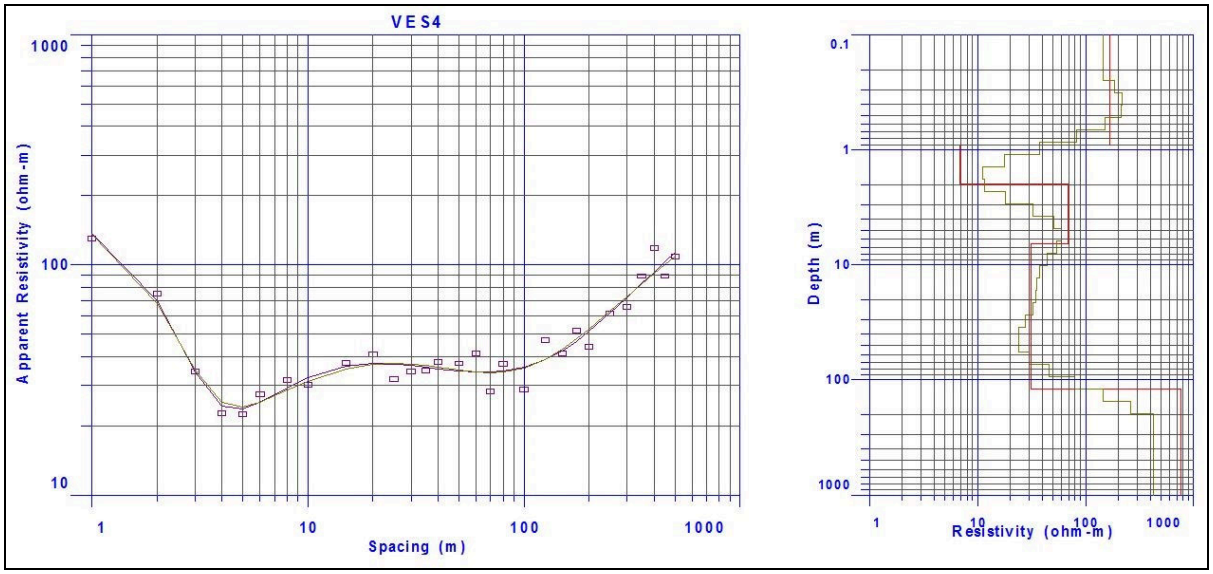

Figure 12.VES 4 Depth of Layers versus Resistivity Curve

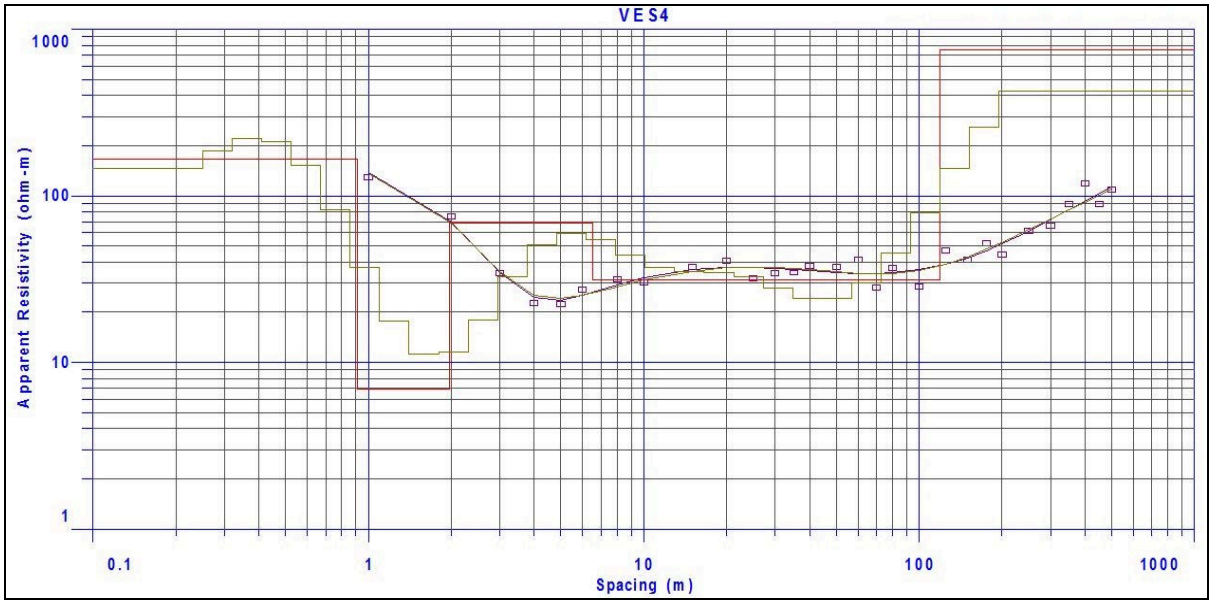

Figure 13.VES 4 Apparent Resistivity versus Spacing Curve

6.1.5 VES 5 Curve

The VES1 Curves (Figure 12 and Figure 13) show the following geo-electrical layers:

- Top layer characterized by average apparent resistivity values of 607.72.m with 1.43 m thickness and the expected deposits made of dry sand silt, gravels, pebbles, cobbles and boulders.
- The second layer characterized by average apparent resistivity values of 41.48Ohm.m with 3.71 thicknesses. The expected litho-logy of layer probably made of silt clay and sand and gravel.
- The third layer characterized by average apparent resistivity values of 5.5319.m with 5.21m thickness. The expected litho-logy of layer probably made of silt clay and clay.
- Fourth layer described by average apparent resistivity values of 30.18 Ohm.m with 194.36m thickness. The expected litho-logy of layer may be consisting of sandy clay sand silt and sand.
- The fifth layer characterized by apparent resistivity value of 2813.5 Ohm.m with the unknown thickness. The expected litho-logy made of fundamental Rocks.

The expected water table ranges between 80 m and 95 m. The depth of layers versus Resistivity Curve (layered model) is shown in the Figure 12 and the apparent resistivity versus spacing curve (layered model) is shown in the Figure 13.

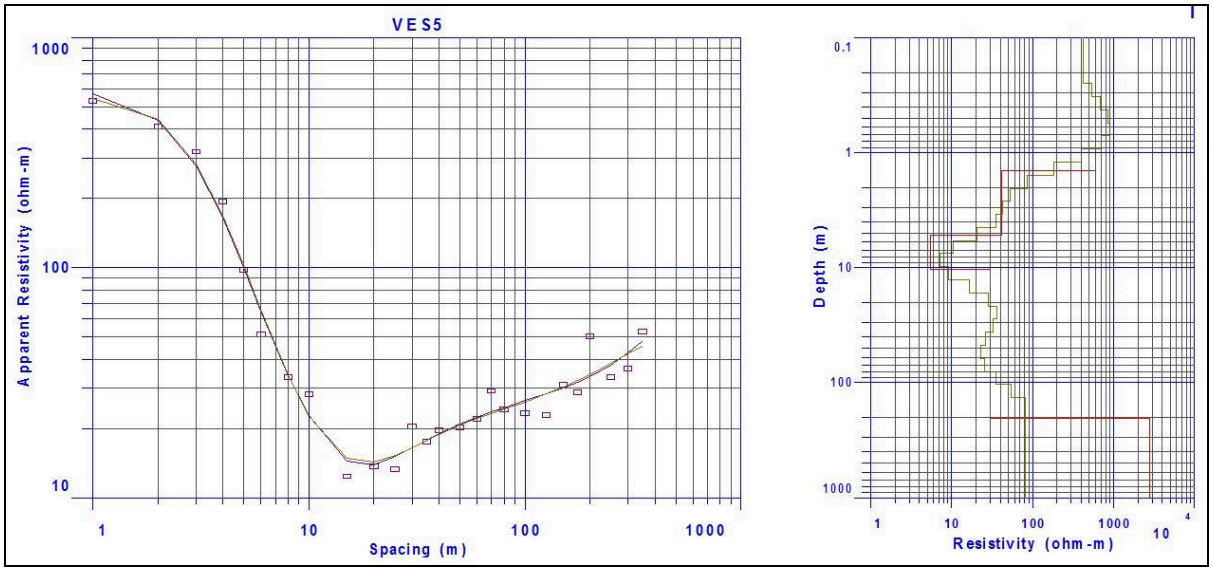

Figure 14.VES 5 Depth of Layers versus Resistivity Curve

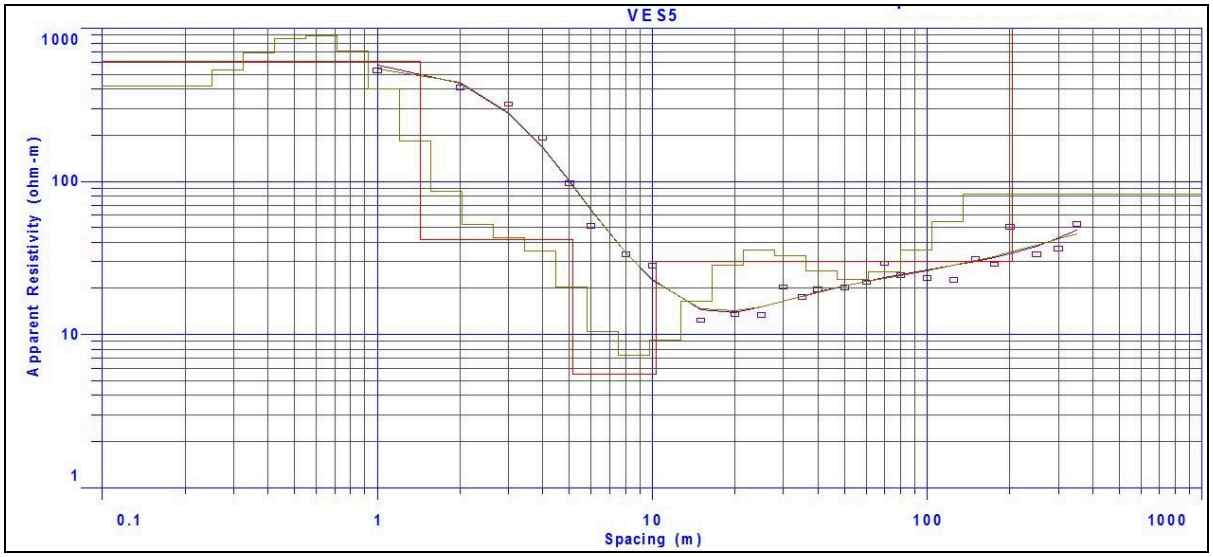

Figure 15.VES 5 Apparent Resistivity versus Spacing Curve

6.2 Vertical Electrical sounding data interpretation results

The apparent resistivity, thicknesses, depth, the number of layers and expected litho log of VES lines is shown in the table 5.

Table 7 VES Stations Interpreted Data Summary

No	VES Stations	Vertical Electrical Sounding data interpretation results					
		App-Resistivity *(Ohm-m)*	Number of Layers	Thickness *(m)*	Depth *(m)*	Elevation *(m)*	Fitting Error (%)
1	VES_1 LAT: 34.48690 LON: 70.49968	3847.2	1	0.25254	0.25254	-0.25254	15.213
		378.42	2	2.0665	2.3191	-2.3191	
		14.437	3	29.11	31.43	-31.43	
		49.242	4	119.02	150.45	-150.45	
		4297.9	5	?	?	?	
2	VES_2 LAT: 34.48696 LON: 70.49963	360.83	1	1.6486	1.6486	-1.6486	5.765
		30.752	2	7.7076	9.3562	-9.3562	
		17.736	3	81.034	90.39	-90.39	
		2398.1	4	?	?	?	
3	VES_3 LAT: 34.48797 LON: 70.49893	646.61	1	1.4831	1.4831	-1.4831	7.567
		162.92	2	5.7289	7.212	-7.212	
		16.434	3	81.512	88.724	-88.724	
		309.29	4	?	?	?	
4	VES_4 LAT: 34.49044 LON: 70.49730	166.65	1	0.90988	0.90988	-0.90988	12
		6.8703	2	1.06	1.9698	-1.9698	
		68.667	3	4.5746	6.5445	-6.5445	
		31.372	4	112.92	119.46	-119.46	
		757.6	5	?	?	?	
5	VES_5 LAT: 34.48779 LON: 70.49873	607.72	1	1.4395	1.4395	-1.4395	15.29
		41.484	2	3.7195	5.159	-5.159	
		5.5319	3	5.2153	10.374	-10.374	
		30.184	4	194.36	204.74	-204.74	
		2813.5	5	?	?	?	

7. Conclusion

The geo- electrical data plot of the different VESs profile show significant similarities of litho-logic layers and the results are as following:

- The graphic data interpretation of VES1 (Figure 6 and Figure7) shows that the apparent resistivity values range from 14.437 Ohm.m to 4297.9.m. The expected litho-logy of layers made of Quaternary-Neogine sedimentary and it is underlain by fundamental Rock. The depth of layers is 150.45 m. The water table ranges between 75 m to 85m.
- The graphic data interpretation of VES2 (Figure 8 and Figure 9) shows that the average apparent resistivity values range from 17.736 Ohm.m to 2398.1 Ohm.m. The expected litho-logy of layers made of Quaternary-Neogine sedimentary and it is underlain by fundamental Rock. The depth of layers is 90.39 m. The depth of water table expected between75 m and 90 m.
- The graphic data interpretation of VES3 (Figure 10 and Figure 11) shows that the average apparent resistivity values range from 16.434 Ohm.m to 646.61 Ohm.m. The expected litho-logy of layers made of Quaternary-Neogine sedimentary and it is underlain by fundamental Rock.
- The graphic data interpretation of VES4 (Figure 12 and Figure 13) shows that the average apparent resistivity values range from 6.8703 Ohm.m to 757.6 Ohm.m. The expected litho-logy of layers made of Quaternary-Neogine sedimentary and it is underlain by fundamental Rock. The depth of layers is 119.46 m. The depth of water table expected between 75 m and 90 m.
- The graphic data interpretation of VES5 (Figure 14 and Figure 15) shows that apparent resistivity values range from 5.5319 Ohm.m to 2813.5 Ohm.m. The expected litho-logy of layers made of Quaternary-Neogine sedimentary and it is underlain by fundamental Rock. The depth of layers is 194.36 m. The depth of water table expected between 80 m and 95 m.

The above results confirm that the south part of the study area relatively has a feasibility for groundwater development. There is no water quality problem and the aquifer has fresh water. The expected depth of water table ranges between 75m and 90 m. The expected litho-logy of layers made of Quaternary-Neogine sedimentary which it is underlain by fundamental Rock.

8. Recommendation

- There is suggested to drill the well to the depth of 160 m in the south part of study area. This area is problematic for well drilling due to deep water table and hard strata. Therefore, there is needed to adjust the well drilling technologies with Geological consideration.
- The discharge of well couldn't determine by this study (geophysical study).This study confirms the availability of groundwater and adjustment of well drilling technologies with geological condition. The discharge of well will be determined after the well drilling and construction and pumping test.
- The selected well site for drilling geo- referenced (Latitude 34.48483 - Longitude 70.50120 and the well location marked in the map and it is shown in the Figure 16.

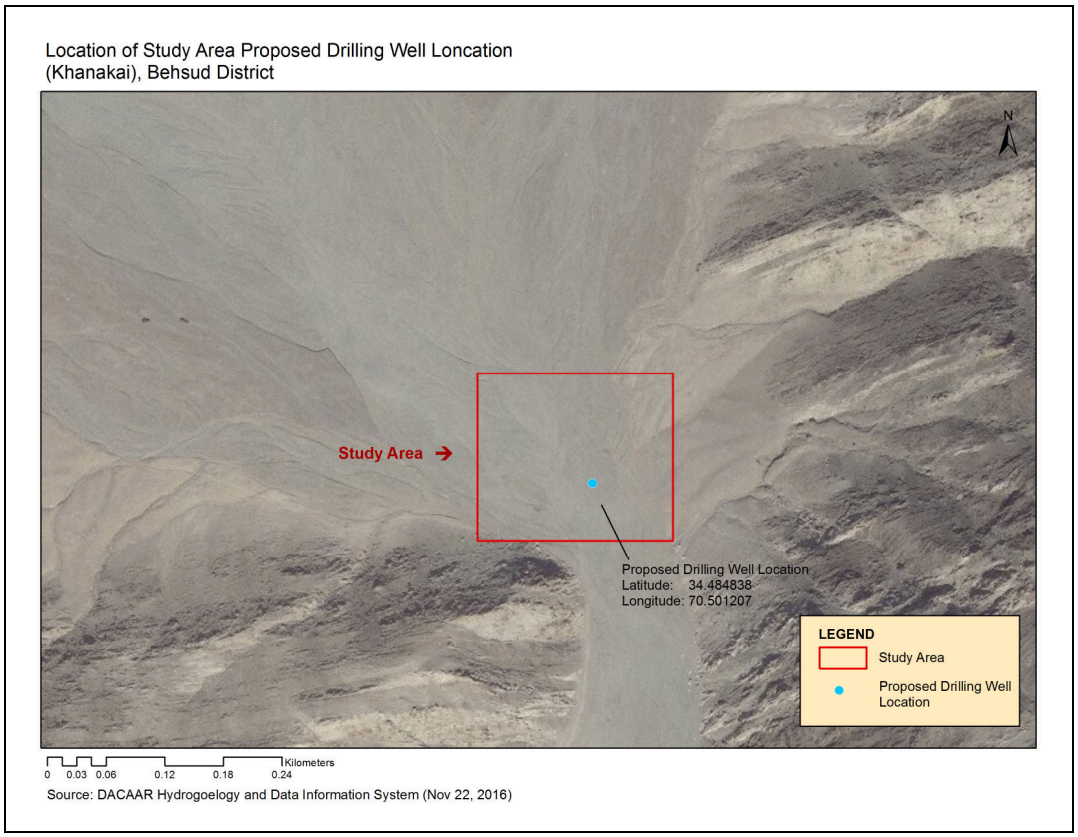

Figure 16. Well site selection location

9. Reference

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