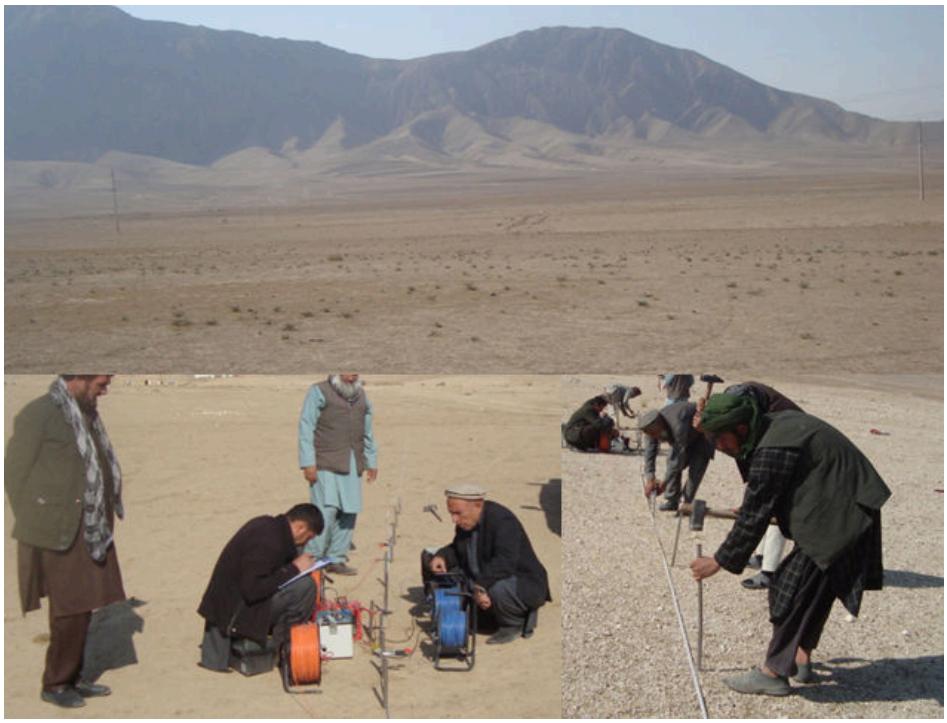
VERTICAL ELECTRICAL SOUNDING FOR GROUNDWATER STUDY IN HAZRATI SULTAN DISTRICT OF SAMANGAN PROVINCE RETURNEE AND INTERNAL DISPLACEMENT PEOPLE SETTLEMENT



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ABSTRACT.

Vertical Electrical Sounding (VES) investigation were carried out in Samangan Returnees and Internal Displacement People (IDPs) Settlement in Hazrati Sultan District of Samangan 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 stations were conducted at inside and outside of this Camp 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. The field data obtained was analyzed using IX1D computer software which gives an automatic interpretation of the apparent resistivity.

Interpretation of VES lines data results confirm the similarities of the subsurface geologic sequence (litho-logic layers). The expected layers of aquifer made of clay, silt clay, silt sand, sandy clay sand and gravel. The maximum depth of study range is between 100.7 m and 259 m. The aquifers apparent resistivity range is between 32 and 77 Ohom.m and the layers of aquifers characterized by fresh water. The depth of water table is prospected between 65 and 85 m.
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 25-26 October 2016, the geo-electrical survey was carried out in Samangan Shaharak-I Mahajireen which was requested by Ministry of Refugee and Returnee of Islamic Republic of Afghanistan. The Samangn Shaharak-i- Mahajireen is located in Hazrati Sultan district of Samangan province along the Main Road of Samangan- Mazar-i-Sharif.

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 the feasibility of drilling wells in the target area. The following are the specific objectives of the survey:

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

3. Rationale to carry out investigation

The Samangan province Refugee and Returnee director has plan to settle three thousands Returnee and Internal displacement families in this area, but this area has groundwater development problem due to deep water table, hard strata and unknown groundwater availability. Therefore, there is a need to perform geophysical study 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.

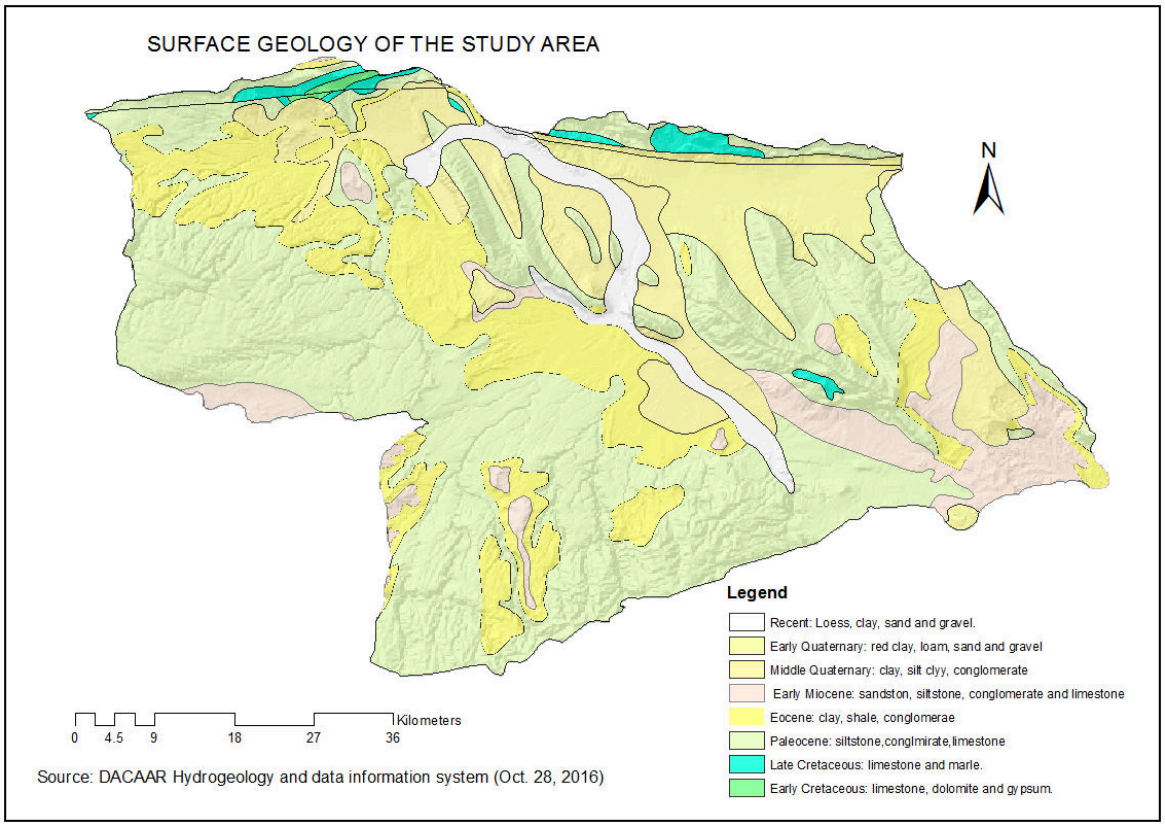

Figure 1.Surface Geological Setting of the Area

5. Materials and method

5.1 Description of the area

The study areas are located about 12 Km in the North direction of Aybak center of Samangan province and positioned at latitude of 36.37521 to 36.40694 and a longitude of 67.95712 to 67.94212. It has semi- arid climate with major fluctuation in day- and night-time fluctuations. The winter is characterized by low temperatures of less than -10 ºC while the summer is dominated by high temperatures of more than 42 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.

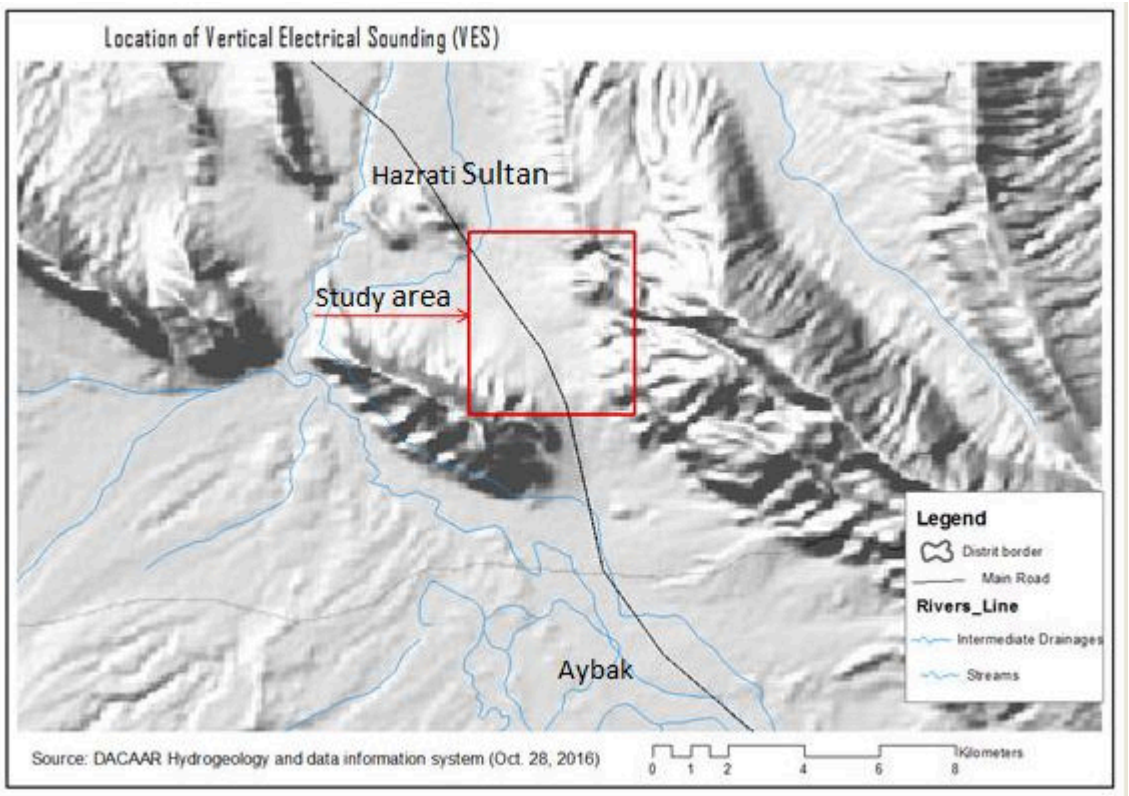

Figure 2.Location of Study Arae

5.2 Data Acquisition

Vertical Electrical Sounding (VES) using Schlumberger array was carried out at five VES stations of Samangan province Returnees Camp. 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.

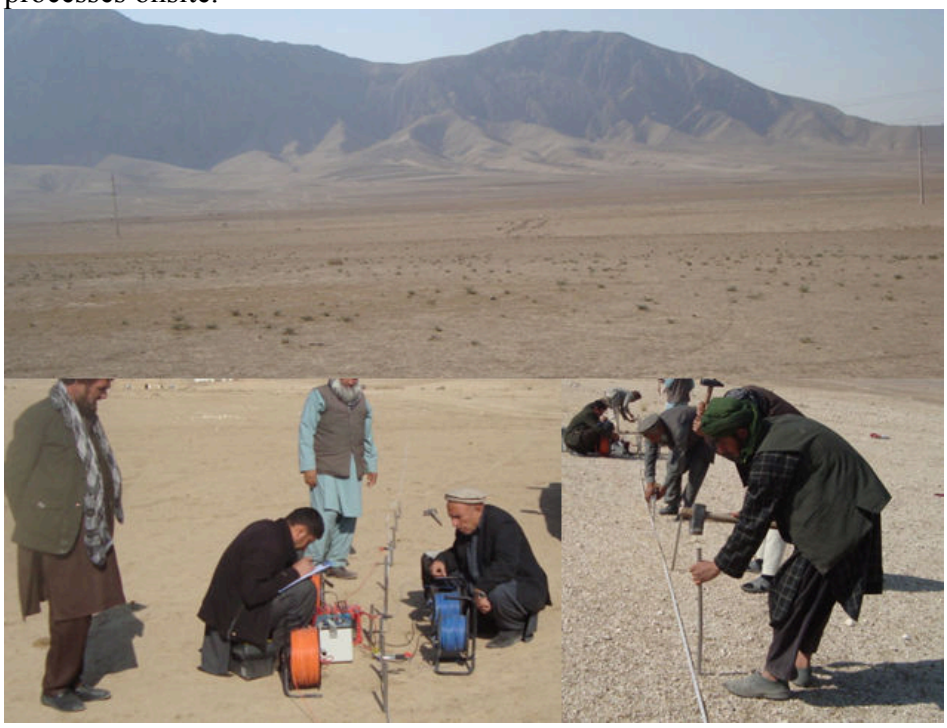

Figure 3.Measured Field Data

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)

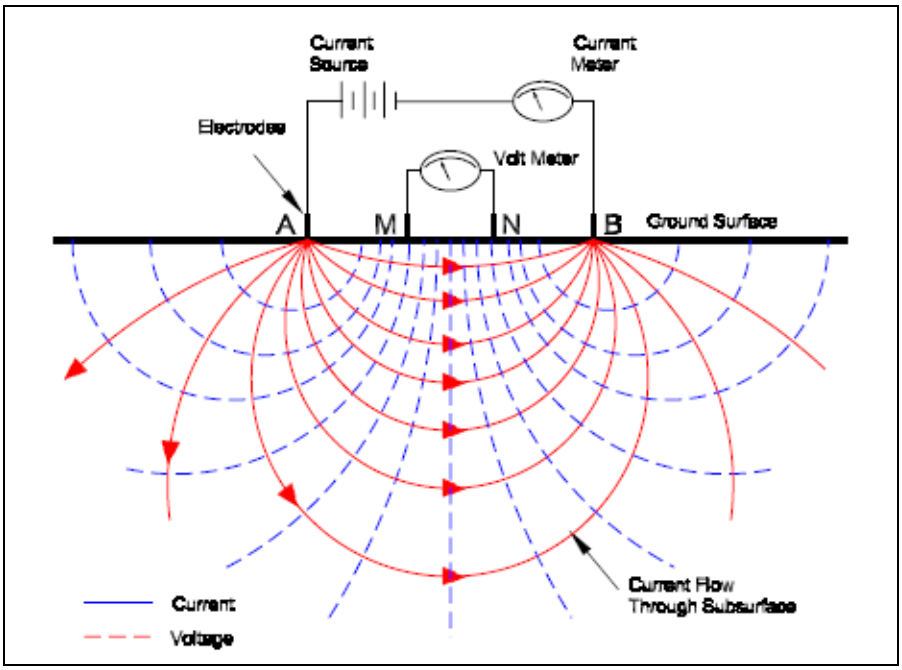

Figure 4.Schlumberger Applied Techniques Method

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. abd 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	36.37402	67.95969	972	1,000
2	VES2	36.39141	67.95264	918	1,000
3	VES3	36.40683	67.94335	850	700
4	VES4	36.393318	67.94033	870	700
5	VES5	36.40314	67.938883	841	700

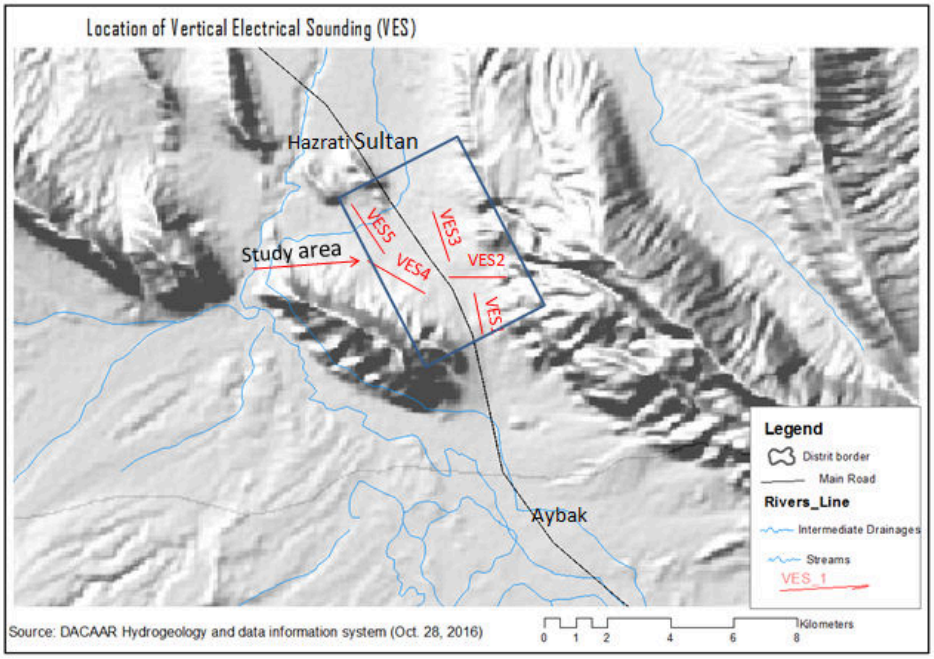

Figure 5.Location of VES lines

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: 36.37402 Longitude:67.95969 Elevation (m):972					
AB/2	MN/2	Pa (Ωm)	ΔV (mV)	I (mA)	K
1	0.5	121.8681	1413.359	27.254	2.35
2	0.5	64.36519	146.769	26.907	11.8
3	0.5	41.03761	48.111	32.24	27.5
4	0.5	35.86819	21.126	29.155	49.5
5	0.5	32.72608	13.384	31.777	77.7
6	0.5	31.57743	6.245	22.15	112
8	0.5	31.44132	4.473	28.453	200
10	0.5	30.81014	3.214	32.651	313
15	0.5	28.4304	1.076	26.682	705
15	5	26.47703	11.211	26.591	62.8
20	5	23.88622	5.024	24.819	118
20	0.5	24.6363	0.485	24.608	1250
25	0.5	23.38566	0.399	33.441	1960
25	5	22.3092	3.953	33.312	188
30	5	27.64105	6.859	68.24	275
35	5	18.33573	2.141	44.021	377
40	5	16.39824	1.692	51.075	495
50	5	13.29815	0.365	21.409	780
60	5	10.04648	0.247	27.536	1120
70	5	7.629595	0.086	17.246	1530
80	5	7.647818	0.48	125.526	2000
80	30	9.180889	3.529	110.703	288

100	30	7.171234	1.465	97.037	475
100	5	6.712139	0.664	309.636	3130
125	5	6.732125	0.648	471.649	4900
125	30	6.334721	3.02	367.088	770
150	30	6.10915	1.236	228.621	1130
175	30	6.120489	0.718	183.005	1560
200	30	5.924779	0.619	213.132	2040
250	30	6.269243	0.365	188.053	3230
300	30	7.095907	0.688	451.821	4660
350	30	7.633832	0.045	37.491	6360
350	100	7.287234	1.531	371.025	1766
400	100	8.017557	0.32	331.273	2360
400	30	8.28469	1.21	344.684	8300
450	30	8.998898	0.042	49.006	10500
450	100	9.679761	0.12	37.191	3000
500	100	10.32565	0.12	43.697	3760

Table 3VES2 Measured Field Data

VES 2 Latitude: 36.39141 Longitude:67.95264 Elevation (m):918					
AB/2	MN/2	ρa (Ωm)	ΔV (mV)	I (mA)	K
1	0.5	284.734	3724.531	30.821	2.35
2	0.5	132.918	312.811	27.726	11.8
3	0.5	121.311	145.122	32.884	27.5
4	0.5	116.431	64.514	27.409	49.5
5	0.5	114.995	32.056	21.675	77.7
6	0.5	113.873	7.873	7.765	112
8	0.5	115.298	18.513	32.158	200
10	0.5	123.981	15.165	38.331	313
15	0.5	147.446	8.375	35.063	705
15	5	147.401	93.845	40.003	62.8
20	5	169.376	5.679	3.95	118
20	0.5	161.418	0.514	3.998	1250
25	0.5	162.023	0.679	8.22	1960
25	5	170.7	7.436	8.211	188
30	5	192.904	23.235	33.11	275
35	5	207.582	12.188	22.134	377
40	5	152.35	3.991	12.962	495
50	5	128.457	6.431	38.928	780
60	5	140.66	3.993	31.88	1120
70	5	145.704	7.658	80.493	1530
80	5	136.428	4.55	66.787	2000
80	30	143.591	33.363	66.912	288
100	30	114.043	8.573	35.817	475
100	5	109.531	1.248	35.704	3130
125	5	88.494	0.7	38.771	4900
125	30	85.672	4.392	39.525	770
150	30	65.464	11.923	205.979	1130
175	30	42.89	10.818	392.565	1560
200	30	30.58	4.943	330.953	2040

250	30	33.039	0.372	23.077	3230
300	30	20.116	1.613	374.137	4660
350	30	18.171	0.978	342.545	6360
350	100	18.874	3.697	346.178	1766
400	100	41.046	0.483	27.75	2360
400	30	385.451	1.289	27.861	8300
450	30	20.014	0.639	337.125	10500
450	100	17.903	1.993	336.578	3000
500	100	27.817	0.496	67.216	3760

Table 4.VES 3 Measured Field Data.

VES 3 Latitude: 36.40683 Longitude:67.94335 Elevation (m):850					
AB/2	MN/2	ρa (Ωm)	ΔV (mV)	I (mA)	K
1	0.5	21.2	63.787	7.067	2.35
2	0.5	15.9	8.684	6.417	11.8
3	0.5	11.9	7.74	17.737	27.5
4	0.5	11.6	3.602	15.36	49.5
5	0.5	11.7	3.289	21.797	77.7
6	0.5	12.2	3.019	27.752	112
8	0.5	13.8	1.59	23.001	200
10	0.5	15.4	0.775	15.702	313
15	0.5	19.1	0.455	16.832	705
15	5	21.6	5.805	16.836	62.8
20	5	25.1	3.203	14.979	118
20	0.5	20.6	0.247	14.993	1250
25	0.5	23.1	0.417	60.856	1960
25	5	27.7	8.933	60.785	188
30	5	29.9	10.306	94.496	275
35	5	31.4	9.575	114.819	377
40	5	32.5	5.391	81.834	495
50	5	34.1	3.348	76.357	780
60	5	35.25	3.78	120.416	1120
70	5	36.7	3.413	142.144	1530
80	5	38.1	1.611	4.712	2000
80	30	37.7	11.101	84.68	288
100	30	45.2	8.122	85.457	475
100	5	44.4	1.219	85.981	3130
125	5	34.8	0.508	71.571	4900
125	30	35.5	3.305	71.66	770
150	30	33.6	2.455	82.619	1130
175	30	31.44	4.12	203.949	1560
200	30	26.1	0.415	32.595	2040
250	30	23.9	2.372	320.27	3230
300	30	13.24	0.26	91.469	4660
350	30	8.8	0.084	62.736	6360

Table 5.VES4 Measured Field Data

VES 4 Latitude: 36.39318 Longitude:67.94033 Elevation (m):870					
AB/2	MN/2	ρa (Ωm)	ΔV (mV)	I (mA)	K
1	0.5	560	3730.742	15.629	2.35
2	0.5	552.4	158.925	3.517	11.8
3	0.5	433.2	938.214	59.532	27.5
4	0.5	361.4	126.988	17.387	49.5
5	0.5	295.3	80.517	21.341	77.7
6	0.5	254.2	30.305	13.388	112
8	0.5	207.5	6.684	6.449	200
10	0.5	173.3	6.834	12.355	313
15	0.5	163.693	10.913	47.072	705
15	5	179.641	137.473	48.038	62.8
20	5	167.1	45.127	31.812	118
20	0.5	160.8	4.15	32.403	1250
25	0.5	166.6	0.585	6.896	1960
25	5	168.4	6.243	6.988	188
30	5	181.5	21.376	32.367	275
35	5	182.1	6.31	13.066	377
40	5	184.4	1.884	5.052	495
50	5	205.2	2.045	7.744	780
60	5	198.1	7.962	45.134	1120
70	5	189.4	2.897	23.419	1530
80	5	173.9	1.857	21.377	2000
80	30	186.4	13.958	21.563	288
100	30	154.2	2.394	7.397	475
100	5	129.1	0.313	7.608	3130
125	5	115	1.68	71.571	4900
125	30	92.8	0.31	2.573	770
150	30	85.5	0.621	8.215	1130
175	30	69.7	1.891	42.212	1560
200	30	60.4	0.96	32.595	2040
250	30	51.1	0.136	8.605	3230
300	30	52.1	0.077	4.311	4660
350	30	53.485	0.081	9.591	6360

Table 6.VES5 Measured Field Data

VES 5 Latitude: 36.40314 Longitude:67.93883 Elevation (m):841					
AB/2	MN/2	ρa (Ωm)	ΔV (mV)	I (mA)	K
1	0.5	95.1	1184.893	29.112	2.35
2	0.5	18.2	65.877	42.871	11.8
3	0.5	19.3	29.205	42.149	27.5
4	0.5	21.5	18.343	42.144	49.5
5	0.5	25.4	27.653	84.706	77.7
6	0.5	28.7	16.055	62.717	112
8	0.5	34.8	6.675	39.537	200
10	0.5	36.8	4.754	40.43	313

15	0.5	44.4	2.825	44.863	705
15	5	35.9	25.53	44.653	62.8
20	5	39.2	16.209	48.697	118
20	0.5	48.1	1.85	48.311	1250
25	0.5	66.3	1.037	30.646	1960
25	5	41.7	6.761	30.528	188
30	5	43.3	18.091	114.76	275
35	5	43.6	4.698	40.61	377
40	5	44.7	9.801	108.386	495
50	5	45.9	11.235	190.315	780
60	5	46.8	21.414	514.088	1120
70	5	46.83	5.823	190.419	1530
80	5	47.304	2.596	109.917	2000
80	30	49.6	18.905	109.766	288
100	30	54.4	26.134	228.778	475
100	5	52.1	3.833	229.816	3130
125	5	55.1	0.602	53.555	4900
125	30	56.3	3.907	53.491	770
150	30	56.1	10.419	209.069	1130
175	30	54.2	3.67	105.253	1560
200	30	52.6	1.935	75.282	2040
250	30	36.3	0.113	10.014	3230
300	30	35.7	0.184	24.057	4660
350	30	31.4	0.56	113.481	6360

6. Results and discussion

6.1 VES lines 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) VES lines 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 152.41 Ohm.m with 0.751 m thickness and the deposits made of dry sand and gravel.
- The second layer characterized by average apparent resistivity values of 30.836 Ohm.m with 19.58 m thickness. The expected litho-logy of layer made of dry silt clay and sand.
- The third layer characterized by average apparent resistivity values of 5.84 Ohm.m with 239.29 m thickness. The expected litho-logy of layer probably made of compact clay. The depth of this layer is expected 259.63 m.

The VES1 curve layers don't have water. 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.

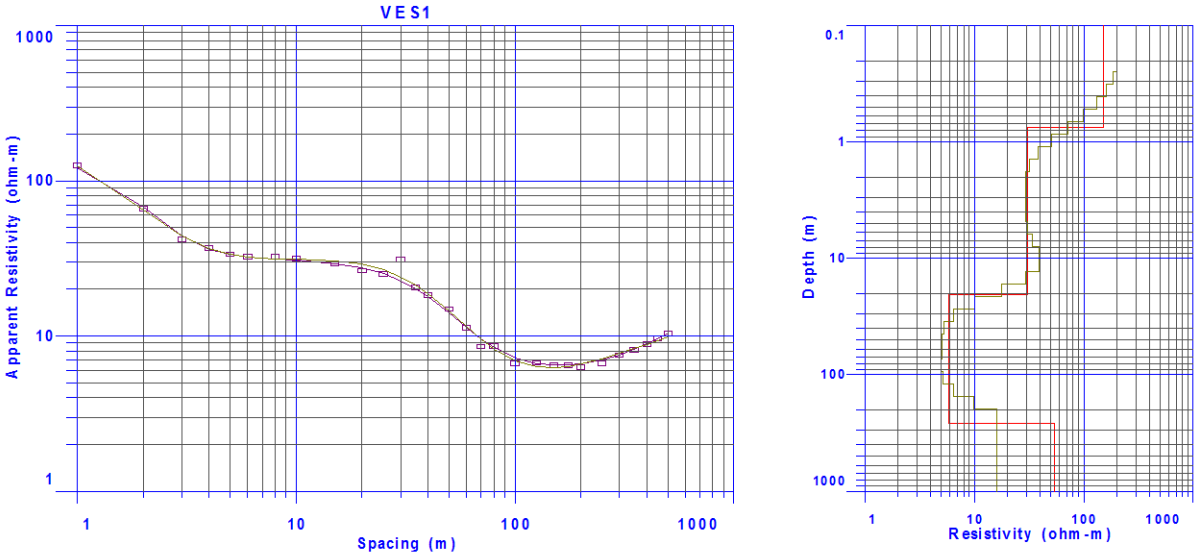

Figure 6.VES 1 Depth of Layers versus Resistivity Curve

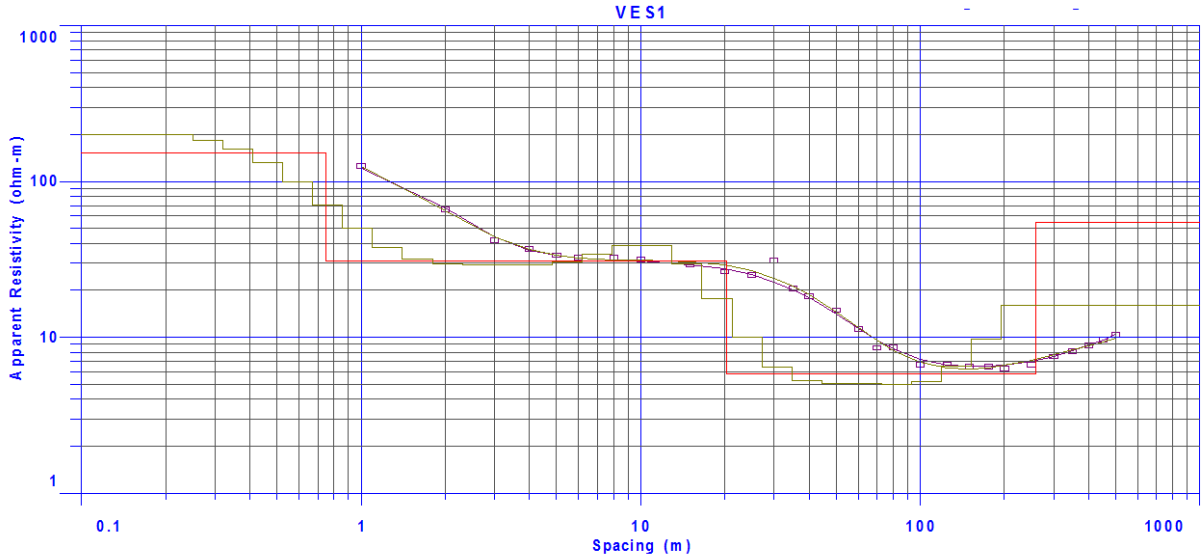

Figure 7.VES 1 apparent resistivity versus spacing curve

6.1.2 VES 2 Curves

The VES 2 Curve (Figure 8 and Figure 9) shows the following geo-electrical layers:

- Top layer characterized by average resistivity values of 66.5 Ohm.m with 1.25 m thickness and the expected deposits made of gravel and sand with clay.
- The second layer characterized by apparent resistivity values of 41.356 Ohm.m with 4.498 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 148.11 Ohm.m with 4.19 m thickness. The expected litho-logy of layer probably made of dry sand and gravel.

- Fourth layer described by average apparent resistivity values of 77.594 Ohm.m with 50.455 m thickness. The expected litho-logy of layer probably made of sand clay and sand without water. The depth of this layer is 60.4 m.
- The fifth layer characterized by apparent resistivity value of 3.501 Ohm.m with 71.302 m thickness. The expected litho-logy of layer made of silt clay and silt. The depth of this layer is 131 m.

The expected water table ranges from 80 m and 90 m. In this VES, the availability of groundwater is very poor. 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.

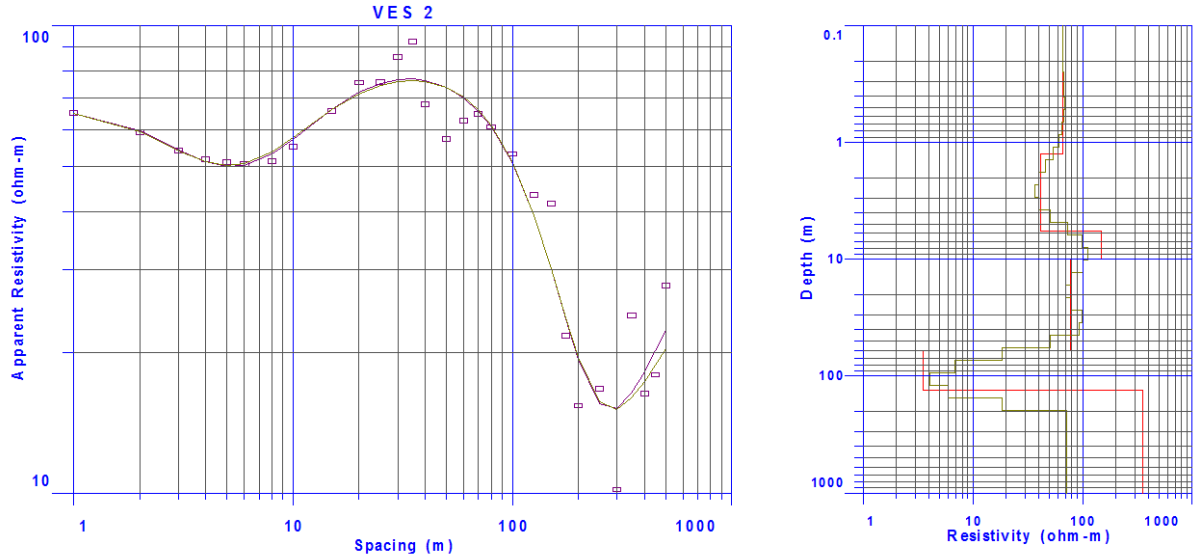

Figure 8.VES 2 Depth versus Resistivity Curve

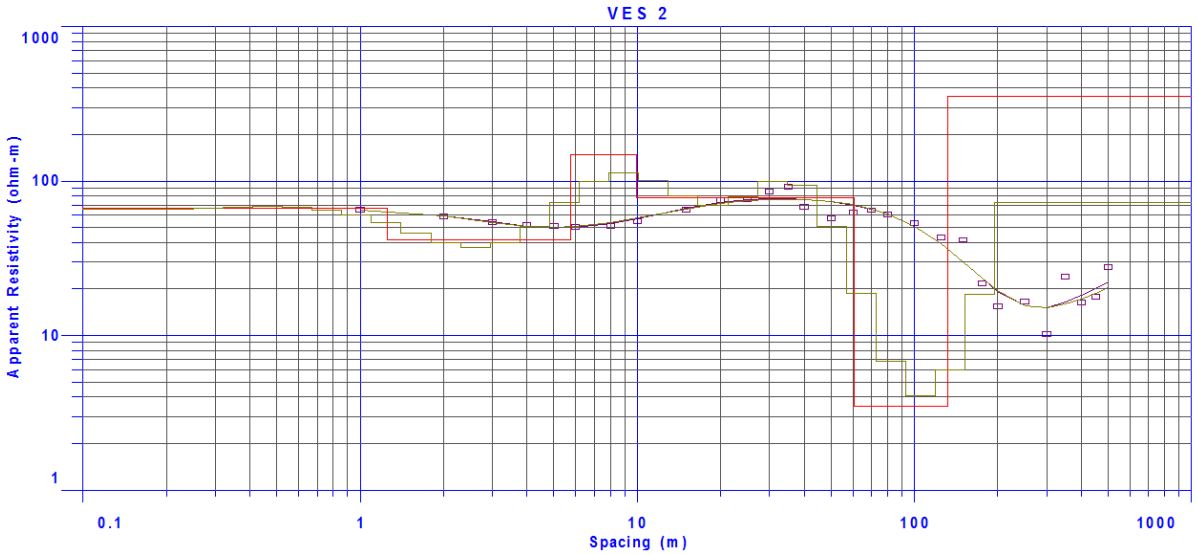

Figure 9.VES 2 Apparent Resistivity versus Spacing Curve

6.1.3 VES 3 Curve

The VES_3 Curve (Figure 10 and Figure 11) shows the following geo-electrical layers:

- Top layer characterized by average apparent resistivity values of 27.66 Ohm.m with 0.73 m thickness and the expected deposits made of dry looses and clayey sand.

- The second layer characterized by apparent resistivity values of 10.96 Ohm.m with 4.84 m thickness. The expected litho-logy made of silt and silt clay.
- The third layer characterized by apparent resistivity values of 50.80 Ohm.m with 0.036 m thickness. The expected litho-logy of layer probably consist of conglomerate.
- Fourth layer described by apparent resistivity value of 46.072 Ohm.m with 105.67 m thickness. The expected litho-logy of layer made of silt clay and sand and gravel with clay. The expected depth of this layer is 111.28m.
- The fifth layer characterized by apparent resistivity value of 0.137 Ohm.m and made of clay without water.

The expected water table ranges between 60 m and 65 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.

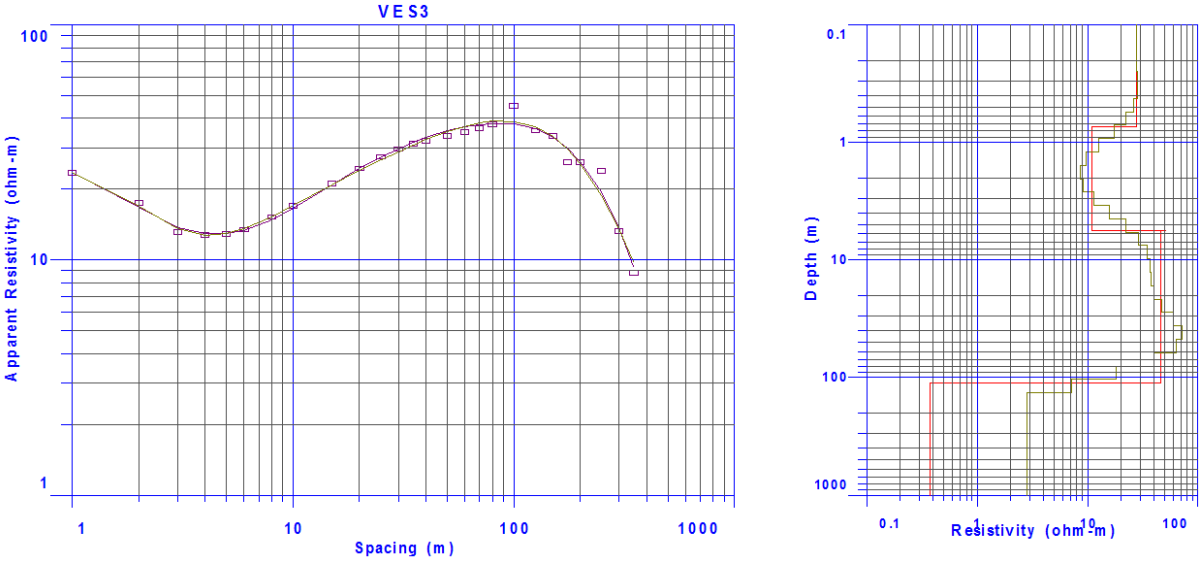

Figure 10.VES 3 Depth of Layers versus Resistivity Curve

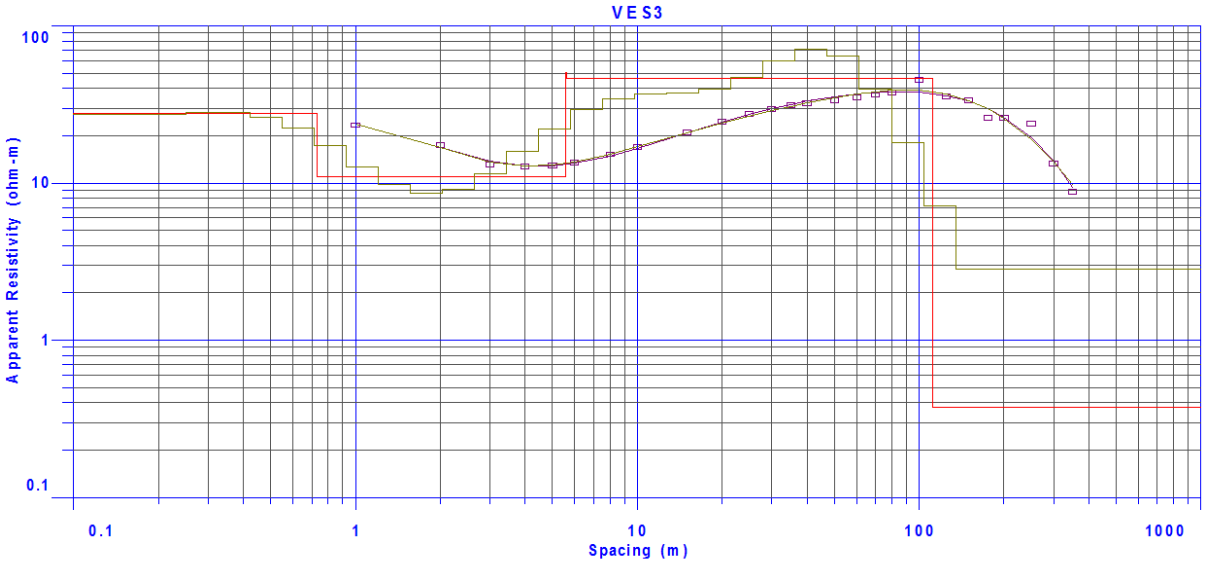

Figure 11.VES 3 Apparent Resistivity versus Spacing Curve

6.1.4 VES 4 Curve

The VES1 Curve (Figure 12 and Figure 13) shows the following geo-electrical layers:

- Top layer characterized by average apparent resistivity values of 432.03 Ohm.m with 0.6983 m thickness and the expected deposits made of dry loose and clayey sand.
- The second layer characterized by average apparent resistivity values of 19.621 Ohm.m with 8.8470 m thickness. The expected litho-logy of layer probably made of silt clay.
- The third layer characterized by average apparent resistivity values of 6.6899 Ohm.m with 38.385 m thickness. The expected litho-logy of layer probably made of clay and silt clay. The depth of this layer is expected 47.930 m.
- Fourth layer described by average apparent resistivity values of 6.9519 Ohm.m with 33.656 m thickness. The expected litho-logy of layer may be consisting of clay, sandy clay. The depth of this layer is expected 81.586 m.
- The fifth layer characterized by apparent resistivity value of 9.4736 Ohm.m with the expected thickness of more than 120 m.

The expected water table ranges between 65 m and 70 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.

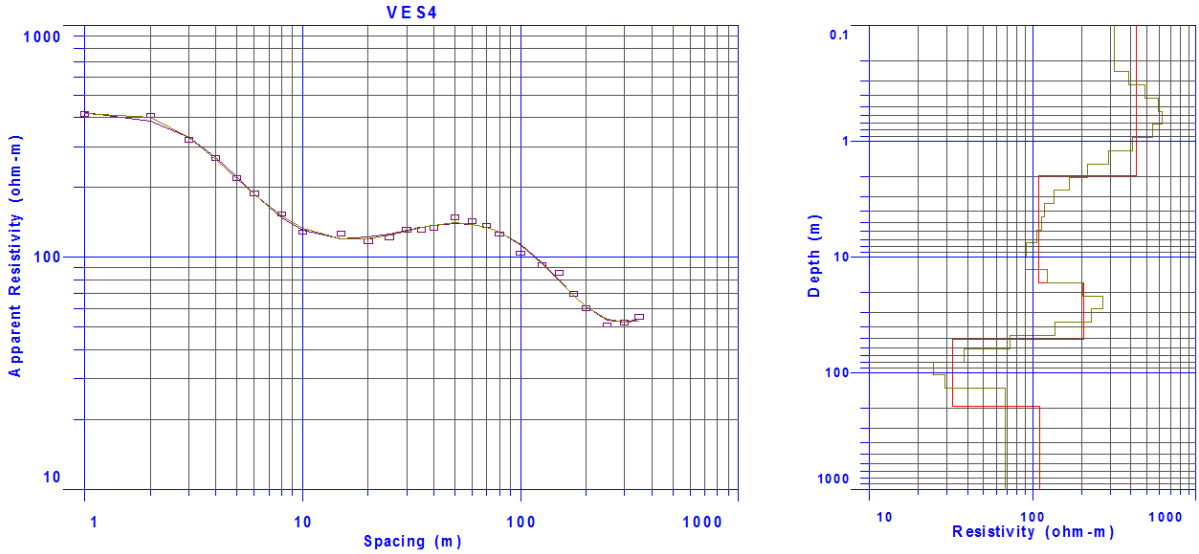

Figure 12.VES 4 Depth of Layers versus Resistivity Curve

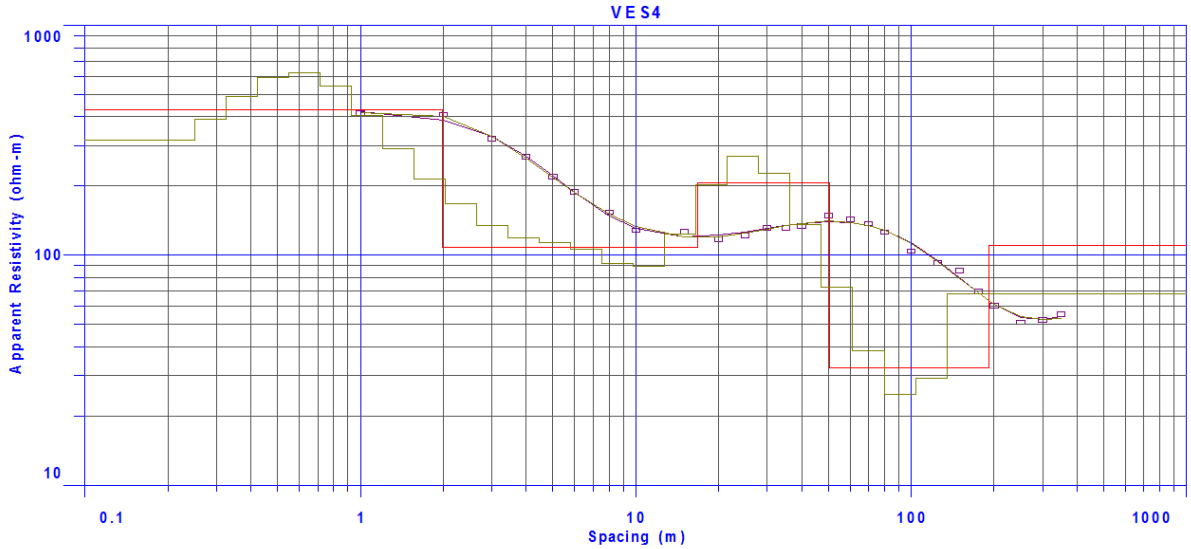

Figure 13.VES 4 Apparent Resistivity versus Spacing Curve

6.1.5 VES 5 Curve

The VES5 Curve (Figure 14 and Figure 5) shows the following geo-electrical layers:
Top layer characterized by average apparent resistivity values of 8.71 Ohm.m with 0.65 m thickness and the deposits made of dry loose and clayey sand.
The second layer characterized by average apparent resistivity values of 11.29 Ohm.m with 2.01 m thickness. The expected litho-logy of layer made of silt clay and sand.
The third layer characterized by average apparent resistivity values of 39.337 Ohm.m with 2.76 m thickness. The expected litho-logy of layer probably made of dry sand and gravel mixed with clay. The depth of this layer is expected 5.43 m.
Fourth layer described by average apparent resistivity values of 50.911 Ohm.m with 40.124 m thickness. The expected litho-logy of layer may be consisting of silt clay, sand and gravel. The depth of this layer is expected 45.56 m.
The fifth layer characterized by apparent resistivity value of 50.911 Ohm.m with the expected thickness of 55.38 m. The depth of this layer is expected 100.70 m. This layer saturated with fresh groundwater.
The expected water table ranges between 65 m and 75 m. The depth of layers versus Resistivity Curve (layered model) is shown in the Figure 14 and the apparent resistivity versus spacing curve (layered model) is shown in the Figure 15.

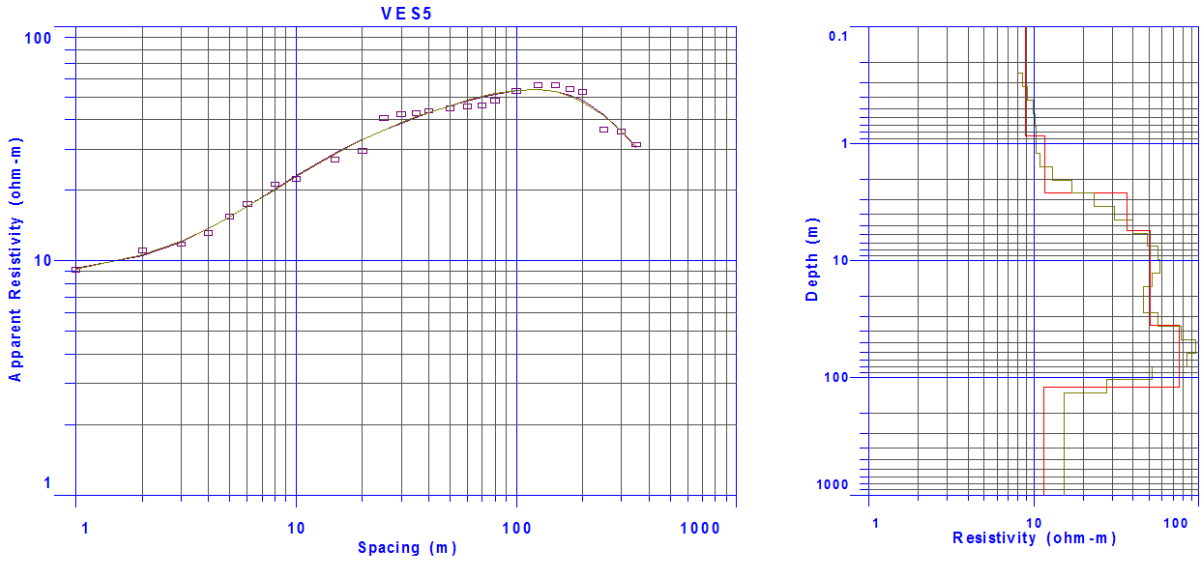

Figure 14.VES 5 Depth of Layers versus Resistivity Curve

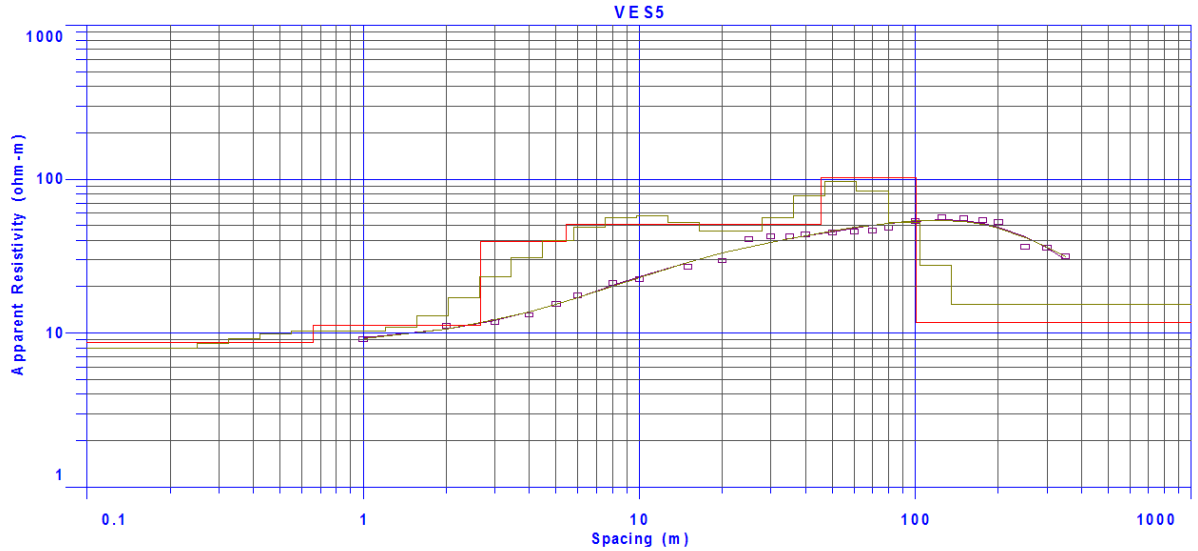

Figure 15.VES 5 Apparent Resistivity versus Spacing Curve

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						Expected litho logy of layers
		App-Resistivity *(Ohm-m)*	Number of Layers	Thickness *(m)*	Depth *(m)*	Elevation *(m)*	Fitting Error (%)	
1	VES_1 LAT: 36.37402 LON: 67.95969	152.41	1	0.7512	0.7512	-0.7512	6.993	Sand and gravel
		30.836	2	19.586	20.337	-20.337		Silt clay and sand
		5.849	3	239.29	259.63	-259.63		Compact clay
		54.411	4	?	?	?		?
2	VES_2 LAT: 36.39141 LON: 67.95264	66.499	1	1.2557	1.2557	-1.2557	4.90	Loose and clayey sand
		41.356	2	4.4985	5.7542	-5.7542		Silt clay
		148.11	3	4.1919	9.9461	-9.9461		Clay and silt clay
		77.594	4	50.455	60.401	-60.401		Sandy clay
		3.501	5	71.302	131.7	-131.7		Sandy clay and gravel
		353	6	?	?	?		?
3	VES_3 LAT: 36.40683 LON: 67.94335	27.664	1	0.73155	0.73155	-0.73155	6.8078	Dry loose and clayey sand
		10.968	2	4.8421	5.5736	-5.5736		Silt clay
		50.803	3	3.63E-02	5.6099	-5.6099		Clay and silt clay
		46.072	4	105.67	111.28	-111.28		Sandy clay and sand
		0.37662	6	?	?	?		Sand clay sand, sand
4	VES_4 LAT: 36.39318 LON: 67.94033	429.94	1	1.9902	1.9902	-1.9902	3.7029	Loose and clayey silt
		108.7	2	14.767	16.757	-16.757		Silt clay.
		205.86	3	33.872	50.629	-50.629		Clay and silt clay
		32.314	4	140.96	191.59	-191.59		Sandy clay
		110.65	5	?	?	?		?
5	VES_5 LAT: 36.40314 LON: 67.93883	8.712	1	0.65885	0.65885	-0.65885	6.2335	Loose, clay and sand
		11.29	2	2.0143	2.6731	-2.6731		Silt clay and sand
		39.337	3	2.7641	5.4372	-5.4372		Sand and gravel
		50.911	4	40.124	45.561	-45.561		Silt clay, sand
		102.38	5	55.138	100.7	-100.7		Sand and gravel with clay
		11.644	6	?	?	?		?

7. Conclusion

The geo- electrical data plot of the different VES lines 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 5.84 Ohm.m to 152.41Ohm.m. The expected lithology of layers made of silts clay, clayey, sand, gravel and compact clay. The depth of layers is 259.63. There is no availability of water
- The graphic data interpretation of VES2 (Figure 8 and Figure 9) shows that the average apparent resistivity values range from 3.5 Ohm.m to 353 Ohm.m. The expected litho-logy of layers made of silts clay, clay, sand. The depth of layers is 131.7. The depth of water table expected between 80m and 90 m. The expected aquifer potential is very poor.
- The graphic data interpretation of VES3 (Figure 10 and Figure 11) shows that the average apparent resistivity values range from 0.3 Ohm.m to 50 Ohm.m. The expected litho-logy of layers made of silts clay, clay, sand and gravel. The depth of layers is 111.8 m. The depth of water table expected between 60 m and 65 m. The expected aquifer potential is very poor.
- The graphic data interpretation of VES4 (Figure 12 and Figure 13) shows that the average apparent resistivity values range from 32.31 Ohm.m to 429.94 Ohm.m. The expected litho-logy of layers made of silts clay, clay, sand and gravel. The depth of layers is 191 m. The depth of water table expected between 65 m and 70 m. The expected aquifer potential is relatively good.
- The graphic data interpretation of VES3 (Figure 14 and Figure 15) shows that apparent resistivity values range from 8.71 Ohm.m to 102.38 Ohm.m. The expected lithology of layers made of clay, sand and gravel. The depth of layers is 100 m. The depth of water table expected between 65 m and 75 m. The expected aquifer potential is relatively good.

8. Recommendation

The study outcome confirms that the VES4 and VES5 relatively have good feasibility for groundwater development. There is no water quality problem and the aquifer has fresh water. Therefore, it is suggested to drill well to the depth of 230 m in the west part of Aybak- hazrati- Sultan Main Road. The discharge of well couldn't determine by this study (geophysical study), but 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 36.39312 - Longitude 67.93821) and the well location marked by cercal with green colour and it is shown in the Figure 16.

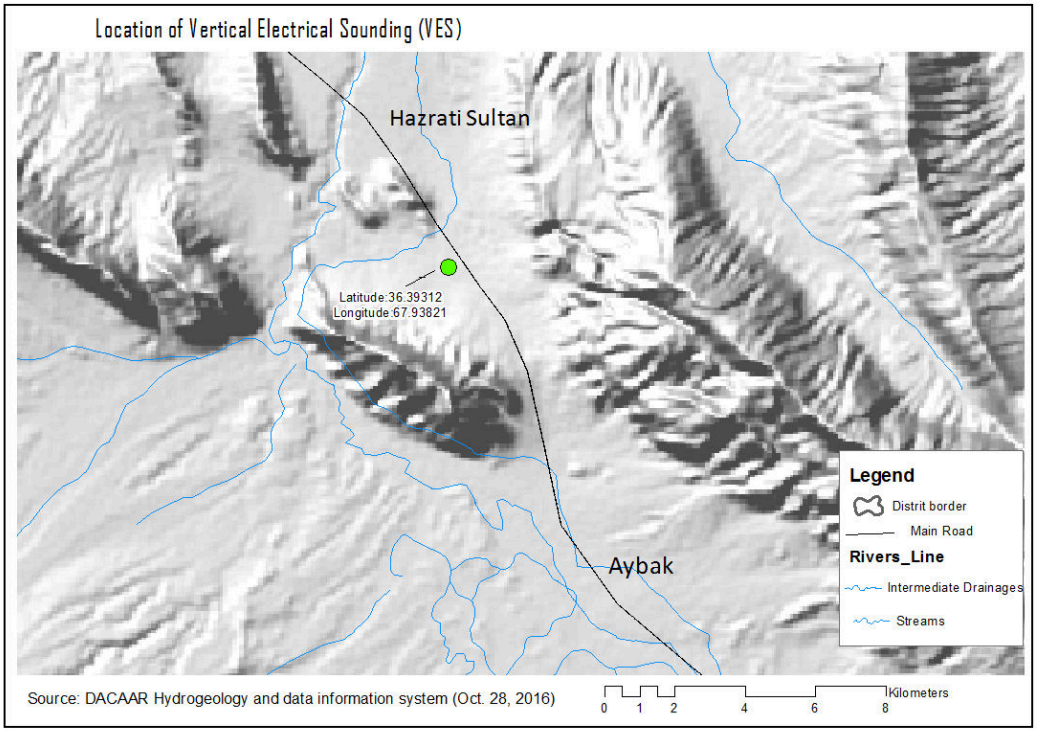

Figure 16. Well site selection location

9. Reference

1. Dr.Laurent Murescot, 2009, Electrical Serving(part a), www.tomoquest.com [1]
2. SYSCAL Pro 10 channels Resistivity and IP measurement manual. www.iris-instruments.com [1]
3. Barker, R.D. 1989. Depth of investigation of collinear four-electrode arrays. Geophysics. 54:1031-1037 [3].
4. Dobrin, M.B. and Savit, C.H., 1988, Introduction to geophysical Prospecting fourth edition, McCraw-Hill, 630p [3].
5. J.Bernard, 2003, The principle geophysical methods for groundwater investigation. www.teraplus.com [4]
6. IXID v2 software, www.Interpex.com[5]