



Geophysical Study in Sholgara Returnee village, Sholgara District of Balkh Province

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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
UNHCR	United Nations High Commissioner for Refugees

1. Introduction

Based on a request by UNHCR, DACAAR dispatched two senior staff to the survey groundwater potential development for Sholgara returnee village:

Sholgara returnee village is located 1.5 Km to the west of Sholgara district centre. The people of this village have safe drinking water problems. A tube well was drilled to the depth of 70m and equipped with a hand pump. The water being pumped is saline and it is potentially a threat to the health of the people. The people are mainly collecting their drinking water from ditches originated from Balkhab River using camels and donkeys (Figure 1).. The water of these ditches is also polluted and a source of water borne-diseases. Therefore the groundwater is the only source of drinking water had it not been saline. There is an urgent need to provide drinking water for the inhabitants of this returnee village, therefore UNHCR officially requested from DACAAR to conduct groundwater survey for groundwater development.

On 25-27 July 2011 DACAAR/WASH Programme (the two DACAAR staff) performed a Vertical Electrical Sounding (VES) survey in Sholgara Returnee village using Shlumberger electrodes arrangement. The field data were measured by SYSCAL Pro resistivity meter and the data interpreted by IPI2 win software (Figure 2).



Figure 1, People collect their drinking water from ditches using camels and donkeys.



Figure 2, Collecting VES profile field data using SYSCAL Pro resistivity meter

2. Geological setting of North Afghanistan

The geological formation of the north Afghanistan is:

- Paleocene: Limestone, marl, dolomite, sandstone, siltstone-and conglomerate,
- Lower Miocene: Red clay, sandstone, siltstone, conglomerate, and limestone.
- Middle Miocene: Brown clay, sandstone, siltstone, conglomerate, and limestone.
- Lower Quaternary: gravel, sand, clay sand, Loess, loam, siltstone, gypsum, andesite, dacite, tuffs, halite and travertine.
- Middle Quaternary: gravel, sand, clay sand, Loess, loam and travertine.
- Upper Quaternary: gravel, sand, clay sand, Loess, loam.
- Upper- Recent Quaternary: gravel, sand, clay sand, loess and travertine.
- Recent Quaternary: gravel, sand, clay and sand.

The Geological setting of North Afghanistan is shown in the figure 3.

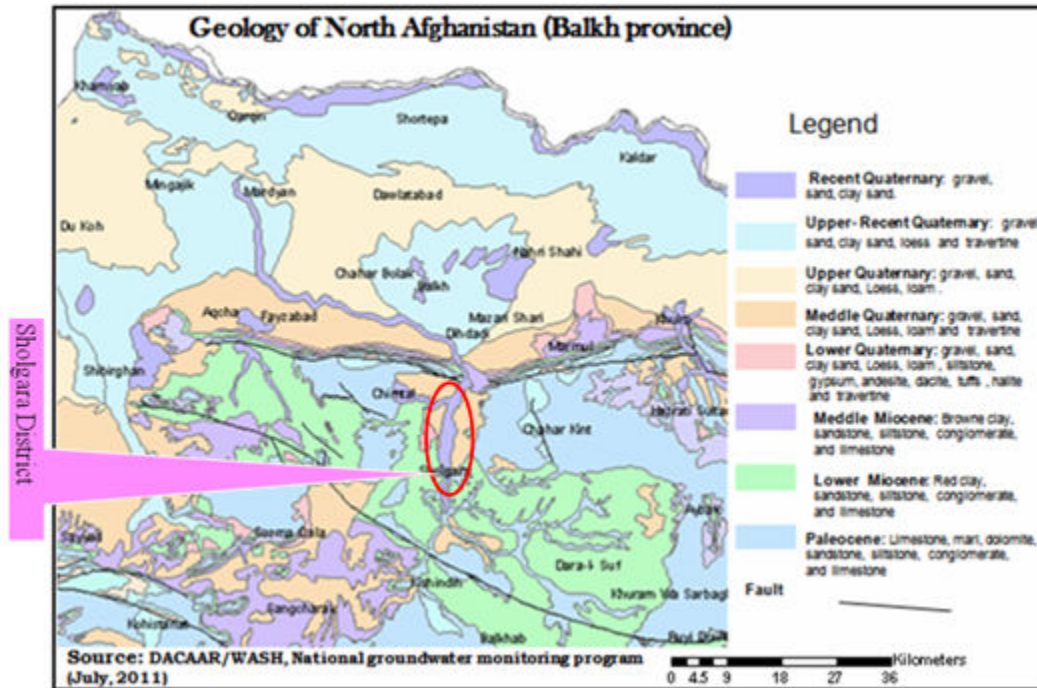


Figure 3, Geology of North Afghanistan (Balkh province)

3. Hydro geological setting

In the studied area the natural groundwater system is characterized by four hydro geologic units:

- Middle Miocene: Browne clay, sandstone, siltstone, conglomerate, and limestone.
- Lower Quaternary: gravel, sand, clay sand, Loess, loam, siltstone, gypsum halite and travertine
- Upper- Recent Quaternary: gravel, sand, clay sand and loess
- Recent Quaternary: gravel, sand, clay and sand.

The Lower Quaternary unit has saline groundwater. The Upper- Recent Quaternary and Recent Quaternary units have fresh ground water. The water table ranges from 27 m to 45 m, it means the depth of water table is 27 m in the center of the district while it is 45 m in the returnees vil- lage. The groundwater salinity ranges from 851 uS/cm (fresh water) to 8,830 uS/cm (saline wa- ter) and the salinity is decreasing from the returnee village to the center of Sholgara district. Table 1 and figure 4 indicate water tables and salinity of groundwater.

Table 1, Groundwater tables and Salinity levels in the center of Sholgara district

No	Prov.	District	Village	LON.	LAT.	Water Point Type	Depth (m)	Water level (m)	EC ($\mu\text{S}/\text{cm}$)	pH	Tem. ($^{\circ}\text{C}$)
1	Balkh	Sholgara	New district compound	66.87788	36.31772	Tube Well	50	39	1300	7.6	25
2	Balkh	Sholgara	Returnee village	66.87138	36.31575	Tube Well	75	45	8830	7.8	23
3	Balkh	Sholgara	Center of Sholgara	66.88485	36.31964	GMW_ID 92	50	29	851	7.5	24
4	Balkh	Sholgara	Center of Sholgara	66.87900	36.32200	Tube Well	87	41	1230	7.9	21
5	Balkh	Sholgara	Center of Sholgara	66.88200	36.32000	Tube Well	64	27	987	7.6	24

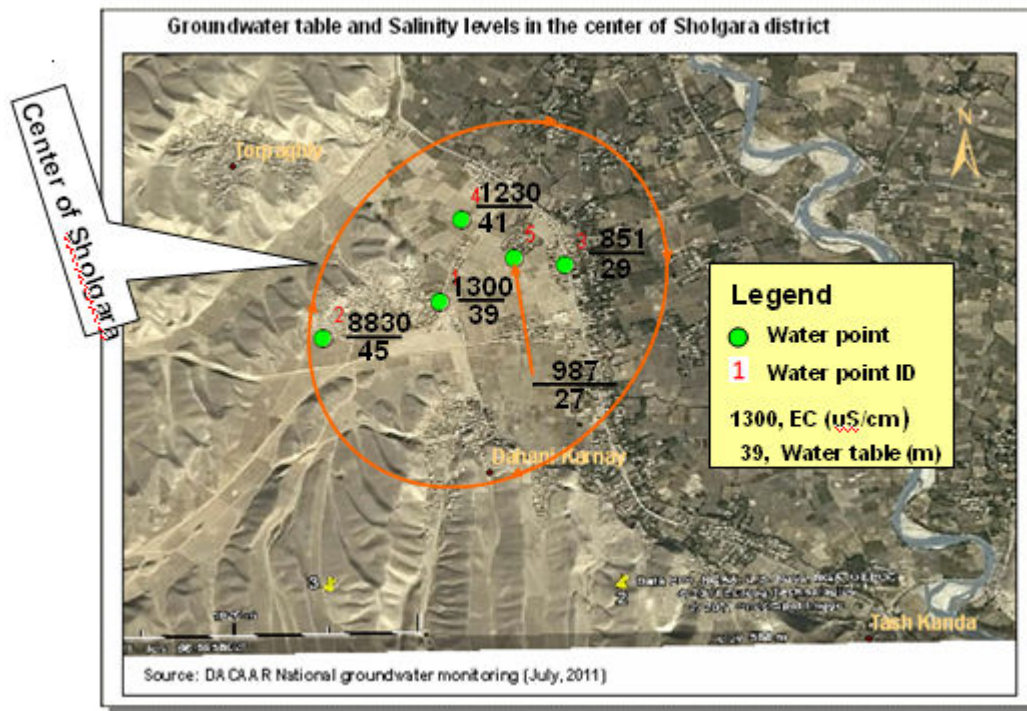


Figure 4, Groundwater level and salinity distribution level in the center of Sholgara district

The Groundwater Monitoring well (GMW_ID 92) is located in the center of Sholgara. The well with hand pump was modified by DACAAR for groundwater monitoring in 2005 and monitored up to date. The water table, electrical conductivity and temperature were measured on a monthly basis and the water samples; physical, chemical and bacteriological analyses were performed on six month basis. The water level and EC variation with time is shown in Figure 5.

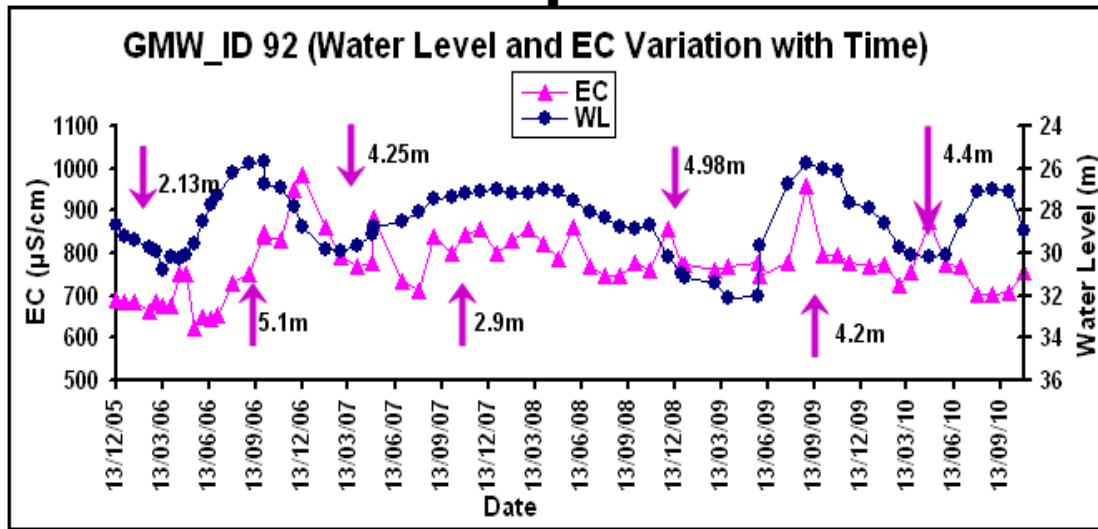


Figure 5, Time series water level and EC variation (2005-2010)

4. Vertical electrical sounding survey

4.1 Vertical Electrical sounding method

In this method the applied Schlumberger techniques was used. Current was transmitted into the ground from DC or low frequency sources by two electrodes (A and B) and the potential difference between a second pair of electrodes (M and N) was measured.

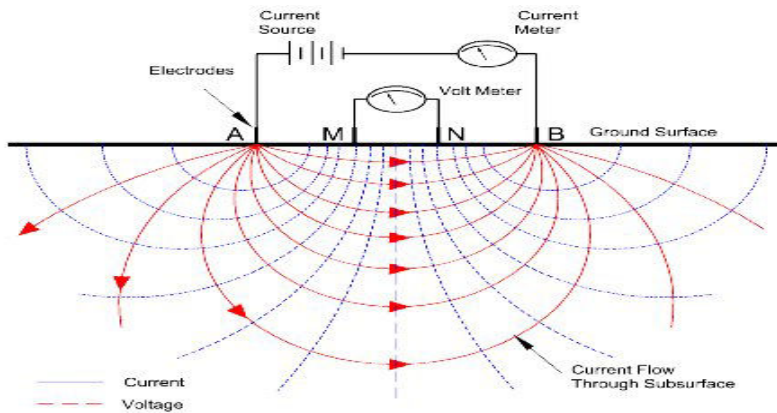


Figure 6, Vertical electrical sounding method

Apparent resistivity value is calculated:

$$\rho_a = K V / I$$

Where:

Pa is the apparent resistivity

K is the geometric factor,

V is a voltage or potential difference between a second pair of electrodes in volts

I is the current from DC or low frequency sources by two electrodes in ampere.

$$K = \pi n (n + 1) a$$



The field data interrelated according to the following resistivity scale for water and rocks.

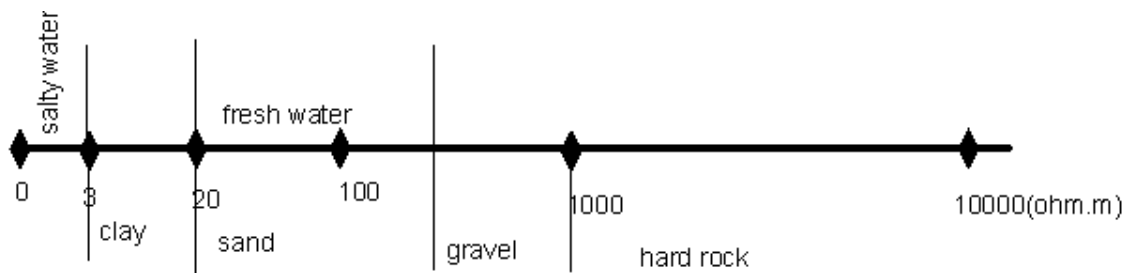


Figure 7, Resistivity scale for water and rocks

4.2 Field study

On 25-27 July 2011 five Vertical Electrical sounding (VES) profiles (VES-1, VES-2, VES-3, VES-4 and VES-5) were applied in west of Sholgara district center. The lengths and locations of VES profiles are indicated in Table 2 and Figure 8.

Table 2, Location of VES profiles

VES profiles	LON.	LAT.	Elevation (m)	Location Name	VES Distance (m)
VES-1	66.87844	36.31732	634	New District Compound	800
VES-2	66.87338	36.31536	633	Returnee Village	600
VES-3	66.87163	36.31439	614	Returnee Village	400
VES-4	66.87828	36.31688	608	New District Compound	600
VES-5	66.88106	36.31915	613	Along the Main road	300



Figure 8, Location and length of VES profiles in the west of Sholgara district center.

4.3 Measured VES field data

The field data were measured by SYSCAL Pro resistivity meter and the measured data are shown in Table 3, Table 4 and Table 5.

Table 3, VES-1 and VES-2 measured field data.

VES-1 Karnail Say Ulya (District Compound)						
LAT: 36.31732						
LON: 66.87844						
AB/2	MN/2	Rho (ohm.m)	Sp (mV)	Vp (mV)	In (mA)	K (m)
1.5	0.5	43.28	6.9	60.994	8.856	8.66
2	0.5	34.69	7.8	38.867	13.2	24.7
3	0.5	32.46	7.4	9.425	7.981	56.2
4	0.5	34.65	6.7	9.06	12.938	100
5	0.5	34.22	6.5	2.954	6.713	157
6	0.5	34.56	6.5	2.594	8.432	226
8	0.5	28.67	4.1	1.051	7.342	402
8	2	39.74	26.4	6.057	7.183	99
10	2	40.6	39	5.543	10.294	156
12	2	40.69	38.1	4.745	12.822	225
15	2	41.72	37.7	3.602	14.987	352
20	2	43.07	36.1	1.817	13.123	627
20	5	45.98	21.7	5.053	12.945	247
25	5	46.04	5.8	7.935	32.49	389
30	5	47.33	11.4	19.577	113.692	562
40	5	52.56	14.2	0.319	3	1001
50	5	60.57	15.3	11.616	149.123	1567
50	10	61.7	29	24.4	149.089	778
60	10	70.61	2.9	15.222	118.531	1123
80	10	80.18	5.5	6.338	78.225	2003
100	10	82.89	7.4	4.884	91.631	3134
120	10	83.47	5.8	4.408	118.623	4516
120	25	77.94	23.1	10.63	118.036	1790
150	25	79.27	12.1	5.348	92.733	2808
200	25	82.11	12.4	0.716	21.578	5007
250	25	85.95	16	3.638	164.57	7834
300	25	87.85	15.4	3.205	204.857	11290
300	50	11.69	11.1	0.933	219.333	5616
400	50	84.77	1.8	0.414	18.393	10014

VES-2 Mahajerin Oashlaq Suflla						
LAT: 36.31536						
LON: 66.87338						
AB/2	MN/2	Rho (ohm.m)	Sp (mV)	Vp (mV)	In (mA)	K (m)
1.5	0.5	64.21	0.2	416.992	40.805	8.66
2	0.5	60.97	4.8	314.87	60.843	24.7
3	0.5	51.34	4.3	109.916	58.853	56.2
4	0.5	46.72	2	52.962	56.093	100
5	0.5	46.74	0.4	42.932	45.445	157
6	0.5	46.64	0.1	31.997	53.34	226
8	0.5	43.69	1	22.288	57.295	402
8	2	38.43	0.7	14.365	74.853	99
10	2	39.12	70.3	61.76	74.395	156
12	2	34.11	20	28.11	62.134	225
15	2	30.05	26.7	14.959	54.729	352
20	2	23.41	30.3	9.888	73.313	627
20	5	17.27	30.7	2.578	46.434	247
25	5	18.21	4.9	6.399	41.406	389
30	5	17.06	0.7	6.193	68.436	562
40	5	21.89	1.5	3.411	77.089	1001
50	5	22.54	1.7	2.55	87.943	1567
50	10	22.68	35.9	5.266	87.544	778
60	10	23.43	2.9	2.496	58.565	1123
80	10	25.13	11.5	1.701	66.979	2003
100	10	24.56	13.5	0.781	49.419	3134
120	10	23.83	13.7	1.175	110.704	4516
120	25	22.95	11.4	2.926	110.338	1790
150	25	22.35	2.8	1.461	89.837	2808
200	25	20.74	7.6	0.224	26.699	5007
250	25	21.88	9.6	1.083	192.432	7834
300	25	21.52	9.3	0.086	22.216	11290
300	50	-	-	-	-	5616
400	50	-	-	-	-	10014

Table 4, VES-3 and VES-4 measured field data.

VES-3 Mahajren Qeshlaq Suflla						
LAT: 36.31439						
LON: 66.87163						
AB/2	MN/2	Rho (ohm.m)	Sp (mV)	Vp (mV)	In (mA)	K (m)
1.5	0.5	39.04	6.5	412.822	66.437	8.66
2	0.5	38.94	6.3	410.054	66.165	24.7
3	0.5	33.28	4.8	164.658	58.287	56.2
4	0.5	32.66	2.4	23.609	19.87	100
5	0.5	31.72	3	22.622	35.286	157
6	0.5	31.83	4.1	10.324	25.218	226
8	0.5	31.32	2.4	11.017	39.508	402
8	2	27	79.4	20.386	35.583	99
10	2	24.95	49.6	7.797	23.56	156
12	2	24.16	43.7	8.385	38.165	225
15	2	23.57	40.8	4.637	34.151	352
20	2	23.95	38.6	2.668	34.642	627
20	5	20.3	3.7	4.791	27.803	247
25	5	19.62	2.2	2.202	21.16	389
30	5	20.5	17.1	1.176	15.771	562
40	5	19.79	28.4	0.371	9.266	1001
50	5	19.7	32.5	1.196	47.217	1567
50	10	21.03	20.1	2.609	46.768	778
60	10	20.66	26.8	0.854	22.726	1123
80	10	20.2	38.8	0.466	22.803	2003
100	10	17.56	43	0.353	31.235	3134
120	10	15.01	49.3	0.269	40.187	4516
120	25	15.1	44.7	0.654	37.469	1790
150	25	14.64	27.9	0.5	46.912	2808
200	25	19.97	26.5	0.487	61.739	5007
250	25	-	-	-	-	7834
300	25	-	-	-	-	11290
300	50	-	-	-	-	5616
400	50	-	-	-	-	10014

VES-4 Mahajren Qeshlaq Ulya						
LAT: 36.31688						
LON: 66.87828						
AB/2	MN/2	Rho (ohm.m)	Sp (mV)	Vp (mV)	In (mA)	K (m)
1.5	0.5	27.39	35.7	71.3	4.292	8.66
2	0.5	53.18	39.9	4.107	0.91	24.7
3	0.5	42.13	43.9	4.849	3.164	56.2
4	0.5	38.54	45	1.57	2.016	100
5	0.5	36.96	47.3	1.717	3.612	157
6	0.5	37.59	49.8	0.738	2.204	226
8	0.5	43.67	24.3	3.855	4.16	402
8	2	45.03	9.2	0.811	1.358	99
10	2	39.97	5.9	0.673	1.852	156
12	2	39.66	4.3	0.202	0.885	225
15	2	32.7	3	0.09	0.851	352
20	2	33.18	8.5	0.238	0.846	627
20	5	32.34	5.4	0.238	1.388	247
25	5	41.77	3	3.878	25.519	389
30	5	53.76	1.9	0.568	5.224	562
40	5	61.32	1.3	0.856	10.851	1001
50	5	62.03	60.7	1.756	10.675	1567
50	10	75.2	25.2	0.252	1.846	778
60	10	81.04	19.5	3.246	39.641	1123
80	10	89.99	14.5	1.348	23.299	2003
100	10	99.72	12.6	0.55	12.382	3134
120	10	94.63	37.7	1.329	12.151	4516
120	25	92.04	21.2	0.482	7.192	1790
150	25	89.19	16	1.422	39.432	2808
200	25	90.25	11.8	0.781	33.629	5007
250	25	96.01	9.9	0.919	53.726	7834
300	25	110	105.7	701.346	4.63	11290
300	50	-	-	-	-	5616
400	50	-	-	-	-	10014

Table5, VES-5 measured field data.

VES-5 Sholgra Main Rode						
LAT: 36.31950						
LON: 66.88106						
AB/2	MN/2	Rho (ohm.m)	Sp (mV)	Vp (mV)	In (mA)	K (m)
1.5	0.5	265.14	89.5	212.397	5.033	8.66
2	0.5	50.71	83.7	19.666	4.569	24.7
3	0.5	23.56	74.2	5.119	5.973	56.2
4	0.5	27.79	69.6	4.156	7.4	100
5	0.5	28.3	70	2.562	7.04	157
6	0.5	29.12	70.5	0.974	3.756	226
8	0.5	30.68	108.9	4.926	7.565	402
8	2	34.5	83.4	1.425	3.114	99
10	2	38.19	70	0.63	2.864	156
12	2	35.92	67.7	0.217	1.876	225
15	2	37.77	31.4	0.664	2.072	352
20	2	41.43	33.2	0.865	3.935	627
20	5	47.76	28.9	0.202	1.164	247
25	5	48.64	24.2	0.594	6.047	389
30	5	49.37	21.9	0.698	6.998	562
40	5	45.31	20.1	0.115	1.966	1001
50	5	46.77	15.3	0.251	2.02	1567
50	10	56.82	8.7	0.301	2.91	778
60	10	59.68	3.5	0.152	2.524	1123
80	10	60.75	0.3	0.066	1.696	2003
100	10	72.55	3.9	0.131	4.047	3134
120	10	75.02	4.9	0.136	4.074	4516
120	25	81.89	62.1	0.41	4.334	1790
150	25	84.01	52.5	0.249	4.072	2808
200	25	81.65	42.6	0.073	2.224	5007
250	25	55.33	33.1	0.014	1.006	7834
300	25	102.55	23.7	0.036	1.961	11290
300	50	-	-	-	-	5616
400	50	-	-	-	-	10014

4.4 Interpreted field data

The collected field data were interpreted by IPI2 wins software. The interpreted data were used to calculate apparent resistivity, thickness, depth and boundaries of layers. The interpreted data are shown in Table 6.

Table 6, VES -1, VES-2, VES-3, VES-4 and VES-5 interpreted data

No	VES Profiles	Vertical Electrical Resistivity Survey in Sholgra Returnee Camp				Converging of evidences and geological interpretation
		App- Resistivity (Ohm-m)	Layer	Thickness (m)	Depth (m)	
1	VES -1 LAT: 36.31732 LON: 66.87844	30.3	1	0.75	0.75	Loess, Clay, Silt,
		40.3	2	18.7	19.5	Silt, clay sand
		90.1	3		>19.5	Sand clay, sand, gravel
2	VES -2 Lat: 36.31536 Lon:66.87338	45.9	1	1.26	1.26	Loess, loam, clay
		14.7	2	1.08	2.34	Clay, silt
		64.7	3	2.53	4.87	Dry sand
		4.87	4	5.73	10.6	Clay
		110	5	7.22	17.8	Dry sand and gravel
		20	6		>17.8	Sand, silt, clay with intercalation of gypsum and halite
3	VES -3 LAT: 36.31439 LON: 66.87163	31.7	1	1.41	1.41	Clay, silt, loess
		22.1	2	49.8	51.2	Clay, silt with intercalation of gypsum
		11.5	3		>51.2	Clay
4	VES -4 LAT: 36.31688 LON: 66.87828	20.6	1	0.75	0.75	Silt clay, clay
		54.1	2	4.1	4.85	Dry sand
		10.1	3	4.16	9.01	Silt clay, clay
		479	4	18.3	27.3	Sandstone, siltstone
		10.1	5	25.9	53.1	Clay, silt, fine sand
		2730	6		>53.1	Conglomerate
5	VES -5 LAT: 36.31950 LON: 66.88106	36	1	1.7	1.7	Clay, fine sand
		62.7	2	52.9	54.6	Sand
		110	3		>54.6	Sand, gravel

4.5 Vertical Electrical sounding data Graphic interpretation

The VES -1, VES-2, VES-3, VES-4 and VES-5 field *data* (Apparent resistivity versus Electrodes distance) were interpreted by IPI2 win software as well as manually. The boundaries, thickness and depth of rocks layers were determined according to the measured and computed apparent resistivity and geo electrical model (Table 6). The rock types were specified according to the computed apparent resistivity based on the geophysical interpretation principles. The Apparent resistivity versus Electrodes distance curve for VES -1, VES-2, VES-3, VES-4 and VES-5 are shown in the Figure 9, Figure 10, Figure 11, Figure 12 and Figure 13.

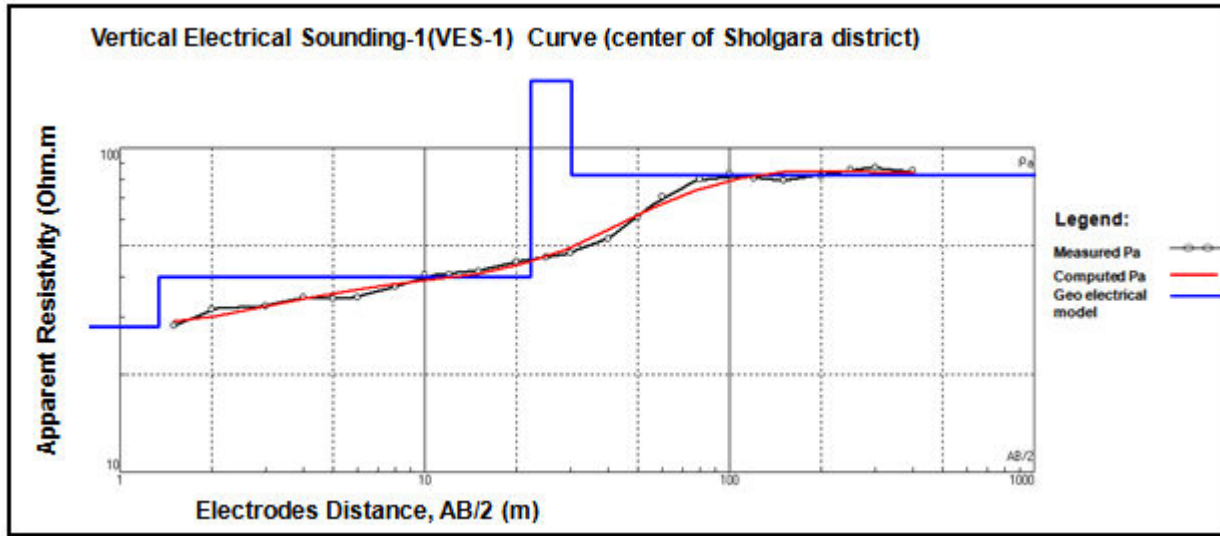


Figure 9, VES-1 Curve

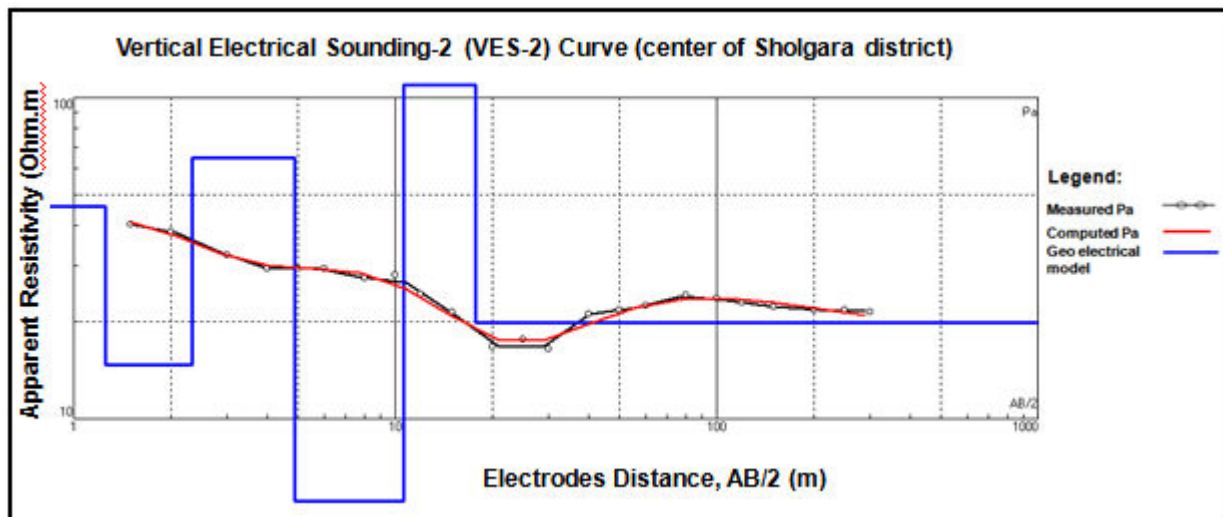


Figure 10, VES-2 Curve

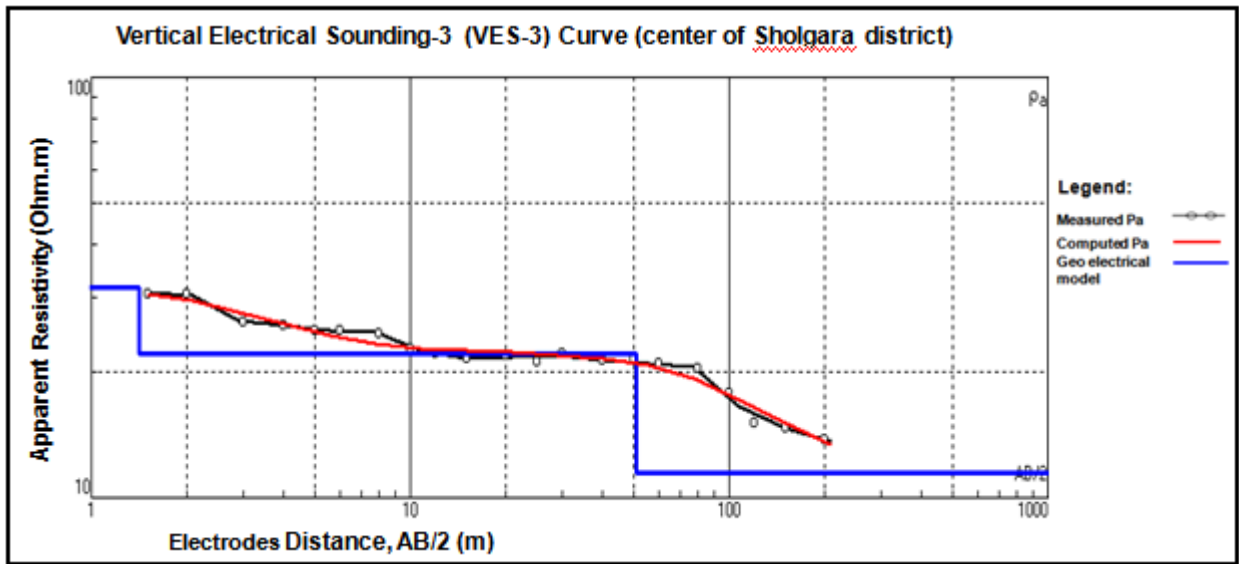


Figure 11, VES-3 Curve

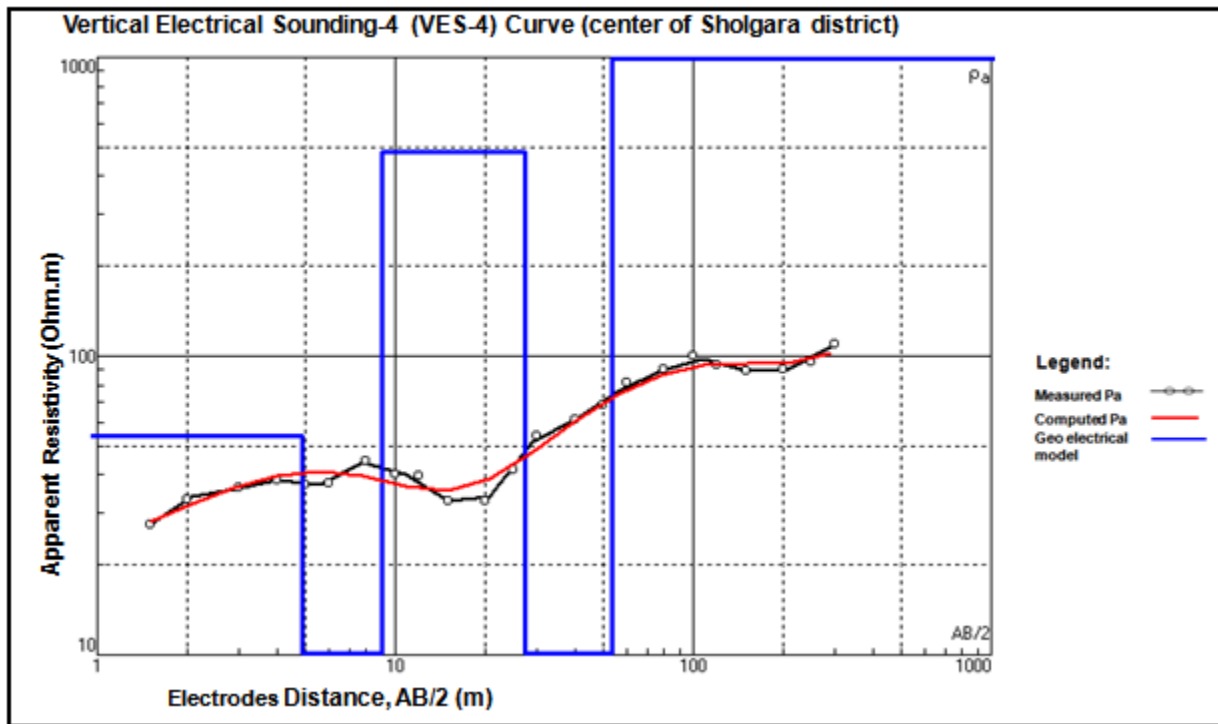


Figure 12, VES-4 Curve

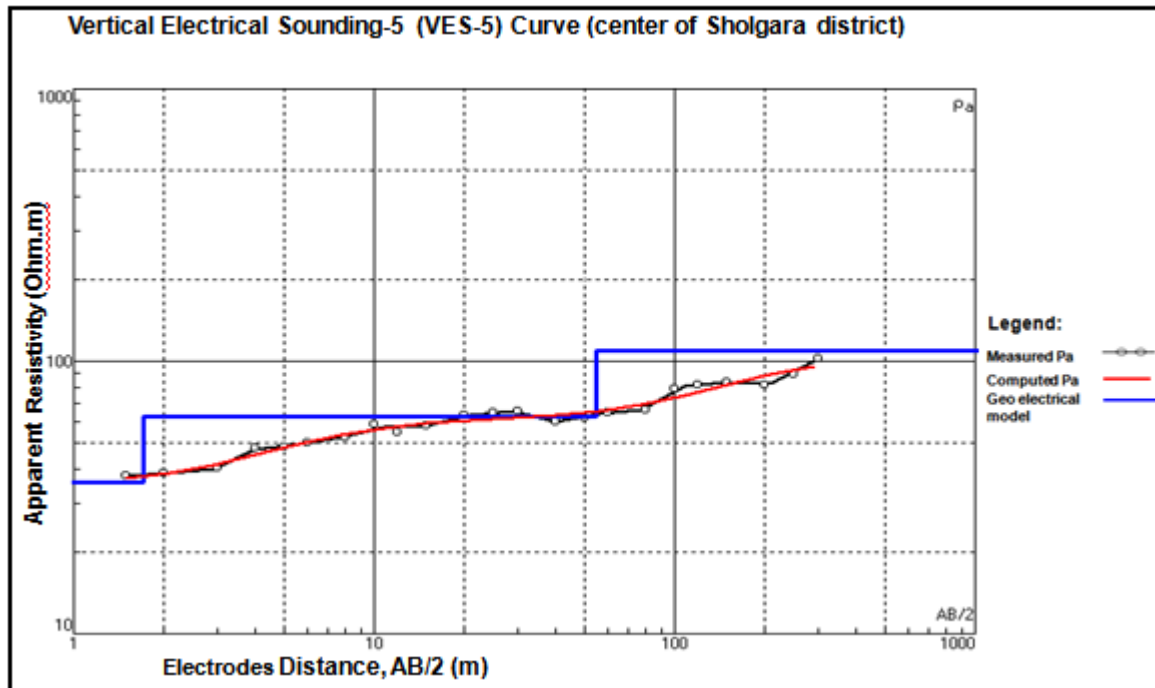


Figure 13, VES-5 Curve

4.6 VES profiles field data Graphic interpretation results

The measured, computed apparent resistivity and geo electrical curves show:

- VES-2 and VES-3 profiles performed around Returnee village (target area). The VES-2 and VES-3 field data interpretation show that the upper part of aquifer consists of clay , silt, Loess, loam and somewhat conglomerate. The aquifer consists of silt, sand and clay with the intercalation of gypsum that has saline groundwater (Table 6). Therefore groundwater cannot be developed for drinking and other purposes.
- VES-1 and VES-4 profiles performed around the new district compound. The VES-1 and VES-4 field data interpretation shows that the upper part of aquifer layers consists of clay , silt, Loess, loam and the aquifer consists of silt, sand and silt clay that has fresh groundwater. This area is a boundary of fresh and saline groundwater.
- VES-5 profile performed along the Main Road in the north-east of new district compound. The VES-5 field data interpretation shows the upper part of aquifer layers consist of silt clay and silt and the aquifer consists of silt clay, sand and somewhat conglomerate, siltstone and sandstone that have fresh groundwater. This area has good possibility for groundwater development.

5. Conclusion

1. In Returnee village, the measured apparent resistivity, computed resistivity and geo electrical model data interpretation show:
 - The water table ranges from 40m to 45m.

- The aquifer media is sedimentary deposits and consist of silt, sand and clay with the intercalation of gypsum and halite.
 - The aquifer has saline water. Groundwater cannot be developed for drinking and other purposes.
2. In new district compound, the measured apparent resistivity, computed resistivity and geo electrical model data interpretation show:
- The water table ranges from 35 m to 40m.
 - This area is boundary of fresh and saline groundwater.
 - The possibility of groundwater is increased from the west (new district compound) to the north-east (Main Road).
 - The aquifer media is sedimentary deposits and consist of silt clay, sand and conglomerate
3. In area between Main Road and new district compound, the measured apparent resistivity, computed resistivity and geo electrical model data interpretation show:
- The water table ranges from 30 m to 35 m.
 - This area has good possibility for groundwater development.
 - The possibility of groundwater is increased from the west (new district compound) to the north-east (Main Road).
 - The aquifer media is sedimentary deposits and consist of silt clay, sand, gravel

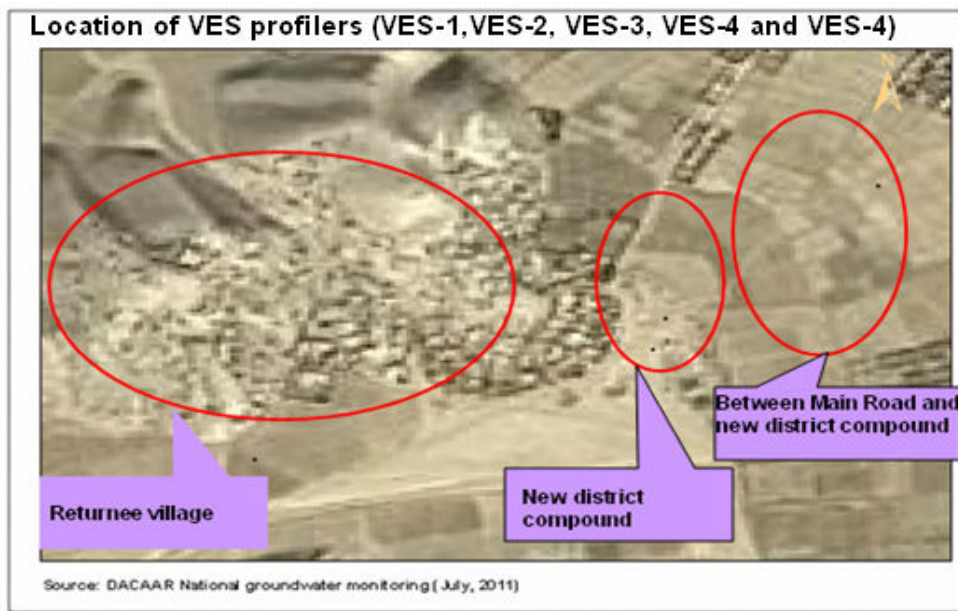


Figure 14, Location of VES profiles

6. Recommendation

- The area which is located between new district compound and Main Road has good possibility for drilling of Tube Well, but this area is a private agriculture land.
- The new district compound (now under construction) has relatively good possibility for drilling of Tube well. There is no problem for the drilling of Tube Well.
- The Tube Well should be drilled up to the depth of 90 m either between new district compound and Main Road or in the new district compound.

- Construct a surface reservoir on the top of the hill that is located in the north of new district compound. The ground elevation of the new district compound is 606 m above sea level and the ground elevation at the top of the hill is 620 m above sea level. The differences of elevation between new district compound and top of the hill are 14 m. The water from the Tube Well should be pumped to the reservoir (top of the hill) then distributed by gravity piped water supply system to the Returnee village. The water pump is available in the market to pump water from Tube Well to the reservoir it is not problem from technical point of view (Figure 15). A detailed feasibility study, design and cost estimate is required prior to the construction of the above recommended system.

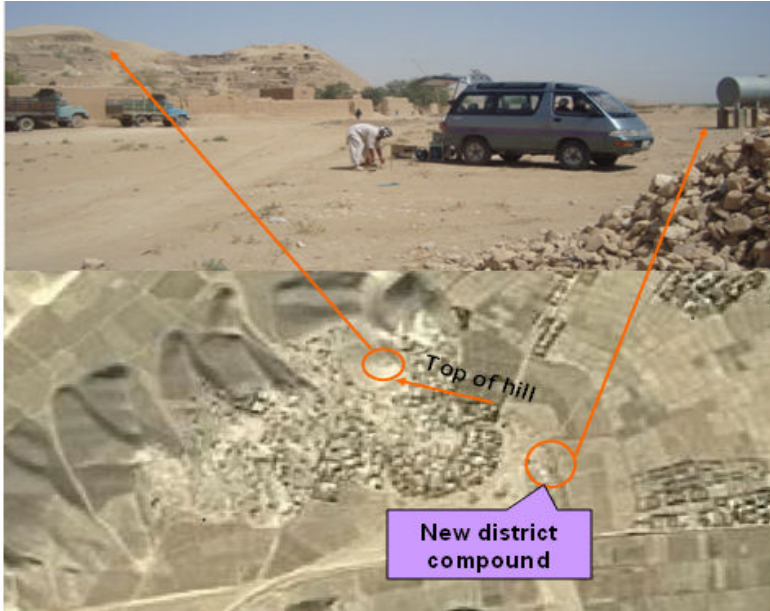


Figure 15, Location of new district compound and top of hill