## 3.3 Jimma Zone

### 3.3.1 Bilu Harsu

The Bily Harsu site is located on the flood plain of Kawa River, and therefore thick alluvium may be expected in the area (Fig 19a). The apparent resistivity map (Fig 19b) shows that the area is generally underlain by very low resistivities below 15 Ohm-m, indicting the presence of widely distributed saturated alluvium. Within the low resistivity area, there are patches of higher resistivity (20-60 Ohm-m) elongated and circular shape, probably representing lenses of more coarser material like sand and/or gravel.

The VES data in the area were mainly distributed in the north-south direction following the flood plain of Kawa, and the results of interpretation (Fig 19c) show the presence of very thick low resistivity layers, although there is slight variation within the generally low resistivities owing to differences in the composition of the loose sediments. The resistivity values varied between 1 and 35 Ohm-m, and the very low resistivity layer of 1-2 Ohm-m forming the sixth layer in the area has the largest thickness in the rage of 50-74m, and it is generally found below depth of 70-90m from the surface. The very low resistivity of the layer probably suggests saturation with saline water.

The unconsolidated sediments and/or pyroclastics in the area are very thick, being in the range of 130-150m, and they are underlain at the bottom by a high resistivity layer (230-250 Ohm-m) probably composed of slightly weathered volcanic bedrock.

**Figure 19a. Location map of VES points and HRP lines, Bilu Harsu.**

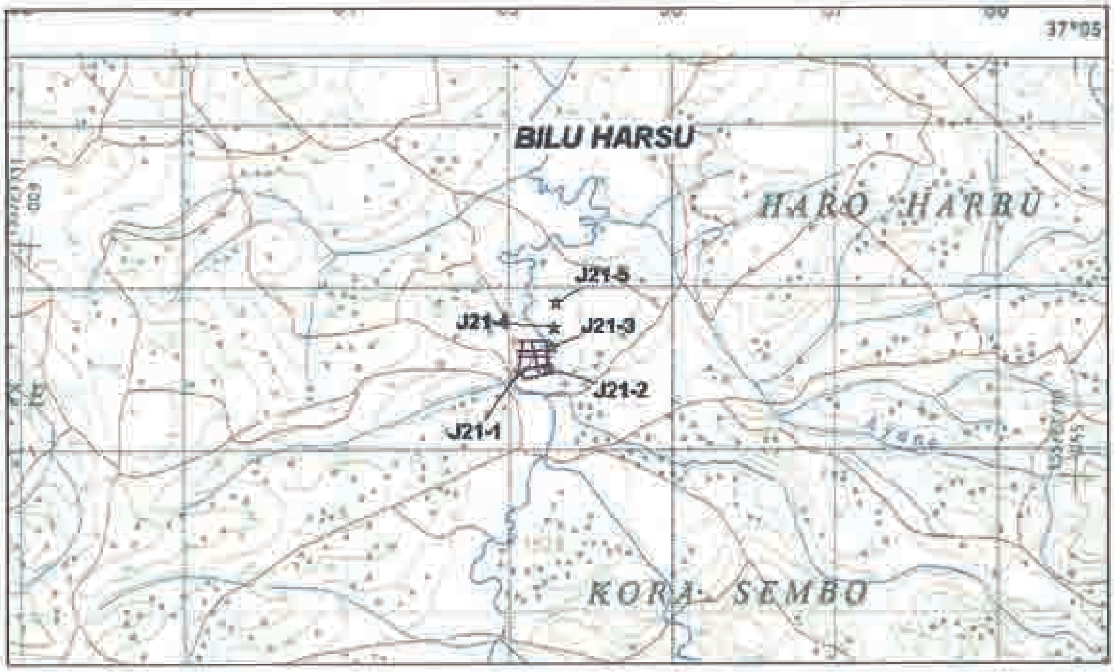
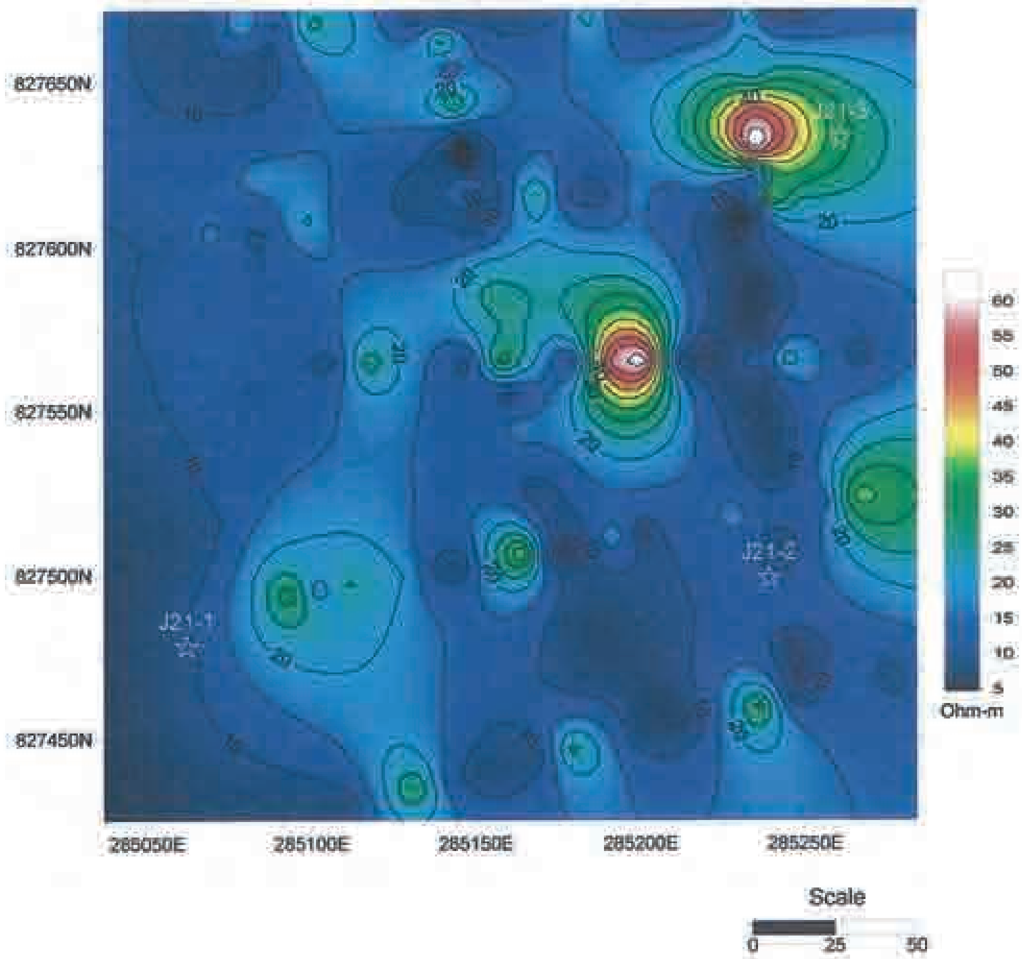


**Figure 19b. Apparent resistivity Map, Bilu Harsu.**



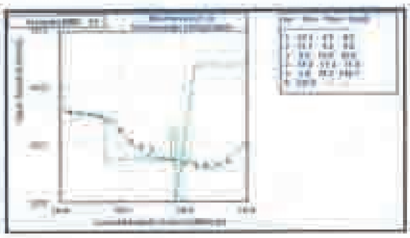
## Figure 19c. Interpreted Layer Parameters, Bilu Harsu.

(a) VES- J21-1

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 31.9 | 0.6 | 0.6 | Alluvium, coarse grained |
| 2 | 35.4 | 7.9 | 8.5 | Ditto |
| 3 | 6.4 | 55.6 | 64.1 | Fine grained alluvium, probably saturated |
| 4 | 33.5 | 20.3 | 84.4 | Coarse grained alluvium, saturated |
| 5 | 1.7 | 60.1 | 144.5 | Fine grained alluvium and/or pyrodastics, probably saturated |
| 6 | 245.3 | | | Volcanic bedrock |

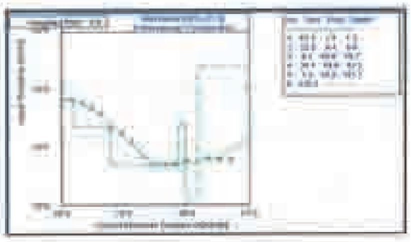
(b) VES-J21-2

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 43.4 | 0.7 | 0.7 | Alluvium, coarse grained |
| 2 | 31.1 | 4.2 | 4.9 | Ditto |
| 3 | 5.5 | 55.6 | 60.5 | Fine grained alluvium, probably saturated |
| 4 | 17.9 | 11.4 | 71.9 | Coarse grained alluvium, saturated |
| 5 | 1 | 74.2 | 146.1 | Fine grained alluvium and/or pyrodastics, probably saturated |
| 6 | 236.8 | | | Volcanic bedrock |



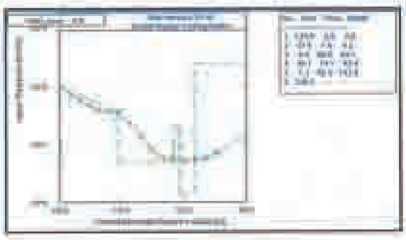
(c) VES-J21-3

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 67.3 | 1.5 | 1.3 | Alluvium, coarse grained |
| 2 | 22 | 4.4 | 5.9 | Ditto |
| 3 | 4.7 | 69.8 | 75.7 | Fine grained alluvium, probably saturated |
| 4 | 26.1 | 16.6 | 92.3 | Coarse grained alluvium, saturated |
| 5 | 1.4 | 58.8 | 151.1 | Fine grained alluvium and/or pyrodastics, probably saturated |
| 6 | 235.3 | | | Volcanic bedrock |



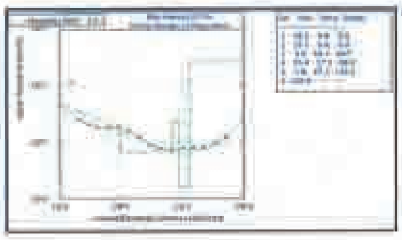
(d) VES-J21-4

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 125 | 0.6 | 0.6 | Alluvium, coarse grained |
| 2 | 37.6 | 7.6 | 8.2 | Ditto |
| 3 | 4.9 | 60.5 | 68.7 | Fine grained alluvium, probably saturated |
| 4 | 20.1 | 15.1 | 83.8 | Coarse grained alluvium, saturated |
| 5 | 1.3 | 58.3 | 142.1 | Fine grained alluvium and/or pyrodastics, probably saturated |
| 6 | 250.7 | | | Volcanic bedrock |



(e) VES-J21-5

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 59.2 | 0.6 | 0.6 | Alluvium, coarse grained |
| 2 | 17.7 | 8.8 | 9.4 | Ditto |
| 3 | 6.5 | 59.3 | 68.7 | Fine grained alluvium, probably saturated |
| 4 | 23.4 | 17.3 | 86 | Coarse grained alluvium, saturated |
| 5 | 1.6 | 47.2 | 133.2 | Fine grained alluvium and/or pyrodastics, probably saturated |
| 6 | 250.8 | | | Volcanic bedrock |



### 3.3.2 Deneba

The geophysical survey at Deneba was conducted in the area of the existing well which has been is use for more than two decades (Fig 20a). A number of east-west and north-south lines were surveyed by the HRP method, in order to detect the presence of structures, if any. The apparent resistivity map (Fig 20b) is characterized by low to very low resistivities in the range of 6 to 26 Ohm-m. The relatively higher resistivities (> 20 Ohm-m) occupy the northwestern and southeastern part of the area, whereas the very low resistivities of less than 12 Ohm-m are mainly found along NNE-SSW direction in the central potion of the area. These low resistivities probably indicated area of high weathering and/or fracturing of the rock which forms the aquifer in the area. The existing borehole is situated within the low resistivity zone in a relatively wide area to the southwest of the site, further corroborating the interpretation.

The VES were distributed within the low resistivity zone identified form the HRP data. And the results of interpretation of the VES data (Fig 20c) show that very low resistivities of less than 10 Ohm-m dominate the subsurface.

Very low resistivities are 4 to 8 Ohm-m contain the major part of the subsurface, although there is a moderately high resistivity layer of 122-177 Ohm-m with thickness varying between 24-35 m is found intercalated within the low resistivity layers.

The low resistivity layer is probably composed of highly weathered/fractured rocks and/or pyroclastics saturated with water and there is a possibility of encountering two aquifers separated by an intermediate high resistivity layer. The bottom part is characterized very high resistivities in the order of 300 Ohm-m, and probably consists of moderately to slightly fractured rock.

**Figure 20a. Location map of VES points and HRP lines, Deneba.**

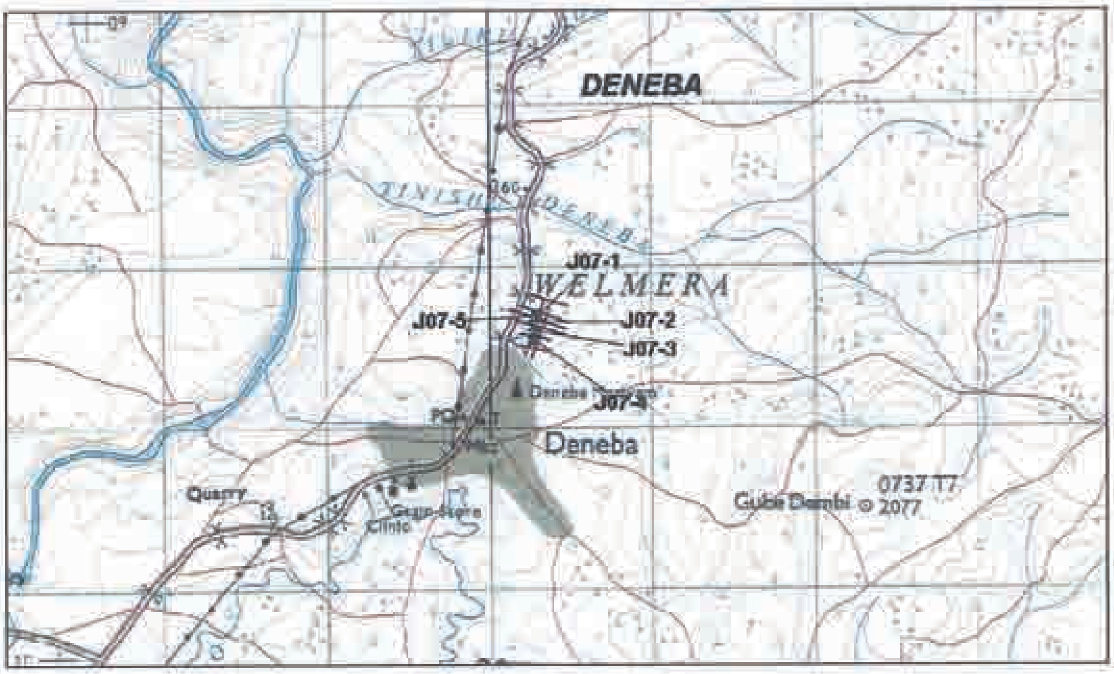
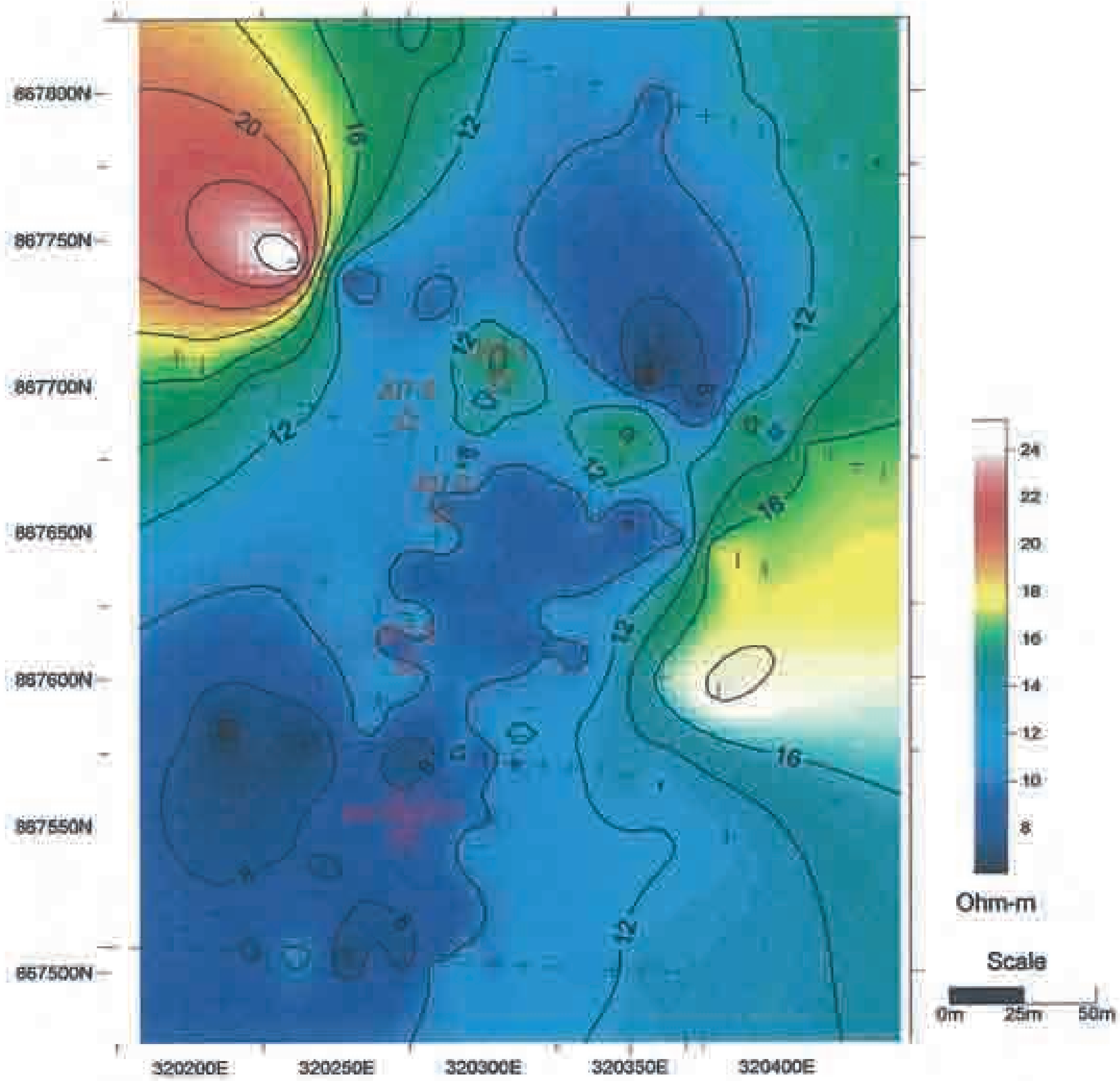


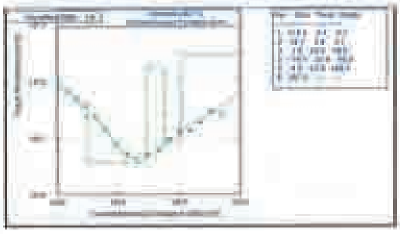
**Figure 20b. Apparent Resistivity Map, Deneba.**



## Figure 20c. Interpreted Layer parameters, Deneba.

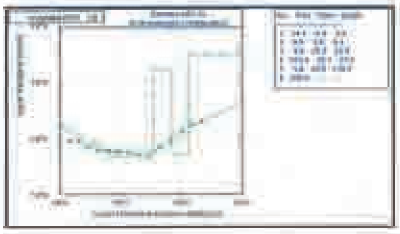
(a) VES- J07-1

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 115.4 | 0.7 | 0.7 | Top soil |
| 2 | 29.7 | 2.4 | 3.1 | Gravelly Clay |
| 3 | 3.8 | 25.9 | 29 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 176.9 | 26.8 | 55.8 | Moderately fractured rock |
| 5 | 8.5 | 52.8 | 108.6 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 297.9 | | - | Moderately to slightly fractured rock |



(b) VES-J07-2

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 24.9 | 0.6 | 0.6 | Top soil |
| 2 | 6 | 5.8 | 6.4 | Clayey soil |
| 3 | 4.8 | 28.5 | 34.9 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 163.8 | 35.3 | 70.2 | Moderately fractured rock |
| 5 | 9 | 60 | 130.2 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 300 | - | | Moderately to slightly fractured rock |

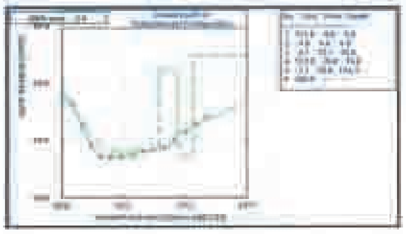


(c) VES-J07-3

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 108.2 | 0.7 | 0.7 | Top soil |
| 2 | 6 | 12.2 | 12.9 | Clayey soil |
| 3 | 6.4 | 28.5 | 41.4 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 162 | 33.8 | 75.2 | Moderately fractured rock |
| 5 | 5.3 | 67.6 | 142.8 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 296.3 | | | Moderately to slightly fractured rock |

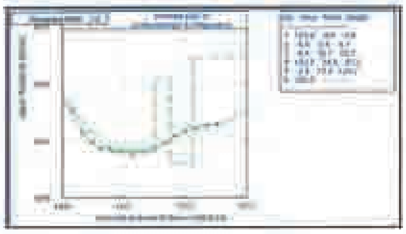
(d) VES-J07-4

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 111.6 | 0.6 | 0.6 | Top soil |
| 2 | 4.6 | 5.8 | 6.4 | Clayey soil |
| 3 | 6.7 | 32.2 | 38.6 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 172 | 36 | 74.6 | Moderately fractured rock |
| 5 | 5.1 | 58.6 | 133.2 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 300.6 | - | - | Moderately to slightly fractured rock |



(e) VES-J07-5

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 104.8 | 0.6 | 0.6 | Top soil |
| 2 | 6.8 | 5.5 | 6.1 | Clayey soil |
| 3 | 6.4 | 26.7 | 32.8 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 122.2 | 24.4 | 57.2 | Moderately fractured rock |
| 5 | 6.1 | 73 | 130.2 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 295.5 | - | | Moderately to slightly fractured rock |



### 3.3.3 Asendabo-Yedi

The Asendabo –Yedi site is located in the plain to the west of the town, and streches for more than two kilometers in width (Fig 21a), the VES being distributed along the plain. But the HRP survey was conducted in the central area. The HRP site is selected in an area where the Gilgel Gibe river makes a sharp bend from a NE-SW direction to almost NNW-SSE direction presumably controlled by a structure. Therefore, the HRP lines were laidout in directions that would allow the detection of the presumed fault.

The apparent resistivity map (Fig 21b) shows that the area is generally underlain by very low to moderate resistivities, varying between 5 and 50 Ohm-m. The moderate resistivities (30-50 Ohm-m) are found in the northern part of the area, the very low resistivities (<15 ohm-m) occupy the southern and eastern parts. These resistivity variations indicate the compositional variation of the loose sediments that may underlie the area.

The VES data cover a large area of about 2.5 km in nearly east-west direction, mainly to see the lateral variation of the subsurface in the area. The results show strikingly similar responses for almost all soundings (Fig 21c). Very thick layers (>200m) of low resistivity in the range of 2-17 Ohm-m underlie the top soil, interpreted as alluvium and/or highly weathered rock or pyroclastics probably saturated with water.

The very low resistivity layer is divided in to two zones by a layer of moderate resistivity (93-143 Ohm-m) at depth of 130-155m. The upper low resistivity zone has relatively higher resistivity (8-17 Ohm-m) and corresponding thickness in the range of 70 to 120m, whereas the lower low resistivity zone is characterized by very low resistivities in the range of 2 to 4 Ohm-m, and thickness of 70-100m. The variation in resistivity may probably point out variation in the quality of the groundwater, the deeper very low resistivity layer probably being saturated by saline water.

The depth to the bottom substratum represented by high resistivity in the range of 165-169 Ohm-m varies between 205 and 237m.

**Figure 21a. Location map of VES points and HRP lines, Asendabo-Yedi.**

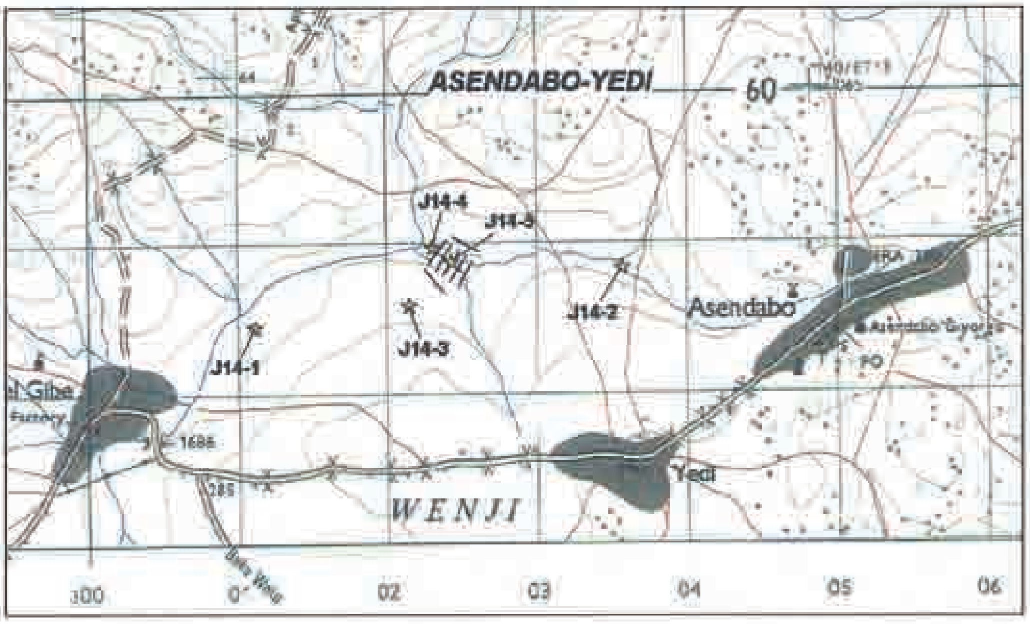
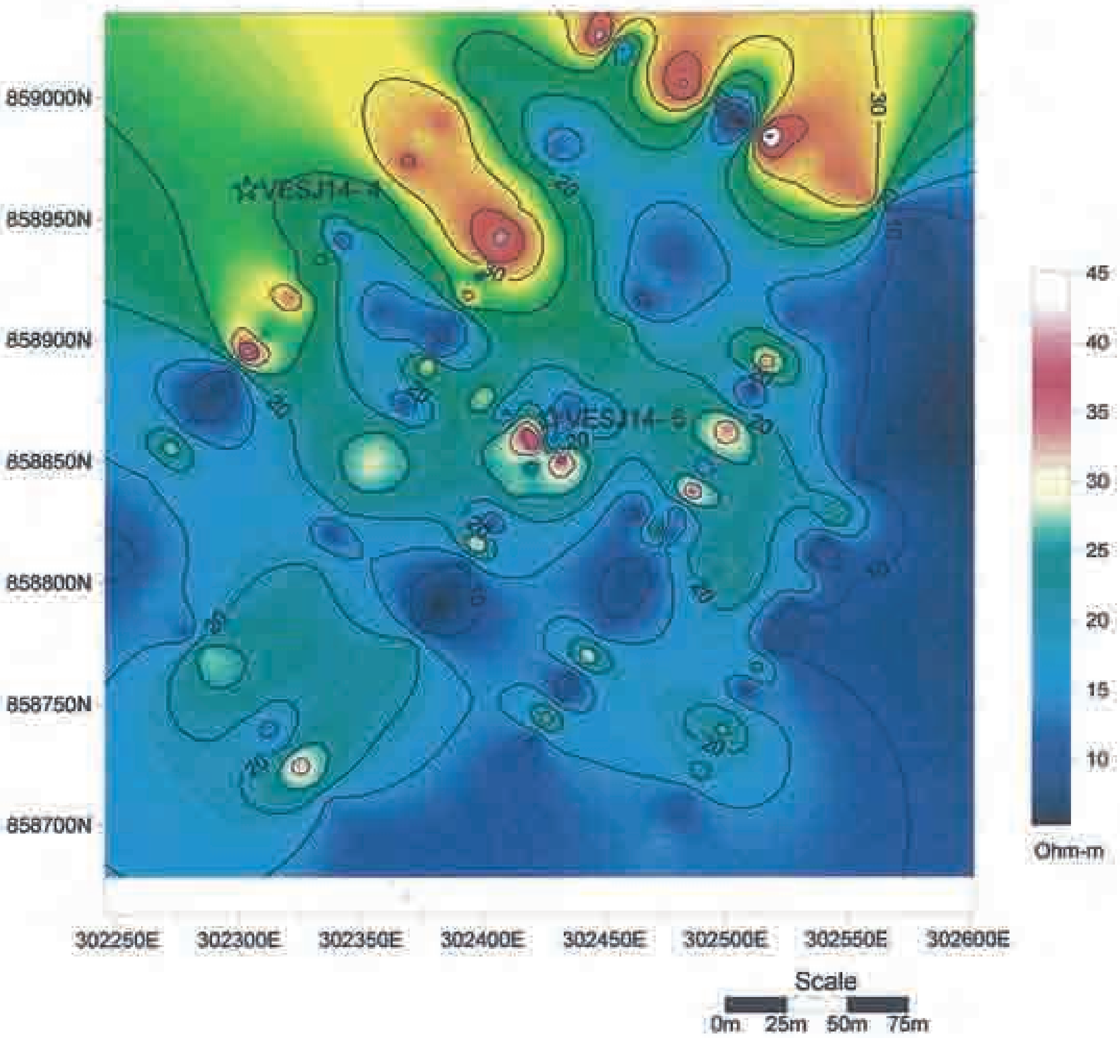


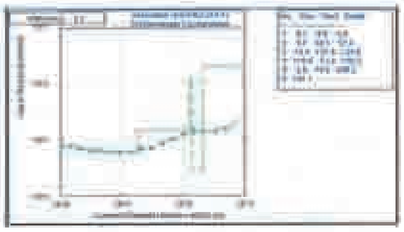
Figure 21b. Apparent resistivity Map, Asendabo-Yedi.



## Figure 21c. Interpreted Layer parameters, Asendabo-Yedi.

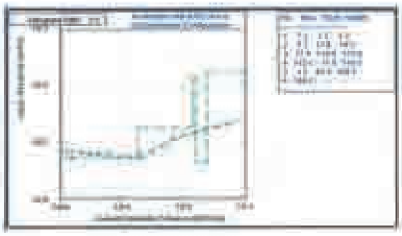
(a) VES- J14-1

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 8.1 | 0.9 | 0.9 | Top soil |
| 2 | 5.7 | 16.5 | 17.4 | clayey soil |
| 3 | 14.4 | 107.4 | 124.8 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 110.5 | 13.4 | 138.2 | Moderately fractured rock |
| 5 | 2.8 | 70 | 208.2 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 191.1 | | | Moderately fractured rock |



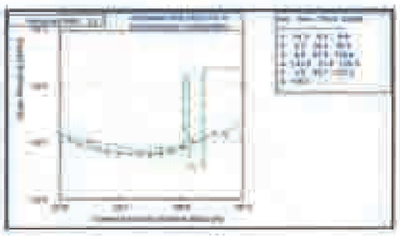
(b) VES-J14-2

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 7.2 | 1.2 | 1.2 | Top soil |
| 2 | 3.1 | 17 | 18.2 | clayey soil |
| 3 | 17.4 | 119.5 | 137.7 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 142.1 | 17.5 | 155.2 | Moderately fractured rock |
| 5 | 4.1 | 81.5 | 236.7 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 164.9 | | | Moderately fractured rock |



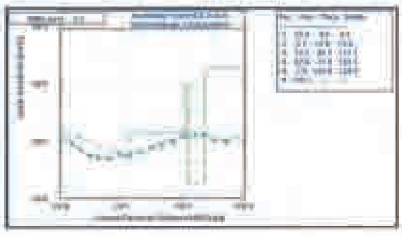
(c) VES-J14-3

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 14.3 | 0.8 | 0.8 | Top soil |
| 2 | 6.3 | 36 | 36.8 | clayey soil |
| 3 | 8 | 67.8 | 104.6 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 143.4 | 21.8 | 126.4 | Moderately fractured rock |
| 5 | 3.3 | 95.7 | 222.1 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 196.1 | | | Moderately fractured rock |



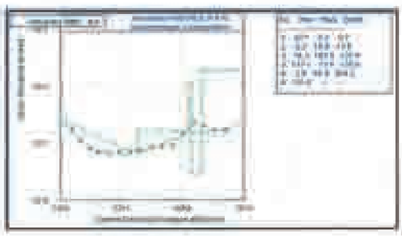
(d) VES-J14-4

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 20.4 | 0.5 | 0.5 | Top soil |
| 2 | 5.1 | 12.9 | 13.4 | clayey soil |
| 3 | 14.1 | 97.7 | 111.1 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 92.8 | 11 | 122.1 | Moderately fractured rock |
| 5 | 1.9 | 101.9 | 224 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 186.1 | | | Moderately fractured rock |



(e) VES-J14-5

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 33.7 | 0.7 | 0.7 | Top soil |
| 2 | 6.3 | 16.9 | 17.6 | clayey soil |
| 3 | 10.3 | 104.2 | 121.8 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 117.1 | 13.8 | 135.6 | Moderately fractured rock |
| 5 | 2.9 | 68.8 | 203.4 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 191 | | | Moderately fractured rock |



### 3.3.4 Boneya

The Boneya site is located within a wide meander of Kawa River about one km southwest of the village (Fig 22a) and near the Kawa Bridge on the road to Dedo (Sheki). Basalt forms the dominant lithology of the area being exposed in most sections of the river.

The HRP survey was made with nearly E-W and N-S profiles, and the apparent resistivity map (Fig 22b) shows areas with contrasting resistivity response. Both the western and eastern parts of the site are characterized by high resistivity greater than 50 Ohm-m. The eastern high resistivity zone, in particular has a nearly N-S trend, and possibly indicate relatively massive parts of the underlying basalt at shallow depth. In contrast the northern and southern parts of the area are underlain by low resistivities below 40 Ohm-m, but at places as low as 25 Ohm-m.

The two low resistivity zones in the north and south are connected by a narrow zone of low resistivity at the centre of the area probably indicating structural control.

The results of the VES interpretation (Fig 22c) indicate the existence of five resistivity layers beneath the surface. The low resistivity values below the topsoil having resistivity values in the range of 14-66 Ohm-m are attributed to highly fractured basalt, the bottom of which may be water bearing. This low resistivity layer has variable thickness, from 15m at VES J15-1 to more than 30m at VES J15-4 and J15-5. Underlying the low resistivities a high resistivity layer of 456 to 1058 Ohm-m is observed, having thickness in the range of 30-62m, and interpreted as slightly weathered to massive basalt. The largest thickness (62m) and resistivity (1058 Ohm-m) of this layer is obtained at VES J15-1 over the N-S trending high resistivity zone interpreted from the HRP data.

Almost all the VES curves show clear descending resistivity branch at depth. This suggests the existence of a low resistivity layer at depth interpreted as the fifth layer, with resistivities varying between 11 and 16 Ohm-m. The thickness of the very low resistivity layer could most be determined due to its large depth extent, but its top is found in the range of 50-77m. This layer forms the deeper aquifer in the area, composed of highly weathered and/or fractured basalt.

**Figure 22a. Location map of VES points and HRP lines, Boneya.**

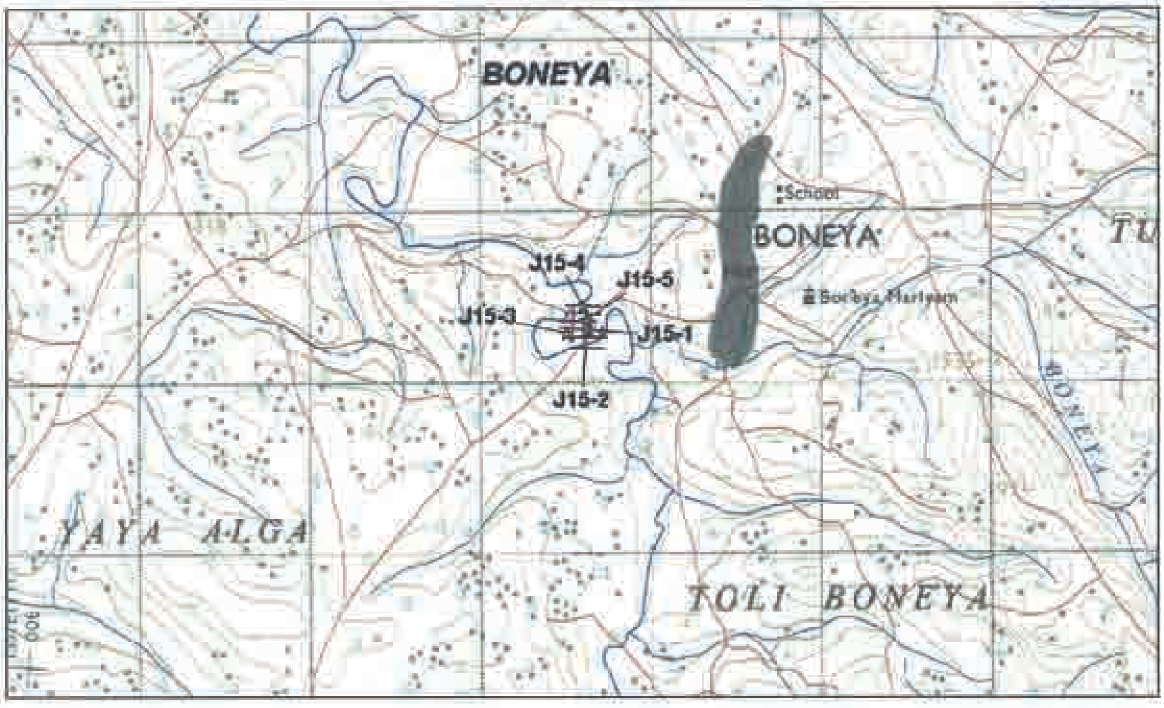
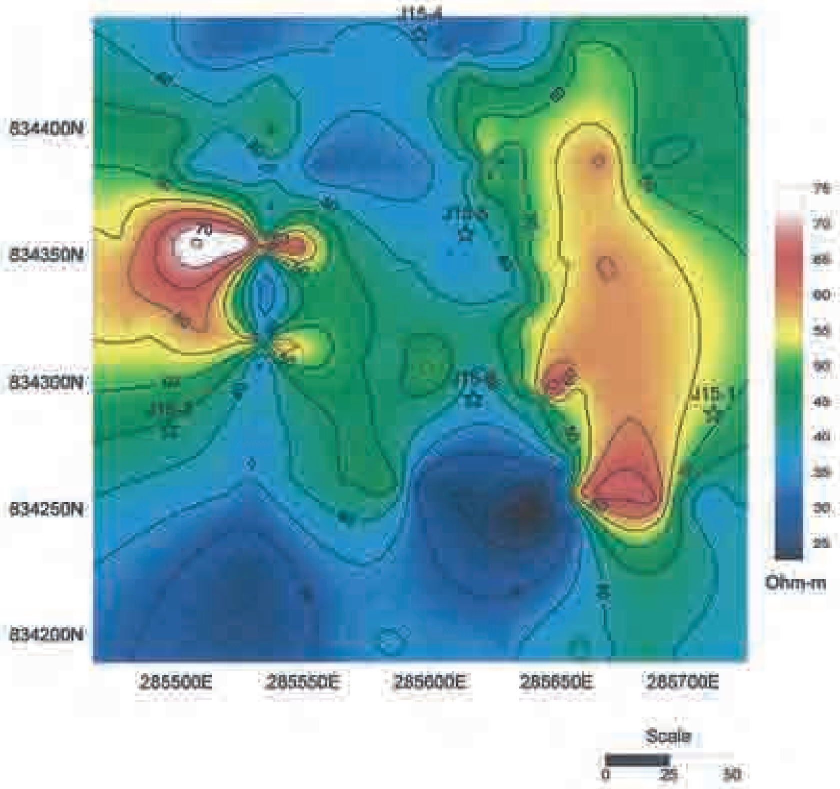
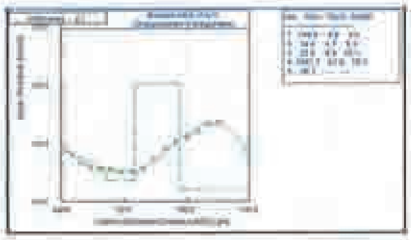



**Figure 22b. Apparent Resistivity Map, Boneya.**

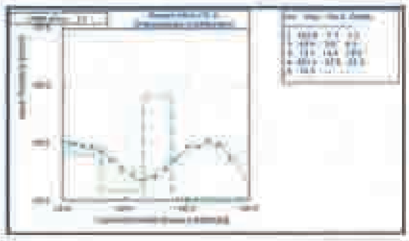


## Figure 22c. Interpreted Layer parameters, Boneya.

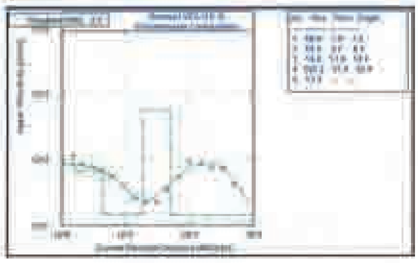
| (a) VES- J15-1 | | | | |
|---|---|---|---|---|
| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
| 1 | 108.9 | 0.6 | 0.6 | Top Soil |
| 2 | 34.6 | 4.7 | 5.3 | Highly weathered basalt |
| 3 | 22.6 | 9.8 | 15.1 | Highly weathered and/or fractured basalt -probably water bearing |
| 4 | 1037.7 | 61.6 | 76.7 | Slightly weathered to massive basalt |
| 5 | 16.3 | | | Highly weathered and/or fractured basalt -probably water bearing |



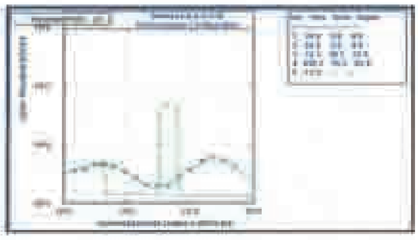
| (b) VES-J15-2 | | | | |
|---|---|---|---|---|
| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
| 1 | 102.9 | 1.3 | 1.3 | Top Soil |
| 2 | 62.6 | 3 | 4.3 | Highly fractured basalt |
| 3 | 13.1 | 15.4 | 19.7 | Highly weathered and/or fractured basalt -probably water bearing |
| 4 | 601.1 | 37.6 | 57.3 | Slightly weathered to massive basalt |
| 5 | 11 | | | Highly weathered and/or fractured basalt -probably water bearing |



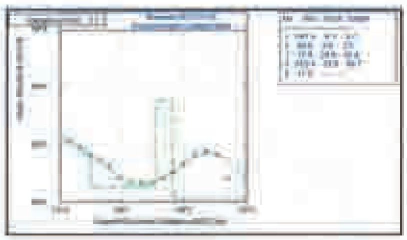
| (c) VES-J15-3 | | | | |
|---|---|---|---|---|
| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
| 1 | 86.8 | 1.6 | 1.6 | Top Soil |
| 2 | 66.4 | 2.7 | 4.3 | Highly fractured basalt |
| 3 | 14.6 | 13.8 | 18.1 | Highly weathered and/or fractured basalt -probably water bearing |
| 4 | 565.2 | 31.4 | 49.5 | Slightly weathered to massive basalt |
| 5 | 13.9 | | | Highly weathered and/or fractured basalt -probably water bearing |



| (d) VES-J15-4 | | | | |
|---|---|---|---|---|
| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
| 1 | 26.6 | 0.6 | 0.6 | Top Soil |
| 2 | 54.2 | 3.9 | 4.5 | Highly fractured basalt |
| 3 | 14.3 | 28.1 | 32.6 | Highly weathered and/or fractured basalt -probably water bearing |
| 4 | 456.7 | 30.2 | 62.8 | Slightly weathered to massive basalt |
| 5 | 13.3 | | | Highly weathered and/or fractured basalt -probably water bearing |



| (e) VES-J15-5 | | | | |
|---|---|---|---|---|
| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
| 1 | 157.9 | 0.7 | 0.7 | Top Soil |
| 2 | 59.8 | 2.4 | 3.1 | Highly fractured basalt |
| 3 | 17.9 | 29.8 | 32.9 | Highly weathered and/or fractured basalt -probably water bearing |
| 4 | 552.4 | 32.9 | 65.8 | Slightly weathered to massive basalt |
| 5 | 11 | | | Highly weathered and/or fractured basalt -probably water bearing |



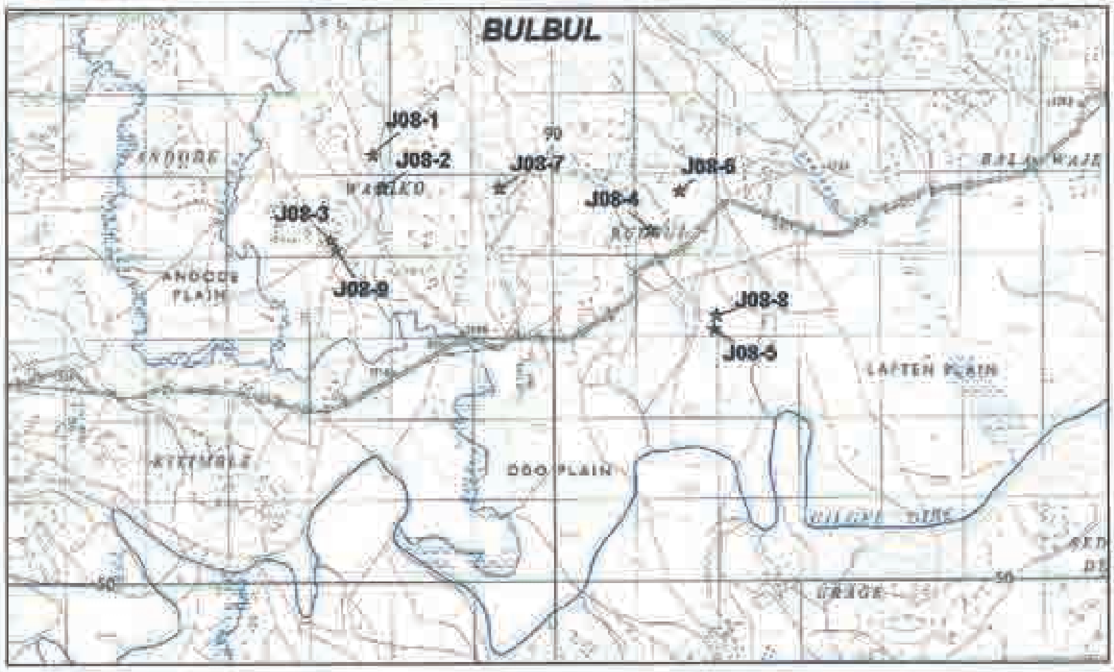
### 3.3.5 Bulbul

At total of nine sounding were measured in Bulbul area (Fig 23a) widely distributed at a distance of 1-2 km between the soundings, though VES J08-3 and J08-9, and VES J08-5 and J08-8 were close together being within 200m distance from each other.

The interpreted VES results (Fig 23b) show that the subsurface is constituted by six resistivity layers. With the exception of the bottom layer, and at place the top layer (e.g. VES J08-3 & J08-4) the other layers are mainly characterized by very low resistivities of 2 to 18 Ohm-m, which is probably associated with highly weathered rock and/or pyroclastics saturated with water. At certain locations, (e.g. VES J08-1 and J08-3) there is an interbed of moderately to highly weathered rock within the low resistivity material, separating it into two zones. In such cases, the lower most layer is characterized by even lower resistivity values of 2 to 3 Ohm-m, which probably indicates saturation with saline water.

VES J08-2, J08-5 and J08-8 have almost uniform and homogeneous resistivity distribution, generally below 10 Ohm-m indicating, uniform subsurface condition. The total thickness of the low resistivity material, overlying the rather moderately fractured rock represented by resistivity range of 93-336 ohm-m, vary between 115m and 202 m.

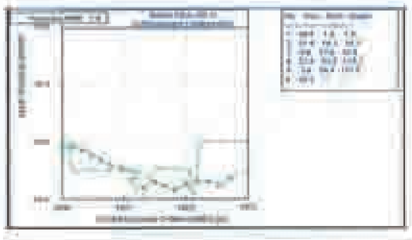
**Figure 23a. Location map of VES points, Bulbul.**



## Figure 23b. Interpreted Layer parameters, Bulbul.

(a) VES- J08-1

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 88.5 | 1.4 | 1.4 | Top soil |
| 2 | 31.4 | 14.3 | 15.7 | Gravelly clay |
| 3 | 6.8 | 17 | 32.7 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 33.3 | 82.5 | 115.2 | Highly to moderately weathered rock |
| 5 | 3.4 | 56.4 | 171.6 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 98.5 | | | Moderately fractured rock |

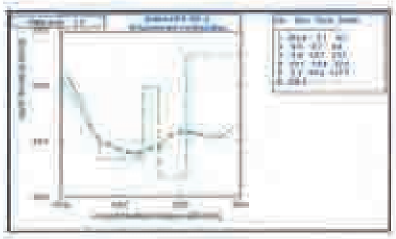


(b) VES-J08-2

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 8.6 | 1 | 1 | Top soil |
| 2 | 10 | 11.1 | 12.1 | Clayey soil or highly weathered rock |
| 3 | 6.7 | 9.4 | 21.5 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 19.7 | 45.2 | 66.7 | Ditto |
| 5 | 2.4 | 72.1 | 138.8 | Ditto |
| 6 | 93.1 | | | Moderately fractured rock |

(c) VES-J08-3

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 302.6 | 0.7 | 0.7 | Top soil |
| 2 | 9.5 | 3.7 | 4.4 | Clayey soil |
| 3 | 4.9 | 18.7 | 23.1 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 93.1 | 19.4 | 42.5 | Highly to moderately weathered rock |
| 5 | 2.3 | 85.2 | 127.7 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 336.8 | | | Moderately fractured rock |

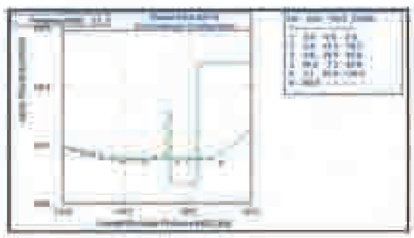


(d) VES-J08-4

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 249.9 | 1.1 | 1.1 | Top soil |
| 2 | 9.2 | 4.3 | 5.4 | Clayey soil |
| 3 | 3.8 | 29.5 | 34.9 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 30.8 | 8.3 | 43.2 | Highly to moderately weathered rock |
| 5 | 1.7 | 105.7 | 148.9 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 298.7 | | | Moderately fractured rock |

(e) VES-J08-5

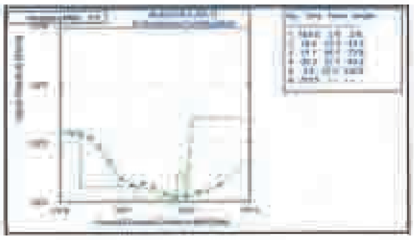
| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 9.8 | 0.8 | 0.8 | Top soil |
| 2 | 5.5 | 15.5 | 16.3 | Clayey soil |
| 3 | 5.6 | 29.4 | 45.7 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 34.8 | 7.2 | 52.9 | Highly to moderately weathered rock |
| 5 | 2.1 | 85 | 137.9 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 248.5 | | | Moderately fractured rock |



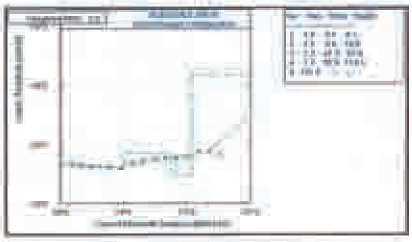
## Figure 23b. Interpreted Layer parameters, Bulbul (cont'd).

| (f) VES-J08-6 | | | | |
|---|---|---|---|---|
| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
| 1 | 103.6 | 2.3 | 2.3 | Top soil |
| 2 | 18.3 | 5.9 | 8.2 | Gravelly clay |
| 3 | 5.2 | 33.6 | 41.8 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 13.6 | 54 | 95.8 | Ditto |
| 5 | 1.7 | 105.7 | 201.5 | Ditto |
| 6 | 120.9 | | | Moderately fractured rock |

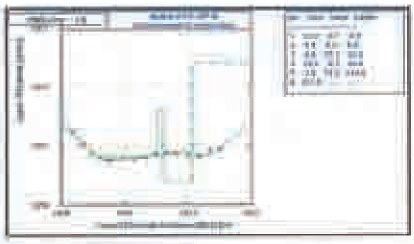
| (g) VES-J08-7 | | | | |
|---|---|---|---|---|
| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
| 1 | 163 | 2 | 2 | Top soil |
| 2 | 18.2 | 13.3 | 15.3 | Gravelly clay |
| 3 | 11.1 | 56.7 | 72 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 30.2 | 21.1 | 93.1 | Highly to moderately weathered rock |
| 5 | 2.8 | 27.3 | 120.4 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 235.5 | | | Moderately fractured rock |



| (h) VES-J08-8 | | | | |
|---|---|---|---|---|
| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
| 1 | 5 | 0.7 | 0.7 | Top soil |
| 2 | 4.1 | 9.9 | 10.6 | Clayey soil |
| 3 | 7.2 | 47.3 | 57.9 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 3.1 | 56.6 | 114.5 | Ditto |
| 5 | 151.5 | | | Moderately fractured rock |



| (i) VES-J08-9 | | | | |
|---|---|---|---|---|
| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
| 1 | 32.2 | 0.7 | 0.7 | Top soil |
| 2 | 5.4 | 4.3 | 5 | Clayey soil |
| 3 | 6.6 | 27.2 | 32.2 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 39.8 | 8.2 | 40.4 | Highly to moderately weathered rock |
| 5 | 2.9 | 74.2 | 114.6 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 231.5 | | | Moderately fractured rock |

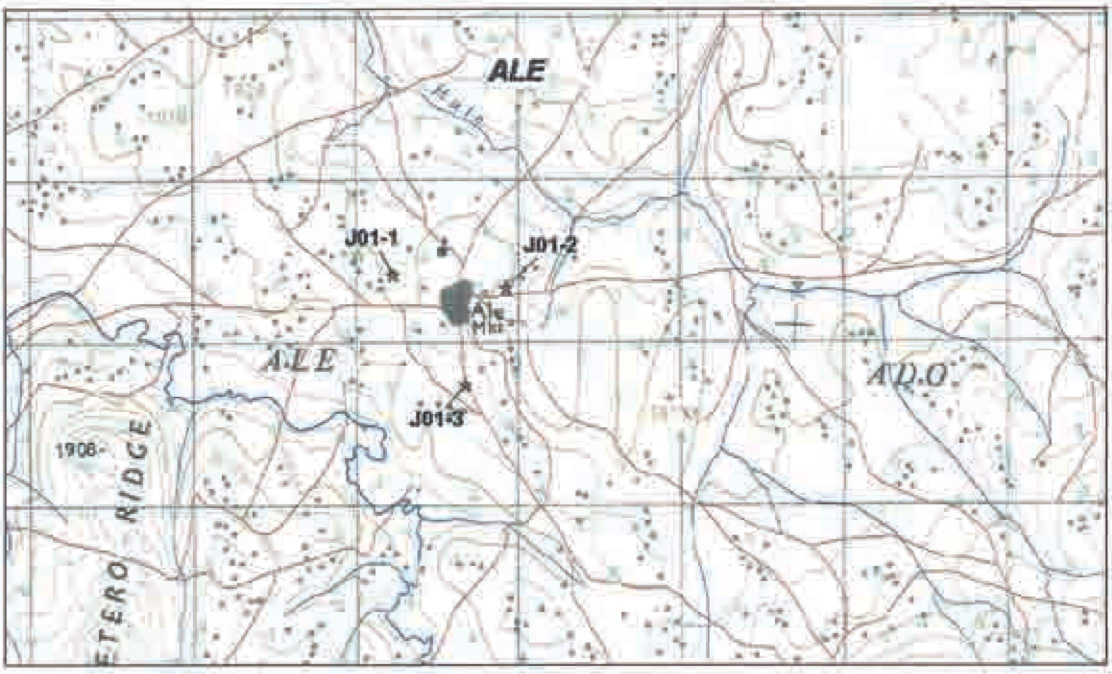


### 3.3.6 Ale

The three sounding conducted in Ale area generally show 5 to 6 resistivity layers (Fig 24a, b). The topsoil is characterized by high resistivities in the range of 72-190 Ohm-m, which is 1-2 m thick. It is underlain by a sequence of low resistivity material (3-16 Ohm-m) up to 77-87 m depth interpreted as either highly weathered rock and/or pyroclastics saturated with water.The presence of a thin layer (6-15m) of high resistivity material interbeded within the low resistivity and interpreted as moderately fractured rock is evident from the nature of the sounding at VES J01-3.

The substratum in the area has a relatively high resistivity of about 163-166 Ohm-m, and may be correlated to moderately weathered rock found at depth.

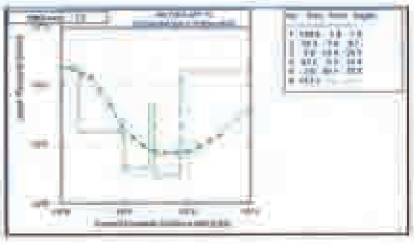
**Figure 24a. Location map of VES points, Ale.**



## Figure 24b. Interpreted Layer parameters, Ale.

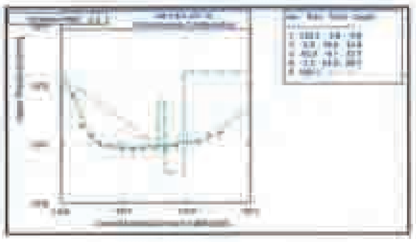
(a) VES- J01-1

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 190.8 | 1.9 | 1.9 | Top soil |
| 2 | 16.2 | 7.8 | 9.7 | Silty soil |
| 3 | 3.9 | 14.4 | 24.1 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 43.2 | 6.3 | 30.4 | Highly to moderately fractured rock |
| 5 | 9 | 46.1 | 76.5 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 163.2 | | | Moderately fractured rock |



(b) VES-J01-2

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 239.2 | 0.6 | 0.6 | Top soil |
| 2 | 8.8 | 34 | 34.6 | Clayey soil, highly weathered rock and/or pyroclastics, probably saturated |
| 3 | 55.4 | 8.1 | 42.7 | Highly to moderately fractured rock |
| 4 | 3.3 | 44 | 86.7 | Highly weathered rock and/or pyroclastics, probably saturated |
| 5 | 106.1 | | | Moderately fractured rock |



(c) VES-J01-3

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 71.7 | 2.4 | 2.4 | Top soil |
| 2 | 5.3 | 8.1 | 10.3 | clayey soil |
| 3 | 115.1 | 15.4 | 25.9 | Moderately fractured rock |
| 4 | 2.7 | 55.9 | 81.8 | Highly weathered rock and/or pyroclastics, probably saturated |
| 5 | 164.5 | | | Moderately fractured rock |

### 3.3.7 Natri

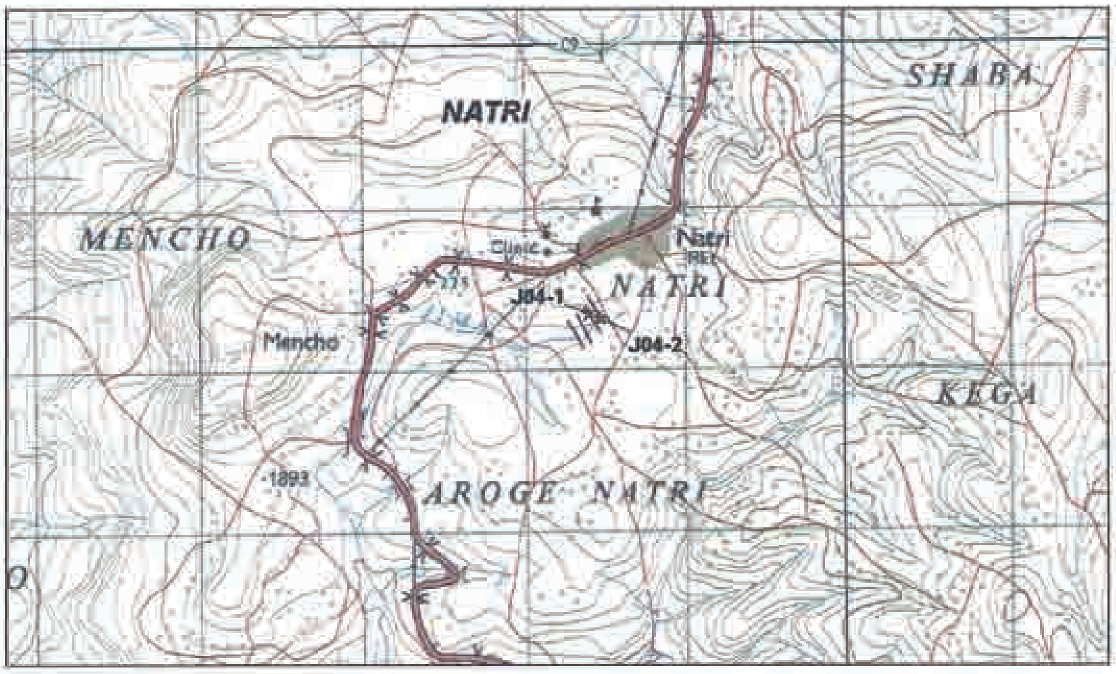
The geophysical survey at Natri consisted of four HRP lines and two VES centering on the existing borehole (Fig 25a).

The apparent resistivity map (Fig 25b) delineated two resistivity zones. The western part of the area is underlain by moderately high resistivity above 40 Ohm-m, and the eastern half is characterized by low resistivity generally below 40 Ohm-m, which becomes even lower to about 20 Ohm-m towards the central eastern part. The former is interpreted as a response of rocks with relatively low weathering and/or fracturing at shallower depth, whereas the latter is response of highly weathered/fractured zones. The existing borehole is located within the latter zone.

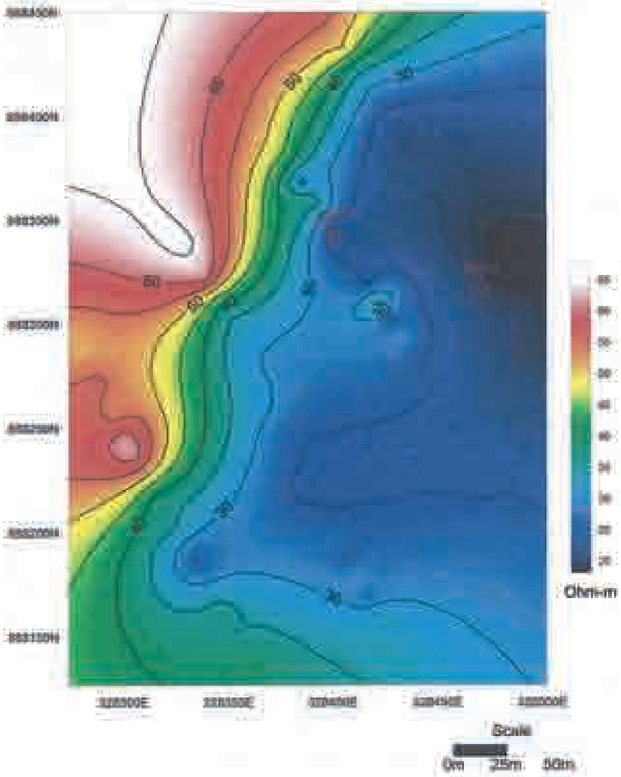
The two sounding were also measured within the low resistivity zone, and both show low resistivity material of about 29m thickness below the surface, which in turn is underlain by high resistivity layer of 157-208 Ohm-m and 30-40m thickness related to moderately fractured rock.

The bottom layer is also characterized by low resistivities of 11-13 Ohm-m, which is interpreted as consisting of a probably water bearing highly weathered rock.

**Figure 25a. Location map of VES points and HRP lines, Natri.**

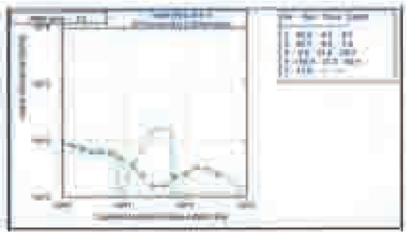


## Figure 25b. Apparent Resistivity Map, Natri.




## Figure 25c. Interpreted Layer parameters, Natri.

| (a) VES- J04-1 | | | | |
|---|---|---|---|---|
| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
| 1 | 95.5 | 0.7 | 0.7 | Top soil |
| 2 | 58.1 | 6.9 | 7.6 | Clayey soil or highly weathered rock |
| 3 | 9 | 21.6 | 29.2 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 156.9 | 31.2 | 68.4 | Moderately fractured rock |
| 5 | 11.6 | | | Highly weathered rock and/or pyroclastics, probably saturated |



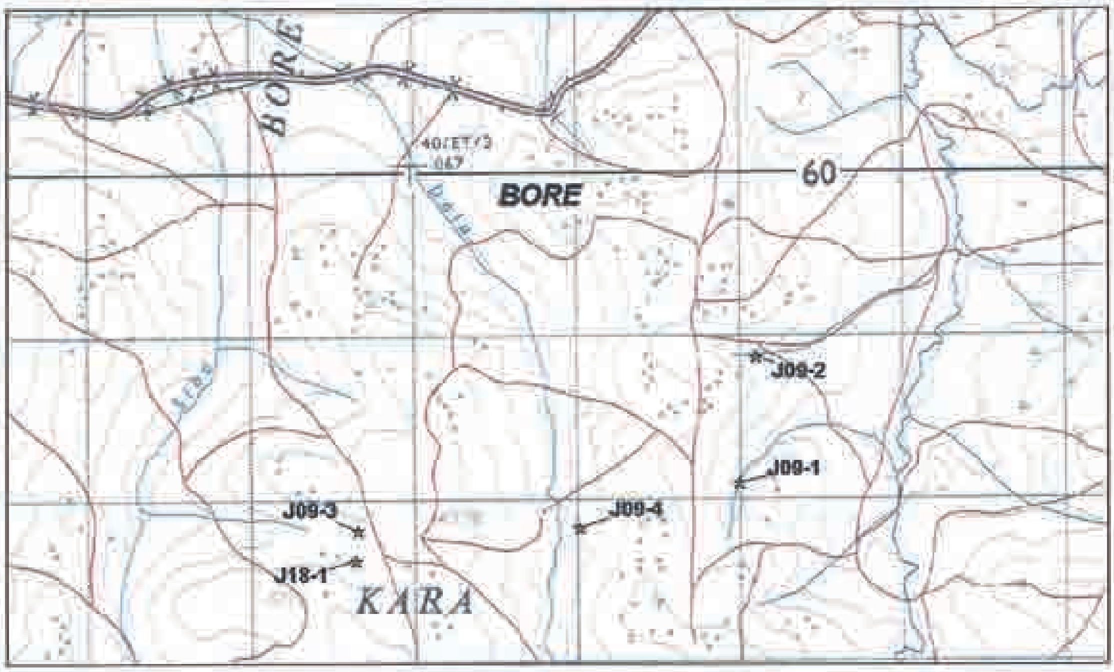
| (b) VES-J04-2 | | | | |
|---|---|---|---|---|
| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
| 1 | 123.4 | 0.6 | 0.6 | Top soil |
| 2 | 39.3 | 7.2 | 7.8 | Clayey soil or highly weathered rock |
| 3 | 8.5 | 20.7 | 28.5 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 208.4 | 40.5 | 69 | Moderately fractured rock |
| 5 | 11 | | | Highly weathered rock and/or pyroclastics, probably saturated |

### 3.3.8 Bore

Four soundings were conducted at Bore, which are fairly identical with similar interpretation. (Fig 26a,b). The curves represent a six-layer earth model. Below the topsoil, the underlying four layers are characterized by low resistivities ranging between 1.2 to 12 Ohm-m, having a combined thickness in the range of 194-235m. This low resistivity layer is interpreted as a highly weathered rock and/or pyroclastics saturated with water, and there could be also sections altered to clay. The very low resistivities represented by 1-2 Ohm-m and found in the deepest part below 73 to 102 m probably suggest saturation with saline water.

A moderately high resistivity layer in the order of 90 Ohm-m forms the substratum in the area, suggesting its moderately fractured nature.

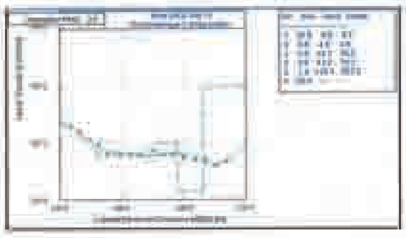
**Figure 26a. Location map of VES points, Bore.**



## Figure 26b. Interpreted Layer parameters, Bore.

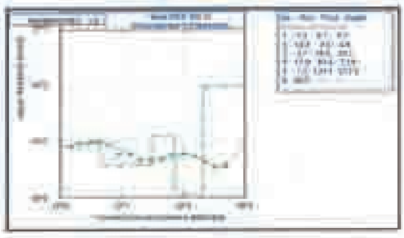
(a) VES- J09-1

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 25.8 | 0.9 | 0.9 | Top soil |
| 2 | 6.9 | 2.9 | 3.8 | Clayey soil or highly weathered rock |
| 3 | 5.8 | 32.1 | 35.9 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 9.8 | 43.2 | 79.1 | Ditto |
| 5 | 1.4 | 124.1 | 203.2 | Ditto |
| 6 | 89.9 | | | Moderately fractured rock |



(b) VES-J09-2

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 7.2 | 0.7 | 0.7 | Top soil |
| 2 | 10.4 | 3.9 | 4.6 | Clayey soil or highly weathered rock |
| 3 | 3.7 | 25.5 | 30.1 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 12 | 43.4 | 73.5 | Ditto |
| 5 | 1.2 | 139.1 | 212.6 | Ditto |
| 6 | 90.5 | | | Moderately fractured rock |

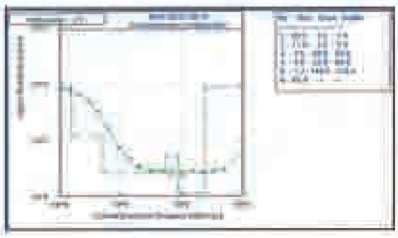


(c) VES-J09-3

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 156.6 | 0.8 | 0.8 | Top soil |
| 2 | 11.2 | 8 | 8.8 | Clayey soil or highly weathered rock |
| 3 | 7.5 | 38.1 | 46.9 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 11.1 | 55.1 | 102 | Ditto |
| 5 | 2 | 91.6 | 193.6 | Ditto |
| | 90.5 | | | Moderately fractured rock |

(d) VES-J09-4

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 83.5 | 1.5 | 1.5 | Top soil |
| 2 | 11.8 | 3.5 | 5 | Clayey soil or highly weathered rock |
| 3 | 2.6 | 48.8 | 53.8 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 5.5 | 32.9 | 86.7 | Ditto |
| | 1.2 | 148.6 | 235.3 | Ditto |
| | 88.9 | | | Moderately fractured rock |



### 3.3.9 Dobi

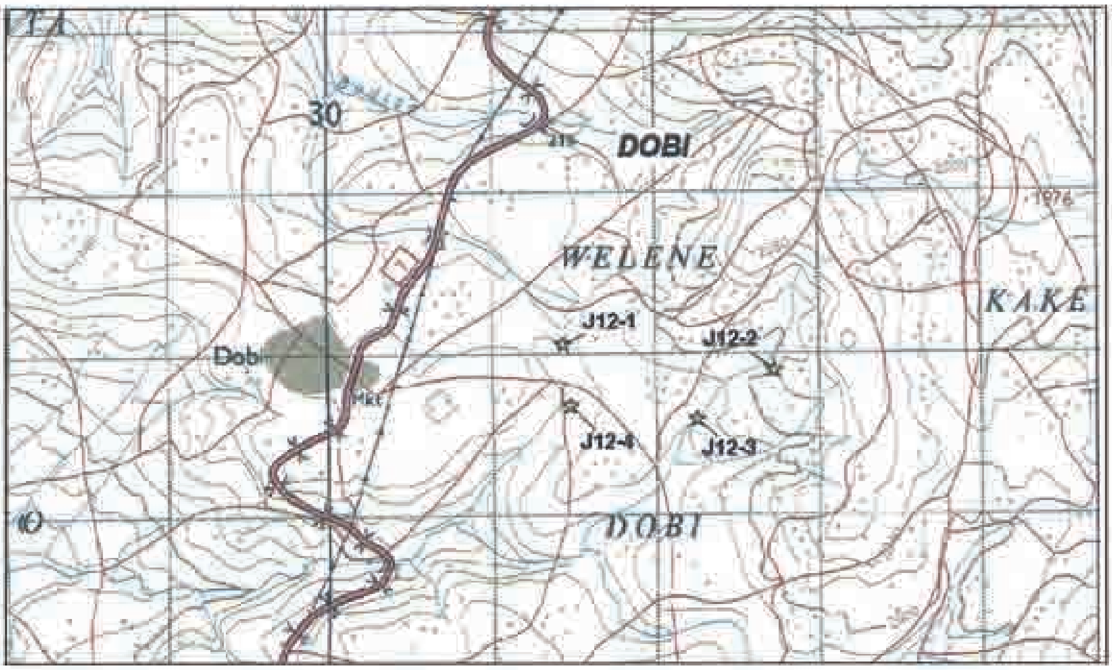
The four soundings conducted in Dobi were located at a distance of 1-2 km east of the village. The distance between the soundings also varied between 400-1300m. (Fig 27a).

The interpreted layer parameters (Fig 27b) show 5 to 6 resistivity layers underlying the area. The topmost 2 layers are characterized by relatively higher resistivities of 15-20 Ohm-m possibly indicating gravelly clay material of up to 4 m thickness.

These are followed by a low resistivity layer of 6-37 Ohm-m interpreted as highly weathered rock, which is probably water bearing and having thickness varying between 11 to 33m. The largest thickness of about 30-33m is found beneath VES J12-1 & J12-4.

The fourth layer is characterized by high resistivity value in the range of 168-254 Ohm-m, with thickness varying between 32-59m, and is interpreted as moderately to slightly fractured rock. Beneath the high resistivity layer, a layer of low resistivity (9-15 Ohm-m) is observed, which has thickness of about 50m below VES J12-1 and J12-4, and even more below VES J12-2 and J12-3 as it forms the bottom layer here. The low resistivity layer is the main water bearing horizon comprised of highly weathered/fractured rocks. A moderately to slightly fractured rock forming the substratum is detected below 123m only at VES J12-1 and J12-4.

**Figure 27a. Location map of VES points, Dobi.**



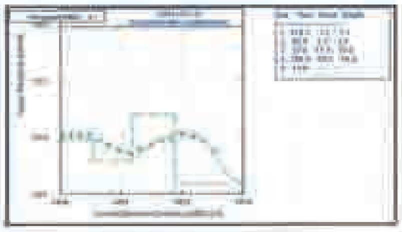
## Figure 27b. Interpreted Layer parameters, Dobi.

(a) VES- J12-1

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 159.8 | 1.3 | 1.3 | Top soil |
| 2 | 14.6 | 2.8 | 4.1 | Clayey soil or highly weathered rock |
| 3 | 6.1 | 29 | 33.1 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 253.7 | 40.5 | 73.6 | Moderately to slightly fractured rock |
| 5 | 10.1 | 49.7 | 123.3 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 300.4 | | | Moderately to slightly fractured rock |

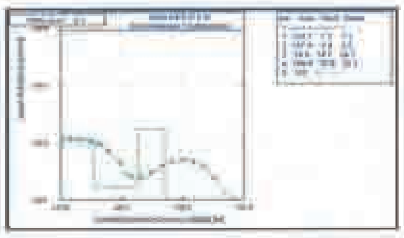
(b) VES-J12-2

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 119.1 | 1.1 | 1.1 | Top soil |
| 2 | 90.8 | 2.3 | 3.4 | Gravelly Clay |
| 3 | 37.4 | 11.5 | 14.9 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 246.5 | 59.3 | 74.2 | Moderately to slightly fractured rock |
| 5 | 14.9 | | | Highly weathered rock and/or pyroclastics, probably saturated |



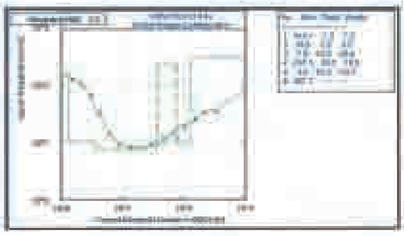
(c) VES-J12-3

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 124.7 | 1.1 | 1.1 | Top soil |
| 2 | 107.9 | 2.4 | 3.5 | Gravelly Clay |
| 3 | 16.6 | 14.7 | 18.2 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 108 | 32 | 50.2 | Moderately to slightly fractured rock |
| 5 | 9.6 | | | Highly weathered rock and/or pyroclastics, probably saturated |



(d) VES-J12-4

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 162.1 | 1.3 | 1.3 | Top soil |
| 2 | 10.5 | 2.2 | 3.5 | Gravelly Clay |
| 3 | 7.6 | 32.9 | 36.4 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 237.5 | 38.1 | 74.5 | Moderately to slightly fractured rock |
| 5 | 9.6 | 52.2 | 126.7 | Highly weathered rock and/or pyroclastics, probably saturated |
| 6 | 297.2 | | | Moderately to slightly fractured rock |



## 3.3.10 Cheka Walaka

The Cheka Walaka site is found about 6 km southeast of Deneda (Fig. 28a) on the northern bank of Yoko River.

The VES conducted at the site reveals four resistivity layers. The top layer has very high resistivity of 1230 Ohm-m, and about 1-4m thickness, probably caused by dry gravelly layer. Below it, a relatively low resistivity layer of 26 Ohm-m, which is about 17m thick is found interpreted as gravelly clay layer.

The third layer has the lowest resistivity of 8.6 Ohm-m, and corresponding thickness of about 54m. It is interpreted as a water bearing highly fractured rock overlying the bottom layer of 312 Ohm-m resistivity related to moderately fractured rock.

**Figure 28a. Location map of VES point, Cheka Walaka.**

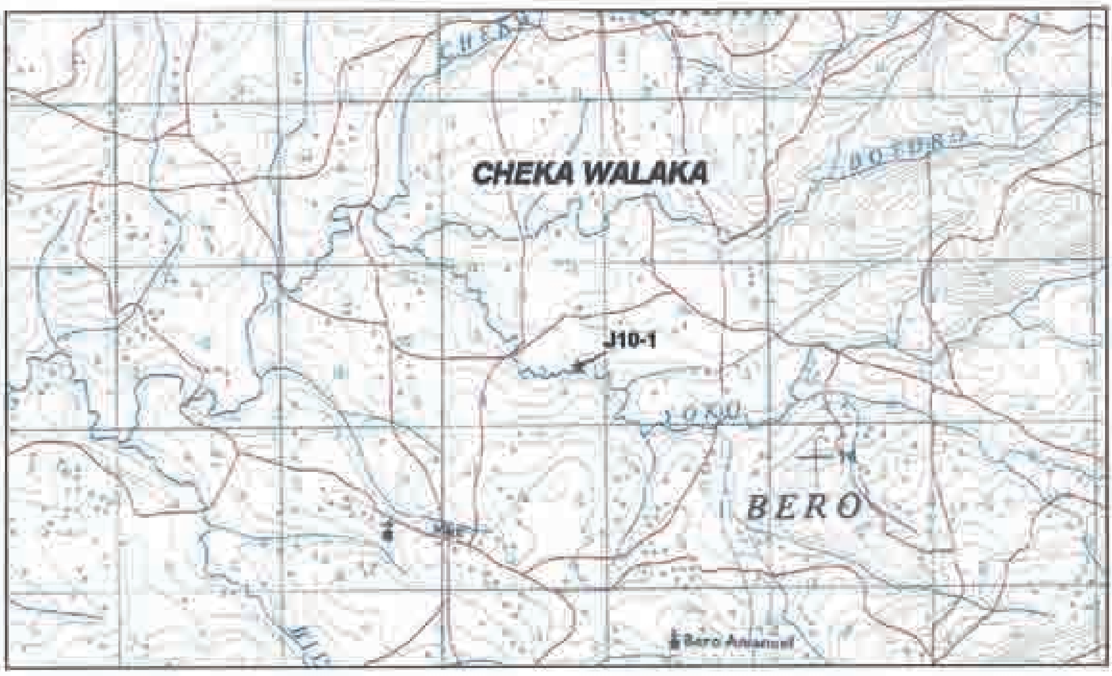



**Figure 28b. Interpreted Layer parameters, Cheka walaka.**

(a) VES-J10-1

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 1229.9 | 1.4 | 1.4 | Top soil |
| 2 | 26.4 | 16.7 | 18.1 | Gravelly clay |
| 3 | 8.6 | 54.1 | 72.2 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 311.6 | | | Moderately fractured rock |

## 3.3.11 Gudeta Bula

Two soundings were measured at Gudeta Bula, which show that the subsurface is underlain by six resistivity layers (Fig 29a,b). The topsoil is represented by very high resistivity of 82-1394 Ohm-m, which is less than 2m thick, and the underlying layers are characterized by low to very low resistivities composed of highly weathered rock and/or pyroclastics saturated with water.

The alternation of low and very low resistivity along the section probably indicate either intercalation of different lithologies or variation in the quality of water. Together the low resistivity layers have thickness varying between 219 and 266 m, and they are underlain at depth by moderately fractured rock characterized by resistivity of 95 -100 Ohm-m and forming the substratum in the area. In particular, the very low resistivity horizons, with less than 2 Ohm-m resistivity found at depth above the bedrock may be attributed to saturation with saline water.

**Figure 29a. Location map of VES points, Gudeta Bula.**

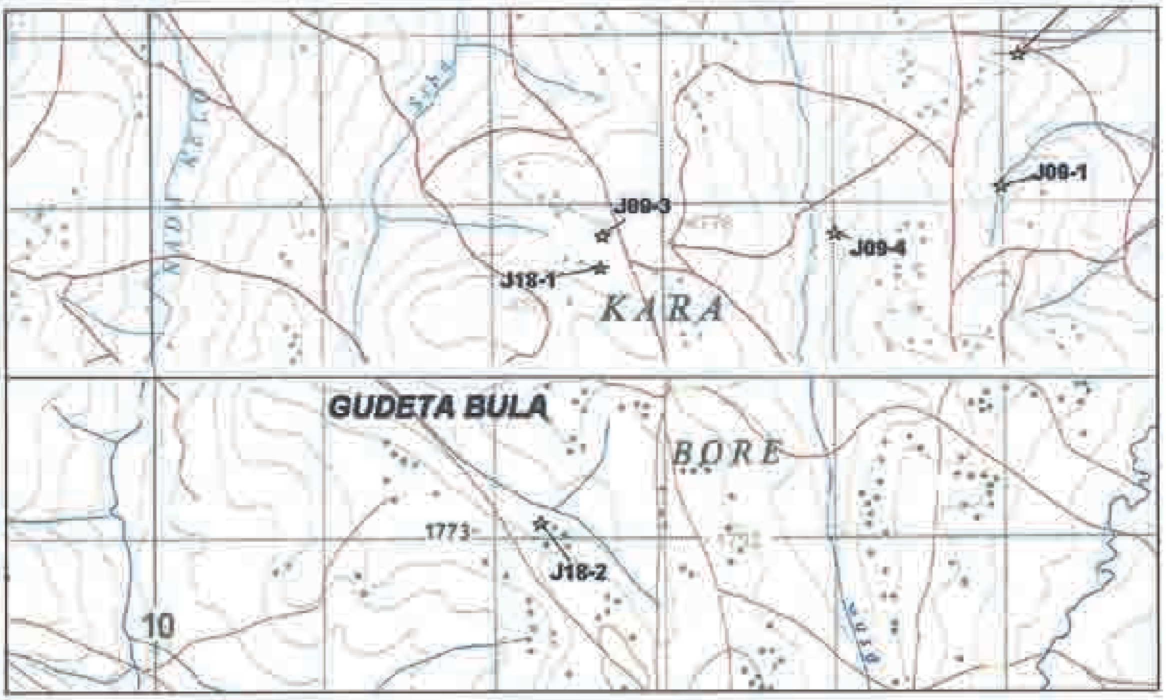
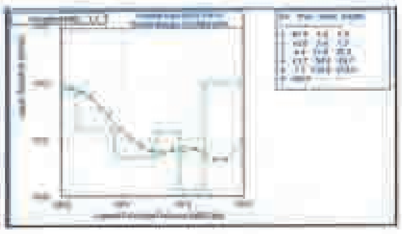


**Figure 29b. Interpreted Layer parameters, Gudeta Bula.**

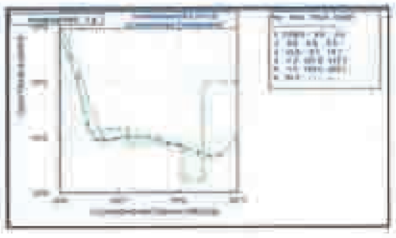
(a) VES- J18-1

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 81.9 | 1.8 | 1.8 | Top soil |
| 2 | 15 | 5.5 | 7.3 | Clayey soil or highly weathered rock |
| 3 | 4.9 | 27.9 | 35.2 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 13.7 | 50.5 | 85.7 | Ditto |
| 5 | 1.3 | 132.8 | 218.5 | Ditto |
| 6 | 100 | | | Moderately fractured rock |



(b) VES-J18-2

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 1394 | 0.5 | 0.5 | Top soil |
| 2 | 8 | 5 | 5.5 | Clayey soil or highly weathered rock |
| 3 | 14 | 8.7 | 14.2 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 7.3 | 101.5 | 115.7 | Ditto |
| 5 | 1.7 | 150.5 | 266.2 | Ditto |
| 6 | 94.9 | | | Moderately fractured rock |



### 3.3.12 Waktola

The two soundings carried out at the site show six to seven resistivity layers. The subsurface is underlain by alternating low and relatively very low resistivities down to about 200m depth. The relatively high resistivity layers (14-21 Ohm-m) towards the top may be interpreted as gravelly clay, whereas the low resistivities correspond to highly weathered rock and/or pyroclastics.

A very low resistivity, layer of 1.8-2.0 Ohm-m is observed below 100-110m depth, having large thickness of 90-96m. Both the low and very low resistivity layers are probably saturated with water, but the latter appears to be saturated with saline groundwater.

**Figure 30a. Location map of VES points, Waktola.**

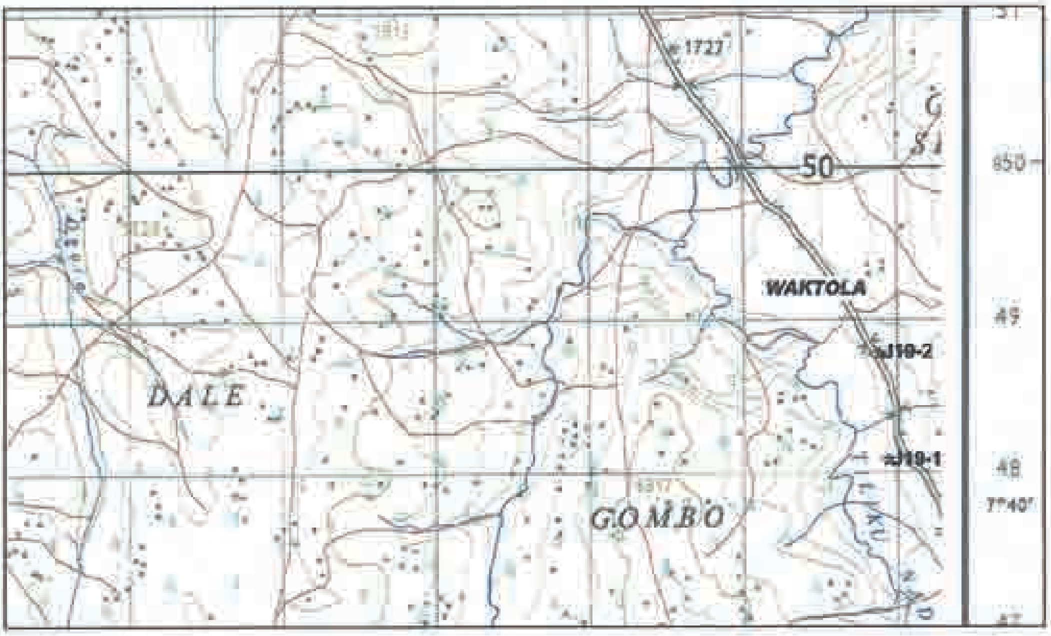
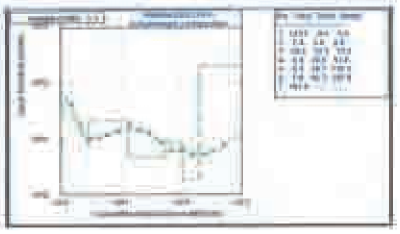


**Figure 30b. Interpreted Layer parameters, Waktola.**

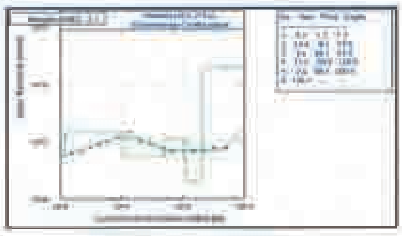
(a) VES-J19-1

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 133.7 | 0.5 | 0.5 | Top soil |
| 2 | 7.4 | 2.4 | 2.9 | Clayey soil |
| 3 | 20.6 | 10.3 | 13.2 | Gravelly clay |
| 4 | 4.6 | 39.6 | 52.8 | Highly weathered rock and/or pyroclastics, probably saturated |
| 5 | 8.5 | 48.7 | 101.5 | Ditto |
| 6 | 1.8 | 96.3 | 197.8 | Ditto |
| 7 | 191.4 | | | Moderately fractured rock |



(b) VES-J19-2

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 5.2 | 1.2 | 1.2 | Top soil |
| 2 | 14.4 | 9.7 | 10.9 | Gravelly clay |
| 3 | 5.6 | 40.1 | 51 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 11.1 | 59 | 110 | Ditto |
| 5 | 2 | 90.5 | 200.5 | Ditto |
| 6 | 190.7 | | | Moderately fractured rock |



## 3.3.13 Toli Sebeta

Only one VES was measured to Toli Sebeta, which shows 4 layer earth (Fig 31a & 31b). The top layer with high resistivity of 191 Ohm-m and less than a meter in thickness represents the topsoil. Underlying the topsoil, a low resistivity layer of 12 Ohm-m, having about 6.5m thickness is observed, which may be attributed to clays soil. The third layer has very low resistivity of 4.2 Ohm-m, and has large depth extent being about 82m thick. This layer may be related to saturated loose sediments and/or pyroclastics.

The bottom layer has high resistivity of about 195 Ohm-m indicating its moderately fractured nature.

**Figure 31a. Location map of VES point, Toli, Sebeta.**

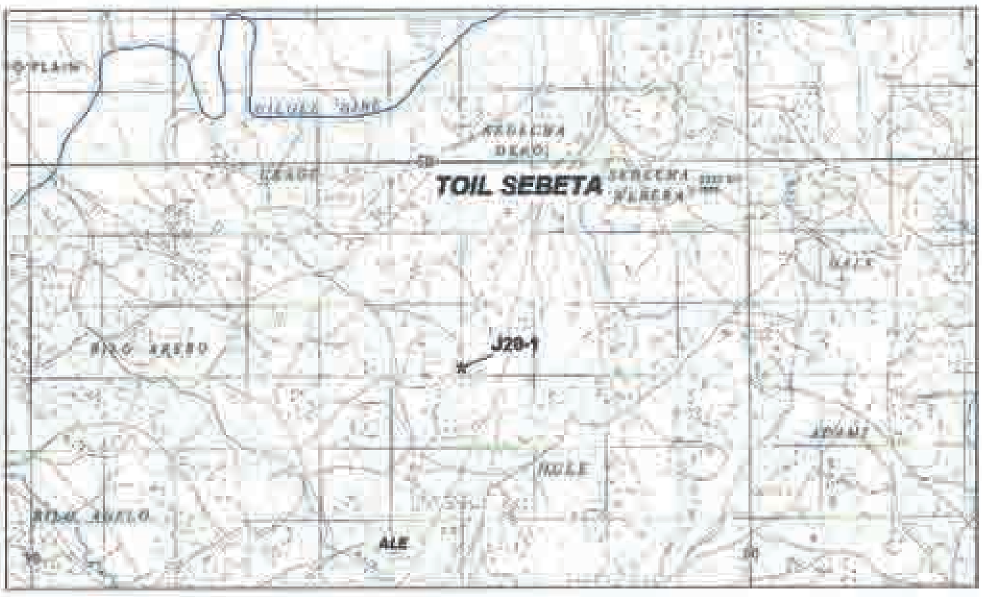
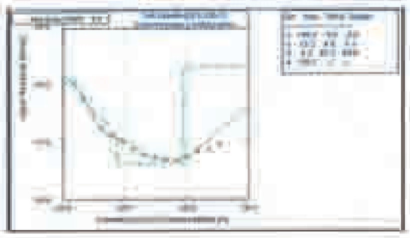


**Figure 31b. Interpreted Layer parameters, Toli Sebeta.**

(a) VES-J20-1

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 190.9 | 0.8 | 0.8 | Top soil |
| 2 | 12.3 | 6.5 | 7.3 | clayey soil |
| 3 | 4.2 | 82.3 | 89.6 | Fine grained alluvium and/or pyroclastics, probably saturated |
| 4 | 195.2 | | | Moderately fractured rock |

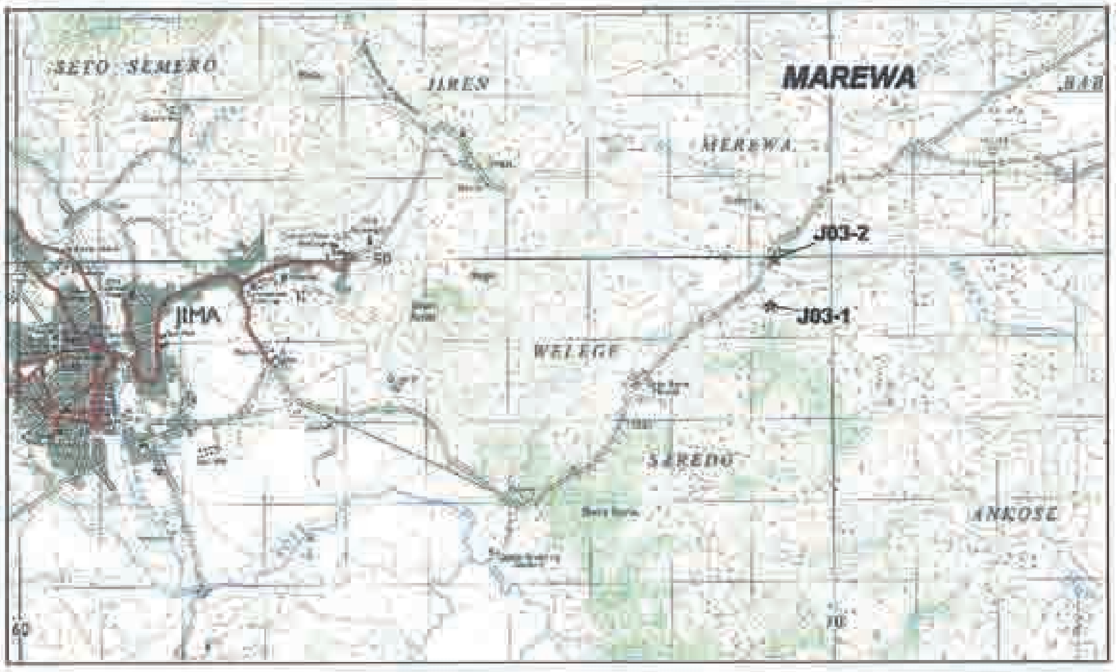


## 3.3.14 Marewa

The two soundings at Marewa were conducted in areas of different geologic setting. The first sounding, VES J03-1, was measured in a foothill region, where depth to rock is expected to be shallow, and the second sounding, VES J03-2, was measured in a wide plain occupying the lowest position in the flood plain of Merwa River. Here thick alluvium may be present (Fig 32a). The interpreted layer parameters of the soundings are given in Figure 23b. The result of the first sounding show low resistivity layers up to 23m depth, underlain by high resistivity layer of 137 Ohm-m, interpreted as moderately fractured rock of about 22m thickness, which is again underlain by low resistivity material (16 Ohm-m). Both the upper low layer (up to 23m) and the lower resistivity layer (below 44m) are presumed to constitute the water bearing formation in the area which may be composed of highly weathered rock and/or pyroclastics.

The interpretation of the second sounding shows about 100m of low resistivity material, characterized by 6-8 Ohm-m overlying a moderately weathered rock. The low resistivity material may be attributed to either saturated fine grained sediments and/or pyroclastics.

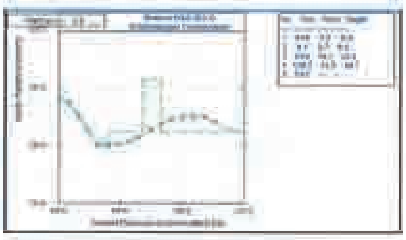
**Figure 32a. Location map of VES points, Marewa.**



## Figure 32b. Interpreted Layer parameters, Marewa.

(a) VES- J03-1

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 94.8 | 0.8 | 0.8 | Top soil |
| 2 | 8.4 | 5.7 | 6.5 | clayey soil |
| 3 | 16.9 | 16.1 | 22.6 | Highly weathered rock and/or pyroclastics, probably saturated |
| 4 | 136.7 | 21.5 | 44.1 | Moderately fractured rock |
| 5 | 16.7 | | | Highly weathered rock and/or pyroclastics, probably saturated |



(b) VES-J03-2

| Layer Number | Resistivity(Ohm-m) | Thickness(m) | Depth(m) | Inferred formation |
|---|---|---|---|---|
| 1 | 37.7 | 0.7 | 0.7 | Top soil |
| 2 | 7.8 | 7.5 | 8.2 | clayey soil |
| 3 | 6 | 92.9 | 101.1 | Fine grained alluvium and/or pyroclastics, probably saturated |
| 4 | 137.6 | | | Moderately fractured rock |

# 4 Conclusions and Recommendations

The results of the geophysical survey conducted on the target areas revealed the nature of the subsurface. In the following sections, concluding remarks are given. Recommendations regarding drilling targets are summarized in Table 2 below.

## 4.1 West Shewa Zone

### Ayeru

Based on both the VES and HRP results, the location of VES S08-4 is selected as the best site for test well drilling. This location lies on the linear NW-SE trending low resistivity zone correlated to the inferred fracture zone. Besides, the VES at that location also revealed the largest thickness (43m) of highly weathered/ fractured rock probably saturated with water at shallower depth (7-43m), and also in the depth range of 75-129 m.

### Guyu Arere

Although both sites (Site I and II) have similar resistivity response at depth, Site I is characterized by thicker highly weathered material and/or alluvium in the first 40-50m of the subsurface. In addition, the very low resistivity (6-9 Ohm-m) layer at depth interpreted as forming the deepest water bearing lhorizon has its maximum thickness of about 80m in Site I. Hence, Site I, in general and the location of VES S17-1 is given priority for test well drilling. The total depth of drilling has been estimated at 160m below the surface.

### Galesa

At Galesa a borehole site was selected at VES S13-2, anticipated to struck the inferred deep aquifer which may be found within the depth range of 88-137m.

### Goremti

The probable water bearing layers characterized by low resistivity are found at depth below 70-90 m, and range in thickness between 38-78 m. The depth to the massive substratum may be in the range of 120-150m. Thus a borehole may be recommended preferably at the low resistivity zone within the two sites (e.g. the central part of Site I, and the NE-SW part of Site II).

### Gosu Qora

The water bearing formation at Gosu Qora detected as the fourth layer is characterized by low resistivity of 5 to 13 Ohm-m, and 20-50m thickness. Therefore, a borehole may be located at the position of the sounding with the largest thickness of the aquifer (i.e. at VES S24-1), and target drilling depth is estimated to be 90m.

### Kolu Gelan

The HRP data indicated a low resistivity zone in the central part of the site within 60m distance northeast of VES S12-3. The low resistivity material is estimated to be more than

70m in thickness, and thus a borehole may be located within this low resistivity zone, having depth of about 90m.

## 4.2 Horo Guduru Zone

### Dedu

The HRP map shows a wide and long low resistivity zone which is still open to the SW, but bounded to the NW and SE by higher resistivities. The low resistivity zone is mainly the effect of the shallow low resistivity layers observed near the surface.

From the groundwater view point, the eastern part of the area, below VES H15-1, H15-2 and H15-3 may be interesting due to the existence of a low resistivity layer (17-37 Ohm-m) at depth of more than 80-100m. Besides, in this part, there is also possibility of encountering shallow water bearing zone within the depth range of 40 to 60. In particular, the area between VES H15-2 and H15-3 may be targeted for drilling deep wells of up to 150m so as to intersect the two anticipated water bearing layers.

The fact that the existing productive well at Dedu is situated on the high resistivity zone of the HRP map can not be explained at the moment, thus requiring detailed study of the local geology and hydrogeology.

### Jardega

It is the low resistivity layer detected as the fifth layer on the first three soundings (H13-1 to H13-3) that is interesting for groundwater development as it is represented by large thickness (60-80m) of highly weathered/fractured material which could be water bearing. A target depth of 140m is sufficient to fully intersect the aquifer.

### Mazoria-Achane

The most interesting location for borehole siting occurs at the intersection of the two low resistivity zones trending in the NE-SW and NW-SE direction close to VES H10-3 and within a radius of 30-50m thereof. A borehole of 150m depth may be enough to intersect the water bearing zones.

### Chala Foka

The HRP map at Chala Foka shows a clear linear low resistivity zone of less than 100 Ohm-m, in the central part of the area, trending in NE-SW direction and having a with of about 100m. The low resistivity zone is mainly the effect of the shallow low resistivity layers observed near the surface as the VES conducted in the low resistivity zone have low resistivity in the shallow upper part only.

From the groundwater view point, the areas below VES H05-1, H015-2 and H05-4 may be interesting due to the existence of a low resistivity layer (15-18 Ohm-m) at depth of more than 90-116m. . In particular, the area of VES H05-4 is recommended for drilling down to 150m depth to penetrate the bottom low resistivity layer which could be water bearing layer.

**Bedo Gidami**

At Bedo Gidami, the presence of water bearing layers within the top 60-80m of the subsurface is apparent. However, the thickness of the highly weathered/fractured rock related to the aquifer in the area sharply decreases towards the north, i.e., towards VES H08-3. Therefore priority should be given to the first two sites for drilling.

**Kelala Didimtu**

At Kelala Didimtu, there exist two layers of low resistivity interpreted as water bearing at shallow and relatively deeper level. These layers are separated in the middle by moderately weathered layer. Together, these make up a sequence of layers 66 to 75m thick overlying the bottom resistive bedrock. Therefore, boreholes should be drilled to 80-90m depth to intersect both water bearing layers.

**Loya Dilelo**

At Loya Dilelo, the results in general show small thickness of highly weathered/fractured rock that could possibly form the aquifer in the area, particularly at the site of VES H14-3, where it is about 20m. At the other sites (i.e. at VES H14-1 and H14-2), there is a slight increment in the thickness of the highly weathered rock, being 19m at the former and 32 m at the latter. Therefore, the latter two sites are selected for test drilling, with the depth of drilling being about 60m.

**Genji Ketala**

At Genji Ketala, there is a highly weathered/fractured layer of 30 to 50 m thickness interpreted as water bearing below 7 to 10m of the surface. This layer extends down to 40-60m depth, and the largest thickness of the water bearing layer is found beneath VES H07-3 and H07-2. Therefore, these two locations are recommended for drilling, with target drilling depth of 70 to 75m.

**Burka Hobo**

At Burka Hobo, highly weathered/fractured rock of up to 26 to 52m thickness may be found within the depth range of 35 to 53m, which extends down to 77 to 85 m depth. Therefore, boreholes of 90 to 100 m depth may be required.

**Haro Habo**

At Haro Habo, there is a low resistivity layer of 18-34 Ohm-m interpreted as being water bearing. This layer may be found at about 30m depth below the surface, and is estimated to be more than 30m thick; so this layer could be the target for drilling. From the first site, the location of VES H22-2 is given priority due to the lowest resistivity of the layer (18 Ohm-m) probably indicating more fracturing and saturation. Therefore the locations of VES H22-2 and H22-3 may be the best drilling targets.

**Tulu Gana**

At Tulu Gana, the depth to the top of the massive bedrock ranges between 15 and 34m. The thickest weathering mantle is found beneath VES H18-1, which is about 26 m thick. In the other sites, the weathered layer has thickness of 15-16m, which is too shallow to be an interesting drilling target. The only choice then appears to be the site of VES H18-1.

Here drilling may be carried out to 60m depth to intersect the highly to moderately weathered/fractured rock.

## 4.3 Jimma Zone

**Bilu Harsu**

The presence of a very thick layer of loose, unconsolidated material having thickness of up to 150m indicate that the area has good groundwater potential. However, the very low resistivity layer of 1-2 Ohm-m found at the bottom part of the loose sediments within depth rage of 70-90m, possibly suggest poor groundwater quality, and therefore precaution should be taken upon development not to intersect the layer. The area of VES J21-1 has been selected for drilling due to the low resistivity feature on the HRP map and the occurrence of thick layer of loose sediments, with drilling depth of about 90-100m.

**Deneba**

The very low resistivity zone extending in the NE-SW direction along the area may be interesting as groundwater reservoir. The thickness of the low resistivity layers as obtained from the VES data is in the range of 110-140 m. Therefore, a borehole can be located any where within the low resistivity zone identified by he HRP survey, with due coordination interference with the existing well.

**Asendabo-Yedi**

The Asnedabo-Yedi area is underlain by very thick layer of low resistivity (2-17Ohm-m) material in excess of 200m, which could be potentially water bearing. However it is expected form the resistivity response of the very low resistivity layer that there could be saturation with saline water below depth range of 120-150m. It is therefore expected that boreholes greater than 120m depth may struck poor quality water.

The available regional geological information suggest the presence of felsic volcanic and sedimentary sequence in the area, and it is probable that thick sedimentary sequence could be the cause of the very low resistivity layers occurring in the area.

**Boneya**

The apparent resistivity map has clearly delineated a N-S trending low resistivity zone, probably correlated to a fracture. Besides, the soundings conducted in the area show a shallow aquifer up to 33m depth and a large more extensive aquifer below 50-77m depth in most parts of the area. It is therefore suggested to locate the test well on the interpreted structure to intercept both the shallow and deeper aquifers. The target drilling depth in this case can be 100m, preferably at the site of VES J15-2 or some 30m southwards in to the low resistivity zone.

**Bulbul**

A major part of the subsurface is characterized by very low resistivities of 2 to 18 Ohm-interpreted as water bearing formation probably associated with highly weathered rock and/or pyroclastics, which have altered to clay at places. These highly weathered rocks extend to about 115 to 200 m below the surface, but the main water bearing zones may be encountered below 10-40m depth. Hence, boreholes with 70-90m depth may be sufficient to develop the groundwater resource.

**Ale**

At Ale, water bearing layers characterized by low resistivities of 3-16m constitute a major part of the subsurface down to 80-90m, hence boreholes of 90-100m may be required to intersect the aquifers.

**Natri**

In Natri area, there is a possibility of encountering two water bearing zones, the first within the top 29m of the subsurface and the second and largest zone below depth of 60-70m. Referring to the result of the HRP data, it is preferable to site the test well in the northeast part of the area in the vicinity of VES J04-2.

**Bore**

The presence of low resistivity material down to 194-235 m depth probably indicates the existence of water bearing layers, although the lowering of the resistivity to 1-2 Ohm-m could have a negative implication regarding the quality of the water. It is there fore suggested that boreholes in the area be drilled to 80-90m depth.

**Dobi**

At Dobi, two low resistivity zones interpreted as water bearing have been interpreted from the soundings at different depths. The first water bearing layer may be encountered up to the depth range of 33-36m, and the second within 74-125m depth. Therefore, drilling to depth of about 130m will provide complete penetration of the aquifers.

**Cheka Walaka**

At Cheka Walaka, it is the third layer characterized by low resistivity of 8-6 Ohm-m and having thickness of about 54m that is potentially water bearing. A borehole of about 90m depth is recommended for complete penetration of the aquifer.

**Gudeta Bula**

The area is dominantly underlain by low to very low resistivity layers indicating the presence of highly weathered/fractured rocks and/or pyroclastics saturated with water, which could be as thick as 220-270m. The very low resistivity layer below 90-120m depth may indicate saturation with poor quality water. Hence, boreholes are recommended to 90-120m depth.

**Toli Sebeta**

At Toli Sebeta, the third layer may be important as a water bearing layer as it is characterized by low resistivity of 4.2 Ohm-m probably indicating saturation. In order to fully penetrate the interacted water bearing layer, a borehole of 100m depth is recommended.

**Marewa**

At Marewa, the two soundings show the presence of water bearing layers at depth, which could be tapped by borehole of 100-110m.

## Table 2. Summary of Drilling Targets.

### (a) West Shewa Zone

| S.No. | Village No | Woreda | Village | No. of sites | Level | UTM E | UTM N | Elevation(m) | Water Strike Depth | Target Depth | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | S-08 | Dano | Ayeru | 1 | 2 | 314020 | 981550 | 1622 | 16m,76m | 130m | S08-4 |
| 2 | S-17 | Jibat | Guyu Arere | 1 | 2 | 343054 | 959318 | 2414.9 | 25m,76m | 160m | S17-1 |
| 3 | S-13 | Dandi | Gelesa | 1 | 2 | 406322 | 1009708 | 2965.2 | 88m | 140m | S13-2 |
| 4 | S-16 | Ambo | Goromti | 1 | 2 | 377558 | 984015 | 2537 | 16m,92m | 160m | S16-2 |
| 5 | S-24 | Ambo | Gosu Qora | 1 | 1 | 373268 | 990191 | 2203.7 | 30m | 90m | S24-1 |
| 6 | S-12 | Jaldu | Kolu Gelan | 3 | 1 | 398563 | 1032139 | 2799.4 | 10m | 80m | S12-1 |
| | " | " | " | | | 397628 | 1030397 | 2787.7 | 10m | 80m | S12-2 |
| | " | " | " | | | 397557 | 1031287 | 2799.6 | 20m | 90m | S12-3 |

### (b) Horo Guduru Zone

| S.No. | Village No | Woreda | Village | No. of sites | Level | UTM E | UTM N | Elevation(m) | Water Strike Depth | Target Depth | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | H-15 | Hababo Guduru | Dedu | 1 | 2 | 338577 | 1070865 | 2318.6 | 40m,85m | 150m | H15-3 |
| 2 | H-13 | Jardega Jarte | Jardega | 1 | 2 | 283543 | 1085178 | 2387.4 | 10m,52m | 140m | H13-1 |
| 3 | H-10 | Abay Chomen | Mazoria-Acharie | 1 | 2 | 315367 | 1068328 | 2347.2 | 20m,87m | 150m | H10-3 |
| 4 | H-05 | Hababo Guduru | Chala Foka | 1 | 2 | 340555 | 1079075 | 2322 | 46m,92m | 150m | H05-4 |
| 5 | H-08 | Jima Ganat | Bedo Gidami | 3 | 1 | 292734 | 1042464 | 2277.6 | 10m,55m | 100m | H08-1 |
| | " | " | " | | | 293056 | 1042578 | 2288.3 | 10m,50m | 90m | H08-2 |
| | " | " | " | | | 292817 | 1043209 | 2276 | 10m,50m | 80m | H08-3 |
| 6 | H-09 | Jima Ganat | Kelala Didimtu | 3 | 1 | 294197 | 1046173 | 2246.6 | 10m,40m | 80m | H09-1 |
| | " | " | " | | | 294687 | 1046252 | 2239.4 | 12m,52m | 80m | H09-2 |
| | " | " | " | | | 294853 | 1046848 | 2235.6 | 10m,40m | 90m | H09-3 |
| 7 | H-14 | Hababo Guduru | Loya Dilelo | 2 | 1 | 334360 | 1062088 | 2308 | 25m | 60m | H14-1 |
| | " | " | " | | 1 | 333496 | 1061498 | 2299.9 | 10m,38m | 60m | H14-2 |
| 8 | H-07 | Abay Chomen | Genji Ketala | 2 | 1 | 312355 | 1062694 | 2251.6 | 10m | 70m | H07-2 |
| | " | " | " | | | 311586 | 1063473 | 2247.2 | 10m | 75m | H07-3 |
| 9 | H-21 | Jima Rare | Burka Hobo | 3 | 1 | 318668 | 1028563 | 2220.3 | 26m | 90m | H21-1 |
| | " | " | " | | | 317826 | 1028165 | 2224.5 | 44m | 90m | H21-2 |
| | " | " | " | | | 317583 | 1029455 | 2228.8 | 10m,59m | 100m | H21-3 |
| 10 | H-22 | Jardega Jarte | Haro Habe | 2 | 1 | 281442 | 1090044 | 2290.3 | 30m | 90m | H22-2 |
| | " | " | " | | | 281055 | 1089594 | 2267.9 | 30m | 70m | H22-3 |
| 11 | H-18 | Abe Dongoro | Tulu Gana | 3 | 1 | 246864 | 1059115 | 1383 | 10m | 60m | H18-1 |

### (c )Jimma Zone

| S.No. | Village No | Woreda | Village | No. of sites | Level | UTM E | UTM N | Elevation(m) | Water Strike Depth | Target Depth | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | J-21 | Dedo | Bilu Harsu | 1 | 2 | 285062 | 827478 | 1813.3 | 10m | 90m | J21-1 |
| 2 | J-07 | Sekoru | Deneba | 1 | 2 | 320274 | 867688 | 1729.6 | 10m,57m | 140m | J07-5 |
| 3 | J-14 | Omo Nada | Asendabo Yedi | 1 | 2 | 302303 | 858962 | 1679.4 | 14m | 120m | J14-4 |
| 4 | J-15 | Omo Nada | Boneya | 1 | 2 | 285616 | 834258 | 1750.5 | 5m,57m | 100m | J15-2 |
| 5 | J-08 | Kersa | Bulbul No.2 | 9 | 1 | 287773 | 855260 | 1731.8 | 16m | 70-90m | J08-1 |
| | " | " | " | | | 287892 | 854841 | 1713.2 | 13m | 70-90m | J08-2 |
| | " | " | " | | | 287257 | 854206 | 1725.8 | 10m,43m | 70-90m | J08-3 |
| | " | " | " | | | 291188 | 854315 | 1746.8 | 10m,43m | 70-90m | J08-4 |
| | " | " | " | | | 291955 | 853094 | 1711 | 16m,53m | 70-90m | J08-5 |
| | " | " | " | | | 291539 | 854783 | 1755.6 | 10m | 70-90m | J08-6 |
| | " | " | " | | | 289334 | 854841 | 1792.8 | 16m | 70-90m | J08-7 |
| | " | " | " | | | 291985 | 853268 | 1713.8 | 11m | 70-90m | J08-8 |
| | " | " | " | | | 287327 | 854085 | 1720.4 | 10m,40m | 70-90m | J08-9 |
| 6 | J-01 | Omo Nada | Ale | 3 | 1 | 294231 | 843413 | 1793.3 | 10m,30m | 90m | J01-1 |
| | " | " | " | | | 294926 | 843329 | 1794.1 | 10m,43m | 100m | J01-2 |
| | " | " | " | | | 294675 | 842734 | 1826.2 | 26m | 100m | J01-3 |
| 7 | J-04 | Sekoru | Natri | 1 | 2 | 328471 | 888317 | 1939.6 | 10m,70m | 110m | J04-2 |
| 8 | J-09 | Sekoru | Bore | 4 | 1 | 314993 | 858084 | 1725.8 | <10m | 80m | J09-1 |
| | " | " | " | | | 315097 | 858861 | 1728.9 | <10m | 75m | J09-2 |
| | " | " | " | | | 312650 | 857804 | 1762.3 | <10m | 100m | J09-3 |
| | " | " | " | | | 314015 | 857812 | 1728.2 | <10m | 85m | J09-4 |
| 9 | J-12 | Sekoru | Dobi | 4 | 1 | 331425 | 894070 | 1947.5 | 10m,74m | 130m | J12-1 |
| | " | " | " | | | 332716 | 893905 | 2003.3 | 10m,74m | 130m | J12-2 |
| | " | " | " | | | 332245 | 893604 | 1977.7 | 10m,50m | 130m | J12-3 |
| | " | " | " | | | 331464 | 893691 | 1946.5 | 10m,75m | 130m | J12-4 |
| 10 | J-10 | Sekoru | Cheka Walaka | 1 | 1 | 324836 | 863369 | 1905.7 | 18m | 90m | J10-1 |
| 11 | J-18 | Omo Nada | Gudeta Bula | 2 | 1 | 312634 | 857614 | 1765.1 | <10m | 90m | J18-1 |
| | " | " | " | | | 312276 | 858107 | 1763 | <10m | 115m | J18-2 |
| 12 | J-19 | Omo Nada | Waktola | 2 | 1 | 305936 | 848091 | 1719.9 | 13m | 100m | J19-1 |
| | " | " | " | | | 305883 | 848790 | 1728.3 | 11m | 100m | J19-2 |
| 13 | J-20 | Omo Nada | Toli Sebeta | 1 | 1 | 295978 | 847120 | 1784.7 | <10m | 100m | J20-1 |
| 14 | J-03 | Kersa | Marewa | 2 | 1 | 269231 | 849392 | 1825.8 | 10m,44m | 100-110m | J03-1 |
| | " | " | " | | | 269293 | 849961 | 1788.9 | <10m | 100-110m | J03-2 |

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# Annex 1. VES points and their coordinates.

| Area | VES_ID | Easting | Northing | Remarks |
|---|---|---|---|---|
| Galesa | S13_1 | 405953 | 1009595 | |
| | S13_2 | 406322 | 1009708 | |
| | S13_3 | 405777 | 1009370 | at existing well |
| | S13_4 | 405810 | 1009603 | |
| Ayeru | S08_1 | 313810 | 980831 | |
| | S08_2 | 313636 | 980753 | |
| | S08_3 | 313986 | 980491 | |
| | S08_4 | 314020 | 981550 | |
| | S08_5 | 314120 | 981453 | |
| Goromti | S16_1 | 378388 | 983868 | |
| | S16_2 | 377558 | 984015 | |
| | S16_3 | 377945 | 983874 | |
| | S16_4 | 377620 | 983931 | |
| | S16_5 | 378442 | 983695 | |
| Guyu Aere | S17_1 | 343054 | 959318 | |
| | S17_2 | 342919 | 959309 | |
| | S17_3 | 343167 | 959352 | |
| | S17_4 | 342422 | 959305 | |
| | S17_5 | 342468 | 959453 | |
| Gosu Qora | S24-1 | 373268 | 990191 | |
| | S24-2 | 373034 | 990186 | |
| | S24-3 | 372702 | 990255 | |
| Kolu Galan | S12-1 | 398563 | 1032139 | |
| | S12-2 | 397628 | 1030397 | |
| | S12-3 | 397557 | 1031267 | |
| Deneba | J07-1 | 320306 | 867701 | |
| | J07-2 | 320286 | 867656 | |
| | J07-3 | 320274 | 867605 | |
| | J07-4 | 320275 | 867549 | |
| | J07-5 | 320274 | 867688 | |
| Boneya | J15-1 | 285712 | 834287 | |
| | J15-2 | 285617 | 834293 | |
| | J15-3 | 285497 | 834281 | |
| | J15-4 | 285596 | 834437 | |
| | J15-5 | 285614 | 834358 | |
| Bilu Harsu | J21-1 | 285062 | 827478 | |
| | J21-2 | 285239 | 827499 | |
| | J21-3 | 285261 | 827633 | |
| | J21-4 | 285280 | 827753 | |
| | J21-5 | 285291 | 827903 | |
| Asendabo Yedi | J14-1 | 301117 | 858443 | |
| | J14-2 | 303565 | 858822 | |
| | J14-3 | 302147 | 858582 | |
| | J14-4 | 302303 | 858962 | |
| | J14-5 | 302428 | 858867 | |
| Marewa | J03-1 | 269231 | 849392 | |
| | J03-2 | 269293 | 849981 | |
| Cheka Walaka | J10-1 | 324836 | 863369 | |
| Natri | J04-1 | 328400 | 888342 | |
| | J04-2 | 328471 | 888317 | |
| Ale | J01-1 | 294231 | 843413 | |
| | J01-2 | 294926 | 843329 | |
| | J01-3 | 294675 | 842734 | |
| Toli Sebeta | J20-1 | 295984 | 847131 | |

| | | | | |
|---|---|---|---|---|
| Waktola | J19-1 | 305936 | 848091 | |
| | J19-2 | 305883 | 848790 | |
| Gudeta Bula | J18-1 | 312634 | 857614 | |
| | J18-2 | 312276 | 856107 | |
| Bore | J09-1 | 314993 | 858084 | |
| | J09-2 | 315097 | 858861 | |
| | J09-3 | 312650 | 857804 | |
| | J09-4 | 314015 | 857812 | |
| Bulbula | J08-1 | 287773 | 855260 | |
| | J08-2 | 287892 | 854841 | |
| | J08-3 | 287257 | 854206 | |
| | J08-4 | 291188 | 854315 | |
| | J08-5 | 291955 | 853094 | |
| | J08-6 | 291539 | 854783 | |
| | J08-7 | 289334 | 854841 | |
| | J08-8 | 291985 | 853268 | |
| | J08-9 | 287327 | 854085 | |
| Dobi | J12-1 | 331425 | 894070 | |
| | J12-2 | 332716 | 893905 | |
| | J12-3 | 332245 | 893604 | |
| | J12-4 | 331464 | 893691 | |
| Mazoria-Achane | H10-1 | 315537 | 1068342 | |
| | H10-2 | 315543 | 1068417 | |
| | H10-3 | 315367 | 1068328 | |
| | H10-4 | 315420 | 1068302 | |
| | H10-5 | 315371 | 1068250 | |
| Dedu | H15-1 | 338607 | 1070703 | Near existing well |
| | H15-2 | 338514 | 1070950 | |
| | H15-3 | 338577 | 1070865 | |
| | H15-4 | 338436 | 1070838 | |
| | H15-5 | 338300 | 1070806 | |
| Chala Foka | H05-1 | 340598 | 1079183 | |
| | H05-2 | 340515 | 1079225 | |
| | H05-3 | 340513 | 1079148 | |
| | H05-4 | 340555 | 1079075 | |
| | H05-5 | 340422 | 1079103 | |
| Jardega | H13-1 | 283543 | 1085178 | |
| | H13-2 | 283438 | 1085183 | |
| | H13-3 | 283357 | 1085188 | |
| | H13-4 | 283282 | 1085197 | |
| | H13-5 | 283182 | 1085198 | |
| Burka Hobo | H21-1 | 318668 | 1028563 | |
| | H21-2 | 317826 | 1028165 | |
| | H21-3 | 317583 | 1029455 | |
| Haro Habo | H22-1 | 281500 | 1090123 | |
| | H22-2 | 281442 | 1090044 | |
| | H22-3 | 281055 | 1089594 | |
| Bedo Gidami | H08-1 | 292734 | 1042464 | |
| | H08-2 | 293056 | 1042578 | |
| | H08-3 | 292817 | 1043209 | |
| Kelala Didimtu | H09-1 | 294197 | 1046173 | |
| | H09-2 | 294687 | 1046252 | |
| | H09-3 | 294853 | 1046848 | |
| Tulu Gana | H18-1 | 246864 | 1059115 | |
| | H18-2 | 246997 | 1059783 | |
| | H18-3 | 246725 | 1059913 | |
| Genji Ketela | H07-1 | 312618 | 1062892 | |

| | | | | |
|---|---|---|---|---|
| | H07-2 | 312355 | 1062694 | |
| | H07-3 | 311586 | 1063473 | |
| Loya Dilelo | H14-1 | 334360 | 1062088 | |
| | H14-2 | 333496 | 1061498 | |
| | H14-3 | 333251 | 1061643 | |