MINISTRY OF WATER & ENERGY (MoWE)
THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
SOMALI REGIONAL WATER RESOURCES DEVELOPMENT BUREAU

# THE STUDY ON JARAR VALLEY AND SHEBELE SUB-BASIN WATER SUPPLY DEVELOPMENT PLAN, AND EMERGENCY WATER SUPPLY IN THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

## FINAL REPORT (6/7)

### SUPPORTING REPORT

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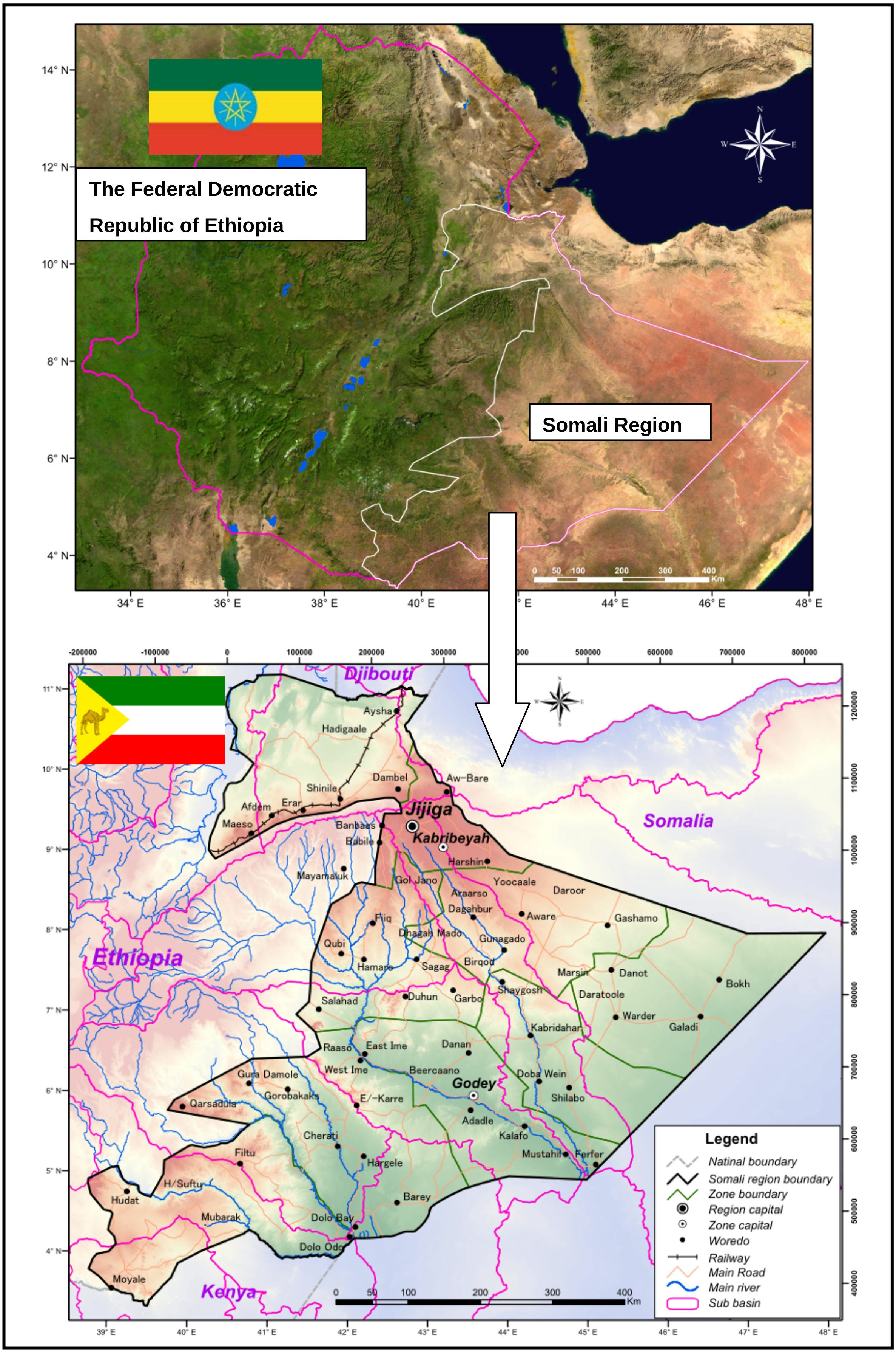


**Location Map of Study Area**

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## Abbreviations

| | |
|---|---|
| ABE | Alternative Basic Education |
| ARRA | Administration for Refugee and Returnee Affairs |
| BoFED | Bureau of Finance and Economic Development |
| BPR | Business Process Reengineering |
| CGIAR | Consultative Group on International Agricultural Research |
| CSA | Central Statistical Agency |
| CSE | The Conservation Strategy of Ethiopia |
| COD | Chemical Oxygen Demand |
| C/P | Counterpart (organization or personnel) |
| DFID | Department for International Development |
| DF/R | Draft Final Report |
| DTH | Down the Hole Hammer |
| DPPB | Disaster Prevention and Preparedness Bureau |
| EC | Electric Conductivity |
| EIA | Environmental Impact Assessment |
| EPA | The Environmental Protection Authority |
| EPC | The Environmental Protection Council |
| ESA | European Space Agency |
| ESIA | Environmental and Social Impact Assessment Unit |
| EU | European Union |
| EU-WATCH | Water and Global Change (WATCH) program funded by the European Union |
| EWTEC | Ethiopia Water Technology Center |
| FAO | Food and Agriculture Organization of the United Nations |
| F/R | Final Report |
| F/S | Feasibility Study |
| GEM | Global Environment Monitoring |
| GIS | Geographical Information System |
| GLCF | Global Land Cover Facility |
| GLG | Grass Land GIS |
| GMT | Greenwich Mean Time |
| GSE | Geological Survey of Ethiopia |
| GPS | Global Positioning System |
| GUPE Map | Groundwater Utilization Potential Evaluation Map |
| IC/R | Inception Report |
| IEE | Initial Environmental Examination |
| IRC | International Rescue Committee |
| ISCGM | International Steering Committee for Global Mapping |
| IT/R | Interim Report |
| JICA | Japan International Cooperation Agency |
| JSS | JAXA Supercomputer System |
| JWSO | Jijiga Water Supply Office |
| MODIS | MODIS Land Cover Product by using Moderate resolution Imaging Spector radiometer of Earth-Observing-System EOS |
| MoFED | Ministry of Finance and Economic Development |
| MoWR | Ministry of Water Resources |
| MoWE | Ministry of Water and Energy |
| MrSID | Multi-resolution Seamless Image Database |
| NFE | Non Formal Education |
| NGO | Non-Governmental Organization |
| NMA | (Addis Ababa) National Meteorology Agency |
| NOAA | National Oceanic and Atmospheric Administration |

| | |
|---|---|
| NRCS | Natural Resources Conservation Service, United States Department of Agriculture |
| O&M | Operation and Maintenance |
| OJT | On the Job Training |
| POSTEL | Postal land surface thematic centre |
| P/R | Progress Report |
| PA | Preliminary environmental assessment study |
| PALSAR | Phased Arrayed L-type Synthetic Aperture Radar |
| R/D | Record of Discussion |
| REA | Regional Environmental Agencies |
| RGSR | Regional Government of Somali Region |
| RWBs | Regional Water Bureaus |
| SAGE | Center for Sustainability And the Global Environment at the University of Wisconsin Madison |
| SEDAC | Socioeconomic Data and Applications Center |
| SEPMEDA | Somali Regional State Environmental Protection, Mine and Energy Development Agency |
| SHAAC | Shaac Consulting Engineers |
| SRTM | Shuttle Radar Topography Mission |
| SRWDB | Somali Regional Water Resources Development Bureau |
| SWWCE | Somali Water Works and Construction Enterprise |
| TDM | Time Domain Method |
| TEM | Transient (or Time-domain) Electromagnetic Method |
| TOT | Training of Trainers |
| TVETC | Technical and Vocational Education and Training College |
| UAP | Universal Access Program |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |
| UNHCR | United Nations High Commissioner for Refugees |
| UNICEF | United Nations Children's Fund |
| USDA | United States Department of Agriculture |
| USAID | United States Agency for International Development |
| USGS | United States Geological Survey |
| UTM | Universal Transversal Mercator |
| VES | Vertical Electrical Sounding |
| WASH | Water Supply, Sanitation and Hygiene Programme |
| WASHCO | Water Supply and Health Committee |
| WATSANCO | Water, Sanitation & Hygiene Committee |
| WFP | World Food Programme |
| WLR | Water Level Recorder |
| WMO | World Meteorological Organization |
| WRI | World Resources Institute |
| WRIM | Water Resources Information Map |
| WSDP | Water Sector Development Program |
| WTP | Willingness to Pay |

# Chapter 1

*Geophysical Survey*

# 1 Geophysical Survey

## 1.1 Study area and objective of geophysical survey

### 1.1.1 Study area

The geophysical prospecting was conducted in the Qaaxo-North and Qaaxo-South areas on the eastern side of the Jarar Valley, and in the Qaaxo-East area on the road leading from Kabribayah City to the Jarar Valley. (Refer to Figure 1.10: Map of Geophysical Survey Location Map; and Figure 1.11 to Figure 1.13: Maps of Measuring Points).

### 1.1.2 Objective of geophysical survey

In order to estimate the geological and hydrogeological conditions in the vicinity of the Jarar Valley, geophysical prospecting (electric and electromagnetic prospecting) was carried out. In the Qaaxo-North area, 2 points were selected where new wells had been drilled to provide water sources for the Jarar Valley water supply system. In the Qaaxo-South and Qaaxo-East areas, geophysical prospecting was conducted to learn about hydrogeological conditions.

## 1.2 Survey points

### 1.2.1 Reasons for selection and number of surveys

The original plan called for 50 sites to be selected for the Vertical Electrical Sounding (VES) and 25 points for TEM (Time-domain Electromagnetic or Transient Electromagnetic) prospecting. However, because some information had already been obtained about the geology and hydrogeology of shallow areas, the number of TEM sites was increased in order to reveal the geological structure of deeper areas.

Measuring points were selected in consideration of the creation of resistivity diagrams. In the Qaaxo-North area, the two candidate sites that were selected for the target places where wells had been drilled, so the TEM prospecting was supplemented with VES prospecting, accounting for more than half of all survey points.

Table 1.1 shows the number of geophysical prospecting surveys, and Table 1.2 shows the types of geophysical prospecting in each of the three areas.

Table 1.1: Number of Geophysical Survey

| | TEM | VES | Total |
|---|---|---|---|
| Planned number | 25 | 50 | 75 |
| Actual number | 42 | 34 | 76 |

Table 1.2: Types of Geophysical Survey in Each Area

| Area | TEM | VES | Total |
|---|---|---|---|
| Qaaxo-North | 22 | 25 | 47 |
| Qaaxo-South | 1 | 9 | 10 |
| Qaaxo-East | 19 | 0 | 19 |
| Total | 42 | 34 | 76 |

### 1.2.2 Reconnaissance and selection of prospecting sites

In the preliminary survey, reconnaissance were carried out in the prospecting sites with hydrogeologists to confirm such as the locations of measuring points and conditions of roads leading to the survey areas. In addition, when the geophysical prospecting was commenced, local residents were briefed about the project and were asked to provide assistance with measurements during the geophysical prospecting.
In the survey of the Qaaxo-North area, TEM was originally used, but later VES was used. VES points were either the same as TEM points, or were chosen to supplement TEM points. Furthermore, VES prospecting points were set up on TEM sites where the TEM measurements indicated an anomalous area, and the VES results were used to supplement the TEM results.

## 1.3 Survey method

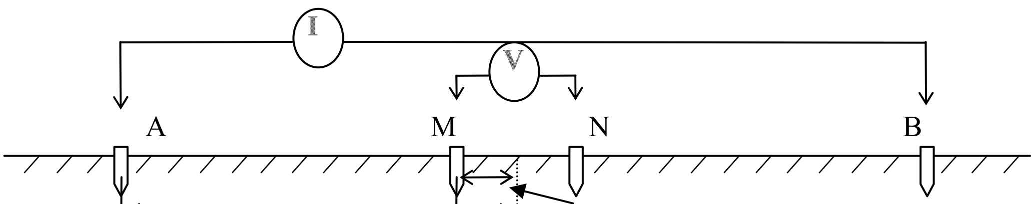
### 1.3.1 Vertical electric sounding (VES)

**a. Principles of electric sounding**

An artificial current is run through electrodes into the ground to measure the distribution of the potential field. The result provides the basis for analyzing the resistivity structure below the ground. In other words, electrical prospecting is conducted to analyze the conditions of groundwater and geological structures by investigating the resistivity of the rocks and the geology in the ground through their respective electrical properties, or associated phenomena. In the present survey we used the vertical electrical sounding and horizontal profiling methods.

**a.1 Vertical electric sounding**

Vertical electrical sounding (VES) is a common method of investigation layered structures as a general principle. Schlumberger electrode configuration was applied to estimate the layered resistivity structure (see Figure 1.1 below).




$\rho_a = \pi/4 \times ((AB^2 - MN^2)/MN) \times (V/I)$、$\rho_a$= apparent resistivity (ohm-m)
AB: current electrodes, MN: potential electrodes

Figure 1.1: Schlumberger Electrode Configurations

The center of the symmetrically-arranged electrode configuration is fixed in place, while the positions of the current and potential electrodes are varied to measure changes in apparent resistivity ($\rho_a$) with the depth. The $\rho_a$-a curve derived from there is used to obtain the thicknesses of the layers and their resistivities. In other words, current is run through outer electrodes A and B that are installed on the measurement profile, while electrodes M and N on the inside are used to measure differences in electrical potential. The equipment used for this measurement is the same as that for horizontal electrical profiling. The measurement data are recorded in a log book and plotted on the $\rho_a - a$ apparent resistivity curve on double-logarithm graph paper as a VES (Vertical Electric Sounding) curve. The electrode spacing used in the Schlumberger configurations are shown in Table 1.3.

Table 1.3: Schlumberger Electrode Spacing

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (AB/2) | 1.5 | 2.1 | 3 | 4.2 | 6 | 9 | 13.5 | 20 |
| (MN/2) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5/6 |
| (AB/2) | 30 | 45 | 66 | 100 | 150 | 220 | 330 | 500 |
| (MN/2) | 0.5/6 | 6 | 6 | 6 | 6/45 | 6/45 | 45 | 45 |

### a.2 Measuring equipment

The measuring equipment consists of a 16GL transmitter/receiver (PASI Co. Italy) and a WDJD-2 transmitter/receiver (Chongging Wanman Geophysical Instrument Company, China). (see Figure 1.2 below). The following chart of Table 1.4 shows the types of equipment used for the electrical prospecting and their respective specifications.

16GL receiver/transmitter

WDJD-2 receiver/transmitter

Figure 1.2: Electrical Prospecting Instruments

Table 1.4: Specs of the Electrical Survey Instrument

| Instrument | Specification |
|---|---|
| 16GL transmitter/receiver | Output current : 1～1000mA |
| WDJD-2 transmitter/receiver | Output current : 1～100mA |

## b. Field measurement

### b.1 Measurement method

Electric surveying was conducted in two areas: Qaaxo-North, at points where wells had been drilled, and at Qaaxo-South. The positions of the measuring points were determined using GPS. The method used was VES, with a maximum current electrode of AB/2=330m.

### b.2 Measuring conditions

In the highland area on the NW side of the study area, there is high ground resistance due to the numerous rocks, so it is difficult to run a current. Attempted techniques for running a large amount of current are increasing the number of current electrodes and changing the positions of the current electrodes. Furthermore, at points where it was difficult to run an electric current, the output voltage was switched to high voltage for measurements. However, there were some unreproducible measured values from measuring points that only very weak electric current could be run. Therefore, the data acquired from measuring points includes some points that could not give a full indication of the true relative resistivity of the ground.

**c. Analysis methods**

The analytical software RESIX-P made by Interpex, Ltd. (USA) was used to make one-dimensional inversion analysis. The analysis took into consideration the groundwater levels at existing wells, drilling points, and analytical results at adjacent points, as well as topography, geology, and other factors. In addition, analyses were conducted to determine how many layers there were and what their structure was from the VES curves. Layer structure analysis is a good way to determine the depth of each layer as accurately as possible, Figure 1.3 is an example of the results of layer structure analysis of measuring point No. 9 in the Qaaxo-South area. The left side of the figure shows the measurement data and the ideal curve of the analyzed relative resistivity structure, while the right side is the resulting analytical diagram of the layer structure.

For the Qaaxo-North area, estimates of the potential for groundwater and its depth were made based on the relative resistivity structure. For the Qaaxo-South and Qaaxo-East areas, estimates were made about hydrogeological conditions.

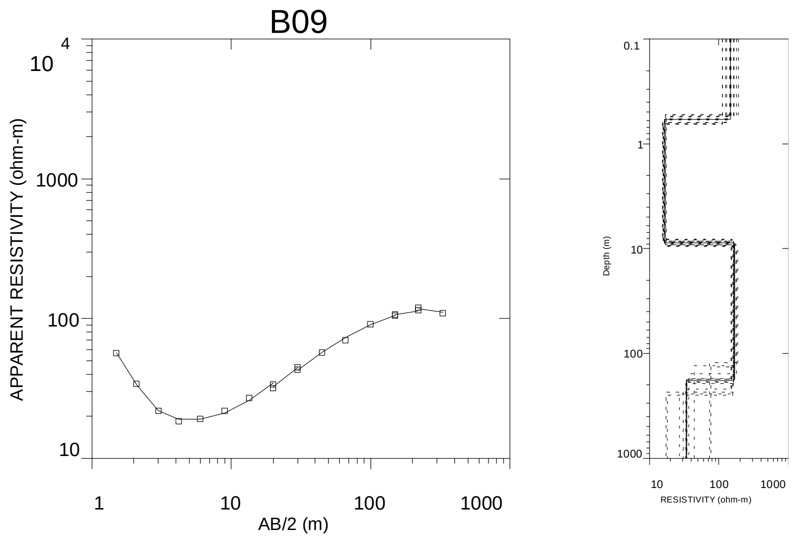



Figure 1.3: Example of the Results of Layer Structure Analysis

### 1.3.2 TEM electro-magnetic sounding (TEM)

#### a. Principles of TEM

The Transient-phenomenon (or Time-domain) Electromagnetic Exploration Method (TEM) is used to investigate underground resistivity structures by artificially exciting a magnetic field by a transmitter and by measuring responses from the underground in a time domain. In this method, a cable is usually installed on the ground in a loop shape and a constant-voltage (DC) current is flowed through this cable. Variation ratios with time of the magnetic field after this current is abruptly cut off are measured by a coiled magnetic-field sensor. The loop transmission source sends signals without directly contacting the ground.
After a current is cut off, a secondary magnetic field is generated by an eddy current that is excited underground. As shown in Figure 1.4, an eddy current flow deep into the ground over time. This phenomenon is likened to the spreading of cigarette smoke and is sometimes called a "smoke ring". On the other hand, the output coil voltage after a current cutoff (changes in a magnetic field over time) is influenced by the resistivity structure of the underground. For example, the output voltage immediately after a current cutoff is high if the resistivity is high. However, the output voltage attenuates rapidly thereafter. Conversely, in a low resistive medium, the output voltage immediately after a current cutoff is low compared with the output voltage of a highly resistive medium, even though its attenuation rate is low. The coil output voltage can be converted into an apparent resistivity value and information on deep areas can be related to time elapsed after a current is cut off.

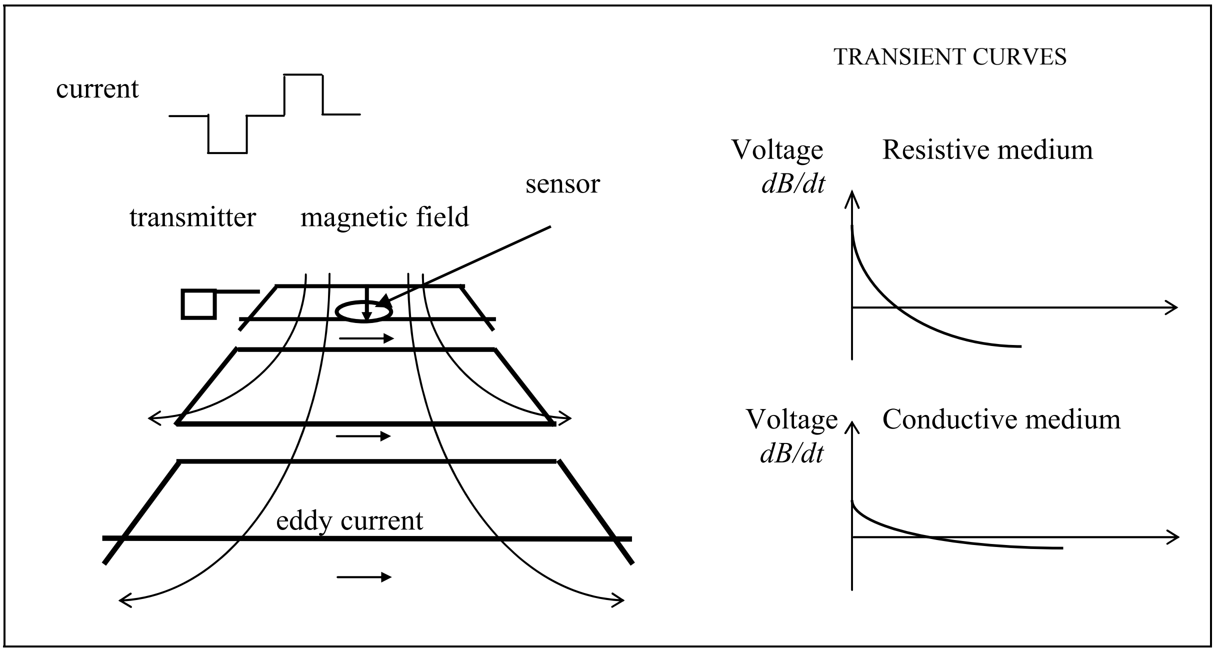



Figure 1.4: TEM Survey Configuration and Transient Curves

#### a.1 TEM electro-magnetic survey

This method has the following features:

1) Electrodes do not have to be grounded and all that is required for the reception coil is to install it on the ground horizontally. A significantly high work efficiency can be achieved in areas where grounding resistance is high such as deserts, and in areas where rock mass is exposed.

2) Because the measuring apparatus is compact and light, the method can also be used in deserts and mountains which are not easily accessible.
3) Transient phenomena of a magnetic field after the transmission current is cut off are measured and a primary magnetic field does not exist during measurement, thereby assuring measurement of very stable reception signals.
4) Only a magnetic field is measured and a static shift (a phenomenon of local resistivity in an anomalous body immediately below the surface affecting deep inside the underground), which presents problems to techniques that require measurement of electric fields, can be prevented.

### a.2 Measuring equipment

The measuring equipment consisted of a TEM system (Geonics Co., Canada) that was borrowed from EWTEC (see Figure 1.5). Table 1.5 shows the specifications of this system. It consisted mainly of a receiver, a receiver coil, and a transmitter.

Protem57-MK2D is a TEM-type data collector/recorder which sets various measuring time ranges based on the target depth in order to record the rate of change in a magnetic field after the current is cut off. This device can use three types of measuring ranges: 85.29～6,980μs for H (after the current is cut off), 352～27,900μs for M, and 881～69,800μs for L. These measuring ranges are called standard frequencies and are controlled along with the transmitter. In addition, each measuring range has about 20 gates that are set at logarithmically-spaced time intervals. Table 1.6 shows an overview of the sampling times of each gate.

The transmitter (TEM57-MK2) can be operated either by battery power or with an electric generator and can transmit up to 25A.
The magnetic field sensor utilizes an induction magnetometer, or coil.
The Protem57-MK2D contains a built-in clock that is used to synchronize its time with the transmitter via connection with a reference cable.
After the signals received from the magnetic field sensor are amplified by an amplifier in the recording equipment, they are subjected to stacking. After stacking, the reception signals are sampled at the 20 gates (measuring times) and are recorded in the internal memory. After the field work is finished, the measurement data are forwarded from the measuring equipment's memory to a computer.

**Receiver** **Transmitter/Generator**

Figure 1.5: TEM Prospecting Instruments

Table 1.5: TEM Measuring System

| Equipment | | PROTEM57 |
|---|---|---|
| Receiver | Measured Quantity | Time rate of decay of induced magnetic field |
| | Repetition Rate(Hz) | 285/237.5, 75/62.5, 30/25,7.5/6.25 ,3/2.5 |
| | Time Gates | 20 geometrically spaced time gates |
| | Synchronization | (1)Reference cable<br>(2)High stability quartz crystal |
| Transmitter | Current Wave Form | Bipolar rectangular current with 50% duty cycle |
| | Maximum Current | 25A |
| | Output Voltage | 110 and 120 VAC for 120V<br>210 and 230 VAC for 220V |
| Receiver Coil | | Air-cored Coil, Effective Area:100m$^2$ |

Table 1.6: Sampling Schedule for the Transmitter

| Gate No | EM57 time range | | |
|---|---|---|---|
| | H | M | L |
| 1 | 0.0859 | 0.352 | 0.881 |
| 2 | 0.104 | 0.427 | 1.06 |
| 3 | 0.129 | 0.525 | 1.31 |
| 4 | 0.159 | 0.647 | 1.61 |
| 5 | 0.198 | 0.802 | 2.00 |
| 6 | 0.248 | 1.00 | 2.50 |
| 7 | 0.312 | 1.25 | 3.14 |
| 8 | 0.393 | 1.58 | 3.95 |
| 9 | 0.497 | 1.99 | 4.99 |
| 10 | 0.629 | 2.52 | 6.31 |
| 11 | 0.797 | 3.19 | 7.99 |
| 12 | 1.01 | 4.05 | 10.13 |
| 13 | 1.28 | 5.14 | 12.86 |
| 14 | 1.63 | 6.54 | 16.35 |
| 15 | 2.07 | 8.32 | 20.80 |
| 16 | 2.64 | 10.59 | 26.47 |
| 17 | 3.37 | 13.49 | 33.72 |
| 18 | 4.29 | 17.19 | 42.99 |
| 19 | 5.47 | 21.90 | 54.74 |
| 20 | 6.97 | 27.92 | 69.77 |

Unit: m/sec

### b. Field measurement

#### b.1 Positions of measuring points

Measurements were taken using GPS (Global Positioning System). The latitude, longitude, and elevation of measuring points are listed in Figure 1.11 to Figure 1.13.

#### b.2 Survey methods

The arrangement of TEM measurements was based on the central loop method. As shown in Figure 1.6, the arrangement of central loop measurements consisted of a 100m x 100m transmission loop with an EM57 sensor set in the middle on the ground surface.
The measurements were taken in a time range of 85.29μs～69.8ms after cutting off the transmission current. Specific resistance data were extracted from a shallow area down to a depth of about 400m.

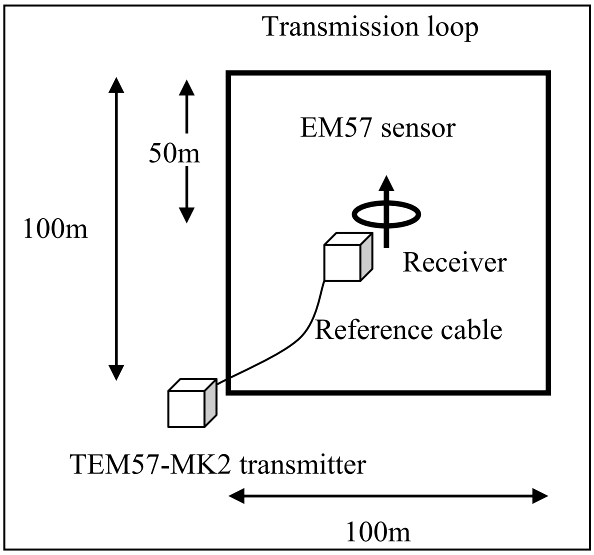



Figure 1.6: TEM Transmission Source and Arrangement of Measuring Points

The procedure for taking measurements with TEM is as follows:
1）The measuring points are determined using a simple positioning device and a tape measure.
2）The direction and length of the transmission loop are measured with the simple positioning device, and a 100m x 100m loop is set up.
3）The two ends of the transmission loop cable are used to connect the TEM57 with the MK2 transmitter.
4）Magnetic sensors are placed horizontally on measuring points set up inside the transmission loop.
5）The receiver is installed about 5m away from the magnetic sensor.
6）The transmitter and receiver are connected to each other via reference cable.
7）The transmission current is set to 9～17A, and measurements are taken in the H/M/L measuring ranges.
8）After finishing the measurements with the Protem57-MK2system, the measuring equipment is taken to the next transmission loop installation site.

### b.3 Measuring conditions

Electromagnetic noise can be mixed in with the measurement data. Because there were commercial power lines running through both the Qaaxo-South and Qaaxo-East areas, measuring points were at least 200 meters away from power lines to avoid electromagnetic noise. This enabled relatively good data to be obtained. In addition, there was some non-conformity in data from some measuring points, but data that could withstand analysis could nonetheless be obtained, and the overall quality of the data was good.

### c. Analytical method

The analytical software used here was IX1D v.3 made by Interpex, Ltd. of the USA. In order to use the data to determine the underground resistivity structure, two analytical methods were employed: Smooth Inversion and Structure Inversion, which are described below.

### c.1 Smooth inversion

In the actual analysis, the first method used was Smooth Inversion (see Figure 1.7).
In Smooth Inversion, the layer thickness is automatically set so that it logarithmically increases with depth, and only the resistance values of each layer are analyzed by inversion. In addition, restraining conditions are set so that there are no abrupt changes in the resistance between layers. In this method, analytical results are obtained without giving an initial value so that the same results can be obtained regardless of who the analyst is. The results of Smooth Inversion analysis are used to create an image of the underground structure ("imaging") which is used to get a general idea of changes in resistivity.

Figure 1.7 shows an example of an analysis of the No.4 site of Qaaxo-North area. The diagram on the left side is a theoretical curve of the resistivity structure, while the diagram on the right is an analytical diagram created from Smooth Inversion.

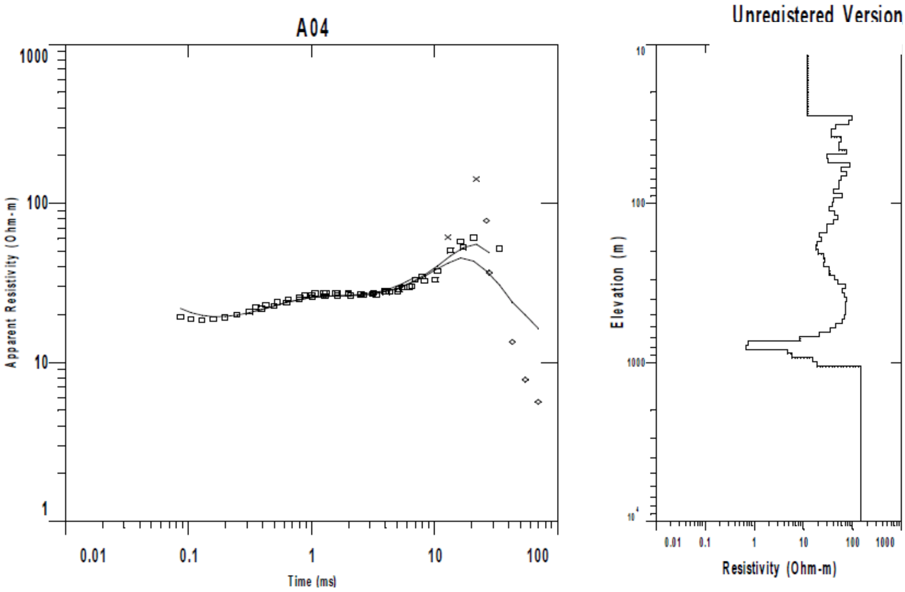



Figure 1.7: Example of Analysis Using Smooth Inversion

### c.2 Structure inversion

If there is an abrupt change in a geological boundary, Structure Inversion is employed to derive accurate information about the depth of layer boundaries because it enables values for resistivity and thickness to be freely varied.

Initial values in Structure Inversion include the number of layers, and resistivity and other values for each layer. Based on these initial values, the most optimal horizontal multi-layer structure is analyzed in the measurement results.
Figure 1.8 shows an example of analysis of the No.4 site of the Qaaxo-North area. The right-hand diagram depicts the results of the structure analysis, with the red line indicating layer structure inversion.

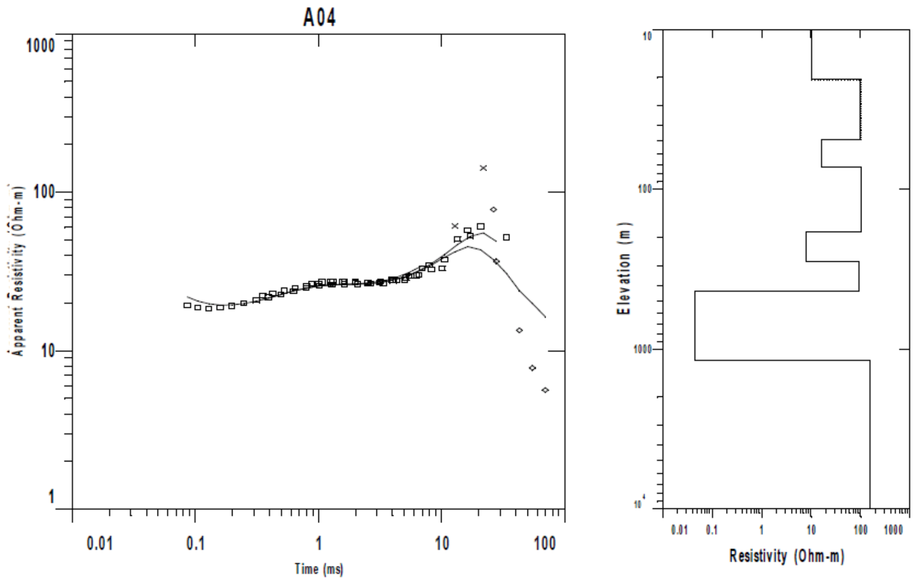



Figure 1.8: Example of Analysis Using Structure Inversion

Figure 1.9 shows the procedure used for analyzing the data in the present study.
After checking such things as dimensions of loops, and values for receiver gain, electrical current, etc., the measured values for each gate were converted into values of apparent resistivity.

$$dB/dt=(V_0\times 19200)／(E\times 2^n)$$

The voltages $V_0$ (in units of mV), which are measured by the PROTEM57(D) system, are converted to magnetic field attenuation rate, *dB/dt* (nV/$m^2$), with the following formula (Geonics, 1992).

$$dB/dt=(V_0\times 19200)／(E\times 2^n)$$

where *E* is the receiver coil moment ($m^2$), and *n* is the amplitude gain setting. Apparent resistivity $\rho_a\ (t)$ (ohm-m) as a function of time is then given by,

$$\rho_a(t)≒(\mu／4\pi t_c)\times(2\mu M／(5t_c dB/dt)^{2/3}$$

where m is magnetic permeability (*4p*$10^{-7}$ in units of H/m), $t_c$ is measurement time or the gate center time in s, and *M* is the transmitter moment which is the product of the loop area ($m^2$) and current (A).

One-dimensional inverse processing is used to obtain one-dimensional resistivity structures which can be assumed to be the layered geological model. In this process, we can estimate structural parameters (e.g., resistivities and thickness) of best fitting models with up to 7 layers using a least squares method called “automatic ridge regression”.

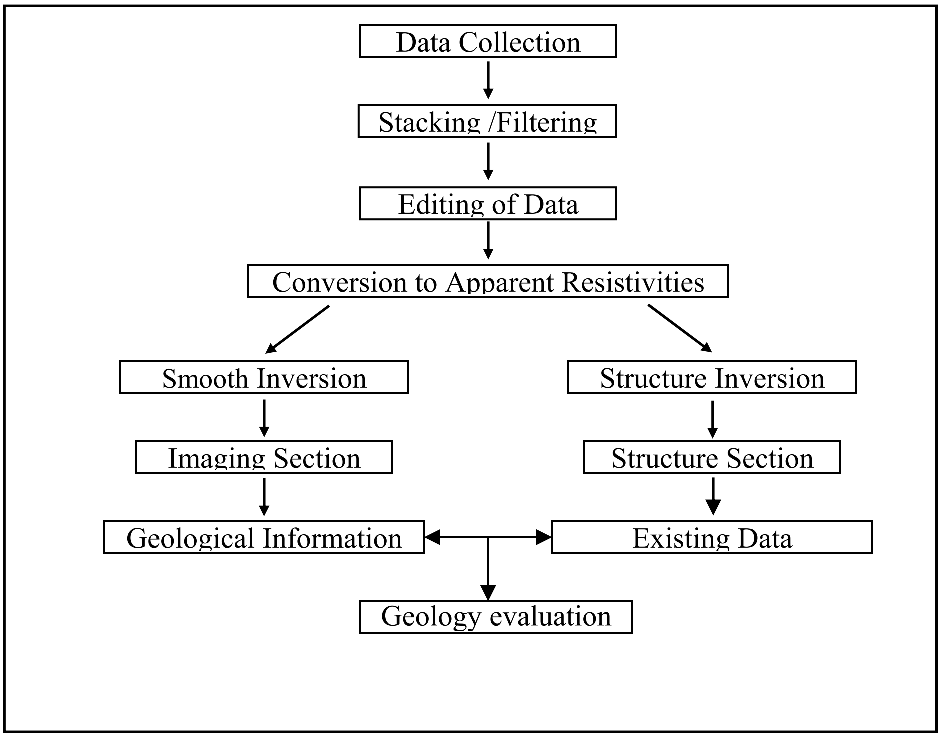



Figure 1.9: Flow of the Analysis

## 1.4 Results of survey and analysis

### 1.4.1 VES

The VES measurement results were compiled as an exploration location map for each area (refer to Figure 1.11 and Figure 1.12), and were also complied as an apparent resistivity distribution map and resistivity profile for each area (refer to Figure 1.14 to Figure 1.18), as VES prospecting measurement data, and VES analytical results diagram (hereinafter Data Book). In addition, photographs showing scenes of the VES prospecting are shown in Data Book.

**a. Qaaxo-North area**

Figure 1.11 shows the prospecting locations in this area. There were 25 measuring points. Figure 1.14 shows 4 types of apparent relative resistivity distribution for 45m～220m below the surface (VES). The depths below the surface are the depths of the positions between current electrodes. It should be noted that the measurement data used to show the distribution of apparent relative resistivity at 150m and 220m may have low reliability, so the interpretation of distribution results was kept to a minimum.

In addition, the structural profile of relative resistivity had 6 measuring lines set up in a NE-SW orientation. The following is a summary of the apparent relative resistivity and the results of the structural profile for relative resistivity for each depth.

**a.1 Distribution map of apparent relative resistivity (Figure 1.14)**

1) The distribution of relative resistivity is similar in all the distribution maps.

2) In each of the distribution maps of apparent relative resistivity, the N-S relative resistivity structure is dominant. There seems to be a discontinuous line of relative resistivity running from measuring point No. 7-1 to No. 28 to No. 15-1, and there is a possibility that there is a lineament traversing the vicinity.

3) The relative resistivity values at 45m below the surface range from 10ohm-m to more than 100ohm-m. On the left (west) side of the distribution map, the relative resistivity is high, while it is low on the right (east) side.

4) The relative resistivity values at 100m below the surface range from 30ohm-m to more than 100ohm-m. As with the previous map, on the left (west) side of the distribution map, the relative resistivity is high, while it is low on the right (east) side.

5) From -150m to -220m as well, relative resistivity is high on the left (west) side, and low on the right (east) side.

**a.2 Profiles of relative resistivity structure (Figure 1.15 and Figure 1.16)**

The VES curves of the measuring points show a high-low-high pattern from the surface down to the deepest section. The main characteristics are as follows:

1) The relative resistivity structure indicates 4～6 layers.
2) The 1st and 2nd layers (and the 3rd in some places) are thin, and show a high-low, or low-high relative resistivity. Below that, from -10m downward, the layers become thicker and the relative resistivity increases. In even deeper sections, the relative resistivity alternates between high and low, but it becomes high in the bottommost section.
3) However, the bottommost layer in profiles 2 and 3 (about 150m below the ground surface) shows low relative resistivity.
4) Discontinuous points of the relative resistivity structure in this area were found in the surface section at measuring points 2 and 3 of Profile 1, and measuring points 14-1 and 15-1 of Profile 4, but these low relative resistivity abnormalities do not continue into deeper sections.

**b. Qaaxo-South area**

Figure 1.12 shows the locations of survey sites in this area. There were 9 measuring points spaced at roughly 300m intervals. In addition, UNHCR was conducting a VES survey in this area (UNHCR, 2011), and the two sets of results were being interpreted together.
The surveying results were compiled into 4 types of apparent relative resistivity (45m～220m below the ground surface), (refer to Figure 1.17) and longitudinal profiles of relative resistivity structure (refer to Figure 1.18). The following is a summary of the main characteristics.

**b.1 Distribution map of apparent relative resistivity (Figure 1.17)**

1) Apparent relative resistivity is predominantly distributed in a N-S direction. Relative resistivity tends to be low on the left (west) side of the plane, and high on the right (east) side.
2) A comparison of distribution maps shows that there is a wide area of low relative resistivity at 45m below the ground, but the area of high relative resistivity expands as

depth increases.

3) About 200m west of measuring point No. 1 there is a river (Waji) which flows from NE to SW, and the rock on the west side seems to have high capability for producing groundwater because it easily fills with river water. Therefore, saturation with river water on the west side may be the cause of the low relative resistivity.
4) The low relative resistivity on this west side appears to be the same even in deep underground areas, suggesting that groundwater development has high potential on the west side.

#### b.2 Profiles of relative resistivity structure (Figure 1.18)

From the surface to the deep underground, the relative resistivity shows a pattern of high-low-high.

1) The relative resistivity structure indicates 4～6 layers.
2) At around AB/2=10m below the ground (layers 2～4), the data for each measuring point show low relative resistivity.
3) However, relative resistivity becomes high in deeper sections.
4) On the surface near measuring points 7 and 8, there was discontinuity in the relative resistivity structure.

### 1.4.2 TEM

The results of the TEM measurements are compiled in the work photos, TEM prospecting measurement data and the TEM analytical results diagram (hereinafter Data Book).
As mentioned earlier, the analysis was conducted using Smooth Inversion to derive the resistivity structure, and Structure Inversion was conducted using 4～8 layers.
Longitudinal resistivity profiles were created based on the results of the two inversions. It should be noted that in the imaging longitudinal profiles of resistivity based on Smooth Inversion, the resistivity values are shown with color bars on the logarithmic axis, which are “warm colors” for areas of high resistivity, and “cool colors” for low resistivity areas.

The characteristics of the resistivity structure at each site are described below.

#### a. Qaaxo-North area

The Qaaxo-North area, on the eastern side of the Jarar Valley, is a pasture, field, and residential area with many rolling hills. There were 22 measuring points here, spaced an average of 500 meters apart, and the elevation ranges from 1,450m～1,520m above sea level (refer to Figure 1.11). In order to create the resistivity longitudinal profiles, 5 measuring lines were set up in the NE-SW direction, and 4 lines were set up in the NW-SE direction. A special effort was made to arrange the points along this longitudinal line.
Figure 1.19 and Figure 1.20 show the resistivity longitudinal profiles made with Smooth Imaging and Figure 1.21 and Figure 1.22 show the resistivity longitudinal profiles made with the Structure Analysis. Figure 1.23 is a resistivity planar diagram made with Smooth Imaging.
The following is a description of the survey results of each measuring line. It should be noted that the values for analytical resistivity were divided into three groups: Low, Medium, and High (see to Table 1.7).

Table 1.7: Classification of Resistivity Values

| Relative resistivity value (ohm-m) | | |
|---|---|---|
| Cool colors | | Warm colors |
| 10 ←→ 20 | 20 ←→ 70 | 70 ←→ |
| Low resistivity | Medium resistivity | High resistivity |

**a.1 Resistivity profiles (Figure 1.19 and Figure 1.20) and structure analysis profiles (Figure 1.21 and Figure 1.22)**

The following is a description of the characteristics of the resistivity longitudinal profiles of the study areas.

1) According to the Smooth Inversion longitudinal profile of resistivity, the surface layers show low to medium resistivity (cool colors), while in deeper areas the resistivity becomes high (warm colors).
2) Generally speaking, the resistivity structure shows stratification.
3) The resistivity structure alternates between low and high resistivity, but at 300m and deeper below the surface, it becomes consistently high.
4) Low resistivity was found at roughly 200m depth in nearly all of the longitudinal profiles.
5) Low resistivity was also found at 200m～300m below the ground surface in profiles 4, 5, 8 and 9.
6) In deep areas near measuring points 4, 19-1, and 24, there was discontinuous distribution of resistivity.

⑦The resistivity longitudinal profiles derived from the Structure Analysis were assumed to consist of 8 layers based on the Smooth Inversion. It should be noted that the display is abbreviated because the surface layer was thin.

⑧Layers 1 to 3 were relatively thin (a few tens of meters), but the layers became thicker from No. 4 downward, There were also areas where No. 6 to the lowest layer, No. 8, were all at least 100 meters thick.

**a.2 Resistivity profiles (Figure 1.23)**

Eight types of resistivity planar diagrams were made for depths of 50ｍ～400ｍ below the ground surface. The following are descriptions of their respective characteristics.

★Planar diagram of 50 meters below the surface

1) Resistivity ranges from medium to high, with medium accounting for about 80%.
2) Resistivity tends to be medium on the SE side, and high on the NW side.
3) There is high resistivity near measuring point No. 23 in the NW.
4) Discontinuity of resistivity distribution was found along a NE-SW line connecting measuring points 11 and 20-1.

★Planar diagram of 100 meters below the surface

1) The distribution diagram and the ratio of medium to high resistivity resemble those of the 50m diagram.
2) At measuring point No. 18 there was medium resistivity at -50m, but it became high at -100m.
3) Discontinuity of resistivity distribution was found along a NE-SW line connecting measuring points 11, 18 and 25.

★Planar diagram of 150 meters below the surface

1) Resistivity ranges from low to medium, and resembles that of the previous diagrams.
2) Resistivity at measuring point No. 2 became low.
3) The area of low resistivity spreads out from measuring point No. 2.
4) Discontinuity of resistivity distribution was found along a NE-SW line connecting measuring points 17 and 20-1.

★Planar diagram of 200 meters below the surface

1) Resistivity ranges from low to medium, with low resistivity accounting for about 40%.
2) The area of low resistivity spreads out from measuring point No. 15-1.
3) The low resistivity at measuring point No. 2 increased somewhat, reaching the medium level.
4) Discontinuity of resistivity distribution was found along a NE-SW line connecting measuring points 23 and 25.

★Planar diagram of 250 meters below the surface

1) Resistivity ranges from low to medium.
2) Unlike the previously described cases, resistivity was high on the SE side and low on the NW side.
3) The area of low resistivity spreads out from measuring point No. 24 in the NW.
4) Discontinuity of resistivity distribution was found along a NE-SW line connecting measuring points 11 and 20-1, and along a NW-SE line connecting measuring points 24 and 14-1.

★Planar diagram of 300 meters below the surface

1) Resistivity ranges from medium to high, but it is higher than at 250m.
2) About 90% of the resistivity is medium.
3) While the low resistivity at measuring point No. 24 does not change, its range of distribution has shrunk.
4) Discontinuity of resistivity distribution was found along a NW-SE line connecting measuring points 24 and 14-1.

★Planar diagram of 350 meters below the surface

1) There is no longer any low resistivity, and the range of high resistivity spreads out.
2) High resistivity accounts for 60% of the total.
3) Discontinuity of resistivity distribution was found along a NW-SE line connecting measuring points 24 and 14-1.

★Planar diagram of 400 meters below the surface

1) As with the 350m diagram, resistivity ranges from medium to high.
2) High resistivity accounts for 80% of the total.
3) Discontinuity of resistivity distribution was found along a NW-SE line connecting measuring points 24 and 14-1.

### b. Qaaxo-South area

This area consists of fields and residences about 1.5 kilometers south of the Jarar Valley water supply system (refer to Figure 1.12). As there was only one measuring point for the security problem, there will be an explanation of the apparent resistivity curve (refer to Figure 1.24) and analytical results instead of longitudinal and planar diagrams of resistivity.

### b.1 Apparent relative resistivity curve and resistivity profiles

1) Because the prospecting depth was more than 10 meters below the ground surface due to the relation with measurement frequency, the analysis did not include calculations of the resistivity and layer thickness immediately below the surface (that is, the resistivity and layer thickness immediately below the surface were unknown). Therefore, depth in the structure analysis diagram that was analyzed with Structure Inversion begins at 10 meters.
2) The analyzed resistivity structure has 7 layers, with values for resistivity gradually increasing from the surface downward.
3) The resistivity ranged from 11～33ohm-m, with little variance in the values.
4) Layers 1, 2, and 4 showed low resistivity, while the others showed a medium level. Resistivity was medium from 210 meters downward.
5) The layers ranged in thickness from 20m to 70m, with No. 6 (70m) being the thickest.

### c. Qaaxo-East area

This area lies along the road leading from Kabribeyah City to the Jarar Valley, and the terrain slopes gently as the valley is approached. There were 19 TEM measuring points which, except for points 1 and 10, were spaced about 1 km apart, at elevations ranging from 1,440m ～1,680m (refer to Figure 1.13).

The analytical results for this area were compiled into longitudinal resistivity profiles using Smooth Inversion and Structure Analysis (refer to Figure 1.25). The characteristics of relative resistivity and stratigraphy are described below.

**c.1 Resistivity profiles and structure analysis profiles (Figure 1.25)**

!) The upper profile shows the results of the Smooth Inversion. With a boundary near measuring point No. 8, the left (SW) and right (NE) sides show differences in resistivity structure.
2) The left (SW) side of the profile shows medium to high resistivity from a few tens of meters to 100 meters below the ground surface. While resistivity starts to becomes low below 100 meters, it becomes high again starting at 300 meters.
3) In contrast, the right (NE) side generally shows low resistivity, especially in the vicinity of measuring points 10 and 15, where it is extremely low at depths below 200m.
4) The bottom part of the profile is a longitudinal resistivity profile based on structure analysis. From the Smooth Inversion results, it can be assumed to have 5 layers. In the surface layer, resistivity ranges from low to high, in the 2$^{nd}$ layer it ranges from low to medium, from medium to high in the 3$^{rd}$ layer, low to medium in the 4$^{th}$ layer, and medium to high in the 5$^{th}$ layer.
5) The 4$^{th}$ layer, at about 200 meters, is thick, while the other layers are relatively thin.
6) From measuring points 10 and 12 toward the northeast, there was no high relative resistivity found in the 5$^{th}$ layer, but there was an expansive area of low resistivity.
7) This low resistivity could be due to one or more factors, including an aquifer, water salinization, fragmentation, the existence of gypsum (a type of evaporite), a fault, and/or lineament.

## 1.5 Comparison among VES, TEM and results of drilling

### 1.5.1 Comparison between the TEM and VES results in the Qaaxo-North area

A comparison was made between TEM and VES results in the excavated areas (refer to Figure 1.26). In the upper part of the figure are 4 planar diagrams showing smooth inversions of TEM results from 50m to 200m below the ground surface. In the lower part of the figure are 4 planar diagrams showing the distribution of VES apparent relative resistivity values for 50m～200m.The depth below the ground with VES shows the locations of current electrode intervals (=AB/2).
Based on the analytical results of each inversion, high relative resistivity is shown with "warm" colors and low relative resistivity is shown with "cool" colors.
First, the VES measurements were taken following the specifications for placement of current electrode and measurements, but the electric current and set resistivity of the potential electrode were high, and there were major differences in apparent relative resistivity. In addition, there were many measuring points that would lose reliability if the electrode series was too developed. Therefore, regarding the relative resistivity for electric prospecting at depths of 150m and 220m, there is a possibility that accurate relative resistivity data could not be obtained for the underground. These distributions were based on the TEM measurement results. However, the two methods are being examined together to make a comprehensive interpretation.

In the TEM method, high-frequency electromagnetic waves reflect ground conditions in shallow areas, while low-frequency electromagnetic waves reflect ground conditions in deep areas. The prospecting depth ranges from a little more than 10 meters to several hundred meters. IX1D ver. 3 software from Interpex, Ltd. (USA) was used to analyze the electrical prospecting. However, analytical values are often biased to the low relative resistivity side, and there are many cases where the analyzed values are lower than the electrical prospecting values.

On the other hand, in the VES method, which is designed to derive relative resistivity which is an electrical property of the ground, potential electrodes are set in the ground. As the intervals become increasingly spaced, the relative resistivity of the ground is measured. The survey depth goes from the shallow section down to a depth of about 200m. In addition, even if there is anisotropy in the ground, there are cases where electrical prospecting cannot detect it, and there are errors with the relative resistivity of ground layers, layer thickness values, and so on. RESIX-P analytical software for electrical prospecting (Interpex Ltd., USA) was used. The analyzed values were often analyzed as shifting toward high relative resistivity, and they were often higher than even the electrical prospecting analytical values.

The following is a summary of the results of comparing the TEM and VES methods.

1) In the present comparison of TEM and VES results, there were some differences seen between the analyzed relative resistivity values; however, the relative resistivity structure showed a similar distribution pattern (layer structure).
2) On the distribution map at 45m～50m below the surface, the relative resistivity tends to be high on the left (west) side, and low on the right (east) side. Relative resistivity values ranged from 30～100+ ohm-m with TEM, and 10～100+ ohm-m with VES, and it is estimated that VES values were several times higher than TEM values. The geological distribution in this area consists of sediments of clay, sand, etc., down to several tens of meters, below which is widely distributed limestone. The west (high relative resistivity) side corresponds with consolidated limestone, while the east side appears to have low relative resistivity due to weathered limestone.
3) On the 100m distribution map, the left (west) side shows high relative resistivity (the same as with the previously mentioned map), while the right (east) side shows medium relative resistivity. In both cases, the values range from 30～100+ ohm-m, and in this distribution map as well, the VES values are higher than the TEM values. In the comparison with geology, the high relative resistivity, like at 45m～50m, is attributed to consolidated limestone, while the medium relative resistivity appears to correspond to weathered limestone.
4) The trend of relative resistivity in the -150m distribution map is, like the previous distribution maps, high on the left (west) side, and low on the right (east) side. However, because there were many measuring points in the VES deep underground results where the measured data were lacking reliability, emphasis was given to the TEM results. The medium relative resistivity on the west side was determined to correspond to semi-consolidated limestone, while it appears that the low to medium relative resistivity on the east side corresponds to an aquifer of weathered limestone or sandstone that contains much water.
5) In the distribution map of -200m～220m, the relative resistivity is medium on the left (west) side, and low on the right (east) side. In this map as well, the geology was considered based on the TEM results. Also, the extent of low to medium relative resistivity is wider than at -150m, with extensive distribution of weathered limestone which shows promise as an aquifer.

### 1.5.2 Selection of drilling points

The area of well drillings which is the source of water for the Jarar Valley water supply system is the Qaaxo-North area, where 2 drilling points were selected. Their locations are shown in Figure 1.27. These two points were selected based on the following criteria:

・Points must provide useful information about hydrogeological conditions in the Jarar Valley area

・Connection with the water supply system should be technologically simple and cost-effective
・It should be determinable whether or not there are layers that have potential as aquifers.
・Vehicle access to the sites is not difficult.
・Sites do not pose problems with land-use.

The main reasons for the selection of candidate sites for well drilling were as follows:

**1) Relative resistivity structure and hydrogeology of this area**

The relative resistivity structure showed roughly 6 layers, as follows (starting from the top): low-high-low-high-low-high.
According to existing geological histograms, there are Pleistocene sediments from the surface down to 27m, Mesozoic limestone from 27m～177m, and shale below 177m. The sediments are composed of clay, mud, sand and gravel, etc. while the limestone contains shale and sandstone. In some places, there may be salinization of water. From a hydrogeological perspective, the limestone layer in the deep section contains much fragmented rock, which can make it a useful aquifer.

**2) Candidate sites for well drilling**

There were 2 candidate well sites in the study area (measuring points 21 and 27). The targeted layers contained limestone, which corresponded to the medium to high relative resistivity of Layer 4 of TEM. The drilling depth was about 200m before reaching the low relative resistivity Layer 5 (which likely has sandstone that contains salt).

### 1.5.3 Comparison with drilling results

VES was used at a well drilling site (measuring point No. 27), while TEM was used at a point about 300m NW of the drilling point (measuring point No. 8). They were still compared with geophysical prospecting results (refer to Figure 1.28). Details are given below.

First, there is a description of the condition and lithofacies of the well drilling (see to Table 1.8). The lithofacies at this site consists of sandstone and weathered limestone sediments from the surface down to -14m, and below that is thick limestone. The underground area consists of weathered and weakly weathered limestone from 14m～43m; alternating layers of marl, sand and limestone from 43m～66m; sandy limestone from 66m～79m; marl and sand from 79m～85m; fissured limestone from 86m～96m; marl from 96m～98m; alternating layers of marl, sand and limestone from 98m～108m; massive, hard limestone (gray with green belts) from 108m～130m; and from 130m downward there is gray sandstone that has developed fissures.

Table 1.8: Comparison between Geology and Geophysical Survey Results in Drilling Sites

| Depth (m) | Geology | VES Measuring point 27 | | | TEM Measuring point 8 | | |
|---|---|---|---|---|---|---|---|
| | | Layer | Depth (m) | Relative resistivity (ohm-m) | Layer | Depth(m) | Relative resistivity (ohm-m) |
| 0～14<br>14～43 | Sediment layer<br>Weathered/weakly weathered limestone | 1<br>2<br>3 | 0～0.4<br>0.4～1.7<br>1.7～31 | 38<br>30<br>60 | 1 | 0～32 | 44 |
| 43～66 | Alternating Marl/Sand/Limestone | 4 | 31～53 | 57 | 2 | 32～49 | 93 |
| 66～79<br>79～85 | Sandy limestone<br>Marl/Sand | 5 | 53～132 | 154 | 3<br>4 | 49～92<br>92～185 | 29<br>74 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 86～96<br>96～98<br>98～108<br>108～130 | Fissured limestone<br>Marl<br>Alternating<br>Marl/Sand/Limestone<br>Massive limestone | | | | | | |
| 130～177 | Fissured sandstone | 6 | 132～ | 54 | 4<br>5 | 92～185<br>185～276 | 74<br>10 |
| − | − | − | − | − | 6 | 276～ | 180 |

The survey depth of VES was sufficient to acquire relative resistivity data from immediately below the ground surface, but with TEM relative resistivity data could be acquired from more than 10 meters below the surface. The relative resistivity structure for VES (measuring point No. 27) and TEM (measuring point No. 8) showed 6 layers. In the two cases, the relative resistivity structure is roughly similar, although there are differences in depths and relative resistivity values. A comparison of the relative resistivity of layers 1～3 of VES with Layer 1 of TEM shows what appears to be TEM values being the average of VES values. Lower sections have high resistivity, especially VES Layer 5 and TEM Layer 4. The low relative resistivity values in lower layers tend to be extremely similar. This high relative resistivity apparently corresponds to alternating layers of marl/sand/limestone, massive limestone, and so on. The low relative resistivity in deeper sections may be due to the occurrence of groundwater from fissured sandstone. However, while Layer 5 seems to correspond to low relative resistivity with TEM, there was a difference in depth of 55m, making it impossible to get an accurate location of this layer.

## 1.6 Hydrogeological interpretation by the results of geophysical survey

The relative resistivity values can show a range even in the same type of rock, and at the same time there are some cases of identical values in different types of rock. This makes it difficult to estimate rock types merely from relative resistivity values.
In most cases, the relative resistivity of limestone distributed in this area ranges from a few ohm-m to several thousand ohm-m, while the relative resistivity of shale ranges from less than 1 ohm-m to a few tens of ohm-m (Geophysical Exploration, 1989). Therefore, the relative resistivity of limestone can be expected to be higher than that of shale. Based in part on the relative resistivity structure, etc., that were derived from physical prospecting in each area, this section describes the conditions of aquifers and ground layers (for example, fault, fragmentation zone, weathered zone, etc.).

### 1.6.1 Qaaxo-North area

A geological histogram of the existing well near measuring point No. 5 is shown in the following Table 1.9. It should be noted that this well is not currently in use.

Table 1.9: Geology of Existing Wells near Points No.5

| Depth(m) | Geology | Lithological description | Stratigraphy |
|---|---|---|---|
| 0～2 | Clay | Clay dark top soil | CEINOZOIC<br>Alluvial Sediment |
| 2～13 | Clay | Reddish clay | |
| 13～22 | Sand | Medium grained sand | |
| 22～27 | Sand | Fine grained sand | |
| 27～38 | Limestone | White limestone | MESOZOIC<br>Hamanlei Series |
| 38～107 | Limestone | Crystalline limestone | |
| 107～177 | Limestone | Gray limestone interbedded with shale | |
| 177～180 | Shale | Dark shale | |

In addition, the following Table 1.10 is a compilation of the TEM results reported for the Qaaxo-North area.

Table 1.10: Details of TEM Results of the Qaaxo-North Area

| | Planar map of relative resistivity | | | |
|---|---|---|---|---|
| | 50m～100m below ground | 150m～200m below ground | 250m～300m below ground | 350m～400m below ground |
| Range of relative resistivity | Medium- high | Low- medium | Low- high | Medium- high |
| Area of low resistivity | None | Around measuring points 2 and 15-1 | Around measuring point 24 | None |
| Area of medium resistivity | Wide area on SE side | Wide area | Wide area on SE side | Near measuring points 3 and 24 |
| Area of high resistivity | Around measuring point 23 | None | Near measuring point 17 | Wide area |
| Discontinuous distribution of relative resistivity | Oriented along measuring points 11～20-1 | Direction of MP 17- 20-1, Direction of MP 23- 25 | Direction of MP 11- 20-1, Direction of MP 24- 14-1, | Direction of MP 24- 14-1, |
| Likely ground layers | NE side: unconsolidated limestone<br>SE side: semi-consolidated limestone | NE side: semi-consolidated limestone<br>Near MPs 2, 15-1 ; weathered limestone, shale | Near MP 24 ; unconsolidated sandstone<br>SE side ; consolidated shale, sandstone | Consolidated shale, sandstone |
| Aquifer | No potential | Potential for existence in wide areas on SE side | In vicinity of MP 24, potential down to -250m | No potential |

The table is summarized as follows:

1) From the ground surface to about -50m, there are sediments of clay, sand, etc. which overlie widely distributed un- and semi-consolidated weathered limestone. From around -150m there are limestone and shale and sandstone that have fragmented, and this appears to continue down to about -250m. The area below -300m appears to be base rock composed of consolidated shale and sandstone.

2) Discontinuity of relative resistivity lies along a NE-SW line connecting measuring points 11 and 20-1, and along a NW-SE line connecting measuring points 24 and 14-1

3) It is possible that an aquifer exists 150m～250m below the ground surface, especially on the SE side.

### 1.6.2 Qaaxo-South area

The hydrogeology of the Qaaxo-South area is derived in the following Table 1.11 based on existing well PB1 (= point VES3).

Table 1.11: Geology of Existing Well PB1

| Depth(m) | Geology | Lithological description | Stratigraphy |
|---|---|---|---|
| 0～20 | Clay/sand | Clay with fine to coarse sand | CENOZOIC Alluvial Sediment |
| 20～25 | Marl | Calcite | |
| 25～60 | Limestone | Yellow limestone, weathered | |
| 60～70 | Marl | Dark gray marl limestone | MESOZOIC Hamanlei Series |
| 70～105 | Limestone | Yellow limestone, weathered | |
| 105～110 | Marl | Dark gray marl limestone | |
| 110～150 | Limestone | Sandy limestone | |
| 150～168.5 | Sand | Fine to coarse sand | |

The following Table 1.12 shows the TEM results and a comparison with the geology

Table 1.12: Comparison of the Geology at Existing Well PB1 and Analytical Results

| Depth (m) | Geology | Measuring point No. 1 | | |
|---|---|---|---|---|
| | | Layer | Depth (m) | Relative resistivity (ohm-m) |
| 0～20 | Clay/Sand | 1 | 0～23 | 11 |
| 20～25 | Marl | 2 | 23～64 | 14 |
| 25～60 | Limestone | | | |
| 60～70 | Marl | 3<br>4 | 64～85<br>85～117 | 21<br>17 |
| 70～105 | Limestone | | | |
| 105～110 | Marl | | | |
| 110～150 | Limestone | 5 | 117～140 | 31 |
| 150～168.5 | Sand | 6 | 140～211 | 22 |
| — | — | 7 | 211～ | 33 |

1) There were differences in the relative resistivity in Layers 1 ～2 and 3～7.
2) Relative resistivity in the upper parts (layers 1 and 2) was low, but it was high in the lower parts (layers 3～7)
3) For the upper layers, comparisons were made of sedimentary clays/sandstone, marl, limestone of the Holocene, and for the lower layers comparisons were made with Hamanlei series mudstone, limestone and sand of the Mesozoic.
4) Because the aquifer of existing wells is in Hamanlei series limestone of the Mesozoic, it appears that this corresponds to the limestone of layers 4-6 and/or the sandstone from Layer 6 and deeper.

### 1.6.3 Qaaxo-East area

The hydrogeology of this area, based on existing well EB2, is described in the following Table 1.13.

Table 1.13: Geology of Existing Well EB2

| Depth(m) | Geology | Lithological description | Stratigraphy |
|---|---|---|---|
| 0～3.5 | Clay | Soil, rounded gravel and clay | CENOZOIC<br>Alluvial Sediment |
| 3.5～56 | Limestone | Limestone with grain of Calcite, OZ, MG, Oxydes | MESOZOIC<br>Hamanlei Series |
| 56～75 | Limestone | Blue marls with thin layers of limestone | |
| 75～95 | Marl | Limestone marl, Marly limestone | |
| 95～127 | Marl | Blue marl, Clay | |
| 127～172 | Limestone | Greyish calcareous sandstone | |
| 172～176.5 | Sandstone | Hard sandstone | |

The following Table 1.14 shows a comparison between the geology of existing well EB2 and the analytical results.

Table 1.14: Comparison between the Geology of EB2 and the Analytical Results

<table>
<tr><th rowspan="2">Depth(m)</th><th rowspan="2">Geology</th><th colspan="3">Measuring point 1-1</th><th colspan="3">Measuring point 1</th></tr>
<tr><th>Layer</th><th>Depth(m)</th><th>Relative resistivity(ohm-m)</th><th>Layer</th><th>Depth (m)</th><th>Relative resistivity (ohm-m)</th></tr>
<tr><td>0～3.5</td><td>Clay</td><td rowspan="2">1～3</td><td rowspan="2">0～25<br>25～36<br>36～50</td><td rowspan="2">14<br>66<br>34</td><td rowspan="2">1～3</td><td rowspan="2">0～30<br>30～42<br>42～54</td><td rowspan="2">15<br>130<br>57</td></tr>
<tr><td>3.5～56</td><td>Limestone</td></tr>
<tr><td>56～75</td><td>Limestone</td><td rowspan="2">4</td><td rowspan="2">50～107</td><td rowspan="2">92</td><td rowspan="2">4</td><td rowspan="2">54～105</td><td rowspan="2">111</td></tr>
<tr><td>75～95</td><td>Marl</td></tr>
<tr><td>95～127</td><td>Marl</td><td rowspan="4">5</td><td rowspan="4">107～310</td><td rowspan="4">18</td><td rowspan="4">5</td><td rowspan="4">105～308</td><td rowspan="4">25</td></tr>
<tr><td>127～172</td><td>Limestone</td></tr>
<tr><td>172～176.5</td><td>Sandstone</td></tr>
<tr><td>—</td><td>—</td></tr>
<tr><td>—</td><td>—</td><td>6</td><td>310～</td><td>47</td><td>6</td><td>308～</td><td>119</td></tr>
</table>

The following is a comparison between the geology of existing well EB2 and the analytical results of measuring points 1 and 1-1.

1) Comparisons were made with the surface soil (clay) and limestone in layers 1-3, the limestone and marl in Layer 4, and the marl and sandstone in Layer 5. It appears that Layer 6 is very dense sandstone that forms the base rock.
2) According to the hydrogeological interpretation, the high relative resistivity down to about 100 meters below the surface in Layer 4 is limestone and/or marl that does not contain groundwater; below that, down to about 300 meters (Layer 5), the low relative resistivity suggests limestone that is saturated with groundwater.
3) The layers extend to the vicinity of measuring point No. 8, but after that the geology changes on the NE side.
4) In the vicinity of measuring points 10 and 15, there appears to be particular discontinuity. These areas may be weathered and/or fragmented layers and base rock, and/or the geology may be saturated with groundwater.

In addition, the geological structure estimated based on the TEM results and the relative resistivity profiles are as follows:

1) Near measuring point No. 8 there is a boundary between the relative resistivity of the Jarar Valley side, and that of the Kabribeyah City side, which are different.
2) The low relative resistivity spreads out from measuring points 10 and 12 to the deep underground section of the Kabribeyah City side.
3) This low relative resistivity indicates the existence of a good quality aquifer, groundwater that has a high salt content, unconsolidated rock, the formation of gypsum, faults, and so on.

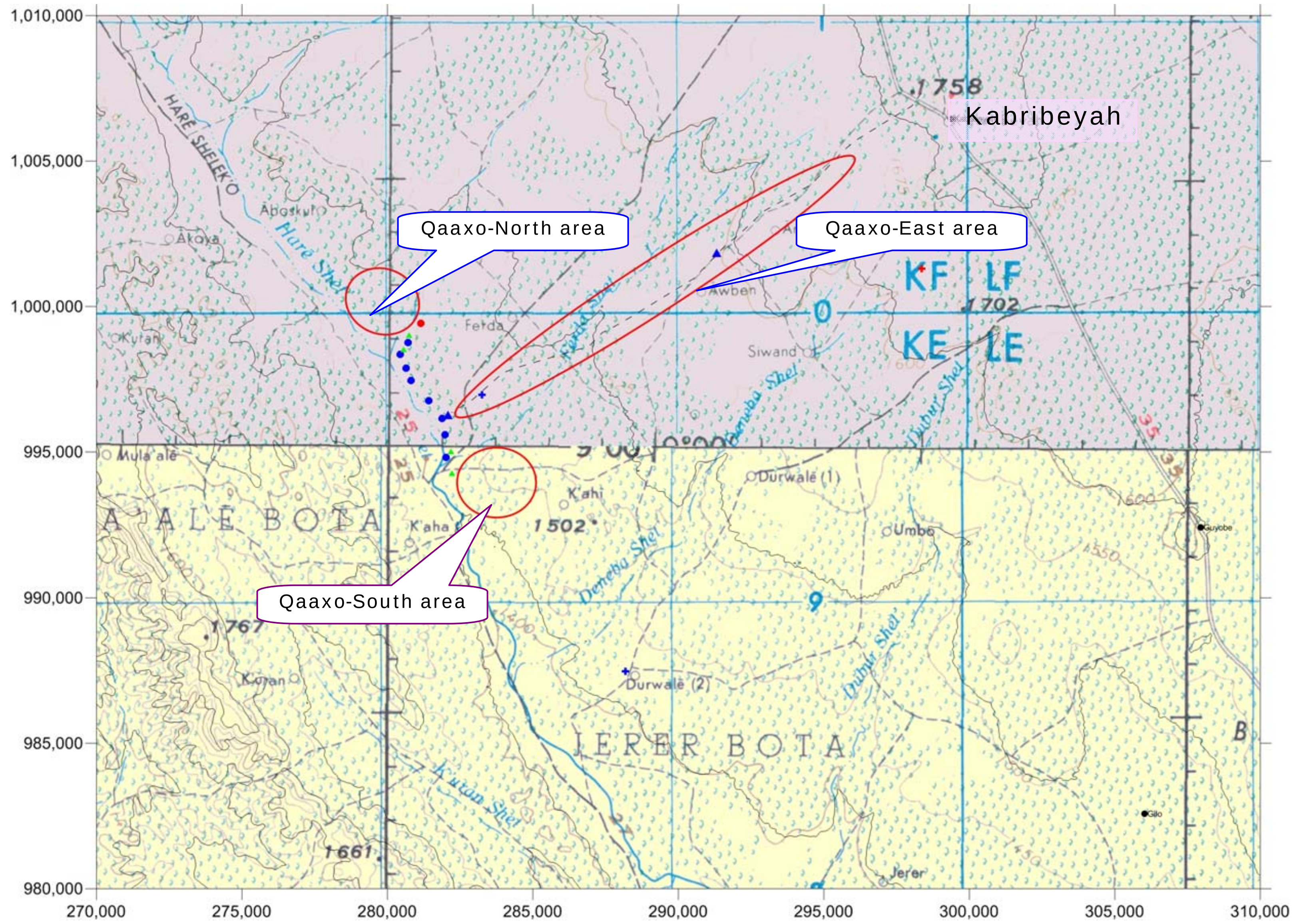
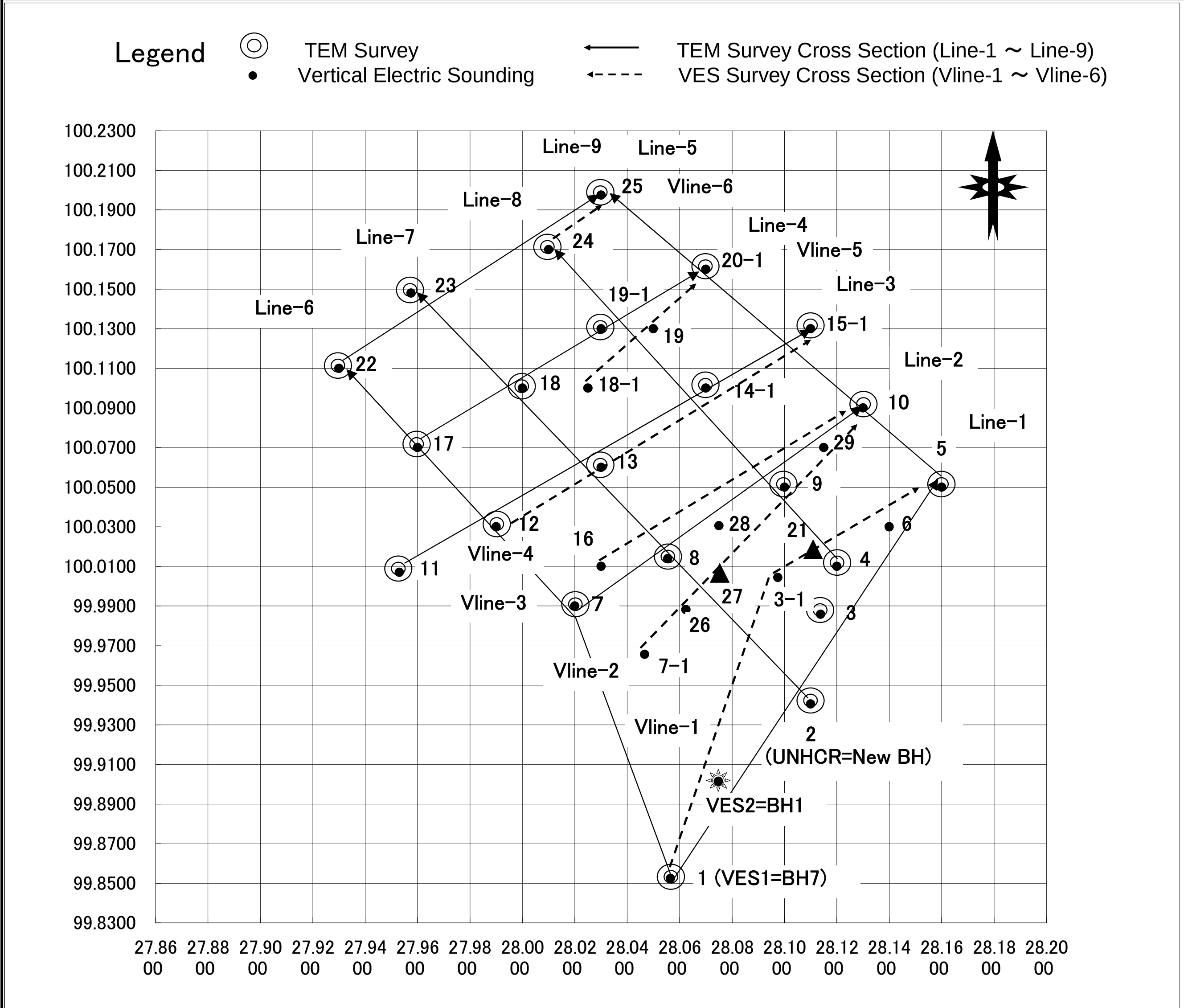
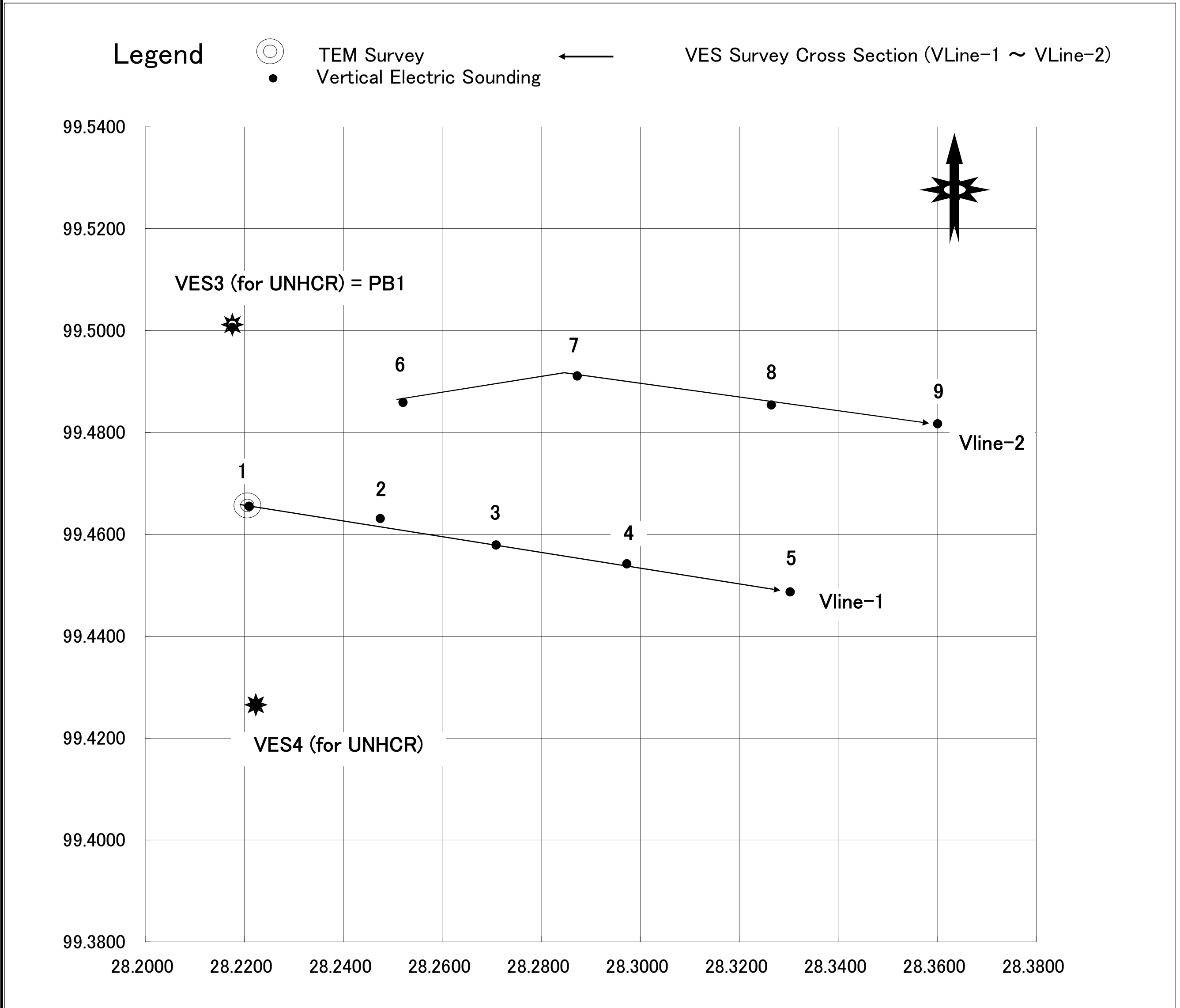



Figure 1.10: Geophysical Survey Location Map



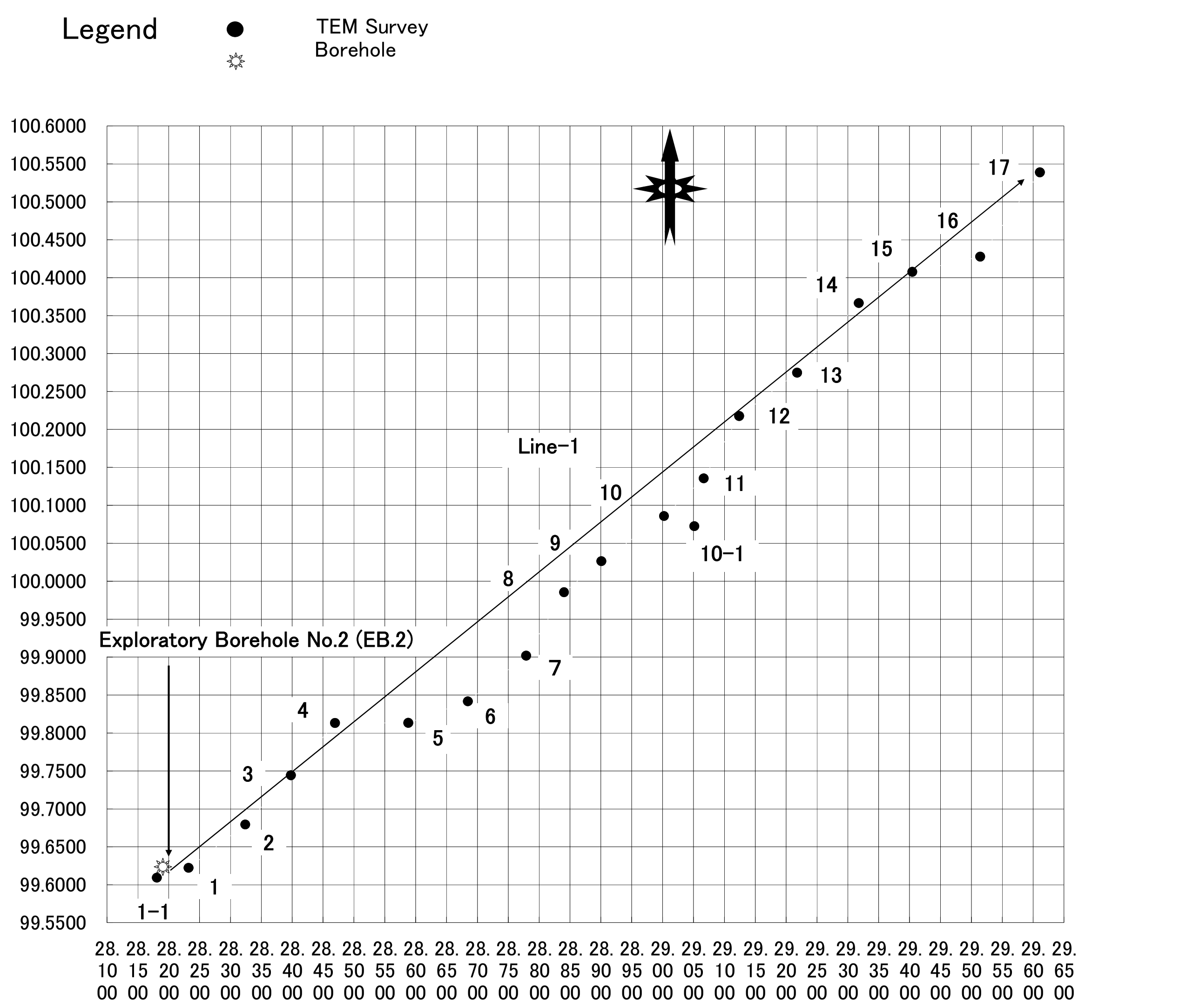

| TEM | VES | BH Point | No. | LNG | LAT | ELE(m) |
|---|---|---|---|---|---|---|
| ◎ | ● | | 1 | 280565 | 998525 | 1453 |
| ◎ | ● | | 2 | 281100 | 999405 | 1454 |
| ◎ | — | | 3 | 281138 | 999858 | 1455 |
| — | ● | | 3−1 | 280975 | 1000044 | 1465 |
| ◎ | ● | | 4 | 281212 | 1000110 | 1464 |
| ◎ | ● | | 5 | 281600 | 1000500 | 1465 |
| — | ● | | 6 | 281400 | 1000300 | 1464 |
| ◎ | — | | 7 | 280200 | 999900 | 1475 |
| — | ● | | 7−1 | 280466 | 999656 | 1466 |
| ◎ | ● | | 8 | 280555 | 1000139 | 1475 |
| ◎ | ● | | 9 | 281000 | 1000502 | 1471 |
| ◎ | ● | | 10 | 281300 | 1000900 | 1468 |
| ◎ | — | | 11 | 279530 | 1000070 | 1463 |
| ◎ | ● | | 12 | 279900 | 1000300 | 1492 |
| ◎ | ● | | 13 | 280300 | 1000600 | 1492 |
| ◎ | ● | | 14−1 | 280700 | 1001000 | 1487 |
| ◎ | ● | | 15−1 | 281100 | 1001300 | 1486 |
| — | ● | | 16 | 280300 | 1000100 | 1481 |
| ◎ | — | | 17 | 279600 | 1000700 | 1499 |
| ◎ | — | | 18 | 280000 | 1001000 | 1496 |
| — | ● | | 18−1 | 280250 | 1001000 | 1495 |
| — | ● | | 19 | 280500 | 1001300 | 1513 |
| ◎ | — | | 19−1 | 280300 | 1001300 | 1510 |
| ◎ | ● | | 20−1 | 280700 | 1001600 | 1506 |
| — | ● | ▲ | 21 | 281111 | 1000179 | 1473 |
| ◎ | — | | 22 | 279300 | 1001100 | 1504 |
| ◎ | — | | 23 | 279575 | 1001480 | 1523 |
| ◎ | ● | | 24 | 280100 | 1001700 | 1515 |
| ◎ | ● | | 25 | 280300 | 1001975 | 1514 |
| — | ● | | 26 | 280624 | 999882 | 1471 |
| — | ● | ▲ | 27 | 280756 | 1000042 | 1470 |
| — | ● | | 28 | 280750 | 1000305 | 1471 |
| — | ● | | 29 | 281150 | 1000700 | 1470 |
| — | — | | VES2 | 280748 | 999015 | |

Figure 1.11: Qaaxo-North Area Measurement Point Map




| TEM | VES | No. | LNG | LAT | ELE(m) |
|---|---|---|---|---|---|
| ◎ | ● | 1 | 282210 | 994655 | 1424 |
| | ● | 2 | 282475 | 994631 | 1424 |
| | ● | 3 | 282709 | 994579 | 1427 |
| | ● | 4 | 282973 | 994542 | 1435 |
| | ● | 5 | 283303 | 994487 | 1444 |
| | ● | 6 | 282521 | 994859 | 1426 |
| | ● | 7 | 282873 | 994911 | 1432 |
| | ● | 8 | 283265 | 994854 | 1438 |
| | ● | 9 | 283601 | 994817 | 1442 |
| | – | VES3 | 282176 | 995006 | 1411 |
| | – | VES4 | 282223 | 994265 | 1408 |

Figure 1.12: Qaaxo-South Area Measurement Point Map




| No. | LNG | LAT | ELE(m) |
|---|---|---|---|
| 1 | 282323 | 996222 | 1441 |
| 1-1 | 281809 | 996093 | 1423 |
| 2 | 283242 | 996794 | 1477 |
| 3 | 283981 | 997442 | 1500 |
| 4 | 284694 | 998131 | 1505 |
| 5 | 285881 | 998133 | 1495 |
| 6 | 286845 | 998417 | 1508 |
| 7 | 287791 | 999018 | 1540 |
| 8 | 288405 | 999854 | 1550 |
| 9 | 289008 | 1000264 | 1545 |
| 10 | 290023 | 1000859 | 1541 |
| 10-1 | 290315 | 1000525 | 1584 |
| 11 | 290668 | 1001355 | 1584 |
| 12 | 291242 | 1002177 | 1599 |
| 13 | 292180 | 1002747 | 1621 |
| 14 | 293179 | 1003665 | 1626 |
| 15 | 294046 | 1004076 | 1639 |
| 16 | 295144 | 1004278 | 1663 |
| 17 | 296112 | 1005388 | 1679 |
| EB2 | 281869 | 996155 | 1427 |

Figure 1.13: Qaaxo-East Area Measurement Point Map

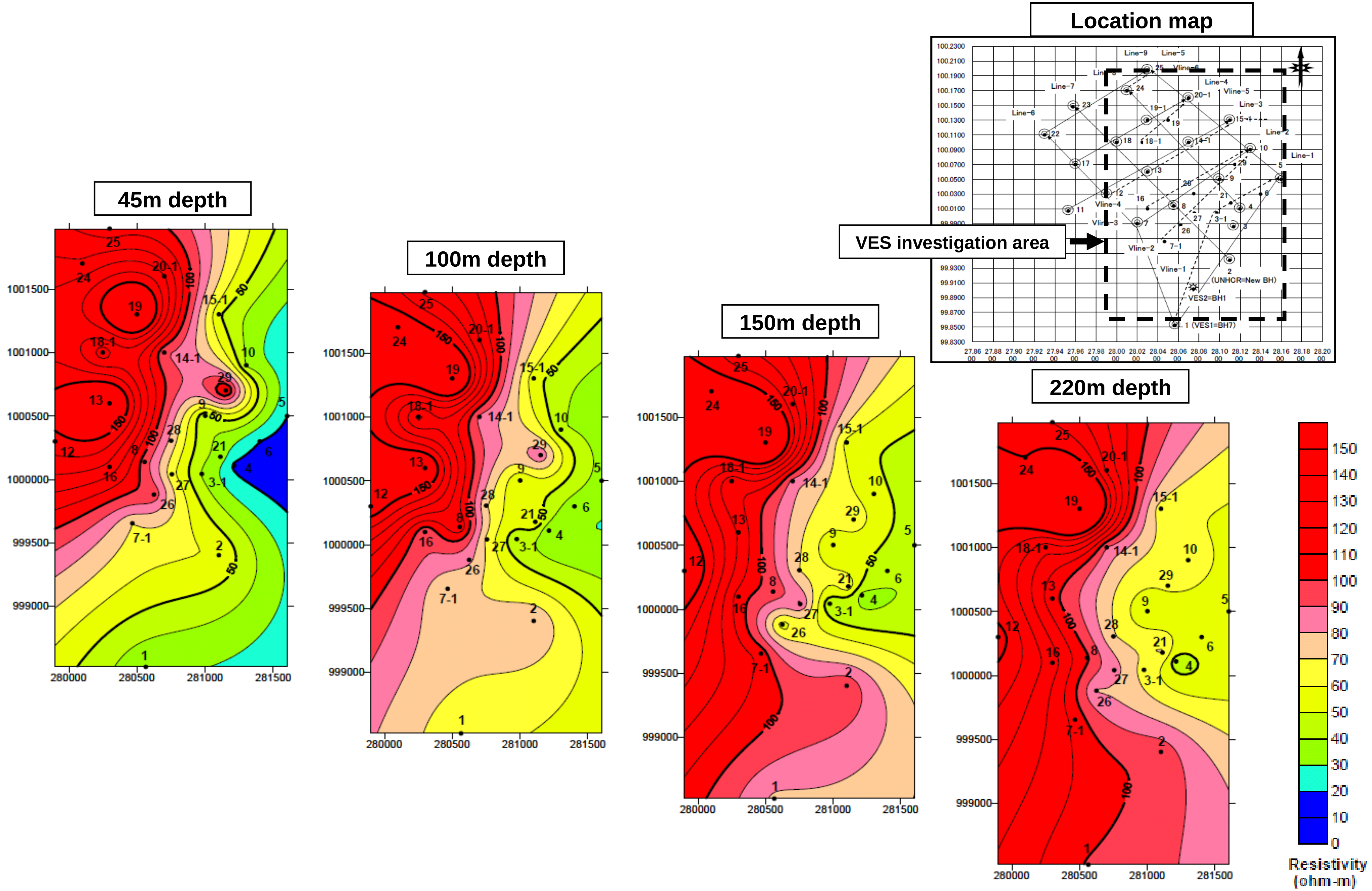



Figure 1.14: Qaaxo-North Area Apparent Resistivity Distribution Map

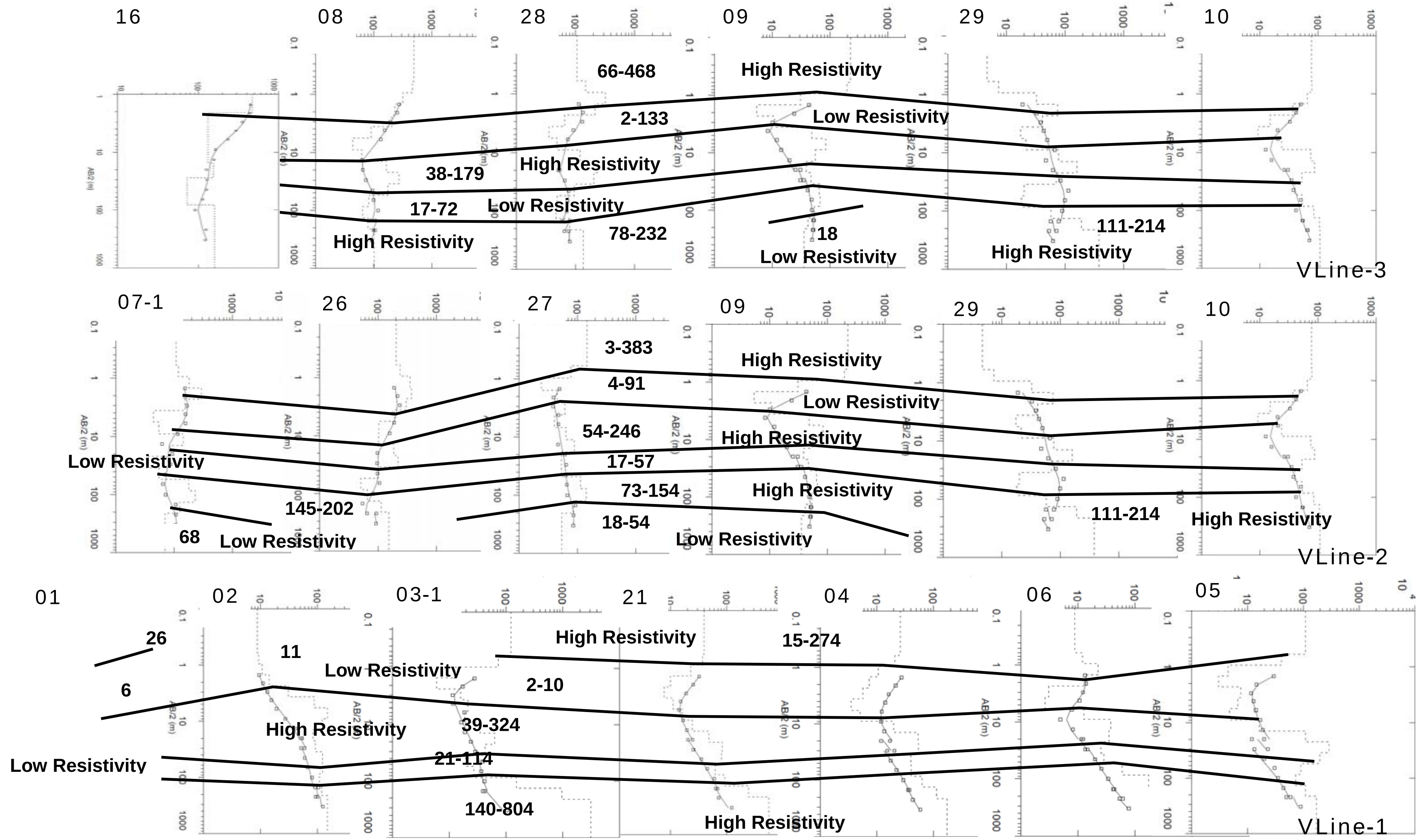


Figure 1.15: Qaaxo-North Area Resistivity Profile (Line1 to 3)

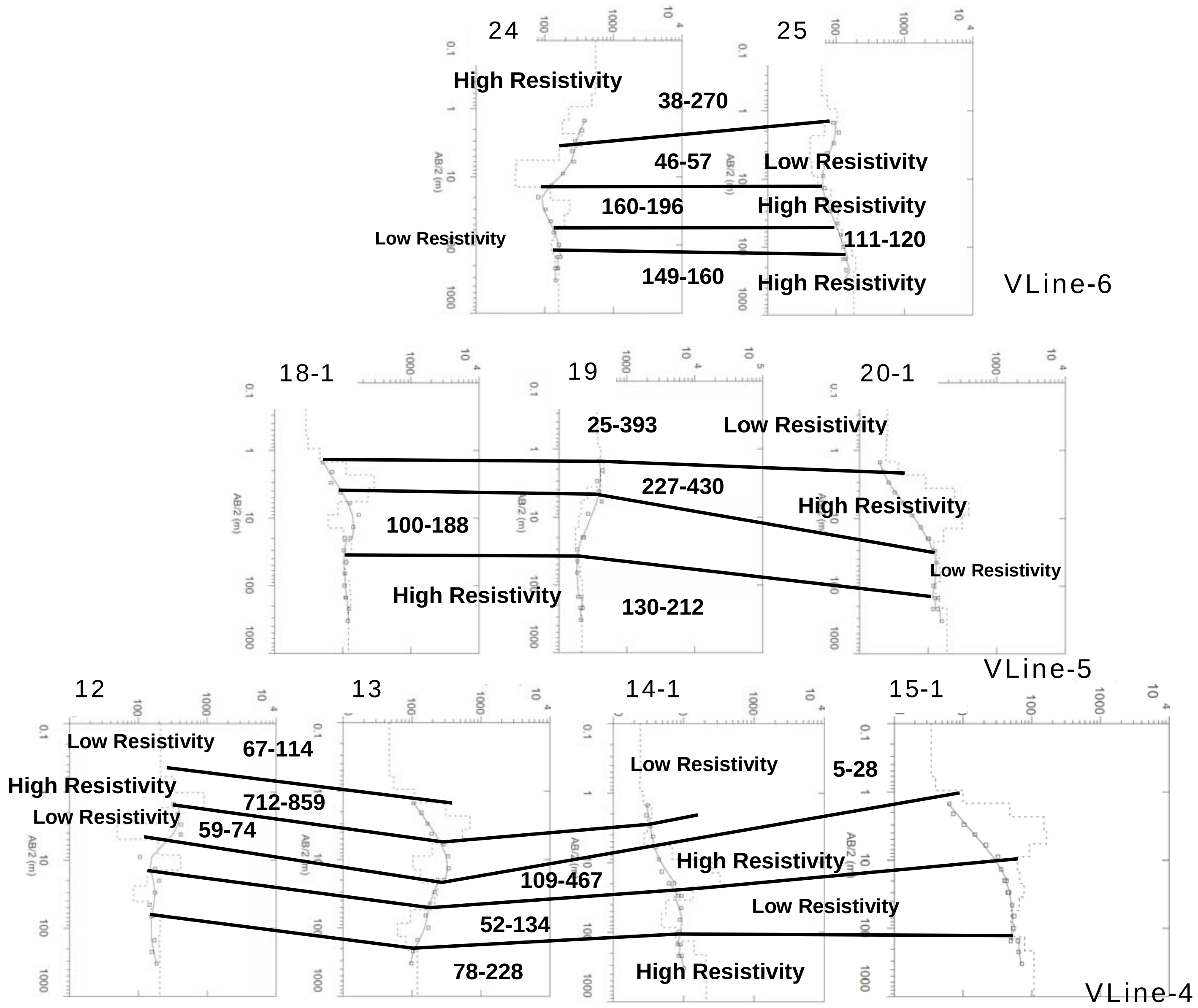



Figure 1.16: Qaaxo-North Area Resistivity Profile (Line4 to 6)

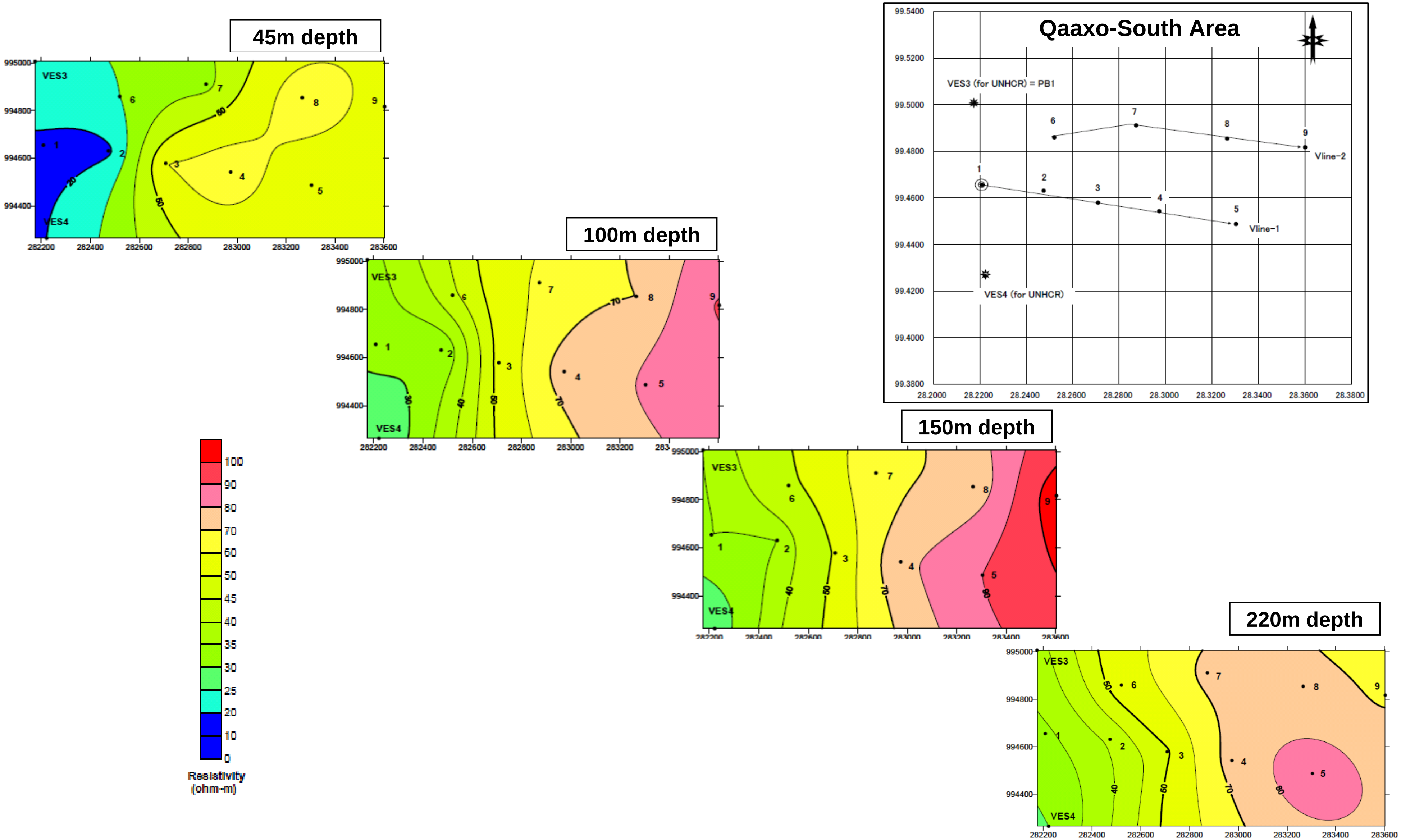



Figure 1.17: Qaaxo-South Area Apparent Resistivity Distribution Map

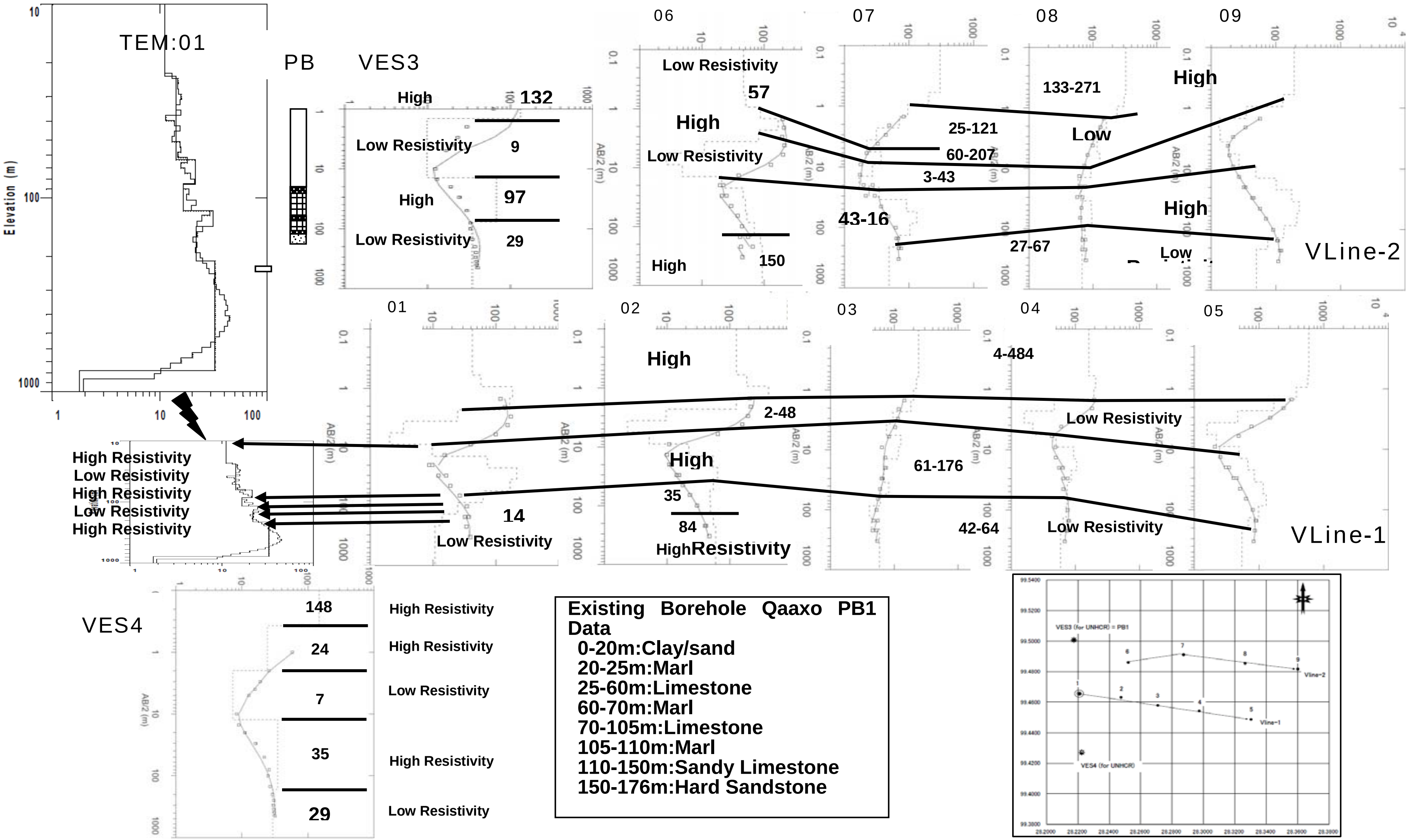



Figure 1.18: Qaaxo-South Area Resistivity Profile (Line1 to 2)

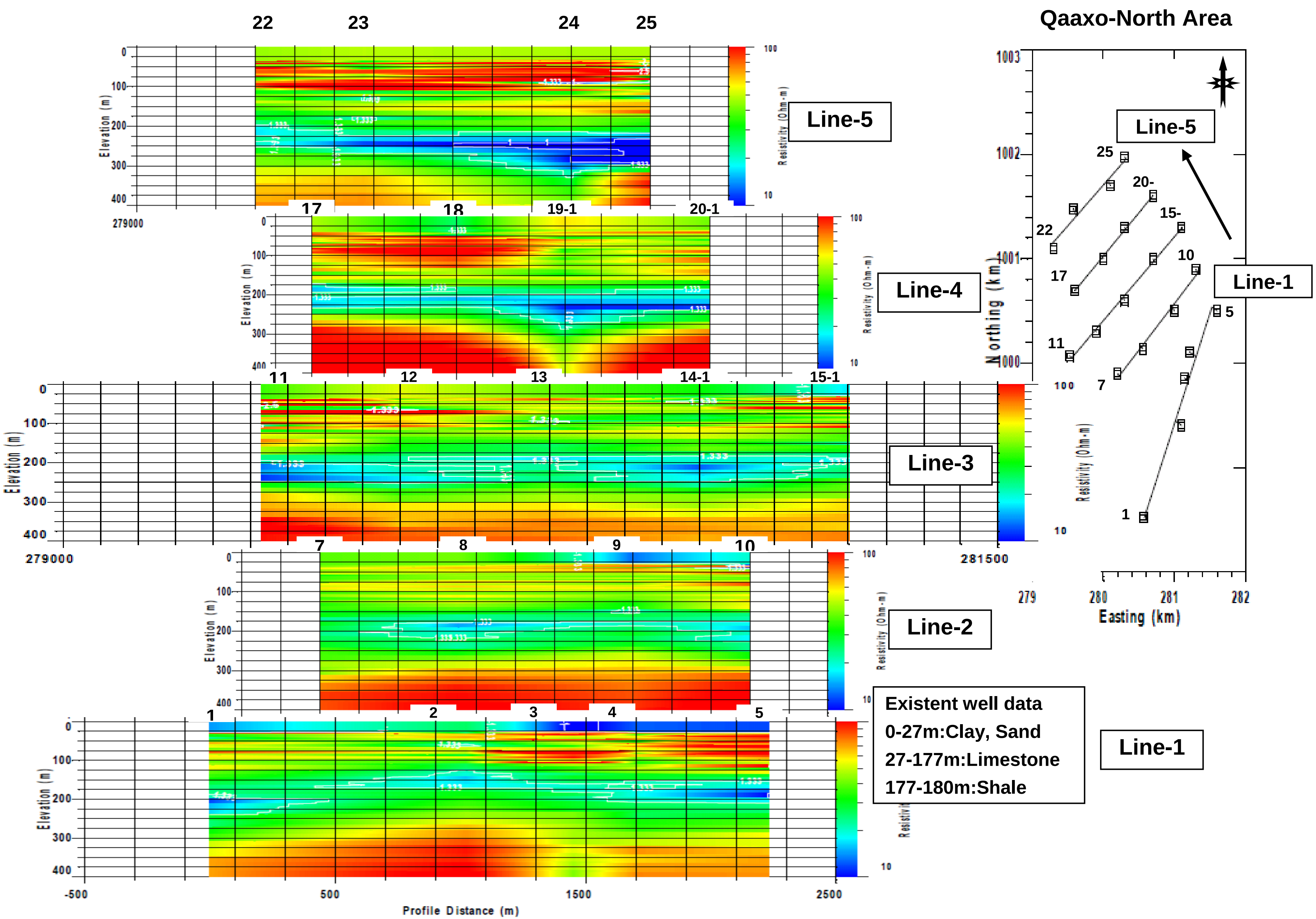



Figure 1.19: Smooth Imaging Resistivity Profile (Qaaxo-North Area, Line1 to 5)

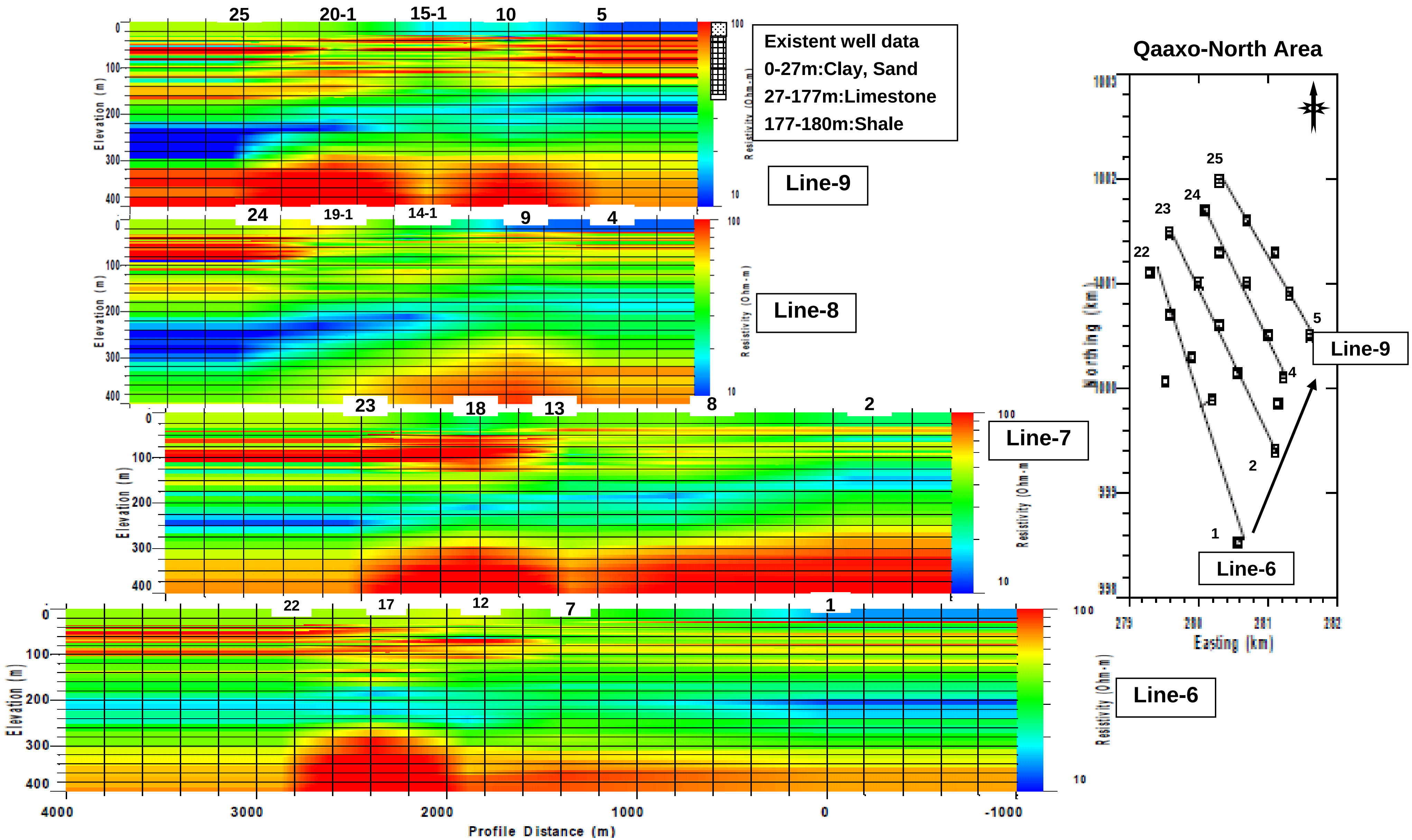



Figure 1.20: Smooth Imaging Resistivity Profile (Qaaxo-North Area, Line 6 to 9)

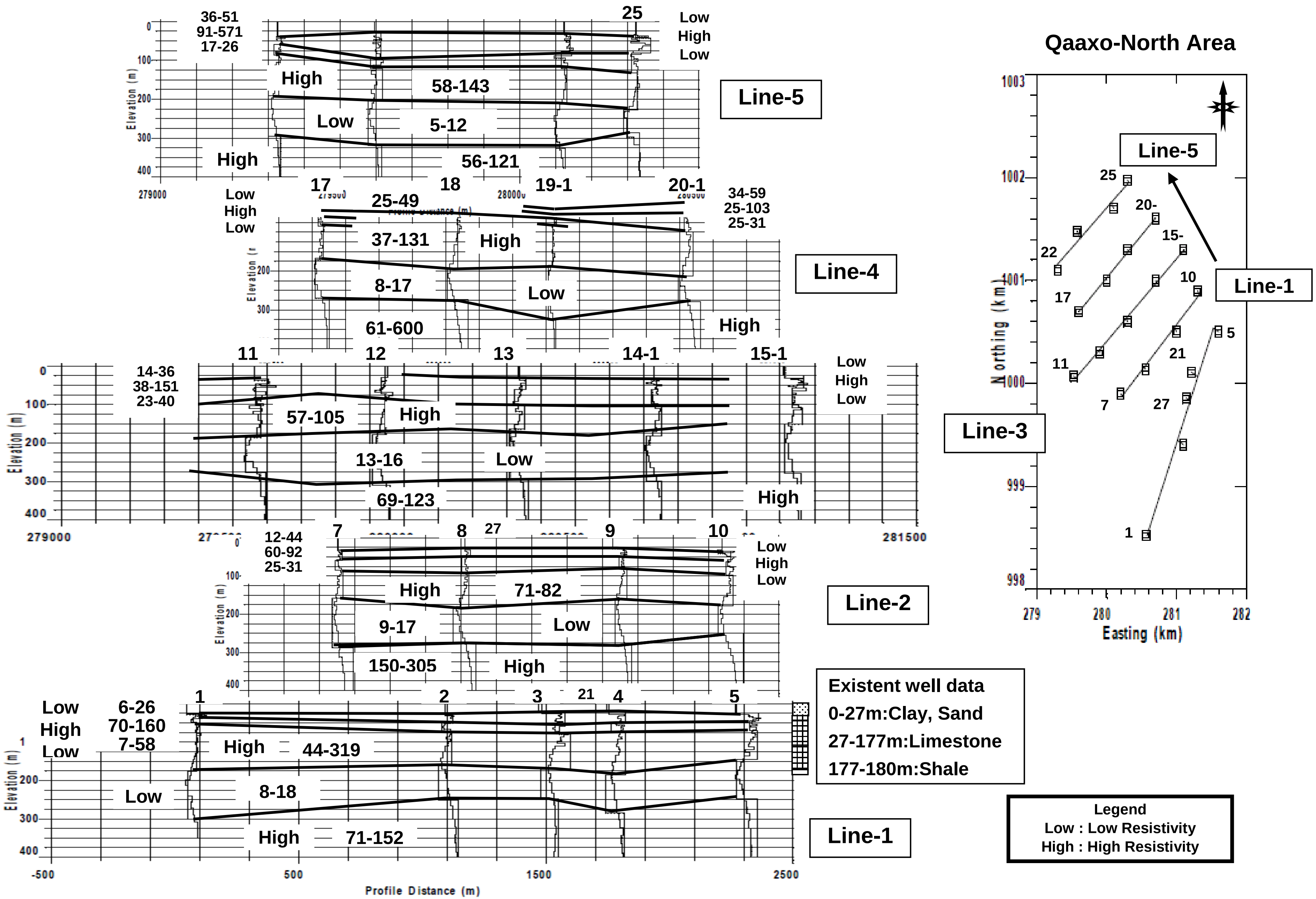



Figure 1.21: Structural Analysis Profiles (Qaaxo-North Area, Line 1 to 5)

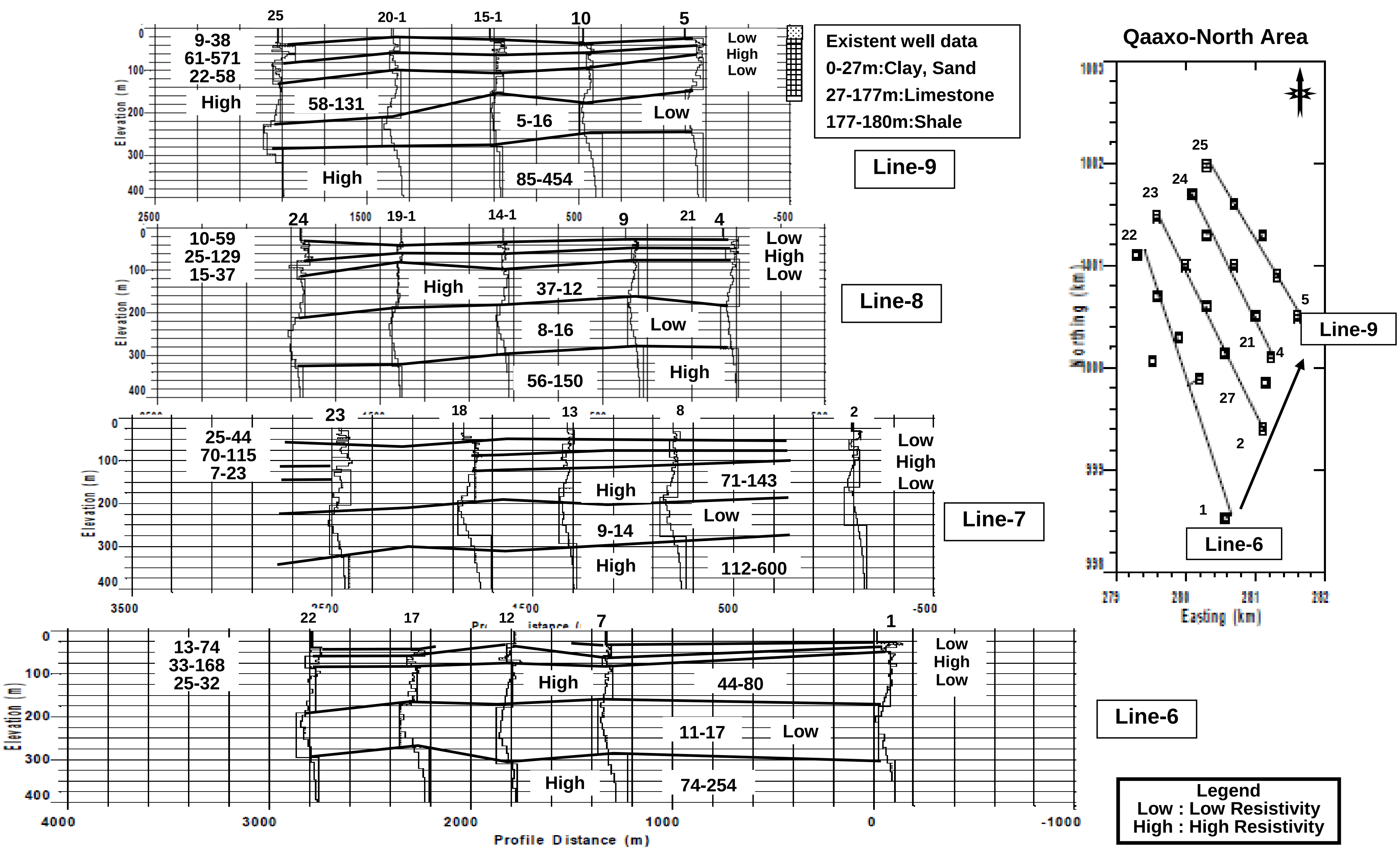



Figure 1.22: Structural Analysis Profiles (Qaaxo-North Area, Line 6 to 9)

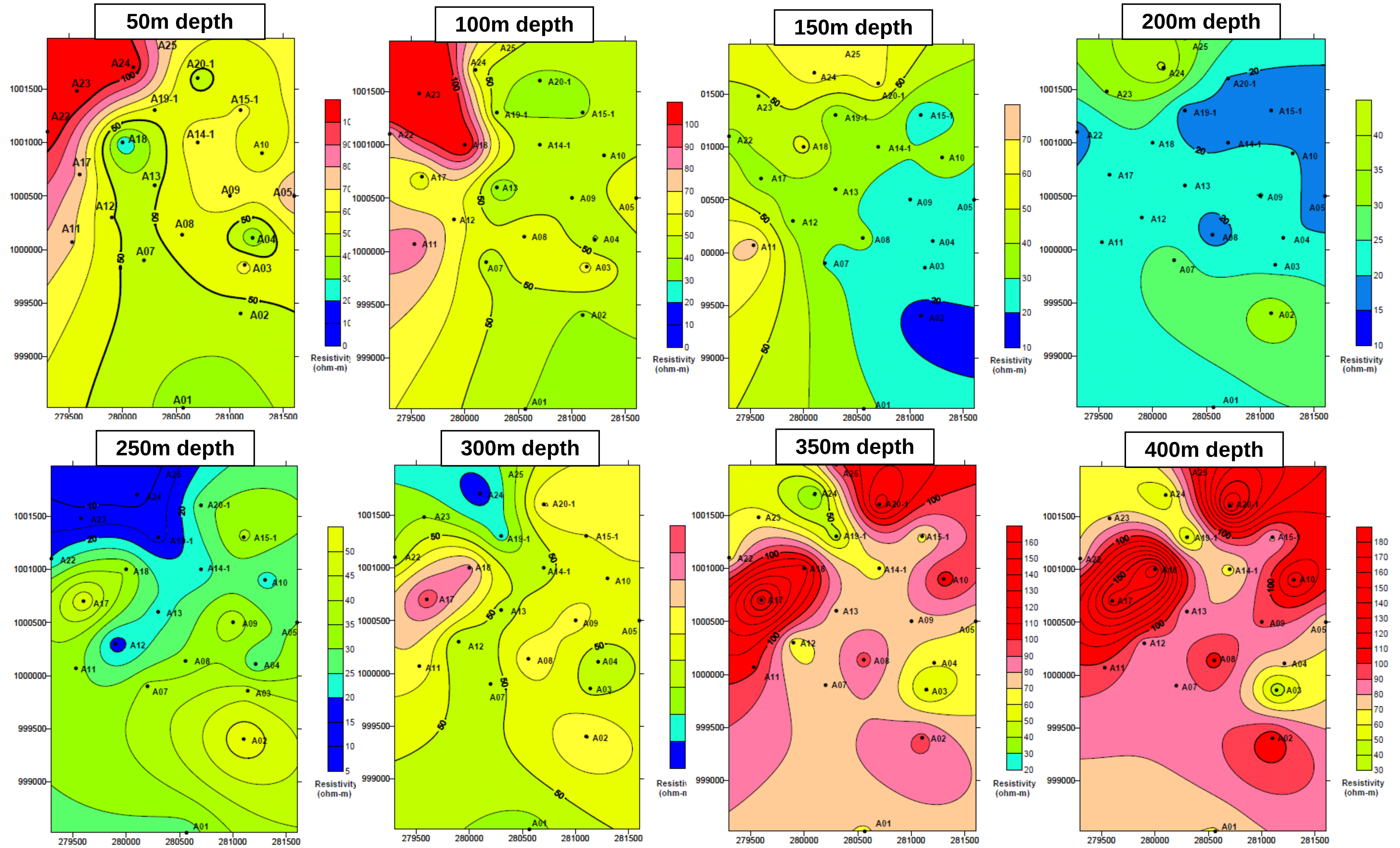
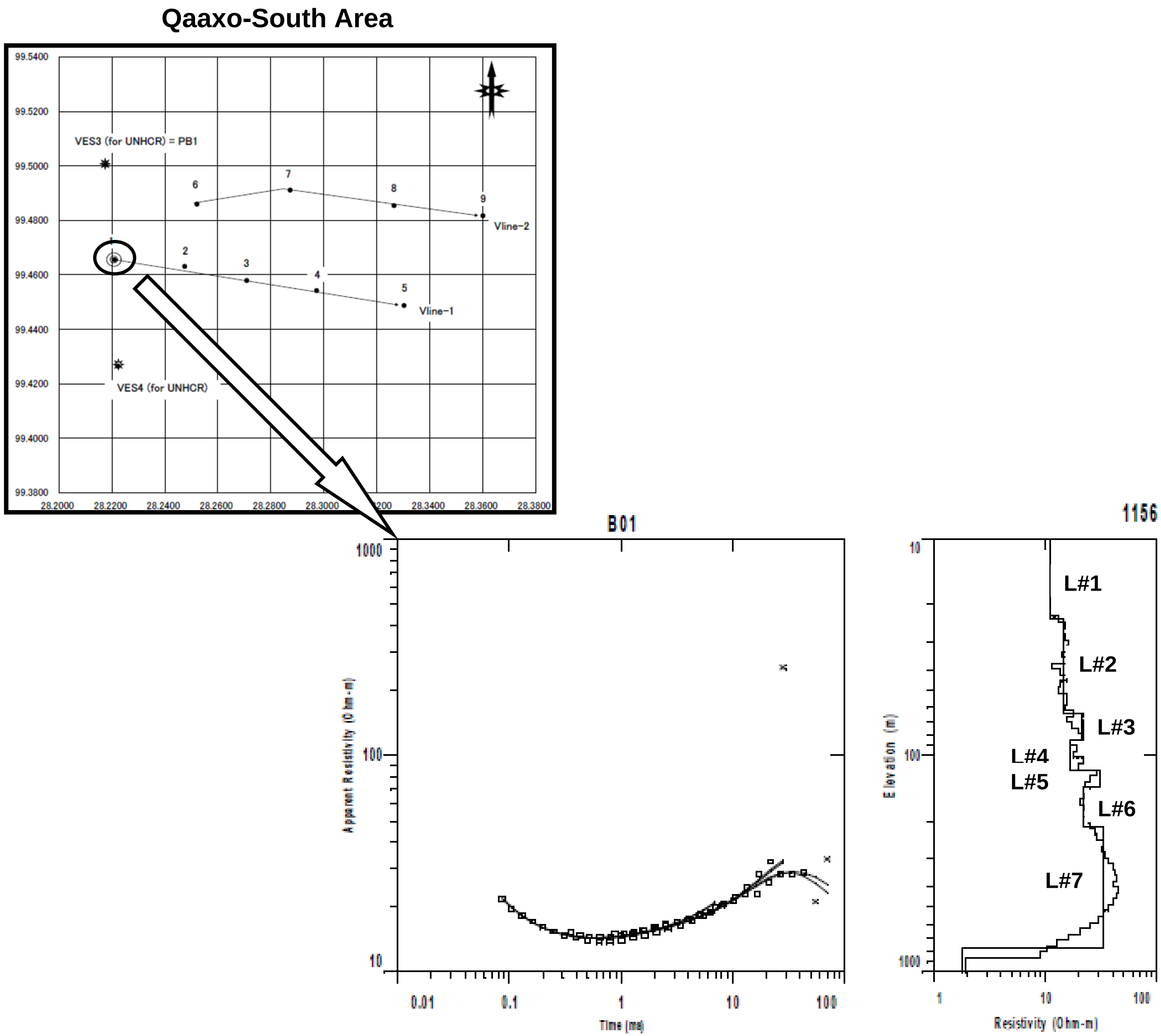



Figure 1.23: Smooth Imaging Resistivity Distribution Map (Qaaxo-North Area)




| L # | RESISTIVITY (ohm-m) | THICKNESS (meters) | DEPTH |
|---|---|---|---|
| 1 | 11.10 | 23.37 | 23.37 |
| 2 | 14.26 | 40.08 | 63.46 |
| 3 | 21.44 | 21.68 | 85.15 |
| 4 | 16.50 | 31.43 | 116.5 |
| 5 | 31.17 | 23.20 | 139.7 |
| 6 | 21.74 | 71.34 | 211.1 |
| 7 | 32.80 | | |

Figure 1.24: Apparent Resistivity Curve and Analysis Results (Qaaxo-South Area)

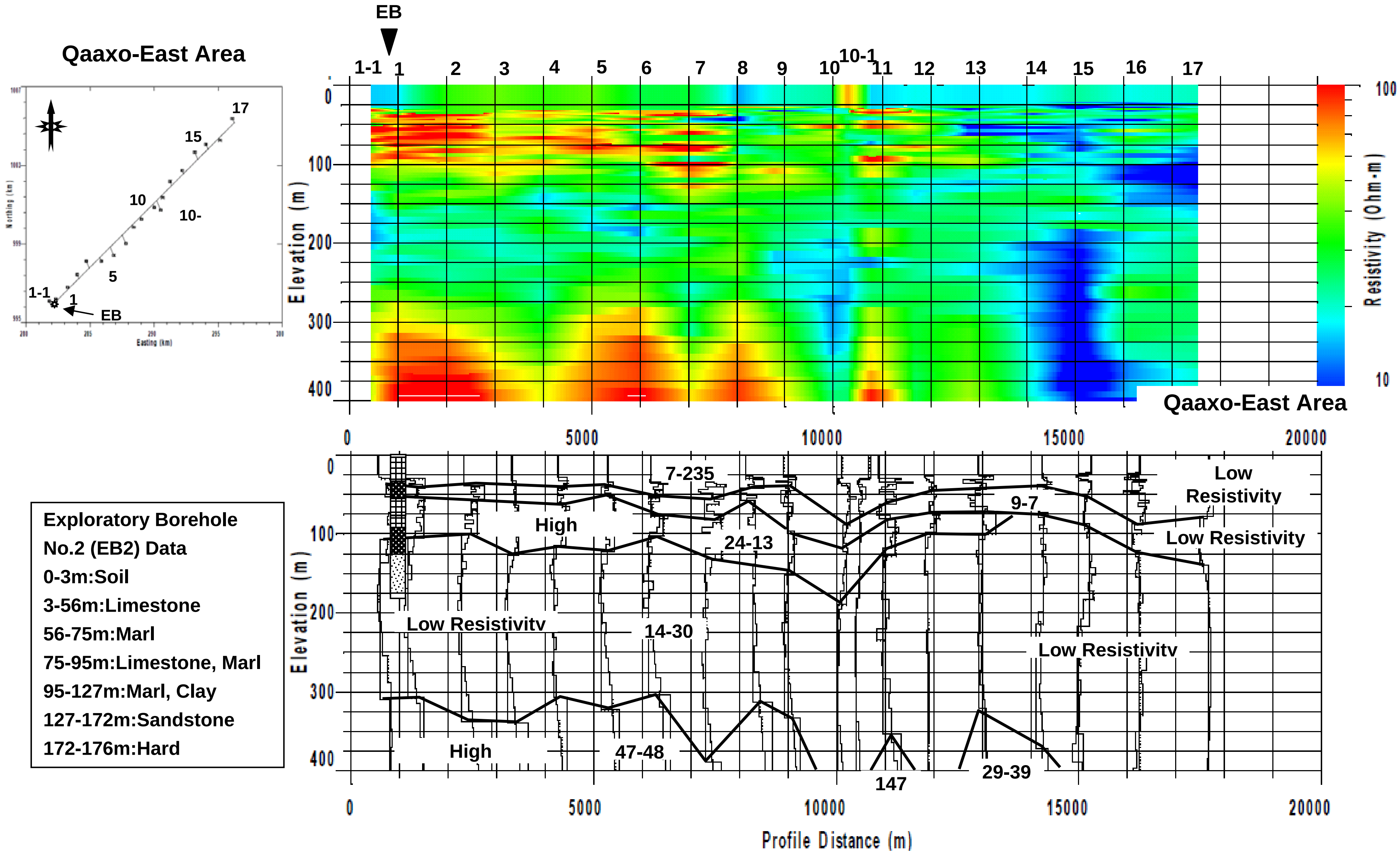



Figure 1.25: Profiles of Resistivity and Structure Analysis (Qaaxo-East Area)

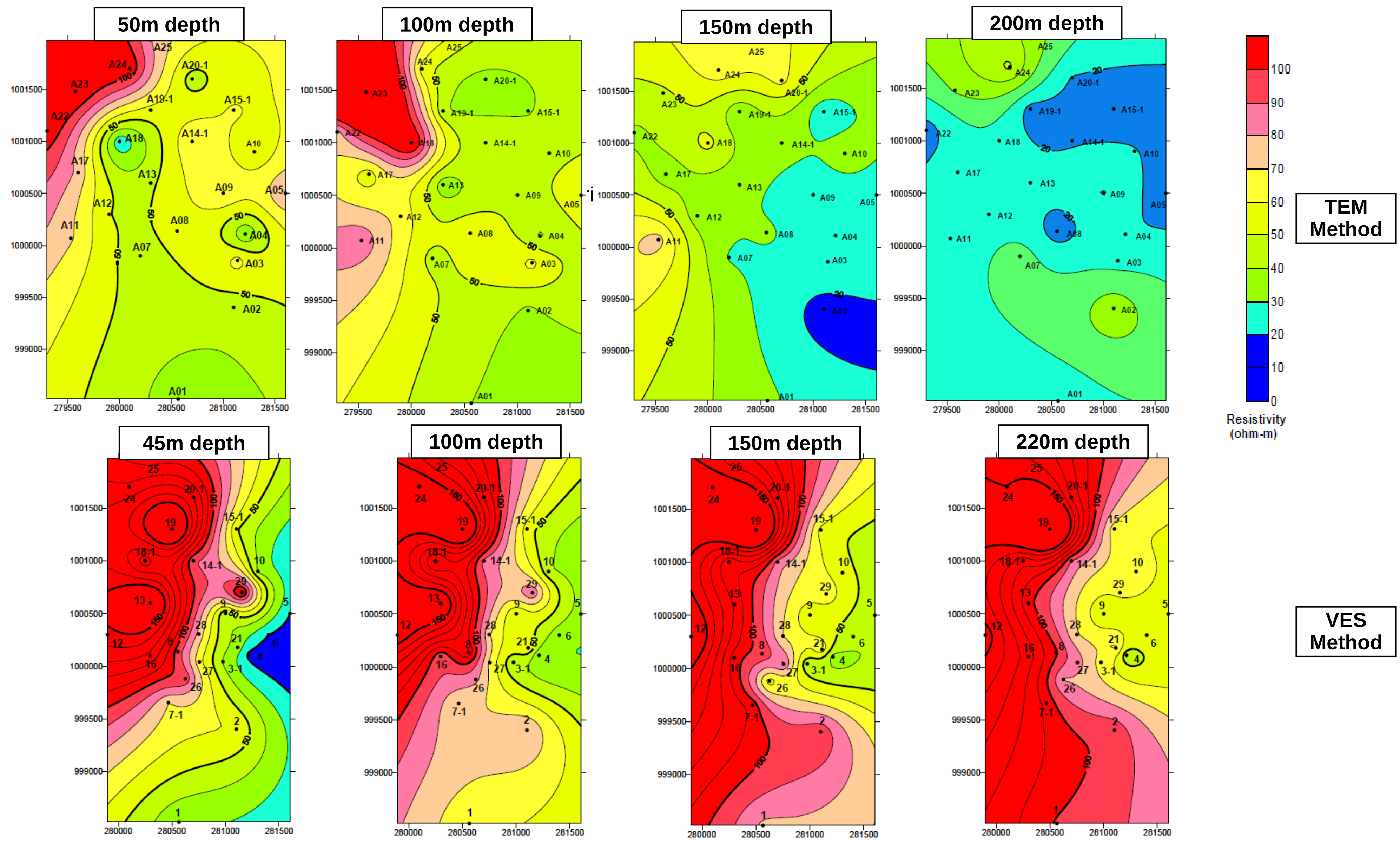



Figure 1.26: Comparison between the TEM and VES Results

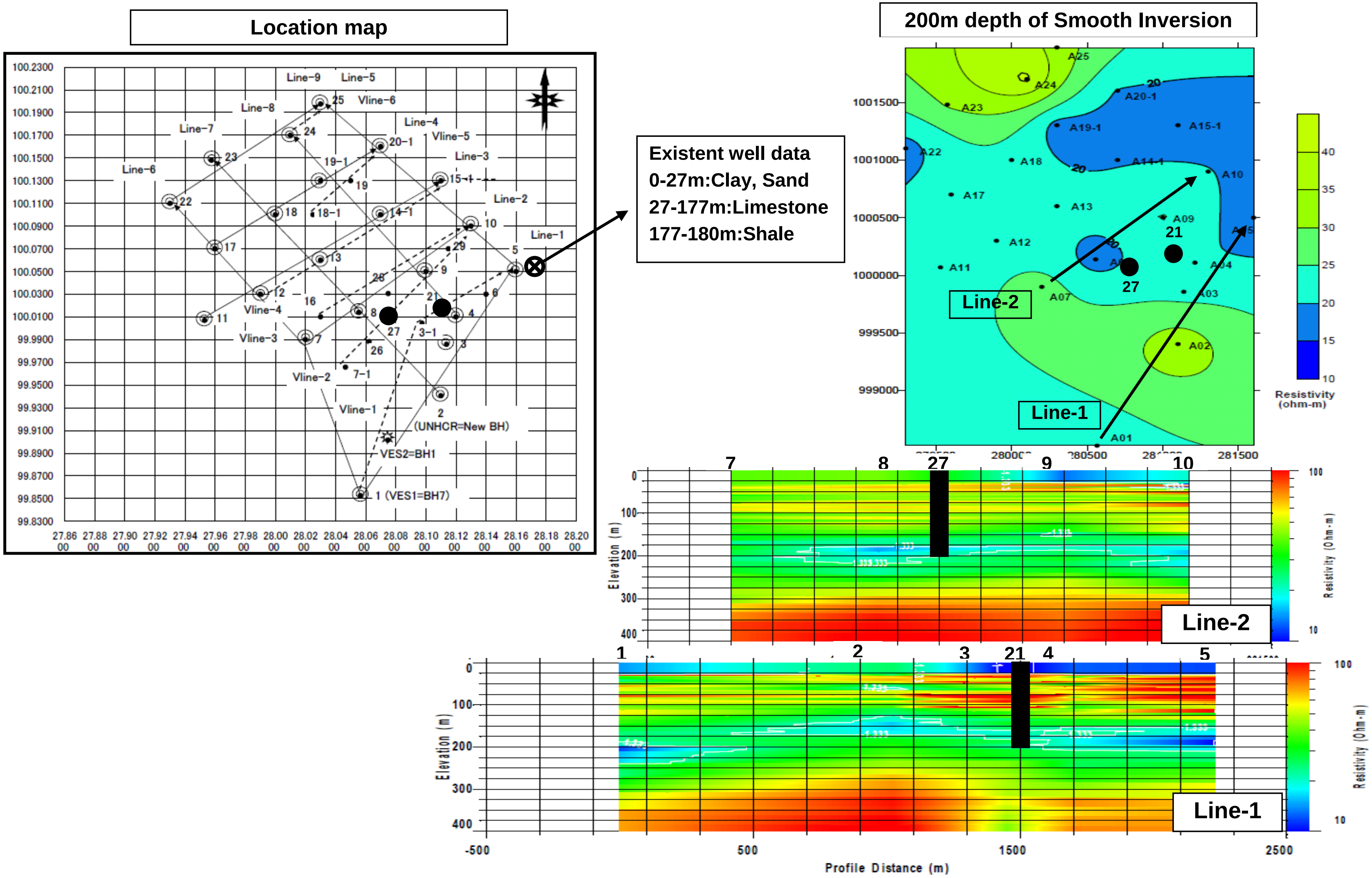
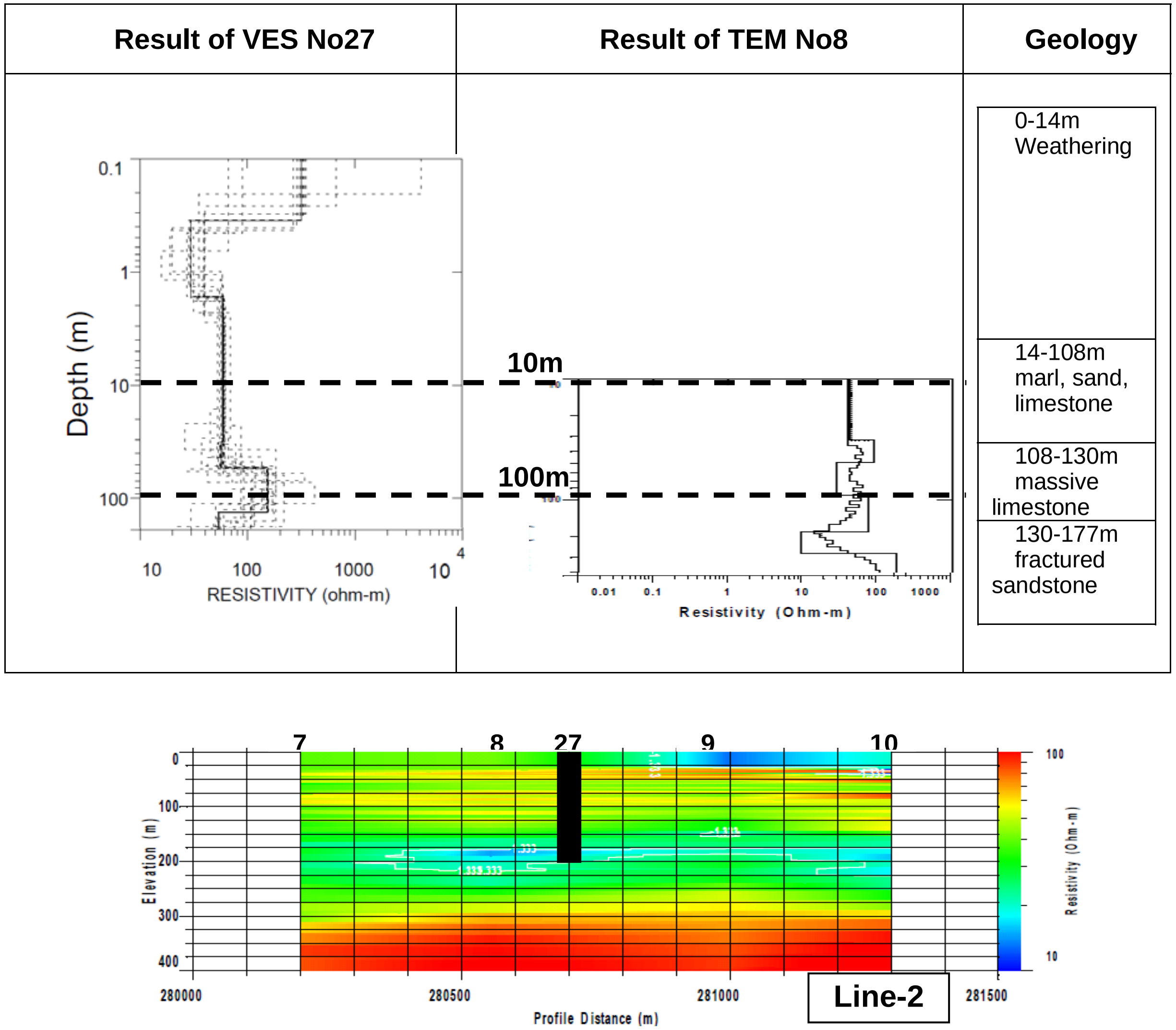



Figure 1.27: Selection of Drilling Sites



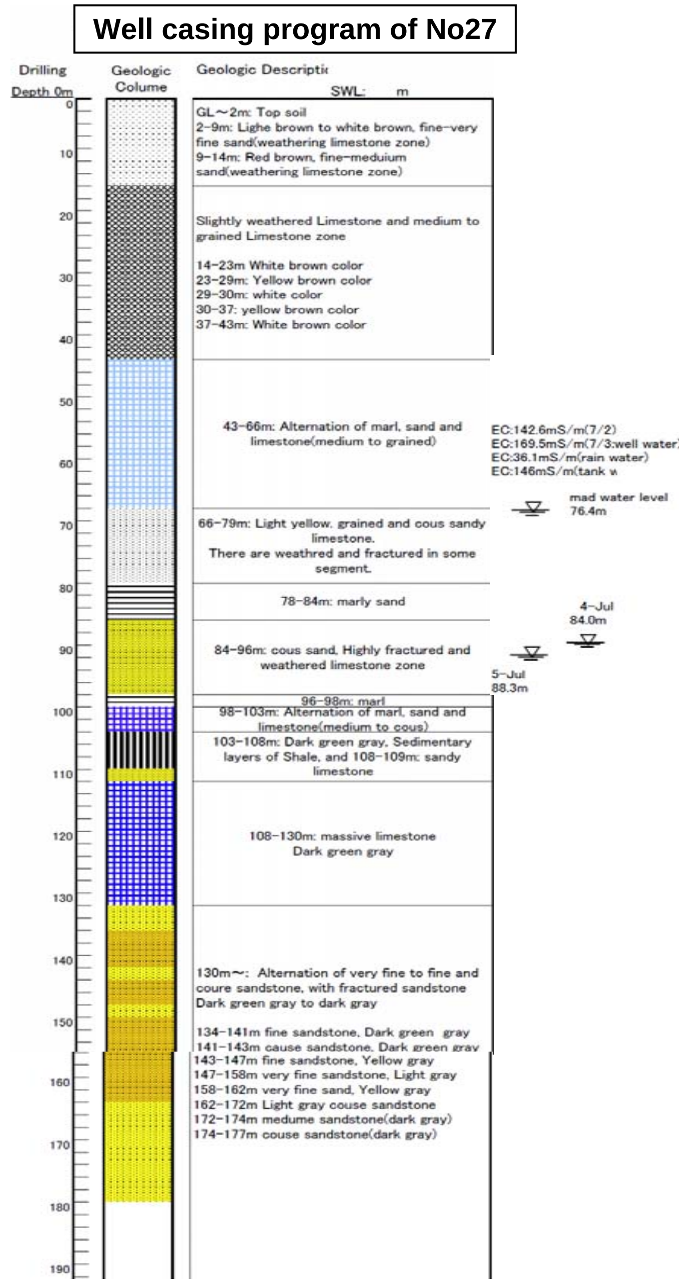




Figure 1.28: Compared Figure with Drilling and Geophysical Survey Results

# Chapter 2

## *Well Drilling and Pumping Test*

# 2 Well Drilling and Pumping Test

## 2.1 Purpose and methodology of well drilling

### 2.1.1 Purpose

The drilling of production well in this Study was conducted for the following purposes.

- To obtain subsurface geological information by observing drill cuttings and slimes.
- To secure and evaluate the depth and potential of aquifers based on the data obtained; the above lithofacies information and the results of geophysical logging and pumping test.
- To secure the discharge as the production well for the supply plan and suitable water quality
- To collect hydrogeological data for the survey area to contribute to the analysis of hydrogeological structure and to secure the basic information of groundwater conditions for future groundwater development plans based on the results of the survey.

In addition, the locations of the drilling points are shown in Figure 2.1 below.

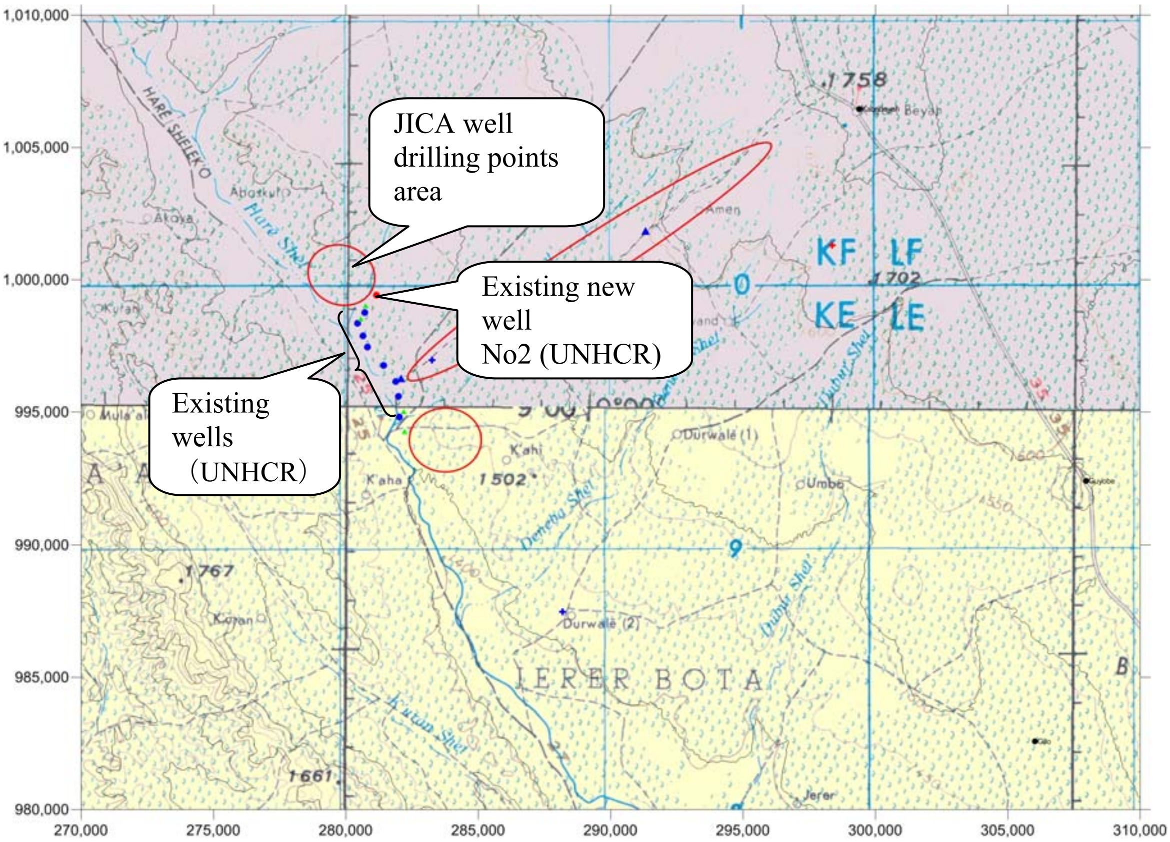



Figure 2.1: Schematic Map of Drilling Points（Farda Block）

### 2.1.2 Methodology

In the Study, two wells were drilled in compliance with the following specifications of the existing production wells. The outline of these specifications is given in Table 2.1. Moreover, the structure of the completed well is illustrated in Figure 2.2.

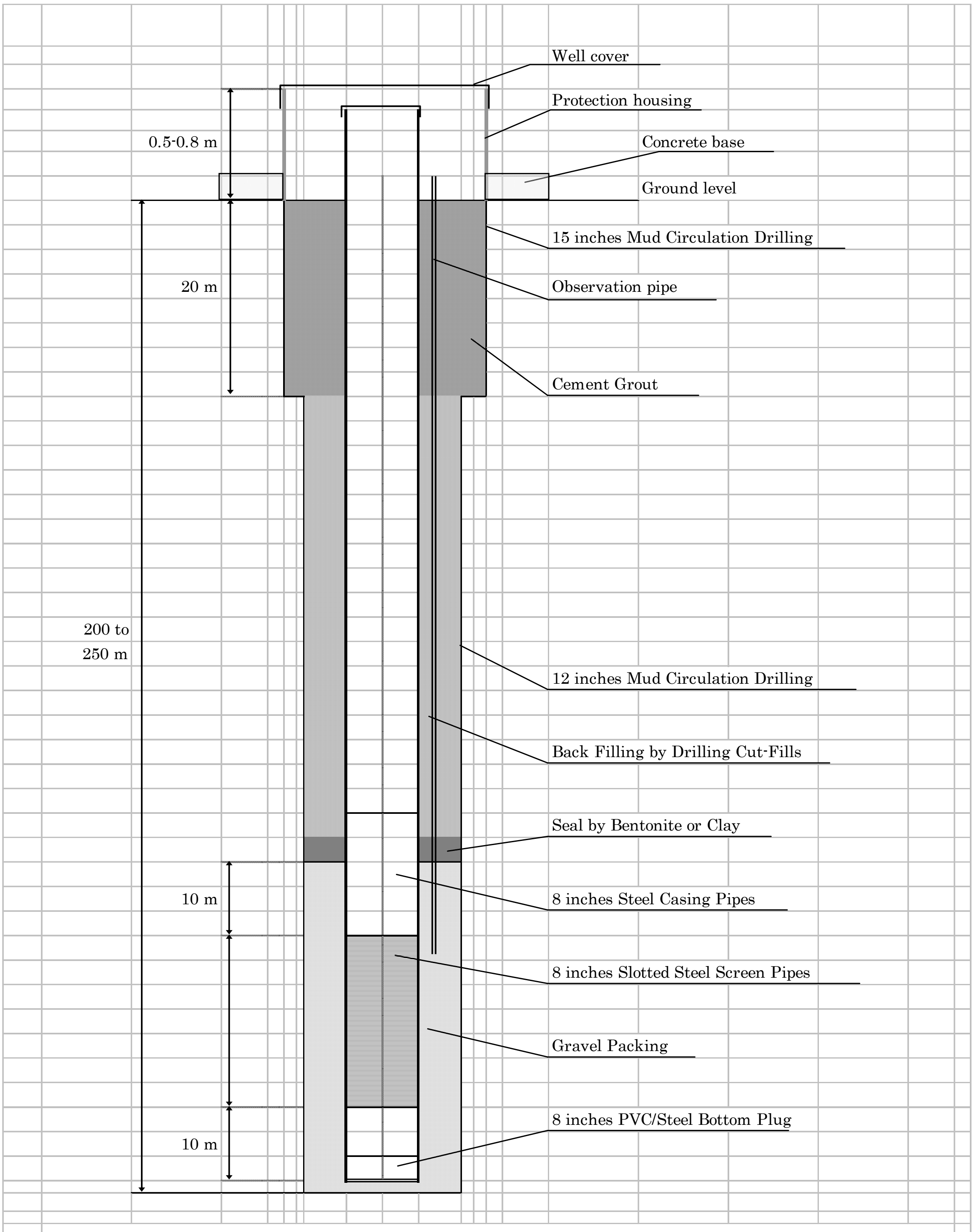
Table 2.1: Basic Specifications of Production Wells

| | Details |
|---|---|
| **Period** | ・ June 11 to August 10 of 2012 |
| **Quantity of drilling** | ・ Total depth of drilling : 400m (average/well 200m) |
| **Drilling Specification** | ・ Drilling method： Rotary mud-water, Air bubble method, and DTH (Down-the-hole hammer) method<br>・ Drilling diameter : 12 inch<br>・ Diameter of casing and screen pips : 8 inch<br>・ Material of casing and screen pipe: steel<br>・ Screen opening ratio : more than 5 %<br>・ Bottom plug: installed at the bottom of the well<br>・ Sealing: cement sealing for upper part of borehole |
| **Drilling Method and Well Development** | ・ Take sample cutting/slime at every one meter of depth<br>・ Geophysical logging of borehole (resistivity, spontaneous potential; taking data continuously)<br>・ Screen and casing installation<br>・ Gravel packing and sealing<br>・ Well development<br>・ Observation pipe installation (diameter 1 inch)<br>・ Protective cover on the well head (Construction of a steel pipe cover and a concrete base) |
| **Specification of a Pumping Test** | ・ Preliminary pumping (about 4 hours)<br>・ Step Drawdown test (five steps, 2 hours each)<br>・ Continuous Drawdown test (24-48-hour continuation)<br>・ Recovery Test (97% of water level recovery, or 12 hours) |

The well drilling works was commissioned to a drilling contractor in Jijiga. The drilling methods employed were: rotary "mud circulation drilling" for the soft rock layers; while the rotary drilling method of "air (foams) pressure" or the DTH (Down-the-hole hammer) method were employed for hard rocks or layer of cavernous rocks. These drilling methods were selected based on the lithofacies and in reference to the experience and ability of local drilling company.

Consequently the following strategy was employed, in consideration of the above conditions, to perform successful drilling:

1) To always secure sufficient drilling material at the site.
2) To adopt the methods of drilling such as the mud drilling, the revolving drilling method by air (forms) pressure, or the DTH method according to the conditions of a stratum.
3) To take measures to stabilize the borehole wall promptly, when a collapse of borehole occurs in drilling borehole.
4) To use longer surface casing pipes to protect the upper section of the borehole from collapse.




Annex 1. Typical Structure for the Observation Well

Figure 2.2: Structure of Production Well

## 2.2 Selection of drilling sites

The position of the drilling well (2 wells) was selected for the following standards in principle.

- Drilling point is a left-bank side of the Jarar valley, and the location of well drilling points is distant from the existing wells.
- Drilling point is the position with limited influence of existing wells by the pumping of groundwater.
- Drilling point is selected as the target area which hydrogeological data are few as the results of arrangement of the existing well data and aquifer information. The data are useful for the analysis of hydrogeological conditions in survey area

After field survey was performed, the site situation was checked and the drilling point was narrowed down. The basis of selection in this stage is as follows;

- The aquifer is likely to be present at a depth of 200 m in depth in accordance to the well development plan of our Study.
- It is easy to access the drilling machine to the site.
- Drilling sites have sufficient space for the works.
- There are very few problems for land use and drilling

Afterwards, the geophysical survey was conducted at each selected site to estimate the subsurface geological and hydrogeological situations. The details of geophysical survey were explained in Chapter 1 in the supporting report of final report. The number of geophysical survey in the candidate area of well drilling is as follows;

Electrical resistivity survey (VES) points: 25 points

Electromagnetic exploration (TEM) points: 9 lines (22 points)

The drilling points were narrowed down based on the resistivity profiles of the above-mentioned surveys. The aspects of target aquifer are assumed to be as follows;

- According to the existing well data of surrounding area, the limestone was sometimes selected for the aquifer, however in the Study survey area, the limestone of about 130m in depth has not been the target of groundwater in many cases, and it has a low yield of groundwater.
- Therefore, groundwater in the limestone distributed at a depth of 130m and its surround was not used in the drilling basically.

The specific geographical and hydrogeological conditions in the drilling points are as follows concretely.

- The JICA well No-1 is approximately 410m from No-2 in a straight line.
- The drilling points are separated from the nearest existing well by about 1.3 km in a straight line.

- A small valley (geological structure line probably) which divides between the two well points exists midway directly between the two sites.

- Well drilling points are located on a plateau which inclines gently from the north-northeast to south-southwest, and the edge of the plateau reaches the right-bank side of the Jarar valley.

- It is highly possible that the aquifer for development (sandstone layer) is distributed in the area of this well drilling point at a shallower depth than 200 m.

The final selected well Drilling sites are shown in Figure 2.3. Moreover, information on the well drilling sites is given in the following Table 2.2.

Table 2.2: Site Information on the Newly Drilled Production Wells

| Site number | WOREDA | Kebele Area name | Drilling Depth(m) | GPS Position | | |
|---|---|---|---|---|---|---|
| | | | | E | N | Elevation |
| JICA Well No-1 | Kabribeyah | Farda | 200 | 281113 | 1000179 | Ab.1447 m |
| JICA Well No-2 | Kabribeyah | Farda | 200 | 280742 | 1000002 | Ab.1448 m |

* coordinates are of actual drilling points in UTM, datum Adindan

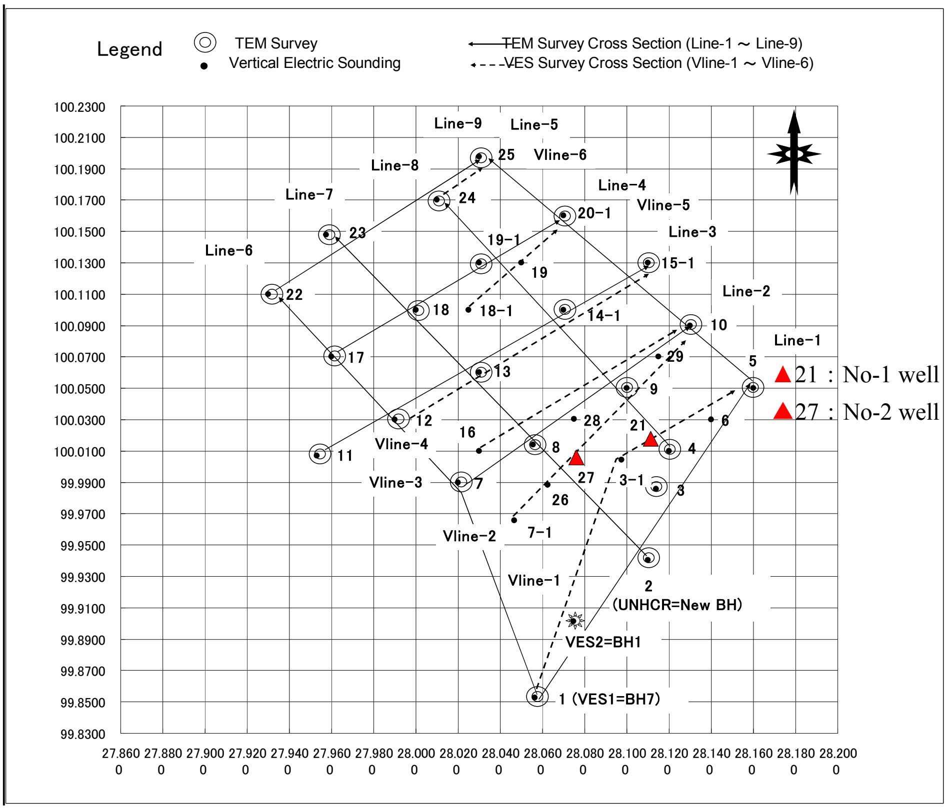



Figure 2.3: Points of Well Drilling

## 2.3 Results of well drilling

### 2.3.1 Summary of drilling work

A total of two wells were drilled and completed as production wells in the project. Well logging was conducted prior to installation of casing and screen pipes. The pumping test was carried out after well completion. Details of the well drilling are given in the following Table 2.3.

Table 2.3: Outline of Well Drilling

| Number of Site / Item | JICA Well No-1 | JICA Well No-2 |
|---|---|---|
| Drilling period | 5 July – 24 July, 2012 | 13 June – 8 July, 2012 |
| Pumping test period | 6 – 8 August, 2012 | 25 – 27 July, 2012 |
| Drilling method | Mud water with air bubbles rotary and DTH | Mud water with air bubbles rotary |
| Drilling Depth（results/plan） | 202m / 200m | 201m / 200m |
| Screen position | 130m-145m, 160m-190m | 135m-159m, 165m-189m |
| Target aquifer | Sandstone | Sandstone |

### 2.3.2 Lithological conditions

A well drilling point is located in the east side of the Jarar valley, and the area name is Farda. No-1 well and No-2 well are located in the plateau which is located from the south-southwest side to north-northeast, and inclines in the Jarar valley side gently. It is separated from the interval of both drilling points by 410 m in a straight line, and a small valley exists in the interstitial segment directly between the two points in terms of geomorphology.

Cutting samples were taken from the borehole at one meter intervals during the drilling operation according to the technical specifications. It is generally difficult to accurately identify subsurface lithology by just observing the cuttings coming out of the borehole, because such samples are crushed fragments of original rock/sediment and do not usually preserve the structure or texture of the rock/sediment. Also, such samples inevitably contain some amount of cuttings that come from the upper section of the borehole (contamination). Nevertheless, effort was made to estimate the subsurface lithology through observation of the cuttings and also using other relevant information (refer to Figure 2.4 and Figure 2.5) such as drilling rates and the results of the surface geological survey (refer to the Volume 1 of final report).

Detailed results of observation of the cutting samples from each depth of boreholes are given as Well Drilling Data in the Data Book along with other relevant information collected during the drilling work. Note that the geological description in these data sheets is primarily based on the observation of cutting samples. The following sections summarize the proceedings of the drilling work and the results of the sample production well at each drilling site.

### a. Site - 1（Farda JICA Well No-1）

Based on experience of the local well contractor who drilled the existing wells, the muddy water drilling method was mainly used for the works this time, and when the leakage of water of circulation loss occurred, the revolving drilling by air (air bubbles) pressure was used together. Drilling was stopped at a depth of 202m – the planned depth being 200 m – upon confirming the presence of the main aquifer, on the seventh day due to various delays. Since the soft weathering layer of clay with a parent rock of limestone is deposited to a depth of 21 m, guide casing pipes (diameter of 350 mm) were inserted to prevent collapses to a depth of 21 m.

As for the lithofacies of this point, the weathering layer of clay (sandy clay layer down to 4m) which has a limestone parent rock is distributed down to 21m, and under this, a thick limestone layer is distributed to the depth of 108m. Sandstone is distributed below the limestone. This sandstone is alternate layers of sandstone and layers of very fine granule size to gravel size deposits. While drilling the limestone, lost circulation occurred repeatedly. This suggests that many fissures and caves exist on the inside of a limestone. Especially the lost circulation at the depth of 117m was severe.

In the drilling work at this point, many places where extraction of cuttings (geology sample) could not be completed existed. The depths at which extraction of cuttings could not be completed are: (1) 74m-86m (limestone layer), and (2) 168m-201m (sandstone layer). When collecting cuttings (geology sample), cuttings become diffused in this cavernous part of a limestone, and it is presumed to be the cause for the inability to collect samples. The penetration rate (drilling depth/drilling time) of this point was comparatively quick, and that of the sandstone strata (semi hard rock) were slightly slow compared with the limestone layer. The first strike place of the groundwater is near the depth of about 110 m, and, probably this part is the boundary portions of limestone and sandstone.

In addition, to obtain geology information — for the statement of subsurface geology — on the sections where samples could not be collected, the lithofacies were estimated from drilling speed, the color tone of circulation loss water, etc. Furthermore, conditions — such as deposition situation, crushing, percolation of groundwater— might overlap, and the cave inside a limestone may have been produced by leaching etc. (refer to Well Drilling Data in the Data Book for detailed description of samples).

### b. Site - 2（Farda JICA Well No-2）

Drilling was stopped at a depth of 201m – the planned depth being 200 m – upon confirming the presence of the main aquifer, on the seventh day due to various delays. Guide casing pipe (caliber of 350 mm) for the prevention of collapse was only need to a depth of 5 m because a hard sediment layer of clay is deposited from the surface at this point. The lithofacies of this point is characterized by limestone. From 2m down to 14 m weathered limestone layer is interspersed with clay layers (alluvium soil layer from surface down to 2 m). From 14m to 110m in depth, the limestone parent rock is interspersed with alternating layers of sandy parts, clayey parts, marly deposits, crushed rock as well as thin layers of shale in some places. An extremely hard limestone is distributed from 110 m to 130 m. A sandstone layer exists from the depth of 130 m to 201 m, the end of drilling. The first strike place of the groundwater was at a depth of about 86 m where limestone is deposited and there was little quantity of groundwater. Moreover, the second strike place of groundwater is about 151 m in depth. And this part is the weathered sandstone strata, which mostly consists of course-to-pebbly conglomeratic sandstone. The drilling operator felt at this stage of drilling that the amount of gushing groundwater increased.

According to observation of cuttings, this sandstone layer is an alternation layer which consisted of very fine-grained sandstone with coarse-grained and conglomeratic sandstone. And it is presumed that groundwater exists in coarse-grained sandstone strata or pebbly sandstone bed (aquifer). There was lost circulation of muddy water in the drilling work of limestone several times. This is presumed to be a result of many fissure belts in the limestone strata. Moreover, at No-2 site, sample recovery of cuttings was completed with all the depth to drilling depth (201 m) (refer to the Well Drilling Data for the detailed description of samples in Data Book).

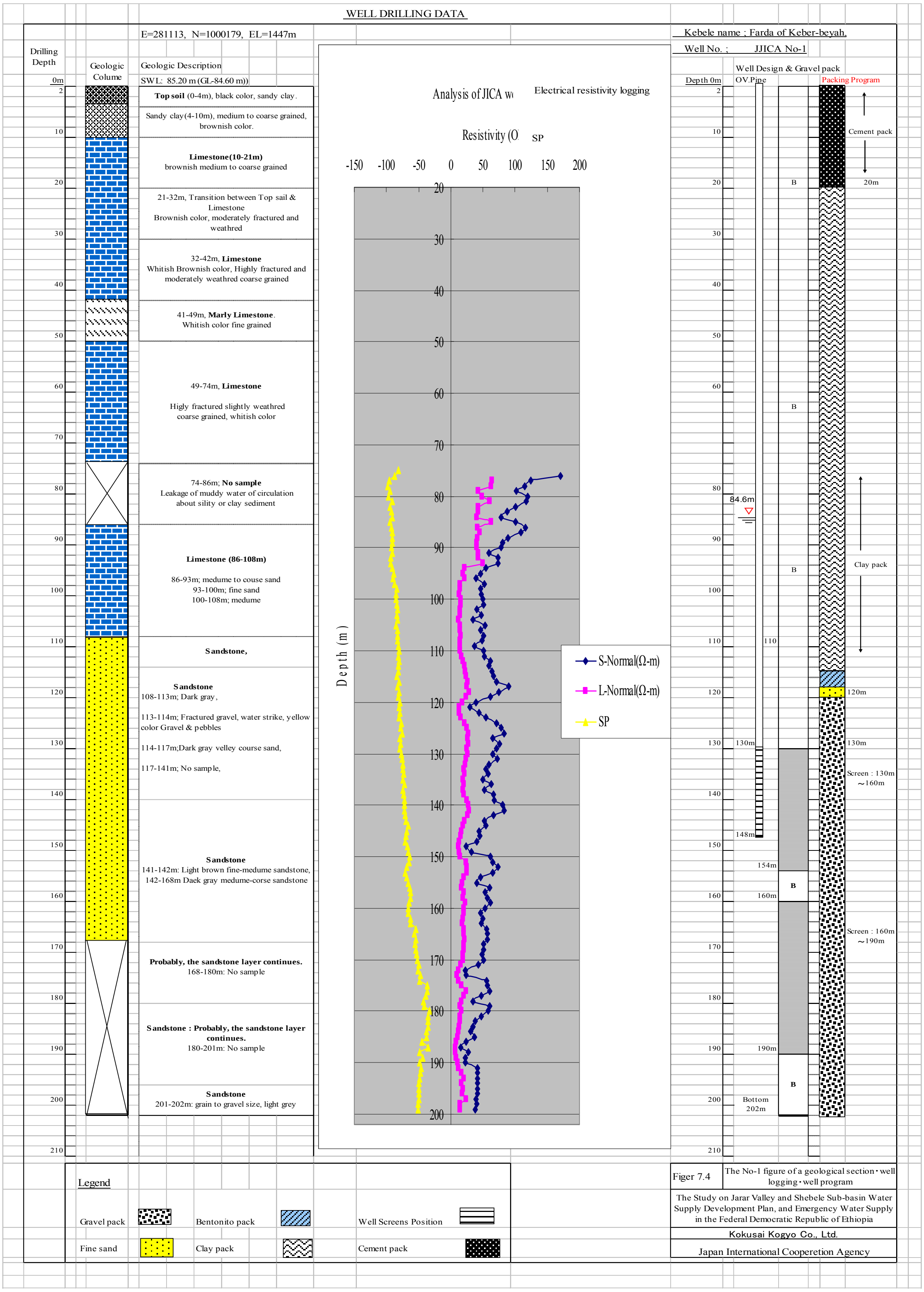



Figure 2.4: General Columnar Section (JICA Well No-1)

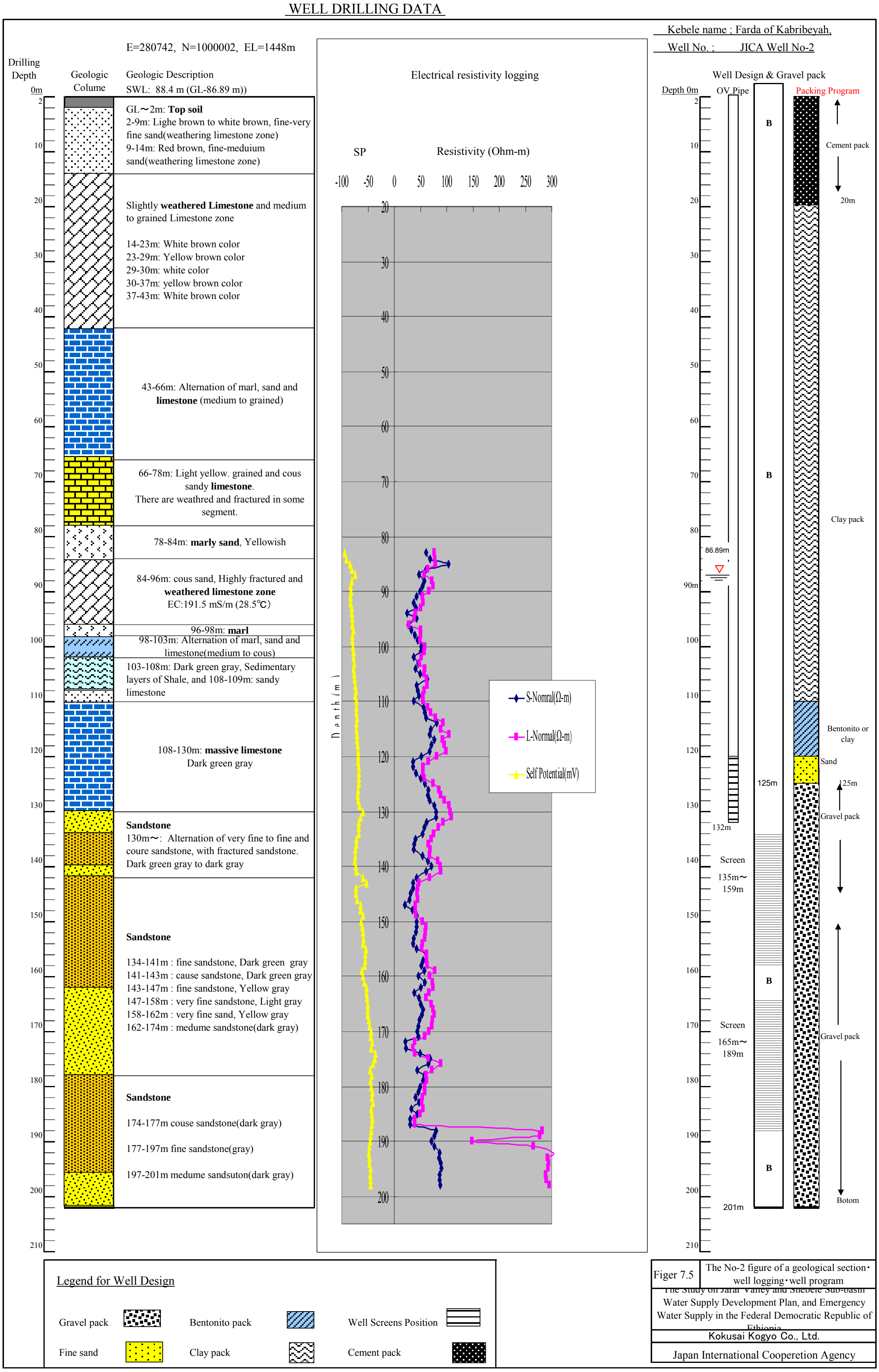



Figure 2.5: General Columnar Section (JICA Well No-2)

### 2.3.3 Results of geophysical logging

Geophysical logging was conducted after the drilling and was completed before installation of casing and screen pipes. Electric logging was carried out in the depth where groundwater exists in a borehole. And the position of screen was decided in consideration of well logging result, the results of observation of geology, the penetration rate, etc, and the program for well construction was completed. The specification of the logging is summarized in the table below. The results of the logging are shown in graphs along with corresponding geological logs in Table 2.4. The data sheets are attached in the Data Book.

Table 2.4: Specification of Well Logging

| Well Logging Item | Measurement Interval |
|---|---|
| Spontaneous Potential (SP) | 1m |
| Electrical Resistivity (Short Normal) | 1m |
| Electrical Resistivity (Long Normal) | 1m |

**a. Site - 1 (Farda JICA Well No-1)**

Well logging was carried out in the portion with a depth of 76m to 199m. In sample observation of cuttings, the sedimentary layers which have limestone as a parent rock (from a soft rock to a semi hard rock) are distributed over the depth from 78m to 108m. And sandstone is from 108m in depth. The results of well logging, with the resistivity by depth are as follows (Table 2.5);

Table 2.5: Resistivity of Each Depth (JICA Well No-1)

| Well Logging Depth（m） | Lithofacies (Geology) | Resistivity（Ω-m） | |
|---|---|---|---|
| | | Long normal | Short Normal |
| 76m～93m | Limestone | 41～64 | 75～125 |
| 93m～109m | Limestone | 12～16 | 34～54 |
| 109m～119m | Limestone／Sandstone | 15～27 | 51～90 |
| 119m～123m | Sandstone | 13～16 | 30～54 |
| 123m～144m | Sandstone | 19～28 | 50～83 |
| 144m～149m | Sandstone | 11～17 | 23～45 |
| 149m～170m | Sandstone | 14～25 | 40～57 |
| 170m～174m | Sandstone | 10～15 | 23～43 |
| 174m～181m | Sandstone | 12～24 | 35～61 |
| 181m～190m | Sandstone | 7～14 | 15～37 |
| 170m～199m | Sandstone | 14～21 | 38～41 |

Although the highest values of specific resistivity are 125 ohm-m before the drilling depth of 199 m, the specific resistivity of this point shows the low value of 100 or less ohm-m generally. Moreover, looking at the specific resistivity curve, the specific resistivity of limestone strata is slightly higher than the sandstone strata. Furthermore, it is presumed that the specific resistivity below 40ohm-m in limestone shows existence of a cave or a fissure. The first depth where groundwater was confirmed (by the operator's feeling) in the limestone strata was 89 m in depth, which is equivalent to the lower portion of the sedimentary layers of limestone. The specific resistivity in the sandstone strata is 30 or less ohm-m in some places, and this is considered to be influence of groundwater.

### b. Site - 2 (Farda JICA Well No-2)

Well logging was carried out in the portion with a depth of 83m to 198m. In sample observation of cuttings, the sedimentary layers with limestone as parent rock (from a soft rock to a semi hard rock) are distributed over the depth of 83m to 130m. Furthermore, the sandstone strata of a semi hard rock are distributed to the bottom of the drilling hole (198m) from the depth of 130m. The results of well logging, with the resistivity by depth, are as follows (Table 2.6);

Table 2.6: Resistivity of Each Depth (No-2)

| Well Logging Depth（m） | Lithofacies (geology) | Resistivity（Ω-m） | |
|---|---|---|---|
| | | Long Normal | Short Normal |
| 83m～91m | Limestone | 54～79 | 50～103 |
| 91m～111m | Limestone | 28～64 | 27～52 |
| 111m～120m | Limestone | 69～110 | 52～81 |
| 120m～124m | Limestone | 55～65 | 36～50 |
| 124m～134m | Limestone／Sandstone | 75～110 | 54～80 |
| 134m～141m | Sandstone | 65～88 | 37～70 |
| 141m～174m | Sandstone | 36～76 | 20～60 |
| 174m～179m | Sandstone | 62～88 | 44～69 |
| 179m～187m | Sandstone | 39～59 | 30～50 |
| 187m～198m | Sandstone | 149～303 | 71～90 |

The specific resistivity of limestone and sandstone is generally low, however, very small changes are apparent. These minute changes in the limestone are consistent with the fact that it contains alternating layers of marl, fine sandstone and dense limestone layers. Furthermore, when the specific resistivity of limestone and sandstone is compared, there is no remarkable difference in the value. Moreover, the part of low specific resistivity has appeared in most portions in the specific resistivity curve in sandstone layer. Moreover, groundwater was confirmed to have been struck at depths of 86 m and 151 m. Existence of low specific resistivity is presumed, and also from this that recharge storage of groundwater is expected in the lower part of limestone strata and in the sandstone strata.

In addition, the section of slightly higher specific resistivity at the bottom of the borehole, depth of 187 m to the bottom (198 m) corresponds to the hard sandstone strata with few fractures by visual observation of cuttings compared with that of higher level strata.

### 2.3.4 Correlation of results between drilling and geophysical survey

As mentioned above, the geophysical survey was conducted at each selected site to estimate the subsurface geological and hydrogeological conditions. The details of geophysical survey are explained in Chapter 1 in the supporting report of final report. The number of geophysical survey in drilling area was as follows.

Electrical resistivity survey (VES) points: 25 points

Electromagnetic exploration (TEM) points: 9 line (22 points)

The resistivity profile maps of several cross sections at each site were described and they were used for selecting drilling points. The data was also reviewed after the drilling results came out to try to correlate the results of the survey to the observed geology and groundwater condition. At each site, the surveys revealed the depth of the aquifer with water bearing layer relatively well. Details are explained in the following section.

#### a. Site -1 (JICA Well No -1)

As the results of geophysical survey, the subsurface geological layers are classified into five (5) layers by specific resistivity in JICA Well No-1 and its surrounding area. The following things can be considered in case of correlation between the results of drilling and geophysical prospecting. In addition, the geophysical prospecting records and analysis results are attached in the Data Book.

- The high specific resistivity strata of 15-273 Ω-m are distributed by specific resistivity from the surface to a depth of 1 m (the first layer) directly under it.
- In the second layer, 1m-10m in depth from the surface, there exist low specific resistivity strata of 2-10 Ω-m, and this is equivalent to the sandy clay layer of a geological section.
- The third layer, from 10-70 m depth, contains high specific resistivity strata of 39-324 Ω-m, and this is equivalent to the alternation layer belt of marl, weathered limestone, and sandy limestone.
- In the fourth layer, from 70 m to 100 m, there are medium specific resistivity strata of 21-114 Ω-m, and the depth is equivalent to the alternation layer part of marl and sandy limestone in geology.
- In the fifth layer, from 100 m to 300 m, there are high specific resistivity strata of 140 - 804 Ω-m, equivalent to the sandstone layer from the depth of 108m in geology.
- Changes in specific resistivity are generally in accordance with the layers of crushed rocks, weathered material, and gravely sediment that were observed in sandstone strata in the results of the drilling sample, and it is thought that this represents an aquifer containing groundwater.

The geophysical prospecting result of this site by depth indicated, in some respects, a small difference between the depth classification obtained by investigation and the classification of the sedimentary layers classified from the drilling results. However, in general, the results of geophysical prospecting accurately reflect the classification of the sedimentary layers of subsurface geology. It is also considered that the numerical values of strata classification by specific resistivity are mostly appropriate.

**b. Site -2（JICA Well No-2）**

As a result of the geophysical survey, the subsurface geological layers were classified into six (6) layers by specific resistivity in JICA Well No-1 and its surrounding area. The following things can be considered in case of correlation between the results of drilling and geophysical prospecting. In addition, the geophysical prospecting records and analysis results are attached to the Data Book.

- The first layer from the surface to the depth of 1.5m has a high specific resistivity of 3-383 Ω-m. And the specific resistivity strata, in which the second layer from the depth of 1.5m to the depth of about 5m is extremely low, 4-91 Ω-m, and this is consistent with these first two layers being made up of topsoil containing much limestone gravel.
- The third layer, about 5m-20m, has a high specific resistivity of 54-246 Ω-m, reflecting a rapid strata change of lithofacies of limestone from gravel to coarse sand.
- Although the low specific resistivity strata of 17-57 Ω-m is distributed between the depth of 20m-50m (the fourth layer), this is reflecting the comparatively soft calcareous sediment containing marl and fine sand.
- The high specific resistivity stratum of 73-154 Ω-m is distributed between 50m-190m (the fifth layer) in depth. Although hard limestone is distributed from 109m to 130m and sandstone strata are distributed from the depth of 130m in this section, specific resistivity classification is difficult for these limestone strata and sandstone strata in lithofacies, that result is reflected and it is thought to be the same specific resistivity.
- Low specific resistivity has suggested occurrence of groundwater. The resistivity of strata from the depth of 190m (the sixth layer) shows a low specific resistivity of 18-54Ω-m. It suggests the distribution of hard sandstone strata.

The geophysical prospecting result of this site by depth indicated the small difference between the depth classification obtained by investigation in some respects and the classification of the sedimentary layers classified from the drilling result. However, generally the result of geophysical prospecting accurately reflects the classification of the sedimentary layers of subsurface geology. It is also considered that the numerical values of strata classification by specific resistivity are mostly appropriate.

Moreover, groundwater was confirmed to have been struck at a depth of 86 m in limestone and 151 m in sandstone. This is reflected in changes in low specific resistivity, and it is considered that these zones of low specific resistivity accurately reflect the distribution of aquifers.

## 2.4 Pumping test

### 2.4.1 Introduction

The pumping test was conducted after completion of drilling and well development. The schedule of pumping test is as follows.

- No-2 well; from 25 to 28 July, and from 7 to 8 August (re-examination of step drawdown test).
- No-1 Well; from 4 to 6 August.

The period of a pumping test is from a preliminary pumping test to the end of a recovery Test. The outline of examination specification is shown in following Table 2.7.

Table 2.7: Specification of a Pumping Test

| Test type | Specification and Detail |
|---|---|
| Preliminary | At least more than 4 hours |
| Step drawdown | 3 steps, 2 hours/each step |
| Continuous | pumping 24 hours,<br>EC, pH, Iron(Fe), fluorine(F), Groundwater temperature measurement |
| Recovery | 97% recovery or maximum 12 hours |

This time, the screen was installed for the sandstone strata which are deposited below limestone strata in both wells. This is thought to reflect the character of the aquifer of the upper part of sandstone strata, which is widely distributed throughout the investigation area.

The preliminary test was carried out for the determination of production capacity (estimated yield) before the step draw down test.

### 2.4.2 Step-drawdown test

The step draw down test was conducted to determine the discharge for the continuous test and also to evaluate the efficiency of the well. The raw data of the pumping test is available in the Data Book of Final Report. Although the step test was planned to be in five steps of 2-hours pumping each at the beginning, since it became clear that the pump discharge would not be as much as expected after considering the results of the preliminary test of JICA Well No-2, it was changed to 3 steps of 2 hours each, this time. The reasons are as follows.

- When the well was pumped up with the maximum pump discharge (about 11 L/sec), the groundwater level descended to the top of screen after 2 minutes.
- When the well was pumped up at a discharge of approximately 6.5 L/sec, it became clear that the drawdown would be about 30m.
- The pump power was too high and if the valve had been closed to reduce the discharge below 3L/sec, that would have caused damage to the pump.
- If the interval of pump discharge is less than 1 L/sec, it is difficult to analyze the data

The result of the step drawdown test in two sites which carried out these examinations was summarized in the following Table 2.8.

Table 2.8: The Pump Discharge and Drawdown of Step Drawdown Test

| Data \ Well | | JICA Well No-1 | JICA Well No-2 | |
|---|---|---|---|---|
| | | Consent | First | Second |
| | SWL (-m) | 85.2 | 88.39 | 88.93 |
| Step-1 | Discharge (L/sec) | 3.8 | 5.8 | 3.0 |
| | DWL (m) | 99.4 | 100.23 | 95.45 |
| | Drawdown (m) | 14.2 | 11.84 | 6.52 |
| Step-2 | Discharge (L/sec) | 5.2 | 5.9 | 4.0 |
| | DWL (m) | 105.48 | 105.32 | 97.87 |
| | Drawdown (m) | 20.28 | 16.93 | 8.94 |
| Step-3 | Discharge (L/sec) | 6.5 | 5.91 | 5.0 |
| | DWL (m) | 116.0 | 105.94 | 103.35 |
| | Drawdown (m) | 30.8 | 17.55 | 14.42 |
| No-1=SWL ; (Static Water Level) was measured from the top of casing observation pipe<br>No-2=SWL ; (Static Water Level) was measured from the top of the well casing | | | | |

One of the objectives of step-drawdown test is to evaluate the efficiency of the well. The evaluation is based on the theory that the total drawdown in a pumping well is a sum of drawdown caused by the head loss in the aquifer (aquifer loss) and head loss due to the well screen and packing material (well loss). It is generally expressed by the following formula.

$$s_w = BQ + CQ^2 \qquad Ew=BQ/(BQ+CQ^2)$$

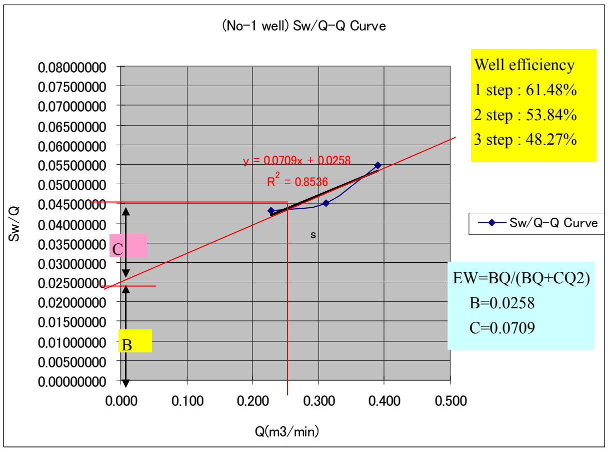
where: $s_w$ is the drawdown in the pumping well, Q is the discharge, B is the coefficient for aquifer loss, and C is the coefficient for well loss. And Ew (%) shows well efficiency.
The results of the analysis are discussed in the following sections.

### a. Site No-1

At first the data was plotted on $s_w$ – Q graph, and the effect of well loss was confirmed in relationship between the change of yield and drawdown (refer to Figure 2.6). At JICA Well No-1 site, the regression line drawn through the three plots probably represents a linear relationship between the drawdown (s) and discharge (Q). At Q = 5.3 L/sec (457.9 $m^2$/day), however, the plot starts to deviate from this linear trend. This is most probably the effect of well loss. Then the data is plotted on $s_w$/Q – Q graph to evaluate the effect of well loss. The plot turned out somewhat atypical probably due to measurement errors for the first few plots. Thus, the regression line was drawn using the last two plots. As a result of analysis, the coefficients B and C for the equation were evaluated as following Table 2.9.

B = 0.0258, C = 0.0709, Q = 6.5 L/sec (0.39 $m^3$/day),

Ew = BQ/(BQ+$CQ^2$)=B/(B+CQ) =48.27 %



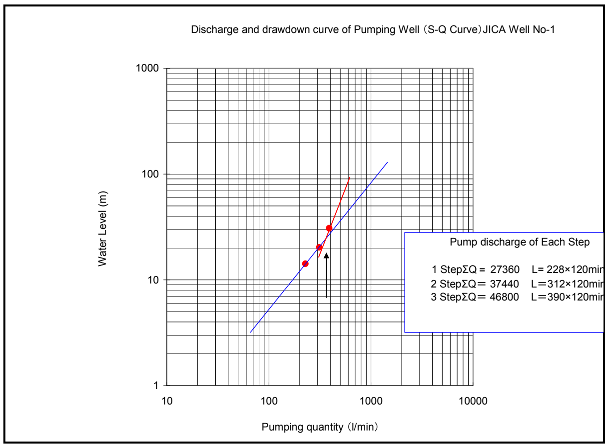




Figure 2.6: Well Efficiency Analysis (JICA Well No-1)

Table 2.9: Well Efficiency of Each Step (JICA Well No-1)

| No-1 | Sw(m) | Q (yield) | | Sc($m^2$/day) | Ew(%) |
|---|---|---|---|---|---|
| | | L/sec | $m^3$/day | | |
| Step-1 | 14.20 | 3.8 | 328.32 | 23.12 | 61.48 |
| Step-2 | 20.28 | 5.2 | 449.28 | 22.15 | 53.83 |
| Step-3 | 30.80 | 6.5 | 561.60 | 18.23 | 48.27 |

Upon completion of Well No-1, it was found that the well efficiency was not as high as hoped, at 48.27% to 61.48%. If the graph of step drawdown test is seen (refer to Figure 2.8), the big difference (about 10 m) will have appeared in the drawdown from the second to the third step, and a graph will also draw not a regression line but a parabola. This suggests the pump discharge of 2nd step is almost near the limit. In the range to the depth of 200 m of the target aquifer (sandstone strata), it seems this time that much pump discharges cannot be expected. However, when average pumping duration is expected to be about 8 hours, the standard of a continuous pump discharge will be considered to be satisfactory if the pump discharge per well can be kept at less than 5.0 L/sec.

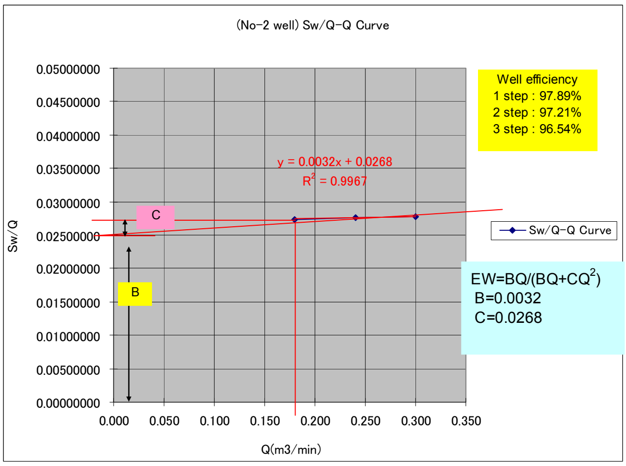
**b. Site No-2**

At first the data was plotted on $s_w$ – Q graph, and the effect of well loss was confirmed in relationship between the change of yield and drawdown (refer to Figure 2.7). At JICA Well No-2 site, the regression line drawn through the three plots represents a linear relationship between the drawdown (s) and discharge (Q). At Q = 5.0 L/sec (432 $m^3$/day), the plot indicated to linear trend. This most probably represents no effect of well loss because of proportional connection between yield (Q) and drawdown (s).

Then the data is plotted on $s_W/Q - Q$ graph to evaluate the effect of well loss. The regression line was indicated by linear trend. As a result of analysis, the coefficients B and C for the equation were evaluated as following Table 2.10.

$$B = 0.0268、\quad C = 0.0032$$

$$Ew = BQ/(BQ+CQ^2)=B/(B+CQ) =96.54\ \%$$



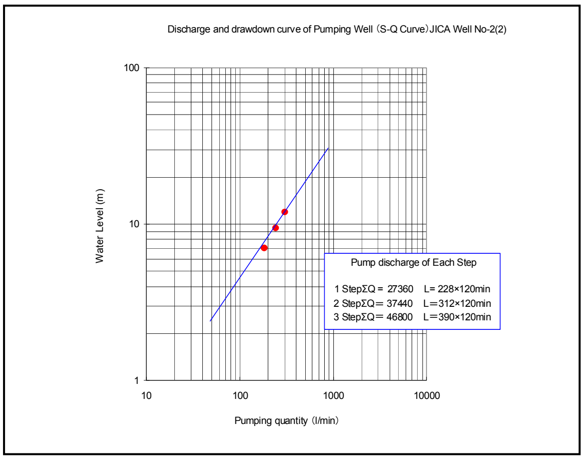




Figure 2.7: Well Efficiency Analysis (JICA Well No-2)

Table 2.10: Well Efficiency of Each Step (JICA Well No-2)

| No-2 | Sw(m) | Q (yield) | | Sc(m²/day) | Ew(%) |
|---|---|---|---|---|---|
| | | L/sec | m³/day | | |
| Step-1 | 7.10 | 3.0 | 259.2 | 36.51 | 97.89 |
| Step-2 | 9.54 | 4.0 | 345.6 | 36.23 | 97.21 |
| Step-3 | 12.00 | 5.0 | 432.0 | 36.00 | 96.54 |

The well efficiency of No-2 well is from 94.54 to 97.89 %. JICA Well No-2 should be a very efficient well. When the graph of a step drawdown test is seen, a drawdown is mostly located in a line on a straight line from the 1st step to the 3rd step, and there is no big difference also in a drawdown (refer to Figure 2.9). If it is within the limits of pump discharge 5.0 L/sec, it is considered that the well of this point will not exceed the standard of a critical yield.

The drawdown is about 12m when the pump discharge is 5.0 L/sec even if the step drawdown test of JICA Well No-2 was pumped up the small quantity. However, although there is less drawdown than JICA Well No-1, the quantity of production is considered to be the same grade as JICA Well No-1.

Moreover, in the range to the depth of 200 m of JICA Well No-2, it seems with it being the same as that of No-1 point that not much pump discharge can be expected. However, when average pumping duration is expected to be about 8 hours, the standard of a continuous pump discharge will be considered to be satisfactory if the pump discharge per well can be kept at less than 5.0 L/sec. The result of time progress of each step drawdown test and a drawdown (S-T curve) is shown in Figure 2.8 and Figure 2.9.

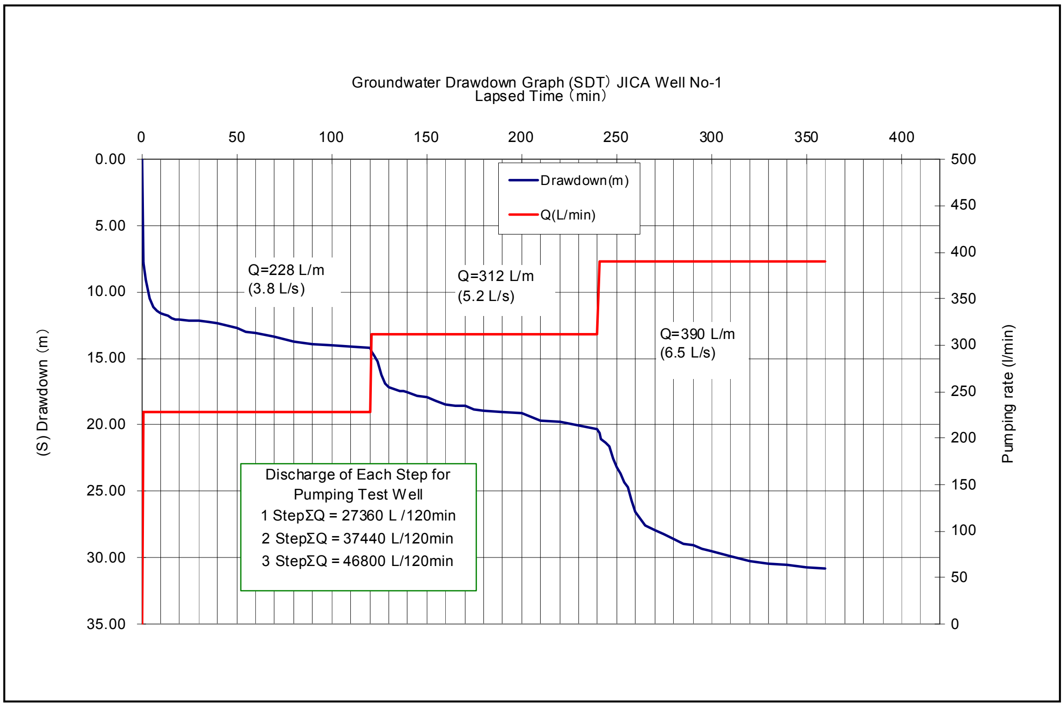



Figure 2.8: Step Drawdown Test S-T curve (JICA Well No-1)

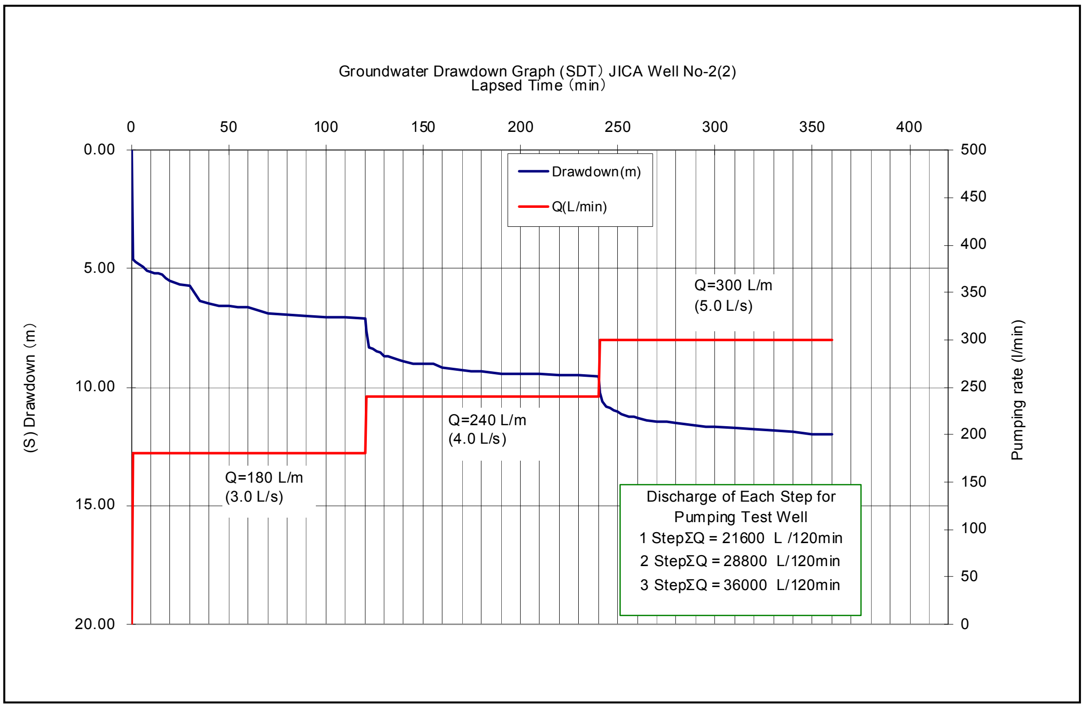



Figure 2.9: Step Drawdown Test S-T curve (JICA Well No-2)

### 2.4.3 Continuous test

The continuous test performed the pumping for 24 hours continuously, and measured recovery of the groundwater level continuously after the end of continuous test (Recovery Test). The continuous test was carried out in order to calculate the coefficient for judging the character of an aquifer. The change of groundwater level during the lapsed time is shown in Figure 2.10 and Figure 2.11 as a result of continuous test. The result of the continuous test was plotted in the graph of the time-drawdown, and analyzed the coefficient of aquifer using a graphic solution.

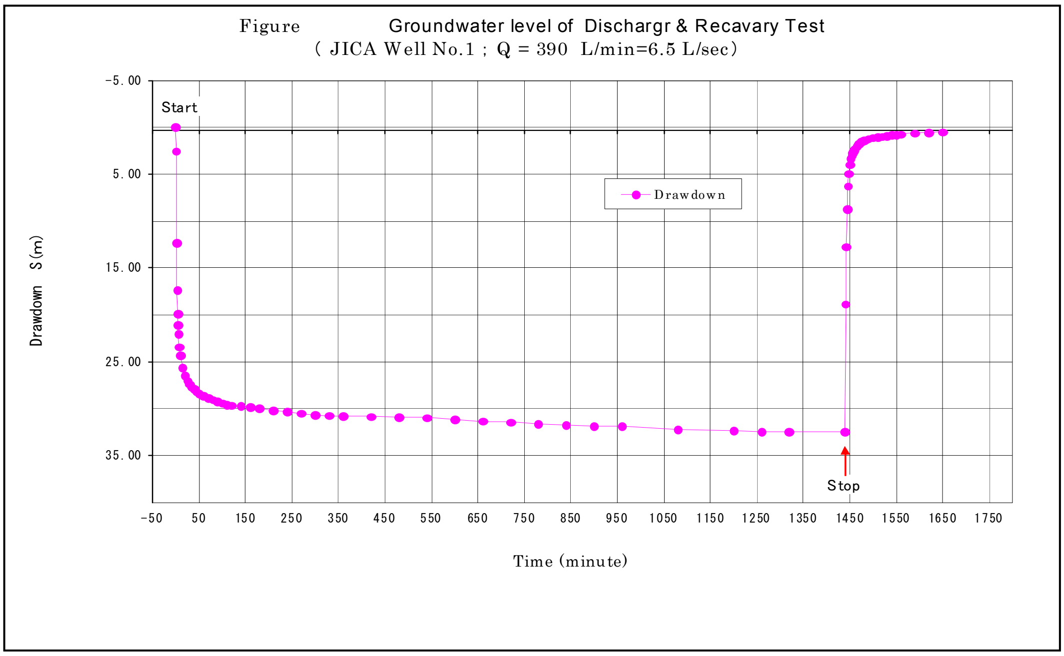



Figure 2.10: Continuous Test S-T curve（JICA Well No-1）

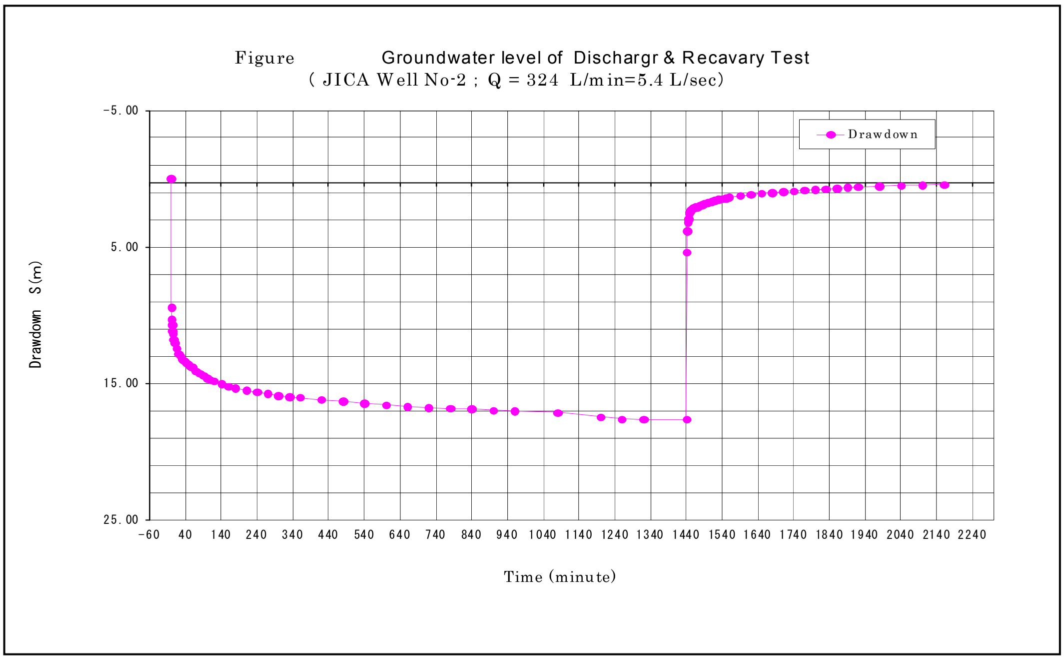



Figure 2.11: Continuous Test S-T curve（JICA Well No-2）

The graphic solution is commonly used to find aquifer constants of Transmissivity (T), Hydraulic conductivity (K), and Storage coefficient (S).The analysis of this Study computed the coefficient of aquifer using the Jacob method and the Theis analysis which are generally used. In Jacob analysis, the data is plotted on a semi-log s (Y axis) – t (X axis) graph. Theoretically the data plots would form a straight line and that is fitted with a regression line to calculate the intersection of the x axis by the line to find "$t_0$" and one log cycle drawdown to find "Δs". In Theis method, the data is plotted on log paper, and the relation at the time of drawdown and well radius / pumping progress, and lays it on top of the Theis type curve of the same size. And it is the method of determining the point (match point) whose plot figure and Theis type curve corresponded, reading W (u) in the point, u, s, and $r^2/t$ (or 1/t), and obtaining an answer. Layer thickness of the aquifer used for analysis was taken as the inserted screen full length. Each analysis result is shown from Figure 2.12 to Figure 2.15.

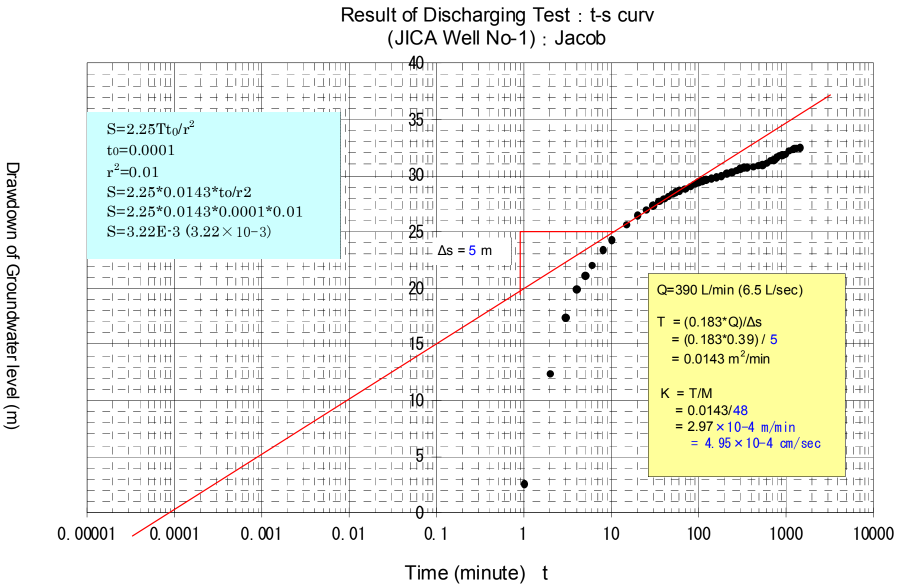



Figure 2.12: Continuous Test：Jacob method (JICA Well No-1)

**Resulut of Pumping Test: Theist curve method (JICA Well No-1)**

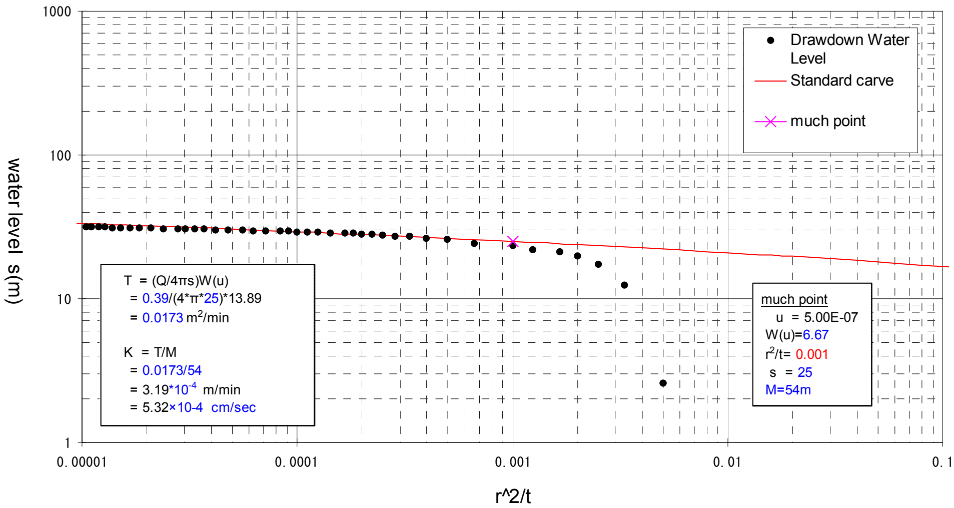



Figure 2.13: Continuous Test: Theis method (JICA Well No-1)

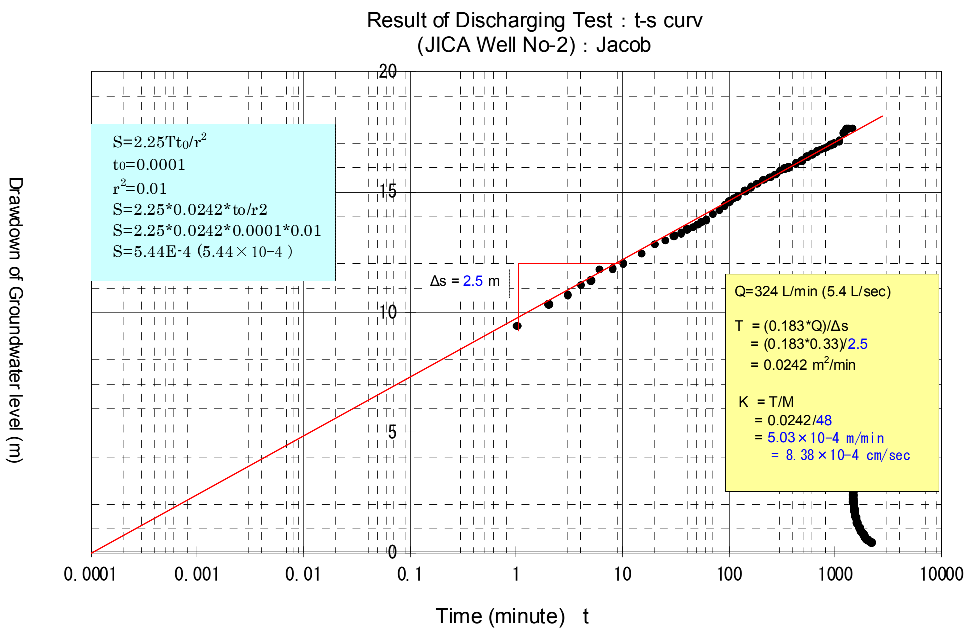



Figure 2.14: Continuous Test : Jacob method (JICA Well No-2)

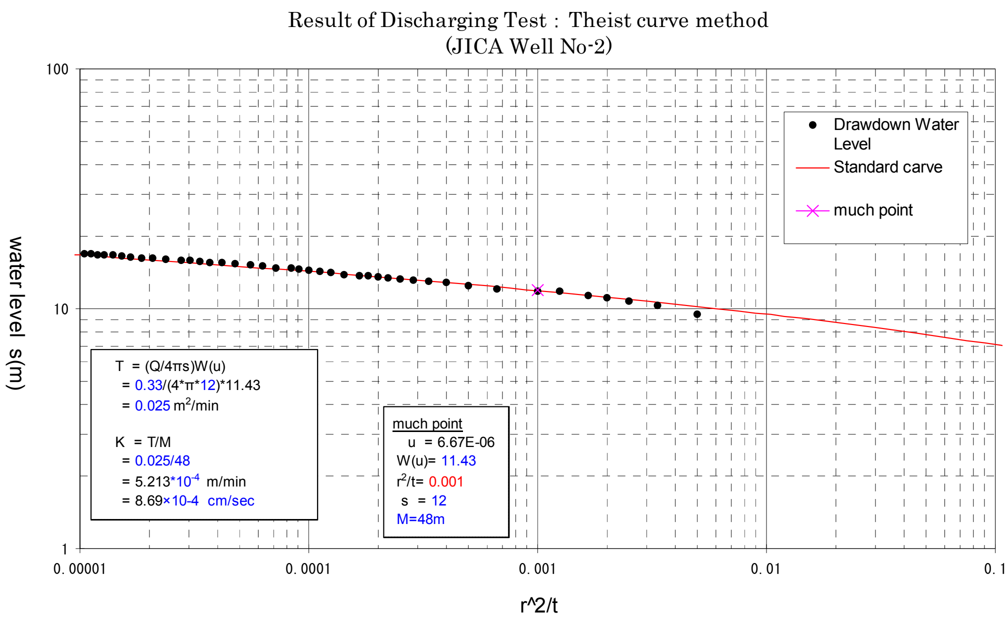



Figure 2.15: Continuous Test：Theis method（JICA Well No-2）

### 2.4.4 Recovery test

The recovery of water level in the borehole was observed immediately after the pump was stopped after 24 hours of operation. Transmissivity (T) can be estimated using this data.
If pumping is stopped, a water level will start to go up, and it is thought that the recovery yield in this case is equal to a pump discharge. The method of working out the recovery water level (s') using eye paper of semi-logarithmic graph, and it takes one cycle to log t/t', if the water difference is at least Δs', it will make the formula of T=0.183Q/Δs', which produces the same result as the formula by Jacob's solution, and can be used to calculate transmissibility (T).The result of the illustration type used for analysis is shown in Figure 2.16 and Figure 2.17.

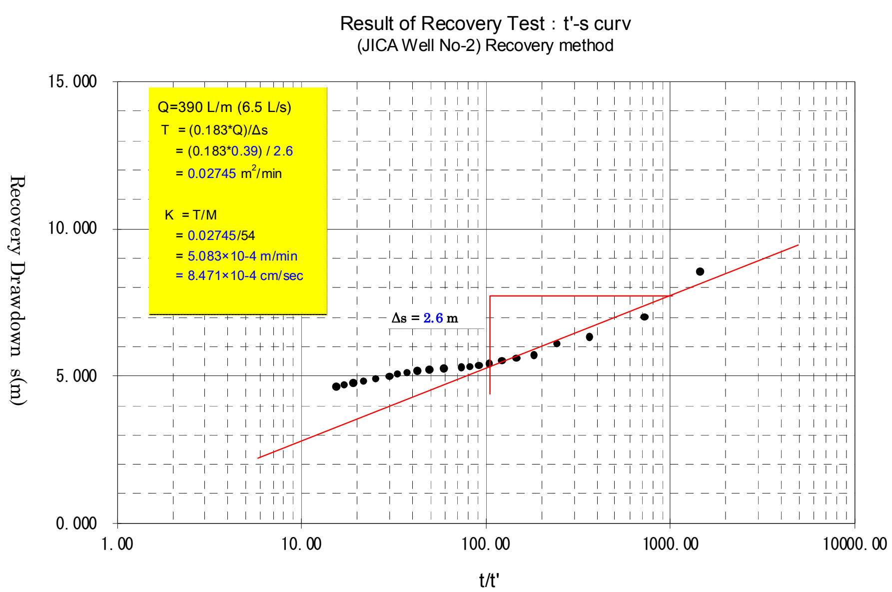



Figure 2.16: Recovery Method（JICA Well No-1）

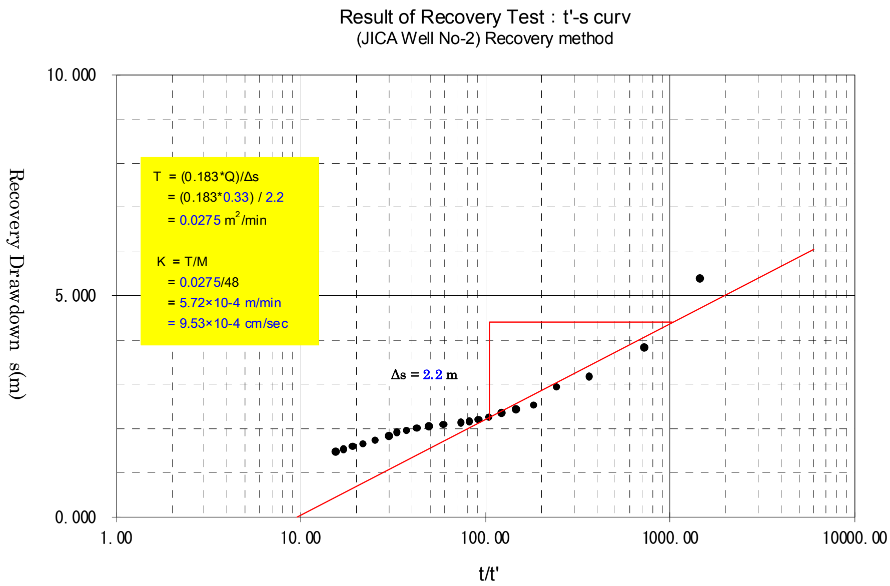



Figure 2.17: Recovery Method（JICA Well No-2）

### 2.4.5 Conclusion of pumping test

Generally, when calculating an aquifer in the analysis of a pumping test, it is assumed that the thickness of aquifer is equal to the full length of screen. The coefficient of aquifer of the drilling point obtained in the analysis of the continuous test is shown in Table 2.11 below. The aquifer for analysis is the sandstone strata deposited the limestone below.

Table 2.11: Coefficient of Aquifer (sandstone)

| Analysis method | Item | Unit | No-1 site | No-2 site | Average |
|---|---|---|---|---|---|
| Jacob method | Transmissivity (T) | $m^2$/min | 0.0143 | 0.0242 | 0.01925 |
| | Hydraulic conductivity (K) | cm/sec | $4.41x10^{-4}$ | $8.40x10^{-4}$ | $6.41x10^{-4}$ |
| | Coefficient storage (S) | — | $3.22x10^{-3}$ | $5.44x10^{-4}$ | $1.882x10^{-3}$ |
| Theis method | Transmissivity (T) | $m^2$/min | 0.0173 | 0.025 | 0.0214 |
| | Hydraulic conductivity (K) | cm/sec | $5.34x10^{-4}$ | $8.68x10^{-4}$ | $7.01x10^{-4}$ |
| | Coefficient storage (S) | — | $3.46x10^{-5}$ | $6.67x10^{-4}$ | $2.063x10^{-5}$ |
| Recovery method | Transmissivity (T) | $m^2$/min | 0.02745 | 0.0275 | 0.0275 |
| | Hydraulic conductivity (K) | cm/sec | $8.47x10^{-4}$ | $9.55x10^{-4}$ | $9.01x10^{-4}$ |

As a result, furthermore, it is as follows when the coefficient of aquifer of two points is summarized.
The range of transmissivity (T): 0.019-0.275 $m^2$/min
Hydraulic conductivity (K): The range of $6.41x10^{-4}$ to $9.01x10^{-4}$ cm/sec
Coefficient storage (S): The range of $2.063x10^{-5}$ to $1.882x10^{-3}$

The result of the simple water analysis at the time of a pumping test is shown in the Table 2.12 below.

Table 2.12: Result of Water Analysis on Site

| Item \ Site | JICA Well No-1 | JICA Well No-2 | Standard of Ethiopia |
|---|---|---|---|
| EC（Electric Conductivity） | 218mS/m | 187.3mS/m | 100 $\mu$ S/cm (push) |
| pH | 6.81 | 6.82 | 6.0－8.5 |
| Water temperature | 25.6 ℃ | 28.8 ℃ | － |
| Fe（iron ion） | 0.8-1.5 mg/l | 0.8-1.5 mg/l | 0.4 mg/l |
| F (fluorine ion) | 0.5-1 mg/l | 1-2 mg/l | 3.0 mg/l |

As a result, although electric conductivity and iron (Fe) are over the recommended value or Ethiopia standard value or both, since these items do not concern human health, they do not present a problem. Also groundwater of the existing well is used for drinking water near JICA drilling area. And other items are almost satisfactory values. However the water quality of both wells will use the regular water analysis result from a lab.

## 2.5 Hydrogeological aspects and prospects

The following thing can be arranged if the hydrogeology aspects near drilling well area are presumed from the result of drilling.

- When the drilling was done by air bubble rotary method or air as drilling fluid, the groundwater strike depth in the borehole can be made with a reasonable accuracy as compared to the case of drilling by mud rotary.

- In JICA Well No-1, the presence of groundwater was confirmed during drilling above hard limestone. The thickness of this layer is about 20m. In JICA Well No-2, groundwater was confirmed in limestone and sandstone strata respectively.

- Compared with the appearance depth of groundwater under drilling, the static water level of the groundwater measured after well completion in both the drilling points is slightly higher. However, what can serve as a clear confining layer in the geology judging from the drilling samples is unclean (refer to Well Drilling Data of Appendix). The storage coefficient calculated in the analysis of the pumping test was a little small value. Therefore the aquifer of this area is considered to be semi- confined aquifer.

For example, at JICA Well No-1 site and No-2 site, it is assumed as follows that the semi-confining layer has accumulated.

- No-1 site; the very fine-grained and clayey marlstone with deposited at the depth of 49m from the depth of 41m.
- No-1 site; the silty deposit and clayey sediment which are deposited at the depth of 74m to 86m.
- No-2 site; the marlstone and the nature sediment of shale which are deposited on the depth of 108m from the depth of 96m.

Existence of these semi-confining layers shown above, at JICA well No-1 site, confine the aquifer (limestone strata and sandstone strata below) at a depth deeper than 86m. And at JICA Well No-2 site, it is a confined aquifer (limestone strata and sandstone strata below) of depth the more deep of 108m.

As original character of rock and sediment, water permeability of a confining layer is very low, and the substrate is hard. Generally, the confining layer is clay or hard rock and very fine grained. Also, the existence of a confining layer can be judged to some extent from change of a drilling rate within the same rock formation.

On the other hand, in case the portion considered to be an aquifer of the lower part is seen, it consists of a sediment of a permeable high unconsolidated, or rock in which the fissure progressed in rock formation. Although based also on the drilling method, a penetration rate is large compared with the former (confining layer). Moreover, as compared with a confining layer, the specific resistivity of well logging appears low in many cases.

In case the hydrogeology information acquired by drilling is compared with the information on geophysical prospecting, then, the stratum unit of the target aquifer can be summarized stratigraphically and it can be compiled as the following Table 2.13.

Table 2.13: Correlation between Geology and Geophysical Survey Results

| Tentative Depth (m) | Lithology | Classification of Geophysical Prospecting | | Geology Stratum |
|---|---|---|---|---|
| | | VES | TEM | |
| 0m- 20m | Unconsolidated soil | 1～3 layer | 1 layer | Alluvium |
| 20m- 66m | Alternation of marl/sand/limestone, with fissure | 4 layer | 2 layer | Sediment of Holocene and Mesozoic of Hamanlei series |
| 66m - 130m | Limestone with fissure | 5 layer | 3 layer and 4 layer | Mesozoic Sediment of Hamanlei series |
| 130m - 180m | Massive limestone with sandstone | 6 layer | 4 layer and 5 layer | |
| 180m - deeper | Sandstone | — | 6 layer | |

The outline of the aquifer of each drilling site which became clear in main enumeration was summarized in Table 2.14 of the following table. In addition, in collecting, the existing results of an investigation were also taken into consideration.

Table 2.14: Outline of Drilling Well and Aquifer

| | JICA Well No-1 | JICA Well No-2 |
|---|---|---|
| Well Depth at Completion | 202m | 202m |
| Elevation (m) | Ab. 1447 m | Ab. 1448 m |
| Aquifer Section Depth | 130m-190m | 135m-189m |
| Aquifer Lithology | Sandstone | Sandstone |
| Static Water Level (GL-) | 84.6m | 86.89m |
| Aquifer Type | Semi-confined | Semi-confined |
| Specific Capacity | 18.23-23.12 $m^2$/day | 29.96-39.75$m^2$/day |
| Well Efficiency | 48.27-61.48 % | 96.54-97.89 % |
| Transmissivity (T) | 0.0143-0.0275 $m^2$/min | 0.0242-0.0275 $m^2$/min |
| Hydraulic Conductivity (K) | 4.41-8.47x$10^{-4}$ cm/sec | 8.40-9.55 x$10^{-4}$ cm/sec |
| Storage Coefficient (S) | 3.46x$10^{-5}$-3.22x$10^{-3}$ | 5.44x$10^{-4}$-6.67x$10^{-4}$ |

Moreover, when change of the water level under pumping test was investigated using two drilling wells, the phenomenon for sphere of influence as shown below appeared (refer to Table 2.15).

1) The drawdown of No-2 well was 0.03m in the 8 hours after starting pumping test in No-1 well.
2) The drawdown of No-2 well was 0.15m in the 24 hours after starting pumping test in No-1 well.
3) In Table 2.15 it can be clearly seen that the influence of groundwater by pumping was quite great between the two wells.
4) Due to this, it cannot be said that the target aquifer (sandstone strata) is very good.
5) Although it is 410 m between the two wells, if simultaneous pumping in this range is performed continuously, it suggests that the mutual interference (influence) of groundwater will become apparent between the two wells.

Table 2.15: The Groundwater Level Change by Pumping Test

| Pumping well<br>JICA Well No-1 | Water Level checked well<br>JICA Well No-2 | |
|---|---|---|
| Continuous Pumping Test 24 hrs. | SWL before Pumping Test started at Site No-1 is 88.15 m | Drawdown (m) |
| SWL (m) | 88.15 | — |
| 8 hrs. Passed Pumping | 88.18 | -0.03 |
| 16 hrs. Passed Pumping | 88.26 | -0.11 |
| 23 hrs. Passed Pumping | 88.28 | -0.13 |
| 24 hrs. Passed Pumping | 88.30 | -0.15 |
| Recovery 1hr. Passed | 88.30 | -0.15 |

Moreover, the drilling well of UNHCR is 1.3 km away from the JICA Well No-1, and No-2. The well of UNHCR is located more in the Jarar valley side from the wells of JICA.
Next, the trial calculation of the sphere of influence in basin in detail will be executed. For example, when making the trial calculation of the sphere of influence in basin will be conducted in the same aquifer by using the results of JICA Well No-2 (by yield of 6.5L/sec and (T) and (S) value in step drawdown test), the results of calculation are shown in Table 2.16.

Table 2.16: Calculation of the Sphere of Influence

| Day / Distance | 5 days | 7 days | 15 days | 30 days | 185 days | 356 days | 730 days |
|---|---|---|---|---|---|---|---|
| 200m | 2.17 | 2.63 | 3.67 | 4.61 | 7.10 | 8.02 | 8.97 |
| 300m | 1.06 | 1.52 | 2.56 | 3.50 | 5.99 | 6.92 | 7.86 |
| 400m | 0.27 | 0.73 | 1.77 | 2.72 | 5.20 | 6.13 | 7.08 |
| 500m | 0.00 | 0.12 | 1.16 | 2.11 | 4.59 | 5.52 | 6.47 |
| 1000m | 0.00 | 0.00 | 0.00 | 0.22 | 2.70 | 3.63 | 4.57 |
| 2000m | 0.00 | 0.00 | 0.00 | 0.00 | 1.59 | 2.52 | 3.47 |
| 2500m | 0.00 | 0.00 | 0.00 | 0.00 | 0.81 | 1.74 | 2.68 |
| 3000m | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 | 1.13 | 2.07 |

If this result is seen, the sphere of influence in basin after starting pumping is considered between each well. For example, if the distance of the well is 500 m: drawdown is 0.12m in 7 days after a pumping start. If the distance of the well is 1000 m: drawdown is 0.22m in 30 days after start of pumping.

As the results of this calculation, when the wells distributed in Jarar valley were pumped up over a long period or the yield of pumping was made to be large all at the same time, it is expected the mutual interference will be caused and there will be a large influence.

Confirmation of what kind of pumping was performed in the existing wells is still pending data analysis. However, when it sees from the relation between discharge and drawdown, there is less recharge than discharge for the time being. Therefore, it seems that the water balance within an aquifer has broken somewhat.

In order to judge hydrogeological aspects in JICA well drilling area, the following items concerning well usage need to be considered.

- It is important to suppress the interference of groundwater of each well as much as possible.
- The discharge per well is limited to the range of 5L/sec to 6L/sec, and groundwater is not withdrawn for extended periods. Each well does not pump up groundwater in the same time zone.
- There needs to be a plan for efficient pumping intervals of all the wells that are working in the Jarar valley.

# Chapter 3

*Socio-Economic Survey*

# 3 Socio-Economic Survey

## 3.1 General

Somali region in the Federal Democratic Republic of Ethiopia is suffering from chronic drought problems and its low water supply ratio is making the problem worse. It was especially hit by the worst drought in the past 60 years in 2010 and 2011. Under such a situation, the Consultant is conducting a study on the water resources development and water supply planning for Jarar Valley and Shebele sub-basin for the purpose of drawing up a plan to improve the water supply systems for the target areas. The study includes the formulation of water supply plan in the study area and the emergency water supply projects of constructing water supply points in Kabribeyah and Godey towns.

One of the components of this study is the socio-economic survey for the target areas. A socio-economic survey was conducted in the target woredas to obtain basic data for the formulation of the water supply plans and also for the evaluation of the water supply plans to be proposed as a result of the study. The Socio-economic Survey entrusted to the local consulting firm was conducted during May and October, 2012. A final report was presented to the Study Team on 15th October 2012.

The socio-economic survey consisted of: (i) interview survey at each woreda water office on the water supply situation of the target woredas; (ii) interview survey at the water supply utility offices in big towns including Kabribeyah and Godey towns; and (iii) interview survey at the sample households selected from the target woredas on the demand and needs of daily water use.

At the initial stage of the study, the socio-economic survey was supposed to be conducted at 17 target woredas in Somali Region. However, due to security reasons, the survey was not conducted in Doba wein woreda located in Jarar valley area. Later the analysis of Doba wein woreda was conducted using the data collected by SRWDB and the data set from a similar woreda in the area. Marsin woreda was found outside the study area as a result of the survey and then excluded from the analysis. As a result, the Survey covered 16 woredas indicated in the following Table 3.1.

Table 3.1: Target Woredas for Survey

| Survey Area | Zone | Target Woredas | Associated new woreda | Remark |
|---|---|---|---|---|
| Jarar valley | Fafan | Kabribeyah | | Zone name was changed form Jijiga |
| | Jarar | Dagahbur | Araarso | Zone name was changed from Dagahbur |
| | | | Birqod | |
| | Korahe | Shaygosh | | Marsin is out of Study area |
| | | Kabridahar | | |
| | | Doba wein | | |
| Shebele sub-basin | Shebele | East Ime | Beercaano | Zone name was changed from Godey |
| | | Adadle | | |
| | | Danan | | |
| | | Godey | | |
| | | Kalafo | | |
| | | Mustahil | | |
| | Afder | West Ime | Rasso | |

In order to grasp the condition of the target areas as accurately as possible, the team employed surveyors who are native of Somali and a pre-test using the questionnaire forms that the study team expert prepared was conducted in Kabribeyah Town. The forms were revised based on the results of the pre-test and then the survey teams were dispatched. The questionnaire forms used are presented in the Date Book.

## 3.2 Development plan and related Laws

### 3.2.1 National level (Federal Ethiopia)

**a. National water resources management policy**

The Ministry of Water and Energy (formerly the Ministry of Water Resources) adopted its National Water Resources Management Policy in 1999. The overall goal of the Policy is to enhance and promote “efficient, equitable and optimum utilization of water resources” for sustainable socio-economic development. It recognizes water as an economic good and encompasses water supply and sanitation, irrigation and hydropower sub-sectors. One of its main objectives for the water supply and sanitation sub-sectors is to ensure that every Ethiopian citizen has access to water of acceptable quality to satisfy the basic human needs. The policy provides a guiding framework within which more detailed sub-sector strategies and institutional reforms are to be developed.

Based on the policy the Ministry of Water and Energy has prepared a national water sector strategy to articulate implementation of the Water Policy. According to the National Water strategy, the sectoral objective is “Provision of safe and sufficient water supply and adequate sanitation services as indispensable components in the sustainable development of Ethiopia’s urban and rural socio-economic well-being.

**b. Water sector development program**

In addition to the National Water Resources Management Policy, the Water Sector Development Program for 2002 – 2016 (WSDP) has been developed within the framework of the poverty reduction strategy. The WSDP sets out targets and investment needs to meet the Millennium Development Goals, aiming at achieving the water coverage of 76% by 2016.

**c. Universal Access Program (UAP)**

The Universal Access Program (UAP) was launched in 2005 and was ratified by parliament in that year. The UAP aims to achieve the water coverage of 98 % in rural areas by 2012 through the provision of 149,024 water points, of which 69,745 water points (47%) are to be covered by the hand dug wells with the depth of less than 10 meters, 38,568 water points (26 %) to be covered by shallow wells with depth of 15 meters, and the rest (27 %) to be covered by wells with boreholes, springs, etc.. The UAP aims to achieve the water coverage of 100 % for urban areas by 2012.

**d. The revised UAP**

In 2009, the Ministry of Water Resources (now Ministry of Water and Energy as of October 2010) reviewed and reformulated these strategies and updated targets in order to accelerate progress at all levels. The revised UAP was made to focus on securing water supply access to a total of 34.5 million people from 2009-2012, implying a two fold increase in implementation rate by giving emphasis to low cost technologies including but not limited to self-supply (family wells). Community mass mobilization, advocacy and promotion, and developing minimum capacity at Woreda level were proposed for enhancing its implementation. The plan was estimated to cost about 6.8 Billion Birr at 2009 prices.

### 3.2.2 Somali region

Water Sector Development Program Phase IV (WSDP IV) has been established in Somali region to formulate the five year strategic plan in the water sector for 2010/2011 – 2014/2015. The Program has the mission to manage the water, mines and energy resources of Somali region in collaboration with other agencies and stakeholders, to benefit the state's people, and to protect, restore and enhance the natural and human environments in an integrated, sustainable, responsible, objective oriented and demand-responsive manner.

Major goals and targets set out in the Program are summarized in the following Table 3.2.

Table 3.2: Summary of the Goals and Targets of WSDP IV

| Strategic Issue | Goal | Target |
|---|---|---|
| 1. Low access to potable water supply | Increase total rural population access to potable water supply | Raise the rural population with access to potable water from 38.4% to 100% by the year of 2015 |
| | Increase total urban population access to potable water supply | Increase urban population with access to potable water from 47% to 100% by the end of 2015 |
| 2. Low implementation capacity of the sector | Strengthening the overall implementation capacity of the water sector | Conducted M&E at the end of each quarter |
| | | Establish database system to produce quality reports monthly, quarterly, semi-annually and annually |
| | | Recruit new technical and administrative staff for the sector |
| | | Provide short, long and on job term trainings for about 180 persons (electricians, mechanics, engineers and other technical / provisional staff) |
| | | Procurement of water drilling rigs, generators and pumps, hand pumps, light vehicles, crane, water investigation and surveying equipment and materials |
| | | Expansion of water quality testing laboratory |
| | | Establishment of garage and expansion and new construction of offices |
| | | Procurement of material and spare parts for rehabilitation |
| | | Establishment of mobile workshops |
| 3. Management problem in the existing water schemes and resources. | Improve management of the existing water schemes and resources | To assign and train scheme care takers (at least one electrician and mechanic) to each woreda |
| | | To establish and follow up on community based organizations such as WUAs, WaSHCOs, and Water boards. |
| | | To reduce the share of mal-functioning rural systems from 29% to 5% by the end of 2015. |
| | | To provide training for local mechanics, artisans, water supply and electro- mechanical technicians. |

Source: Water Sector Development Program Phase IV, Somali Regional Water Bureau, 2010
Note: WUA = Water Users Association; WASHCO = Water, Sanitation and Health Committee

## 3.3 Socio-economic conditions in the Region

### 3.3.1 Population and demographic characteristics

#### a. Census data in 1994 and 2007

The result of censuses in 1994 and 2007 by CSA indicates that the population in Somali region increased from 3,439,860 to 4,445,219 with an average annual growth rate of 1.99 %. Out of the total population of 4,445,219 persons in 2007, the male and female population accounted for 2,472,490 (55.6 %) and 1,972,729 (44.4 %), respectively (refer to Table 3.3).

Table 3.3: Census Data in Somali Region in 1994 and 2007

| Zone | Population in 1994 | Population in 2007 | Average Annual Growth Rate |
|---|---|---|---|
| Shinile | 358,703 | 457,086 | 1.88% |
| Jijiga | 813,200 | 892,262 | 1.35% |
| Dagahbur | 304,907 | 478,168 | 3.52% |
| Warder | 324,308 | 306,488 | -0.43% |
| Korahe | 242,276 | 312,713 | 1.98% |
| Fik | 233,431 | 348,409 | 3.13% |
| Godey | 327,156 | 464,253 | 2.73% |
| Afder | 358,998 | 570,629 | 3.63% |
| Liben | 476,881 | 539,821 | 0.96% |
| Somali Total | 3,439,860 | 4,445,219 | 1.99% |

#### a.1 Ethnic composition

The Somali ethnic group is the most dominant ethnic group in the region, covering 97 percent of the regional population. The second and third largest ethnic groups (Amhara and Oromo) accounted for less than one percent.

#### a.2 Religious composition

The results of the 2007 census indicate that Muslim religion was the most dominant religion in Somali region covering 98 percent of the population. The percentage is higher in rural areas, accounting for 99.1 percent. The remaining types of religions had followers below two percent of the population.

#### a.3 Literacy status

The literacy rate for the 2007 was 13.7 percent, while the corresponding figure for 1994 was 8.1 percent. These show that there were substantial improvements in the literacy status in the last 12 years.

There were significant variations among zones concerning the literacy status of the population. The highest proportion of literate persons in 2007 was reported in Jijiga Zone (17.85 percent) while the lowest proportion of the same was in Fik Zone (8.9 percent).

#### a.4 School attendance

In 2007 the proportion of current school attendance (4.7 percent) shows a slight increment as compared to the 1994 census results (4.1 percent). Liben Zone had the highest percentage (6.7 percent) of students attending school in 2007, followed by Jijiga and Shinile Zones with the proportion of 6.4 percent and 4.7 percent, respectively. On the other hand, Fik and Godey

Zones had the lowest percentage with the proportions of 1.6 percent and 2.8 percent, respectively.

The proportion of current school attendance was higher for males at regional and zonal levels. At regional level, the proportion currently attending school was 5.1 percent for males and 4.2 percent for females.

### b. Population trend in 2007 and 2011

Based on the population data compiled by the Central Bureau of Statistics, the population in Somali region is estimated to have increased from 4,445,219 in 2007 to 4,986,004 in 2011 with an average annual growth rate of 2.91 % ( refer to Table 3.4).

Table 3.4: Population Data in Somali Region in 2007 and 2011

| .Zone | Population in 2007 (Census) | Population in 2011 (Projected) | Average Annual Growth Rate |
|---|---|---|---|
| Shinile | 457,086 | 512,699 | 2.91% |
| Jijiga | 967,652 | 1,086,159 | 2.93% |
| Dagahbur | 478,168 | 536,290 | 2.91% |
| Warder | 306,488 | 343,609 | 2.90% |
| Korahe | 312,713 | 350,799 | 2.91% |
| Fik | 348,409 | 390,622 | 2.93% |
| Godey | 464,253 | 521,014 | 2.90% |
| Afder | 570,629 | 639,653 | 2.90% |
| Liben | 539,821 | 605,159 | 2.90% |
| Somali Total | 4,445,219 | 4,986,004 | 2.91% |

### c. Population of the study area in 2011

On the basis of population data of the Central Statistical Agency (CSA) and the Bureau of Finance and Economic Development (BoFED) in Somali region, the population of the Study area is estimated as 1,220,770 persons in 17 woredas.
The study area consists of 8 Woredas in Jarar valley area and 9 woredas in Shebele sub-basin area (refer to Table 3.5).

Table 3.5: Population of the Study Area by Woreda in 2011

| Study Area | Zone | Woreda | Population in 2011 |
|---|---|---|---|
| Jarar Valley | Jijiga | Kabribeyah | 176,023 |
| | Dagahbur | Dagahbur | 129,773 |
| | | Araarso | 55,000 |
| | | Birqod | 52,200 |
| | Korahe | Shaygosh | 48,624 |
| | | Kebridahar | 75,153 |
| | | Debewein | 70,033 |
| | | Marsin | 64,953 |
| Shebele Sub-basin | Godey | East Ime | 81,000 |
| | | Adadle | 83,489 |
| | | Danan | 38,000 |
| | | Godey | 61,621 |
| | | Beercaano | 58,124 |
| | | Kalafo | 82,000 |
| | Afder | Mustahil | 47,176 |
| | | West Ime | 48,059 |
| | | Rasso | 49,542 |
| Total | | | 1,220,770 |

### 3.3.2 Local administrative divisions

Ethiopia is administratively divided into regions, which are subdivided into zones, which are further subdivided into woredas.

The woredas in Ethiopia are the district administrative levels that are given prominence due to strengthening of the decentralization process since 2002. The woredas comprise a range of 25 to 50 kebeles.

Kebeles are the lowest grassroot levels of administrative structure. Each kebele comprises an estimated of 1,000 households. About 80 % of the kebeles are rural and the remaining 20 % are located in urban areas.

At the time of the 2007 census, Somali region was divided into nine zones, which were further divided into 53 woredas. After the census, some woredas were sub-divided into two or three woredas. As a result, Somali region now consists of nine zones which are sub-divided into 67 woredas.

### 3.3.3 Regional economy

Livestock is the major source of livelihood base for the population of Somali region. Eighty five (85) percent of the population in the region dwell in the rural areas and are either pastoralists who mostly depend on livestock rearing or agro-pastoralists who depend on mixed livestock rearing and crop production. Livestock provides food, cash income, source of wealth saving, means of transport and drought power for land cultivation.

Pastoralism is the most prevalent, comprising about 60% of the region’s rural population. Agro-pastoralism comprises about 25 % of the total population, and is a mixture of extensive livestock rearing and rain-fed crop production; some may be better described as pastoralists with opportunistic farming activities as in Fik and some parts of Liben Zone.

The remaining 15 % of the rural population comprises sedentary (Jijiga) and riverine (Shebele and Dawa-Ganale) farmers. Both farming and agro-pastoral groups keep some livestock but farmers’ herds do not migrate and are sometimes hand-fed, only migrating with other groups if there is a severe drought.

Major food crops grown in Somali region are maize, sorghum, millet, and legumes. Major cash crops are vegetables (e.g. tomato), fruits, and groundnuts.

Livestock sector is providing important source of protein food principally in the form of meat, milk and poultry products. Livestock population is estimated to be 3,796,000 cattle, 9,053,000 sheep, 8,547,000 goats, and 2,032,000 camels in 2011.

## 3.4 Refugee conditions in the Somali Region

**a. General**

UNHCR Sub-office in Jijiga was opened in the early 1990s following the arrival of Somali refugees to Ethiopia. The influx increased significantly with the fall of the Siad Barre Regime in 1991 which lead to the establishment of nine refugee camps at the eastern border of Ethiopia. The total population of Somali refugees at that time was over half a million, namely 627,000 persons. A few years later, most of these refugees were able to return to their places of origin. Following the voluntary repatriation that took place from 1997 until 2005, only Kabribeyah refugee camp remained open, hosting over 16,000 refugees. All other camps were closed in 2005.

However, in 2006, following the new outbreak of violence in Somalia, the operation restarted after receiving 833 new refugee families in Hartisheik (22 km from Kabribeyah) seeking asylum.

A new camp site was found in Awbarre (about 70 km north of Jijiga) to house the new refugees. In May 2007, UNHCR opened a reception center in Kabribeyah, while awaiting the opening of the new camp. After Awbarre camp was full to capacity in 2008, the government started directing asylum-seekers to Lafaissa transit center in May 2008.

To relocate the newly arrived refugees, UNHCR, jointly with the Government Administration for Refugee and Returnee Affairs (ARRA), opened a new camp site at Sheder in May 2008, while Lafaissa reception center was closed in November 2009. Out of 10 refugee camps in Somali region, only Kabribayah refugee camp is located in the study area (refer to Table 3.6).

Table 3.6: Population Statistics of Refugee Camps in Somali Region

| Camp / Site | Households | Individuals | Percent (%) |
|---|---|---|---|
| 1. Awbarre | 2,304 | 13,285 | 6.9 % |
| 2. Sheder | 2,603 | 11,407 | 6.0 % |
| 3. Kabribeyah | 2,201 | 16,340 | 8.5 % |
| 4. Bokolmanyo | 9,779 | 39,034 | 20.4 % |
| 5. Melkadida | 9,242 | 40,351 | 21.1 % |
| 6. Kobe | 6,218 | 26,459 | 13.9 % |
| 7. Hilawein | 6,218 | 26,098 | 13.7 % |
| 8. Buramino | 3,864 | 15,723 | 8.2 % |
| 9. Dolo Ado transit center | 303 | 901 | 0.5 % |
| 10. Gode (God-Dahar) | 648 | 1,354 | 0.7 % |
| Total | 43,380 | 190,952 | 100.0% |

Source: Briefing Kit on the Refugee Protection and Assistance Program in Jijiga, UNHCR, 2012

**b. Social conditions**

Kabribeyah refugee camp was opened in February 1991. It is located about 55 km southeast of Jijiga and at an altitude of 1660 m above sea level. Over 60 percent of the camp population is under the age of 18, which means that more than half of the camp population was born in the camp and has lived there all their lives. The female to male ration is fairly even with 51 percent being women and 49 percent men.

Under support from UNHCR, the Jarar Valley Water Supply Scheme started in 1997 for the supply of water for Kabribeyah refugee camp and also town area. The construction works completed in 2000 and operation of the facility started from 2004 by the Jarar Valley Water Office. Presently Kabribeyah Utility Office (formerly the Jarar Valley Water Office) is responsible for the operation and maintenance of the facility. Maintenance and rehabilitation works were the responsibility of Jijiga Water Supply Office (JWSO),

In the three camps (Kabribeyah, Awbarre and Sheder), preschool, primary school, ABE (Alternative Base Education) and NFE (Non-Formal Education) is provided. Secondary school in Sheder is managed by UNHCR IP while refugees in Awbarre and Sheder go to local secondary schools. In addition, UNHCR Sub-office Jijiga established a partnership with the University of Jijiga that confirmed its willingness to admit a number of refugees for high level education.

ARRA provides comprehensive health care services at the camp health centers and referrals to higher medical facilities. All components of health such as MCH, reproductive health, immunization, family planning, nutrition monitoring, public health, HIV/AIDS are covered at all the camps.

Construction / maintenance of family and communal latrines, waste disposal facilities as well as sanitation education to refugees are provided. In 2011, 2,377 family latrines and 19 waste disposal pits will be constructed and this will significantly improve the latrine to family ratio in the three camps.

## 3.5 Analysis of socio-economic survey

### 3.5.1 Water use survey

#### a. Outline of the survey

As a complement to the socio-economic survey, a simplified survey on the use of water by the residents in the study area, especially on the water use for different purposes was conducted. The target of this survey was the households in Kabribeyah Town (including the refugee camp), Godey Town, and surrounding three woredas. The samples also represent both Jarar Valley and Shebele River basin areas. Fifteen households in the two towns and 10 households in the woredas and in the refugee camps were interviewed as samples. Also, where it was possible, the study team sent a surveyor to make an observation and a measurement on the actual water use at a representative water point in the area. The outline of the survey is shown below.

**Period:** Two weeks in November 2012

**Target:** 2 towns ( Kabribeyah, Godey) and 3 woredas (Araarso, Adadle, Beercaano)

**Method of the survey:** Interview survey of sampled households using a structured questionnaire and observation and measurement of water use at representative water supply points.

**Target households and water points:** Total of 70 households and 5 water points

The target towns and woredas were determined to sample woredas with different water sources and also in consideration of the access limitations. As a result, Kabribeyah and Godey Towns and the 3 woredas in the vicinity of the towns were selected. The household samples were taken uniformly from all areas of the woreda center, in consideration of the distribution of kebeles. Again, due to the limitation in access, no samples were collected from the outskirts of woredas. The samples are, thus, thought to represent the population living in the center of woredas and towns where communities concentrate. The survey was conducted in the rainy season in all the target areas.

#### b. Result of the survey

The major results of the survey are as compiled in Table 3.7 below.

Table 3.7: Results of the Survey by Towns and Woredas

| | Jarar Valley area | | | Shebele River basin area | | |
|---|---|---|---|---|---|---|
| | Kabribeyah | | Araarso woreda | Godey town | Adadle woreda | Beercaano woreda |
| | Town | Refugee camp | | | | |
| Number of HH | 15 | 10 | 10 | 15 | 10 | 10 |
| Major water sources | Public tap (3)<br>Neighbor (3)<br>Water seller (5)<br>Domestic tap (4) | Public tap (10) | Birka (10) | Public tap (1)<br>Water seller(12)<br>Domestic tap (2) | HDW (10) | Water seller (10) |
| Average number of family per HH | 10.5 | 8 | 8.1 | 8.2 | 7.7 | 7.1 |
| Average water use amount / HH (rainy season) | 163 L/day | 112 L/day | 138 L/day | 108 L/day | 94 L/day | 92 L/day |
| Average water use amount / HH (dry season) | 224 L//day | 152 L/day | 196 L/day | 177 L/day | 146 L/day | 140 L/day |
| Water use amount per head (rainy season) | 15.7 L/day | 14.2 L/day | 17.1 L/day | 13.1 L/day | 12.8 L/day | 13.4 L/day |
| Water use amount per head (dry season) | 21.7 L/day | 19.8 L/day | 24.1 L/day | 21.7 L/day | 19.6 L/day | 20.3 L/day |

* Major water source: the water sources that the sampled households utilize. The numbers in parenthesis are number of corresponding samples

* Rainy season and dry season: the divisions of the two seasons differ from area to area.

The calculated water use for the entire survey area including the refugee camp is shown in Table 3.8 below.

Table 3.8: Summary of Water Use Amount

| | Average no. of person per household | Water Use Amount (L/day) | | |
|---|---|---|---|---|
| | | Rainy season | Dry season | Average |
| Jarar Valley | 9.1 | 15.7 | 21.9 | 18.8 |
| Shebele River | 7.7 | 13.1 | 20.7 | 16.9 |
| Entire area | 8.4 | 14.4 | 21.3 | 17.9 |

**c. Water use in different seasons**

The survey results indicate that the average amount of water the residents get is 13 - 17L/day/head in the rainy season and 20 - 24L/day/head in the dry season. The water use amount obtained in this survey signifies those that the sampled households receive or buy from public/private water supply facilities or from water sellers. Thus, in the rainy season when households can use rainwater directly at home, the amount of water they receive from such sources diminishes by 30 to 50%. As a matter of fact, many households were found to use one or two plastic (or steel) drums (200L) at home to collect rainwater (see Table 3.9). Some even possess a birka in their own yards. Meanwhile, in the dry season people tend to use a little more water than in the rainy season in order to wash off abundant dust and to relieve thirst. This is expected to raise average water use amount in the dry season. Therefore, the average actual water use amount throughout a year is probably the average of the values between the two seasons.

Table 3.9: Number of Households Possessing Water Reservoirs

| | Jarar Valley | Shebele River basin |
|---|---|---|
| Total Surveyed | 35 HH | 35 HH |
| HH with Oil drum | 19 HH (54%) | 24 HH (69%) |
| HH with Birka | 1 HH | 1 HH |

The water use amount by different purposes is compiled as in Table 3.10 and illustrated in Figure 3.1.

Table 3.10: Daily Water Use Amount per Head for Different Purposes

(Unit: L/day)

| | Jarar Valley | | | Shebele River basin | | |
|---|---|---|---|---|---|---|
| | Kabribeyah Town | Kabribeyah Refugee camp | Araarso woreda | Godey town | Adadle woreda | Beercaano woreda |
| Drinking (RS) | 3.4 | 2.5 | 3.5 | 2.4 | 2.3 | 2.7 |
| Drinking (DS) | 4.0 | 2.5 | 4.2 | 4.1 | 3.4 | 4.1 |
| Cooking (RS) | 3.4 | 2.5 | 3.7 | 2.6 | 2.3 | 2.7 |
| Cooking (DS) | 4.0 | 2.5 | 4.4 | 4.8 | 3.4 | 3.8 |
| Washing*(RS) | 4.4 | 4.5 | 4.9 | 4.3 | 3.4 | 3.8 |
| Washing*(DS) | 6.7 | 7 | 7.9 | 6.5 | 5.6 | 6.5 |
| Bathing (RS) | 4.4 | 4.5 | 4.9 | 3.7 | 3.4 | 3.8 |
| Bathing (DS) | 6.7 | 7 | 7.7 | 5.9 | 5.6 | 6.5 |
| Farming (RS) | 0 | 0 | 0 | 0 | 0 | 0 |
| Farming (DS) | 0 | 0 | 0 | 0 | 0 | 0 |
| Livestock (RS) | 0 | 0 | 0 | 0.2 | 0.8 | 0 |
| Livestock (DS) | 0 | 0 | 0 | 0.3 | 1.0 | 0 |

Note) Washing include clothes and dishes, RS: Rainy season, DS: Dry season

In the survey area, only four households use water for livestock and no households use water for farming. As a whole, water use for farming and livestock accounts for only a small fraction of the total water use. The water use amount in the dry season is 1.2 (drinking and cooking) to 1.5 (washing and bathing) times of that of the rainy season in Jarar Valley area. On the other hand, the difference is as much as about 1.6 times for all the items in Shebele River basin area. The difference indicates that the water use in the rainy season is much reduced in Jarar Valley area where there is more rain in the rainy season. As a whole, the water use patterns between the two basins are similar.

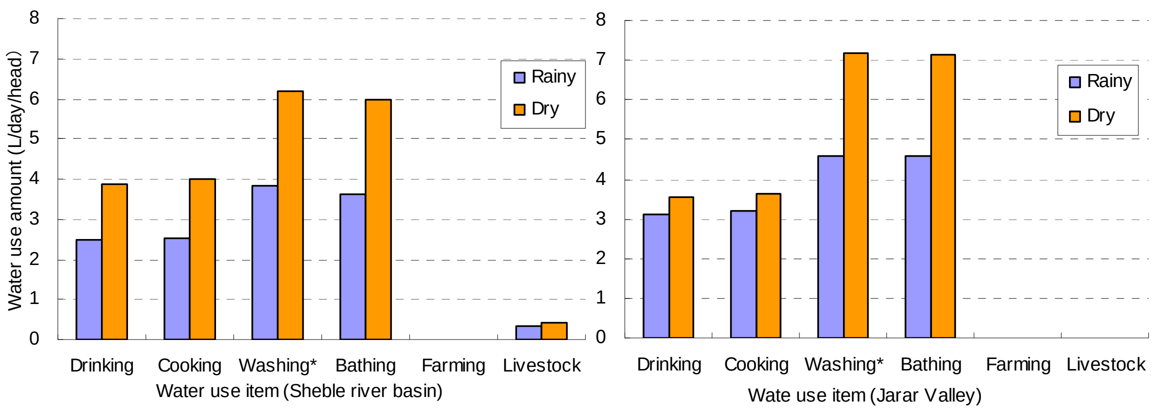



Figure 3.1: Water Use Pattern in Rainy and Dry Seasons in Jarar Valley and Shebele River Basin Areas

The access to the water supply point is compiled in Table 3.11 below.

Table 3.11: Average Distance to Water Source (one way)

| | Jarar Valley area | | | Shebele River basin area | | |
|---|---|---|---|---|---|---|
| | Kabribeyah town | Kabribeyah Refugee camp | Araarso woreda | Godey town | Adadle woreda | Beercaano woreda |
| Distance (m) | 21 | 40 | 2,300 | 190 | 630 | 5 |

Note) if households get water from water sellers at home, it is considered 0

In towns such as Kabribeyah and urbanized areas where houses are concentrated, there are usually many water sellers and public and domestic taps. The access to water is relatively good in such areas (even in Godey Town, 13 households receive water at home). On the other hand, in Araarso woreda where people use birka as a sole water source has small number of water sellers and people are forced to walk a long distance to access water. Ten households in Jarar Valley area and nine households in Shebele River basin area transport water over 500 m distance (one way) but only two of them use donkey carts.

**d. Observation of water use at water supply points**

Observation of how people use water was made at the following representative water supply points shown in Table 3.12.

Table 3.12: Water Supply Points for Observation

| | Kabribeyah town | Godey town | Araarso woreda | Adadle woreda | Beercaano woreda |
|---|---|---|---|---|---|
| Date (Year 2012) | 24 November | 16-18 November | 29 November | 16 November | 19 November |
| Kebele | Kebele 02 | Kebele 03 | Kebele 01 | Kebele 02 | Kebele 02 |
| Type of water point | Public tap | Public tap | Birka | HDW | Natural pond (dam) |
| Location (GPS) | 1006755 N | 065771 N | 0967763 N | 0641124 N | 0673983 N |
| | 0299802 E | 0340102 E | 0318634 E | 0337401 E | 0303605 E |

The observation was made at each site when the water point was operated for the day. How the users get water from the water point and how the water point is managed by WASHCO members were closely observed. In the two towns where public taps were operated only a limited time in a day, the number of people who came to get water was counted and the amount of water used was checked with the water meter. The results are shown in Table 3.13 below.

Table 3.13: Major Findings from the Observation of Water Use

| | Kabribeyah town | Godey town | Araarso woreda | Adadle woreda | Beercaano woreda |
|---|---|---|---|---|---|
| Number of users/HH* | 120 / 20 | 128 / 38 | （25 HH） | （600 HH） | （500 HH） |
| Average water amount per HH** | 115 L | 95L | - | - | - |
| Rate of water (20L) | 1 birr | 0.5 birr | 2.5 birr | Free | Free |
| Dependency | approx. 95% | approx. 85% | approx. 80% | approx. 60% | approx. 100％ |
| WASHCO activity | Lining up people<br>Operation of facility<br>Money collection | | Birka cleaning<br>Channel operation | Lining up people<br>Birka cleaning | No WASHCO |

Note) Dependency is defined as the ratio of surveyed households that uses this water point as an only water source (other than rainwater)
* numbers in parenthesis signify estimated number based on interview,
** Amount measured with the water meter divided by the number of households

At all the sites, the water point was operated only for a few hours in the morning or in the afternoon. Many women lined up for their turns to get water. They carried several water tanks of 20L capacity and filled them and took them home. They repeated this a couple of times a day. Generally they obtained 100 to 200L of water from the water point. At the other sites, due to the nature of the water source facilities, water is available any time of the day and the study team could not confirm the amount of water used nor the number of users.

As shown in Table 3.13, at some crude water points such as natural pond, WASHCO does not exist or even if it exists, no money is collected. In Beercaano woreda, the water was trapped by a crude dam structure in a wadi to create a pond. The water is only available in the rainy season and water is delivered by trucks in the dry season. At all the water points, there are one or two water sellers among the ordinary users to get water and they sell the water to some well-off households in the community. In Beercaano woreda, water from the pond is taken free of charge and the water sellers sell the water at five birr for 20L. In Araarso woreda, the water source, birka is privately owned but the owner shares the water with many residents in the community. In the sample household survey, 10 households in Jarar Valley area and 12 households in Shebele River area get water for free.

**e. Observation at site**

In connection with the observation of water use at the five sites, the observations directly made by study team members in the two towns are also compiled below.

- In many households, people use cylindrical plastic or metal water tanks of 200L capacity to collect and store rainwater in the rainy season. In some households, a crude system of rainwater collection using rainwater gutters and these tanks is found.
- Many households that have a domestic tap sell water from the tap to its neighbors. In such cases, the price of water sold is determined at the discretion of the owner (the price changes depending on the season and demand). Such households usually make around 100 birr per day from selling the water.
- Domestic taps are, in most cases, found in the yard of the household and the tap is placed near the ground level (standing out only about 10 cm above ground). Thus, many households use a plastic hose to lead water to where they want to use. At one household that was visited, the tap was completely buried in the ground and had never been used after installation.

The following essential findings about the water use in the study area have been extracted from the survey data, observation and interview with the people concerned.

- The average per capita water use amount is around 18L/day
- People in Jarar Valley area use a little more water than those in Shebele River basin area but the water use pattern by purpose are similar between the two areas.
- In the rainy season, dependency to water supply system decreases by 20 to 60% because the users use harvested rainwater at home.
- In major communities of woredas and towns, the water use for farming and livestock is very small.
- In rural areas where a crude water source such as birka is used, there is no WASHCO and consequently no money is collected for water use.

**f. Water use during droughts**

The sections above all described the water use under ordinary circumstances. In the time of droughts, according to a report by Oxfam GB titled "Water Trucking Market System in Harsin, 7th – 15th February 2012, Ethiopia", in the areas of severely influenced by droughts, there are not deep wells or perennial rivers to count on as water sources. Thus, in these areas, delivery of water by trucks (water trucking) will be necessary when birkas dry up in the dry season. The water supply by trucks is limited in quantity and supply to communities will be insufficient. Many of the well-off families have a small birka in their yards and can also pay for a truck to bring water from distant sources to their brikas during droughts. Meanwhile, low-income families may get some water from better-off families in the same clan but if it is not possible, they will have to pay several times higher rate for water, which they cannot afford. Such low income families therefore will be forced to live with insufficient water supply. This means that the amount of water households can get depends on the income level of the households. According to the report, the water use amount per person in the dry season in Marsin woreda is 2 to 23 L/day and the low income families get only 2 to 9L/day (whereas it is 5 to 9L/day in non-drought periods)

### 3.5.2 Survey on woreda water supply situation

**a. Results of the Socio-economic Survey**

Interview survey was conducted by the local consultant (SHAAC) at 16 Woredas Water Development Offices to assess the capacity of the said Offices and water supply situation of the target woredas.

**a.1 Staff and office equipment of Woreda Water Office**

Woreda Water Office is in charge of the water supply services in rural areas of each woreda. The results of the Survey indicated that the staff and office equipment of these offices were very limited in terms of the number of staff as well as its office equipment that will lead to limited activities in conducting water supply services in rural areas. Refer to Table 3.14 below.

Table 3.14: Staff and Office Equipment of Woreda Water Offices

| Woreda | No. of Office Staff | Office Equipment | | | | | Motor-cycle |
|---|---|---|---|---|---|---|---|
| | | Desktop | Laptop | Printer | Telephone | Generator | |
| Araarso* | 6 | 1 | 0 | 0 | 0 | 0 | 0 |
| Kabribeyah | 8 | 0 | 0 | 0 | 0 | 0 | 0 |
| Birqod* | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kabridahar | 7 | 1 | 0 | 0 | 0 | 0 | 0 |
| Dagahbur | 8 | 1 | 0 | 1 | 1 | 0 | 0 |
| Shaygosh | 6 | 1 | 0 | 1 | 0 | 0 | 0 |
| Adadle | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rasso* | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Beercaano* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Danan | 5 | 1 | 0 | 1 | 0 | 1 | 1 |
| Godey | 7 | 1 | 0 | 0 | 0 | 0 | 0 |
| Kalafo | 7 | 0 | 0 | 0 | 0 | 1 | 0 |
| Mustahil | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| West Ime | 3 | | 0 | 0 | 0 | 0 | 0 |
| East Ime | 3 | 0 | 0 | 0 | 0 | 0 | 0 |

Note: The woredas with "*" are newly established ones

### a.2 Existing water supply sources

The existing water supply sources in the target woredas can be classified as: (i) boreholes (BHs) with motorized pumps or hand pumps; (ii) hand-dug wells; (iii) birka (cistern) and (iv) river intakes. In addition to these sources, there are many traditional water sources such as pond, lake, spring, etc. in the Study area.

Boreholes can be found mostly in Jarar valley area, while river intake sites are widely distributed along the Shebelle River in Shebele sub-basin area. Refer to Table 3.15 below.

Table 3.15: Existing Water Sources in the Target Woredas

| Study Area | Woreda | Boreholes | Hand-dug Wells | Birka (cistern) | River Intakes | Other Sources |
|---|---|---|---|---|---|---|
| Jarar Valley Area | Araarso | 3 | 4 | 34 | 0 | Lake, pond, haffir dam |
| | Kabribeyah | 4 | 0 | 65 | 0 | Lake, pond |
| | Birqod | 3 | 45 | 1 | 0 | |
| | Kabridahar | 3 | 1 | 10 | 0 | |
| | Dagahbur | 6 | 27 | 12 | 0 | Lake, pond |
| | Shaygosh | 3 | 0 | 10 | 0 | |
| | Marsin | 0 | 0 | 1 | 0 | Lake, pond |
| Shebele Sub-basin Area | Adadle | 0 | 5 | 45 | 1 | |
| | Rasso | 1 | 13 | 0 | 0 | |
| | Beercaano | 0 | 2 | 3 | 0 | |
| | Danan | 2 | 6 | 13 | 0 | Lake, pond, |
| | Godey | 0 | 7 | 5 | 2 | |
| | Kalafo | 0 | 13 | 0 | 1 | |
| | Mustahil | 0 | 16 | 2 | 1 | |
| | West Ime | 1 | 2 | 0 | 1 | |
| | East Ime | 0 | 13 | 0 | 1 | Lake, pond |

### a.3 Health sector

#### a.3.1 Health facilities

In the Study Area, there are six hospitals with a total of 624 health professionals and supporting staff. Other health facilities include 21 health centers (HCs), 56 health posts (HPs) and 21 health clinics with a total of 560 health professionals and supporting staff. Refer to Table 3.16.

Table 3.16: Health Facilities and Staff in the Study Area

| Woreda | Hospitals | | Health Center | | Health Post | | Health Clinics | |
|---|---|---|---|---|---|---|---|---|
| | No. of Facilities | No. of Staff | No. of Facilities | No. of Staff | No. of Facilities | No. of Staff | No. of Facilities | No. of Staff |
| Araarso | 1 | 22 | 3 | 10 | 0 | 0 | 3 | 10 |
| Kabribeyah | 1 | 0 | 1 | 20 | 1 | 2 | 0 | 0 |
| Birqod | 0 | 0 | 1 | 26 | 0 | 0 | 2 | 5 |
| Kabridahar | 1 | 124 | 3 | 0 | 0 | 0 | 0 | 0 |
| Dagahbur | 1 | 182 | 1 | 13 | 2 | 4 | 16 | 80 |
| Shaygosh | 0 | 0 | 1 | 44 | 1 | 14 | 0 | 0 |
| Marsin | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Adadle | 0 | 0 | 2 | 22 | 15 | 30 | 0 | 0 |
| Rasso | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Beercaano | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Danan | 0 | 0 | 1 | 27 | 1 | 13 | 0 | 0 |
| Godey | 1 | 184 | 2 | 59 | 4 | 24 | 0 | 0 |
| Kalafo | 1 | 112 | 1 | 16 | 2 | 29 | 0 | 0 |
| Mustahil | 0 | 0 | 2 | 15 | 15 | 29 | 0 | 0 |
| West Ime | 0 | 0 | 1 | 16 | 2 | 8 | 0 | 0 |
| East Ime | 0 | 0 | 2 | 8 | 13 | 36 | 0 | 0 |
| Total | 6 | 624 | 21 | 276 | 56 | 189 | 21 | 95 |

### a.3.2 Leading causes of water related diseases

The major leading water related diseases are malaria, diarrhea and dysentery in the Study area. Out of 15,071 of diarrhea cases in the Study Area, Kalafo Woreda accounts for 26%, Adadle Woreda 14% and Danar Woreda 10%, respectively. Out of 3,600 of dysentery cases, Kalafo Woreda accounts for 64%, Araarso Woreda 7% and Kabridahar Woreda 6%, respectively.

High diarrhea cases in Kalafo, Adadle and Danan Woredas are most likely due to people's taking drinking water from the river or unprotected dug-wells.

Estimated number of water related diseases patients per year is presented in Table 3.17.

Table 3.17: Estimated Number of Water Related Diseases Patients per Year

| Woreda | Diarrhea | Dysentery | Typhoid | Cholera | Malaria | Other |
|---|---|---|---|---|---|---|
| Kabribeyah | 740 | 167 | 89 | 0 | 205 | 0 |
| Dagahbur | 1,332 | 65 | 315 | 0 | 960 | 79 |
| Araarso | 1,020 | 240 | 108 | 0 | 180 | 1,620 |
| Birqod | 960 | 0 | 0 | 0 | 0 | 360 |
| Shaygosh | 360 | 150 | 2 | 540 | 5,400 | 150 |
| Kabridahar | 120 | 210 | 10 | 0 | 1,800 | 0 |
| Marsin | 0 | 12 | 0 | 0 | 0 | 0 |
| Godey | 600 | 60 | 0 | 0 | 1,800 | 240 |
| East Ime | 1,080 | 0 | 0 | 0 | 0 | 1,200 |
| Adadle | 2,180 | 96 | 0 | 0 | 0 | 1,3000 |
| Danan | 1,440 | 60 | 120 | 0 | 72 | 300 |
| Beercaano | 0 | 36 | 0 | 0 | 0 | 0 |
| Kalafo | 4,000 | 2,300 | 0 | 0 | 4,800 | 0 |
| Mustahil | 514 | 114 | 57 | 0 | 819 | 1,516 |
| West Ime | 600 | 40 | 12 | 0 | 800 | 0 |
| Rasso | 125 | 50 | 0 | 0 | 48 | 192 |
| Total | 15,071 | 3,600 | 713 | 540 | 16,884 | 18,657 |

### a.4 Education sector

There are 860 primary and ABE schools and 27 secondary schools (grade 9 – 12) in the Study Area. Some woredas have no secondary schools as these woredas were newly created ones. The educational facilities in each woreda are summarized in Table 3.18.

Table 3.18: Educational Facilities and Number of Teachers in the Study Area

| | Primary and ABE | | Secondary | |
|---|---|---|---|---|
| Woreda | No. of School | No. of Pupils | No. of School | No. of Students |
| Kabribeyah | 208 | 2,422 | 2 | 989 |
| Dagahbur | 51 | 1,579 | 1 | 520 |
| Araarso | 9 | 484 | 1 | 228 |
| Birqod | 3 | 1,971 | 0 | 0 |
| Shaygosh | 25 | 3,657 | 1 | 142 |
| Kabridahar | 31 | 1,800 | 1 | 9 |
| Marsin | 9 | n.a. | 0 | 0 |
| Godey | 137 | 5,867 | 2 | n.a. |
| East Ime | 55 | 215 | 1 | 315 |
| Adadle | 35 | 647 | 1 | 427 |
| Danan | 43 | 1,125 | 1 | 760 |
| Beercaano | 28 | n.a. | 0 | 0 |
| Kalafo | 118 | 7,000 | 1 | n.a. |
| Mustahil | 72 | 629 | 1 | 10 |
| West Ime | 35 | 1,112 | 1 | 413 |
| Rasso | 1 | 567 | 0 | 0 |
| Total | 860 | 9,308 | 14 | 3,813 |

Note: ABE = Alternative Basic Education

### a.5 Agricultural sector

#### a.5.1 Crop production

Crop production in each woreda is compiled in Table 3.19. In the Study Area, Godey and Kalafo woredas are considered to be agriculturally oriented areas. Out of the total production of maize, Kalafo and Godey woredas accounts for 40.1 % and 39.5%, respectively, accounting for almost 80% of all maize produced in the Study Area. Danan, Godey and Kalafo woredas accounts for 57% of the total sorghum production. As for tomatos, Kalafo woreda accounts for 70% of the total production, followed by Godey woreda.

Table 3.19: Main Crop Production in the Study Area

| Woreda | Maize | | Sorghum | | Teff | | Tomato | |
|---|---|---|---|---|---|---|---|---|
| | Production | % | Production | % | Production | % | Production | % |
| Kabribeyah | 800 | 0.1% | 5000 | 3.3% | 1,000 | 1.5% | 3,000 | 3.4% |
| Dagahbur | 5,450 | 0.8% | 583 | 0.4% | 0 | 0.0% | 90 | 0.1% |
| Araarso | 20,000 | 3.0% | 5,000 | 3.3% | 0 | 0.0% | 0 | 0.0% |
| Birqod | 5,000 | 0.8% | 2,100 | 1.4% | 0 | 0.0% | 0 | 0.0% |
| Shaygosh | 14,400 | 2.2% | 17,268 | 11.5% | 0 | 0.0% | 0 | 0.0% |
| Kabridahar | 2,680 | 0.4% | 3,415 | 2.3% | 0 | 0.0% | 2,100 | 2.4% |
| Marsin | 12,300 | 1.9% | 5,600 | 3.7% | 0 | 0.0% | 400 | 0.5% |
| Godey | 260,009 | 39.5% | 17,600 | 11.7% | 40 | 0.1% | 16,000 | 18.2% |
| East Ime | 26,000 | 3.9% | 600 | 0.4% | 740 | 1.1% | 0 | 0.0% |
| Adadle | 16,720 | 2.5% | 4,200 | 2.8% | 0 | 0.0% | 0 | 0.0% |
| Danan | 0 | 0.0% | 50,000 | 33.3% | 0 | 0.0% | 3,200 | 3.6% |
| Beercaano | 11,000 | 1.7% | 7,000 | 4.7% | 0 | 0.0% | 1,200 | 1.4% |
| Kalafo | 264,285 | 40.1% | 18,425 | 12.3% | 61,561 | 95.4% | 61,561 | 70.1% |
| Mustahil | 10,000 | 1.5% | 4,567 | 3.0% | 1,200 | 1.9% | 275 | 0.3% |
| West Ime | 6,320 | 1.0% | 7,090 | 4.7% | 0 | 0.0% | 0 | 0.0% |
| Rasso | 3,600 | 0.5% | 1,845 | 1.2% | 0 | 0.0% | 0 | 0.0% |
| Total | 658,564 | 100.0% | 150,293 | 100.0% | 64,541 | 100.0% | 87,826 | 100.0% |

### a.5.2 Livestock

Livestock distribution in each woreda is compiled in Table 3.20. Out of the total cattle population, approximately 54% and 28% of cattle are found in Kalafo and Mustahil woredas, respectively. For camels, about 20% each are found in Mustahil and East Ime woredas, respectively. About 12 % of the total camels are found in Shaygosh woreda. For goats, Kalafo and Adadle woredas accounts for 48% and 22%, respectively. For sheep, Mustahil and Adadle accounts for 40% and 36%, respectively. A large number of livestock such as cattle, camels, goat and sheep are found in Adadle, Mustahil and Kalafo woredas in Shebele sub-basin area.

Table 3.20: Livestock Distribution in the Study Area

| Woreda | Cattle | | Camel | | Goat | | Sheep | |
|---|---|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % | Number | % |
| Kabribeyah | 195 | 0.0% | 165 | 0.1% | 450 | 0.1% | 320 | 0.1% |
| Dagahbur | 800 | 0.2% | 2,500 | 2.1% | 8,500 | 1.7% | 5,000 | 1.0% |
| Araarso | 12,440 | 2.8% | 658 | 0.6% | 24,180 | 4.9% | 1,825 | 0.4% |
| Birqod | 5,687 | 1.3% | 2,120 | 1.8% | 6,800 | 1.4% | 4,900 | 1.0% |
| Shaygosh | 850 | 0.2% | 14,000 | 12.0% | 21,000 | 4.2% | 8,000 | 1.6% |
| Kabridahar | 2,610 | 0.6% | 1,435 | 1.2% | 4,816 | 1.0% | 5,078 | 1.0% |
| Marsin | 350 | 0.1% | 1,200 | 1.0% | 8,764 | 1.8% | 4,326 | 0.9% |
| Godey | 15,000 | 3.3% | 9,000 | 7.7% | 9,500 | 1.9% | 15,060 | 3.0% |
| East Ime | 9,800 | 2.2% | 23,000 | 19.7% | 9,500 | 1.9% | 13,000 | 2.6% |
| Adadle | 17,200 | 3.8% | 11,500 | 9.8% | 110,000 | 22.2% | 182,350 | 36.2% |
| Danan | 620 | 0.1% | 1,229 | 1.1% | 3,900 | 0.8% | 5,100 | 1.0% |
| Beercaano | 4,500 | 1.0% | 2,200 | 1.9% | 7,000 | 1.4% | 900 | 0.2% |
| Kalafo | 245,000 | 54.4% | 8,000 | 6.9% | 236,000 | 47.6% | 43,600 | 8.7% |
| Mustahil | 125,460 | 27.8% | 22,970 | 19.7% | 20,760 | 4.2% | 20,3425 | 40.4% |
| West Ime | 5,430 | 1.2% | 8,690 | 7.4% | 13,099 | 2.6% | 1,150 | 0.2% |
| Rasso | 4,550 | 1.0% | 8,116 | 6.9% | 11,543 | 2.3% | 9,974 | 2.0% |
| Total | 450,492 | 100.0% | 116,783 | 100.0% | 495,812 | 100.0% | 504,008 | 100.0% |

## b. Results of supplementary surveys

### b.1 Water supply situation based on the 2007 census data

Based on the 2007 Population and Housing Census of Ethiopia (Statistical Report for Somali Region), water supply situation in the Study Area is summarized as follows.

(1) In big towns of Jarar valley area, such as Kabribeyah, Dagahbur and Kabridahar, the water supply is provided mainly by the piped water system, covering about 40 to 75% of the total population.

(2) In small towns and rural areas in Jarar valley area, protected or unprotected wells and traditional water sources such as springs, rivers, lakes and ponds are the main water sources.

(3) In Shebele sub-basin area, traditional water sources such as rivers, lakes and ponds are the main water sources even in urban areas. It is considered that the river water is the most important water sources in the area.

(4) In urban areas of the Shebele sub-basin area, the water coverage under the piped water system is very low, compared to those in Jarar valley area.

Percentage of houses by sources of drinking water per each target Woreda is presented in Table 3.21.

Table 3.21: Percentage of Houses by Sources of Drinking Water (2007)

| Study Area | Woreda | Urban / Rural | Tap inside the house or in compound | Tap outside the compound | Protected well or spring | Unprotected well or spring | River, lake, pond |
|---|---|---|---|---|---|---|---|
| Jarar Valley Area | Kabribeyah | Urban | 9.0% | 30.9% | 17.3% | 20.7% | 22.1% |
| | | Rural | 1.1% | 1.9% | 28.2% | 37.8% | 31.0% |
| | Dagahbur (Araarso, Birqod) | Urban | 15.0% | 46.0% | 8.5% | 3.5% | 27.0% |
| | | Rural | 2.0% | 6.3% | 23.9% | 49.9% | 17.9% |
| | Shaygosh | Urban | 0.0% | 67.6% | 2.3% | 30.1% | 0.0% |
| | | Rural | 3.1% | 5.9% | 8.4% | 45.0% | 37.7% |
| | Kabridahar (Marsin) | Urban | 34.1% | 41.9% | 7.7% | 6.5% | 9.8% |
| | | Rural | 5.5% | 12.4% | 18.1% | 48.1% | 15.9% |
| | Dobowein | Urban | 7.3% | 9.0% | 30.9% | 50.6% | 2.2% |
| | | Rural | 2.0% | 5.9% | 27.3% | 58.3% | 6.5% |
| Shebele Sub-basin Area | East Ime | Urban | 1.4% | 0.0% | 1.0% | 15.3% | 82.3% |
| | | Rural | 0.4% | 0.0% | 1.5% | 5.6% | 92.5% |
| | Adadle | Urban | 0.0% | 0.0% | 35.4% | 57.6% | 7.0% |
| | | Rural | 1.2% | 1.5% | 14.4% | 24.4% | 63.4% |
| | Godey (Beercaano) | Urban | 9.8% | 10.3% | 3.7% | 9.6% | 66.6% |
| | | Rural | 2.0% | 5.1% | 13.0% | 23.9% | 56.1% |
| | Danan | Urban | 4.8% | 9.8% | 14.6% | 33.0% | 37.8% |
| | | Rural | 0.7% | 3.5% | 16.1% | 43.2% | 36.4% |
| | Kalafo | Urban | 3.1% | 2.3% | 1.5% | 1.1% | 92.0% |
| | | Rural | 1.3% | 2.9% | 1.3% | 17.7% | 76.8% |
| | Mustahil | Urban | 11.5% | 38.2% | 1.9% | 0.0% | 48.4% |
| | | Rural | 0.4% | 0.2% | 5.4% | 15.4% | 78.6% |
| | West Ime (Rasso) | Urban | 1.9% | 0.0% | 0.5% | 16.0% | 81.6% |
| | | Rural | 0.7% | 0.0% | 0.6% | 14.8% | 83.8% |

Source: Statistical Report for Somali Region, 2007 Population and Housing Census

Note: Araarso, Birqod, Marsin, Beeranno and Rasso Woredas are not included in the 2007 Census.

### b.2 Supplementary survey in Dobawein Woreda

Supplementary survey on the water supply situation in Dobawein woreda was conducted by the staff of Water Bureau of Somali region. The survey items included: (i) demographic information; (ii) general water supply conditions; (iii) economic activities in the town and rural areas; (iv) livestock information; (v) social services; and (v) support services of the Woreda Water Office. The results of the supplementary survey are presented in Table 3.22.

Table 3.22: Water Supply Situation in Dobawein Woreda

| 1. Demographic Information | Kebele | Household | Population | Male | Female |
|---|---|---|---|---|---|
| | Kebele 1 | 2,500 | 15,000 | n.a. | n.a. |
| | Kebele 2 | 3,125 | 18,750 | n.a. | n.a. |
| | Higloley | 2,500 | 15,000 | n.a. | n.a. |
| | Haar aano | 1,625 | 9,750 | n.a. | n.a. |
| | Jida'le | 1,500 | 9,000 | n.a. | n.a. |
| | Nagarweyne | 1,250 | 7,500 | n.a. | n.a. |
| | Total | 12,500 | 75,000 | 33,750 | 41,250 |

| 2. Water supply sources | Motorized system with Boreholes (4) | Birka (25) | Hand pumps with Boreholes or Shallow wells (96) |
|---|---|---|---|

| 3. Economic establishments | Hotels (4) | Bars & restaurants (15) | Gas stations (2) | Shops (15) | Stores (8) |
|---|---|---|---|---|---|

| 4. Institutions | | No. of Facilities | No. of Staff |
|---|---|---|---|
| | Government office | 18 | 426 |
| | Primary and ABE schools | 26 | 8,772 |
| | Secondary school | 1 | 4,386 |
| | High school | 1 | 1,462 |
| | Health center | 2 | 13 |
| | Health Post | 6 | 6 |
| | Clinic | 4 | 8 |

| 5. Livestock | Cattle (93,000) | Camel (47,000) | Goat (199,000) | Sheep (131,000) | Donkey (4,200) |
|---|---|---|---|---|---|

| 6. Support services by the Woreda Water Office | Year | Location | Kind of services | Cost (Birr) |
|---|---|---|---|---|
| | 2012 | Jida'le | Maintenance of generator house | 168,000 |
| | 2012 | Higloley | Water trucking | 75,000 |
| | 2012 | Haar aano | Maintenance of water points | 120,000 |
| | 2012 | Higloley | Water trucking | 172,000 |
| | Total | | | 535,000 |

Source: Supplementary Survey conducted by Water Bureau of Somali Region, 2012

### 3.5.3 Survey on urban water supply system

Interview survey was conducted in four relatively big towns in the Study Area to assess the water supply situation in urban areas. Interviews were conducted at each Town Water Supply Utility Office. Four towns surveyed are Kabribeyah, Dagahbur, Kabridahar and Godey.

**a. Results of the Socio-economic Survey**

**a.1 Kabribeyah Town water supply utility office**

Kabribeyah Town is the capital of Kabribeyah Woreda with an estimated population of about 40,000 persons including refugees from Somalia. The water supply sources of the town are boreholes located about 30 km south of the town along the Jarar valley streams. Water is pumped from each borehole to the reservoirs located in the town and distributed through gravity to individual households and water points.

The number of connections is 300 in total, consisting of 269 private and 14 institutional connections. Population served is estimated to be 11,360 persons (about 2,200 households) in the rainy season and 28,685 persons (about 5,700 households) in the dry season. From the field survey, it is observed that one water point is providing water to about 10 to 15 households nearby the water point.

It was mentioned in the final report of the Socio-economic Survey that water volume supplied during 2009 and 2011 was 6,576 m$^3$, 43,447 m$^3$ and 184,752 m$^3$, respectively, based on the result of interview with the executive staff of the Water Supply Utility Office. Revenue during the same period was 10,900 Birr, 141,000 Birr and 33,427 Birr, respectively, while the expenditure was 70,802 Birr, 75,902 Birr and 81,882 Birr, respectively.

Reviewing the financial data as mentioned above, it was clearly found that these data, particularly the revenue data, were not adequate to understand the real financial situation of the Water Supply Utility Office as the figures presented in the report were not consistent with each other. Therefore, it is recommended that a training program on the financial management for the staff of the said Utility Office should be conducted.

#### a.2 Godey Town water supply utility office

Godey Town is the capital of Godey Woreda with an estimated population of 29,379 persons (2012). The water supply source of the town is river intake that was constructed 30 years ago and improved recently. The water supply system consists of: (i) intake structure; (ii) sedimentation/flocculation basin; (iii) filtration through rapid and slow sand filters; (iv) clear water collection chamber; (v) reservoirs; and (vi) distribution network.

Water is pumped from the river intake structure to main reservoir and finally to the customers through the distribution pipes. There 288 connections including 250 private and 38 institutional connections.

It was mentioned in the final report of the Socio-economic Survey that water volume supplied during 2009 and 2011 was 139,348 m$^3$, 130,838 m$^3$ and 138,047 m$^3$, respectively, based on the result of interview with the executive staff of the Office. Revenue during the same period was 836,088 Birr, 1,046,604 Birr and 138,047 Birr, respectively, while the expenditure was 1,095,220 Birr, 270,298 Birr and 380,440 Birr, respectively.

Reviewing the financial data as mentioned above, it was found that these data, particularly the revenue data, were not adequate to understand the real financial situation of the Water Utility Office as the figures presented in the report were not consistent with each other. Therefore, it is recommended that training program on the financial management for the staff of the said Utility Office should be conducted.

#### a.3 Dagahbur Town water supply utility office

Dagahbur town is the capital of Dagahbur woreda with an estimated population of about 69,500 persons. The water supply source of the town is groundwater. A total of six wells are presently functioning. Groundwater from each borehole is pumped into the water supply system through main reservoir (200m$^3$), distribution network and water points. There are 400 connections including 360 private and 46 institutional connections.

Population served is estimated at 28,637 persons in the rainy season and 40,863 persons in the dry season. During the rainy season, some people are using water from the river by excavating a small hole in the riverbed. It is estimated that about 30% of the population use surface water and shallow dug-wells in the rainy season.

It was mentioned in the final report of the Socio-economic Survey that water volume supplied during 2009 and 2011 was 3,580 m$^3$, 2,570 m$^3$ and 3,220 m$^3$, respectively, based on the result of interview with the executive staff of the Office. Revenue during the same period was

250,600 Birr, 179,900 Birr and 22,540 Birr, respectively, while the expenditure was 277,800 Birr, 271,578 Birr and 279,600 Birr, respectively.

Reviewing the financial data as mentioned above, it was found that these data, particularly the revenue data, were not adequate to understand the real financial situation of the Water Utility Office as the figures presented in the report were not consistent with each other. Therefore, it is recommended that a training program on the financial management for the staff of the said Utility Office should be conducted.

**a.4 Kabridahar Town Water Supply Utility**

Kabridahar Town is the capital of Kabridahar Woreda with an estimated population of about 51,000 persons. The water supply source of the town is groundwater. Out of 13 boreholes, only 3 wells are presently functioning. Groundwater from each borehole is pumped into the water supply system through a main reservoir (150m$^3$), distribution network and water points. There are 527 connections including 513 private and 11 institutional connections.

Population served is estimated at 48,000 persons in the rainy season and 51,000 persons in the dry season. During the rainy season, some people are getting water from hand-dug wells.

It was mentioned in the final report of the Socio-economic Survey that water volume supplied during 2009 and 2011 was 28,500 m$^3$, 25,670 m$^3$ and 19,850 m$^3$, respectively, based on the result of interview with the executive staff of the Office. Revenue during the same period was 239,400 Birr, 2,156,280 Birr and 166,740 Birr, respectively, while the expenditure was 381,288 Birr, 383,861 Birr and 371,292 Birr, respectively.

Reviewing the financial data as mentioned above, it was found that these data, particularly the revenue data, were not adequate to understand the real financial situation of the Water Utility Office as the figures presented in the report were not consistent with each other. Therefore, it is recommended that a training program on the financial management for the staff of the said Utility Office should be conducted.

**b. Supplementary Survey in Kabribeyah and Godey Towns**

**b.1 Kabribeyah Town water supply utility office**

In order to obtain adequate record of financial data, the Socio-economic Survey Expert of the Study Team repeatedly tried to contact the executive members of the said Utility Office. As a result, the following financial data were obtained during November and December 2012: (i) four months' data of water volume supplied and the amount of water sale in 2008; (ii) no financial data for 2009; (iii) twelve months' data of revenue and expenditure for 2010; and (iv) four months' data of revenue and expenditure for 2011.

Revenue and expenditure of Kabribeyah Town Water Supply Utility Office is presented in Table 3.23.

Table 3.23: Revenue and Expenditure of Kabribeyah Water Supply Utility Office

| | 2008 | | 2010 | | 2011 | |
|---|---|---|---|---|---|---|
| | June to September | Monthly average | January to December | Monthly average | January to April. | Monthly average |
| Water supplied ($m^3$) | 6,577 * | 1,644 * | 43,478 | 3,623 | 28,770 | 7,192 |
| Revenue (Birr) | 85,844 | 21,461 | 434,776 | 36,231 | 287,698 | 71,925 |
| 1) Salary & office expenses | 61,098 | 15,275 | n.a. | n.a. | n.a. | n.a. |
| 2) Other expenses | 24,631 | 6,157 | n.a. | n.a. | n.a. | n.a. |
| Total Expenditures | 85,729 | 21,432 | 409,310 | 34,109 | 334,277 | 83,569 |

Source: Water Supply Utility Office, Kabribeyah town
Note: * Water supplied does not include the water volume supplied to refugees. n.a. = Data are not available

Reviewing the financial data in the table above, the water volume supplied increased from 3,623 $m^3$ per month in 2010 to 7,192 $m^3$ per month in 2011. The reason for it was not explained by the Utility Office.

Based on the financial data obtained from the Utility Office and also from the field observation, the estimates on the revenue and expenditure have been made as follows.

(1) Volume of water supplied to the customers is estimated at 3,600 to 7,200 $m^3$ per month.

(2) The water revenue is estimated at 36,000 to 72,000 Birr per month on the basis of water tariff of 10 Birr per $m^3$.

(3) The expenditure is estimated at 34,000 to 84,000 Birr per month.

Major problems identified in the Kabribeyah water supply system are as follows.

(1) Kabribeyah water supply system is providing water to both the local population and refugees. However, exact water volume distributed cannot be measured due to lack of water meters.

(2) UNHCR is basically responsible for overall operation and maintenance works of Kabribeyah water supply system, although Water Supply Utility Office is providing water supply services for the town dwellers. The maintenance of the scheme is carried out by JWSO (Jijiga Water Supply Office) under the partnership arrangement between UNHCR and JWSO. The day-to-day routine management and distribution of water is carried out by the Water Supply Utility Office. Under such a situation, exact amount of water production costs is not properly recorded in the Water Supply Utility Office.

(3) There is no proper system of recording on water production, water distribution, water sales, revenue collection, etc. Therefore, the Water Supply Utility Office is not capable of producing any written documents of technical as well as financial reports.

**b.2 Godey Town water supply utility office**

In order to obtain an adequate record of financial data, the Socio-economic Survey Expert of the Study Team tried to contact the executive members of the said Utility Office and also the Woreda Administration office. As a result, the financial data were obtained during November and December 2012: (i) twelve months' data of the expenditure in 2010; (ii) no financial data for 2011; and (iii) seven months' data of revenue and expenditure for 2012.

The revenue and expenditure of Godey Town Water Supply Utility Office is presented in Table 3.24.

Table 3.24: Revenue and Expenditure of Godey Water Supply Utility Office

| | 2010 | | 2011 | | 2012 | |
|---|---|---|---|---|---|---|
| | January to December | Monthly average | January to December | Monthly average | March to September | Monthly average |
| Water supplied ($m^3$) | n.a. | n.a. | n.a. | n.a. | 52,705 | 7,538 |
| Revenue (Birr) | n.a. | n.a. | n.a. | n.a. | 791,477 | 113,068 |
| Expenditure | | | | | | |
| 1) Salary & office expenses | 221,238 | 18,436 | n.a. | n.a. | 145,630 | 20,804 |
| 2) O&M cost | 235,020 | 19,585 | n.a. | n.a. | 666,271 | 95,182 |
| Total | 456,258 | 38,021 | n.a. | n.a. | 811,901 | 115,986 |

Source: Woreda Administration Office and Water Supply Utility Office, Godey
Note: n.a. = Data are not available

Based on the financial data obtained from Godey Water Supply Utility Office and also from the field observation, the estimates have been made as follows.

(1) Volume of water supplied to the customers is estimated at 3,800 to 7,500 $m^3$ per month.

(2) The water revenue is estimated at 38,000 to 113,000 Birr per month on the basis of water tariff of 10 to 15 Birr per $m^3$ (10 Birr/$m^3$ in 2010 and 15 Birr/$m^3$ in 2012).

(3) The expenditure is estimated at 38,000 to 116,000 Birr per month.

### 3.5.4 Sample household survey

**a. Distribution of sample households**

The sample household survey was conducted in 7 woredas in Jarar valley area and 9 woredas in Shebele sub-basin area. A total of 176 sample households were selected in the study area. Distribution of sample households is presented in Table 3.25.

Table 3.25: Distribution of Sample Households in the Study Area

| Study Area | Zone | Woreda / Town | Number of Sample Households |
|---|---|---|---|
| Jarar Valley | Jijiga | Kabribeyah town including refugees | 40 |
| | Dagahbur | Dagahbur | 10 |
| | | Araarso | 4 |
| | | Birqod | 4 |
| | Korahe | Shaygosh | 4 |
| | | Kabridahar | 10 |
| | | Marsin | 4 |
| Shebele sub-basin | Godey | Godey woreda / town | 40 |
| | | East Ime | 12 |
| | | Adadle | 12 |
| | | Danan | 4 |
| | | Beercaano | 3 |
| | | Kalafo | 11 |
| | | Mustahil | 7 |
| | Afder | West Ime | 7 |
| | | Rasso | 4 |
| Total | | | 176 |

### b. Characteristic of the respondents

About 90% of the respondents are engaged in agricultural activities including crop production and livestock rearing. Almost three fourths of the respondents are female. Although nearly 80% of the households are headed by males as is common in Somali Region, there are some households where women are in charge of household matters mainly because their husbands are working in a different area. Average family size is 5 people.

### c. Results of the Survey

#### c.1 Main water sources

Main water sources for domestic use including drinking/cooking, washing and bathing are: (i) piped water system, (ii) hand pumps, (iii) hand-dug wells, (iv) haffir dam, and (v) traditional water sources such as rivers, rainwater, ponds, and lakes.

Piped water system is the major source for domestic water use particularly in urban areas of Kabribeyah, Dagahbur, Kabridahar, and Shaygosh in Jarar valley and Godey, Kalafo and Mustahil in Shebele sub-basin.

In Araarso woreda, traditional water sources such as lakes and ponds are used as main source of domestic water during the rainy season and haffir dams are mainly used during the dry season. In Birqod woreda, hand dug-wells and hand pumps are usually used.

In Godey, East Ime, Beercaano and West Ime woredas that are located in Shebele sub-basin, surface water obtained from rivers is one of the important water sources.

Main water sources for domestic use in sample households are presented in Table 3.26.

Table 3.26: Main Water Sources in the Sample Households

| Study Area | Woreda | Rainy season/ Dry season | Drinking/Cooking | Washing | Bathing |
|---|---|---|---|---|---|
| Jarar Valley Area | Kabribeyah | Rainy | Piped system and Rain | Piped system, rain and lake/pond | Piped system and lake/pond |
| | | Dry | Piped system and lake/pond | Piped system and lake/pond | Piped system and lake/pond |
| | Dagahbur | Rainy | Piped system, HDW, HP, lake/pond | Piped system, HDW, HP, lake/pond | Piped system, HDW, HP, lake/pond |
| | | Dry | Piped system, HDW, HP, lake pond | Piped system, HDW, HP, lake pond | Piped system, HDW, HP, lake/pond |
| | Araarso | Rainy | Lake/pond | Lake/pond | Lake/pond |
| | | Dry | Haffir dam, etc. | Haffir dam, etc. | Haffir dam, etc. |
| | Birqod | Rainy | HDW, HP | HDW, HP | HDW, HP |
| | | Dry | HDW, HP | HDW, HP | HDW, HP |
| | Shaygosh | Rainy | Piped system, HDW, HP | Piped system, HDW, HP | Piped system, HDW, HP |
| | | Dry | Piped system, HDW, HP | Piped system, HDW, HP | Piped system, HDW, HP |
| | Kabridahar | Rainy | Piped system, HDW | Piped system, HDW | Piped system, HDW |
| | | Dry | Piped system, HDW | Piped system, HDW | Piped system, HDW |
| | Marsin | Rainy | HDW, lake pond | HDW, lake pond | HDW, lake pond |
| | | Dry | HDW, lake pond | HDW, lake pond | HDW, lake pond |
| Shebele Sub-basin Area | East Ime | Rainy | River, lake/pond, rain | River, lake/pond, rain | River, lake/pond, rain |
| | | Dry | River, HDW | River, HDW | River |
| | Adadle | Rainy | HDW | HDW | HDW |
| | | Dry | HDW | HDW | HDW |
| | Danan | Rainy | HDW, HP | Lake/pond | HDW, HP |
| | | Dry | HDW, HP | HDW, HP | HDW, HP |
| | Godey | Rainy | Piped system, river | Piped system, river | Piped system, river |
| | | Dry | Piped system, river | Piped system, river | Piped system, river |
| | Beercaano | Rainy | River, rain | River, rain | River, rain |
| | | Dry | River | River | River |
| | Kalafo | Rainy | Piped system, river | Piped system, river | Piped system, river |
| | | Dry | Piped system, river | Piped system, river | Piped system, river |
| | Mustahil | Rainy | Piped system | Piped system | Piped system |
| | | Dry | Piped system | Piped system | Piped system |
| | West Ime | Rainy | River | River | River |
| | | Dry | River | River | River |
| | Rasso | Rainy | HP | HP | HP |
| | | Dry | HP | HP | HP |

Note: HP = hand pump; HDW = hand-dug well

### c.2 Distance to water sources

In general, water users have to travel longer distance to fetch water in the dry season compared to the case in the rainy season. In woredas such as Godey, Beercaano, Danan and West Ime in Shebele sub-basin, water users have to travel 1 to 2 kilometer to fetch water.

In woredas such as Araarso, Birqod, and Rasso where water supply facility (e.g. hand pump) is available, distance to water sources remain the same even in the dry season.

Distance to water sources in the sample households is presented in Table 3.27.

Table 3.27: Distance to Main Water Sources in the Sample Households

Unit: in meter

| Study Area | Woreda | season | Drinking/Cooking | Washing | Bathing |
|---|---|---|---|---|---|
| Jarar Valley Area | Kabribeyah | Rainy | 87 | 201 | 207 |
| | | Dry | 222 | 228 | 262 |
| | Dagahbur | Rainy | 448 | 448 | 448 |
| | | Dry | 1,171 | 1,171 | 1,301 |
| | Araarso | Rainy | 755 | 755 | 755 |
| | | Dry | 750 | 750 | 750 |
| | Birqod | Rainy | 175 | 175 | 175 |
| | | Dry | 175 | 175 | 175 |
| | Shaygosh | Rainy | 438 | 438 | 438 |
| | | Dry | 386 | 386 | 386 |
| | Kabridahar | Rainy | 1,166 | 972 | 972 |
| | | Dry | 1,310 | 1,310 | 1,310 |
| | Marsin | Rainy | 293 | 293 | 293 |
| | | Dry | 325 | 325 | 325 |
| Shebele Sub-basin Area | East Ime | Rainy | 794 | 794 | 794 |
| | | Dry | 1,025 | 1,025 | 1,025 |
| | Adadle | Rainy | 129 | 160 | 160 |
| | | Dry | 184 | 184 | 184 |
| | Danan | Rainy | 863 | 863 | 863 |
| | | Dry | 1,200 | 1,200 | 1,200 |
| | Godey | Rainy | 1,432 | 1,432 | 1,432 |
| | | Dry | 1,382 | 1,382 | 1,382 |
| | Beercano | Rainy | 1,532 | 1,532 | 1,532 |
| | | Dry | 2,633 | 2,633 | 2,633 |
| | Kalafo | Rainy | 766 | 766 | 766 |
| | | Dry | 854 | 790 | 790 |
| | Mustahil | Rainy | 550 | 550 | 550 |
| | | Dry | 521 | 521 | 521 |
| | West Ime | Rainy | 1,857 | 1,857 | 1,857 |
| | | Dry | 1,857 | 1,857 | 1,857 |
| | Rasso | Rainy | 92 | 92 | 92 |
| | | Dry | 92 | 92 | 92 |

### c.3 Time spent by a household to fetch water

In the woredas located in Jarar valley area, more time is spent for fetching water in the dry season than that is used in the rainy season. This is due mainly to the availability of rainwater or other water sources like ponds, dug-wells, etc. during the rainy season.

In the woredas located in Shebele sub-basin area, more time is spent for fetching water in the dry season than that is used in the rainy season. However, the time difference is not much compared to that in Jarar valley area, except Danan and Beercaano where dug-wells and birkas are the main water sources. Average time for fetching water is presented in Table 3.28.

Table 3.28: Average Time for Fetching Water

| Study Area | Woreda | Rainy Season (hours) | Dry Season (hours) |
|---|---|---|---|
| Jarar Valley | Kabribeyah | 0.9 | 2.8 |
| | Dagahbur | 1.4 | 4.6 |
| | Araarso | 1.3 | 4.9 |
| | Birqod | 1.1 | 4.8 |
| | Shaygosh | 0.9 | 4.8 |
| | Kabridahar | 1.3 | 4.6 |
| | Marsin | 1.6 | 3.8 |
| Shebele sub-basin | Godey | 1.6 | 2.0 |
| | East Ime | 1.3 | 1.9 |
| | Adadle | 0.6 | 2.0 |
| | Danan | 2.3 | 8.0 |
| | Beercaano | 2.7 | 7.3 |
| | Kalafo | 0.9 | 1.5 |
| | Mustahil | 2.0 | 2.8 |
| | West Ime | 2.0 | 2.6 |
| | Rasso | 1.2 | 2.1 |
| Average | | 1.44 | 3.78 |

### c.4 Community perception of boiling water

The sample households are not well aware of the usefulness of boiling water for drinking purpose. More than 88% of the interviewed respondents indicated that they never boiled the drinking water they took from unimproved water sources. Community perception of boiling water for drinking water is presented in Table 3.29.

Table 3.29: Community Perception of Boiling Water for Drinking Water

| Study Area | Woreda | Never boil water | Always boil water | Sometimes boil water |
|---|---|---|---|---|
| Jarar Valley | Kabribeyah | 95% | 2.5% | 2.5% |
| | Dagahbur | 80% | 0% | 20% |
| | Araarso | 50% | 0% | 50% |
| | Birqod | 100% | 0% | 0% |
| | Shaygosh | 100% | 0% | 0% |
| | Kabridahar | 100% | 0% | 0% |
| | Marsin | 100% | 0% | 0% |
| Shebele sub-basin | Godey | 69% | 5% | 26% |
| | East Ime | 100% | 0% | 0% |
| | Adadle | 92% | 0% | 8% |
| | Danan | 75% | 0% | 25% |
| | Beercaano | 100% | 0% | 0% |
| | Kalafo | 91% | 0% | 9% |
| | Mustahil | 71% | 0% | 29% |
| | West Ime | 67% | 0% | 33% |
| | Rasso | 100% | 0% | 0% |

### c.5 Percentage of patients of diarrhea

Major leading water related diseases are malaria, diarrhea and dysentery in the Study area, and diarrhea is one of the most common diseases. Out of the sample households in Rasso and Adadle Woredas in Shebele sub-basin area, the percentage of family members who were suffering diarrhea “quite often” were 15.0% and 16.7 %, respectively. Percentage of family members who were suffering diarrhea “sometimes” was higher in such woredas as Araarso (100%), Godey (79.5%), Birqod (75%), Daghahbur (70%) and Kabridahar (63.6%).

Percentage of family members who have suffered from diarrhea during the last 12months is presented in Table 3.30.

Table 3.30: Percentage of Family Members suffering from Diarrhea

| Woreda | Never | Sometimes | Quite often |
|---|---|---|---|
| Kabribeyah | 72.5 % | 27.5 % | 0 % |
| Dagahbur | 30.0 % | 70.0 % | 0 % |
| Araarso | 0 % | 100 % | 0 % |
| Birqod | 25.0 % | 75.0 % | 0 % |
| Shaygosh | 100.0 % | 0 % | 0 % |
| Kabridahar | 36.4 % | 63.6 % | 0 % |
| Marsin | 100.0 % | 0 % | 0 % |
| Godey | 20.5 % | 79.5 % | 0 % |
| East Ime | 66.7 % | 33.3 % | 0 % |
| Adadle | 25.0 % | 58.3 % | 16.7 % |
| Danan | 50.0 % | 50.0 % | 0 % |
| Beercaano | 66.7 % | 33.3 % | 0 % |
| Kalafo | 63.6 % | 36.4 % | 0 % |
| Mustahil | 85.7 % | 14.3 % | 0 % |
| West Ime | 83.4 % | 16.6 % | 0 % |
| Rasso | 25.0 % | 75.0 % | 25.0 % |

**c.6 Willingness to pay for the improved water supply**

The perception of the sample households on the water price to be paid for improved water supply system differs depending on the income level and availability of water sources nearby each household. The water price fluctuation ranges from 0 Birr (minimum) to 400 Birr (maximum) per month. Average water price to be paid by water users ranges from 23 Birr in Birqod Woreda to 81 Birr in Araarso Woreda. Overall average price is 36 Birr per month. Willingness to pay for the improved water supply system is presented in Table 3.31.

Table 3.31: Willingness to Pay for the Improved Water Supply System

| Study Area | Woreda | Willingness to Pay for the Improved Water Supply (Birr/month) | | |
|---|---|---|---|---|
| | | Minimum | Maximum | Average |
| Jarar Valley | Kabribeyah | 15 | 400 | 37 |
| | Dagahbur | 10 | 300 | 26 |
| | Araarso | 10 | 50 | 81 |
| | Birqod | 20 | 30 | 23 |
| | Shaygosh | 0 | 30 | 20 |
| | Kabridahar | 10 | 100 | 40 |
| | Mustahil | 5 | 50 | 26 |
| | Marsin | 20 | 50 | 29 |
| Shebele sub-basin | Godey | 15 | 250 | 67 |
| | East Ime | 20 | 50 | 33 |
| | Adadle | 10 | 150 | 50 |
| | Danan | 20 | 50 | 31 |
| | Beercaano | 20 | 50 | 38 |
| | Kalafo | 0 | 60 | 30 |
| | Mustahil | 5 | 50 | 26 |
| | West Ime | 10 | 45 | 24 |
| | Rasso | 10 | 50 | 29 |
| Average | | | | 36 |

### c.7 Household income

Household income sources consist of such items as crops, livestock, employment, remittance, commercial and other. Household income ranges from 24,225 Birr (Shaygosh) to 80,295 Birr (Kabribeyah), with average income of 44,952 Birr in Jarar valley area and 40,359 Birr in Shebele sub-basin area.

The highest income was recorded in Kabribeyah Woreda where the main income source was remittance from family members or relatives who were working in a different area. The lowest income was recorded in Shaygosh where no income came from agricultural activities. In general, higher livestock income was reported in Shebele sub-basin area.

Annual household income by each woreda is presented in Table 3.32.

Table 3.32: Annual Household Income in the Study Area

Unit: Birr

| Woreda | Crop | Livestock | Employment | Remittance | Commercial | Other | Total |
|---|---|---|---|---|---|---|---|
| Kabribeyah | 3,360 | 928 | 15,432 | 47,758 | 11,900 | 917 | 80,295 |
| Degehabur | 750 | 150 | 25,644 | 4,404 | 13,320 | 530 | 42,998 |
| Araarso | 1,750 | 1,250 | 17,550 | 4,250 | 3,600 | 0 | 28,400 |
| Birqod | 5,625 | 3,100 | 19.8 | 10,200 | 22,500 | 0 | 61,225 |
| Shaygosh | 0 | 0 | 14,800 | 425 | 9,000 | 0 | 24,225 |
| Kabridahar | 2,091 | 273 | 19,527 | 10,145 | 4,036 | 0 | 36,073 |
| Marsin | 5,000 | 1,715 | 22,500 | 10,213 | 6,000 | 0 | 41,450 |
| Jarar valley area average | | | | | | | 44,952 |
| Godey | 2,225 | 950 | 6,982 | 3,846 | 13,950 | 2,575 | 30,336 |
| East Ime | 2,950 | 6,000 | 13,240 | 9,800 | 10,500 | 0 | 42,490 |
| Adadle | 4,892 | 1,808 | 11,342 | 4,256 | 13,756 | 1,050 | 37,052 |
| Danan | 1,625 | 2,438 | 22,750 | 0 | 9,600 | 0 | 37,033 |
| Beercaano | 2,833 | 7,500 | 8,000 | 0 | 45,600 | 0 | 63,933 |
| Kalafo | 13,233 | 3,750 | 7,569 | 9,492 | 6,100 | 0 | 40,265 |
| Mustahil | 16,714 | 5,143 | 20,197 | 0 | 7.143 | 0 | 49,690 |
| West Ime | 2,386 | 2,186 | 19,543 | 3,400 | 5,657 | 0 | 32,686 |
| Rasso | 12,500 | 8,250 | 0 | 0 | 9,000 | 0 | 29,750 |
| Shebele sub-basin area average | | | | | | | 40,359 |

# Chapter 4

*Environmental and Social Consideration*

# 4 Environmental and Social Consideration

## 4.1 Title of the project

The Study on Jarar Valley and Shebele Sub-basin Water Supply Development Plan, and Emergency Water Supply

## 4.2 Name of the proponent

### 4.2.1 Responsible organization

Ministry of Water and Energy (MoWE)

### 4.2.2 Implementing organization

Somali Regional Water Development Bureau (SRWDB)

## 4.3 Introduction of the project

### 4.3.1 Introduction

This study, "Jarar Valley and Shebele Sub-basin Water Supply Development Plan, and Emergency Water Supply in the Federal Democratic Republic of Ethiopia (hereafter, the Project)" is carried out in Jarar Valley and Shebele Sub-basin (see Figure 4.1) based on the results of the record of discussions (R/D) agreed and signed by the Federal Democratic Republic of Ethiopia and Japan International Cooperation Agency (JICA) on 23 December 2011.

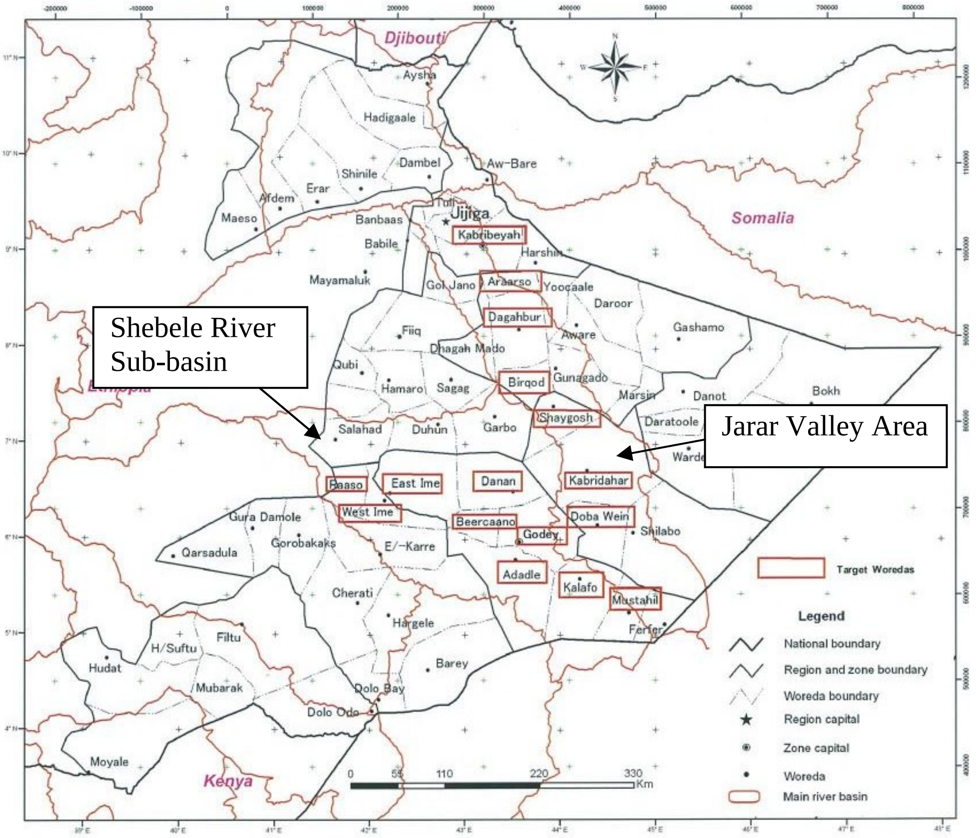



Figure 4.1: Project Area

### 4.3.2 Background

Eastern Ethiopia and its neighbors in the eastern part of the African continent are called “the horn of Africa”. It is an area prone to repeated droughts and food shortages. In fact, the area was hit by the worst drought in the past 60 years from the mid 2010 to around September 2012: affected by scarce rainfall in October 2010 during the rainy season that generally has the heaviest rainfall, and also consecutively in April 2011 during the rainy season. The Ministry of Agriculture together with some donor agencies reported that around 4.57 million people across the country suffered from food shortages and required humanitarian aid as a result of the drought. About 80% of the affected population is actually in the lowland areas of the country such as Somali Region.

Moreover, Somali Region has a strong and chronic need for better water supply, with a water supply coverage as low as 59.7% (64.0% in urban areas and 49.0% in rural areas), being lower than the national average of 68.5% (91.5 % for urban areas and 65.8% for rural areas after UAP). The need for water supply suddenly increases in emergencies, especially at the time of drought such as in recent years. However, technical and organizational capacity of the Somali Regional State Water Resources Development Bureau (SRWDB) that is in charge of water supply and facilities management in the region to satisfy the water supply need is not adequate to cope with the situation. Donor agencies and NGOs are making efforts to ameliorate the situation by constructing and repairing water supply facilities, supplying water by water trucks for emergency supply, but the supply is still significantly under the demand. In order to improve the immediate situation, one of the expected measures is to provide emergency water supplies by truck, and another is to raise the capacity of the Ethiopian government to cope with droughts by themselves. Also, as a mid- to long-term measure, drawing up of a water supply plan and effective and efficient implementation of the prepared plan is envisaged.

In this context, JICA organized and dispatched a team to the region to investigate and confirm the situation of the drought, water supply need, and detailed need for cooperation in water supply. As a result of the investigation, JICA had discussion with relevant Ethiopian agencies to determine the scope of cooperation (October to November 2011). Then in December 2011, the Ethiopian side requested to the government of Japan for cooperation in water supply planning and execution of emergency water supply in the two areas of Jarar Valley watershed and Shebele River watersheds both of which have a high potential of water resources development. In response to this request, JICA discussed the detailed scope of the cooperation with the relevant Ethiopian agencies and compiled the outcome in the R/D and finally both parties signed and exchanged the document in the same month.

### 4.3.3 Outline of the project components

The Project consists of five components (refer to Table 4.1). The purpose of environment and social consideration is to estimate environmental and social impact of water supply drawn up by the Project according to Somali Regional State Adopted Guideline for Reviewing Environmental Impacts Study Reports (February 2012; SRS guideline) and JICA Environment and Social Consideration Guideline (April 2010; JICA guideline). Alternative plans and mitigations would also be studied if the impacts are not evitable. The summary of the environmental impact assessment study is to be feed back to the Study Team.

## Table 4.1: The Project Components

<table>
<tr><th colspan="2">Components</th><th>Target area/ organization</th><th>Detail</th></tr>
<tr><td colspan="2">1. Water supply planning</td><td>Jarar Valley basin and Shebele River basin</td><td>Target year: Change from 2015 to 2020 (after the first steering committee)<br>• Plans will be drawn up for each of the 16 woredas included in the study area.<br>• Plans for Kabribeyah and Godey towns will be prepared separately.</td></tr>
<tr><td colspan="2" rowspan="2">2. Study on water resources potential</td><td>Jarar Valley basin</td><td>Preparation of “Groundwater utilization potential map” at 1/250,000 scale or more</td></tr>
<tr><td>Shebele River basin</td><td>Preparation of “Water resources utilization potential map” at 1/250,000 scale or more</td></tr>
<tr><td rowspan="4">3. Emergency water supply</td><td rowspan="2">Pilot project implementation</td><td>Jarar Valley basin (Kabribeyah Town)</td><td>1) Improvement of Jarar valley water supply system<br>• Drilling and construction of wells (200m x 2)<br>• Replacement of booster pumps (3 pumps)<br>• Construction of public taps (human, animal use) (5 sites)<br>• Construction of pump house and installation of submersible pump and generator (for 2 wells)<br>• Installation of pipeline to connect the wells to the water supply system</td></tr>
<tr><td>Godey Town</td><td>2) Improvement of Godey Town water supply system<br>• Conduct F/S for the prepared water supply plan<br>• Provision of water truck (1 truck)<br>• Construction of water supply points to be filled by water trucks (5 sites)</td></tr>
<tr><td rowspan="2">Procurement and provision</td><td rowspan="2">Whole Somali Region</td><td>1) Procurement and provision of water supply equipment and materials<br>• Water truck (x 4)<br>• Water tank for water supply x 150<br>• Chlorination tablets (for 3,600 $m^3$ water)<br>• Mobile workshop (x 3)</td></tr>
<tr><td>2) Provision of technical training for effective utilization of the equipment and materials above<br>• Provision of technical training for utilization of the mobile workshop in the case of emergency</td></tr>
<tr><td colspan="2">4. Compilation of hydrogeological data</td><td>Whole Somali Region</td><td>Collected hydrogeological and other relevant information will be compiled for future use by the Ethiopian side.</td></tr>
<tr><td colspan="2">5. Capacity development of personnel of Ethiopian side</td><td>Staff of SRWDB, Town water supply utility office and SWWCE</td><td>- Operation and management of water supply system<br>- Maintenance of equipment and facilities<br>- Capacity development in water well drilling</td></tr>
</table>

[yellow box]: Project component to be studied by environmental and social considerations

## 4.4 Outline of the water supply plan

### 4.4.1 Urban water supply plan

Table 4.2 summarized urban water supply plans in the project area. In the planning, well, river water and rainwater (water storage by birka) are adopted as new water sources for 16 towns in 16 woredas.

Table 4.2: Summary of Urban Water Supply Plan

| No. | Woreda | Town | Estimates in 2020 | | | Water supply planning in the Project | | |
|---|---|---|---|---|---|---|---|---|
| | | | Population | Water demand ($m^3$/day) | Water supplied population | Supply volume ($m^3$/day) | Facility design ($m^3$/day) | Water ource |
| 1 | Dagahbur | Dagahbur | 87,425 | 2,798 | 26,829 | 851 | 1,021 | Deep well |
| 2 | Kabridahar | Kabridahar | 64,155 | 2,034 | 19,689 | 621 | 745 | Deep well |
| 3 | Doba wein | Doba wein | 42,457 | 1,446 | 13,031 | 431 | 646 | Shallow well |
| 4 | Arrarso | Arrarso | 26,416 | 837 | 8,106 | 255 | 383 | Deep well |
| 5 | Adadle | Bohelxagare | 18,871 | 604 | 5,793 | 184 | 276 | Deep well |
| 6 | Shaygosh | Shaygosh | 15,724 | 573 | 4,826 | 167 | 251 | Deep well |
| 7 | Birqod | Birqod | 12,579 | 425 | 3,861 | 127 | 190 | Deep well |
| 8 | Danan | Danan | 12,328 | 402 | 3,784 | 122 | 182 | Deep well |
| 9 | Kabribayah | Kabribayah | 50,373 | 2,249 | 15,459 | 2,699 | 166 | Deep well |
| 10 | Godey | Godey | 36,958 | 1,418 | 36,958 | 2,212 | 2,212 | River water |
| 11 | Kalafo | Kalafo | 33,848 | 1,124 | 10,387 | 1,124 | 1,855 | River water |
| 12 | Mustahil | Mustahil | 29,537 | 932 | 9,065 | 932 | 1,538 | River water |
| 13 | East Ime | East Ime | 11,717 | 374 | 3,595 | 374 | 617 | River water |
| 14 | West Ime | West Ime | 9,938 | 284 | 2,664 | 284 | 469 | River water |
| 15 | Beeraano | Beeraano | 7,926 | 248 | 2,433 | 248 | 410 | River water |
| 16 | Rasso | Rasso | 8,681 | 316 | 3,050 | 96 | 100 | Birka |

To maximize the 1,021 $m^3$/day in Dagahbur town, all water supply planning by well construction is set to 2,000 $m^3$ /day or less. Well system of water supply is constituted submergible pump with generator, pipeline to reservoir, elevated reservoir, distribution pipes, public taps and cattle trough (refer to Figure 4.2).

River water supply facilities consist of intake pump with generator, sedimentation pond, rough filter, clear water reservoir, surface pump, transmission pipeline, reservoir, distribution pipeline, public tap, and cattle trough. All components are the same structure for urban and rural water supply systems; however, mechanical specifications, facilities' capacity, and pipeline length are different in each project (refer to Figure 4.3). Pipeline, reservoir volume, water point, and cattle trough apply to the same design as the borehole/shallow well water supply system.

Meanwhile, birka is the underground reservoir made by concrete. Roof is provided to protect from wastes. The roof is a checkered pattern; rainwater can drop directly into the main body. The storage capacity is around 1,000m$^3$. Hand pump is provided to pump water out. Runoff water flows into the inlet, and sand and soil particles are stored at the silt trap. Supernatant water flows into the body (refer to Figure 4.4).

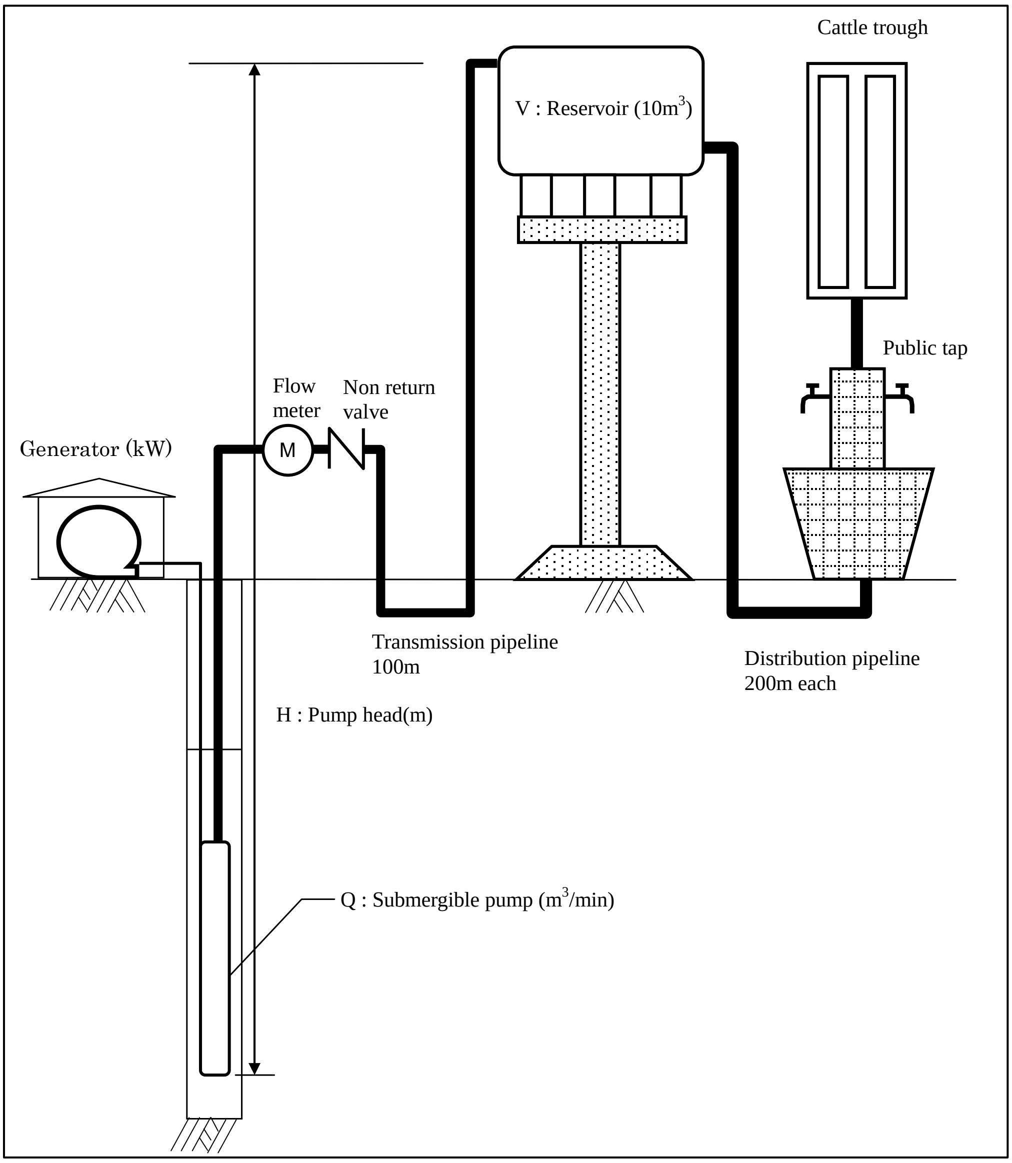



Figure 4.2: Water Supply System by Well Construction

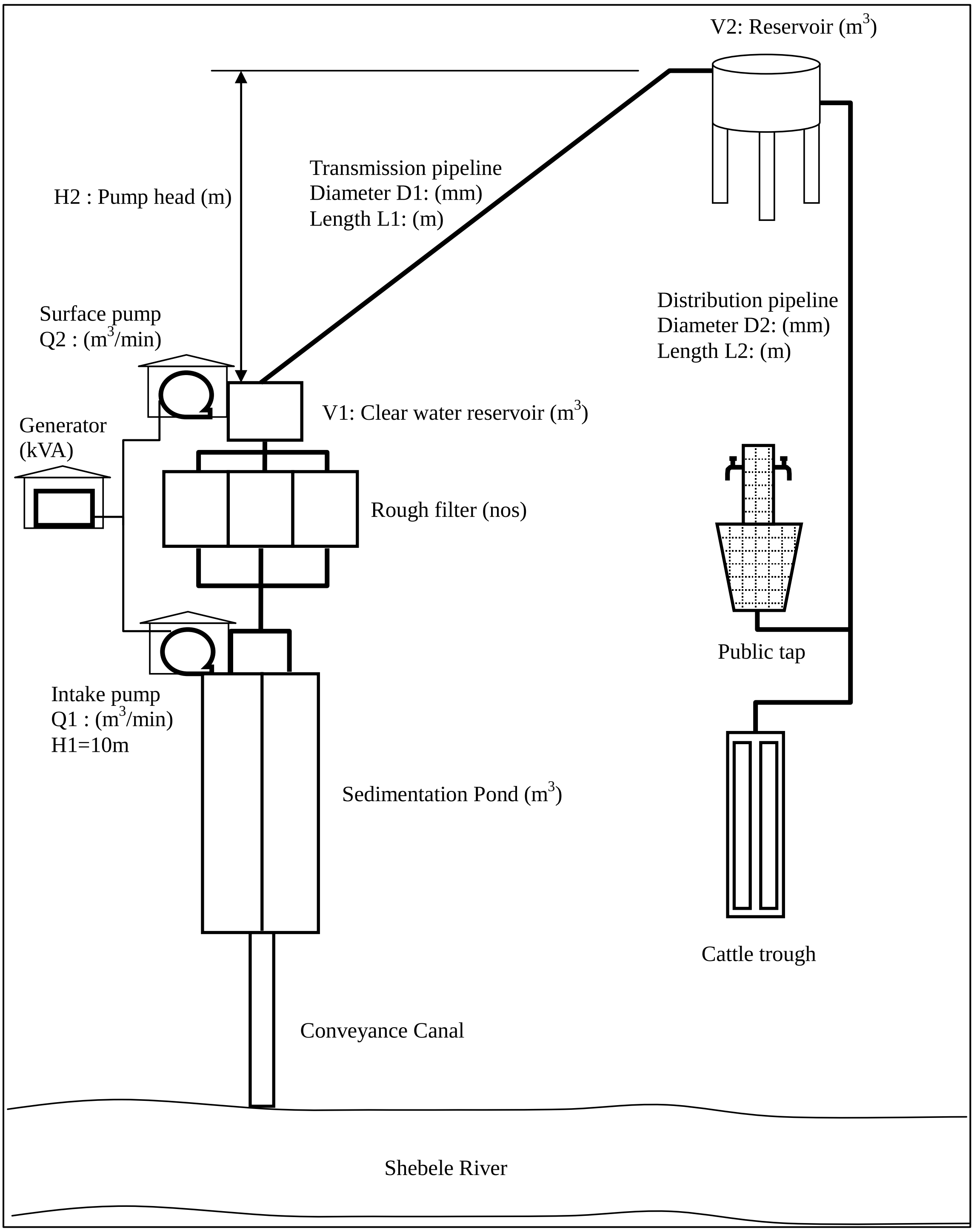



Figure 4.3: Water Supply System from River Water

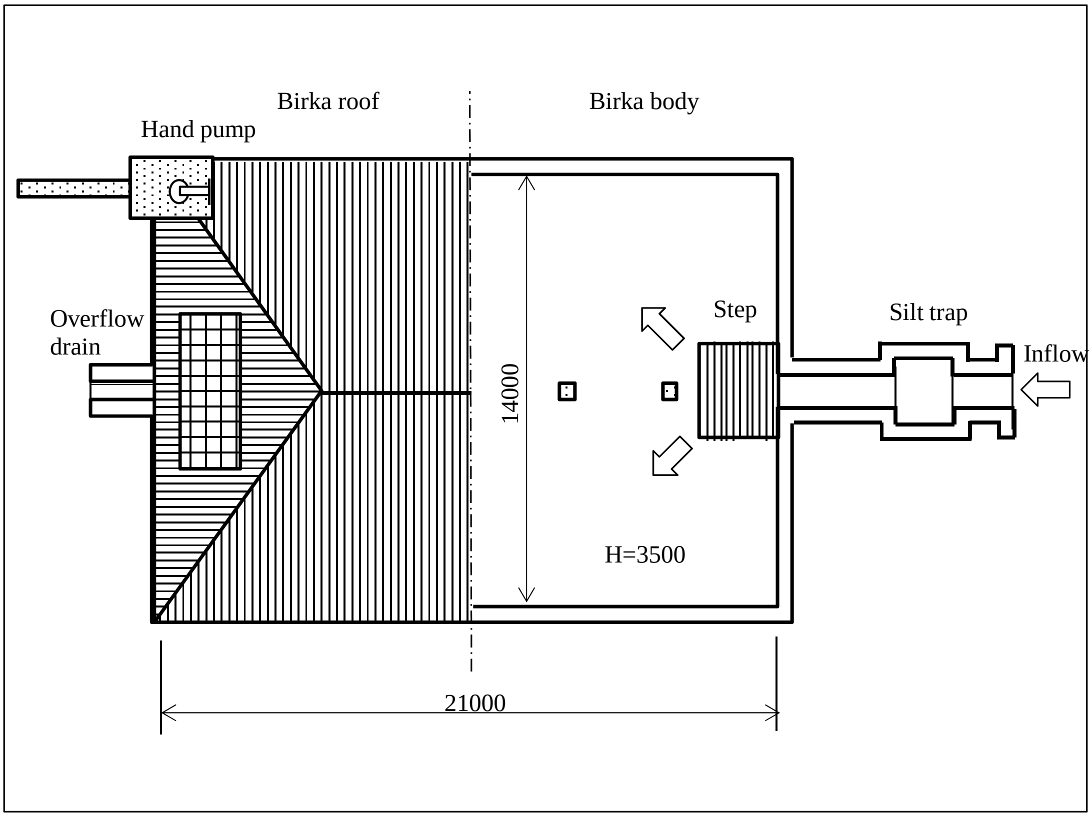



Figure 4.4: Birka Plan (from SRWDB)

### 4.4.2 Rural water supply plan

Table 4.3 summarized rural water supply plans in the project area. In the planning, well, river water, haffir dam (refer to Figure 4.5) and birka are adopted as new water sources in the area.

Table 4.3: Summary of Rural Water Supply Plan

| | Woreda | Number of covered Kebele | water supplied population | Planned constructions in the Project | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Deep well | Shallow well | River intake | Haffir dam | Birka |
| 1 | Dagahbur | 16 | 26,363 | 11 | 0 | 0 | 4 | 31 |
| 2 | Kabridahar | 9 | 47,602 | 11 | 0 | 0 | 12 | 12 |
| 3 | Doba wein | 4 | 15,925 | 0 | 14 | 0 | 1 | 1 |
| 4 | Arrarso | 8 | 7,951 | 7 | 0 | 0 | 0 | 28 |
| 5 | Adadle | 10 | 34,598 | 4 | 0 | 2 | 0 | 79 |
| 6 | Shaygosh | 4 | 19,664 | 4 | 0 | 0 | 4 | 16 |
| 7 | Birqod | 6 | 3,785 | 6 | 0 | 0 | 0 | 4 |
| 8 | Danan | 4 | 7,852 | 6 | 0 | 0 | 0 | 0 |
| 9 | Kabribayah | 29 | 62,262 | 11 | 0 | 0 | 2 | 126 |
| 10 | Godey | 9 | 21,536 | 2 | 0 | 5 | 0 | 25 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 11 | Kalafo | 9 | 29,400 | 0 | 0 | 6 | 0 | 51 |
| 12 | Mustahil | 8 | 19,206 | 0 | 0 | 6 | 0 | 24 |
| 13 | East Ime | 11 | 31,330 | 0 | 0 | 7 | 0 | 53 |
| 14 | West Ime | 10 | 9,448 | 0 | 0 | 6 | 0 | 19 |
| 15 | Beeraano | 4 | 8,069 | 0 | 0 | 3 | 0 | 12 |
| 16 | Rasso | 3 | 8,496 | 0 | 0 | 0 | 0 | 44 |

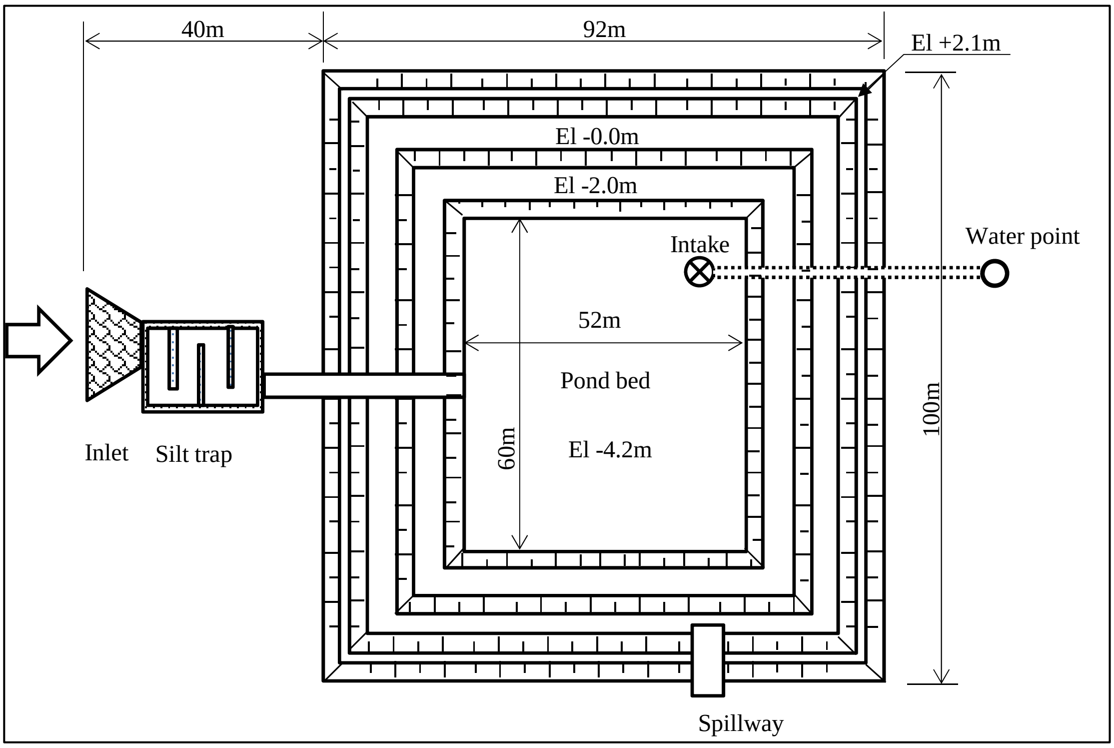



Figure 4.5: Haffir Dam Plan (from SRWDB)

## 4.5 Environmental and social categorization

### 4.5.1 Categorization

The Project is regarded as "Type II Schedule-2" and "Category B" according to the SRS Guideline (February 2012) and the JICA Guideline (April 2012) for environmental and social consideration, respectively.

### 4.5.2 Account

1) The project area doesn't be situated in the sensitive areas designated by both SRS and JICA guidelines and the Project doesn't possess the sensitive characteristics in accordance with the JICA guideline (refer to Table 4.4 and Table 4.5).

2) Ground water development for urban water supply is less than 2000 m3/day. Therefore it is not required fill EIA in accordance with SRS guideline.

3) The Project will be applied to "Rural and urban water supply and sanitation" in SRS guideline.

4) Any significant negative impacts are not expected due to the project.

Table 4.4: Applicability of Sensitive Areas on the Environment and Society Designated by SRS Guideline (February 2012)

| Sensitive areas on the environment and society | Yes/No |
|---|---|
| (1) Land prone to erosion | No |
| (2) Land prone to desertification | No |
| (3) Areas which harbor protected, threatened or endangered species | No |
| (4) Areas of particular historic or archaeological interest | No |
| (5) Primary forests | No |
| (6) Wetland of national or international importance | No |
| (7) National park and protected area | No |
| (8) Important landscape | No |
| (9) Religiously important area. | No |

Table 4.5: Applicability of Sensitive Characteristics and Areas on the Environment and Society Designated by JICA Guideline (April 2010)

| Sensitive characteristics and areas on the environment and society | Yes/No |
|---|---|
| (1) Sensitive Characteristics | |
| 1) Large-scale involuntary resettlement | No |
| 2) Large-scale groundwater pumping | No |
| 3) Large-scale land reclamation, land development, and land clearing | No |
| 4) Large-scale logging | No |
| (2) Sensitive Areas | |
| 1) National parks, nationally-designated protected areas | No |
| 2) Areas that are thought to require careful consideration by the country or locality | |
| ・Primary forests or natural forests in tropical areas | No |
| ・Habitats with important ecological value (coral reefs, mangrove wetlands, tidal flats) | No |
| ・Habitats of rare species that require protection under domestic legislation, international treaties, etc. | No |
| ・Areas in danger of large-scale salt accumulation or soil erosion | No |

| | |
|---|---|
| ・Areas with a remarkable tendency towards desertification | No |
| ・Areas with unique archeological, historical, or cultural value | No |
| ・Areas inhabited by ethnic minorities, indigenous peoples, or nomadic peoples with traditional ways of life, and other areas with special social value | No |

## 4.6 Location of the project

### 4.6.1 Project site

Construction sites of water supply facilities in each woredas are shown in planning drawings of Volume 2 of Final Report.

### 4.6.2 Social conditions

**a. Population**

On the basis of result of social survey, total target woreda population is 508,578 people, the difference between the least woreda (Beercaano, 6,100 people) and the largest woreda (Godey, 123,000 people) reaches 20.2 times. The ratio of male to female is 48 % of male and 52 % of female, respectively.

**b. Race and religion**

Ethnic groups include Somalis (97.2 %), Oromo (0.46 %), Amhara (0.66 %), foreign-born Somalis (0.20 %) and Gurages (0.12 %). 98.4 % of the population is Muslim, 0.6 % Orthodox Christian, and 1.0 % are followers of all other religions. Racial clash and religious conflict cannot be forecasted so far.

**c. Health sector**

**c.1 Health facilities**

In the Study Area, there are six hospitals with a total of 624 health professionals and supporting staff. Other health facilities include 21 health centers (HCs), 56 health posts (HPs) and 21 health clinics with a total of 560 health professionals and supporting staff (see Table 4.6).

Table 4.6: Health Facilities and Staff in the Project Area

| Woreda | Hospitals | | Health Center | | Health Post | | Health Clinics | |
|---|---|---|---|---|---|---|---|---|
| | Facilities | Staff | Facilities | Staff | Facilities | Staff | Facilities | Staff |
| Araarso | 1 | 22 | 3 | 10 | 0 | 0 | 3 | 10 |
| Kabribeyah | 1 | 0 | 1 | 20 | 1 | 2 | 0 | 0 |
| Birqod | 0 | 0 | 1 | 26 | 0 | 0 | 2 | 5 |
| Kabridahar | 1 | 124 | 3 | 0 | 0 | 0 | 0 | 0 |
| Dagahbur | 1 | 182 | 1 | 13 | 2 | 4 | 16 | 80 |
| Shaygosh | 0 | 0 | 1 | 44 | 1 | 14 | 0 | 0 |
| Marsin | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Adadle | 0 | 0 | 2 | 22 | 15 | 30 | 0 | 0 |
| Rasso | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Beercaano | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Danan | 0 | 0 | 1 | 27 | 1 | 13 | 0 | 0 |
| Godey | 1 | 184 | 2 | 59 | 4 | 24 | 0 | 0 |
| Kalafo | 1 | 112 | 1 | 16 | 2 | 29 | 0 | 0 |
| Mustahil | 0 | 0 | 2 | 15 | 15 | 29 | 0 | 0 |
| West Ime | 0 | 0 | 1 | 16 | 2 | 8 | 0 | 0 |
| East Ime | 0 | 0 | 2 | 8 | 13 | 36 | 0 | 0 |
| Total | 6 | 624 | 21 | 276 | 56 | 189 | 21 | 95 |

### c.2 Leading causes of water related diseases

The major leading water related diseases are malaria, diarrhea and dysentery in the Study area. Out of 15,071 of diarrhea cases in the Study Area, Kalafo Woreda accounts for 26%, Adadle Woreda 14% and Danar Woreda 10%, respectively. Out of 3,600 of dysentery cases, Kalafo Woreda accounts for 64 %, Araarso Woreda 7 % and Kabridahar Woreda 6 %, respectively. High diarrhea cases in Kalafo, Adadle and Danan Woredas are most likely due to people’s taking drinking water from the river or unprotected dug-wells. Estimated number of water related diseases patients per year is presented in Table 4.7.

Table 4.7: Estimated Number of Water Related Diseases Patients per Year

| Woreda | Diarrhea | Dysentery | Typhoid | Cholera | Malaria | Other |
|---|---|---|---|---|---|---|
| Kabribeyah | 740 | 167 | 89 | 0 | 205 | 0 |
| Dagahbur | 1,332 | 65 | 315 | 0 | 960 | 79 |
| Araarso | 1,020 | 240 | 108 | 0 | 180 | 1,620 |
| Birqod | 960 | 0 | 0 | 0 | 0 | 360 |
| Shaygosh | 360 | 150 | 2 | 540 | 5,400 | 150 |
| Kabridahar | 120 | 210 | 10 | 0 | 1,800 | 0 |
| Marsin | 0 | 12 | 0 | 0 | 0 | 0 |
| Godey | 600 | 60 | 0 | 0 | 1,800 | 240 |
| East Ime | 1,080 | 0 | 0 | 0 | 0 | 1,200 |
| Adadle | 2,180 | 96 | 0 | 0 | 0 | 1,3000 |
| Danan | 1,440 | 60 | 120 | 0 | 72 | 300 |
| Beercaano | 0 | 36 | 0 | 0 | 0 | 0 |
| Kalafo | 4,000 | 2,300 | 0 | 0 | 4,800 | 0 |
| Mustahil | 514 | 114 | 57 | 0 | 819 | 1,516 |
| West Ime | 600 | 40 | 12 | 0 | 800 | 0 |
| Rasso | 125 | 50 | 0 | 0 | 48 | 192 |
| Total | 15,071 | 3,600 | 713 | 540 | 16,884 | 18,657 |

### c.3 Supplementary Survey of health sector in Kabribeyah woreda

Due to the poorly-developed basic infrastructure such a water supply, medical institution has fallen into the most serious situation. Figure 4.6 shows the breakdown of top 10 diseases in Karamara Hospital which is the largest general hospital in The Somali Regional State in the period from 8th July 2010 to 7th July 2011 (1st July 2002 – 30th June 2003 in Ethiopian calendar). The number of patients was 11,565 and the top 6 diseases were all microbial (bacterial and viral) illness such as pneumonia and diarrhea. Besides, serious acute malnutrition and diabetic mellitus were suggested to reflect the lifestyle and poverty in the region.

In addition, Figure 4.7 also shows the breakdown of top 10 inpatients in the hospital in the same period. It should be noted here that about 270 patients with meningitis, is chaemic heart disease and appendicitis were hospitalized and had surgery as necessary. According to interviews with the hospital director, clean water is desperately short for washing surgical instruments and surgical clothing more than or even equal in treating. He mentioned that secondary infections in surgery will be reduced and the survival rate of patients will be improved dramatically if clean water can be secured.

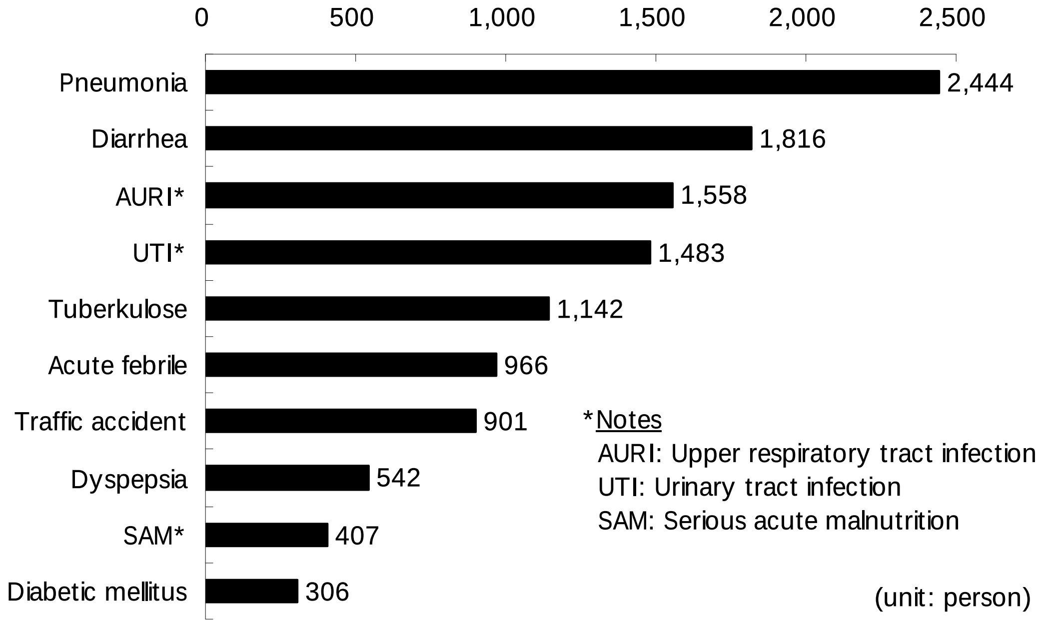



Figure 4.6: Breakdown of Top 10 Diseases in Karamara Hospital for the Year

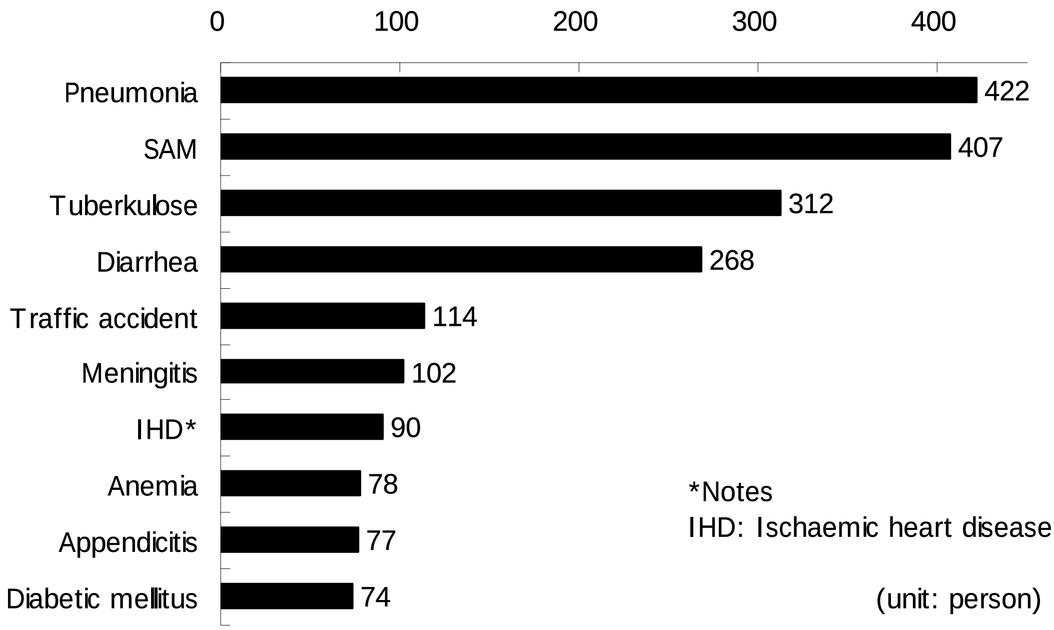



Figure 4.7: Breakdown of Top 10 Inpatients in Karamara Hospital for the Year

### d. Water supply situation

### d.1 Domestic water supply

Based on the 2007 Population and Housing Census of Ethiopia (Statistical Report for Somali Region), water supply situation in the Study Area is summarized as follows.

(1) In big towns of Jarar valley area, such as Kabribeyah, Dagahbur and Kabridahar, the water supply is provided mainly by the piped water system, covering about 40 to 75% of the

total population.

(2) In small towns and rural areas in Jarar valley area, protected or unprotected wells and traditional water sources such as springs, rivers, lakes and ponds are the main water sources.

(3) In Shebele sub-basin area, traditional water sources such as rivers, lakes and ponds are the main water sources even in urban areas. It is considered that the river water is the most important water sources in the area.

(4) In urban areas of the Shebele sub-basin area, the water coverage under the piped water system is very low, compared to those in Jarar valley area.

Percentage of houses by sources of drinking water per each target Woreda is presented in Table 4.8.

Table 4.8: Percentage of Houses by Sources of Drinking Water (2007)

| Area | Woreda | Urban / Rural | Tap inside the house or in compound | Tap outside the compound | Protected well or spring | Unprotected well or spring | River, lake, pond |
|---|---|---|---|---|---|---|---|
| Jarar Valley Area | Kabribeyah | Urban | 9.0% | 30.9% | 17.3% | 20.7% | 22.1% |
| | | Rural | 1.1% | 1.9% | 28.2% | 37.8% | 31.0% |
| | Dagahbur (Araarso, Birqod) | Urban | 15.0% | 46.0% | 8.5% | 3.5% | 27.0% |
| | | Rural | 2.0% | 6.3% | 23.9% | 49.9% | 17.9% |
| | Shaygosh | Urban | 0.0% | 67.6% | 2.3% | 30.1% | 0.0% |
| | | Rural | 3.1% | 5.9% | 8.4% | 45.0% | 37.7% |
| | Kabridahar (Marsin) | Urban | 34.1% | 41.9% | 7.7% | 6.5% | 9.8% |
| | | Rural | 5.5% | 12.4% | 18.1% | 48.1% | 15.9% |
| | Dobowein | Urban | 7.3% | 9.0% | 30.9% | 50.6% | 2.2% |
| | | Rural | 2.0% | 5.9% | 27.3% | 58.3% | 6.5% |
| Shebele Sub-basin Area | East Ime | Urban | 1.4% | 0.0% | 1.0% | 15.3% | 82.3% |
| | | Rural | 0.4% | 0.0% | 1.5% | 5.6% | 92.5% |
| | Adadle | Urban | 0.0% | 0.0% | 35.4% | 57.6% | 7.0% |
| | | Rural | 1.2% | 1.5% | 14.4% | 24.4% | 63.4% |
| | Godey (Beercaano) | Urban | 9.8% | 10.3% | 3.7% | 9.6% | 66.6% |
| | | Rural | 2.0% | 5.1% | 13.0% | 23.9% | 56.1% |
| | Danan | Urban | 4.8% | 9.8% | 14.6% | 33.0% | 37.8% |
| | | Rural | 0.7% | 3.5% | 16.1% | 43.2% | 36.4% |
| | Kalafo | Urban | 3.1% | 2.3% | 1.5% | 1.1% | 92.0% |
| | | Rural | 1.3% | 2.9% | 1.3% | 17.7% | 76.8% |
| | Mustahil | Urban | 11.5% | 38.2% | 1.9% | 0.0% | 48.4% |
| | | Rural | 0.4% | 0.2% | 5.4% | 15.4% | 78.6% |
| | West Ime (Rasso) | Urban | 1.9% | 0.0% | 0.5% | 16.0% | 81.6% |
| | | Rural | 0.7% | 0.0% | 0.6% | 14.8% | 83.8% |

Source: Statistical Report for Somali Region, 2007 Population and Housing Census
Note: Araarso, Birqod, Marsin, Beeranno and Rasso Woredas are not included in the 2007 Census.

### d.2 Retail of daily life water

There are a large number of retailers who buy daily life water from sources such as an irrigation pond and supply it to town area using their livestock (see Figure 4.8). According to hearing with them in Godey town, 12-14 year-old boys are in charge of retail, they purchase a drum of the water for 3 Birr from the source and sell at 15 Birr apiece in the city. The owner of the water source in Godey said that there were about 650 such retailers in the city.

Figure 4.8: Irrigation Pond for Water Supply in Godey Town and Retailers

### e. Waste management

There is no information on systematic services of waste collection and management in the Project area. Based on the result of on-site review in Godey Town, it is estimated that wastes generated from households and business establishments are buried or left the vacant lot naturally (see Figure 4.9).

Figure 4.9: Discarded Waste in Godey Town (March 2013)

### f. Agriculture and stock raising

#### f.1 Crop production

Crop production in each woreda is compiled in Table 4.9. In the Project Area, Godey and Kalafo woredas are considered to be agriculturally oriented areas. Out of the total production of maize, Kalafo and Godey woredas accounts for 40.1 % and 39.5%, respectively, accounting for almost 80% of all maize produced in the Study Area. Danan, Godey and Kalafo woredas accounts for 57% of the total sorghum production. As for tomatos, Kalafo woreda accounts for 70% of the total production, followed by Godey woreda.

Table 4.9: Main Crop Production in the Project Area

| Woreda | Maize | | Sorghum | | Teff | | Tomato | |
|---|---|---|---|---|---|---|---|---|
| | Production | % | Production | % | Production | % | Production | % |
| Kabribeyah | 800 | 0.1% | 5000 | 3.3% | 1,000 | 1.5% | 3,000 | 3.4% |
| Dagahbur | 5,450 | 0.8% | 583 | 0.4% | 0 | 0.0% | 90 | 0.1% |
| Araarso | 20,000 | 3.0% | 5,000 | 3.3% | 0 | 0.0% | 0 | 0.0% |
| Birqod | 5,000 | 0.8% | 2,100 | 1.4% | 0 | 0.0% | 0 | 0.0% |
| Shaygosh | 14,400 | 2.2% | 17,268 | 11.5% | 0 | 0.0% | 0 | 0.0% |
| Kabridahar | 2,680 | 0.4% | 3,415 | 2.3% | 0 | 0.0% | 2,100 | 2.4% |
| Marsin | 12,300 | 1.9% | 5,600 | 3.7% | 0 | 0.0% | 400 | 0.5% |
| Godey | 260,009 | 39.5% | 17,600 | 11.7% | 40 | 0.1% | 16,000 | 18.2% |
| East Ime | 26,000 | 3.9% | 600 | 0.4% | 740 | 1.1% | 0 | 0.0% |
| Adadle | 16,720 | 2.5% | 4,200 | 2.8% | 0 | 0.0% | 0 | 0.0% |
| Danan | 0 | 0.0% | 50,000 | 33.3% | 0 | 0.0% | 3,200 | 3.6% |
| Beercaano | 11,000 | 1.7% | 7,000 | 4.7% | 0 | 0.0% | 1,200 | 1.4% |
| Kalafo | 264,285 | 40.1% | 18,425 | 12.3% | 61,561 | 95.4% | 61,561 | 70.1% |
| Mustahil | 10,000 | 1.5% | 4,567 | 3.0% | 1,200 | 1.9% | 275 | 0.3% |
| West Ime | 6,320 | 1.0% | 7,090 | 4.7% | 0 | 0.0% | 0 | 0.0% |
| Rasso | 3,600 | 0.5% | 1,845 | 1.2% | 0 | 0.0% | 0 | 0.0% |
| Total | 658,564 | 100.0% | 150,293 | 100.0% | 64,541 | 100.0% | 87,826 | 100.0% |

### f.2 Livestock

Livestock distribution in each woreda is compiled in Table 4.10. Out of the total cattle population, approximately 54 % and 28 % of cattle are found in Kalafo and Mustahil woredas, respectively. For camels, about 20% each are found in Mustahil and East Ime woredas, respectively. About 12 % of the total camels are found in Shaygosh woreda. For goats, Kalafo and Adadle woredas accounts for 48% and 22%, respectively. For sheep, Mustahil and Adadle accounts for 40 % and 36 %, respectively. A large number of livestock such as cattle, camels, goat and sheep are found in Adadle, Mustahil and Kalafo woredas in Shebele sub-basin area.

Table 4.10: Livestock Distribution in the Study Area

| Woreda | Cattle | | Camel | | Goat | | Sheep | |
|---|---|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % | Number | % |
| Kabribeyah | 195 | 0.0% | 165 | 0.1% | 450 | 0.1% | 320 | 0.1% |
| Dagahbur | 800 | 0.2% | 2,500 | 2.1% | 8,500 | 1.7% | 5,000 | 1.0% |
| Araarso | 12,440 | 2.8% | 658 | 0.6% | 24,180 | 4.9% | 1,825 | 0.4% |
| Birqod | 5,687 | 1.3% | 2,120 | 1.8% | 6,800 | 1.4% | 4,900 | 1.0% |
| Shaygosh | 850 | 0.2% | 14,000 | 12.0% | 21,000 | 4.2% | 8,000 | 1.6% |
| Kabridahar | 2,610 | 0.6% | 1,435 | 1.2% | 4,816 | 1.0% | 5,078 | 1.0% |
| Marsin | 350 | 0.1% | 1,200 | 1.0% | 8,764 | 1.8% | 4,326 | 0.9% |
| Godey | 15,000 | 3.3% | 9,000 | 7.7% | 9,500 | 1.9% | 15,060 | 3.0% |
| East Ime | 9,800 | 2.2% | 23,000 | 19.7% | 9,500 | 1.9% | 13,000 | 2.6% |
| Adadle | 17,200 | 3.8% | 11,500 | 9.8% | 110,000 | 22.2% | 182,350 | 36.2% |
| Danan | 620 | 0.1% | 1,229 | 1.1% | 3,900 | 0.8% | 5,100 | 1.0% |
| Beercaano | 4,500 | 1.0% | 2,200 | 1.9% | 7,000 | 1.4% | 900 | 0.2% |
| Kalafo | 245,000 | 54.4% | 8,000 | 6.9% | 236,000 | 47.6% | 43,600 | 8.7% |
| Mustahil | 125,460 | 27.8% | 22,970 | 19.7% | 20,760 | 4.2% | 20,3425 | 40.4% |
| West Ime | 5,430 | 1.2% | 8,690 | 7.4% | 13,099 | 2.6% | 1,150 | 0.2% |
| Rasso | 4,550 | 1.0% | 8,116 | 6.9% | 11,543 | 2.3% | 9,974 | 2.0% |
| Total | 450,492 | 100.0% | 116,783 | 100.0% | 495,812 | 100.0% | 504,008 | 100.0% |

### g. Traffic and road

Figure 4.10 shows road condition in the Project area. Most of the residents in rural areas use animals such as donkeys and camels as transportation of goods. It results in high transport costs, leading to soar in prices of food and supplies in inland areas. It is also causing the economic difficulties such a low-income for the agro-pastoralists and pastoralists. Currently, there is no information about the new pavement planning of the main road in the town area.

Figure 4.10: Road Condition in the Project Area (Left：Kabribeyah, Right：Godey)

#### h. Cultural assets, historical structures and heritage

There are no registered cultural assets, historical structures and heritage in the Project area.

### 4.6.3 Natural environment

#### a. Geography

Somali Regional State is one of nine administrative regions in Ethiopia and is located in the eastern part of the country. In the east, north and south it shares international boundaries with Djibouti, Somalia Republic and Kenya respectively. In the northwest and west it shares boundaries with Afar and Oromia regions respectively. Somali Region is the largest region and covers an area of 363,300 km$^2$ (refer to Figure 4.11). The region is bounded between the geographical coordinates of 38.758884° East - 47.986780° East Longitude and 3.393054° North - 11.226088° North Latitude and the elevation varies between 210 m amsl – 2000 m amsl.

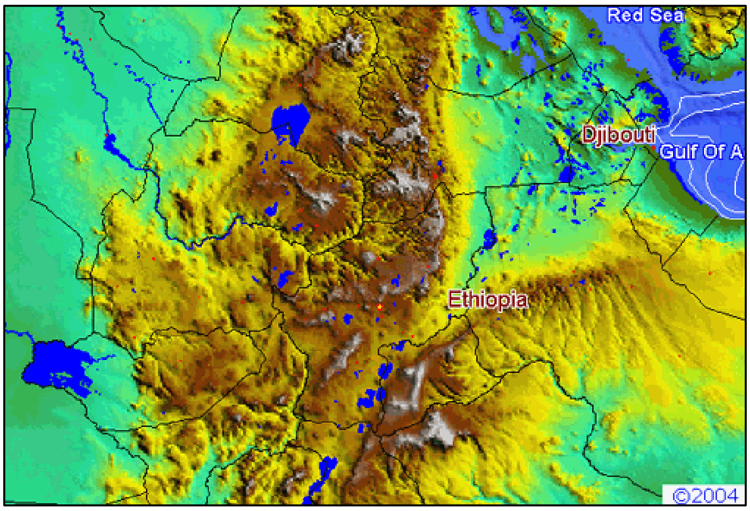


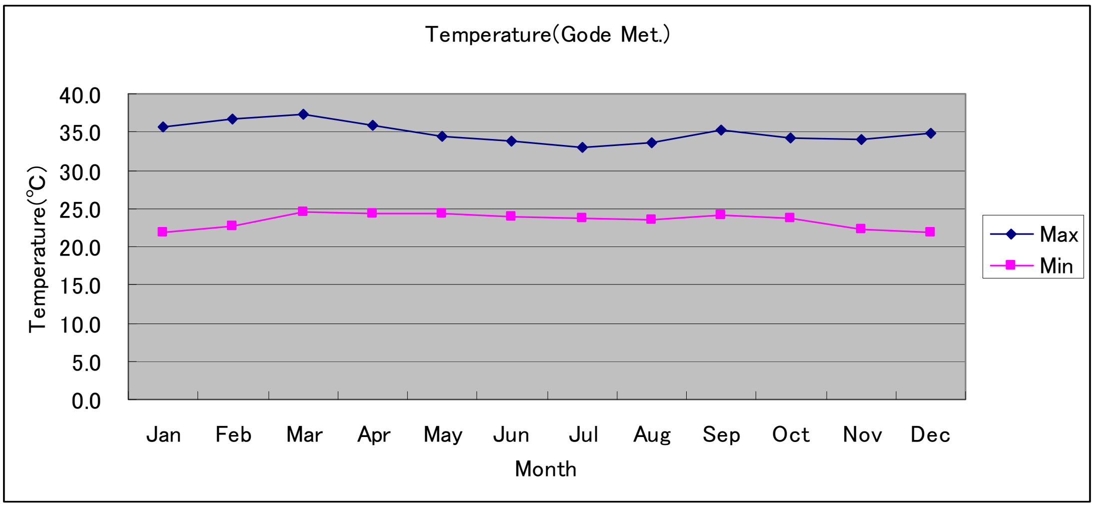

Figure 4.11: Ethiopia with major physiographic zones (Tamiru Alemayehu, 2006)

#### b. Meteorological condition

#### b.1 Temperature

The monthly average temperatures of Godey and Jijiga satiations were shown in Figure 4.12. Records of Godey show it is relatively constant throughout the year (the variation is less than 5$^{o}$C). The variation of maximum temperature of Godey is also small and Min temperature of

Nov. to Dec. is less than 10°C indicating the feature of highlands.



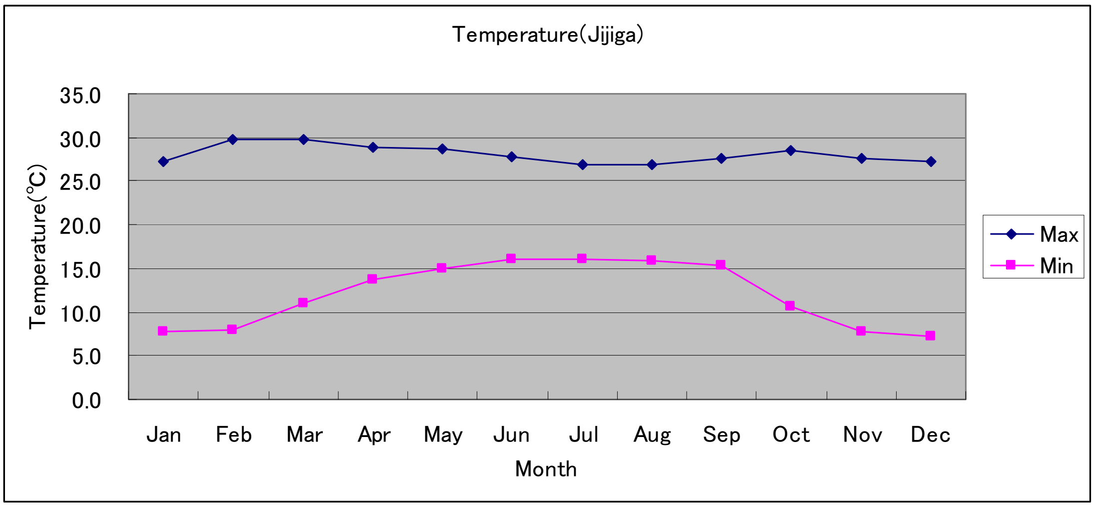




Figure 4.12: Monthly Temperature of Godey and Jijiga

### b.2 Rainfall

The maximum, minimum, and average of annual precipitation in Somali Regional State are 1,171, 115 and 366 mm, respectively. On the other hand, those of the rest of Ethiopia are 2,228mm, 94mm, and 990 mm (refer to Figure 4.13). The most definitive factor in generation of groundwater is considered to be the precipitation. However, the precipitation in Somali Region is only one-thirds of the other areas of Ethiopia. This is clearly the reason that Somali Region has smaller amount of water resources as compared to the rest of Ethiopia.

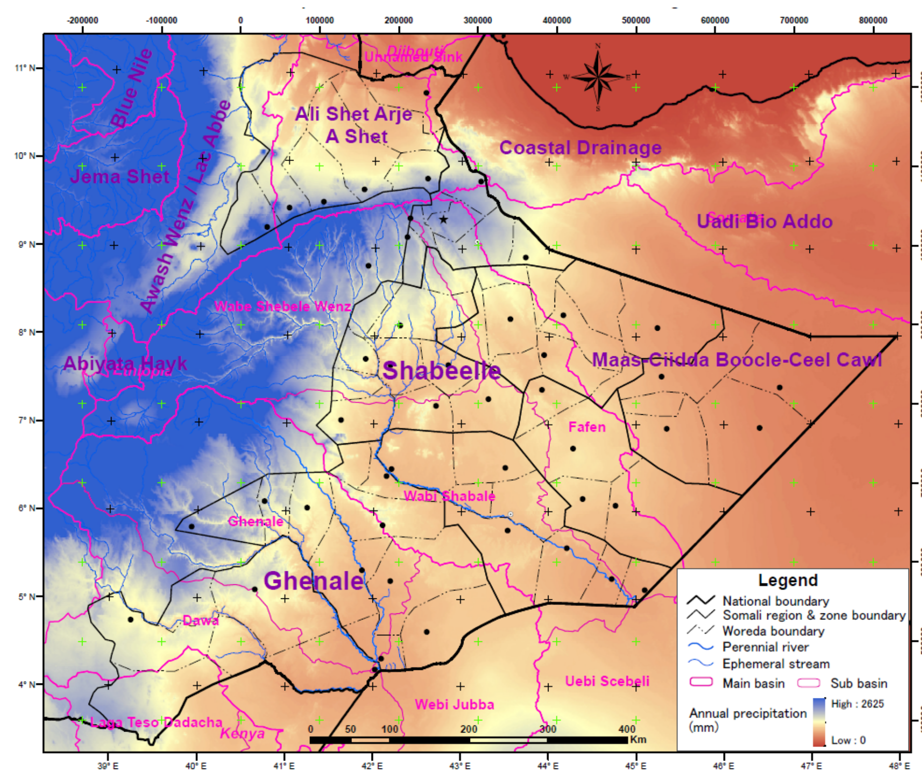



Figure 4.13: Annual Precipitation Distribution in and around Somali Regional State

## c. Geology

The geological formations of Somali Region range in age from Precambrian to Quaternary deposits. The oldest geological formations are undifferentiated Precambrian crystalline rocks, which include granite, granitic gneiss, amphibolite and diorite. The basement rocks are overlain by Mesozoic sediment, which are in turn overlain by Tertiary to Recent volcanic and alluvial deposits (refer to Figure 4.14).

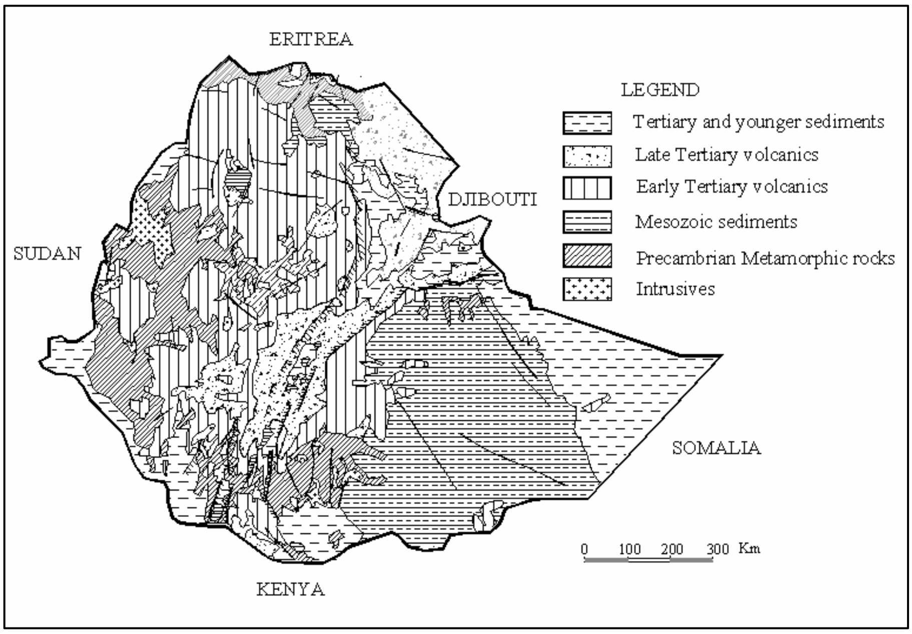



Figure 4.14: Simplified Geological map of Ethiopia (Tamiru Alemayehu, 2006)

**d. Protected areas, ecosystem and biota**

There are no protected areas near Jarar Valley and Shebele Sub-basin, the main target areas of the Project, defined by national laws and international treaties and conventions. Although Gerale National Park has been located across Hudat Woreda and Moyale Woreda near the border with Kenya, more than 500km away from the city. In addition, Elkare Forest in Afdher Zone, may be mentioned as an ecologically valuable habitat, which is located at a distance of more than 200km from Godey city as well. According to hearing with an official of SEPMEDA, Ogaden Horse as an endangered species may make the habitat in Aware Woreda near the border of Somalia. However, ecological survey has not been carried out until now and the detailed information could not be obtained in this study.

### 4.6.4 Environmental pollution

**a. Air pollution**

There are no air pollution generated from offices and factories in the Project area and its surroundings. However, Sandstorms occur frequently from dried ground surface during interval between rainy season and dry season (see Figure 4.15).

Figure 4.15: Sandstorm in the Dry Season (Kabribeyah woreda, February 2013)

**b. Water pollution**

There are also no water pollution and water contamination generated from office and factory in the Project area and its surroundings.

Figure 4.16 shows water quality characteristics of groundwater and river water in the Project area. Calcium ion ($Ca^{2+}$) and chloride ion ($Cl^{-}$), followed by magnesium ion ($Mg^{2+}$) and sulfate ion ($SO_4^{2-}$), dominate the chemical composition of the major ions.

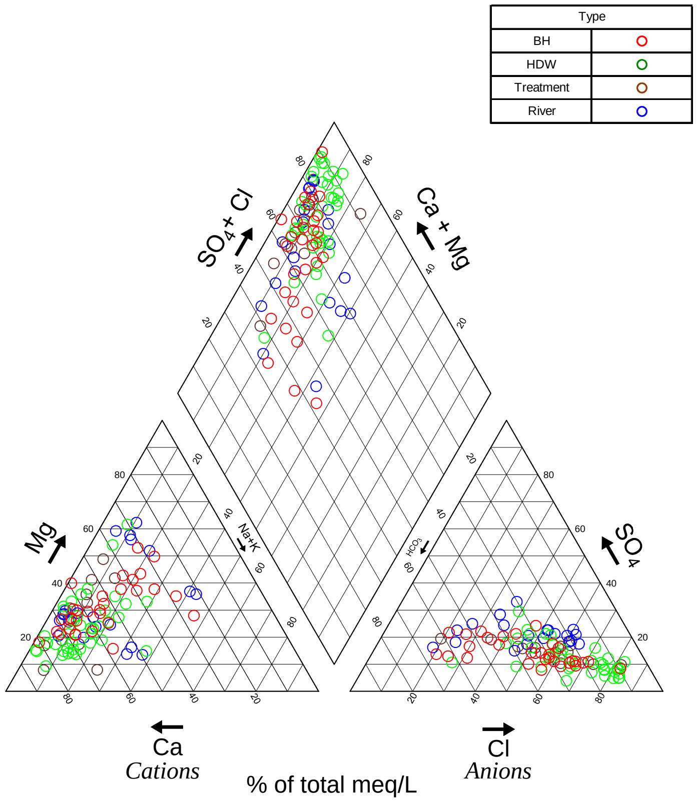



Figure 4.16: Water Quality Characteristics in the Project Area

### c. Noise and vibration

Currently there are no office facilities to generate noise and vibration in the Project area. Furthermore, any damage caused by noise and vibration has not been reported because passage of heavy vehicles is quite sparse and its driving speed is suppressed due to dirt road (see Figure 4.17).

Figure 4.17: Passage of Heavy Vehicle (in Godey town, March 2013)

## 4.7 Alternatives (zero option case)

As alternatives to the proposed water supply plan, zero option case (without the project case) is examined in Table 4.11.

Table 4.11: Effect Comparison between with- and without-Project

| | No. | Impacts | Without the Project | | Implementation of the Project | |
|---|---|---|---|---|---|---|
| | | | Description | Rating | Description | Rating |
| Social Environment | 1 | Involuntary Resettlement | (No change) | — | (Non occurrence) | — |
| | 2 | Local economy | There is a possibility of decline of local economy due to water shortage crisis. | (-) | Fostering job opportunities for villagers is expected, but manager of current water source and retailers may lose their employments. | (+/-) |
| | 3 | Land use and utilization of local resources | Degradation of vegetation will occur in the long term due to water shortage. | (-) | Increasing of the land value is expected. | (+) |
| | 4 | Local communities and decision-making institutions | There is a possibility of damaging to the relationship of mutual trust with local community, the city government and SRWDB. | (-) | There is a positive impact on local communities and decision maker due to buildup of relationship among them. | (+) |
| | 5 | Existing infrastructures and services | (No change) | — | There is close to no interference and obstruction with existing infrastructures and services. | — |
| | 6 | The poor/ indigenous/ ethnic minority/ women/ children | Vulnerable groups will be suffering for water shortage in the future. | (-) | Living environment of vulnerable groups will be improved due to water supply. | (+) |
| | 7 | Misdistribution of benefit and social cost | (No change) | — | Unnecessary confusion or dispute over managing the water source and distribution can be avoided. | (+) |
| | 8 | Historical/ cultural heritage | (No change) | — | (No change) | — |
| | 9 | Local conflict of interests | Scramble for water may increase in the local community in the future. | (-) | The opportunity of local conflict may be decreased. | (+) |
| | 10 | Water usage, Water rights, Communal rights | No change. Water shortage rather has negative impacts for communal rights. | (-) | Water facility should highly contribute to the communal rights of villages | (+) |
| | 11 | Sanitation | Human health and hygienic environment will deteriorate. | (-) | Sanitation condition will improved by safe water. | (+) |
| | 12 | Health Hazards/Risk, Infectious Diseases such as HIV/AIDS | The same with above “11”. | (-) | The same with above “11”. | (+) |
| Natural Environment | 13 | Important/ valuable geographical and geological features/ resources | (No change) | — | (No change) | — |
| | 14 | Soil erosion | (No change) | — | (No change) | — |
| | 15 | Amount and quality of groundwater | (No change) | — | Groundwater level may be decreased in long-term. | **(-)** |
| | 16 | Amount of natural reservoir/ flow | (No change) | — | (No change) | — |
| | 17 | Coastal zone | (Not applicable) | — | (Not applicable) | — |
| | 18 | Flora, Fauna, Biodiversity | (No change) | — | (No change) | — |
| | 19 | Meteorology/ climate | (No change) | — | (No change) | — |
| | 20 | Aesthetic landscape | (No change) | — | (No change) | — |
| | 21 | Global warming | (No change) | — | (No change) | — |

| | No. | Impacts | Without the Project | | Implementation of the Project | |
|---|---|---|---|---|---|---|
| | | | Description | Rating | Description | Rating |
| Pollution | 22 | Air pollution | (No change) | — | There will be some exhaust emission from trucks and machineries. | **(-)** |
| | 23 | Water pollution | (No change) | — | (No change) | — |
| | 24 | Soil contamination | (No change) | — | (No change) | — |
| | 25 | Solid waste amount increase | (No change) | — | Solid waste will generate in the construction phase. | **(-)** |
| | 26 | Increase of noise and vibration | (No change) | — | Noise and vibration will occur in the construction phase. | **(-)** |
| | 27 | Ground level subsidence | (No change) | — | (No change) | — |
| | 28 | Offensive odor | (No change) | — | (No change) | — |
| | 29 | Sedimentation | (No change) | — | (No change) | — |
| | 30 | Increase of Accidents | (No change) | — | Traffic accidents might increase due to passage of construction vehicles. | **(-)** |

**Rating**

**(+)** Positive impact might be expected.
**(-)** Negative impact might be expected.
**(+/-)** Both positive and negative impacts could occur.
— No change or not applicable to the Project

There may be possibilities of causing negative impact such as creation of unemployment, increase in amount of groundwater use, generation of noise and vibration in facility construction, increasing of solid waste. On the other hand, the Project implementation might be expected improvement of drinking water shortage, fair distribution of drinking water, reduction of drought damage, proper groundwater use, the creation of employment opportunities, and increase in social capital. Furthermore, it can be expected to mitigate the negative effects by taking appropriate measures.

However the Project implementation has some possibilities to adversely affect the natural and social environments in the area, serious negative impacts are not foreseen and great benefits can be expected. Consequently, it is concluded that Project implementation case is more appropriate choice compared to without the Project case.

## 4.8 Results of environmental and social impact assessment

The likely adverse impacts that may be caused by implementation of the proposed water supply plan are summarized in Table 4.12.

Table 4.12: Result of Scoping for the Water Supply Plan in Godey Town

| | No. | Impacts | Rating | | Brief description |
|---|---|---|---|---|---|
| | | | Construction phase | Operation phase | |
| Social Environment | 1 | Involuntary Resettlement | **d** | **d** | Resettlement of residents will never occur. |
| | 2 | Local economy such as employment and livelihood | **d** | **c** | There would be some job opportunity provided to locals by water users' groups. On the other hand, manager of current water source and retailers may be adversely affected their livelihoods due to the new facilities. Therefore, it is recommended to monitor their economic and working conditions in the operation phase. |
| | 3 | Land use and utilization of local resources | **d** | **d** | No adverse impacts are expected on land use and utilization of local resources, but positive impacts by installation of water supply facility such as increasing of the land value are expected. |
| | 4 | Local communities and decision-making institutions | **d** | **d** | No negative impacts are expected on local society; new water supply facility is going to give good and profound impacts to the local community since securing water is one of the most significant needs in their community. Unnecessary confusion or dispute over managing the water source and distribution should be avoided. |
| | 5 | Existing infrastructures and services | **c** | **d** | There would be some interference with construction vehicles and obstruction of traffic in case pipes would be laid crossing village road. However, since there are almost no paved roads in the rural area, the burying work of a pipe crossing the road should be finished in a short time. |
| | 6 | The poor/ indigenous/ ethnic minority/ women/ children | **d** | **d** | Highly positive impacts are expected for women and children by saving their time for water fetching and spend the time for other productive work. |
| | 7 | Misdistribution of benefit and social cost | **d** | **d** | The same with above "4". |
| | 8 | Historical/Cultural heritage | **d** | **d** | There is no cultural and historical heritage at the proposed project site. |
| | 9 | Local conflict of interests | **d** | **d** | Ethnic and tribal conflict is not expected. Although there are Muslim (about 70 %), Christian (about 30%) and other believers in Somali Regional State, religious conflict can not be forecasted so far. |
| | 10 | Water usage, Water rights, Communal rights | **d** | **d** | Since water supply facility will provide water, there would be highly positive impact on water usage of the community. The facility will contribute to the respective village as a whole because the distribution is managed by village water committee or water users group. |

| | | | | | |
|---|---|---|---|---|---|
| | 11 | Sanitation | **d** | **d** | Water quality is checked in test drilling phase. The facility allows amount of water supply for sanitation use. It gives highly positive impact to the community health. |
| | 12 | Health Hazards/Risk, Infectious Diseases such as HIV/AIDS | **d** | **d** | Public health and sanitation condition will be improved by improving accessibility to clean water. HIV/AIDS problem will not occur at water facility installation work. |
| Natural Environment | 13 | Important/ valuable geographical and geological features/ resources | **d** | **d** | There is no such place in the Regions. No impact is expected. |
| | 14 | Soil erosion | **d** | **d** | No soil erosion is expected by installation and use of water supply facility. |
| | 15 | Amount and quality of groundwater | **d** | **d** | There would be no negative impact on quality of groundwater by installation and operation of the facility. Since the facility will be built at the site only with sufficient amount of groundwater, depletion of water is not expected in short-term and long-term periods. |
| | 16 | Amount of natural reservoir/ flow | **d** | **d** | Extracting deep groundwater has almost no impact on the flow rate of river at the surface. |
| | 17 | Coastal zone | **d** | **d** | There is no coastal area in the target Regions. |
| | 18 | Flora, Fauna, Biodiversity | **d** | **d** | Game Reserve or Forest Reserve is excluded from the project area. |
| | 19 | Meteorology/ climate | **d** | **d** | There is no plan of large scale construction or facility as to give negative impact on the climate. |
| | 20 | Aesthetic landscape | **d** | **d** | There will be no large scale facility that may affect surrounding landscape. Surge tank of Level-2 facility may change the surrounding view; however, it is not much impact. |
| | 21 | Global warming | **d** | **d** | Diesel motor pumps emit $CO_2$; however, there would be no large scale generators to be installed as to give negative impact on global warming. |
| Pollution | 22 | Air pollution | **c** | **d** | There will be some exhaust emission from trucks and machineries during the construction work, and diesel generator of Level-2 facility emits exhaust gas, which contain $SO_X$ and $NO_X$ gases. Therefore, SRWDB should monitor ambient air quality regularly in conformity to Pollution Control -proc # 300/2002. |
| | 23 | Water pollution | **d** | **d** | Although temporal turbid water occur due to soil contamination during construction phase, it is a quite minor phenomenon and also in very short period. Since turbidity of Shebele River is extremely high in rainy season originally, it is essential for domestic water use to treat properly in sand settling basin (sedimentation facility). |
| | 24 | Soil contamination | **d** | **d** | Falling down of some oil droplets from heavy machineries is expected during construction phase, which is negligible impact; and there is no soil contamination occurs during operation phase either. |

| | | | | | |
|---|---|---|---|---|---|
| | 25 | Solid waste amount increase | **d** | **d** | Excavated soil is properly disposed in routine manner. There is no solid waste produced by water supply facility during operation phase. |
| | 26 | Increase of noise and vibration | **c** | **d** | Since heavy machineries will be operated during construction phase, noise and vibration will occur; however, the duration is quite limited. |
| | 27 | Ground level subsidence | **d** | **d** | The capacities of pump motors are extremely small compared to those that cause ground subsidence. |
| | 28 | Offensive odor | **d** | **d** | There will be no source of odor at the water supply facility. |
| | 29 | Sedimentation | **d** | **d** | There is no sedimentation on river bed or reservoir bed occurred by installation of the water supply facility. |
| | 30 | Increase of Accidents | **c** | **d** | Traffic accidents are likely to occur due to the increase of construction vehicles at the construction phase and container trucks at the operation phase. |

**Rating**

**a**: Significant negative impact is expected.

**b**: Negative impact is expected to some extent.

**c**: Extent of negative impact is unknown.

(A further examination is needed, or the impact could be clarified as the study progresses)

**d**: No impact or negligibly small impact is expected.

### 4.9 Mitigation

Table 4.13 shows the mitigation measures and monitoring for key adverse impacts which were proposed. Also, the recommended surveys at the following implementation phase are explained.

Table 4.13: Proposed Mitigation Measures, Monitoring and Surveys

| Impact items | Rating | Proposed mitigation measures, monitoring and surveys |
|---|---|---|
| 1) Construction phase | | |
| Existing infrastructures and services | c | • To draw up a proper implementation plan to reduce traffic congestion.<br>• To disseminate information on a construction plan (schedule, traffic restriction section, and etc.) through public consultation meetings.<br>• To consider the installation of a fence to protect the school-commuting routes. |
| Air pollution | c | • To provide proper construction machines and heavy vehicles in order to reduce the emission of exhaust gas. To maintain construction machines and heavy vehicles properly. To stop unnecessary idling.<br>• To keep down dust by watering during the dry season.<br>• To reduce the emission of air pollutants by utilizing low-emission construction machines and vehicles. |
| Noise and vibration | c | • At the following implementation phase, conduct the noise and vibration survey in order to understand the current baseline condition of the project sites.<br>• To estimate the levels of noise and vibration based on the predicted traffic flow, and to study the measures if necessary.<br>• To inform construction schedule to residents in advance. To control construction works at night.<br>• To use low-noise construction machines and heavy vehicles.<br>• To consider traffic regulations on controlling the lane for heavy vehicles to reduce noise and vibration. |
| Traffic accidents | c | • To provide pedestrian crossing. Crossing locations should take into account community preference.<br>• To determine the routes for construction vehicles through the meeting with residents.<br>• To disseminate information on a construction plan (schedule, traffic restriction section, and etc.).<br>• To provide adequate education and training to construction workers regarding traffic safety.<br>• To deploy the traffic control workers and install an information board at appropriate position to avoid traffic accidents.<br>• To control traffic flow collaborating with traffic police. |

| 2) Operation phase | | |
|---|---|---|
| Local economy such as employment and livelihood | c | • To disseminate information on a construction plan (schedule, traffic restriction section, and etc.) through public consultation meetings.<br>• SRWDB should monitor their economic and working conditions after relocation.<br>• SRWDB should assign a grievance team for project affected persons (PAPs). |

## 4.10 Conclusion

The negative impacts to be considered with the highest priority in the examination items of environmental and social assessment are the compensation for involuntary resettlement, the occurrence of secondary pollution source (generation of new environmental pollution sources derived from hazardous substances and heavy metals), damage and loss of ruins and cultural assets, and adverse impact on the natural protected areas. In the proposed water supply plan, no serious impacts can foresee (refer to Table 4.14).

Table 4.14: Negative Impacts to be Considered with the Highest Priority

| Examination items | Impact | The water supply plan |
|---|---|---|
| Involuntary resettlement | No | No involuntary resettlement is foreseen due to the land acquisition. |
| Occurrence of secondary pollution source | No | Excavated soil is properly disposed in routine manner. There is no possibility to occur secondary pollution source. |
| Damage and loss of ruins and cultural assets | No | There is no cultural and historical heritage at the proposed project sites. |
| Adverse impact on the natural protected areas. | No | There is no natural protected area in and near the Project sites. |

However environmental impacts to be considered might be foreseen in the construction and operation phase, serious adverse effects cannot be expected by enforcement of appropriate mitigation measures and proper monitoring.

In conclusion, implementation under proposed water supply plan might be unlikely to significantly degrade the social environment as well as the natural environment in the Project area.

# Annex 1

*Minutes of Meeting*

# MINUTES OF MEETING
# ON
# THE INCEPTION REPORT
# FOR
# THE STUDY ON
# JARAR VALLEY AND SHEBELE SUB-BASIN WATER SUPPLY DEVELOPMENT PLAN, AND EMERGENCY WATER SUPPLY
# IN
# THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

Jijiga Somali Region
April 6th, 2012

Mr. Toshiyuki Matsumoto
Team Leader
Study Team
Japan International Cooperation Agency (JICA)

Dr. Markos Wijore
Director, Water Sector and Capacity Building Directorate
Ministry of Water and Energy
Federal Democratic Republic of Ethiopia

Fu'ad Hassan Bashir (Deputy Water Bureau Head)

Mr. Fuad Hassen
Deputy Bureau Head,
Somali Region Water Development Bureau
Federal Democratic Republic of Ethiopia

Witnessed by
Mr. Yukiyasu Sumi
Water Sector Advisor
Japan International Cooperation Agency (JICA)

Witnessed by
Mr. Dinku Gutema
Advisor
Ministry of Water and Energy

In response to the official request of the Government of the Federal Democratic Republic of Ethiopia (hereinafter referred to as "the Government of Ethiopia"), the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Preparatory Study Team of Ethiopia Office. The Japanese side and the Ethiopian side came to an agreement on the Record of Discussions (hereinafter referred to as "R/D") which was signed on Dec. 23rd, 2011.

JICA sent to Ethiopia the JICA Study Team (hereinafter referred to as "the Team") for THE STUDY ON JARAR VALLEY AND SHEBELE SUB-BASIN WATER SUPPLY DEVELOPMWNT PLAN, AND EMERGENCY WATER SUPPLY (hereinafter referred to as "the Study"). The Team held meetings with the officials of the Ministry of Water and Energy (hereinafter referred to as "MoWE"), Somali Region Water Development Bureau (hereinafter referred to as "SRWDB") and other authorities concerned with the Study. The list of those who attended these meetings is shown in Appendix-1.

In the course of discussions, both sides confirmed the main items described in the Inception Report (hereinafter referred to as "IC/R"). The Team will submit the Final Report in August 2013, when the Study comes to an end.

## 1. Explanation of Inception Report (IC/R)

The Team submitted an electronic file of IC/R (draft) on 27th March and ten (10) copies of IC/R to MoWE and SRWDB on 4th, 5th April, 2012.

The Team presented IC/R to MoWE and concerned authorities, and discussed its contents in Jijiga Somali Region on 5th, 6th April, 2012. In this presentation, Mr. Ephrem Legesse (Emergency Water Supply and Sanitation Program Senior Expert, MoWE) who attended the meeting on behalf of Dr. Markos (Director of Water Sector and Capacity Building Directorate, MoWE) chaired the meeting.

The Team presented the basic objectives and policy, outline of contents and scope of the study proposed in IC/R, including the capacity development for counterpart (hereinafter referred to as "C/P") personnel proposed in the Study. Technical discussions were made between the Team and MoWE, SRWDB and concerned authorities on each of the study items, surveys, data required and water supply plan for the Study.

The Ethiopian side agreed on the contents of IC/R in principle, understood the study objectives, schedule, ~~activities~~ and methodology, and promised close cooperation with the Team during the Study.

Major issues raised during the discussions regarding IC/R are as follows:

1) Assignment of C/P personnel

The Ethiopian side and the Team discussed assignment of C/P personnel mentioned in the R/D. All C/P members shall closely cooperate with the Team for smooth implementation of the Study. The Team asked the Ethiopian side to provide appropriate staff members as C/Ps for each of the Team members as soon as possible. The Team also proposed the following list of candidates of the C/P personnel and stressed especially urgent assignment of the item 4 below.

1. Project Director : Dr. Markos: Director, Waters Sector and Capacity Building Directorate MoWE
2. Project Manager : Head of SRWDB
3. Deputy Project Manager:
   - Deputy Head of SRWDB in charge of Water Supply Core Process
   - Deputy Head of SRWDB in charge of Water Supply Management Core Process
   - Deputy Head of SRWDB in charge of Water Resources Study and Management Core Process
4. Counterpart Personnel: All related staff members of SRWDB (refer to C/P personnel list of appendix)

The Ethiopian side agreed to provide the list of specific names of C/P personnel (to complete Appendix 2) to the Team by 12th April, 2012.

2) Sharing of information on security situation of Somali Region between the Ethiopian side and the Team

The Team emphasized that it was very important to share the information of security in Somali Region and for the Ethiopian side to ensure the safety of members of the Team. The Ethiopian side agreed to do so.

3) Utilization of equipment for geophysical survey of EWTEC

In the meeting held in MoWE in Addis Ababa, the Team requested for permission to borrow and use the geophysical equipment of EWTEC along with a technical staff member from EWTEC during the study. The Ethiopian side agreed to render EWTEC's equipment and machinery.

4) Provision of office space in MoWE in Addis Ababa and in SRWDB in Jijiga

The Team requested the Ethiopian side to prepare an office space in MoWE in Addis Ababa. The Ethiopian side understood the need of an office in MoWE building and told to try to look for the office space within MoWE.

SRWDB suggested that the Team have an office within or close to SRWDB in order to work closely with SRWDB. The Team understood the merit of the idea and replied to consider it.

## 2. Undertakings by the Government of Ethiopia

The Government of Ethiopia shall accord privileges, exemptions and other benefits to the Team in accordance with the Agreement on Technical Cooperation between the Government of Japan and the Government of Ethiopia, signed on December 23, 2011.

## 3. Other relevant issues

1) Steering Committee (SC)

The Team explained the roles and importance of the SC according to IC/R. The Ethiopian side proposed to add a "Secretary" as a member from SRWDB.

The Team agreed to include a "Secretary" as a member of the SC.

2) Correction of IC/R

The Team promised to make corrections on the terms and sentences that were erroneous or inappropriate in the draft version of IC/R and to submit the final version to the Ethiopian side in the middle of April 2012.

3) Specifications of the equipment

The Ethiopians side made requests concerning the specifications and quantity of some items of the equipment that were to be procured by JICA as follows:

a) The capacity of the tank of water trucks should be more than 10 $m^3$, preferably 15 $m^3$.

b) The capacity of water tanks should be about 10 $m^3$,

c) The chlorination chemical should not be limited to tablets

d) The water trucks should also be equipped with a dewatering pump to pump water to the tank

The Ethiopian side also raised questions about the quantity of project cars.

The Team explained that the specifications shown in IC/R were tentative ones and the details would be determined through discussions with the Ethiopians side as mentioned in IC/R. The Team further explained that the specifications of these items should be determined in consideration of duration of procurement and budget restrictions.

JICA explained, with respect to the quantity of the project cars, that the number of project cars had been changed to four from the previously agreed number of six, because UNHCR and WFP offered to provide two cars for the project after the signing of the R/D.

The SWRDB requested for further explanation and clarification on this issue between MoWE and JICA.

The both sides agreed to continue discussions on the issue of the specifications of the equipment.

END

Appendix-1

# ATTENDANCE LIST

*ETHIOPIAN SIDE*

**Ministry of Water and Energy (MoWE)**

| | |
|---|---|
| Dr. Markos Wijore | Director, Water Sector Support and CB Directorate |
| Mr. Ephrem Legesse | Hydrogeologist, Water Sector Support and CB Directorate |

**Somali Region Water Resources Development Bureau (SRWDB)**

| | |
|---|---|
| Mr. Fuad Hassen | Deputy Head, Water Supply core process |
| Ms. Fartuun Cabdi Abdi | Deputy Head, Water Supply scheme management core process |
| Mr. Mohamed A. Bihi | Water Supply scheme management core process |
| Mr. Aden Abdisemed | NGO Coordinator for water supply planning |
| Mr. Dinku Gutema | Advisor |

*JAPANESE SIDE*

**JICA Study Team**

| | |
|---|---|
| Mr. Toshiyuki Matsumoto | Team Leader of Study Team |
| Mr. Naoki Yasuda | Sub-Leader/O&M and Management |
| Mr. Kenichi Ishii | Water Supply Planning1/Facilities Design |
| Mr. Shigeki Kihara | Hydrogeology/Water quality |
| Mr. Yosuke Yamamoto | Coordinator/Assistant to Water Resources Development |

**JICA Ethiopia Office**

| | |
|---|---|
| Mr. Yukiyasu Sumi | Representative |

KOKUSAI KOGYO CO., LTD. Addis Ababa, Ethiopia

Japan International Cooperation Agency 3

Appendix-2

# List of Counterparts Personnel (draft)

| Study Team | | C/P | |
|---|---|---|---|
| Expertise | Name | Name | Position |
| Team Leader/Water resources development | Toshiyuki MATSUMOTO | 1. 1 person (Mr. Fuad Hassen) | 1. Deputy Head of SRWDB |
| Sub-leader/O&M and management | Naoki YASUDA | 1. 1 person | WSSM of SRWDB |
| Water supply planning 1/Facilities design | Kenichi ISHII | 1. 1 person | WS of SRWDB |
| Water supply planning 2/Cost estimation | Daisuke SAKAMOTO | | |
| Hydrogeology/ Water quality | Shigeki KIHARA | 1. 1 person | WRS&M of SRWDB |
| Hydrology | Shigekazu FUJISAWA | | |
| Geophysical survey | Tsugio ISHIKAWA | 1. 1 person | WRS&M of SRWDB |
| Remote sensing/GIS | Peifeng LEI | 1. 1 person | WRS&M of SRWDB |
| Mechanical equipment | Tamotsu ISHII | 1. 1 person<br>2. 1 person<br>3. 1 person | WSSM of SRWDB |
| Well Drilling | Masatoshi TANAKA | 1. 1 person | WS of SRWDB |
| Socio-economic survey and social and financial survey | Shoji MASUMURA | 1. 1 person | WS of SRWDB |
| Social and environmental consideration | Hirokatsu UTAGAWA | 1. 1 person | WS of SRWDB |
| Procurement/logistical support | Masami TAKAHATA | 1. 1 person | WS of SRWDB |
| Coordinator/assistant to water resources development | Yosuke YAMAMOTO | 1. 1 person (Mr. Bihi) | WS CP Head of SRWDB |

# MINUTES OF MEETING

# ON

# THE 1st STEERING COMMITTEE

# FOR

# THE STUDY ON

# JARAR VALLEY AND SHEBELE SUB-BASIN WATER SUPPLY DEVELOPMENT PLAN, AND EMERGENCY WATER SUPPLY

# IN

# THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

Jijiga, Somali Region
November 2nd, 2012

Mr. Toshiyuki Matsumoto
Team Leader
JICA Study Team
Japan International Cooperation Agency (JICA)

Dr. Markos Wijore
Director, Waters Sector and Capacity Building Directorate
Ministry of Water and Energy
Federal Democratic Republic of Ethiopia

Mr. Mohamed A Bihi
Water Supply Scheme Management CP/Owner
Somali Region Water Development Bureau
Federal Democratic Republic of Ethiopia

Witnessed by
Mr. Yukiyasu Sumi
Water Sector Advisor of Ethiopia Office
Japan International Cooperation Agency (JICA)

Witnessed by
Mr. Wossen Demissie
Expert
Ministry of Finance and Economic Development

In response to the official request of the Government of the Federal Democratic Republic of Ethiopia (hereinafter referred to as "the Government of Ethiopia"), the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Preparatory Study Team of Ethiopia Office. The Japanese side and the Ethiopian side came to an agreement on the Record of Discussions (hereinafter referred to as "R/D") which was signed on Dec. 23rd, 2011.

JICA sent to Ethiopia the JICA Study Team (hereinafter referred to as "the Team") for THE STUDY ON JARAR VALLEY AND SHEBELE SUB-BASIN WATER SUPPLY DEVELOPMWNT PLAN, AND EMERGENCY WATER SUPPLY (hereinafter referred to as "the Study"). The Team held the first Steering Committee ("SC") Meeting with the officials of the Ministry of Water and Energy (hereinafter referred to as "MoWE"), Somali Region Water Development Bureau (hereinafter referred to as "SRWDB") and other authorities concerned with the Study. The list of those who attended the SC Meeting is shown in Appendix-1.

In the course of discussions, SC members confirmed the main items described in the Progress Report (hereinafter referred to as "PR/R"). The Team will submit the Final Report of the Study in August 2013, when the Study comes to an end.

## 1. Explanation of PR/R

The Team submitted seventeen (17) copies of PR/R to MoWE, SRWDB and other authorities on 22nd and 23rd October, 2012.

The Team presented the progress of the Study focusing on the results of geology, hydrogeology, geophysical survey, observation well drilling, water supply plan, the emergency water supply and C/P Training, O&M and Socio-economic survey.

The Ethiopian side agreed on the contents of PR/R in principle, in particular, on the methodology of the Study, the Study results and schedule after the discussion.

Major issues and the contents of the discussion regarding PR/R are as follows:

### 1) Comments on PR/R

MoWE and DPPB gave the Team specific technical comments on PR/R for correction. DPPB also pointed out the misunderstanding in the description of their tasks and duties. In addition to these errors, MoWE suggested the Team to read two reports relevant to the study conducted by German and French companies. MoWE suggested that the list of water quality survey results should include evaluation of the quality based on WHO and Ethiopian guidelines. Finally, MoWE asked the Team to send them the PC files of PR/R. The Team proposed to review all the comments and, where necessary, update the descriptions in the next reports.

### 2) Comments and questions on the presentation by the Team

Both SRWEB and DPPB made comments on the amount of water for livestock, proposing that groundwater should be used for livestock. The Team accepted the proposal and asked about the validity of the estimated percentage of water for livestock that the Team proposed for the master plan. The committee members raised no objections. Also, SRWDB suggested that the Team confirm the amount of water to be used for fire fighting and the Team replied that it would consider the amount in the master plan.

SRWDB raised concern about insufficient mutual communication between the C/P personnel and the members of the Team, pointing out that the C/P persons were appointed at the request of the Team at the time of discussion of Inception Report but the system was not properly utilized and that the transfer of technology to the C/P was not sufficient. The Team replied that the Team considered that it was working closely with the C/P personnel and would maintain even closer relation with the C/P team and continue technical transfer. The Team added that if SRWDB desired, the Team was ready to consider augmentation of technical transfer.

SRWDB mentioned that the description of the O&M work conducted by the O&M staff of SRWDB did not reflect the reality. The Team suggested to have a meeting to discuss and re-confirm this issue when the member who was in charge of this issue would come to Jijiga in late November. The Team also replied that the technical training was still under planning and the number of people that would be involved in the training would not be very big.

### 3) Other issues

MoWE mentioned that PR/R as a single volume that covers various topics was not easy to read and understand and suggested that PR/R should be prepared in different volumes for easier comprehension.

SEPMEDA suggested that the environmental assessment report should be a different volume and that the Team include proposed measures to mitigate project's impact on the environment. The Team replied that PR/R was compiled as one volume and an appendix this time.

Y. S.

### 4) Comments made in the field visit

Kabribeyah Water Supply Utilities Office made the following comments: At this stage, in Kabiribeyah water supply system new wells have been drilled but there are some broken source wells left unattended. These facilities need to be repaired or improved. It is necessary to clearly understand what is required for the improvement of the system. The residents need water urgently and so we demand the intervention. However no improvement has be done yet.

MoFED pointed out that it was necessary to extract feedback (experience, case study) to the master plan from some of the water source facilities that were operating properly.

MoWE pointed out the importance of community participation at the time of construction of the facilities, mentioning that the users would develop stronger sense of ownership when they were involved from the beginning. SRWDB appreciated the good communication with the local and publicity effort made by Team at the time of drilling of the two boreholes.

**5) Specific propositions on the pilot project**

MoWE raised concern about the ventilation system of the generator house, indicating that the small openings for ventilation might allow small animals to enter the house. MoWE also pointed out that the height of the cattle trough was too high for smaller animals. The Team replaced that the Team designed the ventilation system because of the generator that was to be placed inside the house and that mesh-wire will be placed to cover the openings. The Team replied that the Team would improve the design of the cattle trough and that the improvement was being done at site.

## 2. STEERING COMMITTEE

In this meeting, some issues recognized in the course of implementing the study were discussed along with the contents of PR/R.

**1) Roles of steering committee**

The committee members discussed the contents of PR/R in the morning session and at the beginning of the afternoon session. Then, the Team proposed the following roles of steering committee and the committee members agreed to the proposal.

- Coordinate with C/P agencies
- Review reports
- Discussion of problems and finding solutions on the study
- Monitor the progress of the project activities (The way forward to something)
- Advice in the overall technical and strategic approach of the study

**2) Confirmation of target woredas for water supply master planning**

At the beginning of the study, the Team proposed 17 woredas as target although exact boundaries of some of the woredas were unknown. The, the site survey revealed that one woreda, Marsin, was located outside the sub-basin and also another woreda, Doba Wein, was inaccessible due unavailability of armed security escort to the survey team. Consequently, the socio-economic data was not collected for Deba Wein woreda. In this context, the Team proposed not to prepare water supply master plan for these two woreadas. SRWDB agreed to the exclusion of Marsin woreda but asked the Team to include Deba Wein woreda, explaining that there was not security problem and that some projects were currently under way in the woreda. The both parties agreed to have a discussion on the issue in a separate occasion.

**3) Target year of water supply master plan**

The Team proposed to change the target year of the master plan from 2015 to 2020, pointing out that the implementation period would be too short in the case of 2015. and also that the planned water supply ratio of SRWDB was likely to be achived by 2015. MoWE accepted the proposal in principle, commenting that the target year of GTP-2 would also be from 2012 to 2020 and the master plan would be compatible with this plan. MoWE added that it would later confirm the target year of GTP-2 with another section of the Ministry.

**4) Authorization agency and implementation agency of EIA**

The Team mentioned that it was necessary to specify the authorization agency and implementation agency in charge of social and environmental consideration aspects of this study but could not clearly confirm the issue. Thus, the Team proposed to discuss the issue at this meeting. The attendants confirmed that Somali Regional State Environmental Protection, Mine and Energy Development Agency (SEPMEDA) was the authorization agency. It remained still unclear how the environmental assessment should be conducted, MoWE mentioned that SRWDB and SEPMEDA would have to cooperate with each other on this issue.

**5) SRWDB`s strategy in O&M**

The Team asked about detailed O&M related strategy of SRWDB.SRWDB gave the following answers: It is difficult for only woredas to conduct proper O&M under the decentralization policy. It is one of the major problems of O&M to manage all the many boreholes in the region.

MoWE added that the issue of supply chain establishment was just as important as the strategy and added that this system had various problems under the decentralization policy even in other regions. MoWE mentioned that the same issues applied to deployment of cranes that were used to replace submersible pumps and to hand tools. The Team replied that the Team would discuss details of these issues deeply with SRWDB.

**6) Hand over of equipment and other issues**

The Team explained to the participants that it was necessary for everyone to understand that the ground pumps, submersible pumps, and generators would be brought under the management of UNHCR after their handover. MoWE suggested that SRWDB and UNHCR sign a document on the equipment to confirm that the equipment would be managed by UNHCR until the whole system was eventually handed over to SRWDB.

SRWDB mentioned that the O&M of facilities in the system was conducted by UNHCR at present and that SRWDB was not involved and that the case was the same this time.

**7) Other relevant issues**

JICA raised concern about the delivery plan of water tanks, pointing out the fact that only seven water tanks had been delivered to woerdas at this time. JICA also added that if the delivery was not properly done, JICA might have to stop further assistance to SRWDB. SRWDB replied that it was asking for assistance from stakeholders and other organizations. SRWDB added that it was difficult to immediately deliver all the 150 tanks at one time due to rainy season but that it would make the maximum effort to send out all the tanks by the end of December 2012.

END

Appendix-1

## ATTENDANCE LIST

*ETHIOPIAN SIDE*

**Ministry of Water and Energy (MoWE)**

| | |
|---|---|
| Dr. Markos Wijore | Director, Water Sector Support and CB Directorate |
| Mr. Abebe Gulma | Emergency Wash Coordinator |

**Somali Region Water Resources Development Bureau (SRWDB)**

| | |
|---|---|
| Mr. Mohamed A. Bihi | Water supply scheme management core process |
| Mr. Mohamud Mohamed | Water supply study design case coordinator |
| Mr. Dinku Gutema | Advisor |

**Administration for Refugee and Returnee Affairs (ARRA)**

| | |
|---|---|
| Mr. Samuel | Zonal coordinator |

**Disaster Provision and Preparedness Bureau (DPPB)**

| | |
|---|---|
| Mr. Guled | Head of DPPB in Jijiga |

**Kabribeyah Town Water Supply Utility Office**

| | |
|---|---|
| Mr. Ahmed | Manager |

**Godey Town Water Supply Utility Office**

| | |
|---|---|
| Mr. Ismaiil | Manager |

**Ministry of Finance and Economic Development (MoFED)**

| | |
|---|---|
| Mr. Wossen Demissie | Expert |

Y. S.

**United Nations High Commissioner for Refugees (UNHCR)**

| | |
|---|---|
| Mr. Dereje Bogale | Food Security & Nutrition Assistant |

**Somali Regional State Environmental Protection, Mine and Energy Development Agency**

| | |
|---|---|
| Mr. Abdikadir Ahmed Khalif | Acting Head of SRPMEDA |

*JAPANESE SIDE*

**JICA Study Team**

| | |
|---|---|
| Mr. Toshiyuki Matsumoto | Team Leader of Study Team |
| Mr. Naoki Yasuda | Sub-Leader/O&M and Management |
| Mr. Kenichi Ishii | Water Supply Planning1/Facilities Design |
| Mr. Daisuke Sakamoto | Water Supply Planning2/Cost Estimation |
| Mr. Shigeki Kihara | Hydrogeology/Water quality |
| Ms. Masami Takahata | Procurement1/Logistical Support |

**JICA Ethiopia Office**

| | |
|---|---|
| Mr. Yukiyasu Sumi | Project Formulation Advisor (Water Sector) |
| Mr. Atsushi Nasimoto | Project Formulation Advisor for Drought in the Horn of Africa |
| Mr. Ephrem Fufa Leta | In-house Consultant for Water Sector |

Y.S.

# MINUTES OF MEETING

# ON

# THE 2nd STEERING COMMITTEE

# FOR

# THE STUDY ON

# JARAR VALLEY AND SHEBELE SUB-BASIN WATER SUPPLY DEVELOPMENT PLAN, AND EMERGENCY WATER SUPPLY

# IN

# THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

Jijiga, Somali Region
April 4th, 2013

MARKOS WIJORE (Dr.)
Director, Water Sector Support and Capacity Building Directorate

Mr. Toshiyuki Matsumoto
Team Leader
JICA Study Team
Kokusai Kogyo Co., Ltd.

Dr. Markos Wijore
Director, Waters Sector and Capacity Building Directorate
Ministry of Water and Energy
Federal Democratic Republic of Ethiopia

For
Ms. Fartuun Gabdi Mahdi
Bureau Head
Somali Region Water Development Bureau
Federal Democratic Republic of Ethiopia

Witnessed by
Dr. Yuji Maruo
Senior Advisor
Japan International Cooperation Agency (JICA)

for
Witnessed by
Mr. Dereje girma
Senior Desk Officer
Ministry of Finance and Economic Development

In response to the official request of the Government of the Federal Democratic Republic of Ethiopia (hereinafter referred to as "the Government of Ethiopia"), the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Preparatory Study Team of Ethiopia Office. The Japanese side and the Ethiopian side came to an agreement on the Record of Discussions (hereinafter referred to as "R/D") which was signed on Dec. 23rd, 2011.

JICA sent to Ethiopia the JICA Study Team (hereinafter referred to as "the Team") for THE STUDY ON JARAR VALLEY AND SHEBELE SUB-BASIN WATER SUPPLY DEVELOPMWNT PLAN, AND EMERGENCY WATER SUPPLY (hereinafter referred to as "the Study"). The Team held the second Steering Committee ("SC") Meeting with the officials of the Ministry of Water and Energy (hereinafter referred to as "MoWE"), Somali Region Water Development Bureau (hereinafter referred to as "SRWDB") and other authorities concerned with the Study. The list of those who attended the SC Meeting is shown in Appendix-1.

In the course of discussions, SC members confirmed the main items described in the Interim Report (hereinafter referred to as "IT/R"). The Team will submit the Final Report of the Study in August 2013, when the Study comes to an end.

## 1. Explanation of IT/R

The Team submitted sixteen (16) copies of IT/R to MoWE, SRWDB and other relevant authorities on 25th and 26th March, 2013.

At the meeting, the Team made presentation on the progress of the Study focusing on the results of water resources utilization evaluation survey (hydrology, geology, hydrogeology, water quality), water supply plan including the pilot project, the emergency water supply and C/P Training, O&M, Socio-economic survey and environmental and social consideration. The participants had some discussions on these topics.

After the discussion, the Ethiopian side agreed on the contents of IT/R in principle, in particular, on the methodology of the Study, the Study results and future schedule of the Study.

Major issues and the contents of the discussions regarding IT/R are as follows:

**1) Comments on IT/R and the presentation**

Kabribeyah water supply utility office made comments on the issues concerning the technical aspects of pilot project implementation in Kabribeyah town and in Jarar valley. The Team replied that all the comments had already been discussed between the Team and the office once and again explained the Team's opinion for all the comments made by the office. The comments raised were as follows:

- No relation between the office and the contractor that conducted the pilot project
- The wells need stainless steel riser pipes
- The quality of the PVC transmission pipeline is not good
- The proposed design of the animal trough is not familiar
- The water supply points constructed near the JICA wells are not close to the community
- The office can not install the remaining (3rd) surface pump by itself and will seek for assistance from UNHCR.
- The raw water from the well contains high Ca and Fe and thus it needs some corrective measures.

SRWDB asked if the Team has any plans to expand the water supply system in Godey Town. The Team explained again the outline of the master plan for Godey Town and the pilot project in Godey Town to stress that the five water supply points constructed in the pilot project will be connected to the main system that is going to be upgraded in the master plan.

Godey Town water supply utility office requested that the present water supply system be improved and a water truck be delivered to the town. The Team replied that the improvement of the system would be realized when the master plan was implemented and that the office should consult with SRWDB though the Team had recommended one water truck to be used in Godey Town.

JICA asked several questions about the water supply master plan and about its O&M aspect for confirmation. The Team confirmed all the points. The questions raised are as follows:

- whether the Team has explained that a feasibility study would be conducted for Godey Town
- whether the capacity development plan for Kabribeyah water utility office will be included

JICA also asked if the Team had sufficient socio-economic and financial data to make decisions on the viability of the project in terms of cost recovery. The Team answered that the Team had collected enough data and would analyze the viability of the project with the use of capacity to pay data that would be calculated from the household income data.

JICA also asked why the water for fire fighting of 10% of storage tank volume was included in the water supply plan. The Team answered that the urban water supply design criteria of Ethiopia proposed the water for fire fighting be included in water supply.

MoWE mentioned that the socio-economy was closely related to the environmental issues and that the Team should take that into consideration to avoid problems such as water pollution. The Team replied that the results of the preliminary study on environmental and social consideration so far in this study indicated no physical impacts to the environment and the

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The Federal Democratic Republic of Ethiopia Ministry of Water & Energy

issue would be rather a social one (donkey water sellers).

MoWE asked the Team that the water quality evaluation should be done using also more practical criteria such as potable or not-potable. The Team replied that such classification of water had been conducted with the use of WHO and Ethiopian water quality guidelines and was already included in the report.

MoWE also made some detailed comments on how the report describes the basins in Somali Region and others. The Team asked MoWE to send corrections on the report in writing to the leader of the Team later and also promised to use proper basin names in consideration of the main twelve basins.

MoWE commented that it would be better to separate the report into several volumes based on the field of the contents. The Team replied that it was considering producing DF/R in at least three volumes and would like to discuss the detail with MoWE later.

**2) Other issues**

The Team raised the following topics for discussion after the questions and answers session.

- Better use of water resources evaluation (hydrogeolgical) maps in future
- Effective use of the proposed master plans
- Future of water supply in Kabribeyah town

MoWE commented that the idea of distributing such maps was fine and the experts of the Ethiopian side would naturally know how to utilize the maps once they received hard or soft copies. JICA added that similar maps were provided to GSE (geological survey of Ethiopia) for sale after the Rift Valley Lakes Basin project and that JICA was planning also a workshop to make presentation of the maps at the time of presentation of DF/R. The Team added that the water resources study and management core process was expected to play an important role in dissemination of the maps.

MoWE also replied that the woredas for which water supply master plans was prepared would check its consistency with national plan and would use the plan as the woreda's water supply master plan.

MoWE also agreed to the idea of providing capacity building to Kabribeyah town water supply utility office in immediate future. ARRA also expressed its opinion to strongly support the idea of providing capacity development to the town water supply utility office by SRWDB.

SRWDB mentioned that Kabribeyah town water supply office would be able to operate the system with support from SRWDB if capacity development is done.

SRWDB also added that the bureau would be ready to give comments on the DF/R if it was handed to them early enough.

**3) Future schedule**

The Team announced that it would prepare DF/R by the beginning of July 2013 and would send the draft reports to all members of the steering committee in advance. The Team also said that it would schedule the next steering committee meeting tentatively for 10 July 2013.

END

Appendix-1

## ATTENDANCE LIST

*ETHIOPIAN SIDE*

**Ministry of Water and Energy (MoWE)**

| | |
|---|---|
| Dr. Markos Wijore | Director, Water Sector Support and CB Directorate |
| Mr. Abebe Gulma | Emergency Wash Coordinator |

**Somali Region Water Resources Development Bureau (SRWDB)**

| | |
|---|---|
| Ms. Fartuun Cabdi Mahdi | Bureau Head |
| Mr. Elias Hussein | Water supply core process owner |
| Mr. Ahmednur Abdulahi | NGO and Emergency Coordination |
| Mr. Nour Mohamed | Water Supply Scheme Management CP |
| Mr. Abdi Mohamed | Planning M&E SP |

**Administration for Refugee and Returnee Affairs (ARRA)**

| | |
|---|---|
| Mr. Samuel | Zonal coordinator |

**Bureau of Finance and Economic Development (BoFED)**

| | |
|---|---|
| Mr. Mubashir Dibad Raage | Deputy Head of BoFED in Somali Region |

**Kabribeyah Town Water Supply Utility Office**

| | |
|---|---|
| Mr. Ahmed Abdi Aden | Manager |

**Godey Town Water Supply Utility Office**

| | |
|---|---|
| Mr. Mohamed Isak | Manager |

**Ministry of Finance and Economic Development (MoFED)**

| | |
|---|---|
| Mr. Dereje Girma | Senior Desk Officer |

**United Nations High Commissioner for Refugees (UNHCR)**

| | |
|---|---|
| Mr. Dereje Wubishet | Associate Program Officer |

**Somali Regional State Environmental Protection, Mine and Energy Development Agency**

| | |
|---|---|
| Mr. Tahir Abdulla | Head of Department |

*JAPANESE SIDE*

**JICA Study Team**

| | |
|---|---|
| Mr. Toshiyuki Matsumoto | Team Leader of Study Team |
| Mr. Naoki Yasuda | Sub-Leader/O&M and Management |
| Mr. Kenichi Ishii | Water Supply Planning1/Facilities Design |
| Mr. Daisuke Sakamoto | Water Supply Planning2/Cost Estimation |
| Mr. Shigeki Kihara | Hydrogeology/Water quality |
| Mr. Tamotsu Ishii | Mechanical Equipment |
| Mr. Shoji Masumura | Social-economic survey |
| Mr. Yosuke Yamamoto | Coordinator |

**JICA Ethiopia Office**

| | |
|---|---|
| Dr. Yuji Maruo | Senior Advisor |
| Mr. Jun Moriguchi | Assistant Director |
| Mr. Yukiyasu Sumi | Project Formulation Advisor (Water Sector) |
| Mr. Ephrem Fufa Leta | In-house Consultant for Water Sector |

# MINUTES OF MEETING
# ON
# THE 3rd STEERING COMMITTEE
# FOR
# THE STUDY ON
# JARAR VALLEY AND SHEBELE SUB-BASIN WATER SUPPLY DEVELOPMENT PLAN, AND EMERGENCY WATER SUPPLY
# IN
# THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

Jijiga, Somali Region
July 10th, 2013

Mr. Toshiyuki Matsumoto
Team Leader
JICA Study Team
Kokusai Kogyo Co., Ltd.

MARKOS WIJORE (Dr.)
Director, Water Sector Support and Capacity Building

Dr. Markos Wijore
Director, Waters Sector and Capacity Building Directorate
Ministry of Water and Energy
Federal Democratic Republic of Ethiopia

Ms. Fartuun Cabdi Mahdi
Bureau Head
Somali Region Water Development Bureau
Federal Democratic Republic of Ethiopia

Witnessed by
Dr. Yuji Maruo
Senior Advisor
Japan International Cooperation Agency (JICA)

Kokeb Misrak
Bilateral Cooperation Directorate
Director

Witnessed by
Mr. Meseret Abebe
Expert of Asia ODA program, Bilateral Cooperation Directorate
Ministry of Finance and Economic Development

In response to the official request of the Government of the Federal Democratic Republic of Ethiopia (hereinafter referred to as "the Government of Ethiopia"), the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Preparatory Study Team of Ethiopia Office. The Japanese side and the Ethiopian side came to an agreement on the Record of Discussions (hereinafter referred to as "R/D") which was signed on Dec. 23rd, 2011.

JICA sent to Ethiopia the JICA Study Team (hereinafter referred to as "the Team") for THE STUDY ON JARAR VALLEY AND SHEBELE SUB-BASIN WATER SUPPLY DEVELOPMWNT PLAN, AND EMERGENCY WATER SUPPLY (hereinafter referred to as "the Study"). The Team held the third Steering Committee ("SC") Meeting with the officials of the Ministry of Water and Energy (hereinafter referred to as "MoWE"), Somali Region Water Development Bureau (hereinafter referred to as "SRWDB") and other authorities concerned with the Study. The list of those who attended the SC Meeting is shown in the Appendix.

In the course of discussions, SC members confirmed the main items described in the Draft Final Report (hereinafter referred to as "DF/R").

## 1. Explanation of DF/R

The Team submitted twenty (20) copies of DF/R to MoWE, SRWDB and other relevant authorities on 28th June and 1st July, 2013.

At the meeting, the Team made presentation on the results of the Study focusing on the results of water resources (groundwater) utilization evaluation survey (hydrology, geology, hydrogeology, water quality) and of the water supply plan. The presentation also included the following topics:

- the feasibility study for Godey Town,
- the emergency water supply
- the current situation of O&M and O&M plan,
- Socio-economic survey
- Environmental and social consideration.

The participants had discussions on these topics.

After the discussion, the Ethiopian side agreed on the overall contents of DF/R, in particular, the proposed water supply master plans and the result of the feasibility study of the water supply plan for Godey Town.

Major issues discussed regarding DF/R during the meeting are as follows:

### 1) Comments on DF/R and the Presentation

UNHCR asked when the constructed facilities in Kabribeyah town will be officially handed over. The Team answered that the completion ceremony had already been conducted in April in the presence of UNHCR and Kabribeyah town water supply utility office and that the Team regarded the facilities had already been handed over. The team added that it understood that UNHCR is in charge of the O&M of the facilities but should discuss this with Kabribeyah town water supply office if necessary.

UNHCR and Kabribeyah water supply utility office raised concern about the one JICA borehole that has not been functional. The Team asked them to first to check the pump condition and water level in the borehole using the dip meter that was to be supplied to SRWDB and make the assessment based on the data.

Godey town water supply utility office asked why the implementation period for Godey town system is as long as four years and if there was any possibility of project realization. The Team replied as follows: In order to attain 100% supply ratio in 2020, 16 months will be needed for detailed design and tender and additional 24 months for implementation. Thus, the total period will be about four years. The Team also replied that the Ethiopian side was expected to move on to secure fund for the project on its own because the study end at this F/S stage.

Godey town water supply utility office asked for supply of one of the five water trucks for the purpose of utilizing the constructed five water supply points that are not connected to the distribution network. The Team replied that the trucks had already been procured and asked the office to negotiate the deployment of the truck with SRWDB. The Team added that it had already asked SRWDB to assign one truck to Godey Town.

Bureau of Finance and Economic Development (BoFED) asked if this project would be sustainable when the study had been conducted mostly be the study team with little involvement of the regional government. The Team replied that it had conducted workshops and a C/P meeting and also that each team member reported the progress regularly to their C/P persons of SRWDB during the study.

BoFED asked what were the criteria for the selection of 16 woredas. The Team replied that the area of study had been determined based on R/D document and that target woredas had been selected based on the area. The Team added that the Team had confirmation on the selected woredas by the Somali side.

BoFED asked how the population figures were determined. The Team replied that the figures were calculated based on the census data of 2007 using the population growth rate.

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BoFED asked if JICA had any contingency or back up plans for the project. The Team replied that this Study ended at F/S level and that JICA had no specific plan to conduct any specific project at the moment.

SRWDB commented that it was highly satisfied about the results of the Study but would like to give some comments. The comments made by SRWDB are as follows:

- Some of the comments made by SRWDB in previous SC meetings had not been reflected yet.
- The budget for five years of SRWDB amounts to 293 million.
- The implementation period of borehole system is too long. It is about four months from the experience of the bureau and implementation of a birka takes only six months.
- The O&M cost of water supply plans for woredas is too high.

The Team replied that it would discuss some of the comments with SRWDB at another occasion to ask for more specific comments in written form and answered the other comments as follows:

- The budget figure shown in the report (DF/R) is the data the Team obtained from SRWDB as one year budget.
- The period of a borehole system implementation covers the preparation period of designing and geophysical prospecting as well as tender in addition to drilling work. It also considered the experience of the pilot project. Thus the Team regards one year as reasonable.
- The project and O&M costs were calculated based on quantities and unit price and the unit price is of Somali local price. Thus, the Team considers it to be reasonable. The detailed data for calculation will be attached to the final report. It should be noted that the fuel cost to operate generators accounts for as large portion of the O&M cost.

Ministry of Water and Energy (MoWE) commented that some figures and tables were too fine to see and those should be enlarged. The Team replied it would do so.

MoWE asked the Team to provide the shape files to the Ministry. The Team replied it would do so.

MoWE made some technical comments on the hydrogeological aspects of the Study (inclusion of geological structure in the potential evaluation map, relation between lithology and water quality, evaluation of Amba Aradam sandstone aquifer). The Team promised to consider their comments in the final report.

MoWE commented that 50 Birr/m³ of spending on water was too high and that probably 20 Birr/m³ would be reasonable. The Team replied as follows: the figure was calculated based on the results of field interview survey in Godey Town. It is the actual price the terminal uses pay and if the annual income of households were considered, it is not necessarily too expensive. If the price is set at 20 Birr, the result will be different.

MoWE suggested that the member list and photos be moved to the appendix. The Team replied that it would consider the idea.

MoWE commented that basic data for cost estimation was not shown in the F/S report. The Team replied that it would attach the data sheets used for cost estimation to the final report.

MoWE commented that 1500 Birr per month as ability to pay is too high. The Team replied that it should have been 1500 Birr per year and that it would be equivalent to about 120 Birr per month, which was not too expensive.

MoWE suggested that introduction of progressive tariff system might be possible. SRWDB commented that flat rate worked better from its experience. The Team replied that it would consult with SRWDB on this issue.

MoWE suggested that changing conditions of the project was worth consideration to find ways to make the project more feasible. The Team replied that the most of the O&M cost was explained by fuel cost and that it would try to see how much reduction in O&M cost could be achieved if the commercial power supply was used in the F/S report.

JICA commented that current legend notation of "Q series" in the geological map should be reconsidered and suggested an option. MoWE said that it would not agree to the option. The Team mentioned that the Q series layers do not have enough thickness in the area and that it would reconsider the expression in consideration of the suggested options.

**2) Other issues**

The Team suggested two issues for discussion.

1. Utilization of proposed water supply plans

MoWE gave its opinions about the issue as follows: the proposed water supply plans should be shared with each of the woredas concerned so that they can move on to realize the plans on its own. SRWDB should provide assistance in sharing the information and the reports should be provided to the woredas. The other parties agreed to this idea.

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2. Utilization of produced maps

The Team commented that it was planning to supply the maps to Geological Survey of Ethiopia (GSE) and asked how SRWDB would use the maps mentioning the possibility of

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involvement of the Water Resources Study and Management core process of SRWDB mentioned that collection and utilization of various data at the regional level as well as the federal level was important. The other parties agreed to this idea.

The Team mentioned that it would consider supplying the maps to GSE, MoWE, SRWDB. MoWE commented that it would like to have 30 copies and also the water point data so it would integrate the data into its database.

**3) Future schedule**

The Team asked the participants to send any additional comments by E-mail to the Team leader by 25 July 2013.

The Team announced that it would prepare the final report of the study containing all the comments from the members of the 3rd Steering Committee by the end of August 2013. The Team also mentioned that it would send these reports to MoWE through JICA Ethiopia office by the middle of September 2013 from Japan.

END

Appendix

# ATTENDANCE LIST

*ETHIOPIAN SIDE*

**Ministry of Water and Energy (MoWE)**

| | |
|---|---|
| Dr. Markos Wijore | Director, Water Sector Support and CB Directorate |
| Mr. Tesfaye Tadese | Director, Groundwater Study Development & Management Directorate |

**Somali Region Water Resources Development Bureau (SRWDB)**

| | |
|---|---|
| Mr. Abdirashid Mohamed | Bureau Deputy Head |
| Mr. Ali Mohamed | Water Resources Study & Management CP Owner |
| Mr. Mohamed A Bihi | Water supply scheme management CP Owner |

**Administration for Refugee and Returnee Affairs (ARRA)**

| | |
|---|---|
| Mr. Dawit Huddis | Environmental officer |

**Bureau of Finance and Economic Development (BoFED)**

| | |
|---|---|
| Mr. Abdulahi Weirah Karie | Officer |
| Mr. Abdurahman Shek Hassan | Officer |

**Kabribeyah Town Water Supply Utility Office**

| | |
|---|---|
| Mr. Abdifetah Beshir | Manager |

**Godey Town Water Supply Utility Office**

| | |
|---|---|
| Mr. Mohamed Isak | Manager |

**Ministry of Finance and Economic Development (MoFED)**

| | |
|---|---|
| Mr. Meseret Abebe | Expert on Asia ODA program, Bilateral Cooperation Directorate |

**United Nations High Commissioner for Refugees (UNHCR)**

| | |
|---|---|
| Mr. Dereje Bogale | Program associate |

**Somali Regional State Environmental Protection, Mine and Energy Development Agency**

| | |
|---|---|
| Mr. Hamdi Abdulahi | Officer |
| Mr. Ahmed Muhamed | Officer |

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JICA Japan International Cooperation Agency

The Federal Democratic Republic of Ethiopia Ministry of Water & Energy

*JAPANESE SIDE*

**JICA Ethiopia Office**

| | |
|---|---|
| Dr. Yuji Maruo | Senior Advisor |
| Mr. Jun Moriguchi | Assistant Director |
| Mr. Yukiyasu Sumi | Project Formulation Advisor (Water Sector) |

**JICA Study Team**

| | |
|---|---|
| Mr. Toshiyuki Matsumoto | Team Leader of Study Team |
| Mr. Naoki Yasuda | Sub-Leader/O&M and Management |
| Mr. Kenichi Ishii | Water Supply Planning1/Facilities Design |
| Mr. Shigeki Kihara | Hydrogeology/Water quality |
| Mr. Yosuke Yamamoto | Coordinator |

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The Federal Democratic Republic of Ethiopia Ministry of Water & Energy

Japan International Cooperation Agency 1

# Annex 2

*Confirmation Letter*

**KOKUSAI KOGYO CO., LTD.**
Overseas Operations Department:
2 Rokubancho, Chiyoda-ku, Tokyo 102-0075, Japan
TEL:**81-3-6361-2452 FAX:**81-3-3237-5477

*The Study on Jarar Valley and Shebele Sub-basin Water Supply Development Plan, and Emergency Water Supply in The Federal Democratic Republic of Ethiopia*

Date: 9 July 2013

Ref: No.35/TM/13

**Re: Note of Confirmation on the Supply and Management of the Equipment and Facilities for the Pilot Project in Kabribeyah Town**

The two parties named at the bottom of this document mutually confirmed the following:

The equipment and facilities installed by JICA in Jarar Valley water supply system within the headed study have been supplied to Somali Regional Water Bureau (SRWDB) and all the equipment and facilities except for the public water taps in Kabribeyah Town will be managed and maintained by UNHCR Jijiga sub-office that is currently in charge of management of the system. The installed equipment and facilities are listed below:

Equipment

- Three (3) surface pumps to be installed at the pumping station and booster pump station
- Two (2) submersible pumps to be installed in JICA well No-1 and No-2
- Two (2) generators to be installed at JICA well No-1 and No-2

Facilities

- Five (5) public taps with a water tank and a cattle trough
- Two (2) borehole wells
- Two (2) generator houses for each well
- One (1) conveyance pipeline system connecting the two borehole wells to the existing system
- Two (2) public taps the near the two borehole wells

The detailed information of the items above is attached to this document (see attached sheet 1, 2, and 3).

Mr. Toshiyuki MATSUMOTO
Team Leader/Water Resources Development Plan for JICA Study Team
The Study on Jarar Valley and Shebele Sub-basin Water Supply Development Plan, and Emergency Water Supply
Kokusai Kogyo Co., Ltd.

Ms. Fartuun Cabdi Mahdi
Head of Somali Regional Water Development Bureau

*Attached sheet 1*

Equipment 1. Surface and Booster Pumps

| Equipment | Brand and Model | Specifications | | | Qt'y | Remark |
|---|---|---|---|---|---|---|
| | | Head (m) | Discharge (m3/hr) | Power (kW) | | |
| Surface Pump | Rovatti pomp<br>ME100K80-90/4A-TB<br>Type: Y2-2805-2 | 223 | 75<br>at 214m | 75kW,<br>100HP | 3 | - Green painted,<br>- Equipped with control panel and connecting cable<br>SN: 00710019004<br>SN: 0000040009<br>SN: 7004682 |

Equipment 2. Submersible Pumps

| Equipment | Brand and Model | Specifications | | Qt'y | Remark |
|---|---|---|---|---|---|
| | | Discharge (m3/hr) | Max sand content | | |
| Submersible Pump | **WILO**<br>TWI 6.18-20-B-5D-R | 5.13L/sec<br>at 143m | $50 g/m^3$ | 2 | SN: 650161751<br>SN: 650161752<br>SN: 50248929/0001 (control panel)<br>SN: 50248928/0001 (control panel) |

Equipment 3. Generators for Submersible Pumps

| Equipment | Brand and Model | Specifications | | Qt'y | Remark |
|---|---|---|---|---|---|
| | | Type | Power (kW) | | |
| Generator | **PRAMAC**<br>Model: GSW45<br>Type: SU 450 TPAW02 | 3 phase, diesel engine | 34.4kW | 2 | - black painted, Perkins engine<br>DK51278*U336511W<br>DK51278*U335476W<br>SN: PEE2525064<br>SN: PEE2524732 |

*Attached sheet 2*

Facility 1. Public water supply points

| Facility | Components | Specifications | | Qt'y | Remark |
|---|---|---|---|---|---|
| | | Dimension (m) | Material | | Location |
| Public tap | -Tap stand for human use with 6 taps with concrete apron and drain ditch<br>-Elevated plastic water tank ($10m^3$)<br>-Animal trough | 1.5 (H) x 2 (W) x 1.8(L)<br>1.4 (H) x 2.4 (W) x 10.6(L) | Reinforced concrete and blacks<br>Tank: FRP | 5 | 1. 998917 N, 287258 E<br>2. 1007263 N, 299597 E<br>3. 1007082 N, 300444 E<br>4. 1006601 N, 298715 E<br>5. 1006616 N, 299766 E<br>* No-5 only has the tap stand |

Facility 2. Borehole wells

| Facility | Components | Specifications | | Qt'y | Remark |
|---|---|---|---|---|---|
| | | Depth | Diameter | | |
| Borehole well | Borehole deep well with iron screen and casing pipes, and GI riser pipe, associated valves | 200 m | 8 inch | 2 | Location<br>No1 : 1000179 N, 281113 E,<br>No2 : 1000002 N, 280742 E |

Facility 3. Generator house

| Facility | Component | Specifications | | Qt'y | Remark |
|---|---|---|---|---|---|
| | | Dimension (m) | Material | | |
| Generator house | A block walled housing for generator with ventilation holes with tin roof | 3.4 (H) x 3.8 (W) x 7.4 (L) | Block and reinforced concrete and corrugated metal sheet | 2 | Location<br>Located beside the wells<br>No1 : 1000179 N, 281113 E,<br>No2 : 1000002 N, 280742 E |

*Attached sheet 3*

Facility 4. Conveyance pipeline system

| Facility | Component | Specifications | | | Qt'y | Remark |
|---|---|---|---|---|---|---|
| | | Diameter | Length | Material | | |
| Pipeline system | Conveyance pipe 1 | 75 mm | 660 m | u PVC | 1 set | Conveyance pipeline connects the 2 JICA wells and existing conveyance pipeline. |
| | Conveyance pipe 2 | 150 mm | 2500 m | u PVC | | Distribution pipelines connect the public water taps with the existing pipeline system. Includes valve boxes. |
| | Distribution pipes | 50 – 75 mm | 2088 m | GI, u PVC | | |

Facility 5. Additional water points near the JICA wells

| Facility | Component | Specifications | | Qt'y | Remark |
|---|---|---|---|---|---|
| | | Dimension (m) | Material | | |
| Public water supply point | Public water stand with 4 taps with apron and drain ditch (similar to standard of SRWDB). | 4 (W) x 1.4 (H) x 1.2 (L) | Reinforced concrete | 2 set | Location<br>30m from the well at each site |