APPENDIX-4

Micro-seismic Monitoring

Appendix-4 Micro-seismic Monitoring

A4.1 Tendaho 2 Area

A4.1.1 Purpose of the exploration

The purpose of exploring for micro-seismic is to gain an understanding of areas with signs of geothermal activity, and earthquake events that occur in the surrounding area, and to confirm fault structures and the positions of fault systems. Figure A4.1.1 shows the locations where seismometers were set up.

The results of the earthquake observations will be used to construct a model of geothermal retention layers and formulate plans for survey drilling.

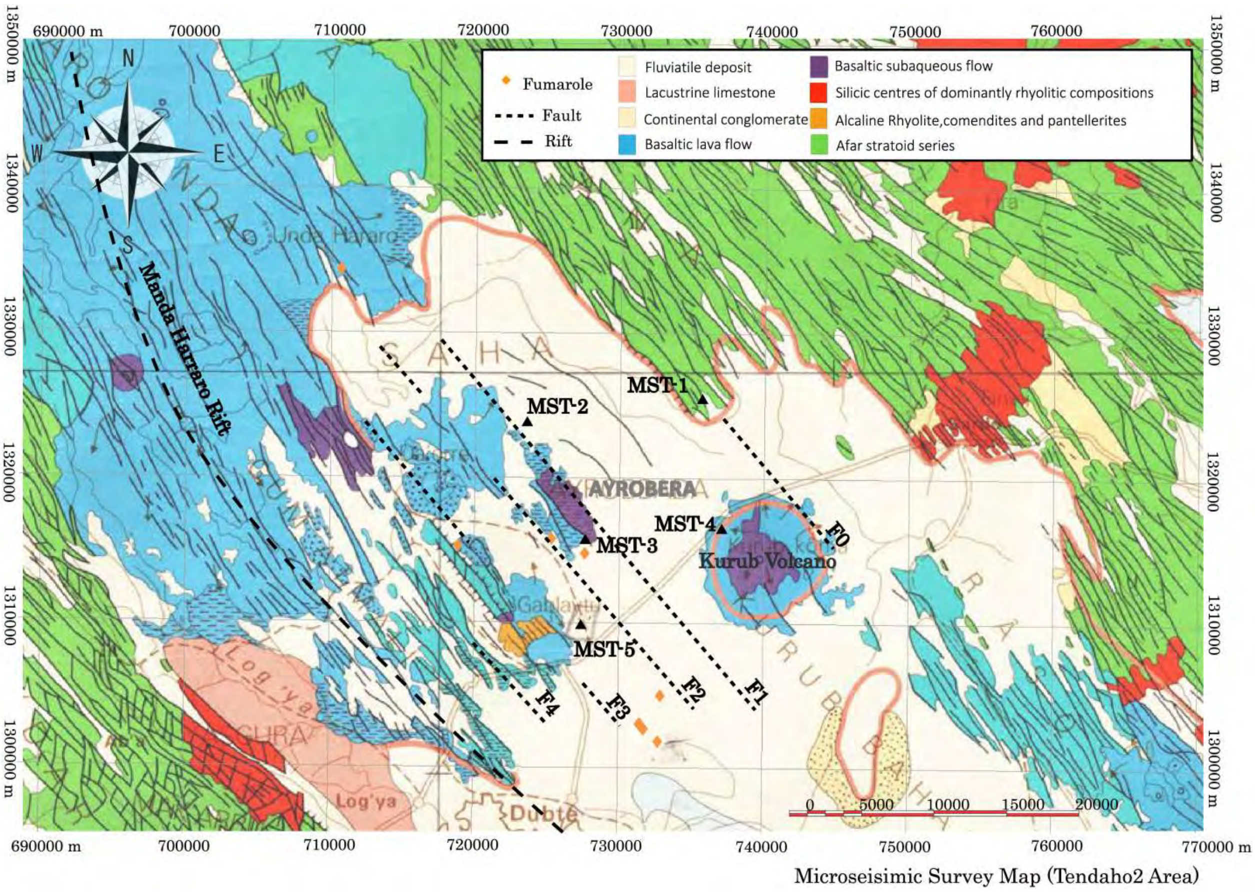

Figure A4.1.1 Locations of micro-seismic observations (Tendaho 2 Area)

A4.1.2 Overview of the geology

According to the Final Report of the Survey Project for Formulating a Master Plan on Development of Geothermal Energy (2015), Tendaho 2 Area is located in the Manda-Harraro trough zone (V.Acocella, 2008, p.2). The basement is composed of the Afar Stratoid from the Pliocene-Pleistocene, and there are distributions of basaltic lava, pyroclastic rock, and sedimentary rock. In the Southwest part of the study area, lava flows from fissure eruptions of Pleistocene recent basalt have been observed. In the Ayrobera area, these are covered by alluvium which forms a plain. In addition, faults F0～F4 have a NW-SE orientation along the trough direction. As one sign of geothermal activity, a fumarolic gas belt has been observed in a fault that runs through areas near microseismic stations (hereafter, "stations") MST-3 and MST-5. The temperature of the fumarolic gas near MST-3 is very high, close to 100 °C.

A4.1.3 Overview of the exploration

The following describes the contents of surveys in this study.

(1) Selection of micro-seismic station

First, candidate sites for measurements were identified by using Google Earth to examine areas of exposed rock. After that, reconnaissance was conducted at the sites to sift out prospective stations. The stations that were selected were those that were least affected by basement noise caused by traffic, trees, etc.

The background noise at each candidate microseismic station was measured. The following figure shows the results of ground noise level measurements that were taken at MST-1 in Tendaho 2 Area. The seismometer used to measure noise levels had 3 components: the top part of the figure is the N-S component, the middle part is the E-W component, and the bottom part is the Up-Down component. The polarity of the initial rise direction was positive at N、E、Up, and negative at S、W、and Down.

The noise level at MST-1 was a very low 10μkin, making it an optimal location for a station. It should be noted that the large wave on the right side of the oscillation was the wave that was generated when the ground was impacted.

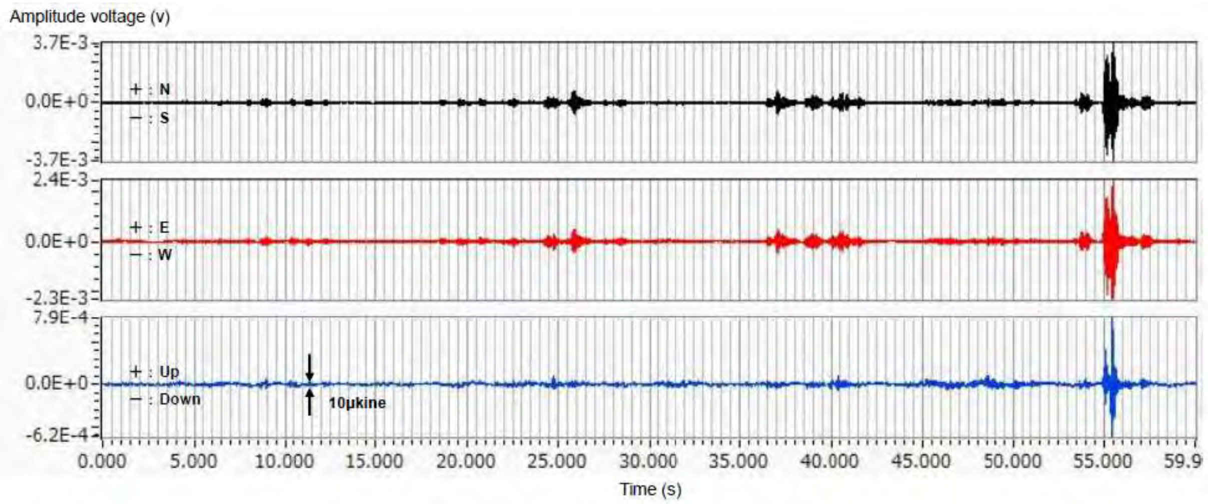

Figure A4.1.2 Results of ground noise level measurements (MST-1, Tendaho 2 Area)

The results of the noise level measurements at stations MST-1～MST-3 were all low values of 30μkine or less. However, despite the hard ground at stations MST-4 and MST-5, they showed high values for noise, 90μkine and 190μkine, respectively. The location and elevation of each observation point were derived with kinematic surveying by Ethiopian surveyors using GPS surveying instruments. Table A4.1.1 shows the location, elevation, and noise level at each station.

Table A4.1.1 Overview of seismometer installations (Tendaho 2 Area)

Station No.	Longitude	Latitude	UTM (easting)	UTM (northing)	Elevation (m)	Ground noise(μkine)
MST-1	41° 9′ 53.8″ E	11° 58′ 53.3″ N	1325430	735742	367	10
MST-2	41° 3′ 17.6″ E	11° 58′ 01.4″ N	1323743	723765	384	20
MST-3	41° 5′ 30.1″ E	11° 53′ 33.5″ N	1315539	727835	376	25
MST-4	41° 10′ 39.1″ E	11° 53′ 58.7″ N	1316387	737184	375	90
MST-5	41° 5′ 18.6″ E	11° 50′ 26.5″ N	1309790	727531	366	190

(2) Data acquisition system

The observation equipment was a system consisting of an LE-3Dlite Mk II seismometer made by Lennartz Electronic GmbH of Germany, and a GSX-3 data logger and a 12V battery made by Geospace of the United States.

The 3-component waveform data that was captured by the velocity-type seismometer was automatically recorded in the data logger (SD card). The data logger had a built-in GPS, and it was calibrated to take measurements every 6 minutes.

Because measurements of micro-seismic were taken over a long 3-month period, two 12V50Ah shield batteries connected in parallel to provide power to the data logger. As a result, it was not necessary to replace any battery during the 3-month period, and measurements could be taken continuously. Figure A4.1.3 shows a block diagram of the data acquisition system.

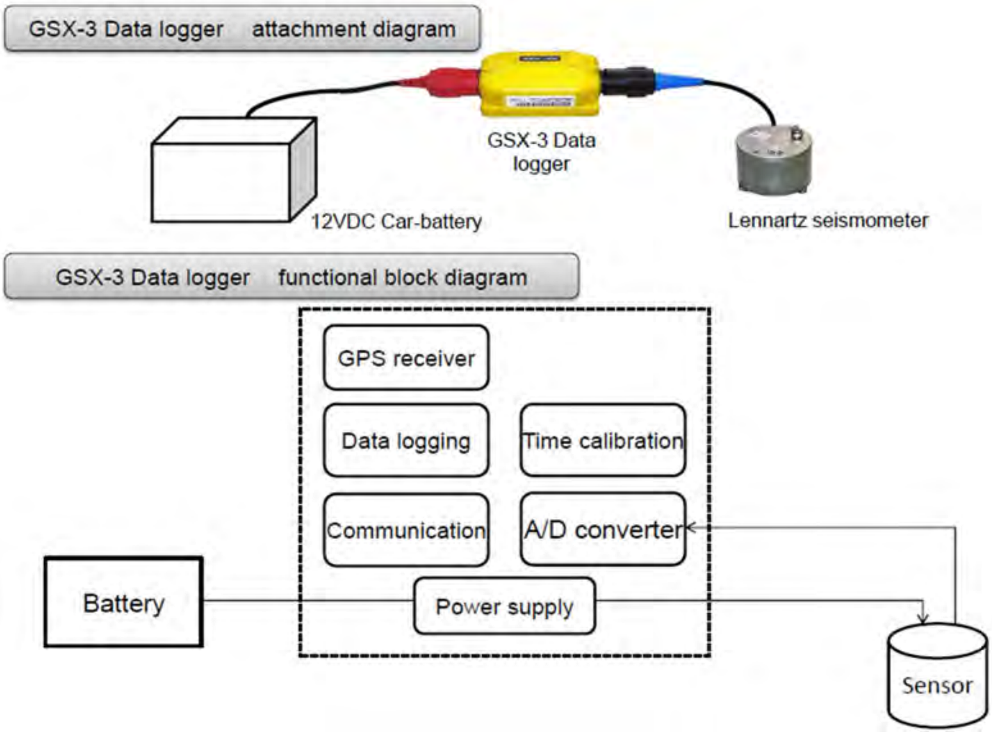

Figure A4.1.3 Block diagram of the data acquisition system

(3) Installation of seismometers and peripheral equipment

There were 5 points set up as measuring stations in Tendaho 2 Area. All of these stations had 3 components (N-S, E-W, and Up-Down), and each station was installed with a velocity-type seismometer. The seismometers were installed using the following procedure:

1) Dirt and gravel were removed from the ground.
2) Gypsum was poured onto the ground to create a base for the seismometer, which was embedded in the gypsum base.
3) Using a compass, an arrow symbol was carved to align the seismometer with magnetic north.
4) The seismometer and the data logger were connected, then the data logger and battery were connected.
5) To prevent theft of the equipment, the batteries were fixed into place with a chain and padlock, then mortar was used to adhere the chain to the battery.
6) The measuring equipment was covered with a vinyl sheet, and a humidity-absorbing sheet was placed inside of tat. Lastly, the measuring equipment was hidden by covering it with rocks.

Table A4.1.2 lists the equipment that was used to take earthquake measurements.

Table A4.1.2 Equipment for taking earthquake measurements

Item	Type	Specifications	Photo
Seismometer	LE-3Dlite Mk II (Lennartz Electronic GmbH., Germany)	Eigenfrequency：1Hz Upper Corner Frequency：100Hz RMS Noise @ 1 Hz：<3nm/s	
Data Logger	GSX-3 (Geospace Technology, USA)	A/D Converter：24bit GPS Time Calibration： Every 6 minutes GPS Accuracy：<20μsec Recording capacity：30Gbytes	
Seismic Recorder	MS-3000 (JGI, Inc., Japan)	Dynamic Range：121dB Sampling：1-4000Hz	

(4) Protecting the measuring equipment and measures to prevent theft

Because the micro-seismic stations were unmanned, Survey team members made regular rounds to check the equipment and make sure that electric power was being supplied to the data logger and that the GPS signals being received were accurate. Furthermore, to prevent theft of the equipment, two watchmen were posted, one in the daytime and one at night.

(5) Observation/measurement period

The measurement period in this study area started on the day when the installation of all 5 seismometers was completed, and ended on the day and at the station where the seismometers were first being collected. Therefore, the measurement period extended past 90 days, from 11:00 a.m. on December 23, 2015, to 11:30 a.m. on March 22, 2016. There was no trouble with the equipment, etc., during any of the measurement periods, and there were no interruptions with the measurements. Table A4.1.3 shows the measurement periods of the observation stations.

Table A4.1.3 Installation of a seismometer at the microseismic station and date of removal (Tendaho 2 Area)

Site Code	Measurement start time	Measurement stop time	Measurement days
MST-1	2015.12.22 12:00	2016.3.23 9:00	92days and 21hours
MST-2	2015.12.23 11:00	2016.3.24 8:30	92days and 21hours
MST-3	2015.12.21 11:20	2016.3.22 11:30	93days
MST-4	2015.12.22 15:10	2016.3.23 9:40	92days and 21hours
MST-5	2015.12.21 14:10	2016.3.22 12:20	92days and 22hours

A4.1.4 Processing the measurement data

(1) Processing the measurement data

The data were processed by connecting each of the data loggers from 6 microseismic stations (including one in the Boseti Area) to a Data Transfer Unit to integrate the waveform data. From the integrated waveform data, the parts that appeared to be seismic waves were visually sorted, then the seismic waveform parts were removed. The following is a conceptual diagram of the data collection system (Figure A4.1.4).

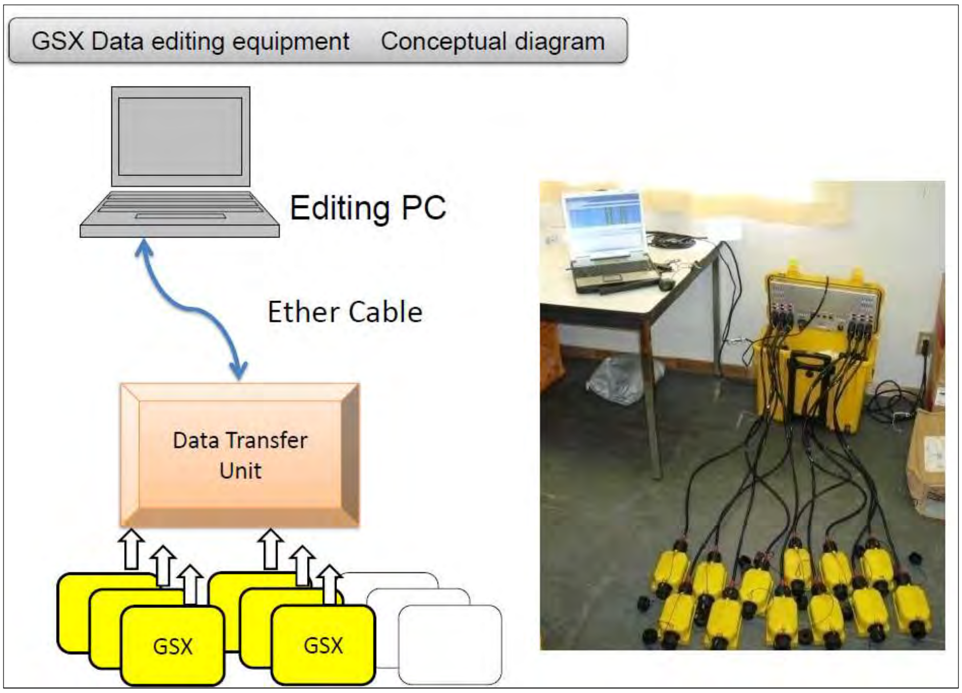

Figure A4.1.4 Conceptual diagram of the data collection system

(2) Reading and organizing the records, calculating epicenters

For the data that were determined to be seismic, readings were made of the times of P-wave arrival, S-wave arrival, and the end of the seismic motion. Locations of epicenters and magnitude were calculated for earthquakes whose arrival times for P and S waves from 3 or more measuring stations could be read. In this study, the magnitude was derived with a method that used the time of continuous seismic motion. Calculations were made using either M=-2.53+2.85logTd+0.014r or M=-2.36+2.85logTd. (Complete Geothermal Energy Development Handbook, 1982; Micro-earthquakes, p282-290. It should be noted that Td is the time of continuous seismic motion (in seconds), and r is 200km or less.

(3) Structure of seismic wave velocity

In 2015, the Italian company ELC-Electro consult S.p.A was commissioned by the Ethiopian Geological Survey and the Icelandic International Development Agency was commissioned to measure micro-seismic in the Tendaho-Alalobeda geothermal region about 25km southwest of Tendaho 2 Area. Table A4.1.4 shows the model that was created from the 4 horizontal layers that were used at the time. In the present study, the velocity structure model used in the Italian study was employed to derive the locations of epicenters.

Table A4.1.4 Velocity structure model (Tendaho 2 Area)

Number of layers	Thickness (km)	Depth (km)	Vp (km/s)	Vp/Vs
1	5.0	5.0	4.0	1.78
2	4.0	9.0	6.1	
3	17.0	26.0	6.9	
4	—	—	7.8	

A4.1.5 Survey results

From the measured data records, the daily frequency of earthquake occurrence, the frequency of earthquake occurrence by S-P times, the distribution of epicenters, etc., were compiled. The following is a description .

(1) Distribution of the frequency of earthquake occurrence by day

There were 846 observed earthquakes (averaging 9.4 quakes/day). The two days with the largest number of quakes were January 21 (60) and January 22 (119). Figure A4.1.5 shows the distribution of the frequency of earthquake occurrence on a daily basis.

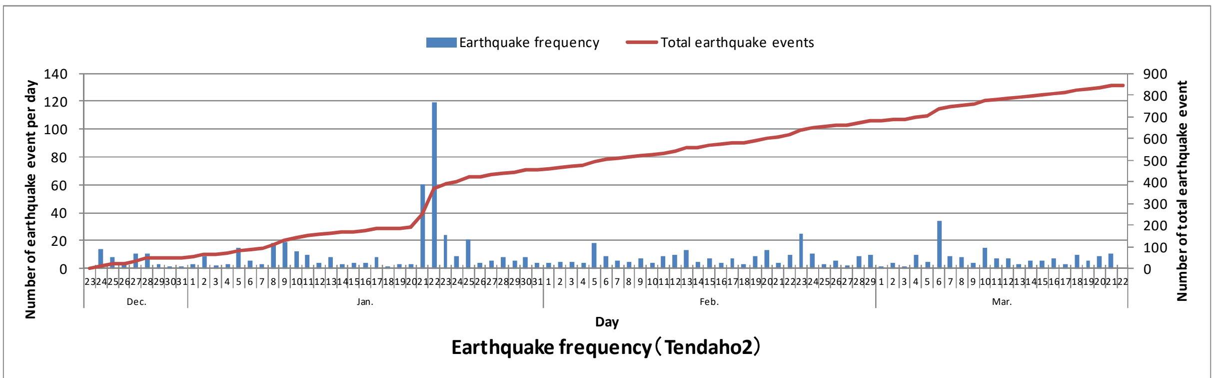

Figure A4.1.5 Distribution of the frequency of earthquake occurrence by day (Tendaho 2 Area)

(2) Distribution of the frequency of earthquake occurrence by S-P time

The frequency of earthquake occurrence by S-P time was based on station MST-1 where, among all observations at the 5 micro-seismic stations, the noise was the lowest and the arrival times of the P and S waves could be read (Figure A4.1.6)

By far, most (393) of the observed earthquakes had S-P times of less than 6 seconds, accounting for more than half of all quakes. The frequency of occurrence of 4～6 seconds was particularly high. Those quakes occurred in series that were concentrated in the period January 21~23.

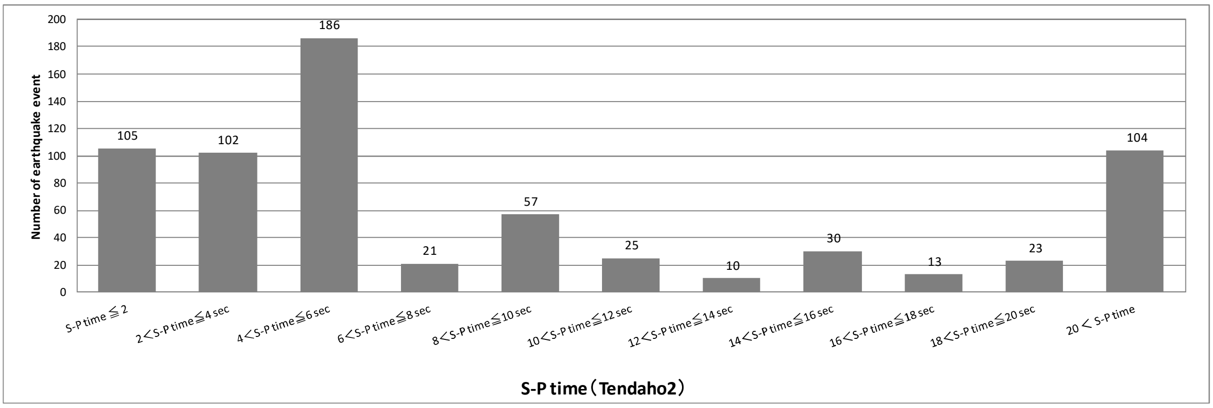

Figure A4.1.6 Distribution of the frequency of earthquake occurrence by S-P time (Tendaho 2 Area)

(3) Epicenter distribution map

Of the 846 earthquakes that were observed, there were 202 events whose epicenters were estimated. The results of epicenter distribution were compiled into 2 figures. One was the distribution of epicenters of local quakes near the observation network (Figure A4.1.7), while the other was distribution of distant epicenters that were up to 200km away from microseismic station MST-3 (Figure A4.1.8). The data from the earthquake readings and the epicenter coordinates and estimated magnitudes are attached in the Appendix.

Figure 3.7 shows the locations of faults in this zone which have a predominately NW-SE orientation, and the locations of fumaroles that were confirmed between the faults F2～F4.　Figure 3.8 shows the location of the Ethiopian Rift Valley (Meseret Teklemariam, 2008) and the fracture system based on the geological survey results of the JICA study tem.

[Local earthquakes]

The following is a description of local earthquakes.

- On the eastern side of fault F0 which passes through MST-1, earthquakes occur in an array along the NW-SE orientation of the fault.
- The depths of earthquakes that occurred near the F0 fault ranged from 2～6km, and their magnitude was 1 or less.
- No earthquakes were observed between faults F0 and F2.

- There was a concentrated occurrence of earthquakes around the fumaroles zone that interrupts faults F2～F4. The depths of these earthquakes were divided into two categories: shallow depths of 1-km or less, and deeper depths of 3km～6km. Most of the magnitudes were 1 or less.
- Some of the earthquakes that occurred near fault F4 had magnitudes of 1~2.

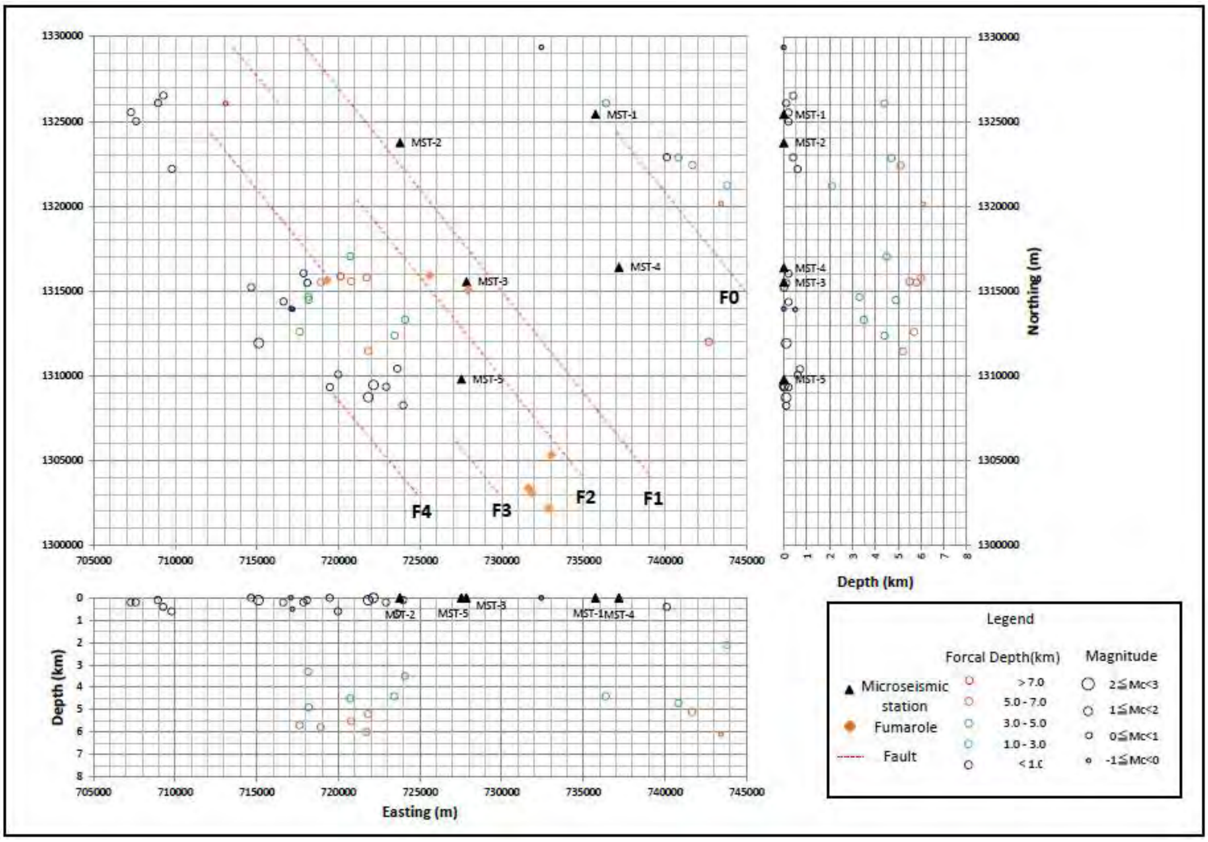

Figure A4.1.7 Estimated distribution of epicenters (near the observation network of Tendaho 2 Area)

[Earthquakes including both local and distant quakes]

- Earthquakes occurred at depths of 20km～30km within 100km of Tendaho 2 Area, and their distribution is arranged in a vertical direction. Magnitudes were 2 or less.
- Earthquakes that occurred more than 100km from Tendaho 2 Area were in relatively shallow places. Magnitudes of 2 or greater were dominant.
- About 100km south of Tendaho 2 Area, the distribution of earthquakes had a NNE－SSW orientation, but many of the quakes were scattered.
- Epicenters were observed near fractures such as Dallo, Boina, Tendaho and Danab.
- Near the Tendaho Dam around 30km SW of Tendaho 2 Area (129000N, 720000E), there was a series of earthquakes that occurred on January 21, 22 and 23. Their depth was about 20km and their magnitudes ranged from 2 to 3. As will be discussed in Section 4.1.6, there was a series of earthquakes that occurred near the Tendaho Dam in March and April of 1969.

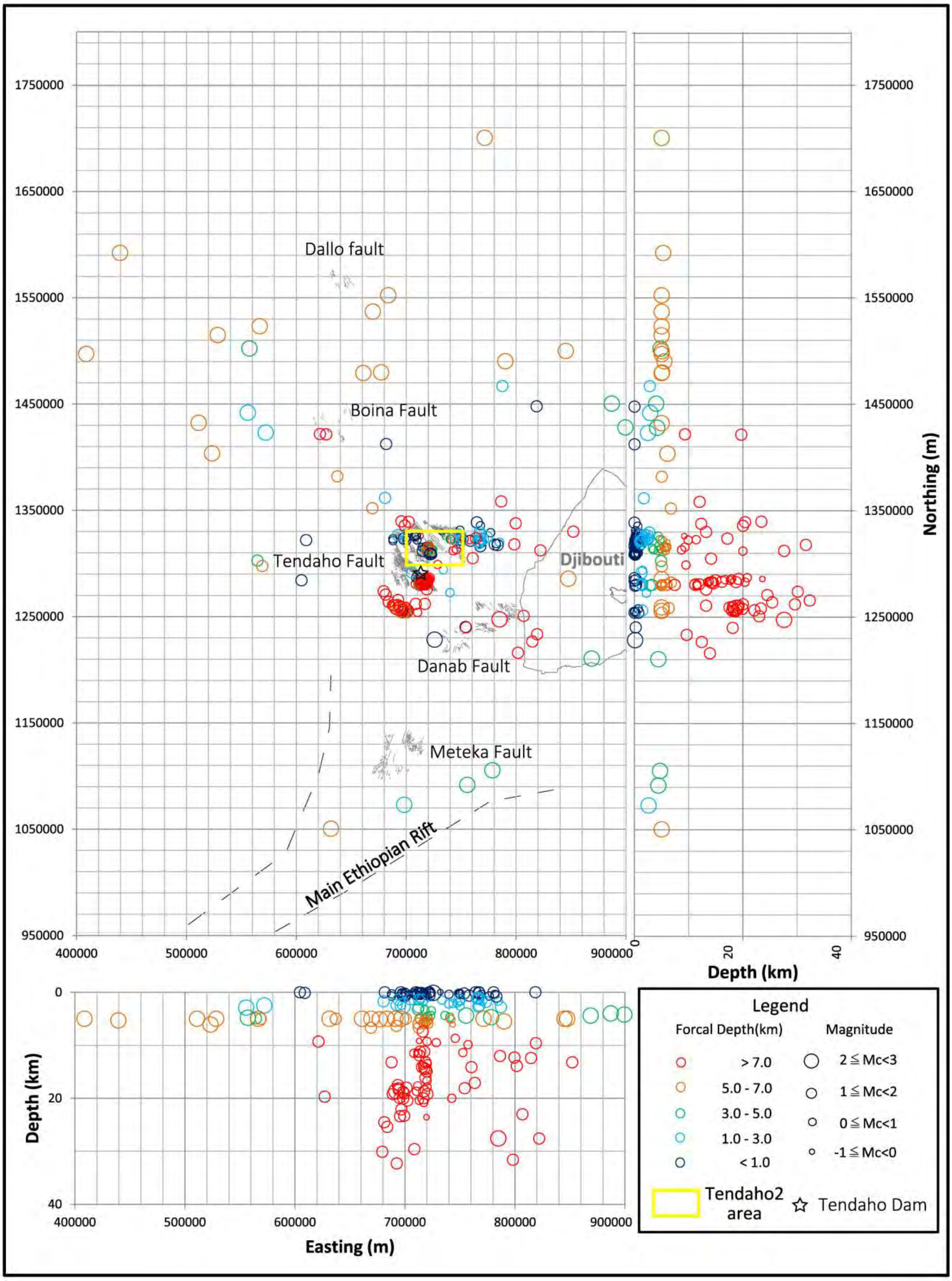

Figure A4.1.8 Estimated distribution of earthquakes (distant from the Tendaho 2 Area measurement network)

(4) Map of the distribution of epicenters (relation between epicenters and geology)

The following describes the relation between the estimated epicenters and the geology (Figure

A4.1.9).

- The epicenters on the western side of MST-5 were near pyroclastic flows resulting from eruptions in fissures of recent basalt of the Pleistocene. There were many occurrences of earthquakes near the faults.
- Fumarole belts were confirmed near stations MST-3 and MST-5, and epicenters were distributed in these fumarole belts.
- Earthquakes occurred in the vicinity of the Manda-Harraro Rift Valley.
- Estimated epicenters on the eastern side of fault F0 were distributed in lacustrine deposits.
- In areas where there were distributions of basaltic lava, pyroclastic rock and sedimentary rock derived from the Afar Stratoid, there were numerous fracture systems that developed, and epicenters were distributed in these fracture systems.

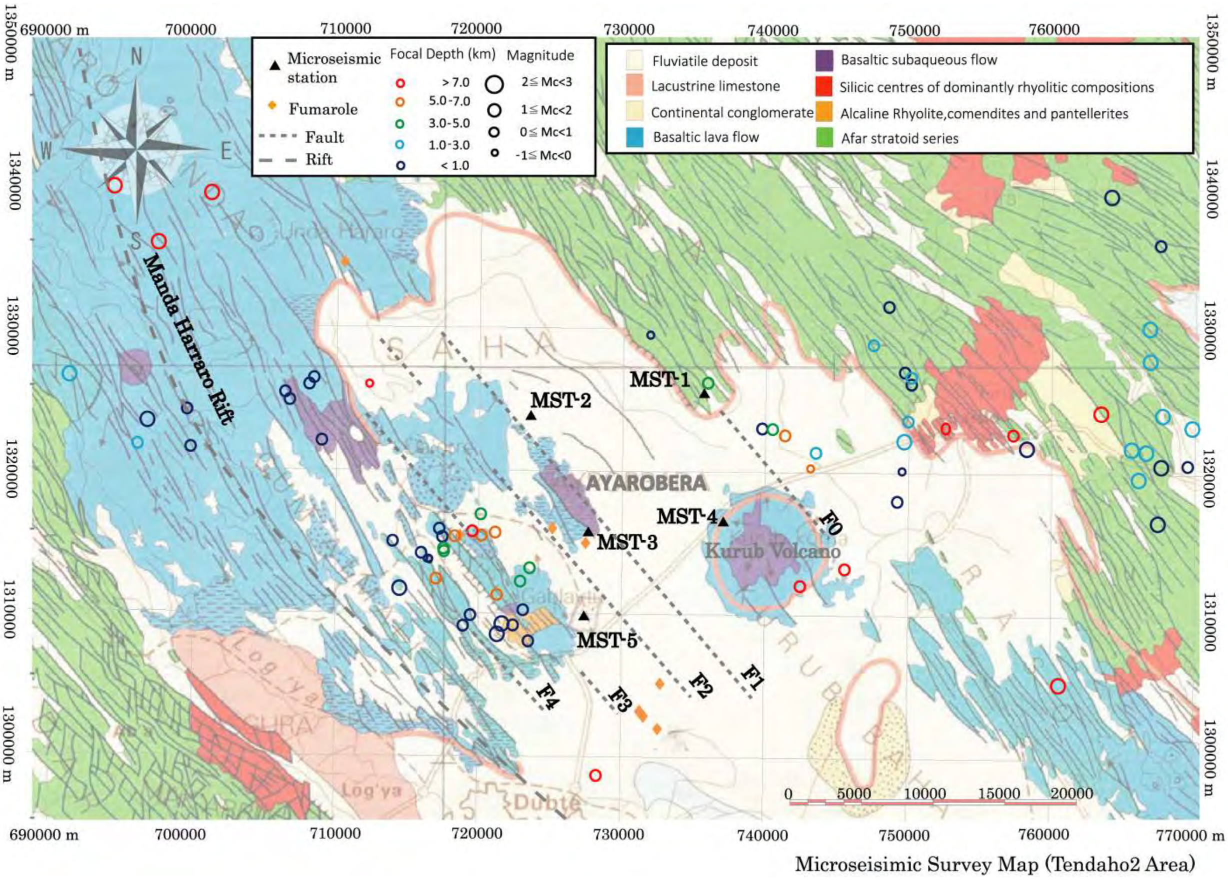

Figure A4.1.9 Distribution of estimated epicenters (geology and epicenters of Tendaho 2 Area)

(5) Cumulative frequency distribution, by magnitude

Based on magnitude, natural earthquakes are classified as follows:

- Ultra-micro earthquakes：M＜1
- Micro-earthquakes：1≦M＜3
- Small earthquakes：3≦M＜5
- Moderate earthquakes：5≦M＜7
- Large earthquakes：7≦M

The magnitudes that were observed in this study showed peaks with a Gaussian distribution at magnitudes of around 0.8～1, with magnitudes ranging from -1.2～2.9 (Figure A4.1.10). In the study area, all natural earthquakes corresponded to ultra-micro or micro-earthquakes.

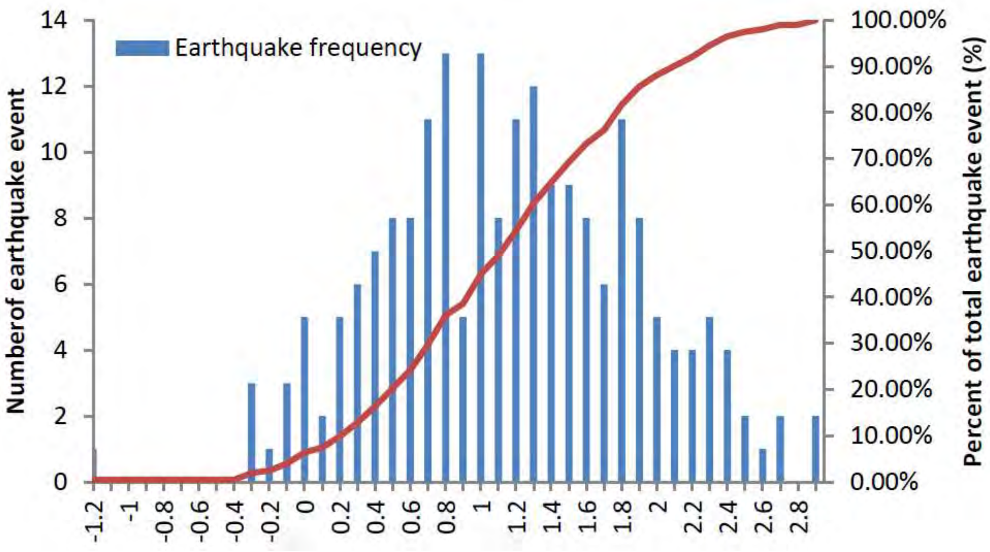

Figure A4.1.10 Distribution of frequency by magnitude (Tendaho 2 Area)

(6) b values

The seismological meaning of b values was described by Yasuhiro Umeda (2014) as follows. A b value of 1.0 is normal (over a wide area and a long time, the b value becomes 1.0). However, when the b value is large, the slope of the line becomes steep, and the proportion of small earthquakes is large (for example, series of earthquakes can easily occur in places where the underground structure is complex and uneven). On the other hand, when the b value is small, the proportion of small earthquakes is also small, or there is a high proportion of large earthquakes to small earthquakes (for example, the earth's crust is very hard and large earthquakes sometimes occur).

Figure A4.1.11 shows b values calculated in the present study. The blue dots align in a somewhat straight line from Mc1.5 to Mc2.7. Starting at Mc1.5 the number of small earthquakes falls below the straight line, apparently because the small earthquakes could not be observed, so the small earthquakes that were less than Mc1.5 were removed from the calculations. Large earthquakes greater than Mc2.7 also fall below the straight line, apparently because the observation period was a short 90 days.

The b value in the present observations was estimated to be 1.06, which is close to the b value (0.7-1.0) of normal tectonic earthquakes (Tokuji Utsu, 1977, p133).

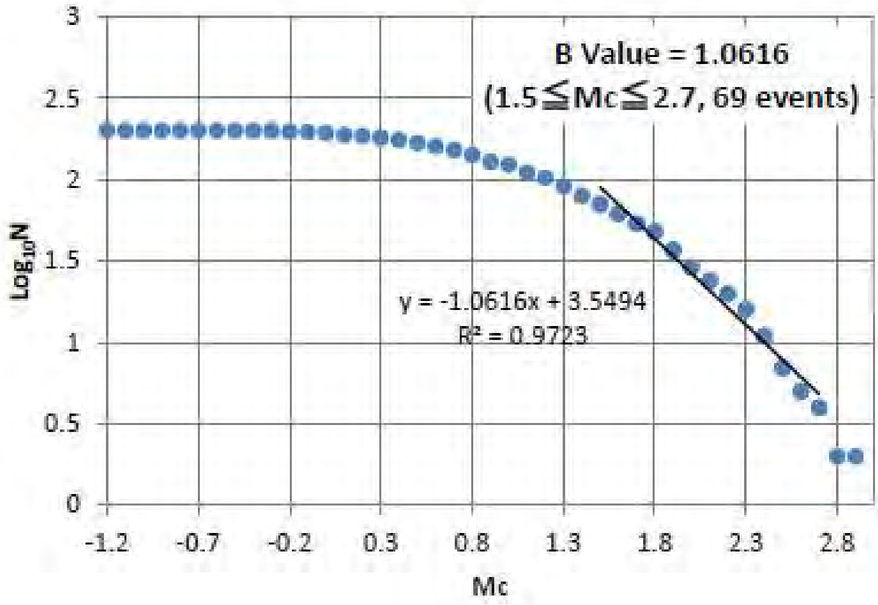

Figure A4.1.11 b values (Tendaho 2 Area)

(7) Wadati diagrams

Evaluations of the Vp/Vs of micro-earthquakes that occur in this area were made using Wadati diagrams. Using the P- and S-wave arrival times from at least 4 stations from which accurate values were obtained from observed earthquakes, a plot was made of each of the stations with the P arrival on the x-axis, and the S-P time on the y-axis (Figure A4.1.12). The gradients of Wadati diagrams related to Vp/Vs were calculated from the running time data from the readings from each station using the least squares method. The Wadati diagrams that were derived based on the seismograms and associated reading values are included in the Appendix.

Table A4.1.5 below shows the Vp/Vs calculated using the earthquake data, and the average value. As a result, an average value of 1.814, which nearly corresponded to the Vp/Vs value of 1.78 that was used in the epicenter calculations, was obtained, and it was concluded that Vp/Vs=1.78 was a suitable value.

Table A4.1.5 Values of Vp/Vs (Tendaho 2 Area)

Event No.	Event origin time	Vp/Vs	Average of Vp/Vs
58	2016.1.11 02:06	1.722	1.814
65	2016.1.15 03:50	1.913	
99	2016.1.22 04:00	1.906	
142	2016.2.12 03:53	1.779	
172	2016.2.29 02:57	1.751	

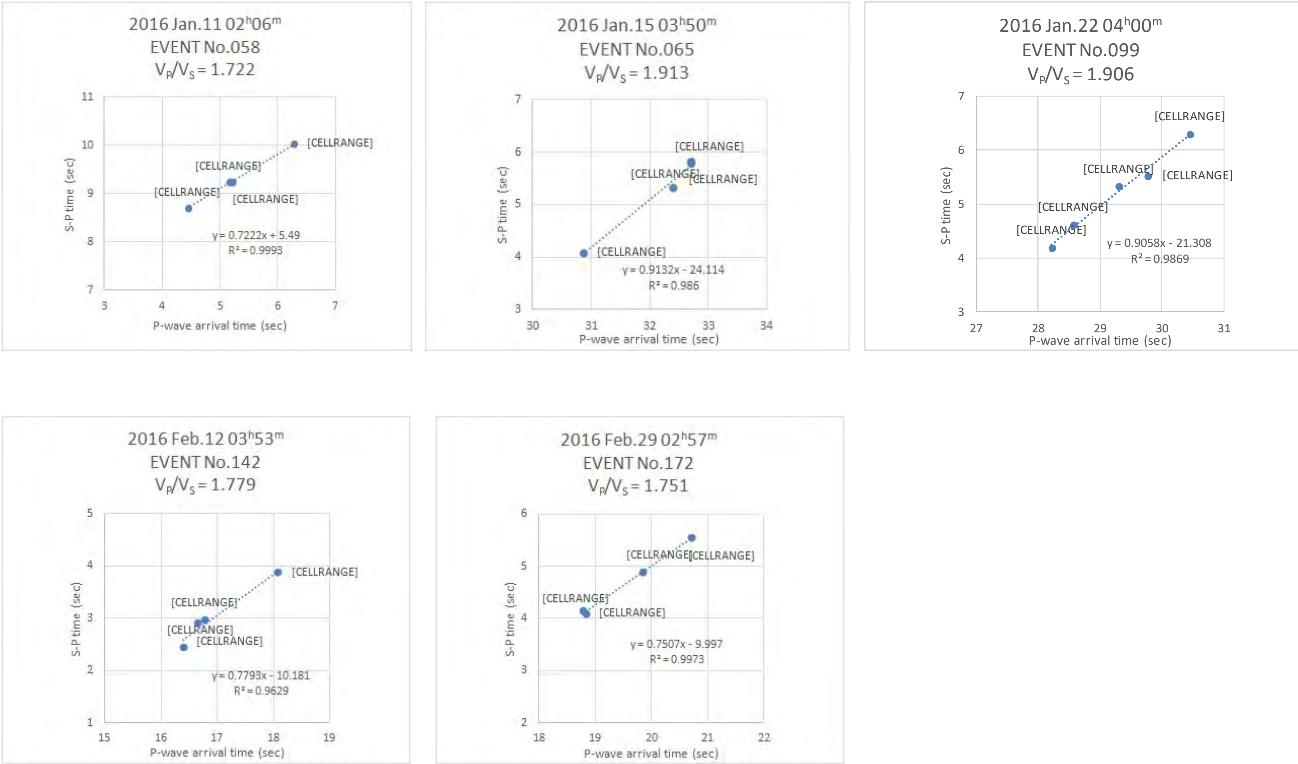

Figure A4.1.12 Wadati diagrams

A4.1.6 Discussion

(1) Relationship with areas of epicenters of earthquakes that occurred in 2009 to 2015

The red dots show the distribution of epicenters in the present study, while the blue dots show the locations of seismic activity from 2009 to 2015. The distribution of earthquakes for 2009~2015 was based on data from micro-earthquake observations made by the Italian foreign ministry in 1995, Earthquake-report.com of the Center for Disaster Management and Risk Reduction Technology (CEDIM), and Earthquake-Report.com of the United States Geological Survey (USGS). However, the data for 2009-2015 are limited to earthquakes of Magnitude 4 or greater that were observed in Ethiopia and Djibouti; the distribution of small- and micro-earthquakes from that time of less than M4 is unknown.

From the figure, we can see that the areas of seismic activity in the 2009-2015 period were around the Ethiopian Rift Valley, and the Hanle district of Djibouti (where observations of micro-earthquakes had been carried out as part of a study to gather and confirm data for geothermal energy development in Djibouti), and were near the Tendaho 2 Area, and the Boina and Tendaho faults.

The locations of epicenters estimated from these observations correspond roughly with the 2009-2015 earthquake distribution. It was determined that seismic activity is occurring in this wide area, which includes Tendaho 2 Area.

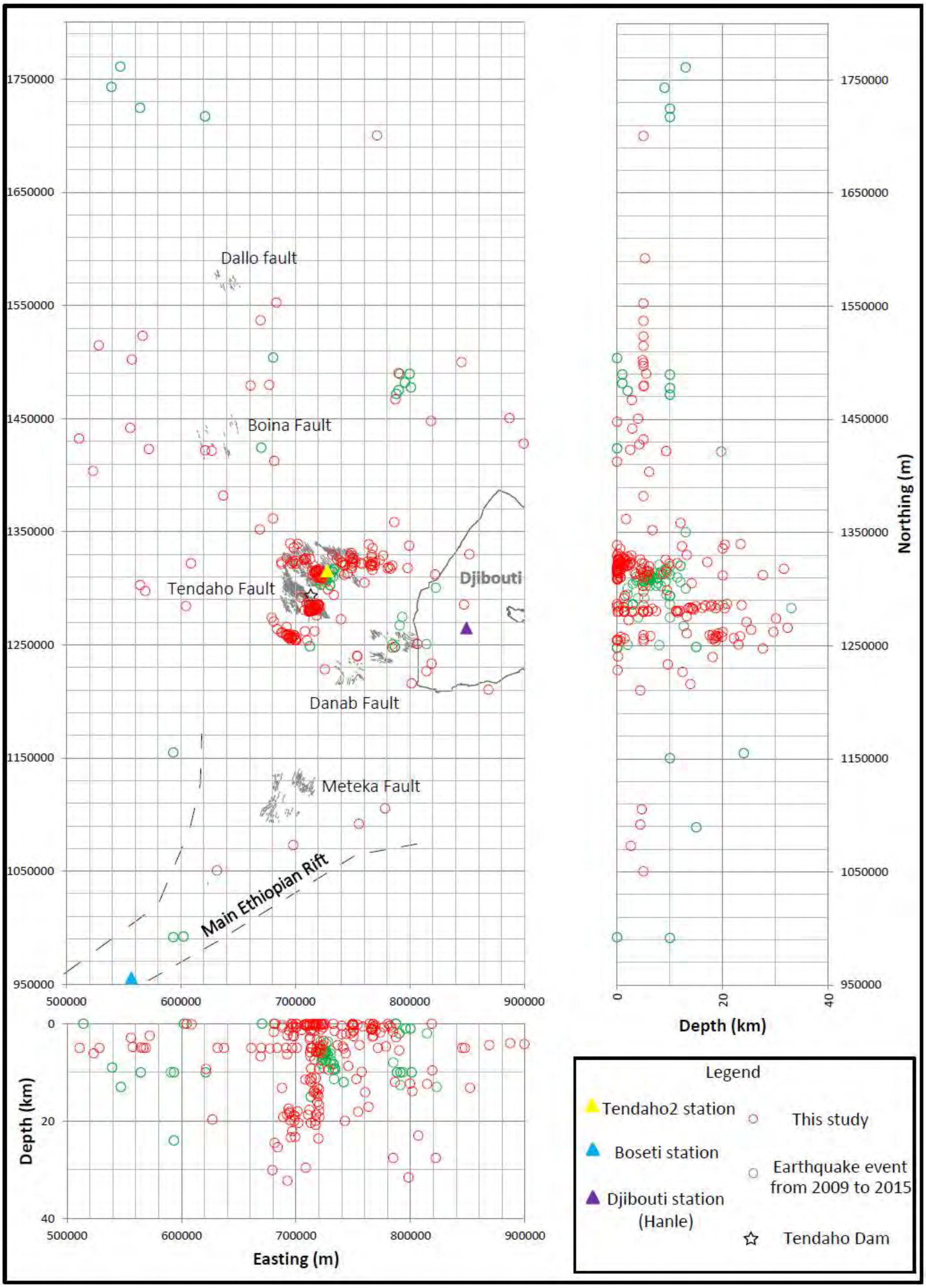

Figure A4.1.13 Estimated distribution of earthquakes (M4 or greater) in 2009-2015 and estimated distribution of earthquakes in the present study

(2) Comparison between the rate of seismic activity in the Afar region and the results from the present measurements

According to Ayele et al, (2015), seismic activity in the Afar region includes a series of earthquakes (yellow stars) that occurred in 1969 in the Tendaho Dam area (Figure A4.1.14). In addition, assuming the Dobi and Guma rift valleys that are in the central part of the Afar region as epicenters, there were several hundred earthquakes that occurred. Dobi is the name of a town that is about 15km south of microseismic station MST-5.

Table A4.1.6 Comparison between the rate of seismic activity in the Afar region and the results of the present study

Region of seismic occurrence	Rate of seismic activity (Ayele et al, 2015)	Results of the present study
Tendaho Dam area	- A series of earthquakes occurred in March and April 1969	- A series of earthquakes occurred on January 21~23, 2016 - Depth was about 20km, magnitude was 2～3
Dobi,Guma Rift	- Numerous earthquakes (MS4.5~6.5) occurred from August 20 to 22, 1989	- Earthquakes were observed near Dobi

Earthquakes in the present study area usually occurred where there was movement of faults or on the Afar rift valleys, and seismic and volcanic activity appears to have a close relation with these faults and valleys. In addition, it is said that in the geothermal region, earthquakes occur mainly due to slippage of fissures and cracks. Therefore, the epicenters estimated in the present study appear to have occurred near faults, which seems to provide supporting evidence for seismic activity near the faults.

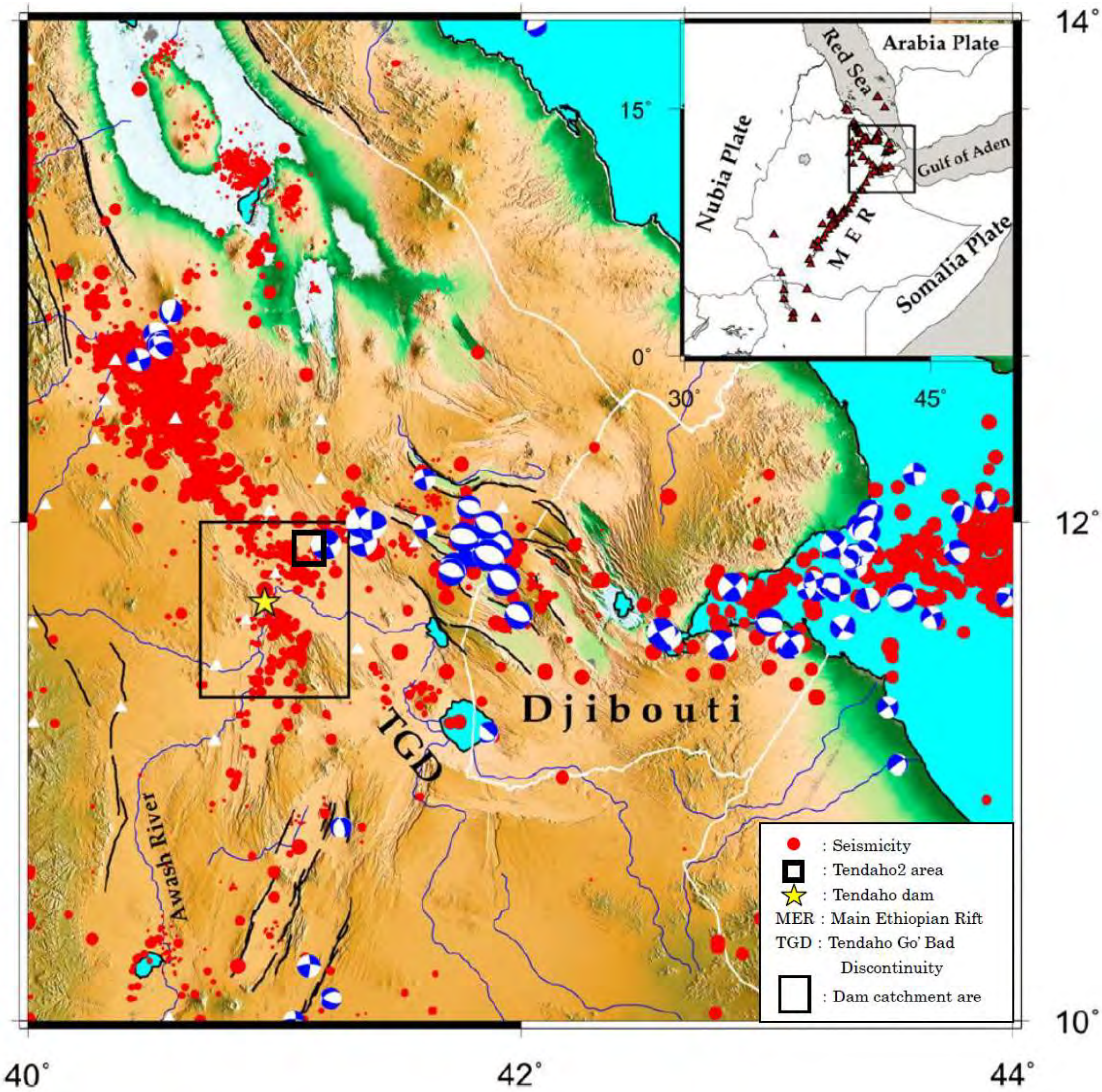

Figure A4.1.14 Seismic activity in the Afar region

(3) Relationship between subterranean heat and micro-earthquakes

In Tendaho 2 Area, faults F0~F4 are aligned in a NW-SE orientation, and numerous fumaroles can be confirmed between faults F2 and F4. Earthquakes are concentrated around faults and fumaroles. The depths of these earthquakes can be divided into 1km or shallower, and 3km～6km groups, and it appears that the depth of earthquake occurrence may be due to the relationship with geothermal fluids. In addition, from the positional relationship between the fumarole zone and areas of frequent earthquake occurrence, it is estimated that areas of frequent occurrence correspond to areas where geothermal liquids are rising. Areas where earthquakes are concentrated have a particularly high possibility of indicating the development of fissures.

(4) Comparison with past calculated b values

In order to evaluate the seismic activity of the area around the Tandaho Dam, Ayele et al (2015), using the same method as Keir et al (2006), determined the magnitude (ML) for 5320 earthquakes that had occurred in that region from 2009 to 2011. As a result, their b value was 0.79±0.01.

The b value in the present study is 1.06, which is slightly higher than that calculated by Ayele et al. (2015), but it is a normal value for tectonic earthquakes.

A4.1.7 Summary

The following is a compilation of the characteristics of micro-earthquakes that occur in Tendaho-2 Area:

Table A4.1.7 Characteristics of epicenter distribution

Item	Characteristics
Earthquakes	・Earthquakes occur near faults and correspond with the positions of previous earthquake observations. These earthquakes are thought to occur in conjunction with the release of stress along these faults. ・The depths of earthquakes between faults F2 and F4 are divided into 1km or shallower, and 2km～6km. They are micro-earthquakes of magnitude 0～1. ・Earthquakes between faults F2 and F4 roughly correspond with areas of fumarole activity. It is estimated that there is seismic activity directly below the fumaroles. ・The magnitudes of all earthquakes whose epicenters were calculated, ranged from -1.2～2.8, corresponding to micro-earthquakes or ultra micro-earthquakes. ・The b value calculated in the present study was 1.06, which is roughly the same as the value of 1.0 for a normal tectonic earthquake. ・A Vp/Vs value of 1.814 was derived from the gradient of the Wadati diagram, which was nearly the same value as the Vp/Vs=1.78 that was used in the epicenter calculations
Geology	・Epicenters near MST-5 were near what appear to be pyroclastic flows resulting from eruptions of fissures of recent basalt of the Pleistocene, and the epicenters were near faults. ・Epicenters are distributed in areas where fracture systems of basaltic lava, pyroclastic rock, and sedimentary rock derived from Afar Storatoid developed. ・Earthquakes are concentrated between Afar rift valleys, and it appears that there is a close relationship between these faults and seismic and volcanic activity.
Geothermy	・Earthquakes are concentrated around faults and fumaroles. ・The depths of these earthquakes can be divided into 1km or shallower, and 3km～6km groups, and it appears that the depth of earthquake occurrence may be due to the relationship with geothermal fluids. ・The positional relationship between the fumarole zone and areas of frequent earthquake occurrence, it is estimated that areas of frequent occurrence correspond to areas where geothermal liquids are rising.

A4.2 3.2 Boseti Area

A4.2.1 Purpose of the observations

Figure A4.2.1 shows the location of a seismometer installed for observing micro-earthquakes

Because the purpose is to confirm whether or not earthquakes occur in the Boseti area, one micro-seismic station was set up to observe micro-earthquakes.

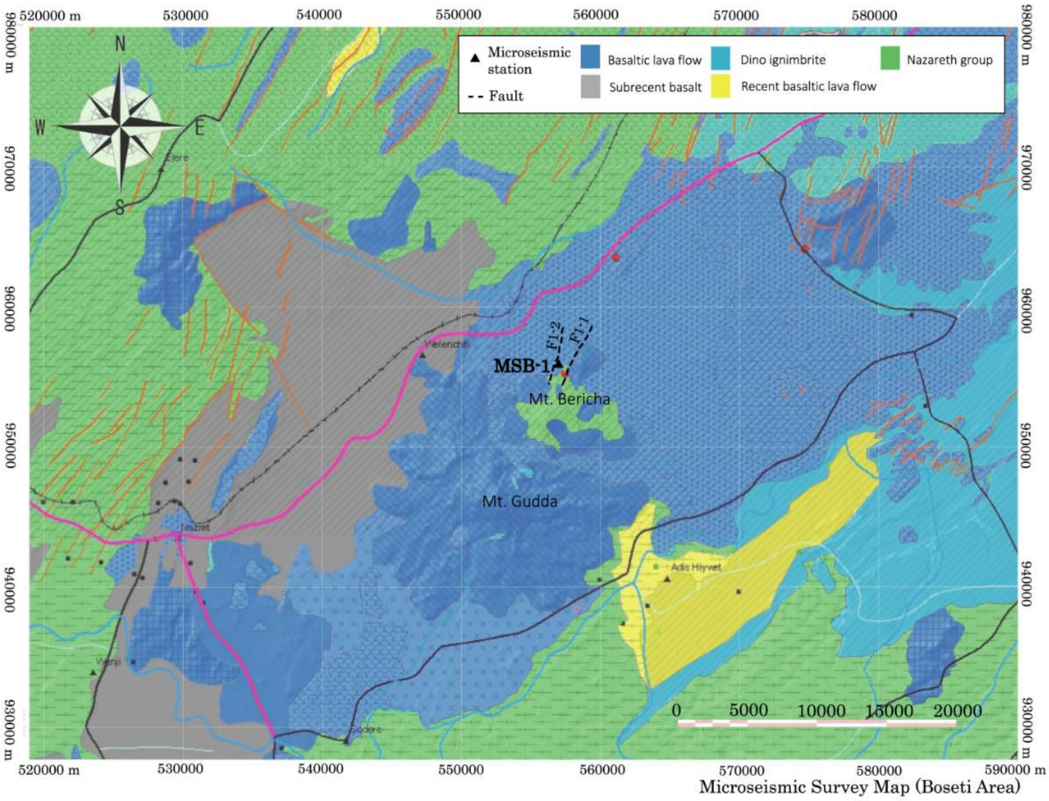

Figure A4.2.1 Location of the micro-seismic station (Boseti Area)

A4.2.2 Overview of the geology

According to the Final Report of the Survey Project for Formulating a Master Plan for Geothermal Power Development (2015), the Boseti Area is located in the center of the Ethiopian Rift Valley that developed along a NE-SW direction, and NE-SW oriented fracture systems have developed in the interior of the rift valley. The basement rock, which is composed of basalt, is covered by volcanic ejecta, which itself is covered by basalt, rhyolite lava and pyroclastic rock belonging to the Nazereth formation. Geothermal signs include fumerolic gas, hot springs, etc., along a fault fracture zone (F1-2, F1-1) that passes through an area near the summit of Mt. Bericha

A4.2.3 3.2.3 Overview of the surveys

The contents of the surveys in the present study were as follows:

(1) Selection of micro-seismic station

The microseismic station was set up on the northern foot of Mt. Bericha. Ground noise was measured, and a seismometer was installed at a place on a small lava bed where noise was low. The area around the microseismic station had many fumaroles, and the seismometer was set up a few tens of meters away from a fumarole.

(2) Data acquisition system
The observation equipment was a system consisting of a LE-3Dlite Mk seismometer made by Lennartz Electronic GmbH of Germany, and a GSX-3 data logger and a 12V battery made by Geospace of the United States.

(3) Installation of the seismometer and peripheral equipment
The seismometer used to measure noise levels in the Boseti Area had 3 components: a N-S component, an E-W component, and an Up-Down component. Table A4.2.1 lists the coordinates, the elevation, and the noise level of the site where the seismometer was installed.

Table A4.2.1 Overview of the seismometer installation (Boseti Area)

Station No.	Longitude	Latitude	UTM (easting)	UTM (northing)	Elevation (m)	Ground noise (µkine)
MSB-1	39° 31′ 01.5″ E	8° 38′ 50.5″ N	955906	556889	1356	40

(4) Protection of measuring equipment and theft prevention measures
As with Tendaho Area 2, the state of the observation equipment was regularly checked by staff of the Survey team. Furthermore, to prevent theft of the equipment, two watchmen were posted, one in the daytime and one at night.

(5) Observation period
The observation period in the Boseti Area was 93 days. During that period, there was no trouble with the equipment, etc. Table A4.2.2 shows temporal information about the observations.

Table A4.2.2 Installation of a seismometer at the micro-seismic station and date of removal (Boseti Area)

Site Code	Measurement start time	Measurement stop time	Measurement period
MSB-1	2015.12.24 17:50	2016.3.26 9:50	93days and 16hours

A4.2.4 3.2.4 Processing of measurement data

(1) Processing of measurement data
The processing of the seismic measurement data was done simultaneously with the data from the 5 Tendaho Area 2 stations (6 stations in all). From the integrated waveform observation data, areas with seismic waves were sorted by eye, and areas with seismic waveform were removed.

(2) Reading and organizing the records

From the waveform data in SEG-D format, readings were made of P-wave and S-wave arrival time data that were determined to be from earthquakes.

A4.2.5 Survey results

As a result of the 93 days of micro-earthquake observations, 230 earthquakes were confirmed. However, because there was only one micro-seismic observation station, epicenters were not calculated.

The survey results are compiled into Figure A4.2.2 (the frequency of earthquake occurrence by day), and Figure A4.2.3 (the frequency of earthquake occurrence by S-P time),

(1) Distribution of the frequency of earthquake occurrence by day

During the observation period, 230 earthquakes (average 2.4/day) were observed. The largest concentrations of earthquakes occurred on January 8 (13 events) and March 6 (43 events).

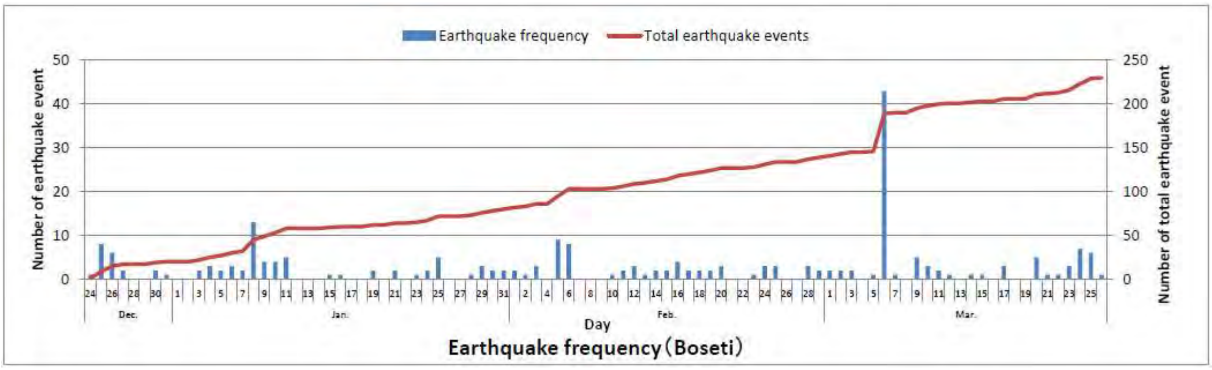

Figure A4.2.2 Distribution of the frequency of earthquake occurrence by day (Boseti Area)

(2) The frequency of earthquake occurrence by S-P time

The overwhelming majority S-P times of earthquakes lasted less than 4 seconds, accounting for more than half of all earthquakes. Especially noticeable are the 73 local earthquakes (average 0.7/day) with S-P times of 2 seconds or less. This was the result of the occurrence of a series of quakes on March 6.

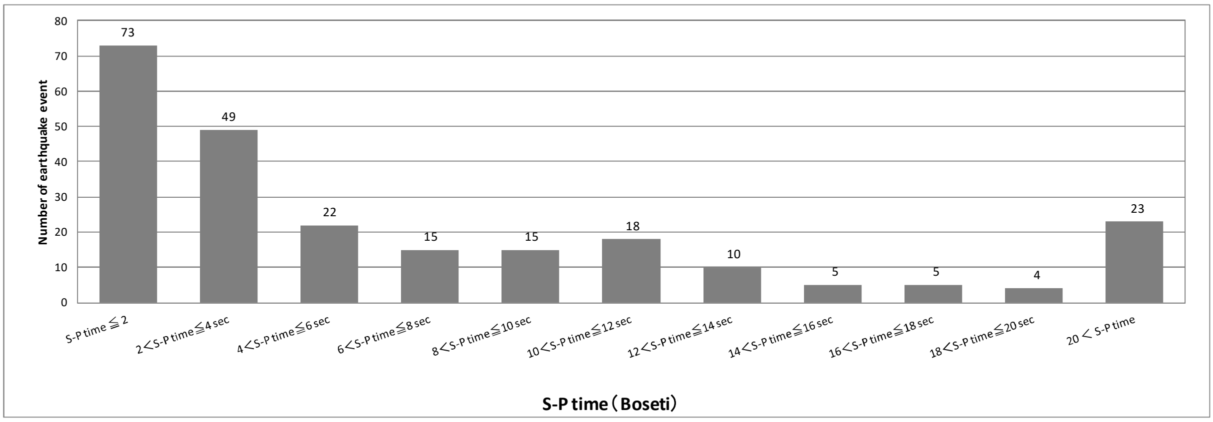

Figure A4.2.3 The frequency of earthquake occurrence by S-P time (Boseti Area)

A4.2.6 Discussion

(1) Relationship with past epicenter distributions

Based on seismic observations that have been conducted up to this point, the vicinity of faults in places such as the Ethiopian Rift Valley have been judged to be zones of high earthquake occurrence . The distribution of epicenters is along the same NE-SW orientation, and micro-earthquakes with a magnitude of 3 or less are dominant (Ayele et. Al, 2015). In addition, many fumaroles have been found in fissures around the summit of Mt. Bericha, and it appears that the temperature increases as one approaches the center of the mountain (Final Report of the Survey Project for Formulating a Master Plan for Geothermal Power Development (2015)).

In this area, earthquake observations have indicated that there are many local earthquakes with an S-P time of 2 seconds or less. These local earthquakes are thought to occur in faults near the Boseti Area, and in places where there are sudden changes in underground tectonics in highly uneven crust.

A4.2.7 Summary

The following table lists characteristics of seismic movements in the Boseti Area

Table A4.2.3 Characteristics of epicenter distribution (Boseti Area)

Item	Characteristics
Earthquakes	・Small-scale earthquakes occur in this area ・During the 93-day observation period, 230 earthquakes (average of 2.4/day) were observed. ・Local earthquakes with an S-P time of 4 seconds or less were concentrated on January 8 and March 6 ・Earthquakes with an S-P time of 4 seconds or less accounted for more than half of all quakes. Of particular note, there were 68 local earthquakes with an S-P of 2 seconds or less (average of 0.7/day).
Geology	・Earthquakes are thought to occur in places where there are faults near the study area, sudden changes in tectonic structure, etc. ・There is a possibility that earthquakes may occur in fumarole areas.

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APPENDIX-5

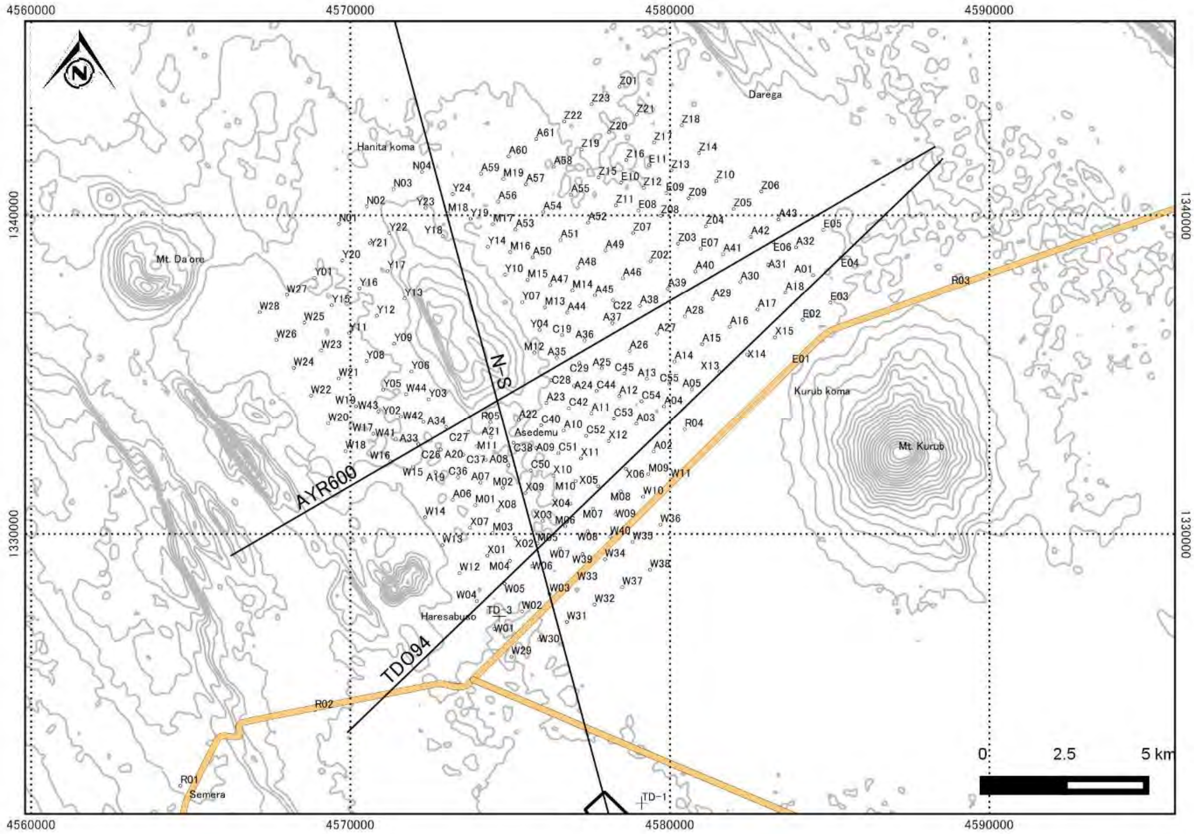
Temperature Survey

Appendix-5 Temperature Survey

A5.1 Methodology

(1) Survey Area

Figure A5.1.1 shows the survey area and stations of temperature survey. Underground temperature were measured at 220 stations, and 5 reference stations were set and measured every day during survey period for verifying seasonal variation of underground temperature.



Source: JICA Survey Team

Figure A5.1.1 Location Map of Temperature Survey

(2) Procedure

The survey was excited following procedure below. Figure A5.1.2 shows pictures of the survey.

- Drill up to 30 ~ 50cm in depth by engine auger (φ40mm).
- Install a stainless-steel probe (total length=2.2m, outside diameter=13.8mm using electric hammer up to 2.0m in depth. Coordinates of installation points are recorded by mobile GPS device.
- In case that it was not possible to drill up to 2.0m in depth due to hit with gravels, installation points were shifted a few meter, and probe was drilled again.
- On the following day after probe installation (about 17 hours later), underground temperature of 0.5m, 1.0m, 1.5m 2.0m in depth is measured with a thermistor thermometer.
  Time for temperature equilibrium condition after installation of probe is verified as showing below.
- After measurement of underground temperature, installed probe is pulled out by hydraulic jack.

	
Drill by engine auger (0.3~0.5m in depth)	Drill by probe (2.0m in depth)
	
Measurement of underground temperature	Pull-out by hydraulic jack

Source: JICA Survey Team

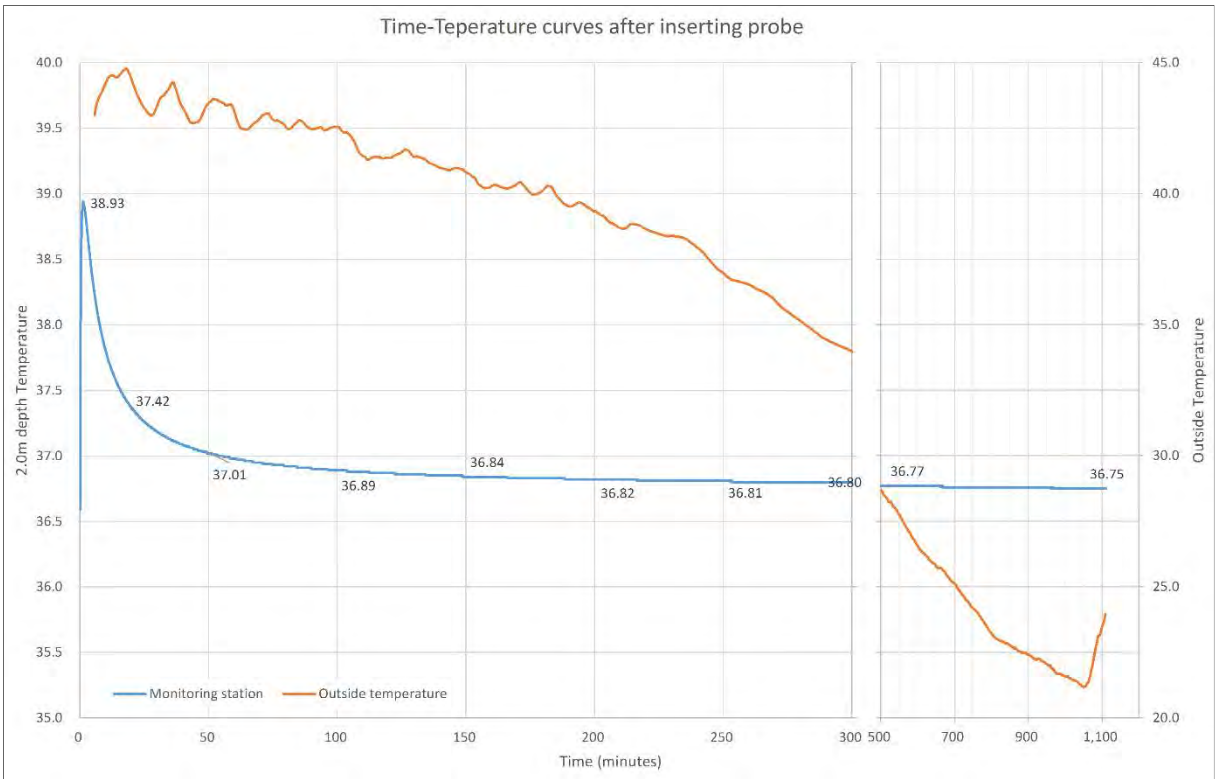
Figure A5.1.2 Photographs of Temperature Survey

(3) Temperature Equilibrium

2.0m depth temperature was measured continuously just after drilling and installation of probe, and time for temperature equilibrium was verified.

Figure A5.1.3 presents variation of 2.0m depth temperature just after probe installation. Temperature was high just after prove installation because of frictional heat by the installation, but temperature equilibrium can be verified after around 3 hours. As seasonal variation is confirmed maximum 0.13°C/day and average -0.028°C/day during the survey period as mentioned below, very small decrease of underground temperature was confirmed even in the equilibrium condition

In this survey, the measurement was conducted on the following day after probe installation considering working efficiency. Accordingly, the measurement has been done after more than 17 hours passed from prove installation and underground temperature completely reached equilibrium condition.



Source: JICA Survey Team

Figure A5.1.3 Variation of 2.0m-depth Temperature after Probe Installation

(4) Diurnal Variation

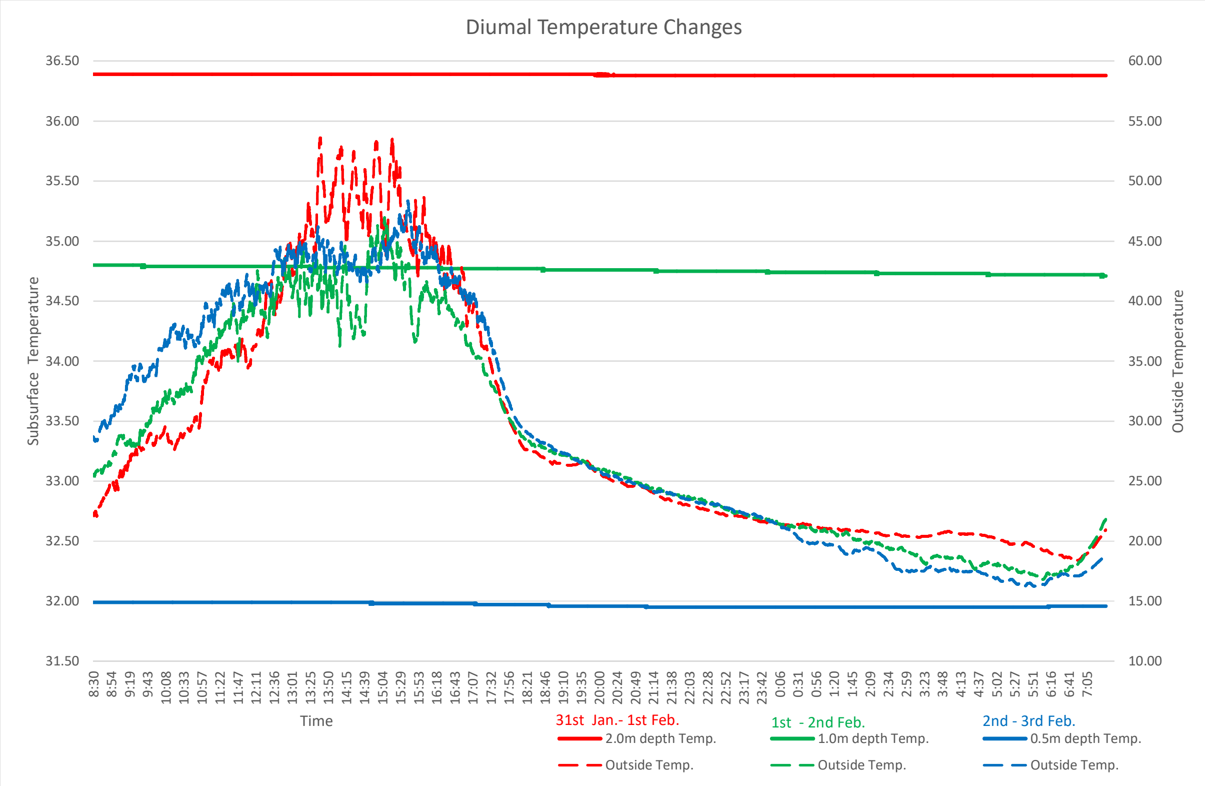
In order to verify effect on underground temperature by solar insolation and outside air temperature, diurnal variation of underground temperature at 0.5m to 2.0m in depth was monitored. The diurnal variation was measured around the clock at the reference points which is located on almost same latitude and elevation as the survey station.

Table A5.1.1 and Figure A5.1.4 presents the survey results. Diurnal variation of 2.0m-depth temperature is very small and about 0.01°C. Temperature at 1.0 in depth had decreased 0.09°C, but doesn't have correlation with variation of outside air temperature. Variation of underground temperature at 0.5m in depth is very small, but variation trend including temperature decrease with sunset and increase with sunrise can be confirmed. Therefore, similarly to the past study (e.g. Coolbaugh et al. 2007), 2.0m-depth temperature is not affected by solar insolation and outside air temperature.

Table A5.1.1 Diurnal Variation Monitoring Result (°C)

Depth	Maximum	Minimum	Difference
0.5m	31.99	31.95	-0.04
1.0m	34.80	34.71	-0.09
2.0m	36.39	36.38	-0.01

Source: JICA Survey Team



Source: JICA Survey Team

Figure A5.1.4 Diurnal Variation of Underground Temperature

(5) Correction by Seasonal Variation

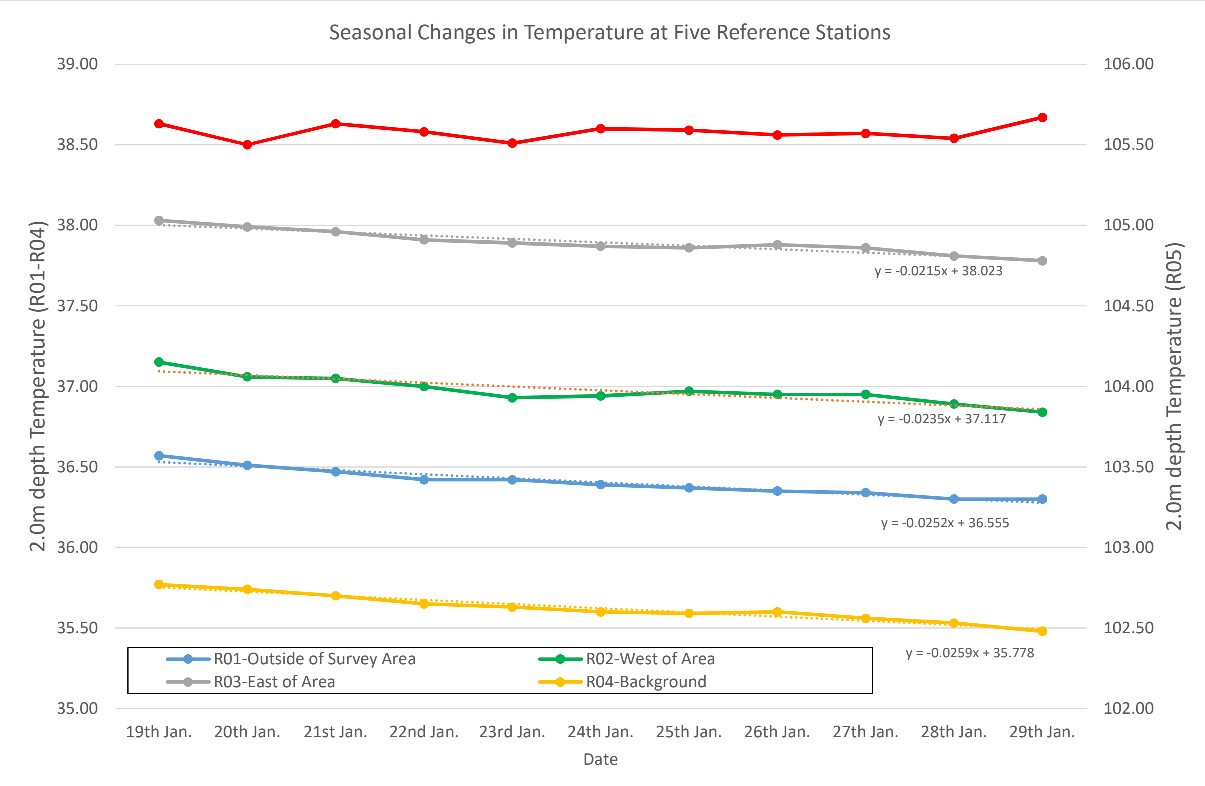
The temperature survey was conducted for 12 days from 18th to 29th January, 2016. In order to set the correction value for the measurement result by seasonal variation for 12 days, 2.0m-depth temperature at the reference points located in and out survey area were measured every day during the survey period, and temperature variation for 12 days was clarified.

Figure A5.1.5 shows a graph of temperature variation for 12 days. It is confirmed that temperature has been decreased from the beginning to the end of the survey period at all reference points except for R05 located in fumarole area. Because the survey was completed foe a very short period, decrease is very small, maximum 0.31°C and averaged -0.024°C as shown in Table A5.1.2. The correction value for seasonal variation was set based on this data, and all measurement data were corrected to the first measurement gay (19th January, 2016). As the correction value is so small that the data don't have huge difference before and after the correction.

Table A5.1.2 Measured Temperature at Reference Points (°C)

Sta. No.	Average	Maximum	Minimum	Difference
R01	36.40	36.57	36.30	0.27
R02	36.98	37.15	36.84	0.31
R03	37.89	38.03	37.78	0.25
R04	35.62	35.77	35.48	0.29
R05	105.58	105.67	105.50	0.17

Source: JICA Survey Team



Source: JICA Survey Team

Figure A5.1.5 Variation of 2.0m-depth Temperature during Survey Period

A5.2 Survey Result

Measurement Data of 2.0m-depth Temperature Survey are shown below.

Table A5.1.3 Measurement Data of 2.0m-depth Temperature Survey (1)

S.No.	Cordinates		Day	Time	Outside	Subsurface Temperature				Ground Type	Vegetation	Other
	X	Y	dd.mm.yy	HH:MM	Temp.	2.0m	1.5m	1.0m	0.5m	Soil/Gravel/Rock	Yes/No	
A01	737757	1320125	19.01.16	2:02	39.9	37.04	36.68	36.14	35.47	Soil	No	
A02	732916	1314692	22.01.16	2:32	32.2	37.23	36.69	35.83	34.83	Soil	No	
A03	732381	1315537	22.01.16	10:48	34.4	39.29	38.32	36.9	35.36	Soil	No	
A04	733225	1316072	22.01.16	11:16	35.55	38.74	38.28	37.56	36.34	Soil	No	
A05	734070	1316607	22.01.16	11:55	34.45	36.71	36.22	35.89	35.14	Soil	No	
A06	726777	1313170	21.01.16	11:59	35.67	41.39	40.61	39.01	37.05	Soil	No	
A07	727622	1313705	21.01.16	1:08	34.64	49.57	45.85	43.08	40.14	Soil	No	
A08	728467	1314240	21.01.16	1:29	34.23	54.97	51.94	47.05	41.39	Soil	No	
A09	729311	1314776	21.01.16	1:58	36.69	52.63	49.73	45.71	41.17	Soil	No	
A10	730158	1315311	19.01.16	9:45	30.8	46.05	44.25	41.62	38.26	Soil	No	
A11	731003	1315847	19.01.16	10:16	30.5	40.2	39.24	38.06	36.53	Soil	No	
A12	731848	1316381	19.01.16	10:41	33.4	38.18	37.13	36.02	34.91	Soil	No	
A13	732693	1316916	19.01.16	11:09	35.5	36.91	36.21	35.41	34.35	Soil	No	
A14	733535	1317450	19.01.16	11:32	34.8	36.21	35.69	34.85	33.94	Soil	No	
A15	734379	1317985	19.01.16	11:56	35.1	36.19	35.83	35.31	34.72	Soil	No	
A16	735219	1318523	19.01.16	12:25	37.7	37.59	37.12	36.58	35.65	Soil	No	
A17	736069	1319056	19.01.16	12:48	38.5	37.78	37.41	36.81	36.06	Soil	No	
A18	736913	1319590	19.01.16	1:36	39.1	38.65	38.27	37.55	36.66	Soil	No	
A19	726242	1314015	21.01.16	11:27	32.56	45.66	43.42	40.71	36.96	Soil	No	
A20	727087	1314550	21.01.16	12:39	35.41	63.96	58.22	51.82	45.15	Soil	No	
A21	727931	1315085	19.01.16	11:03	33.36	53.15	49.82	46.6	43.38	Soil	No	
A22	728776	1315620	19.01.16	11:40	35.3	50.92	48.07	44.7	40.57	Soil	No	
A23	729621	1316156	19.01.16	11:59	35.64	46.36	44.04	41.32	38.5	Soil	No	
A24	730465	1316691	19.01.16	12:16	38.72	38.76	38.06	37.06	35.6	Soil	No	
A25	731310	1317226	19.01.16	12:24	38.61	37.4	36.82	36.1	35.1	Soil	No	
A26	732155	1317762	19.01.16	12:44	37.93	36.49	36.11	35.57	34.76	Soil	No	
A27	732999	1318297	19.01.16	12:59	38.89	36.39	35.8	35.05	34.33	Soil	No	

Source: JICA Survey Team

Table A5.1.3 Measurement Data of 2.0m-depth Temperature Survey (2)

S.No.	Cordinates		Day	Time	Outside	Subsurface Temperature				Ground Type	Vegetation	Other
	X	Y	dd.mm.yy	HH:MM	Temp.	2.0m	1.5m	1.0m	0.5m	Soil/Gravel/Rock	Yes/No	
A28	733844	1318832	23.01.16	10:04	31.25	35.53	35.16	34.69	34.16	Soil	No	
A29	734689	1319367	19.01.16	1:28	37.08	36.99	36.57	35.95	35.01	Soil	No	
A30	735533	1319903	19.01.16	2:09	36	38.16	37.77	37.17	35.99	Soil	No	
A31	736378	1320438	19.01.16	2:27	36.71	37.58	37.12	36.45	38.12	Soil	No	
A32	737225	1320972	19.01.16	2:17	37.85	38.98	38.61	38.02	37.16	Soil	No	
A33	725707	1314859	21.01.16	10:45	32.25	49.92	46.13	41.83	39.02	Soil	No	
A34	726551	1315395	21.01.16	10:14	29.36	43.9	42.6	40.61	38.39	Soil	No	
A35	729930	1317536	20.01.16	10:23	39.69	41.3	40.34	39.09	37.17	Soil	No	
A36	730778	1318067	20.01.16	10:40	30.86	37.88	37.04	35.93	34.27	Soil	No	
A37	731619	1318606	20.01.16	11:02	32.09	37.98	37.32	36.5	35.24	Soil	No	
A38	732464	1319141	20.01.16	11:21	33.09	36.27	35.67	34.89	34.07	Soil	No	
A39	733309	1319677	20.01.16	11:00	31.1	35.4	34.96	34.36	34.62	Soil	No	
A40	734153	1320212	20.01.16	10:23	31.1	35.53	35.07	34.35	33.23	Soil	No	
A41	734998	1320747	20.01.16	10:00	39.7	38.47	38	37.21	36.43	Soil	No	
A42	735843	1321283	20.01.16	9:31	39.4	36.98	36.57	36.01	35.33	Soil	No	
A43	736687	1321818	20.01.16	9:05	27.4	35.93	35.36	34.72	33.8	Soil	No	
A44	730239	1318916	20.01.16	12:18	33.5	38.1	37.36	36.23	34.95	Soil	No	
A45	731084	1319451	20.01.16	11:55	32.8	37.21	36.58	35.68	35.63	Soil	No	
A46	731932	1319985	20.01.16	11:32	33.6	36.65	36.08	35.31	34.44	Soil	No	
A47	729704	1319760	20.01.16	12:39	36.1	36.98	36.36	35.64	34.67	Soil	No	
A48	730549	1320296	20.01.16	1:19	36.8	37.47	36.92	36.13	35.02	Soil	No	
A49	731394	1320831	20.01.16	1:50	38.3	37.15	36.49	35.77	34.98	Soil	No	
A50	729169	1320605	21.01.16	9:43	29.5	36.87	36.34	35.65	34.8	Soil	No	
A51	730014	1321140	21.01.16	9:21	27.2	37.01	36.39	35.42	34.32	Soil	No	
A52	730858	1321676	21.01.16	8:52	26.8	37.61	37.06	36.3	35.35	Soil	Yes	
A53	728634	1321450	26.01.16	1:42	37.89	36.87	35.94	34.57	33.8	Soil	No	
A54	729476	1321987	21.01.16	10:12	31.2	37.9	37.4	36.51	35.5	Gravel	No	
A55	730323	1322520	21.01.16	10:48	33.1	37.19	36.7	35.94	35.27	Soil	No	
A56	728098	1322294	21.01.16	2:37	36.5	39.02	38.56	37.7	36.48	Gravel	No	
A57	728943	1322830	21.01.16	12:09	32.5	37.29	36.72	35.94	35	Soil	No	
A58	729788	1323365	21.01.16	11:23	34.2	35.48	35.03	34.42	33.55	Soil	No	
A59	727563	1323139	21.01.16	12:37	32.2	37.92	37.6	36.96	36.1	Soil	No	
A60	728408	1323674	21.01.16	1:12	36.4	36.21	35.77	35.22	34.67	Soil	No	
A61	729252	1324210	21.01.16	1:45	35.4	36.37	35.75	35.05	34.22	Soil	Yes	
X01	727848	1311481	22.01.16	10:35	29	42.99	41.65	40.22	38.34	Soil	No	
X02	728692	1312016	22.01.16	11:02	30.1	48.19	45.06	41.87	38.34	Soil	No	
X03	729537	1312551	22.01.16	1:28	36.9	47.76	45.26	42.33	39.3	Soil	No	
X04	730382	1313086	22.01.16	12:57	34.7	48.37	46.29	43.92	40.67	Soil	No	
X05	731227	1313622	22.01.16	12:26	35.7	42.36	41.07	39.4	37.13	Soil	No	
X06	732071	1314157	22.01.16	12:02	34.5	39.52	38.78	37.82	36.38	Soil	No	
X07	727313	1312325	22.01.16	10:08	29.1	41.16	39.8	38	36.2	Soil	No	
X08	728157	1312861	22.01.16	9:25	26	48.65	45.28	41.99	39.12	Soil	No	
X09	729002	1313396	22.01.16	8:52	25.9	48.99	46.24	43.34	40.1	Soil	No	
X10	729847	1313931	22.01.16	8:16	25.1	48.5	45.35	41.76	38.2	Soil	No	
X11	730691	1314466	22.01.16	10:15	29.46	42.72	40.96	39.02	36.54	Soil	No	
X12	731536	1315002	22.01.16	10:31	30.56	40.22	39.06	37.73	36.41	Soil	No	
X13	734915	1317143	22.01.16	12:11	34.2	37.29	36.91	36.3	35.61	Soil	No	
X14	735759	1317678	22.01.16	12:31	36.85	36.89	36.68	36.17	65.49	Soil	No	
X15	736604	1318213	22.01.16	12:46	35.39	38.64	38.17	37.2	36.22	Soil	No	
Y01	722495	1319927	24.01.16	11:05	34.5	39.56	38.61	37.31	35.91	Soil	No	
Y02	725171	1315704	24.01.16	8:20	24.3	51.97	48.62	44.54	40.06	Soil	No	
Y03	726016	1316239	24.01.16	1:15	39.83	44.67	42.62	40.08	37.14	Soil	No	
Y04	729395	1318380	24.01.16	10:03	30.36	39.91	39.32	39.24	38.4	Soil	No	
Y05	724622	1316524	24.01.16	8:54	25.8	41.08	39.42	37.47	33.73	Soil	No	
Y06	725481	1317084	24.01.16	12:54	37.55	41.15	40.1	38.58	36.65	Soil	No	
Y07	728860	1319225	26.01.16	11:11	31.14	38.42	37.81	36.8	35.5	Soil	Yes-sparse	
Y08	724101	1317393	24.01.16	9:25	27.9	44.01	42.43	40.45	37.9	Soil	No	
Y09	724946	1317929	24.01.16	1:08	34.7	44.86	42.66	40.23	37.37	Soil	No	
Y10	728324	1320070	26.01.16	11:38	34.11	40.39	39.5	38.12	36.4	Soil	No	
Y11	723566	1318238	24.01.16	9:55	31.9	41.63	40.01	38.03	35.97	Soil	No	
Y12	724410	1318773	24.01.16	12:39	36.5	42.46	41.16	39.77	36.97	Soil	No	
Y13	725255	1319309	25.01.16	10:09	31.6	41.46	40.59	39.36	37.21	Soil	No	
Y14	727789	1320914	26.01.16	11:52	34.24	38.74	38.07	37.1	35.79	Soil	No	
Y15	723030	1319083	24.01.16	10:25	32.1	40.23	39.18	38.07	36.5	Soil	No	
Y16	723875	1319618	24.01.16	12:13	32.9	42.7	41.07	39.1	36.64	Soil	No	
Y17	724720	1320153	25.01.16	9:35	30.6	39.87	38.49	37.3	35.87	Soil	No	Near fault scarp
Y18	726409	1321224	26.01.16	1:25	38.54	40.67	39.56	38.05	36.4	Soil	Yes-Grass	Near fault scarp
Y19	727254	1321759	26.01.16	12:06	34.78	37.29	36.57	35.38	33.54	Soil	No	
Y20	723340	1320463	24.01.16	11:35	36.8	39.15	38.31	37.34	35.86	Soil	Yes	
Y21	724184	1320998	25.01.16	8:31	26.5	40.61	39.53	38.4	36.63	Soil	No	
Y22	724771	1321306	25.01.16	8:55	28.2	37.82	37.33	36.6	35.36	Soil	No	Near fault scarp
Y23	725877	1322086	26.01.16	12:48	36.6	39.14	38.35	37.42	35.79	Soil	No	
Y24	726701	1322512	26.01.16	12:32	34.42	38.24	37.56	36.47	35.24	Soil	No	

Source: JICA Survey Team

Table A5.1.3 Measurement Data of 2.0m-depth Temperature Survey (3)

S.No.	Cordinates		Day	Time	Outside	Subsurface Temperature				Ground Type	Vegetation	Other
	X	Y	dd.mm.yy	HH:MM	Temp.	2.0m	1.5m	1.0m	0.5m	Soil/Gravel/Rock	Yes/No	
Z01	731786	1325815	23.01.16	8:23	22.9	36.56	36.21	35.67	34.97	Soil	Yes	
Z02	732774	1320521	23.01.16	10:28	31.52	36.03	35.63	35	34.09	Soil	No	
Z03	733618	1321057	23.01.16	10:57	34.6	35.81	35.38	34.82	34.05	Soil	No	
Z04	734463	1321592	23.01.16	11:20	33.17	36.39	36.11	35.56	34.81	Soil	No	
Z05	735308	1322127	23.01.16	11:34	33.72	37.34	36.95	36.32	35.39	Soil	No	
Z06	736152	1322663	23.01.16	11:48	34.42	35.65	35.2	34.7	33.73	Soil	No	
Z07	732238	1321366	23.01.16	1:10	35.06	37.14	36.61	35.75	34.54	Soil	No	
Z08	733083	1321901	23.01.16	12:52	34.77	35.88	35.22	34.3	33.4	Soil	No	
Z09	733928	1322437	23.01.16	12:28	35.73	35.76	35.4	34.89	34.02	Soil	No	
Z10	734772	1322972	23.01.16	12:10	35.1	37.04	36.44	35.58	34.7	Soil	No	
Z11	731703	1322211	23.01.16	1:40	38.7	37.42	36.98	36.29	35.31	Soil	No	
Z12	732548	1322746	23.01.16	2:16	38.1	38.06	37.51	36.78	35.58	Soil	No	
Z13	733392	1323281	23.01.16	1:38	38.37	37.66	37.17	36.54	35.66	Gravel	No	
Z14	734237	1323817	23.01.16	2:04	37.55	36.23	35.7	35.17	34.3	Soil	Yes-shrubs	
Z15	731168	1323055	23.01.16	12:54	36.7	35.77	35.31	34.68	32.65	Soil	No	
Z16	732012	1323591	23.01.16	12:51	34.8	35.26	34.73	34.03	32.94	Soil	No	
Z17	732857	1324126	23.01.16	12:14	33.7	36.34	35.75	35.01	34.12	Soil	No	
Z18	733702	1324661	23.01.16	11:47	34.1	36.4	36.03	35.49	34.67	Soil	No	
Z19	730632	1323900	23.01.16	9:55	29.09	35.65	35.22	34.51	33.39	Soil	Yes	
Z20	731477	1324435	23.01.16	10:34	32.8	34.83	34.29	33.55	32.49	Soil	Yes	
Z21	732322	1324971	23.01.16	11:25	33.3	36.23	35.75	35.01	34.01	Soil	Yes	
Z22	730097	1324745	23.01.16	9:22	27.4	35.89	35.45	34.63	33.64	Soil	No	
Z23	730942	1325280	23.01.16	8:52	26.8	34.51	34.2	33.66	32.2	Soil	Yes	
C19	730085	1318226	28.01.16	11:17	29.73	39.45	38.47	37.16	35.52	Soil	No	
C22	731636	1319300	21.01.16	8:14	24.3	37.65	35.94	35.35	34.5	Soil	No	
C26	726397	1314705	26.01.16	9:32	30.69	47.98	45.03	41.63	37.94	Soil	No	
C27	727241	1315240	26.01.16	9:53	32.03	45.85	43.88	41.07	37	Gravel	No	Near foothill
C28	729775	1316846	28.01.16	10:58	31.4	41.98	40.86	39.19	37.35	Soil	No	
C29	730620	1317381	28.01.16	10:40	28.8	37.39	36.66	35.72	34.8	Soil	No	
C36	726932	1313860	27.01.16	7:51	25.36	44.31	42.8	41.08	38.64	Soil	No	
C37	727777	1314395	26.01.16	12:38	34.4	59.59	55.56	50.65	44.03	Soil	No	
C38	728621	1314930	26.01.16	12:09	33.03	50.62	47.98	44.9	40.87	Soil	No	
C40	729466	1315466	26.01.16	10:43	34.63	55.47	51.7	47.71	41.83	Soil	No	
C42	730311	1316001	26.01.16	11:38	30.2	42.06	40.52	38.24	35.35	Soil	No	
C44	731155	1316536	26.01.16	11:16	29.5	37.55	36.81	35.93	34.61	Soil	No	
C45	732000	1317072	26.01.16	10:55	30.42	37.47	36.48	35.21	33.66	Soil	No	
C50	729157	1314086	26.01.16	8:40	27.4	49.36	46.79	43.7	39.94	Soil	No	
C51	730001	1314621	26.01.16	9:01	28.7	54.75	51.82	48.07	42.29	Soil	No	
C52	730846	1315156	26.01.16	9:25	29.79	41.6	40.41	38.48	36.56	Soil	No	
C53	731691	1315692	26.01.16	9:50	29.6	39.52	38.76	37.8	36.26	Soil	No	
C54	732535	1316227	26.01.16	10:12	30.5	40.2	39.58	38.61	36.51	Soil	No	
C55	733380	1316762	26.01.16	10:32	32.9	36.6	36.13	35.37	34.03	Soil	No	
M01	727467	1313015	26.01.16	7:41	28.2	42.46	40.97	39.1	35.84	Soil	No	
M02	728312	1313550	26.01.16	8:17	27.01	52.43	49.27	45.34	40.33	Soil	No	
W01	728074	1309256	25.01.16	1:09	36.08	38.99	37.74	36.35	34.64	Soil	No	
W02	728918	1309791	25.01.16	1:27	38.18	42.54	41.13	39.16	36.49	Soil	No	
W03	729763	1310326	25.01.16	1:44	35.9	42.16	40.97	39.24	37.14	Soil	No	
W04	727538	1310101	25.01.16	12:52	35.95	39.4	38.51	37.4	35.7	Soil	No	
W05	728383	1310636	25.01.16	12:30	35.65	44.53	42.7	40.27	37.43	Soil	No	
W06	729228	1311171	25.01.16	12:10	34.4	44.22	42.88	40.73	37.8	Soil	No	
W07	730072	1311706	25.01.16	10:52	33.65	42.28	40.6	38.61	36.4	Soil	No	
W08	730917	1312242	25.01.16	10:29	32.49	50.41	48	44.56	39.6	Soil	No	
W09	731762	1312777	25.01.16	10:10	31.46	39.58	38.84	37.71	35.88	Soil	No	
W10	732606	1313312	25.01.16	9:45	31.8	38.16	37.46	36.57	35.07	Soil	No	
W11	733451	1313848	25.01.16	9:28	30.82	35.36	34.96	34.36	33.19	Soil	No	
W12	727003	1310945	25.01.16	1:01	35.03	37.98	36.87	35.46	33.19	Soil	No	
W13	726468	1311790	25.01.16	12:40	34.5	41	39.93	38.57	36.36	Soil	No	
W14	725933	1312635	25.01.16	12:19	32.3	39.8	38.94	37.59	35.25	Soil	No	
W15	725552	1314169	25.01.16	11:45	33.9	41.69	39.88	37.95	35.81	Soil	No	
W16	724862	1314324	25.01.16	11:08	32.9	43.91	42.04	39.75	37.11	Soil	No	
W17	724327	1315169	27.01.16	8:51	25.3	39.33	37.97	36.5	34.72	Soil	No	
W18	723482	1314633	27.01.16	8:28	25.1	39.3	38.26	36.93	35.14	Soil	No	
W19	723791	1316013	27.01.16	10:08	30.73	38.68	37.39	35.8	33.79	Soil	No	
W20	722947	1315478	27.01.16	1:35	32.35	35.49	34.64	33.22	31.83	Dessicated clay	Yes-shrubs	
W21	723256	1316858	27.01.16	10:25	35.55	39.92	38.83	37.49	35.84	Soil	No	
W22	722412	1316323	27.01.16	12:50	36.63	33.44	32.63	31.58	30.8	Dessicated clay	Yes-shrubs	
W23	722721	1317703	27.01.16	10:42	32.42	40.5	39.18	37.68	36.05	Soil	No	
W24	721876	1317167	27.01.16	12:20	33.44	32.96	32.41	31.7	31.03	Dessicated clay	Yes-shrubs	
W25	722186	1318547	27.01.16	11:01	33.65	38.5	37.81	36.79	35.47	Soil	No	
W26	721341	1318012	27.01.16	11:55	37.33	33.34	32.64	31.8	31.27	Dessicated clay	Yes-shrubs	
W27	721650	1319392	27.01.16	11:17	33.44	37.37	36.6	35.55	34.27	Soil	No	Near fault scarp
W28	720806	1318857	27.01.16	11:34	33.13	32.65	32.21	31.57	31.08	Dessicated clay	Yes-shrubs	
W29	728609	1308411	27.01.16	12:54	32.2	39.68	38.45	36.8	35.23	Soil	No	

Source: JICA Survey Team

Table A5.1.3 Measurement Data of 2.0m-depth Temperature Survey (4)

S.No.	Cordinates		Day	Time	Outside	Subsurface Temperature				Ground Type	Vegetation	Other
	X	Y	dd.mm.yy	HH:MM	Temp.	2.0m	1.5m	1.0m	0.5m	Soil/Gravel/Rock	Yes/No	
W30	729454	1308947	27.01.16	12:37	36.5	43.56	41.86	39.77	37.2	Soil	No	
W31	730298	1309482	27.01.16	12:01	30.6	40.33	39.42	38.31	37.02	Soil	No	
W32	731143	1310017	27.01.16	11:24	32.9	40.18	38.9	37.64	35.86	Soil	No	
W33	730608	1310862	27.01.16	10:59	31.3	43.77	42.2	39.94	37.28	Soil	No	
W34	731452	1311397	27.01.16	10:27	30.9	41.73	40.16	38.43	36.78	Soil	No	
W35	732297	1311932	27.01.16	10:01	26.8	39.47	38.53	37.38	35.84	Soil	No	
W36	733142	1312468	27.01.16	9:39	26.5	35.98	35.32	34.49	33.22	Soil	No	
W37	731988	1310552	29.01.16	8:01	25.4	40.7	39.62	38.34	36.34	Soil	No	
W38	732832	1311088	29.01.16	8:20	24.5	38.53	37.18	35.71	33.62	Soil	No	
W39	730762	1311552	29.01.16	8:44	23.49	48.37	45.47	42.1	38.46	Soil	No	
W40	731607	1312087	29.01.16	9:03	24.5	41.08	39.53	38.03	35.3	Soil	No	
W41	725017	1315014	29.01.16	11:29	26.5	45.25	42.61	39.46	36.03	Soil	No	
W42	725861	1315549	29.01.16	11:58	26.3	51.65	49.2	45.3	39.81	Soil	No	
W43	724481	1315859	29.01.16	12:30	26.8	49.32	46.53	43.56	40.4	Soil	No	
W44	725326	1316394	29.01.16	1:05	30.7	49.91	46.84	42.39	37.43	Soil	No	
E01	737139	1317369	28.01.16	8:00	22.2	38	37.54	36.79	35.6	Soil	No	
E02	737449	1318749	28.01.16	8:28	24	36.86	36.53	35.78	34.78	Soil	No	
E03	738293	1319284	28.01.16	8:49	25.3	36.47	36.04	35.46	34.34	Soil	No	
E04	738603	1320664	28.01.16	9:24	26.7	37.97	37.61	37.09	36.22	Soil	No	
E05	738067	1321508	28.01.16	9:46	25.3	35.1	34.57	33.87	31.99	Soil	No	
E06	736533	1321128	28.01.16	10:18	24.5	37.28	36.89	36.23	35.41	Soil	No	
E07	734308	1320902	28.01.16	10:40	25.8	35.49	35.07	34.45	33.85	Soil	No	
E08	732393	1322056	28.01.16	11:09	29.9	37.34	36.76	35.91	34.85	Soil	No	
E09	733238	1322591	28.01.16	11:34	26.4	38.02	37.58	36.71	35.46	Soil	No	
E10	731858	1322901	28.01.16	12:00	27.7	37.51	37.05	36.31	35.16	Soil	No	
E11	732702	1323436	28.01.16	12:20	28.06	34.86	34.43	33.82	32.56	Soil	No	
M03	728003	1312171	28.01.16	11:47	28.77	37.83	36.61	35.17	34.73	Soil	No	
M04	728538	1311326	28.01.16	12:29	28.89	41.12	39.74	37.93	35.71	Soil	No	
M05	729382	1311861	28.01.16	12:47	29.65	45.22	43.69	41	38.48	Soil	No	
M06	730227	1312396	28.01.16	1:05	30.02	47.92	45.43	42.4	39.55	Soil	No	
M07	731072	1312932	28.01.16	1:24	30.29	45.34	43.3	40.82	38.42	Soil	No	
M08	731916	1313467	29.01.16	9:26	25.7	38.82	38.18	37.15	35.63	Soil	No	
M09	732761	1314002	29.01.16	9:46	26.5	36.54	35.84	35.05	34.05	Soil	No	
M10	730537	1313776	29.01.16	10:09	24.1	44.11	42.36	40.3	37.45	Soil	No	
M11	727509	1314818	29.01.16	10:53	23.04	66.82	61.46	54.22	45.32	Soil	No	
M12	729240	1317690	29.01.16	10:18	25.56	40.76	39.44	37.77	35.46	Soil	No	
M13	729549	1319070	29.01.16	10:41	26.77	37.27	36.52	35.5	34.2	Soil	No	
M14	730394	1319606	29.01.16	10:59	28.52	37.36	36.83	36.04	34.76	Soil	No	
M15	729014	1319915	29.01.16	11:14	29.78	37.77	37.22	36.48	35.46	Soil	No	
M16	728479	1320760	29.01.16	11:29	30.75	36.56	35.93	35.1	33.85	Soil	No	
M17	727944	1321604	29.01.16	11:44	31.03	39.16	38.64	37.66	36.2	Soil	No	
M18	726564	1321914	29.01.16	11:59	27.7	38.06	36.86	35.8	34.4	Soil	No	
M19	728253	1322984	29.01.16	12:37	30.18	37.06	36.62	35.84	34.7	Soil	No	
N01	723227	1321575	29.01.16	2:20	29.88	37.25	36.53	35.38	33.64	Soil	No	
N02	724071	1322110	29.01.16	2:05	32.18	36.79	36.32	35.62	34.56	Soil	No	
N03	724888	1322645	29.01.16	1:37	27.44	40.03	40.03	39.36	37.54	Soil/Rock	No	Basalt outcrops nearby.
N04	725761	1323181	29.01.16	1:22	30.56	38.28	37.76	36.94	35.72	Soil	No	

Source: JICA Survey Team

APPENDIX-6

Environmental, Social Impact Assessment (ESIA)

Full Report

Federal Democratic Republic of Ethiopia
Geological Survey in Ethiopia (GSE)

DRAFT REPORT
ON
ENVIRONMENTAL AND SOCIAL ASSESSMENT (ESIA)
IN
TENDAHO-2 (AYROBERA) GEOTHERMAL SITE

AUGUST 2016

NIPPON KOEI CO., LTD.

SUMIKO RESOURCES EXPLORATION & DEVELOPMENT CO., LTD.

JMC GEOTHERMAL ENGINEERING CO., LTD.

Table of Contents

ACRONYMS

CHS: Community Health and Safety

CSA: Central Statistics Agency

EA: Environmental Assessment

EEP: Ethiopian Electric Power

EEU: Ethiopian Electric Utility

EIA: Environmental Impact Assessment

EMP: Environmental Management Plan

EMP: Environmental Monitoring Plan

EPE: Environmental Policy of Ethiopia

ESIA: Environmental and Social Impact Assessment

ESMP: Environmental and Social Management Plan

FDRE: Federal Democratic Republic of Ethiopia

FGD: Focused Group Discussion

FI: Financial Intermediary

GSE: Geological Survey of Ethiopia

IFC: International Finance Corporation

ILO: International Labor Organization

NGO: Non Governmental Organization

NMSA: National Meteorological Survey Authority

OHS: Operational Health and Safety

TOR: Terms of Reference

UN: United Nations

WB: World Bank

WHO: World Health Organization

WMP: Waste Management Plan

EXECUTIVE SUMMARY

This report deals with Environmental and Social Impact Assessment for a geothermal Test Well Drilling project at Ayrobera Site. The site is located in Afar Regional State, Dubti woreda, Ayrolaf-gebelaytu kebele. The study was launched in the first week of February 2016, of which about 20 days were actual field work. The study employed a range of methodologies: review of documents, field survey, Focus Group Discussions, interview, and public consultations; all of the data collections were supported by audio and video recordings. Environmental guidelines using locally accepted standards were also employed where they are appropriate. All significant impacts were evaluated using appropriate parameters and impact rating. The study involved about 50 kebele dwellers as well as nearly 50 key stakeholders representing different organizations, institutions, offices and local administrations.

The project is to be carried out in part of Ayrolaf-gebelaytu kebele, a location deserted and uninhabited. It is characterized by sandy, dry, flat, and harsh climatic condition. Due to this, almost no single plant species, or grazed cattle are observed. Except at the eastern corner of the site (10 km away) where it is temporarily settled by little pastoral households, no human being dared to live within the proposed site.

Findings from environmental assessment reveal a number of adverse impacts derived from the proposed test well drilling project. These are gaseous emissions that are carried in the source stream. The other is water pollution from well drilling, stimulation, and production. Dissolved minerals could also poison surface or ground waters. Solids emissions due to accident associated with a fluid treatment or minerals recovery system; noise pollution, dust and vibration from drilling and testing operations.

To address negatively impacting environmental issues, the following measures should be considered.

In light of the nature and features of Ayrobera site (arid, climatically harsh and deserted) the implementation of the project would bring no adverse environmental and social impact throughout the phases. The study reveals that likely adverse impacts might be generic, particularly involving occupational accidents and hazards. This includes health ailments such as malaria, bodily injuries, and fire hazard, among others. These accident, would definitely affect project staff and temporary workers who would appear in all phases of the project. The impacts could occur provided that the project owner and the concerned contractor failed to implement mitigation measures.

The economic impact assessment covered analysis on project related to job opportunity, disposable income, cost of living, and enhancing local economy. The finding reveals nearly all of the economic impacts of the project as favorable. Among others, the project would provide with 106 temporary job opportunities for the local community, in all phases of the project. The creation of additional income on the part of migrant and local people (in the form of wage) will bring about a change in the life of particularly households of respective workers. This in turn will enhance the flow of cash and disposable income in the kebele and nearby towns. The increase in the demand for goods and services would also contribute to

the expansions of the existing businesses and establishments of small ventures, at least in the nearest towns. The project will contribute to the revenue generating sources of the Government in the form of withholding and profit taxes.

In general, the findings from document review at international, national, regional and local levels fit with the objective of the test well drilling project. In addition, all of the stakeholders consulted expressed their positive view over the exploration of the site. Similarly, the concerned regional and local administration already given their confirmation in that, the site has not been settled, not used for grazing, or never been reserved for other development works. On top of that, the project fully accords with the Federal Environmental Guideline of EPA, 2003, in that the proposed site is not classified as environmentally sensitive. What is more, the processional conclusion of the study team is strongly positive; thus the proposed site could be explored.

CHAPTER ONE: BACKGROUND AND JUSTIFICATION

1.1 Overview

This ESIA report is the continuation of the previous study, "Environmental and Social Impact Study for formulating Master Plan on Development of Geothermal Energy in Ethiopia". One of the objectives of the study was to select and prioritize fifteen potential geothermal sites in three Regional States: Afar; Oromiya and Somali. Multidisciplinary approaches were used to prioritize the potential sites, ESIA study being among others.

Accordingly, the result was achieved mainly from reconnaissance field survey and from ground surface scientific investigation only. However, geothermal power plant development by its very nature is complex with high coefficient of uncertainty and high cost of well drilling. Thus, it is quite reasonable that the selected site need to be supplemented//verified// by further and detail scientific investigations so as to locate the most appropriate and potential drilling points within the selected Ayrobera site. Hence, the following activities (or studies) are planned to be carried out:

- Geophysical field survey
- Analysis of conceptual model
- Cost estimation for test well drilling
- Environmental and social consideration

The purpose and/ or objective of the above activities is to generate viable justification to conduct test well drilling at the selected site. As can be expected from the nature of the project, outcome the above studies will again be inter-disciplinary for decision making. Thus, ESIA as one component was planned and conducted in the selected Ayrobera site, in Afar Regional State.
From the perspective of geothermal power plant development, this particular phase of the study can be perceived as pre-construction or prefeasibility phase. Thus, it will be too early to set targets on production capacity of the power plant and corresponding time schedule.

This ESIA study is carried strictly based on EPA guidelines and in reference to national standards. After determining the capacity of the power plant, however, securing approval of Regulatory Bodies will be mandatory; in such cases, from Ministry of Environment and Forest.

Here it will be important to notify that TOR of the previous prioritization study site list does not request //or mention// Ayrobera but Allalo Beda as Tendaho-3. Though the Woreda /Dubti/ is the same for both sites they are nearly 40 Km apart along the road and 12Km air distance. The ESIA study team, however, has conducted baseline survey of Ayrobera within a specified period for the present study. Findings of this study revealed that it will not significantly affect the results of the previous prioritization study.
The previous master plan study was a comprehensive document consisting of a wide range of information. Thus, it will be worthwhile to notify that this report is squeezed as much as possible to focus only on specific findings of the selected site by omitting common and

repetitive features. Hence, any official or evaluator interested in reviewing this report may need to refer both documents (?) for sound decision making.

1.2. Objective

The main objective of this study is to produce specific ESIA report for test well drilling on the selected Ayrobera; Tendaho-2; Dubti Woreda; Afar Region. With this understanding, the proposed ESIA study is expected to carry out the following tasks;

- Describe the present state of human and natural environment and its surrounding;
- Identify potential negative and positive impacts of the envisaged test well drilling;
- Develop//propose// mitigation measures and the corresponding management plan;
- Serve as a spring board for ESIA of the upcoming power plant development in the project area;

1.3 Definitions

The following definitions, in the context of this ESIA report, are selectively made for common understanding. Some of these definitions are directly taken from JICA guideline for environmental and social considerations, 2010.

1. "**Scientific investigation or technical studies**": These studies are limited to geotechnical studies such as geophysics, geochemistry, geology etc.

2. "**Techno-economic studies**": Studies primarily based on the findings of technical studies but incorporate engineering and economic aspects at project level.

3. "**ESIA studies**": These are based on findings of techno-economic results, analyzes environmental and social aspects at project level and approval of regulatory bodies.

4. "**Environmental and social considerations**": It refers to the means considering environmental impacts including air, water, soil, ecosystem, flora, and fauna, as well as social impacts including involuntary resettlement, respect for the human rights of indigenous people, and so on.

5. "**Projects"**: Undertakings that project proponents conduct and get JICA's support.

6. "**Environmental and social considerations studies**": It incorporates baseline surveys, predicting and evaluating the adverse and likely impacts of projects on the environment and on local community, and the subsequent mitigation measures that are set to avoid and minimize negative effects.

7. "**Environmental impact assessment**": includes evaluating the environmental and social impacts of projects, analyzing alternative plans, and preparing adequate mitigation measures and monitoring plans in accordance with the laws/guidelines of host countries.

8. A “**strategic environmental assessment**”: It is an assessment implemented at policy, planning, and program levels, but not a project-level EIA.

9. An “**examination of environmental and social considerations**”: This is a confirmation of the measures taken by project proponents etc. to meet the requirements of the guidelines in view of the project’s characteristic features and the inherent nature of the affected countries and/or area.

10. “**Screening**”: Deciding whether proposed projects are likely to have impacts that need to be assessed by conducting environmental and social considerations studies according to project description and site description. JICA conducts screening by classifying proposed projects into four categories: A, B, C, and FI (Financial Intermediary).

11. “**Scoping**”: Refers to choosing alternatives for analysis, a range of significant and potentially significant impacts, and study methods.

12. “**Local stakeholders**”: They are affected individuals or groups (including illegal dwellers) and local NGOs. “Stakeholders” are also individuals or groups, who have views about cooperation projects, including local stakeholders.

13. An “**Environmental Impact Assessment (EIA) level study**”: It is a study that includes the analysis of alternative plans, the prediction and assessment of environmental impacts, and the preparation of mitigation measures and monitoring plans based on detailed field surveys.

14. An “**Initial Environmental Examination (IEE) level study**”: A study that includes an analysis of alternative plans, a prediction and assessment of environmental impacts, and a preparation of mitigation measures and monitoring plans based on easily available information including existing data and simple field surveys.

15. “**Detailed design study**”: It is a study that decides the detailed plan of a project such as project objective, confirmation of feasibility, scale of input and activities, and it is conducted after the approval of the project by concerned body.

1.4 Study Approach and Methodology

The Environmental and Social Impact Assessment for the project site was conducted based on nationally and internationally accepted practices, procedures and regulations. The study focuses on the activities of the test well drilling, and thus evaluates the possible environmental and social impacts, and ultimately provides recommendations. Launching the test well drilling, need to follow the Ethiopian Government legal requirements. For issues that don’t have national regulation or standard, best international practices and guidelines would be considered.

Methodology: The methodology used for the study was mainly primary and secondary data. The secondary data included reviewing of documents related to the test well drilling project. The primary data involved, interview, structured questionnaires and professional observations.

Sources of Data:

The major sources of data were:-

- Documents involving prior studies on the targeted area;
- Project related documents from the concerned stakeholders such as JICA and GSE;
- Relevant regulations, codes and technical standards of Federal Democratic Republic of Ethiopia.
- CSA’s census and other related documents;
- Government organizations in Afar Regional State;
- Dubti woreda and kebele administrations and sector offices;
- Baseline information from field survey;
- Current related literature review and emerging technologies in thermal well drilling sector;

***Questionnaire*:** Standardized questionnaire was employed for households. The questionnaire was meant for the sample settlers located in two different locations within the woreda. The data collected were, mainly, on livelihood/ and economic situations, level of income and household expenses, environmental issues, major constraints of the kebele/community, and views of target group on the proposed Project.

Interview: Semi structured questionnaire was conducted with selected stakeholders at all level: federal level authorities/experts, regional officials and experts, woreda and kebele representatives, etc. The interview revolved around:

- Launching test well drilling for geothermal power plant;
- Extent of stakeholders’ support on the activity;
- Potentially negative and/or positive impacts of the test well drilling;
- Identifying mitigation measures, if there is a need.

Focus Group Discussion: FGD was conducted around the selected site. The participants included community representatives, elders, religious leaders, representatives of women, and youth, among others. The FGD was meant to gather the views of the community, whether or not they would be willing to support the activity of the drilling project. Furthermore, they were let to discuss their fears and worries about displacement and other unforeseen reverse impacts which could result from the test well drilling, etc.

Observations: Firsthand data collections through preplanned observations were carried out within and around Ayrobera site. The purpose of the observation, among others, was to look into the situation of the environment, settlement pattern, land use, existing infrastructure, the available social services, visual amenity, among others. The data collected through professional observation was presumed to strengthen other data and what is more fill the information gap that might occur on the interview and questionnaire.

Audio and visuals: The other firsthand data collection was audios, pictures and movies. The technique was used for capturing the real scene of the study area, record scenario and events valuable for the study. On top of that, meetings and discussions conducted between the study team and the concerned stakeholders have been audio taped, pictures taken and videos recorded.

Concerned stakeholders from different offices and households from Ayrolaf-Gebelayitu kebele (in two villages, namely, Boina and Asboda) were consulted. The whole setting of field data collection is systematically presented in Table 1.1.

Table 1.1: ***Designs of Data Collection Method***

Activity	*Purpose*
Orientation to leading members of each woreda administration	Awareness creation for common understanding about the project objective
	Secure permission and letter of cooperation to the corresponding Kebeles and target sites
	Assignment of facilitator and local guide from woreda administration
Interview through structured questioners to Dubti woreda sector offices(Head//Expert)	Determine alignment of their guideline(office) with the proposed project
	Enables to know if there is existing or planned activity in the project surrounding
Agriculture /pastoralist office	
Economic & finance office	Visualize synergy or destructive effects with proposed objective of the project
Education office	
Health office	Get personal view of the respondents from their professional experience.
Culture & tourism office	
Land use and environment office	
Water & energy office	To access official documents (localized)relevant to the proposed project
FG discussion consisting of 5 up to 7 community members; elders; religeious leaders; community leaders; youths; women;	Get their collective (averaged)view through discussion
Interview through structured questioners to directly//indirectly// affected communities	Get personal view of each household and his expectation from the proposed Project
Personal observation of the study team	Strengthen information collected
Interview of Key experts or specialists	Capture policy or planning level issues (Federal & Regional)
Pictures ; video camera and sound tracks taken during each orientation and interview	To enhance credibility of the data collection
	Data conformation or justification for any deviation that may occur in implementation phase

1.5 Scope

From the perspective of geothermal power plant development, this particular phase of the study can be perceived as pre-construction or prefeasibility phase. Thus, it will be too early to set targets on production capacity of the power plant and corresponding time schedule. The scope of this ESIA study is, thus, limited to "test well drilling phase". That is why; this particular ESIA study is designed for internal consumption of JICA but after review made by concerned bodies from Ministry of Mine Petroleum and Natural Gas. As long as data gap exists, we believe that it is a wise decision and the right move. On top of that, this ESIA study is carried strictly based on EPA guidelines and in reference to national standards so as to serve as a spring board for ESIA of the power plant development. After determining the capacity of the power plant, however, securing approval of Regulatory Bodies will be mandatory; in such cases, it will be from Ministry of Environment and Forest.

On the other hand, scope of the study has been governed by review of readily available data, documents reviewed (either from GSE or JICA resources), and findings of previous studies conducted in some particular sites. Data from field survey was properly exploited and limiting values of national guidelines adequately assessed. In addition to this, literature data and experiences of other projects were thoroughly reviewed.

1.6 Significance of the study

It is well understood that geothermal projects are costly, time consuming and long lasting. Even in the absence of feasibility study, preliminary investigation on socio-environmental conditions of the prospected site seems a wise decision as it is also a cost minimizing option. This is what shall be practiced for other mega projects. Carrying out parallel or side-by-side ESIA study with other sectors is, thus, quite justifiable for various project phases. It is a widely accepted fact that ESIA is a pro-active means of avoiding such socio-environmental consequences that otherwise would be much more expensive (risky) to correct them after their occurrence.

Experience learnt from mega projects of Ethiopia demonstrated that critical issues and grievances arise not from imported, well established technology or techno-economic study findings but mainly from socio-environmental aspects.

Hence, the significance of this study is to: (i) provide, decision makers, with background to socio-environmental facts about the proposed site; and (ii) help to identify issues to be considered and incorporated during implementation of the proposed project.

1.7Assumptions

It can be observed that both techno-economic and ESIA studies have common border to share with and at the same time play different role/scope/ to deal with certain issues. Some basic data such as generation rates, capacity, amount etc. that serve as inputs for ESIA are taken from techno-economic studies. It is natural therefore detailed works of these input data are dealt in techno-economic while analysis of their outcome is carried out by ESIA study team. It is with this approach that the overall project feature can be easily understood.

However, in conditions of such data-gaps, assumptions generated from professional judgment are employed. It is strongly believed that these assumptions are not far from what might be expected after completion of techno-economic study findings and may not significantly affect the final outcome. Any project reviewer interested in detailed works shall be offered this ESIA study findings with a copy of techno-economic study documents as a reference. As a result the following assumptions are made.

- As this ESIA document is a continuation of the Master Plan Study, the current report is squeezed focusing only on Ayrobera project site by omitting common and repetitive features, particularly, on policy frame work and analysis alternatives.

- The study team reviewed existing and available geothermal technologies used elsewhere and selected most widely practiced technology with moderate capacity for its impact assessment.

- The ambient air, noise and dust levels are assumed to be at their best quality/level/ as compared to threshold values of national standards due to the pristine nature of the environmental setting of the project site. The area is also characterized by sparsely populated community with traditional way of life that has insignificant influence on the natural setting. In most of the sites, geothermal springs and fumaroles still exist for several years and no significant effect had been observed.

- Any change after detailed techno-economic feasibility study may require an additional environmental management measures which will again require an amendment of this ESIA study.

1.8 Organization of the Report

This ESIA report is organized in to the following seven Chapters: Chapter One is *Background* of the study. Chapter Two is devoted to *Project Description on Test Well Drilling*. Chapter Three overviews findings of, *Legal, Policy and Institutional Framework* governing environmental issues as related to the envisaged project. The existing *Baseline Conditions* of the project areas are described in Chapter Four; which is followed by impact assessment at chapter Five. Then mitigation measures and management plan is dealt in Chapter Six; finally Chapter Seven deals with Conclusions *and Recommendations*

CHAPTER TWO: PROJECT DESCRIPTION

2.1 Overview

This section describes the scope and technologies to be employed in geothermal power plant. Scope of this project is limited to the determination of geothermal viability through test well drilling at Ayrobera site. Scientific investigations carried so far are limited to ground surface studies. This project is formulated to verify findings of ground surface studies through test

well drilling. Due to this effect, production capacity of the prospected power plant and related utilities may not be accurately determined. Thus, discussions on power generation, transmission and distribution are not major topics to be covered in this study. Hence, the scope of this study can be viewed as prefeasibility. Basic data required for project description are not yet finalized. In few cases, professional judgment and assumptions are made to describe the project.

It is a widely practiced procedure that a full-fledged development project has various phases in common to accomplish its task. In a similar approach, test well drilling projects have various interdependent phases, such as:

- Pre drilling phase (survey & conceptual modeling);
- Construction phase (civil & non-civil works);
- Drilling phase (development & commissioning phase);
- Testing phase (operation phase);
- Decommissioning phase;

Starting from the very inception, test well drilling involves the following major steps;
Site survey;

- Land securing;
- Fencing and bordering;
- Land escaping and leveling;
- Resource mobilization;
- Camp site construction and utility development;
- Water development works for drilling purpose & domestic consumption
- Well pad preparation;
- Usage of consumable row materials and chemicals;
- Well drilling;
- Testing;
- Commissioning;

The above activities are reviewed from socio-environmental perspectives in the following sections. Basic data required for reviewing are listed in table 2.1but still with some data gap.

Table 2.1: Basic data required from findings of techno-economic studies

Description		Remark
Project Name	ESIA study for test well drilling	
Location	Ayrobera; Dubti Woreda; Afar Region	
GPS location	Not yet decided	
Estimated plant size	In hectare, not yet determined	
Proposed drilling technology	Reported to be on procurement bid	
Purpose of the project	Confirm the potential of geothermal systems and resources	
Number of operating days	300 days/year	

Consumable raw materials & input chemicals	Described in the body of the document	
Plant life time	One year	
Main water source	Irrigation pond at Dubti drilling sub-surface water in the site	
Water requirement	300 m^3 / day	
Flow rate of water source	At least five years data at the worst scenario	
Waste water generation /day	Industrial and domestic waste water	
Power source & requirement	Government captive power	
Project cost	Data not available	
Employees:	Expatriate:	Taken from similar projects such as Aluto
	Direct and indirect employment: a total of 69 workers. Of this, skilled 23, unskilled: 46 (for detail see chapter 4).	

2.2 Existing Technologies for Extracting Geothermal Energy

Key technologies for exploration and drilling, reservoir management and stimulation, and energy recovery and conversion are described below.

2.2.1 Technologies for exploration and drilling

Since geothermal resources are found in deep underground, exploration methods (including geological, geochemical and geophysical surveys) have been developed to locate and assess them. The objectives of geothermal exploration are to identify and rank prospective geothermal reservoirs prior to drilling, and to provide methods of characterizing reservoirs (including the properties of the fluids) that enable estimates of geothermal reservoir performance and lifetime. Exploration of a prospective geothermal reservoir involves estimating its location, lateral extent and depth with geophysical methods and then drilling exploration wells to test its properties, minimizing the risk.

Today, geothermal wells are drilled over a range of depths down up to 5 km using methods similar to those used for oil and gas. Advances in drilling technology have enabled high-temperature operation and provide directional drilling capability. Typically, wells are deviated from vertical to about 30 to 50° inclination from a 'kick-off point' at depths between 200 and 2,000 m. Several wells can be drilled from the same pad, heading in different directions to access larger resource volumes, targeting permeable structures and minimizing the surface impact.

Reservoir engineering efforts are focused on two main goals: (a) to determine the volume of geothermal resource and the optimal plant size based on a number of conditions such as sustainable use of the available resource; and (b) to ensure safe and efficient operation during the lifetime of the project. The modern method of estimating reserves and sizing power plants is to apply reservoir simulation technology. First a conceptual model is built, using available

data, and is then translated into a numerical representation, and calibrated to the unexploited, initial thermodynamic state of the reservoir (Grant et al., 1982). Future behavior is forecast under selected load conditions using a heat and mass transfer algorithm, and the optimum plant size is selected.

Injection management is an important aspect of geothermal development, where the use of isotopic and chemical tracers is common. Cooling of production zones by injected water that has had insufficient contact with hot reservoir rock can result in production declines. In some circumstances, placement of wells could also aim to enhance deep hot recharge through production pressure drawdown, while suppressing shallow inflows of peripheral cool water through injection pressure increases.

Given sufficient and accurate calibration with field data, geothermal reservoir evolution can be adequately modeled and proactively managed. Field operators monitor the chemical and thermodynamic properties of geothermal fluids, and map their flow and movement in the reservoir. This information, combined with other geophysical data, is feedback to recalibrate models for better predictions of future production (Grant et al., 1982).

2.2.2 Geothermal Power Plants

There are different geothermal technologies with distinct levels of maturity. Geothermal energy is currently extracted using wells or other means that produce hot fluids from: a) hydrothermal reservoirs with naturally high permeability; and b) EGS-type reservoirs with artificial fluid pathways. The technology for electricity generation from hydrothermal reservoirs is mature and reliable, and has been operating for more than 100 years.

The basic types of geothermal power plants in use today are steam condensing turbines and binary cycle units. Steam condensing turbines can be used in flash or dry-steam plants operating at sites with intermediate- and high-temperature resources (≥150°C). The power plant generally consists of pipelines, water-steam separators, vaporizers, de-misters, heat exchangers, turbine generators, cooling systems, and a step-up transformer for transmission into the electrical grid. The power unit size usually ranges from 20 to 110 MW (Di Pipe, 2008), and may utilize a multiple flash system, flashing the fluid in a series of vessels at successively lower pressures, to maximize the extraction of energy from the geothermal fluid. The only difference between a flash plant and a dry-steam plant is that the latter does not require brine separation, resulting in a simpler and cheaper design.

As it is discussed in the preceding sections, the scope of this ESIA study is limited to the level of test well drilling. Thus, discussion on the details of geothermal power plants is not timely except perhaps issues that link with the test well drilling. The following table summarizes types of widely used geothermal power plants.

Table 2.2: Commonly used geothermal energy technologies

No.	Technology	Resource temperature	Reservoir fluid	Working fluid
1	Dry Steam Power Plants	≥150°C	Steam	Geo-fluid
2	Single Flash Steam Power Plants	≥150°C	Steam and water	Geo-fluid
3	Double Flash Power Plants	≥150°C	Steam and water	Geo-fluid
4	Binary Cycle Power Plants	107° to 182°C	steam or water or both	Organic solvent or ammonia
5	Combined Cycle Plants	107° to 182°C		Organic solvent or ammonia and Geo-fluid

Despite a more complex design, binary power systems are generally less expensive than steam systems for temperature close to 176^{0}C.. The cost of binary systems rises as temperature drops. Binary systems may be preferred in highly sensitive environmental areas, since they operate as closed-loop, virtually emissions-free system produced.

2.2.3 Resource Characteristics

Temperature, pressure, and volumes of fluid geothermal reservoirs are the primary determinants of the size and type of power conversion equipment//technology option//. Assuming sufficient volumes of fluid are produced, temperature determines the most efficient conversion design. While binary plants can utilize any temperature resource, low temperature resources are constrained to the binary model. Medium temperature resources can be economical by using either flash or binary systems.

High temperature resources are most economical when steam or flash systems are employed, as these are simpler and therefore less costly. Flash systems are less expensive than binary systems, but may not be efficient at lower temperatures. Steam plant equipment costs rise as temperature decreases (as a result of efficiency losses).

2.2.4 Cooling systems

Developers have two basic cooling options: water or air cooling. Hybrid air-water systems have been demonstrated to a limited extent and are considered important for future advancement (see “New Technology” for more information). Both air and water-cooled systems use cooling fan motors. Some maintenance is required; typically an annual check-up of fan motors and belts as well as system lubrication.

Most power plants, including most geothermal plants, use water-cooled systems typically in cooling towers. As these are more efficient, they generally require less land than air-cooled systems. Water-cooled systems are less expensive to build and operate if water is readily available and inexpensive to obtain. These systems lose most of the water to the atmosphere by evaporation in the form of water vapor, while the remainder is injected back into the system. Emissions from a wet cooling tower (i.e. water vapor plus dissolved solids or minerals) depend upon the quality of the geothermal liquid injected back through the system.

Because the efficiency of power generation is affected by the difference between the temperature of the fluid exiting the turbine and the temperature of the cooling medium, air-cooled systems are influenced by seasonal changes in air temperature. These systems can be extremely efficient in the cold months, but are less efficient in hotter seasons when the contrast between the air and water temperature is reduced.

The ideal temperature difference between the air and the resource is 200^{o}F (93^{o}C) for an air-cooled system. Air cooling is beneficial in areas where extremely low emissions are desired, where water resources are limited, or where the view of the landscape is particularly sensitive to the effects of vapor plumes (as vapor plumes are only emitted into the air by water cooling towers). While air-cooled systems are only used at binary facilities today, these could theoretically be used with any geothermal conversion technology

Detailed evaluation of surface water and/or groundwater availability should be carried out before recommending a particular technology. Most of the geothermal prospect areas are located at reasonable distance from Awash River and Lakes. But some sites will face difficulties concerning the availability of water of the right quality.

2.3 Processes and Activities in Test-well Drilling

Activities of this phase includes bordering and fencing; site lay out development; construction of road**;** water supply system, electric power supply; site clearing earth work; temporary camp construction; resource mobilization including rig transportation and derrick/mast foundations; drainage, drill site cellar and waste sump development;

Road construction: Heavy duty road compacted with gravels might be required as rig components are as heavy as 50 tons and possess unusually big width // up to 8 m height // of the machinery.
Site preparation: Drilling site need to be labeled, compacted and covered with heavy thick layer of good surfacing material (i.e., quarried stone). Dimensions of the drilling area need to provide maximum maneuverability for drilling operations. Figure below provides for the minimum area dimensions required for drilling rig and its different components.

Drilling site need to have adequate drainage and ditches not to allow accumulation of water and also to prevent having a muddy and unsafe working area. Drainage ditches should be dug on the base of the slope to prevent flooding of the drill site. The areas not occupied by any rig component should slope slightly towards the outer working perimeter of the drill site and the slope to end at the ditches. Slope should be no less than two degrees (2°).

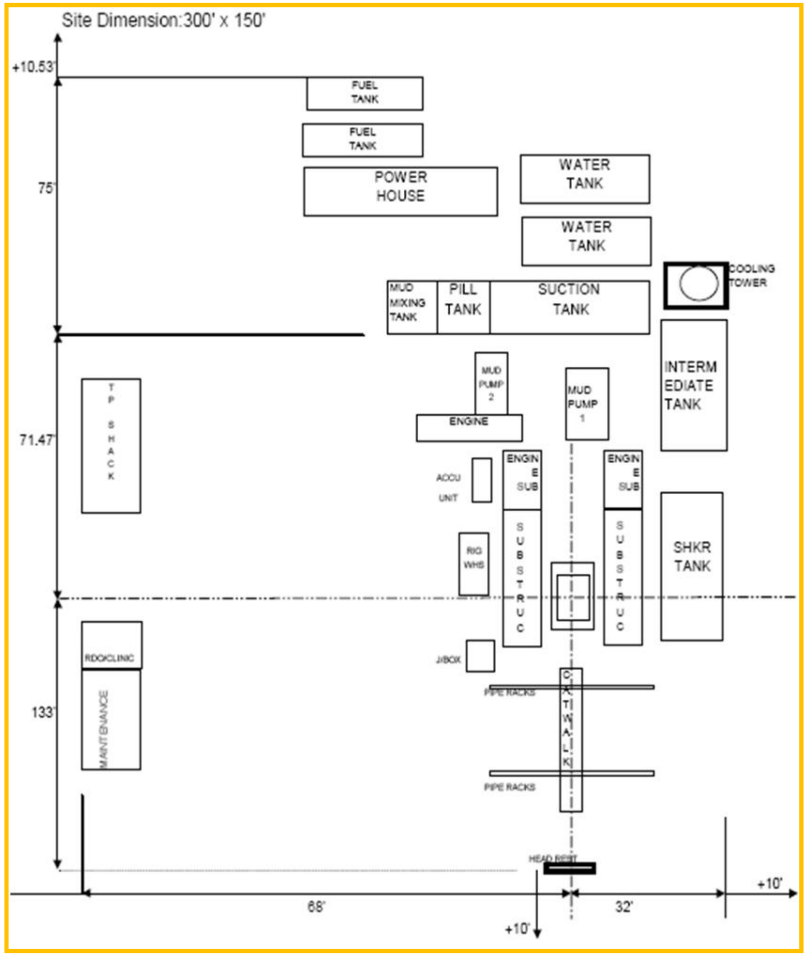


Fig 2.1: Representative drilling site and its components

Shallow ditches (rig perimeter canal) around the rig substructure, mud and fuel tanks, mixing hoppers, cementing unit, and other rig components near the substructure should be channeled into the cellar terminating on the floor area of the cellar under the rig's V-door where a shallow ditch can be channeled into the cellar for drainage to the sump. Areas outside the perimeter of the drill site must have proper slopes (angle of repose) to totally discard possibility of landslides or washouts. Shallow ditches (sump berms) are to be constructed on this slope if directly above the waste pond (sump) and channeled away from the sump to prevent flowing of rainwater, excess clean water and the like to the sump. This will maximize usage of sump capacity to hold only rig fluid wastes and rainwater directly flowing to the sumps.

***Waste pond (sump)*:** For all wells drillings and work-over, comparable waste pond must be provided, up to 3000m^2 or sometimes its volume may increase or decrease depending on the limitations of the pad layout. Sump walls should be built up from fill materials and should be systematically and adequately compacted and reinforced with cement lining to prevent fluid from escaping through the walls and/or prevent sump walls from breaking. Ideally, a sump should be divided into two compartments with the intake section at a slightly higher elevation than the outlet or discharge end of the sump. The weir between the sump compartment and at the discharge end should be built to act as an efficient filter for the different pollutants (i.e. oil, mud chemicals, cement and cement additives, etc.) discarded during drilling or work-over.

Two discharge outlets with the other at a higher elevation might be installed on the second sump (and or succeeding sumps for two or more sump system) for effective recycling of discarded fluid during drilling. This will also serve as suction ends during re-injection of fluid wastes. Intake end of this outlet should have a strainer installed to prevent suction of undesirable solids that may damage suction/recycling pumps. The drill site will be consolidated by injecting cement in 30m deep holes drilled at various locations on drill site using small rigs

***Water and electric supply*:** Electric power for drilling purpose can be tapped either from neighboring Dry Port Terminal or Semera Town. Step up transformers might be required. On the other hand, well drilling is a water intensive operation. Ayrobera project site, on the other hand, does not have access to water.

Water lines from source to drilling site must be installed in an accessible terrain so as to easily remedy possible causes of low water rig supply. Water supplied to the drill site should be analyzed first to determine the presence of hazardous elements which might be detrimental to any of the drilling operations. The water line should be provided with proper flow controls at the suction and discharge end. Suction end of the water line should be provided with screens or filters to ensure that no materials will flow through the water line to cause its clogging.

For Ayrobera project two options can be planned:

1. To pump water from Dubti irrigation ponds through pipeline all across Dubti to Ayrobera
2. To drill water well for this purpose and insert a submersible pump for water supply.

Rig move/up of drilling rig and associated equipment: Rig dismantled into various parts and its accessories will be moved using heavy duty tracks at various steps. Moving sequence should be followed. Drilling materials, consumables and equipment required for spud should be at the drill site right before completion of rig up operations.

2.3.1 Drilling processes

The rig has drill strings with strong drill bit at the bottom end to exert a rotating force to crash stones and penetrate to the depth. Drilling fluid is pumped through the drill pipes to the well and come out through the nozzles of the bit to the surface carrying with it drilled cuttings of rocks. These drilling fluids and disposed cuttings might be of environmental concerns, thus need to be assessed.

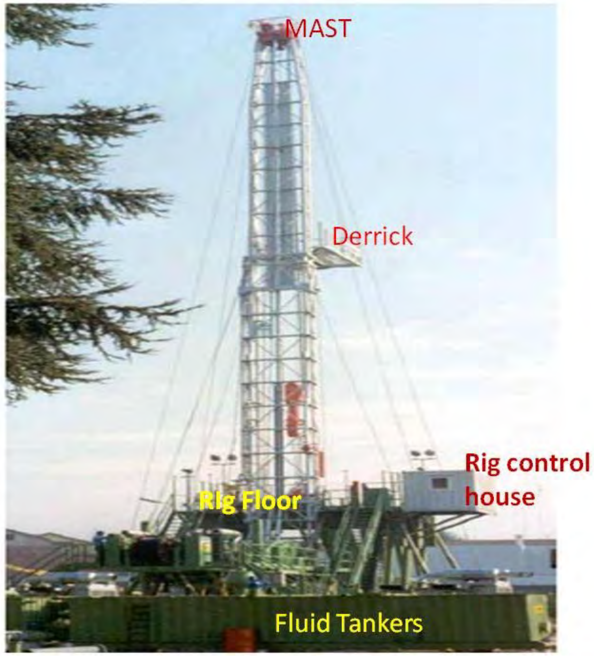


Photo 2.1: A view of a rig

A number of well drillings, up to ten, can be drilled in a single project site for a medium geothermal power plant development. Each well is dug up to 2500 m depth into the ground. Thus, socio-environmental concerns, particularly from resource mobilization, emission and waste disposal are expected to be high. The above picture demonstrates a representative drilling machine (what is usually called Rig).

2.3.2 Drilling fluids

Drilling fluids could be pure water. Aerated water with soap or bentonite mud with some additives can be used. Nature of rock formation and extent of circulation loss determines fluid selection. Various types
//combination// of additives can be used depending on the type //diameter//of well to be drilled. Table 2:3 summarizes mud chemicals and other additives to that purpose.

Table 2.3: Mud chemicals and additives

Classification	Application	Typical Product
Ph Control Additives	product designed to control the degrees of acidity or alkalinity of a fluid	1. Caustic Soda (NaOH) 2. Lime 3. Sodium Bicarbonate 4. Potassium Hydroxide (KOH)
Calcium Removers	chemicals designed to prevent and overcome the contaminating effects of anhydrite, gypsum and cement	1. Sodium Carbonate (Soda Ash) 2. Sodium Bicarbonate
Thinners/Dispersants	Chemicals that are used to modify the clay particle properties of drilling mud to control viscosity, gel strength and filtrate loss. Additives referred to lignosulfonate and lignite chemicals	1. Lignosulfonate Q-Broxin II Sperseme CF Unical CF CFL 2. Lignites Carbonox Ligco Tannathin Ground Lignite
Filtrate Reducers	chemicals designed to control and reduce filtrate or fluid loss of drilling fluid into the formation	1. Sodium Carbox Methyl (CMC) 2. Polyanionic Cellulose (PAC, Polypac, IDF FLA) 3. Sodium polyacrylate (SP101, MYDRON P-29) 4. Synthetic Resin Polymer (Resinex) 5. Organic Polymer (Hi-temp II, Mil-temp II)
Weighting Materials	product used to increase mud density, to control formation, check caving, facilitate pulling dry pipe and as an aid in combating some types of circulation loss	1. Barites MI Bar, Baroid, Milbar 2. Iron Oxides 3. Calcium Carbonate 4. Galena

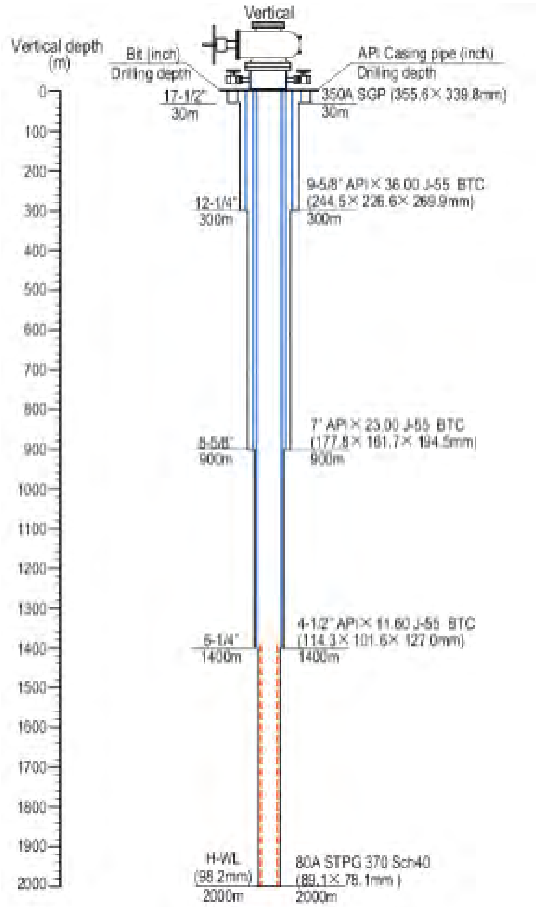


Figure 2.1: Typical Geothermal well casing configuration (slim hole)

Test wells are constructed with concentric casings, called surface; anchor; and production casings that are cemented with G-grade cement, bentonite and other additives until the production casing.

Table 2.4: Chemicals and additives

CEMENT ADDITIVES (APPROXIMATE EQUIVALENTS)

FUNCTION	USE	PRODUCTS
Extender Bentonite	To absorb free water allowing a lower slurry density, increase gel strength and yield	Premium Gel, Hydrogel, Aquagel
Silica Flour	HT strength retrogression	ERC 200 mesh, Seagull 200 mesh, Repcas 200 mesh, Insulyte 325 mesh
Accelerator	To speed up setting time in surface jobs	$CaCl_2$ (78-80%), CA-1, D98, A3-L
Friction Reducer	To indicate turbulence flow at low pump rates. To reduce slurry viscosity	BJ CD-31, Dowell D59, Messina CAFR-3P, Halliburton CRR22
Fluid Loss Reducer	To control slurry fluid loss in permeable zones, reducing "Bridging"	BJ FL-22, FL-50, Halliburton Hallad-22A Messina CAFL-1
Low Temperature Retarder	To retard thickening time of cement to allow placement in moderate temperature.	BJ R-5, Dowell D28, Halliburton HR7, Messina CA-RB
High Temperature Retarder	To retard thickening of cement and to allow placement in higher temperature	BJ R-11, Dowell D13, Halliburton HR-12, Messina CA-R10
Silica Sand	As an LCM material in loss circulation plugs.	70 Mesh Sand
Silicate Sealing Pre-Flush	Gelling agent to replace flushed mud wall cake with quick sealing cement wall cake to reduce bridging & LCM problems	Flochek P (Flochek 21) D 75 (Zoneloks)

Waste cuttings and mud: Huge amount of waste is expected from this activity, particularly if the number of test wells is more. Percolation of this fluid will contaminate ground water resources.

Emission: During well testing emission of gases along with the steam is inevitable, at least in testing phase. Major component of the gas is Hydrogen Sulphide, H_2S, which is toxic. Data on other constituents of the gas is not available. Mitigation measures need to be sought to minimize the impact of toxic gas emission. On the other hand, the following table summarizes percentage composition of samples taken from geothermal sites.

Table 2.5: Trace constituents in selected geothermal fields (mg/1)

Geothermal field	As	B	H_2S	NH_3	Li	Source
Tendaho (TD-4) (separated water)	0.4	4.6	< 0.1	1.49	1.06	Aquater, 1996
Wairaki (NZl) (deep water)	4.7	30	1.7	0.2	14	Brown, 1995
Salton Sea (USA) (deep water)	12	390	16	386	215	Brown, 1995
Cerro Prieto (Mexico) (deep water)	4.7	19	0.6	127		Brown, 1995
Nesjavellir (Iceland) (separated water)	0.05	2.1				Wetangula, 2004
Threshold value	0.3	0.5	*0.05	*1.5		EPA, 2000 and *Brown, 1995

2.3.4 Potential Impacts Associated with Drilling Process

It is well understood that geothermal fluids contain high concentrations of heavy metals and other toxic elements, including radon, arsenic, mercury, ammonia and boron, which may damage the freshwater systems into which they are released as waste water depending on site specific conditions.

Hydrogen sulphide (H_2S) is a main component of geothermal steam and is responsible for the rotten egg smell of geothermal areas. It is corrosive and classed as very toxic. H_2S is a heavy gas and can linger in valleys, polluting local populations. It forms sulphur dioxide (SO_2) in the atmosphere causing acid rain.

Landscape impact is another significant factor. As each geothermal borehole produces only a few megawatts of power, a number of boreholes may be drilled across large area, connected to the main power station with pipes and roads. Numerous test holes are drilled for every borehole that goes into production. In a similar approach, the following specific environmental impacts may likely to happen:

- Gaseous emissions
- Water pollution
- Solids emissions
- Noise pollution
- Land use
- Land subsidence
- Induced seismicity
- Induced landslides
- Water use
- Disturbance of natural hydrothermal manifestations
- Disturbance of wildlife habitat and vegetation
- Altering natural vistas
- Catastrophic events.

Thus, it can be concluded that certain impacts must be considered and managed if geothermal energy is to be developed as a larger part of a more environmentally sound, sustainable energy portfolio for the future. Most of the potentially important environmental impacts of geothermal power plant development are associated with ground water use and contamination, and related concerns about land subsidence and induced seismicity as a result of water injection and production into and out of a fractured reservoir formation. Issues of air pollution, noise, safety, and land use also merit some consideration.

CHAPTER THREE: POLICY FRAMEWORK

3.1 Over view

It is quite obvious that policy elements for this "test well drilling project" are nearly the same with what has been dealt for the Master Plan on Development of Geothermal Energy in Ethiopia. In addition to this, results of this study are supposed to be used until capacity of the reserve is determined for power plant development. On the other hand, regulation of financial institution for this transition period project is assumed to be at minimal. Therefore, this chapter focuses only on summary of policy elements that are useful to generate conclusion and recommendation. Hence, any official interested in reviewing this document may need to have a copy of the master plan study for further verification.

Huge development projects usually impose certain environmental and social impacts. There are a number of standards in the world that impose limits on the harmful substances that may be contained in the industrial emissions and effluents. These standards, however, vary based on the type and scale of the industries. Countries also have their own regulatory framework that provides guidelines regarding these emissions and effluent. The government of Ethiopia through specific legislations regulates the environmental management system for all projects across the country. Following this, the statutory bodies responsible for insuring environmental compliance by the project promoters include:

- The then Environmental Protection Authority of Ethiopia, EPA, now Ministry of Environment and Forest;
- Regional Environmental Authority Bureau;
- Ministry of Mine Petroleum and Natural Gas, and,
- Ethiopian Electric Utility

Similar to other developmental projects, the proposed test well drilling is subject to several policies and programs aimed at development and environmental protection. Therefore, as part of ESIA reviewing policies, legislations and institutional frameworks most relevant to the proposed project is necessary. In addition to this, standard requirements of ESIA process need to be adhered to. For the purpose ESIA scoping process-those national and international environmental standards, regulations and guidelines that can provide a framework for the ESIA Study process are identified, reviewed and presented.
These standards are, then, used as a benchmark to measure and evaluate significance of environmental and social impacts. Environment is a cross-cutting issue for several development sectors that use natural resources as raw materials and for other development activities which may pollute the environment. To deal with environmental issues, Ethiopia has developed a number of legal frameworks and guidelines that emanates from international conventions.

3.2 International Conventions and Protocols

In addition to national environmental legislations, the Federal Democratic Republic of Ethiopia is also member of a number of regional and international conventions and protocols on environment. The government has established an Environmental Protection Authority, and then Ministry designated to implement the conventions and protocols.

According to Article 9(4) of the Constitution of the Federal Democratic Republic of Ethiopia, once an international agreement is ratified through the established procedure, it automatically becomes an integral part of the law of the land. Consequentially, the adopted Conventions and the Protocols have already become the integral part of the national laws. In line to this, the following documents are relevant to the ESIA study of this project.

• **Convention on Biological Diversity:** Goals of the conservation of biodiversity: the sustainable use of the components of biodiversity; and the fair and equitable sharing of the benefits arising from the use of genetic resources.

• **The United Nations Convention to Combat Desertification (CCD):** The objective of the Convention is to combat desertification and mitigate the effects of droughts in countries experiencing serious drought and/or desertification, particularly in Africa.

• **Framework Convention on Climate Change (FCCC):** This convention takes into account the fact that climate change has trans-boundary impacts. The basic objective being to provide with agreed limits on the release of greenhouse gases into the atmosphere so as to prevent the occurrence of climate change. It also aims to prepare countries to minimize the impact of climate change.

- **The Universal Declaration of Human Rights**: The declaration makes clear a common standard of achievement for all peoples and all nations: to promote respect for human rights and freedoms, and to secure their universal and effective recognition and observance. Environmental and social considerations refer not only to the natural environment, but also to social issues such as involuntary resettlement and respect for the human rights of indigenous peoples.

- **Japan International Cooperation Agency, JICA**
  Owing to the recent increase of public Interest in environmental issues and adopting most international conventions, the government of Japan, through JICA has developed Guidelines for Environmental and Social Considerations (2010) and applied them to Loan aid and technical cooperation. Among these conventions, Principle 17 of the Rio Declaration; Agenda 21; and Organization for Economic Cooperation and Development (OECD) Council Recommendations are prominent. JICA's Business Protocol and Mid-term Plan clearly state that JICA implements cooperation activities in accordance with these guidelines. With respect to human rights and in view of the principles of democratic governance, measures for environmental and social considerations are implemented by ensuring a wide range of meaningful stakeholder participation and transparency of decision-making, as well as by working for information disclosure and by ensuring efficiency.

3.3 Legal and Policy Context

The concept of Sustainable Development and Environmental Rights are enshrined in Articles 43, 44 and 92 of the Constitution of FDRE.

In Article 43: the Right to development, where people's right to:

- Improved living standards and to sustainable development;
- Participate in national development and, in particular, to be consulted with respect to policies and projects affecting their community;
- The enhancement of their capacities for development and to meet their basic needs, are recognized;

In Article 44: Environmental Rights, all persons are entitled to:

- Live in a clean and healthy environment;
- Compensation, including relocation with adequate state assistance

In Article 92: Environmental Objectives, it is declared that;

- Government shall ensure that all Ethiopians live in a clean and healthy environment;
- Programs and projects design shall not damage or destroy the environment;
- Peoples have the right to full consultation and expression of views;
- Government and citizens have the duty to protect the environment.

3.4 Environmental Policy of Ethiopia

Ethiopia adopted its Constitution in 1995, which provides the basic and comprehensive principles and guidelines for environmental protection, and management. The Environmental Policy is predicated on a growing concern for the degradation of the natural resource base. The overall policy goal is to improve and enhance the health and quality of life of all Ethiopians and to promote sustainable social and economic development through sound management and use of natural, human made and cultural resources and the environment as a whole.

The following are extracts from the National Environmental Policy which provide essential guidance for activities of environmental agencies in general.

- ➢ Incorporate the full economic, social and environmental costs and benefits of natural resources development;
- ➢ Appropriate and affordable technologies which use renewable resources efficiently shall be adopted, adapted, developed and disseminated;
- ➢ When a compromise between short term economic growth and long term environmental protection is necessary, then development activities shall minimize degrading and polluting impacts on ecological and life support systems;
- ➢ Regular and accurate assessment and monitoring of environmental conditions shall be undertaken;
- ➢ Ensure that ESIAs consider not only physical and biological impacts but also address social, socio-economic, political and cultural conditions;

- ➢ Recognize that public consultation is an integral part of ESIA and ensure that ESIA procedures make provision for both an independent review and public comment before consideration by decision makers;
- ➢ Establish the necessary institutional framework and determine the linkage of its parts for undertaking, coordinating and approving ESIAs and the subsequent system of environmental audits required to ensure compliance with conditions;
- ➢ Develop detailed sectoral technical guidelines in ESIA and environmental audits;
- ➢ Ensure that preliminary and full ESIAs are undertaken by the relevant sectoral ministries or departments, if in the public sector, and by the developer if in the private sector.

3.4.1 Institutional Framework

The FDRE consists of 9 Federal and Regional States. Proclamations 33/ 1992, 41/ 1993 and 4/ 1995 define the duties and responsibilities of the Regional States which include planning, directing and developing social and economic development programs as well as protection of natural resources. The most important step in setting up the legal framework for the environment in Ethiopia has been the establishment of the Environmental Protection Authority (EPA), Proclamation no. 299/ 2002. According to this Proclamation, The EPA as a Federal Environmental agency is responsible for:

- The establishment of a required system for Environmental Auditing of public and private sector projects, as well as social and economic development policies, strategies, laws, and programs of federal level functions;
- Reviewing and passing decisions and follow-up the implementation of Environmental Impact Study Reports of projects, as well as social and economic development programs or plans where they are:
    - o subject to federal licensing, execution or supervision;
    - o proposed activities subject to execution by a federal agency;
    - o Likely to entail inter or trans regional, and international impacts.
- Notifying its decision to the concerned licensing agency at or before the time specified in the appropriate law or directives;
- Auditing and regulating the implementation of the conditions attached to the decision;
- Provide advice and technical support to the regional environmental agencies, sectoral institutions and the proponents;
- Making its decisions and the EA report available to the public, resolving all complaints and grievances in good faith and at the appropriate time;
- Developing incentive or disincentive structures required for compliance of EA requirements pave the way and involve in EA awareness creation, etc.

The Regional Environmental Agencies are responsible to:

- Adopt and interpret federal level EA policies and systems or requirements in line with their respective local realities;

- Establish a system for EA of public and private projects, as well as social and economic development policies, strategies, laws, or programs of regional level functions;
- Inform EPA about malpractices that affect the sustainability of the environment regarding EA and cooperate with EPA in compliant investigations;
- Administer, oversee, and pass major decisions regarding impact assessment of:
    - projects subject to licensing by regional agency;
    - projects subject to execution by a regional agency;
    - projects likely to have regional impacts.

The Proclamation assigns responsibilities to different organizations for environmental development and management activities on one hand, and environmental protection, regulation and monitoring on the other. It gives the EPA the legal powers required for enforcing as well as spearhead the enforcement of and ensure compliance with environmental laws and standards.

In this regard, EPA has established an Environmental Impact Assessment system including the preparation of Procedural and Sectoral Guidelines as a prerequisite for the approval of new development activities and projects.

"Environmental Protection Organs Establishment Proclamation (Proclamation no. 295 of 2002)" stipulates the need to establish a system that enables to foster coordinated but differentiated responsibilities among environmental protection agencies at Federal and Regional levels. The proclamation requires the establishment of Sectoral and Regional Environmental Units and Agencies, respectively. This shows that institutionalizing and mainstreaming environmental concerns involve legal foundation.

"Environmental Impact Assessment Proclamation (Proclamation no. 299 of 2002)" provides EA with mandatory legal prerequisite for the implementation of major development projects, programs and plans. This proclamation is a proactive tool and a backbone to harmonizing and integrating environmental, economic and social considerations into a decision making process in a manner that promotes sustainable development.

"Environmental Pollution Control Proclamation (Proclamation no. 300 of 2002)" is promulgated with a view to eliminate or, when not possible to mitigate pollution as an undesirable consequence of social and economic development activities. This proclamation is one of the basic legal documents, which need to be observed as corresponding to effective EA administration.

In addition to the above proclamations, other relevant regulations in relation to the proposed project, as listed in Table 3.1 are also reviewed.

3.4.2 Applicable Proclamations/ Guidelines

Proclamations and EPA Guidelines applicable to the proposed project are listed in Table 3.1.

Table 3.1: Proclamations and Guidelines

Sn	*Title*	*No.*	*Date of Issue*
1	Environmental Impact Assessment Proclamation	299	31-Dec-02
2	Environmental Pollution Control Proclamation	300	03-Dec-02
3	Environmental Protection Organs Establishment Proclamation	295	31 Oct 2002
4	Expropriation of Landholdings for Public Purposes and Payment of Compensation Proclamation	455	15-Jul-05
5	Rural Land Administration Proclamation	89	07-Jul-97
6	Ethiopian Water Resource Management Proclamation	197	Mar, 2000
7	Solid Waste Management Proclamation	513	12-Feb-07
8	Environmental Impact Assessment Procedural Guideline Series 1		Nov. 2003
9	Draft EMP for the Identified Sectoral Developments in the Ethiopian Sustainable Development & Poverty Reduction Program (ESDPRP)		01-05-04
10	Investment Proclamation	280	02 Jul 2002
11	Council of Ministers Regulations on Investment Incentives and Investment Areas Reserved for Domestic Investors	84	07-Feb-03
12	The FDRE Proclamation , "Payment of Compensation for Property Situated on Landholdings Expropriated for Public Purposes	455	Y,2005
13	The Council of Ministers Regulation , "Payment of Compensation for Property Situated on Landholdings Expropriated for Public Purposes"	135	Y,2007
14	Oromya Regional Administration Council Directives, "Payment of Compensation for Property Situated on Landholdings Expropriated for Public Purposes".	5	Y,2003
15	Investment (Amendment) Proclamation	373	28 Oct 2003

Here, it is worthwhile to summarize the provisions, particularly those key sectors relevant to the project, namely water, and energy, among others.

Water Resources Management policy of Ethiopia: The overall goal of Water Resources Policy is to enhance and promote all national efforts towards the efficient, equitable and optimum utilization of the available Water Resources of Ethiopia for significant socioeconomic development on sustainable basis that incorporate environmental conservation and protection requirements.

Ethiopian National Energy Policy and Energy Law: Ensuring that the development of energy supply and utilization is environmentally benign. The energy policy gives priority to the planning and expansion of the energy supply required for economic development, particularly the implementation of the Agriculture Development Led Industry, ADLI, while at the same time, taking measures to transform energy consumption in the country from traditional to modern sources.

Proclamation on Solid Waste Management: The proclamation on Solid Waste Management No. 513/2007 is intended to create a sustainable path to limit the adverse effects of waste and maximize all potential benefits. The primary objective of the proclamation is to enhance at all levels capacities to prevent the possible adverse impacts while creating economically and socially beneficial assets out of solid waste. It also sets clear guidelines on the interregional transportation of waste as well as the disposal of toxic materials and recyclable goods. Urban administrations are required to create enabling conditions to promote investment on the provision of solid waste management services. Following the proclamation, all waste disposal facilities need to follow relevant environmental and local regulations as well as secure all required permits before implementation. EPA is empowered to issue directives for the proper implementation of the proclamation and regulations.

Environmental Pollution Control Proclamation: The law recognizes the fact that some social and economic development endeavors may inflict environmental harm that could make the endeavors counterproductive. It also underlines the fact that the protection of the environment, in general, and the safe guarding human health and well-being, as well as maintaining the biota and the aesthetic value of nature, in particular, are the duty and responsibility of all. To this end, the law aims to eliminate or, when not possible, to mitigate pollution as an undesirable consequence of social and economic development activities.

The national EPA Guideline provides categories, relevant requirements for an EIA, and lists project types under each category. In accordance with this Guideline, projects are categorized into three schedules:

Schedule-I: Projects, which may have adverse and significant environmental impacts and therefore require a full Environmental Impact Assessment.

Schedule-2: Projects whose type, scale or other relevant characteristics have potential to cause some significant environmental impacts but are not likely to warrant a full EIA study.

Schedule-3: Projects which would have no impact and do not require an EIA.

Accordingly, the 2002 guideline categorizes geothermal power plant establishments under Schedule I activity.

A closer look from perspectives of above mentioned conventions, policies and strategies it can be inferred that there is a qualitative need to conduct a complete ESIA assessment in order to safeguard the environment and concerned inhabitants from any possible negative impacts that may emanate from development of this power plant. Other aspects which impose requirement of conducting a full ESIA, as discussed in subsequent sections, will also demonstrate the need for quantitative determination.

Realizing the causes and impacts of industrial projects, the Environmental Assessment and Management Guidelines of Ethiopia recommends the following criterion for environmental management.

- New industry should be situated at a sufficient distance from environmentally sensitive areas wherever practically possible;
- Environmental monitoring during construction and operation;
- Implement an environmental management system which ensures environmental responsibility at all levels;
- Knowledge of local, national and international environmental requirements;

- Utilize environmentally friendly technologies;
- Implement cleaner production strategy - alternative products, production processes, raw materials, energy sources, prevent or reduce waste, waste recycling, re-use;
- Introduce water and energy saving measures;
- Discharge points should be located downstream of supply sources of drinking water;
- Delineation of location of waste dumps;
- Locate chimneys and waste pipes appropriately;
- Monitor volume and composition of discharges regularly;
- Ensure that sensitive environments and residential areas will not be affected by noise, especially at night;
- Develop reliable information system and mechanism for labelling, handling, and stocking of dangerous substances;
- Maintain safety equipment;
- Emergency procedures and rehabilitation upon closure of industry;
- Training programme to assist labour force in adapting to an industrial life style.

The following issues of health and safety are also addressed in the Council of Ministers Regulations on Industrial Operation No. 182/1994, and Labor Proclamation No.42/1993:

- Protective clothing and equipment;
- Training;
- Medical facilities;
- Procedures for safe transport, storage, handling, and use of explosives and chemicals;
- Notification of licensing authority upon serious accidents, and necessity for mitigation measures
- All installations to be rendered safe upon termination of license;
- Forbids industrial establishment in sensitive location as outlined in the regulations;
- Waste of hazardous products should be treated properly;
- Measure for reduction of discharges to the air;
- Location of discharge outlets for waste water and of chimneys to ensure dispersal of discharge substances;
- Plan of operation which considers short and long-term pollution;
- Management of hazardous waste to be in accordance with the strictest national and international regulations and guidelines;
- Controlled use of dangerous substances;
- Water consumption to be in accordance with existing water use in the area;
- Utilize environmentally friendly technology;

3.5 EIA Procedures in Ethiopia

Table 3.2: Outlines of the EIA procedures in Ethiopia.

N	*EIA Stage*	*Action*	*Agency involved*

o			
1	*Screening*	Preparation of project profile; decision on whether or not the project requires an EIA	EPA
2	*Scoping of the EIA*	Developing TORs initiating initial public consultation.	EPA, funding agency, consultant
3	*Environmental Impact Study*	Impact assessment; design of mitigation measures; design monitoring and audit plan	EPA, funding agency, consultant, proponent
4	*Reviewing the adequacy of the EIA*	Review contents and provide comments for necessary revisions.	EPA, funding agency
5	*Decision Making*	Summary evaluation made available to public; decisions & conditions for approval made public	EPA
6	*Systematic EIA Follow ups*	Ensuring implementation of agreed mitigation measures; periodic review & alteration of management plan if required	Private contractors, EPA, funding agency

EIA Process: The general description of the EIA process and the permit requirements are detailed in the Environmental Impact Assessment Procedural Guideline Series 1 of the FDRE released in Nov 2003. As per the Guidelines, it involves sufficient information that enable the determination of whether and under what conditions the project shall proceed. Thus, as a minimum, the following descriptions shall be presented:

- the nature of the project, including the technology and processes to be used and their physical impacts;
- the content and amount of pollutants that will be released during implementation as well as during operation;
- source and amount of energy required for operation;
- characteristics and duration of all the estimated direct or indirect, positive or negative impacts on living things and the physical environment;
- measures proposed to eliminate, minimize, or mitigate negative impacts;
- a contingency plan in case of accidents;
- procedures of internal monitoring and auditing during implementation and operation.

Reviewing: The purpose of review is to examine and determine whether the EIA report is an adequate assessment of the environmental effects and of sufficient relevance and quality for decision- making. Reviewing is conducted at various stages in the EIA processes and includes reviewing of Screening report, Scoping report, TORs, EIA Report, and Performance (monitoring or audit) reports at different stages in the project cycle.

Reviewing may include considerations of the adequacy of:

- Compliance with the "approved TOR";
- Required information;
- The examination of alternatives, assessment of impacts, appropriateness of mitigation measures and monitoring schemes as well as implementation arrangements;
- The use of scientific and analytical techniques;
- The extent of public involvement and reflection of their concerns;
- Presentation of the information to decision makers at Regional, Sectoral, and Local levels.

Decision Making: EIA is an on-going process of review, negotiations and incremental decision-making at various levels of the project cycle, about whether or not the proposal is to proceed, and under what conditions. Decision-making is consultative, participatory and influences others to behave responsibly and sustainably. It also acknowledges and implements mandates and responsibility. Full-scale assessment is required where the project is known to have significant adverse environmental impacts. Important considerations of decision-making are:

- A summary of evaluation is made available to the public;
- Reasons for decision and conditions of approval are made public;
- There is the right of appeal against decision;
- Approval can be reversed or permit can be revoked on the advent of changing circumstances;
- Approval of a proposal cannot immune the proponent from being accountable of the occurrence of adverse significant impacts in the course of the implementation of the project.

The licensing agency shall, prior to issue of an operating license for a project, ensure that the EIA of the project has been approved. Approval of an EIA report is only to mark a simple agreement to the proposal. The culmination of the approval procedure will be the issuance of an Environmental Clearance Certificate upon the satisfactory trial operation phase.

3.6 Regulatory Requirements of Financial Institutions

Here, it will be necessary to notify that the government of Japan, through JICA has developed Guidelines for Environmental and Social Considerations (2004) and applied them to Loan aid and technical cooperation. As a representative sample, techno-feasibility study of the power development at the Aluto-Langano geothermal field has been conducted as part of FY2009 Studies for Economic Partnership Projects in Developing Countries promoted by the "Ministry of Economy, Trade and Industry of Japan (METI)" and that was entrusted to West Japan Engineering Consultants Inc. (West JEC) through Ernst & Young Shin Nihon LLC and the Japan External Trade Organization (JETRO).

Other key institutions for financial support: World Bank, the African Development Bank (AfDB), the International Finance Corporation (IFC), the European Investment Bank (EIB) and the local Development Bank of Ethiopia (DBE). However, detailed guidelines of these financial institutions are omitted for this particular study since test well drilling is an intermediate project for power plant development.

3.7 National Standards and Limit Values

The EPA of FDRE has been actively engaged in the preparation of national environmental quality standards for air, water, noise, etc. To date, some of these standards are still in draft form. In such cases, International Standards are commonly relied upon. The provisional standards for industrial pollution control and prevention which has been prepared by EPA in collaboration with UNIDO and issued in 2003 provides:

- Standards for Specified Industrial Sectors;
- Standards for Industrial Effluents (General);
- Standards for Gaseous Emissions (General);
- Standards for Noise Limits.

Ambient air and water qualities; noise levels: The proposed draft standards as formulated by the FDRE for ambient air quality, noise levels, emission levels and discharge to wastewater are given in the Table 3.3, Table 3.4 and Table 3.5 respectively.

Table 3.3: Draft Standards for Industrial Emission and Effluent limits; EPA, FDRE

No.	*Process*	*Pollutant*	*Parameter Required*	*Draft Standard*	*Competent Authority*
1	Processing Industry	Discharge of wastewater	pH	6 up to 9	EPA, FDRE
			BOD5 at 20ºC	25 mg/ l	
			COD	150 mg/ l	
			Total Phosphorus as P	5 mg/ l	
			Suspended Solids	50 mg/ l	
			Mineral oils at the oil trap or interceptor	20 mg/ l	
2	Stack Emissions	Emission of pollutant gases	Total particulates	150 mg/ Nm3	EPA, FDRE
			SO2	1000 mg/ Nm3	
	Industrial processing		NO2	2000 mg/ Nm3	

Table 3.4: Draft Standards for Ambient air condition; EPA,FDRE

Ambient Air Quality		
Parameter	*Standard (µg/ m3)*	*Averaging Time*
SO_2	500	10 min
	125	24 hr
	50	1 yr
NO_2	200	24 hr
	40	1 yr
CO	100,000	15 min
	60,000	30 min
	30,000	1 hr
PM10	50	1 yr
	150	24 hr

Limit values for industrial emission and effluents: The above mentioned draft standard also issued draft limit values for industrial emission and effluents as indicated in Table 3.6.

In September 2003 EPA and the United Nations Industrial Development Organization have announced national noise standards to be achieved at noise sensitive locations. Such areas include domestic dwellings, hospitals, schools, places of worship, or areas of high amenity. The sensitivity to noise is usually greater at night-time than during the day, by about 10dB (A). Ideally, if the total noise level from all sources is taken into account, the noise level at sensitive locations should be kept within the following values.

Table 3.5: Ambient noise Quality / noise standards/ where people live or work

Category of the area	*Limits in dB(A) Leq*		*Remark*
	Day time	*Night time*	
Industrial	75	70	1: Day time reckoned from 6 am to 9 pm 2: Night time reckoned from 9 pm to 6 am
Commercial	65	55	
Residential	55	45	

Note: In some particularly quiet areas, such as pastoral, rural settings, where the background noise levels are very low, lower noise limits may be more appropriate.

In cases where sector specific standards are not available then general standards for industrial effluent and for gaseous emission are adapted from other countries in our case, South Africa and Netherlands. In this part of the document the following three standards are stated:

- standards which shall be applied to all effluents discharged to inland waters, other than those from specific sectors;
- standards which shall be applied to all effluents which shall be applied to lands (for all industrial sectors);
- standards for gaseous emission.

3.8 International Limit values, as of IFC Standards

The EHS Guidelines released on 30 April 2007 are technical reference documents with general and industry specific examples of Good International Industry Practice (GIIP). The World Bank 'EHS Guidelines for manufacturing industries have set standards for air emissions levels and effluent levels from manufacturing as given below.

Emissions: Table 3.6 gives the emission guidelines for specified manufacturing sector. These guidelines are achievable under normal operating conditions in appropriately designed and operated facilities through the application of pollution prevention and control techniques. These are: levels should be achieved, without dilution, at least 95% of the time that the plant is operating, to be calculated as a proportion of annual operating hours.

Table3.6: EHS Emission guidelines

No.	*Pollutants*	*Units*	*Guideline values*
1	Particulate Matter	mg/ Nm3	30 (a)
2	Dust	mg/ Nm3	50
3	SO_2	mg/ Nm3	400
4	NOx	mg/ Nm3	600
5	HCI	mg/ Nm3	10 (b)
6	Total organic carbon	mg/ Nm3	10
7	Dioxins-furans	mgTEQ/Nm3	0.1 (b)
8	Total Metals ©	mg/ Nm3	0,5
	Notes		
*	* Emissions from the stack unless otherwise noted. Daily average values corrected to 273K, 101.3 kPa,10 percent O2 and dry gas, unless otherwise noted		
a	a10 mg/ Nm3 if more than 40 percent of the resulting heat release comes from hazardous waste.		
b	b If more than 40 percent of the resulting heat release comes from hazardous waste average values over the sample period of a minimum of 30 minutes and a maximum of 8 hours.		
c	c Total Metals = Arsenic (As), Lead (Pb), Cobalt (Co), Chromium (Cr), Copper (Cu), Manganese (Mn), Nickel (Ni), Vanadium (V) and Antimony (Sb)		

Ambient Air Quality: As per EHS General Guidelines, projects with significant sources of air emissions should ensure that emissions do not result in pollutant concentrations that reach or exceed relevant ambient air quality guidelines and standards by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines.

Effluents: Effluent guidelines as specified in the EHS Guidelines is applicable for discharges of treated waters for general use may equally applied to the proposed geothermal power plant and is given in Table 3.7.

Table 3.7: EHS Guidelines for effluent

No.	*Pollutant*	*Units*	*Guideline value*
1	pH	pH	6 – 9
2	BOD	mg/l	30
3	COD mg/l	mg/l	125
4	Total Nitrogen mg/l 10	mg/l	10
5	Total Phosphorus mg/l 2	mg/l	2
6	Oil and grease mg/l 10	mg/l	10
7	Total suspended solids mg/l 50	mg/l	50
8	Total coliform bacteria	MPNb/100 ml	400(a)
	a Not applicable to centralized, municipal, waste water treatment systems which are included in guidelines for Water and Sanitation EHS b MPN = Most Probable Number		

Noise Levels: For noise levels beyond the property boundary of the Plant, the general EHS Guidelines on Noise Management specify the noise level guidelines applicable to this project. Noise levels should not exceed the levels as given in Table 3.8, or result in a maximum increase in background levels of 3 dB at the nearest receptor location off site.

Table 3.8 : EHS Guidelines on Noise Management

No	Receptor	One hour Leq (dBA)*	
		Day time	Nighttime
		07.00-22.00	22.00-07.00
1	Residential, institutional, educational (a)	55	45
2	Industrial, commercial	70	70
* Guidelines values are for noise levels measured out of doors. Source : Guidelines for Community Noise, WHO, 1999 @ For Acceptable indoor noise level for residential, institutional, and educational settings, WHO, 1999.			

The General EHS Guidelines on Occupational Health & Safety specify the noise level guidelines **applicable to different working environments. Noise levels should not exceed the above levels:**

- No employee shall be exposed to noise levels greater than 85 dB (A) for a duration of more than 8 hours per day without hearing protection. In addition, no unprotected ear should be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(C). The use of hearing protection shall be strictly enforced when the sound level

over 8 hours reaches 85 dB (A), the peak sound levels reach 140 dB(C) or the average maximum sound level reaches 110 dB (A).

- For every 3 dB (A) increase in sound levels, the 'allowed' exposure period or duration should be reduced by 50%.

Effluent and emission from geothermal activities: During operation phase, emission of particularly H_2S, fluoride or carbonates and discharge that contains solubilized metals is expected. As per the 'EHS Guidelines for industrial processes, the concentration of Total Suspended Solids (TSS) should be limited to 50 mg/ l at the point of discharge. EHS General Guidelines for Ambient Air Quality standards as specified above shall also apply to the industrial area.

3.9 Strategic Environment Assessment, SEA

From basic definition of the concept it can be inferred that SEA focuses mainly on policy level issues before implementing certain programs or projects between two or more parties; I.e. bilateral or multilateral relations. To this effect, the ESIA study team has identified the following policy guidelines relevant.

- Alignment of the project from policy perspectives;
- Energy policy of the country verses geothermal;
- Project perspective from guidelines of financial institutions;
- Alignment of JICA guidelines with national policies.

3.9.1 Alignment of the Project from Policy Perspectives

The entire legislative framework applicable to the proposed project is governed by the laws of Federal Democratic Republic of Ethiopia (FDRE). National policies and regulation were reviewed; guidelines of relevant Federal and Regional Offices were studied; sufficient numbers of officials were also interviewed. It is concluded that the proposed project can be materialized in alignment with national regulations and international conventions. However, from policy perspective the following two important findings are identified:

- *As per 'Environmental Impact Assessment Procedural Guidelines Series 1'* of November 2003, t*he proposed geothermal power plant or test well drilling has significant environmental impacts, and, therefore, requires a full ESIA/EA. The plant will be, then, responsible/accountable/ for implementing environmental management plans at its facilities in coordination with the Federal EPA or the Regional EPA*

- Guideline of National Environmental Policy, Article 7; *Recognize that public consultation is an integral part of EIA and ensure that EIA procedures make provision for both an independent review and public disclosure before consideration by decision makers,*

The proposed project inevitably requires environmental and planning approvals from the Federal or Regional Government Authorities. Thus, this study has been prepared to form part of the development application, assessment and approvals process of the proposed project.

Geothermal power plant Project Office will be responsible for the construction, commissioning and operation of the project.

3.9.2 Project Perspective from Regulatory bodies of Financial institutions

This ESIA study for the proposed geothermal power plant has been carried out within the framework of local, national and international environmental regulations and guidelines of relevant financial institutions: African Development Bank (AfDB), World Bank, the International Finance Corporation (IFC), the European Investment Bank (EIB) and the local Development Bank of Ethiopia (DBE) are among potential financial institutions.

ESIA study of this project is, thus, screened in line with World Bank Standard Guidelines and then six Safe Guard Policies of the Bank are identified as relevant and subsequently adequately reviewed. These Operational Policies are: OP 4.01; OP 4.02; OP 4.04; OP 4.10; OP 4.11; and OP 4.12. Next to this, guidelines of remaining banks are reviewed. In the course of doing the task, it is learnt that once required activities, say, for World Bank is carried out successfully then similar approaches can be used for the other financial institutions. Hence, for the purpose of this ESIA study, those national and international environmental standards, regulations and guidelines that can be used as benchmark to measure and evaluate significance of environmental and social impacts are identified, reviewed and presented.

Bankable document: Findings from local financial institutions revealed that approval of both the feasibility and the ESIA study of this project by authorized government body enable the proposed geothermal power plant project secure basic requirements of local bank loans. However, some additional work on the above operational Policies is further required for bank loans from international financial institutions.

3.9.3 Energy Policy of the Country verses Geothermal Energy

As Ethiopia is situated in the Rift System rich with geothermal resource, power plant development using these resources seems sensible. Only few countries in the world have such resources. These days, the need for clean energy is fundamental not only at country level but also become worldwide demand through various international conventions (protocols) to sustain climate changes. With this regard and having sufficient resource with appropriate technology, establishment of geothermal plants seems the right option for the current power demands of Ethiopia. It is for this reason EEPCo puts priority of geothermal energy development second to hydropower.

3.9.4 Alignment of JICA's Guideline with National Policies

Main elements of JICA's guidelines for Official Development Assistance, ODA, are briefly discussed in the preceding section. On the other hand, Ethiopian guidelines for environmental assessment are thoroughly discussed in different parts of this document.

3.9.5 Summary of findings

From the above discussions, it can be concluded that the two guidelines do not have major contradiction, except perhaps certain procedural adjustments during project implementation. Thus, Strategic Environment Assessment, SEA, proves to be applicable for this test well

drilling project as one component of geothermal power plant establishment. Level of alignments of these guidelines is summarized in Table 3.9 format below

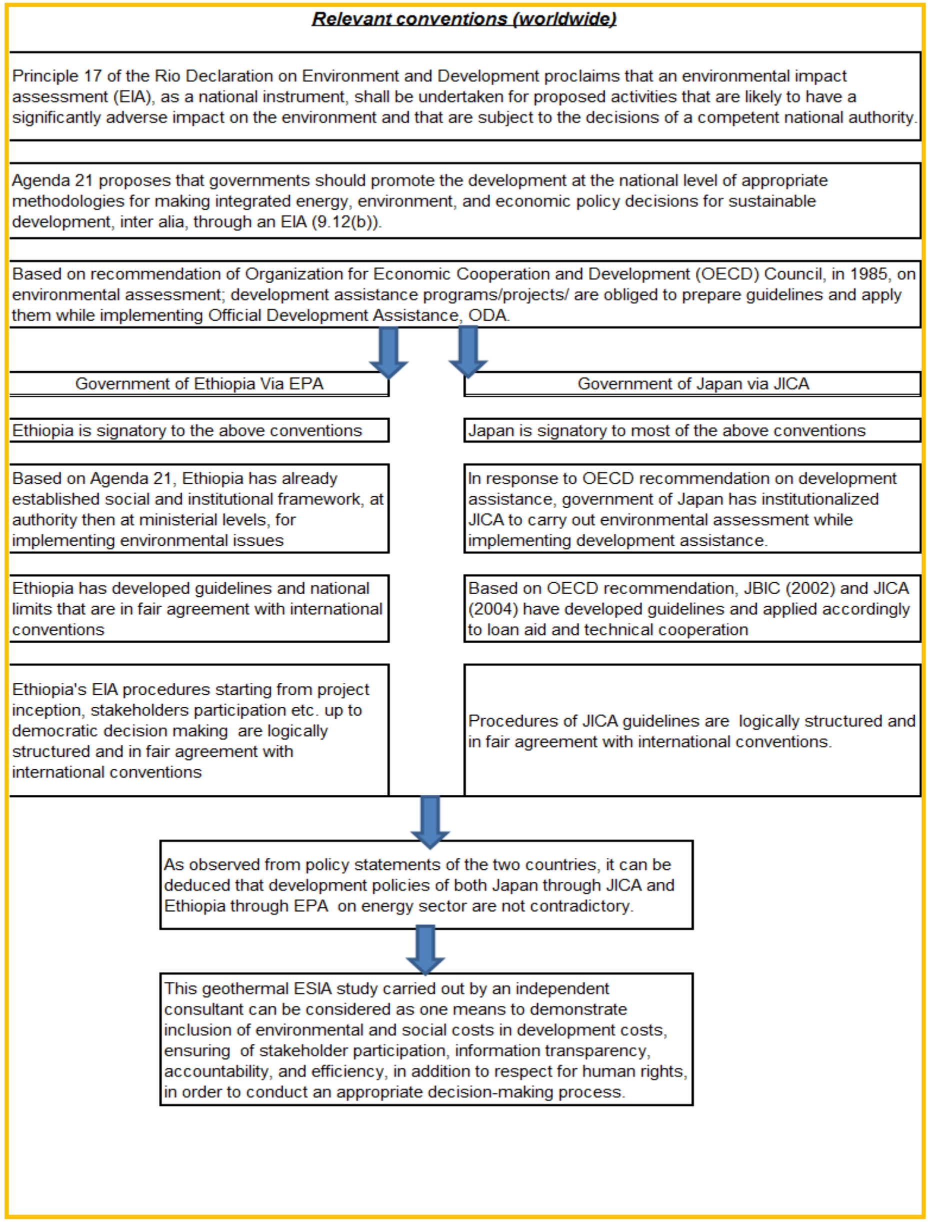


Table 3.9: Alignment between JICA's and EPA's Guidelines

CHAPTER FOUR: BASELINE SURVEY

This chapter discusses the base line data collected during the field work. Some information is also gathered from documents and AFD study for test drilling in Ayrobera. Here it will be important to notify that TOR of the previous prioritization study site list does not request/or mention Ayrobera but Allalo Beda as Tendaho-3. Though the Woreda /Dubti/ is the same for both sites they are nearly 40 Km apart on the road and 12Kms on air distance. In this chapter, the past ESIA information on Ayrobera is updated as follows.

4.1 Major Features of the Site

4.1.1 Location

Ayrobera geothermal site is located in the Afar Region at the central part Afar depression. Administratively it is found in Dubti Woreda (Zone 01). As shown in the Map below, the site is specifically located within Ayirolef–Gebelaytukebele borders and closely located to Semera Town (23kms NE). The neighboring village is Krrub or BattiHurrde. In the local language of the community Hurrde means “town” while Krrub is the name of a hill around the village. Elders of the community say that the village is very old and served as camp site during Italian invasion. The project site is situated about 35 km away from Logia town which is at about 596 km from Addis Ababa. According to the National Geothermal Energy Resource survey map there are two potential geothermal sites in and around Tendaho. The geographical location of Ayrobera site found to be 41^0 9’ 20’’ Easting and 11^0 54’ 34” Northing.

4.1.2 Other Features of the Site

Ayrobera site is a flat dry land covered with mainly sand and ash, not fertile for agriculture. It is characterized by shortage of rain/water, both for drinking and farming. Summary of meteorological data of the project surrounding is given in the table below while its detail is attached at Annex. The community depends on water from precipitation of fumaroles. According to the woreda administrators, the community has been embraced by relief/safety net program.

4.1.3 Physical Settings

(a) ***Isohyets and elevation zone:*** The area is arid and dry and with very low and erratic rain fall pattern. Its annual rain fall is very low which ranges between 20ml – 30ml precipitation. Tendaho including Ayrobera area is one of the valley floor of Afar Depression, which resulted due to the continued and slowly rift apart of the Earth's crust, which is the immediate consequence of continuous sequence of earthquakes and the valley floor sinking which forms grabens. Thus, the Ayrobera geothermal potential site is located at low altitudes, which is in between 250 -500mts above sea level. On the other hand the eastern & western mountain ranges which are found close to these thermal sites, have relatively high altitudes which range from 800-1500 m above sea level.

Table 4.1: Climatic data of the site and its surrounding

Summary of meteorological data available for the targeted Ayrobera site measured from its nearest surrounding Dubti

Component	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Rain fall	22.18	13.63	7.47	21.72	13.88	21.39	15.57	30.99	14.60	15.06	19.90	10.58	19.47		
Average max temp	37.54	37.68	38.14	37.89	36.69	36.80	38.15	37.97	38.48	39.73	37.26	37.65		37.76	
Average min temp	22.31	22.28	23.61	23.15	23.01	22.13	23.89	23.28	21.66	23.93	22.80	21.91		22.62	
Relative humidity	48.2	52.9	46.2	50.5	49	45.8	50.4	51.6	50.9		54.8	52.3		55.6	
Wind	1.30	1.30	1.50	1.40	1.40	1.60									
Sun hour											8.20	8.60		8.60	

Source: Ethiopian Meteorological Agency

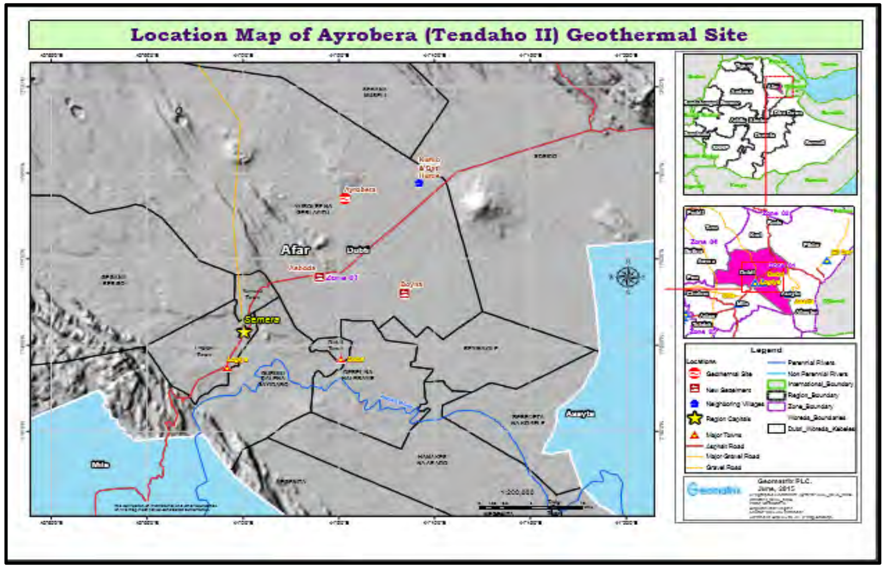


Fig. 4.1: Location Map of Ayrobera (Tendaho II) Geothermal Site

(b) ***Land cover:*** In general, Tendaho valley floor is predominantly covered by exposed sand soil surface specifically the central part; while the northern part of the Tendaho valley floor and its eastern and western mountain ranges /plateau is covered by Exposed Rock Surfaces with Scattered Grass Vegetation. Moreover, State farm and perennial marsh is also located in the south and near (6-10km) to Tendaho Geothermal sites. On the other hand, salt deposits/flats and pockets of Exposed rock surfaces are found in the North Eastern direction of Tendaho Geothermal sites. For the detail please refer Map # 3.3.

(c) ***Soil types:*** The major soil types in the area are Lithosols, Eutric Regosols, Orthic Solonchaks and Calcaric Fluvisols. Among these, Orthic Solonchaks and Lithosols are the predominant soils which occupy Tendaho valley floor. Calcaric Fluvisols soil type also dominates and extends to perennial Marsh areas. On the other hand, Eutric Regosols also partially covers its Western part plateau.

(d) ***Geology:*** In general, Tendaho area is predominantly covered by the recent quaternary period deposition (such as extrusive and intrusive basalt flows, rhyolites, trachyte and alluvial and/or lacustrine sediments. Moreover, Cenozoic period deposition such as alluvial lacustrine & Marine sediments, Bishoftu Formation (such as Alkaline basalt & trachyte) and Afar Series-Alakaline basalt occupies the small portion of the central part of Tendaho valley floor.

Tendaho geothermal Energy sites are specifically located in Miocene_Pliocene age Afar Series-Alakaline basalt (with subordinate alkaline & per-alkaline silicics rhyolitic dome & flows & Ignimbrites). Some portion of the geothermal bound site is also covered by the recent period (Holocene) deposits of undifferentiated alluvial lacustrine & beach sediments. In this regard, it is assumed that Afar Series-Alkaline basalt is the main sources for the geothermal energy in the area.

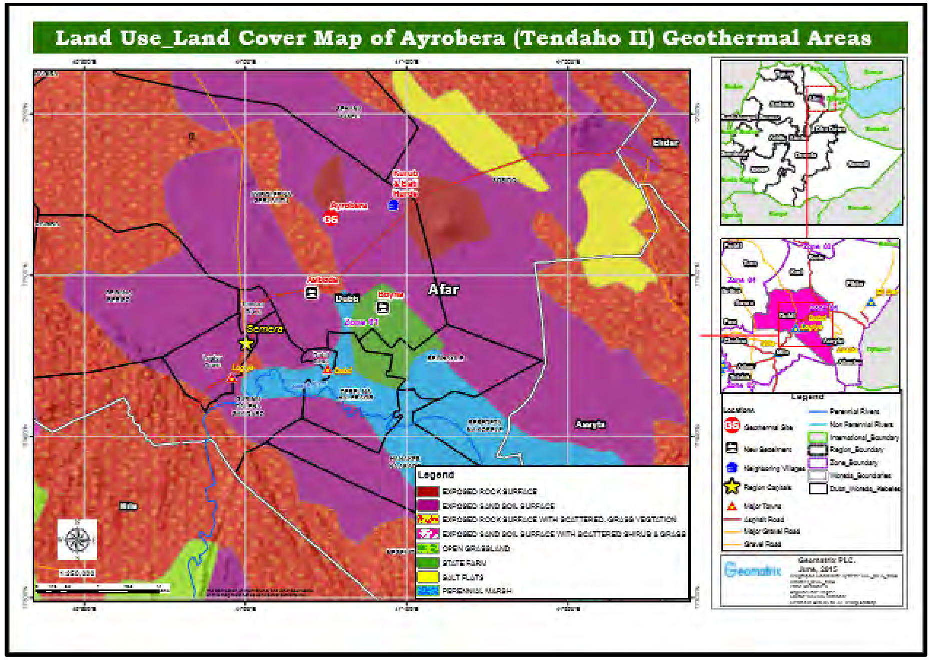


Fig.4.2 Land Cover Map of Tendaho Geothermal Energy Development Area

4.2 The Sample

From the total 1,138 people settled in the two villages 50 sample of representatives were selected to involve them in the study. Of this, 25 from Boina and 25 from Asboda were selected. Female participants were 9 while the rest 41 were male (Table 4.2).

The age of the sample group ranges from 18-65. Except six of them, all participants were married. In terms of educational status, more than half of them (56%) claimed to be illiterate. Except one person, with high school level the, remaining 21 sample population were elementary graduates (Table 4.2).

Occupation wise, 50% of the participants claimed to engage in cattle rearing while the rest equal percent were employed in Tendaho Sugar Plantation. Their yearly income ranges between ETB 10, 000 to 40, 000 (Table 4.3). As reported, on average, the workers at the plantation earn a monthly salary of ETB 800.

Table 4.2: Respondents Background

Village	**Sex**		**Age**		**Marital status**		**Educ. status**	
	M	F	18-30	>30	Single	Married	Illiterate	Elementary
Boyina	22	3	22	3	6	19	16	8*
Asboda	19	6	3	22	0	25	12	13
Total	***41***	***9***	***25***	***25***	***6***	***44***	***28***	***21***

Table 4.3:-Number of Respondents, Occupation and Annual income

Village	**Occupation**		**Annual income (birr)**	
	Cattle rearing	**Employed**	**10-20,000**	**21-40,000**
Boyina	12	13	25	0
Asboda	13	12	6	19
Total	***25***	***25***	***31***	***19***

In the sample house hold, there were 115 children; the smaller proportion is girls (30%). Of the total children, 60% of them go to school while the rest 40% were off school. In fact about 10% of the children were found under school age. Different reasons were forwarded for not sending 30% of the children to school; two of them were lack of awareness and children having responsibility in household chores.

Table 4.4:-Sample household, number of children and school children

Village	Nº of children		Nº of school children	
	Boys	Girls	Boys	Girls
Boyina	9	19	3	3
Asboda	66	16	50	13
Total	***75***	***35***	***53***	***16***

Although land is taken as communal property in the entire Afar Region, some people claim that they occupy limited plot of land particularly meant for agriculture practice. As reported, hundreds of out growers are working with sugarcane plantation. In line with that, the average land holding size is about 1/2 hectare. The total size owned by Boyina participants for example was only 6 hectare, while that of Asboda was 14 hectare Table 4.5).

Table 4.5:-Households who owned land

No of households	Size within the site	Size outside the site	Type of production
Boyina	-	75 hectare	Sugarcane
Asboda	-	25 hectare	Sugar/maize
Total	-	***100 hectare***	-

Except one person who reported that he produced maize, the rest are out-growers engaged in sugarcane production. The sample household owned about 1,455 livestock mainly cattle, goat, and camel. Goat and sheep represent the larger number; see Table 4.6. The price of the animals (at the time of data collection), in terms of the total value of livestock owned by the sample population has been ETB 2,720,000.

Table 4.6:Number, Type and Price of Livestock Owned by Respondents

Village	Type of livestock	No of livestock	Current price (birr) per livestock	Total Price/birr
Boyina	Cattle	319	2,000	638,000
	Goat/sheep	470	1,000	470,000
	Camel	84	10,000	840,000
Asboda	Cattle	284	2,000	568,000
	Goat/sheep	668	1,000	668,000
	Camel	30	10,000	300,000
	Total	***1,855***		***2,720,000***

4.3 Socio-Econimic Baseline Data

4.3.1 Demographic Characteristics

In the two settlement areas, there are 1,138 people: Boyna 554 and Asboda 584. The gender distribution of the two kebeles is significantly wide. For example in Boyna of the 554 dwellers only 93 of them are female. On the other hand the bigger majority of Asboda community is female, of 584 people they are 350 (Table 4.7).

Table 4.7: Number of People and Gender Proportion in, the two Villages

Kebele	Male	Proportion	Female	Proportion
Boyna	461	83%	93	17%
Asboda	234	40%	350	60%
Total	**695**		**443**	

In terms of accessing socio-economic services, Ayrolaf-Gebelaytu kebele is by far benefited. One reason for such favor is the fact that the kebele has been selected for a resettlement area. Initially, the settlers had been provided with water, energy, education and health services. However, since the last one year, even water has become scarce. The issue has been discussed in the other section of this chapter.

4.3.2 Land Use and Settlement Pattern

With 16 kebeles, and 4 small towns, the area of Dubti Woreda is about 5,400 km^2. Following the traditional land holding system, the entire land of the woreda belonged to no one but the community at large. The land holding size in the Dubti woreda is from 3 to 4.5 hectares per person. The big proportion of the fertile land, particularly that proximate Awash River, is assigned for sugar production- Tendaho sugarcane plantation. In fact, there are out-grower farmers who supply the same sugar cane for the factory. The rest body of the land is dry, sandy and barely habitable. The good example is Ayrolaf-Gebelaytu kebele which is dominantly dry and sandy; however, some part of the area is closer to the sugar plantation. Except for the government led settlement area, the land is practically empty, uninhabited. The site Ayrobera, as already mentioned, is also extremely dry and dusty, and it is a no man's land.

4.3.3 Religion, Language, Custom and Values

Ayrolaf-Gebelaytu residents belonged to mainly Afar speaking people. According to the kebele officials, nearly all of the residents are Afar. And yet, tribes, namely Asobakari, Bedewaita, Mandit, and Hintiba are dominant. Due to the proximity of Ayrolaf-Gebelaytu kebele to Semera town and the prevalent harsh climate of the area, nearly all of the kebele residents are resettled in to two separate places. The first settlement area is called Boina while the other is Asboda.

In both settlement areas, basic necessities such as water and health services were accessed through the effort made by Afar Regional government. However, due to engine failure, the supply of water and energy has been discontinued for more than a year. As the result, women, for example, are forced to travel for more than four hours per day to fetch water.

Photo 4.1: FGD in Boina village

4.3.4 Water Facility

Independent questionnaires were developed for energy and water sector offices at woreda levels with the aim of assessing sources and supply status around the site (see the attached format). Data on water sector is included with the assumption that clean and adequate water supply is among the priorities in the surrounding community. On the other hand, settings of Woreda Administration structure assign energy and water issues in one sector office.

With regard to water source and supply, Ayrolaf-Gebelaytu is supplied with communal tap water from Tendaho Sugar Project. It seems that Resettlement Action Plan was undertaken by the sugar project. However, currently this tap water supply is not functional due to technical failure in the electrical pump. These days, water is supplied to the residents using heavy trucks at a cost of ETB 6,000.00 per truck. Each day five trucks of water is supplied at a cost of ETB 30,000.00 per day. One can compare maintenance cost of existing water supply system with the cost of water transporting over a month, two months, and three months.

On the other hand, few households (nearly 25) located at closer to Ayrobera geothermal site do not have any access to water. They lived at the buffer zone of Ayrolaf-Gebelaytu kebele bordering with Serdo and Saha kebeles. There seems unclear administrative boundary among the kebeles.

Thus there is a strong need of residents to implement community projects to access potable water source (characterized by community participation in collaboration with other development organizations), parallel to the main geothermal project.

4.3.5: Education Facility, Ayrolaf-Gebelayitu Kebele

As it is depicted in Table 4.8, the kebele runs three schools. The first two schools, Dubti 2nd Ersha and Dubti 4th Ersha are located in the center of the two settlement sites. Although the peoples are known for being pastoralists with frequent mobility, the people were already settled. Such a life style would make it possible for the community to have access to Education.

Table 4.8: Number of Schools, Teachers and Students, Ayrolaf-Geblaytu Kebele

School name	Grade Level	Number of Students			Number of Teachers		
		Male	Female	Total	Male	female	Total
Dubti 2nd Ersha	Grade 1- 7	102	64	166	9	4	13
Dubti 4th Ersha	Grade 1-6	92	31	123	5	4	9
Gumeatameli	Grade 1- 2	287	33	320	2	-	2

Photo 4.2: A School in Asboda

Dubti 2nd Ersha conducts class up to grade 7 whereas Dubti 4th Ersha limited to grade 6 only. Students qualified for grade 8 have to travel 5 to 10 kilometer, which is very difficult taking in to account the economic condition and awareness level of the community. As per the information obtained from the representatives of the community, most of female students give up before completing grade 6 or 7. According to the observation of the study team, class rooms are wide enough and relatively properly equipped for teaching and learning process.

The third school, Gumeatameli, hosts larger number of students. It is located 41 kilometer away from the Woreda. The school provides class only for grade 1 and grade 2 students. According to the Woreda education office, except road there is no basic facilities such as water, electricity and latrine (Table 4.9) Data from the Woreda education office shows that student teacher ratio is extremely low i.e.143.5 (287:2).

Table 4.9: Level of Schools STR and Facilities, Ayrolaf-Gebelayitu Kebele

School Name	STR	Dropout rate	Water	Electricity	Latrine	Clinic	Road
Dubti 2nd Ersha	.08	zero	Yes	No	Yes	No*	Yes
Dubti 4th Ersha	.07	zero	Yes	No	Yes	No*	Yes
Gumeatameli	.00625	Zero	No	No	No	No	Yes

The clinics are not located within the school compound, but found at the center of their settlement village where students could access them easily. Dubti 2nd and 4th schools have better facilities. The student teacher ratio and dropout rate are encouraging. For example students access to clinics, latrine and water, and enjoy ventilation. Currently both schools do not have electric service. However, the electric line is already in place. As depicted in Table 4.9, the third school is devoid of facilities under discussion; thus, the situation calls for immediate attention.

4.3.6 Health Facilities

When compared to other Kebeles of Dubti woreda, Ayrolaf-Gebelaytu Kebele is said to be much better in accessing socio-economic services. For example each of the settlement areas has its own health centers run by 3 professionals in Boina and 4 in Asboda.

Table 4.10: Health Facility Centers, Ayrolaf-gebelaytu kebele

Village	Nº of nurses	Others
Boina	2	1
Asboda	2	2

Critical challenges were identified by respondents. In line with that, water has remained number one problem for all groups of participants. The issue has been given priority not only among the community but also offices and institutions (Table4.11). Lack of energy and shortage of animal feed were the second and the third serious challenges respectively facing the community of Boyina and Asboda.

Table 4.11: Major challenges of the Study area in Priority Order

Priority	Asboda	Boyna	Water/energy office	Health office
First	Water	Water	Water	Electricity
Second	Electricity	Animal Feed	Road	Water
Third	Animal feed	Energy-fuel wood	Education	Medicine

Table 4.12:Kebele Level Critical Health Ailment in Priority Order

Priority	Ailments
First	Water born disease
Second	Malaria

4.3.7 Woreda and Kebele Level Development Organizations

Tendaho Sugar Factory, one of the giant sugar factories is found in Dubti Woreda particularly in the project kebele. 84% of sample households are employees in the factory or on the plantation. The other big public enterprise in the project kebele is Semera Dry port which has also created and provided job opportunities to the community. The establishment of the Tendaho Sugar plantation/factory and the Dry Port in the Ayrolaf-Geblaytu Kebele has brought about a significant change in the economy and the life style of the community. In line with this, the existence of the two organizations brought about a positive impact on reducing the level of poverty. The experience of the community to work with big firms on wage basis is an asset and a fertile ground to join the test well drilling project.

Kebele Level basic infrastructures: The project site is located by the side of the main asphalt road, Addis Ababa to Djibouti, which allows the project site to be easily accessible. There is a network of electric power, meant to supply energy to the residents of the Ayrolaf-Geblaytu kebele, though power has not yet been released. Like the rest of the rural part of the country, the main source of energy in the kebele is biomass, in the form of firewood or charcoal.

According to the sample respondents, a household spends close to ETB 150 per month for electricity and fuel consumption. The kebele enjoys access to mobile and internet network. Other services like banking, fuel stations, hospitals and pharmacies are available in either Semera, or the woreda, Dubti.

Road Construction: The proposed site for test well drilling in Ayrobera is located about 7 km away from the main asphalt road, Addis Ababa-Djbuti. Thus, the implementation of the test well drilling requires the construction of about 7 kilometer road along the sandy land. Besides, there is a need to construct additional 5 kilometer (depending on the distance between test wells) road to move resources and machineries within the project area, from one potential test well to the other. The construction of roads will be relatively less costly.

4.3.8 Woreda Level Farming and Livestock

Dubti Woreda is one of the woredas of Afar Regional State. The woreda consists of 14 kebles, 4 of which are pastoralist, 8 are semi pastoralist and the remaining 2 are kebeles/ town.

Table 4.13: - Major types of crops produced in the semi pastoral areas

Major crops	Average/h	Land Coverage
Maize	29 quintal	753 hectare
Onion	180 boxes	41 hectare
Tomato	240 boxes	67 hectare
Green paper	9 boxes	5 hectare
Other crops		8 hectare

According to the woreda agricultural office, a total of 1,923 hectares of land is appropriate for farming. Recently most of the fertile land owned by the community in the woreda is used for sugar cane out-grow program. The livestock that are found in the woreda is indicated in Table 4.14.

Table 4.14:Number of livestock owned by sample group

Cattle	Donkey, horse mules	Sheep	Goats	Camel
40599	1591	46819	5727	5966

Although the community is dependent on livestock and livestock products, shortage of food is becoming more and more serious. One of the reasons is that the incorporation of fertile land into sugarcane development. Shortage of rain has also influenced the crop production, and feed for animals and /or grazing land. The view of the agricultural experts in the woreda agrees with the community representatives, in that the major problem of livestock breeding in all kebeles is lack of fertile land and water; mainly due to the inclusion of fertile land for sugar cane farming. Loss of livestock due to disease is becoming common, thus the government has been trying to compensate it by providing animal medicine free of charge.

4.3.9 Kebele Level Economy and Livelihood

The two major settlement villages of the kebele- Boina and Asboda, are located in different places. Although both villages are established within areas with fertile ground for business, there is no observable business like activities. In both villages there are only cooperatives shops owned and run by the community for basic goods and food items.

The entire community is mainly pastoralists, but nearly all households depend on wage from the sugar factory, sugarcane plantation and Semera dry port. As the data collected from a sample indicates, the annual income of nearly all households is from wage. About 84% of the sample is employees of the two government organizations. Only 16% of the 50 households are engaged in other activities. Except one person who completed high school, the rest didn't have the required skill and qualification to earn a better salary.

As mentioned earlier, members of both villages didn't engage in other agricultural work except sugar cane production. Almost all households in Boina village for example have 1 hectare of land used for farming sugar cane under outgrown program, and ½ hectare for grazing. Similarly each household in Asboda village own ½ hectare for out-grow program; however, no one owned privately land for grazing. As per the kebele officials, the sugar cane out-grow program was launched for the first time; thus, the actual annual production and income earned was not determined. In line with this, the sugar factory presumed sugarcane out grower with 1 hectare could earn annual income of ETB 35,000; and ETB 15,000 up to 20,000 on ½ hectare of land. It is on this assumption that the annual revenue of the sample from crop production was determined (see Table 4.15). Although the sugar cane outgrow program is new in Ayrolaf-Gebelaytu kebele, it has been implemented and feasible for people living around sugar cane factories elsewhere in Ethiopia. If well handled, the arrangement will have a significant positive impact on earning of the target community.

Table 4.15:Economic and Basic Social Services in Boyna and Asboda villages

Nº	Nº of family	Annual Income			Value of live stock	Farm land(h)	Grazing land (h)	Access to				Major Occupation
		Wage &Other	Crop	Total				school	Health center	Water	Electric	
1	2	15000	35000	50000	51000	1	½	√	√	√	No	Employee
2	1	10000	35000	45000	40000	1	½	√	√	√	No	Employee
3	5	10000	35000	45000	135000	1	½	√	√	√	No	Employee
4	1	10000	35000	45000	135000	1	½	√	√	river	No	Employee
5	1	10000	25000	35000	75000	1	½	√	√	√	No	House wife
6	4	10000	25000	35000	74000	1	½	√	√	river	No	Employee
7	4	15000	35000	50000	90000	1	½	√	√	√	No	Employee
8	2	12000	35000	47000	140000	1	½	√	√	√	No	Employee
9	1	15000	35000	50000	51000	1	½	√	√	√	No	Employee
10	3	20000	35000	55000	105000	1	½	√	√	√	no	Employee
11	5	12000	35000	47000	40000	1	½	√	√	√	No	Employee
12	4	10000	35000	45000	120000	1	½	√	√	√	No	Employee
13	3	15000	35000	50000	80000	1	½	√	√	√	No	Employee
14	2	6000	35000	41000	64000	1	½	√	√	√	No	House wife
15	4	10000	35000	45000	44000	1	½	√	√	√	No	Employee
16	7	15000	35000	50000	36000	1	½	√	√	√	No	Employee
17	1	15000	25000	40000	76000	1	½	√	√	√	No	Employee
18	5	12000	25000	37000	126000	1	½	√	√	√	No	Employee
19	3	5000	35000	40000	52000	1	½	√	√	√	No	Semi-Past
20	1	12000	35000	47000	55000	1	½	√	√	√	No	Employee
21	7	10000	35000	45000	65000	1	½	√	√	√	No	Employee
22	4	15000	35000	50000	133000	1	½	√	√	√	No	Employee
23	6	10000	35000	45000	58000	1	½	√	√	√	No	Employee
24	4	12000	35000	47000	90000	1	½	√	√	√	No	Employee
25	5	10000	20000	30000	78000	1	½	√	√	√	No	Pastoralist

Asboda Village												
1	6	12000	10000	50000	30000	½	No	√	√	River	No	Employee
2	5	12000	20000	20000	30000	½	No	√	√	River	No	Employee
3	4	20000	20000	40000	29000	½	No	√	√	river	No	House wife
4	3	40000	0	40000	80000	½	No	√	√	river	No	Employee
5	14	40000	15000	55000	120000	½	No	√	√	river	No	Employee
6	8	40000	15000	55000	60000	½	No	√	√	river	No	Employee
7	5	30000	20000	50000	30000	½	No	√	√	River	No	Employee
8	8	60000	20000	80000	44000	½	No	√	√	River	No	Employee
9	6	15000	35000	50000	51000	½	No	√	√	River	No	Employee
10	7	20000	20000	40000	105000	½	No	√	√	river	no	Employee
	Sub T			1542000								

No	No. family members	Annual Income			Total value of live stock	Farming land in hectare	Grazing land in hectare	Access to				Major occupation
		Wage &Others	Crop	Total				school	Health center	Water	Electric	
11	8	12000	20000	32000	35000	½	No	√	√	River	No	Employee
12	5	15000	20000	35000	78000	½	No	√	√	River	No	Employee
13	4	12000	25000	37000	52000	½	No	√	√	River	No	Employee
14	3	6000	25000	31000	35000	½	No	√	√	River	No	House wife
15	1	20000	20000	40000	43000	½	No	√	√	River	No	Employee
16	2	18000	18500	36500	46000	½	No	√	√	River	No	Employee
17	4	20000	18500	38500	36000	½	No	√	√	River	No	Employee
18	5	10000	20000	30000	95000	½	No	√	√	River	No	pastoralist
19	3	20000	20000	40000	45000	½	No	√	√	River	No	Employee
20	1	30000	18500	38500	36000	½	No	√	√	River	No	Employee

21	6	15000	20000	35000	38000	½	No	√	√	River	No	Employee
22	8	30000	20000	50000	91000	½	No	√	√	River	No	Employee
23	3	20000	20000	40000	82000	½	No	√	√	River	No	Employee
24	1	30000	18500	48500	120000	½	No	√	√	River	No	Pastoralist
25	2	10000	18500	28500	60000	½	No	√	√	River	No	Employee
	Sub T			**560500**								
	G. Total			**2102500**								

The average annual real earnings of the household (excluding the expected revenue from the sugar cane outgrow program) is ETB 17,060 and only ETB 1,421 per month. The lowest annual earning is as low as ETB 5,000 or ETB 416 per month. The highest annual income among the sample was ETB 60,000 (ETB 5000 per month). This shows how difficult life could have been without earning from employment.

Assuming that the presumed annual revenue (from sugar cane outgrow program) will be actualized, the estimated average income of the sample will reach ETB 42,050. While the lowest is ETB 20,000, the highest is ETB 80,000. In other words, the average monthly income of the household is expected to grow to ETB 3504.167; the highest ETB 6,666 and the lowest ETB 1,666.

Being semi- pastoralist, every household masters the skill of livestock breeding. However the return from livestock breeding has been low when seen from the number of livestock that each family owned. Two reasons can be attributed for the lower return: severe shortage of grazing land and the culture/values of the Afar community (as it does not encourage sale of livestock products such as dairy products. The estimated value of live stocks as obtained from the sample group is as low as ETB 29000 and as high as ETB 140,000.

4.3.10 Ecological Features

4.3.10.1 Flora

The National Biodiversity and Action Plan (IBC,2005) recognizes the following new classification of ecosystems in Ethiopia: Afroalpine and Sub-Afroalpine, Dry Evergreen Montane Forest and Grassland Complex, Moist Evergreen Montane Forest, *Acacia-Commiphora* Woodland, *Combretum-Terminalia* Woodland, Lowland Semi-evergreen Forest, Desert and Semi- Desert Scrubland, and Inland Waters.

These diverse ecosystems have endowed Ethiopia with a diverse biological wealth of plants, animals, and microbial species. In the view of this, the study area falls within the *Acacia- Commiphora* woodland which occupies the main rift valley, desert and semi-desert Scrubland towards the Afar Depression.

According to Simon and Zerihun (2006), the rift valley area where most of the proposed geothermal sites are located has three tree-shrub type of vegetation which can be recognized based on species composition and differences in environmental factors. These are: (1) the highly extensive *Acacia tortilis*, *A. Senegal* and *A. seyal* dominated type on flat and undulating terrain; (2) *Acacia tortilis, Euphorbia candelabrum* and *Croton dychogamus*dominated type on rocky substratum, and (3) *Oleaeuropaea*ssp. *cuspidata*, *Acacia ebtaica* dominated type at higher altitude along the escarpment of the Rift Valley. Tendaho-Dubti areas fall in the third category.

Conservation attentions need to be employed to grasses and sedge as they are used as food for animals. In Afar, animals play a central role in all walks of life. Cattle, goats and camels, in particular, have values that go beyond the production of meat. Their importance is based on the full set of services they provide (milk, meat, hides, draught power), and above all they have cultural symbolism. Those plants identified by the community as having medicinal value need to get conservation attention. As a representative effect, Environment and Rural land office head of Dubti Woreda remind the study team that eradication of draught resistant trees due to expansion of sugar project causes dislocation of local residents beyond what has been planned by the government. Afar community uses these draught resistant trees as an indicator of water availability in that surrounding. He emphasizes the necessity of public participation and benefit involvement in project formulation.

4.3.10.2 Fauna

The two ecosystems mentioned above, namely, *Acacia- Commiphora* woodland and Desert and Semi-Desert Scrubland are also home to a high diversity of wildlife. Around Ayrobera Geothermal site, on Dubti Woreda level, the following Common Wildlife are recorded which include: Hyena (*Crocutacrocuta*), Anubis Baboon (*Papioanubis*), Jackal (*Canisaureus*, *C. mesomelas*), Bush duiker (*Sylvicapra sp.*), Vervet monkey (*Cercopithecusaethiops*), Porcupine (*Hystrixcristata*), Leopard (*Pantherapardus*), Guenther's dikdik (*Rhynchotragusguentheri*), Genet (*Genetta* sp.), Soemmering's gazelle (*Gazellasoemmeringii*), and Warthog (*Phacochoerusaethiopicus*). According to the informants,

small mammals such as rats, different kinds of reptiles are found in the area. Some of the bird species found include: Ostrich (*Struthiocamelus*), Goose (*cyanochen sp.*), Francolin (*Francolinus sp.*), Pigeon (*Treton* sp.), Guinea fowl (*Acrylliu sp.*) and Dove (*Streptopelia sp.*). We believe that there are a lot more mammals as well as birds but it seems that there was no detailed survey carried out in the area.
The biodiversity in actual project site seems low as the area is arid- dry –windy flat land with little vegetation. The study team was able to observe only wild goats (local name) and some reptiles around the project area.

Potential tourist attraction or recreation sites: One of the objectives of national parks is to "set aside certain areas of outstanding scenic and scientific value for the enjoyment of present and future generations" and thereby, visit is an essential condition for the existence of national parks. With about 320 species of mammals, Ethiopia is one of Africa's most diverse countries for mammals. A great selection of the famous African mammals is still present in the country. This diverse wildlife, which includes 36 endemic species potentially, could make Ethiopia one of the top safari destinations in Africa. Species whose conservation state have been a global concern, include: 5 critically endangered 8 endangered 12 near-threatened species and 27 vulnerable species. For the survival of all those globally concerning species, Ethiopia plays a critical role.
The study area has also a number of spectacular scenic landscapes such as the sulphur springs at Lake Assale, Erte Ale Vocano; the Fenatle volcanic mountain, the traditional salt mining and camel caravan in Dallol which play a great role as tourist attractions. With this respect, the selected project site is does not serve as national park and not suitable for potential tourist attraction due to its harsh climate, flat topography and negligible diversity.

Possible impacts of the project on the ecology: There is a debate as to whether geothermal resource development and wildlife conservation are compatible. The key socio-economic impacts associated with developing these resources involved both positive and negative, opening up and modernizing sites on one hand, and loss of wildlife habitat as well as visual intrusion in scenic tourist areas on the other. Because capacity and areal coverage the geothermal plant to be developed is not yet determined, it is not possible to envisage the magnitude of the impacts of the project on the existing fauna and flora of the surrounding areas. In general however, it is an established fact that geothermal activities mostly affect vegetation by gaseous emissions, physical removal of vegetation to pave way for roads, drilling pads, and buildings and hot or cold geothermal brine flowing on the surface. Disposal of geothermal water on the surface can cause high metal concentrations in soils and vegetation.

Table 4.16: Regional Level National Parks, Wildlife Reserves, and Controlled Hunting Areas

Site	Managed by	Established	Area in ha
National Parks			
AbijataShala Lakes	Oromia	1963	88,700
Awash	Oromia & Afar	1958	75,600
Geralle	Somali	1998	385,800
YangudiRassa	Afar	1969	473,100
Wildlife Reserves			
Alledeghi	Afar		193,389
Awash west	Afar		415,000
Gewane	Afar		-
Mille Serdo	Afar		650,354
Controlled Hunting Areas			
Aluto	Oromia		28,000
Bilen Hertalie	Afar		109,000
MelkeSadi	Afar		-
TelalkDewe	Afar		72,000

(Data source: Different Publications)

4.4. Public Consultation and Stakeholders Meetings

4.4.1 Objectives of Public Consultation

During the field assessment, consultations were carried out with different stakeholders: This means, public consultation with the community and meetings with the rest of key stakeholders of the project. The different groups that participated in the consultation include, representatives of the community, woreda officials, kebele authorities, experts and officials from Geological Survey of Ethiopia (GSE). The following section deals with the whole issues of the consultations.

The objective of the consultations were:

- To create a platform for the key stakeholders to actively participate in the project, and what is more, to have a say in the planning and implementation of the project.
- To inform the concerned key stakeholders about the nature, scale and other features of the project.
- To discuss about the potential ion benefits and adverse impacts that may occur in the project cycle.
- To capture the attitude of the stakeholders particularly the community on the selected site.

4.4.2 Approaches to Consultation

All key stakeholder meetings were chaired by the concerned authorities. The consultation took place in different days in the offices of the stakeholders. All members of the study team attended the consultation program. Participants' pictures were taken while the consultation took place.

The other consultation was public consultation. Participants were representatives of the community from two villages that are found in Ayrolaf-Gebelaytu kebel. In each village two public consultation were conducted, the first with community representatives the other with elders. The entire public consultation took two days, one day for each village. The whole consultation process was audio taped, pictures taken and video recorded. The entire activity of the consultation and the result of the findings as mentioned above is presented here in different sub-titles.

4.4.4 Stakeholders' Consultation

Regional level consultation (February 13th 2016): The team of experts conducted meetings with the concerned regional bureaus, mainly with Afar Region water and energy bureau representatives (in Semera). The objective of the consultation was to explain all about the envisaged project. In addition, the meeting was meant to secure information about the status of the test well drilling, and other issues such as facilities, potential, and plans available in the regions. The other purpose of the consultation was to receive permission letter for the study team that would allow conducting the assessment and consulting concerned institutions. Many of the objectives of the consultations were achieved (see the names of officials participated in the consultations at Appendix).

Woreda consultation (14thFebruary2016): Consultation was conducted with Dubti Woreda officials. Different officials and experts including sector heads were present (see Appendix). The purpose of the discussion was to introduce them about the objective of the envisaged project, to capture their views over the project; to discuss about the adverse impacts of the project, if any, and seek alternate mitigation measure.

The consultation was indeed successful and achieved its objective. The woreda representatives confirmed that they would welcome the project to the extent that it would bring about adverse impact. In line to this, they had bad experience concerning geothermal projects. According to them, there was an explosion in one of the geothermal well (TD 6) in 2001, and yet they still hope the envisaged test well drilling wouldn't entail similar adverse impact. For them, Afar in general and Dubti woreda in particular are one of the least economically backward areas of Ethiopia. The prevailed pastoralist cultural value coupled with the harsh climate of the region attributed to limited attraction of investment. Participants also assured the study team that, not only the woreda administration but also the community in the project area would do their best and cooperate for the success and implementation of the project.

Photo 4.3: Consultation with Dubti Woreda Officials

Consultation with Geological Survey of Ethiopia (GSE), (8th February 2016): The study team conducted discussion with Geological Survey of Ethiopia (GSE), at their head office in Addis Ababa. Participants included concerned officials of the organization and Japanese experts from JICA (Appendix). The purpose of the consultation was to introduce the study team with both stakeholders, listen briefings of JICA on the existing status of the geological and other technical works so far done in the project site. The discussion carried out mainly through questions and answers. The consultation wound up when the required explanation was exhaustively done.

GSE staff stationed in Afar Region, at Semera town, was also consulted about how the study activity would go along the existing test well drilling activities. Following the consultation, representative of GSE at the site, facilitated the assignment of the study team. She also guided the team to visit the entire site and the surrounding areas. What is more she introduced the team members with the community who are settled at the far end of the site. The consultation made both in Addis and Semera with GSE staff was valuable and fruitful.

4.4.4 Public Consultation

Public consultations were undertaken in the two settlement areas of Ayrolaf-Gebelaytu, kebele. Both settlement areas are located within the kebele but far from the projected site. The participants of the meetings were: officials of the kebeles, elders and religious leaders; representatives of the community, and representatives of women and youth. The objective of the consultations were to (i) make aware the community about the project (ii) to capture their views on the project, i.e., their worries concerning negative impacts, if any, and their hopes and their expectation from the project (iii) solicit their views on the possible mitigation measures to be taken if they think of negative impacts.

4.4.4.1 Consultation with Boina village community (February 18/ 2016)

The consultation meeting was conducted in Sugar cane plantation workers camp. The meeting was chaired by the study team leader. About 25 persons attended the meeting. This includes two officials from Dubti woreda administration, all kebele leaders and community representatives as mentioned above. After the team leader introduced the agenda and the purpose of the consultation, participants actively engaged in the discussion. The summary of the discussion is as follows: The representatives in general were happy about the project. None of the participants were against the prospective test well drilling. According to them the project is free from human and animals. The area is totally abandoned due to the harsh climatic condition. In this respect therefore the introduction of the new project is a blessing. Villagers however expressed their worries over the project. According to them, similar project had been undertaken in the woreda some years back. The result was totally discouraging as it was blasted with a reason unknown to them. What is more the project is still suspended.

Photo 4.4: Consultations with Boina village community

Consultation with elders: Immediately after public consultation with Boina villagers wound up the study team had a session with selected persons involving community elders, and religious leaders of the same village. The discussion focused on the values of community, means of conflict resolution, and their views over development projects in general and test well drilling in particular; about ownership claim for site area. According to the elders the site has been deserted and known for no man land. The only thing that has been taken as valuable was the thermal smoke used by some people for medicinal purpose. And yet, the emission of the smoke is limited to a very small area; a maximum of a fourth of a hectare. According to them, if the area developed for geothermal project, the community would benefit the thermal hot water much better than the current use. The do nothing alternative is highly disadvantageous. In general, the elders and religious leaders were over joined on the project which would be launched on an area where it has been abandoned and deserted.

Photo 4.5: Consultations with Boina Elders

4.4.4.2 Consultation with Asboda village community (February 20/ 2016)

Similar to Boina villagers, consultation was undertaken with Asboda community in the kebele school compound. The same officials from both Dubti and Ayrolaf-Gebelyatu kebele were present in the meeting. Mainly, representatives of the community from different social groups attended. Points rose, and issues discussed were almost identical with Boina consultation session. For example, the

representatives were highly positives on the launching of the test well drilling. Similarly, their reservation geared to the past bad experience, i.e., the failure of similar geothermal project in 2011. Even if their past experience is gloomy, representatives reiterated that they have been optimist since then; according to them they wish the failed project would continue and what is more other new geothermal projects would be launched. As they said, the issue of the claim over Ayrolaf between two kebeles has been solved in the near past. Thus, project owner shouldn't get worry about ownership claim in both the site and the surrounding areas.

Photo 4.6: Consultations with Asboda Village Community

Consultation with elders: The public consultation with the villagers was followed by a meeting with representatives involving elders, and religious leaders of Asboda village. The theme of the session was around the values of community, means of conflict resolution, and their views over development projects in general and test well drilling in particular, and what is more, about ownership claim over the site. Similar to the views of elders from Boina, the site belonged to no one because it has been extremely unfavorable for people and livestock to live on. In fact, people even from distance areas go to certain location of the site to make use of the thermal smoke, which they believe would heal different ailments such as body ache. The study team assured the participants that the test well drilling has nothing to do with limiting the thermal smoke. One purpose of the project is to identify the extent and magnitude of the thermal power in the area. If the result of the test well drilling produced positive, the next phase of the project would make the use of the thermal smoke easy and comfortable for users. The consultation was conducted with mutual agreement and understanding.

Photo 4.7: Consultations with Asboda elders

Public disclosure: The report of the study would make known to the concerned stakeholders and the public at large. The first action would be to put it in the website of the project owner. Then copies of the report would be sent to the concerned authorities/offices. In addition the project owner needs to open its door and allow users to make use of the report in all possible means prior to the processing of the project.

CHAPTER FIVE: IMPACT ASSESSMENT

5.1 Overview

As a rule of thumb, ESIA studies are usually carried out side-by-side or in parallel (or immediately after) with techno-economic studies. Both studies need to have harmonized data to share with. Basic data such as generation rates, plant size, amounts etc. that are considered as important inputs for ESIA are usually taken from techno-economic studies. However, in conditions of such data-gaps, assumptions generated from professional judgment are employed. It is strongly believed that these assumptions are not far from what might be expected after completion of techno-economic study findings and may not significantly affect the final outcome. To this effect, widely practiced geothermal technologies with moderate capacity have been chosen as a representative power plant so as to carry out the task of impact assessment.

5.2 Impact Rating Method

No single best assessment method is yet universally practiced. Thus, a combination of methods can be applied for impact assessment. Checklists and environmental guidelines along with locally accepted standards are generally applied for most of the cases. As much as possible all significant impacts are evaluated using appropriate parameters.

In this section, nature, extent, significance etc. of potential impacts is assessed using EPA national guidelines. This ESIA process includes prediction (e.g. duration, intensity, severity, status, reversibility) of impacts based on legal requirements. The purpose of this activity is to decide whether the project is likely to cause significant adverse environmental effects resulting from various project phases. The assessment is performed in three steps:

Step 1: Based on the nature of project and environmental baseline, a detailed matrix of project activities and environmental receptors is prepared and it is determined whether an interaction exists between an activity and a receptor.

Step 2: Based on the interactions in Step 1, potentially significant impacts due to the proposed changes are identified. These impacts may be beneficial/ adverse, direct/indirect, reversible/ irreversible and short-term/ long-term.

Step 3:Adverse impacts that are rated as “low” or “medium” or “high” are treated only qualitatively while all potentially *significant impacts* are quantitatively evaluated (Table 3.1).

Table .1: Criteria for impact assessment

Rating parameter	Definition	Scale	Description	Score
Duration	*Describes how long the impact persists*	Very short term	less than a month;	1
		Short term	Months but less than a year;	2
		Medium term	More than a year but less than the operational life of the project	3
		long term	Over the operational life of the project	4
		Residual	Permanent; remains after the closure	5
Extent	*Describes coverage of impacts*	Limited	Impact affects the immidiate site only	1
		Small	Impact affects immidiate site & surrounding	2
		Medium	Impact affects the entire project area	3
		Large	Impact affects including neighboring areas	4
		Very large	Impact that affects greater area than neighboring	5
Likelihood	*Describes the probability or chance a given impact could occur*	Highly unlikely	The impact is highly unlikely to occur	0.2
		Unlikely	The impact is unlikely to occur	0.4
		possible	The impact could possibly occur	0.6
		Probable	The impact will probably occur	0.8
		Definate	The impact will occur	1
Intensity	*Describes magnitude of the impact*	Insignificant	Impact is of a very low magnitude	1
		Low	Impact is of low magnitude	2
		Medium	Impact is of medium magnitude	3
		High	Impact is of high magnitude	4
		Very high	Imact is of of highest order	5
Consequence	*Quantitative approach used to describe combination effects of Severity & Extent*		Consequence = (Severity + Extent)/ 2	
Severity	*Quantitative approach used to describe combination effects of Intensity & Duration*		Severity = (Intensity + Duration) / 2	
Significance *(both for +ve &-ve impacts*	*A mathematical tool used to describe combination effects of Consequence & Probability*	Very low	Impact is negligeble; No mitigation required	≤ 1
		Low	Impact is of low order; Mitigation could be considered to reduce impact but does not affect environment acceptably.	> 1 & ≤ 2
		Moderate	Impact is real but not sustantial in relation to other impacts. Mitigation should be implemented to reduce the impact	> 2 & ≤ 3
	Signifi =(Conseq + Probability)/ 2	High	Impact is substantial. Mitigation is required to lower impacts to acceptable levels	> 3 & ≤ 4
		Very high	Impact is of the highest order possible. Mitigation is required to lower impacts to acceptable levels or other project option.	> 4 & ≤ 5

Source: Different documents

To quantify identified potential risks of the project, score range method can be used to provide distinction between risks. Impact rating is determined based on two parameters: the "significance of impact" and the "likelihood of impact occurrence". Significance depends mainly on the nature and size of the activity and the environmental sensitivity while the "likelihood of occurrence" depends mainly on nature of the activity and the control measures to be taken. Thus, impact assessment is an important pre-curser for effective impact evaluation. Thus, the beginning of this task starts from narration of

identified potential impacts from common geothermal plant development and particularly on test well drilling at various phases.

5.2 Geothermal Development Stages and Associated Environmental Impacts

Potential environmental impacts are associated with the different stages of geothermal energy development. The main stages of geothermal energy development involve:

- Reconnaissance Stage
- Prefeasibility Stage
- Feasibility stage
- Construction and operation of geothermal plant

The reconnaissance surface survey (geological, geochemical and airborne geophysical survey at a scale of 1: 500,000 and above) may not have any significant interaction with the environment.

The prefeasibility stage involves:

- Semi Detailed Surface Exploration (geological, geochemical, and geophysical) at a scale of 1: 100,000 to 1: 250,000 scale. No significant interaction, unless road construction is required
- Detailed Surface Exploration (geological, geochemical, and geophysical) at a scale of 1: 50, 000 or lower scale. No significant interaction, unless road construction is required
- Temperature Gradient Drilling (wells usually 50- 300m are drilled for measurement). Road construction and drilling fluids interact with the environment.
- Exploratory Drilling (2-3) deep wells are drilled per target to a depth up to 3000m using a deep drilling rig

Potential environmental impacts during the prefeasibility stage are associated with the following activities:

- Road construction
- Excavation of drill site, back filling with selected material, leveling and compaction for drill pad preparation (200mx200m)
- Grouting with cement of the drill pad surrounding with small rig by drilling about 20 wells of 30m depth
- Drill cellar preparation with concrete and Iron bars
- Mobilization
- Drilling (Drilling fluids include: Fresh water (3500 Cubic m/day), bentonite mud, Soap and air, chemical additives)
- Well testing vertical discharge to clear wells
- Production testing

The Feasibility Stage involves:

- Appraisal drilling
- Delineation of the boundary,
- Detailed further resource evaluation
- Production drilling
- Power plant design
- Design of other physical structures

The feasibility study stage may cause some environmental impacts if not conducted with due consideration of the environmental systems.

The construction and operation stage involves:

- Construction of drilling plant and other components
- Construction of camp
- Monitoring

Most of the environmental damages associated with the test well drilling will be short term, if there is. To capture all potential impacts, it is necessary to have a completed techno-economic feasibility study. However, the current ESIA study is at a preliminary stage where potential impact assessment can be qualitative based on secondary information and experiences of similar projects in other countries. Therefore, in the absence of a complete techno-economic feasibility study of the project, the study team can only undertake a preliminary ESIA. From discussion made in the previous chapter of project description, the following potential impacts may need further elaboration for credible assessment and evaluation.

5.3 Identified Impacts on Natural Environment

5.3.1 Gaseous emissions

Gaseous emissions result from the discharge of non-condensable gases (NCGs) that are carried in the source stream to the power plant. For hydrothermal installations, the most common NCGs are carbon dioxide (CO_2) and hydrogen sulfide (H_2S), although species such as methane, hydrogen, sulphur dioxide, and ammonia are often encountered in low concentrations. Emissions of H_2S – distinguished by its "rotten egg" odor and detectable at 30 parts per billion – are strictly regulated to avoid adverse impacts on plant and human life. Studies conducted at the geothermal prospect sites in Ethiopia showed that the H2S concentration is relatively high.

Emissions can be managed through process design. In steam and flash plants, naturally occurring NCGs in the production fluid must be removed to avoid the buildup of pressure in the condenser and the resultant loss in power from the steam turbine. The vent stream of NCGs can be chemically treated and/or scrubbed to remove H_2S, or the NCGs can be recompressed and injected back into the

subsurface with the spent liquid stream from the power plant. Both of these solutions require power, thereby increasing the parasitic load and reducing the plant output and efficiency. Binary plants avoid this problem because such plants only recover heat from the source fluid stream by means of a secondary working fluid stream. The source geo-fluid stream is re-injected without releasing any of the non-condensable.

The selection of a particular H_2S cleanup process from many commercially available ones will depend on the concentration of contaminants in the geo-fluid stream and on the established gaseous emissions standards at the plant site.

So far in Ethiopia, there are no standards to be met for the emission of CO_2 and H_2S. Nevertheless, geothermal steam and flash plants emit much less CO_2 on an electrical generation basis (per megawatt-hour) than fossil-fueled power plants, and binary plants emit essentially none. The concentrations of regulated pollutants – nitrogen oxide (NOx) and sulfur dioxide (SO_2) – in the gaseous discharge streams from geothermal steam and flash plants are extremely minute.

5.3.2 Water pollution

Liquid streams from well drilling, stimulation, and production may contain a variety of dissolved minerals, especially for high-temperature reservoirs (>230°C) which may not be the case in similar projects. Some of these dissolved minerals (e.g., boron and arsenic) could poison surface or ground waters and also harm local vegetation only in some locations. Liquid streams may enter the environment through surface runoff or through breaks in the well casing. Surface runoff can be controlled by directing fluids to impermeable holding ponds and by injection of all waste streams deep underground.

To guard against fluids leaking into shallow fresh-water aquifers, well casings should be designed with multiple strings to provide redundant barriers between the inside of the well and the adjacent formation. Nevertheless, it is important to monitor wells during drilling and subsequent operation, so that any leakage through casing failures can be rapidly detected and managed.

5.3.3 Solids emissions

There is practically no chance for contamination of surface facilities or the surrounding area by the discharge of solids *per se* from the geo-fluid. The only conceivable situation would be an accident associated with a fluid treatment or minerals recovery system that somehow failed in a catastrophic manner and spewed removed solids onto the area. There are no functioning mineral recovery facilities of this type at any similar project elsewhere.

5.3.3.1 Noise pollution, dust and vibration

Noise from geothermal operations is typical similar to many industrial activities. The highest noise levels are usually produced during the well drilling, stimulation, and testing phases when noise levels ranging from about 80 to 115 decibels. A-weighted (dBA) may occur at the plant fence boundary.

During normal operations of a geothermal power plant, noise levels are in the 71 to 83 decibel range at a distance of 900 m. Noise levels drop rapidly with distance from the source, so that if a plant is sited within a large geothermal reservoir area, boundary noise should not be objectionable. If necessary, noise levels could be reduced further by the addition of mufflers or other soundproofing means but at added cost.

During normal operations, there are three main sources of noise: the transformer, the power house, and the cooling tower. Because the latter is a relatively tall structure and the noise emanates from the fans that are located at the top, these can be the primary source of noise during routine operation.

Air cooled condensers employ numerous cells, each fitted with a fan, and are worse from a noise perspective than water cooling towers, which are smaller and use far fewer cells for a given plant rating. The air cooled systems may not be recommended in the Ethiopian context as ambient temperature is relatively high in the prospected Ayrobera site.

However, it should be noted that test well drilling plants will likely be located in locations where water may be in short supply, they may require air-cooling, and proper attention may be needed to muffle the sound from their air-cooled condensers.

Drilling activities and movement of trucks carrying heavy load machineries cause dust and vibration. On top of that and in the absence of project intervention, topography //land scape// of the Ayrobera project site by itself is a wide-flat and sandy with ash. The prevalent strong wind in the area is capable of creating visual intrusion and induces health risks. Thus, the proposed drilling activity will have cumulative effect with respect to dust. As the project area is susceptible for seismic, huge vibrations may also exacerbate the seismic risk.

Soil contamination and degradation: Soil contamination due to geothermal energy development during its different stages is very minimal. However, soil erosion could be a problem if the various activities are not managed properly.

5.3.3.2 Land use
Land footprints for test well plants vary considerably by site because the properties of the geothermal reservoir fluid and the best options for waste stream discharge (usually reinjection) are highly site-specific. Typically, the power plant is built at or near the geothermal reservoir because long transmission lines degrade the pressure and temperature of the geo-fluid. Although well fields can cover a considerable area, typically 5 to 10 km^2 or more, the well pads themselves will only cover about 2% of the area. With directional-drilling techniques, multiple wells can be drilled from a single pad to minimize the total wellhead area. However, it is important to note that availability of land is not a major challenge in the Ayrobera geothermal prospect area; it is a no man's land.

Gathering pipelines are usually mounted on stanchions, so that most of the area could be used for farming, pasture, or other compatible use. The footprint of the power plant, cooling towers, and auxiliary buildings and substation is relatively modest. Holding ponds for temporary discharges (during drilling or well stimulation) can be sizeable but represent only a small fraction of the total well field.

5.3.3.3 Land subsidence
If geothermal fluid production rates are much greater than recharge rates, the formation may experience consolidation, which will manifest itself as a lowering of the surface elevation, i.e., it may lead to surface subsidence. This was observed early in the history of geothermal power at the Wairakei field in New Zealand where reinjection was not used. Subsidence rates in one part of the field were as high as 0.45 m per year. Wairakei used shallow wells in a sedimentary basin. Subsidence in this case is very similar to mining activities at shallow depths where raw minerals are extracted; leaving a void that can manifest itself as subsidence on the surface. After this experience, other geothermal developments adopted actively planned reservoir management to avoid this risk.

Most of geothermal developments are likely to be in granitic-type rock formations at great depth, which may contain some water-filled fractures within the local stress regime at this depth. After a geothermal well is drilled, the reservoir is stimulated by pumping high-pressure water down the well to open up existing fractures (joints) and keep them open by relying on the rough surface of the fractures. Appropriate precautions should be considered concerning the depth as well as reinjection of the geothermal fluid. In particular case of Dubti, the shallow reservoir is estimated at the depth of 300 to 500m, so the ground subsidence may not occur.

5.3.3.4 Water use
Geothermal projects, in general, require access to water during several stages of development and operation. Water use can be managed in most cases to minimize environmental impacts. The upcoming feasibility study shall clearly identify and evaluate the availability and potential of water supply sources at Ayrobera site. Two options are sited: One, from Dubti irrigation pond through pipelines; the second one is by drilling sub surface ground water and abstract the resource using electrical pump.

Access to potable (treated) water is still a priority. Water resource competition from currently growing (expanding) sugar industries is pessimistically perceived by the community. Respondents were asked about the negative impact of the project on water in terms of pollution, water supply/ system; the possible competition of the project for the existing water resources; and options to reduce or avoid the impacts. The finding reveals that the community believed the project would bring about no negative impact. However in terms of the critical shortage of water all community in all sites required the supply of water at least in their respective kebele.

5.3.4 Other Impacts

5.3.4.1 Resource competition

It is a collective term used to evaluate pressure on existing land use; competition on farm site and grazing land; clearing of bushes; pressure on existing flora & fauna; increased price on locally available products and services; water resource competitions. Impacts on each of these socio-environmental components are discussed in the subsequent section.

5.3.4.2 Fauna, flora and biodiversity

Ayrobera project site is arid area covered mainly with sand ashes. Few bushes are found here and there. Desert goats (local name) and reptiles are observed in the area. Fauna and flora found in the Dubti Woreda are discussed in the Baseline chapter. Even though productive well fields can cover considerable area, gathering pipe lines are mounted on stanchions so that most of the available area remains unaffected (even in the production phase). Thus, the existing biodiversity may not be disturbed. The impact on biodiversity during test well drilling phase is almost negligible.

5.3.4.3 Local warming

Geothermal steam releases heat along with CO_2 to the surrounding. Other secondary heat sources are condensers (heat exchangers), air fans; lengthy transmission pipe lines etc. These heat sources are suspected to enhance local warming contributing to the global. Sufficient reference literature may not be available to determine significance of this issue.

5.3.4.4 Deforestation

With respect to energy in few households, kerosene lamps and solar cells have been used, particularly in health posts and schools. However, the assessment reveal that the main source of energy both for cooking and light is fuel wood, coal and dung. Thus, existing pressure on natural resources and consequent degradation of environmental quality needs to be assessed. The impact of wide use of wood and coal would be not significant as the number of rural community is few and scattered, compared to the available resource and its regenerative capacity. In addition to this, energy consumption per capita of the community is very low. Social impacts such as unnecessary time and labor wastage should also be addressed.

5.3.4.5 Occupational Safety and Health

Out of many, major safety issues during test well drilling phase are: Safety on Rig operation; Gas blow outs; and hydrogen sulphide emission. Safety issues for power plant development are too technical and are not included in the scope of this study; it requires an institutional arrangement during operational phase through monitoring and auditing activities.

Uncontrolled well blowouts may bring injuries or loss of life, environmental damage, wasting of resources, and loss of equipment. Blow-out-prevention equipment (BOPE) capable of shutting in the well during any operation shall be installed on the surface casing tested, and maintained ready for use at all times. Fig 3.1 depicts such representative controlling equipment.

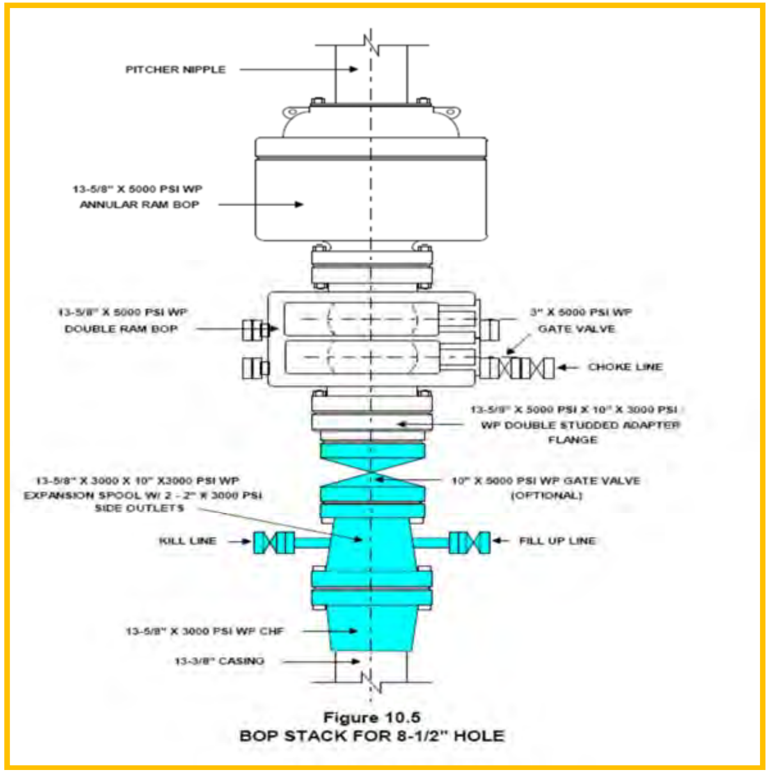


Fig 5.1: Representative controlling equipment

5.3.4.6 Community Safety and Health

As the project area is arid zone with water scarcity the surrounding community and cattle might be forced to consume pond water that is supposed to be disposed. The other community health risk emanates from gaseous emission, noise and increased traffic movements.

5.3.4.7 Waste disposal of Cuttings and Mud Products

Huge amount of waste is expected from this activity, particularly if the number of test wells is more. Percolation of this fluid will contaminate ground water resources. No recharge wells might be expected on test well drilling phase. Thus, professionally designed waste disposal structure (pond) need to be constructed, preferably to dispose waste after air-dried.

5.3.4.8 Environment related components to be affected

Environmental components most likely affected include ambient air quality; water bodies; soil (land use); fauna and flora; eco-system; natural noise levels. Social components most likely affected, on the other hand, include change in life pattern; livelihood; culture; heritage etc. of the surrounding communities. In addition to these, resource competition, safety and health, community development etc. are among joint issues to be addressed in light of existing national and international guidelines as socio-environmental effects. The subsequent section presents major findings of the field survey for the candidate site.

5.3.5 Impacts from Site Selection and Land Acquisition

Due to various negative repercussions of geothermal power plants on man and environment, it is not possible to set up such facilities anywhere. Selection of a site that fits best for the proposed projects was pre-determined in the scientific or technical studies at reconnaissance study using relevant professional parameters/criteria. Thus, there is no room for alternative site analysis.

The candidate site, from socio-environmental point of view, however, was also further screened using standard check-list methods and parameters to assess level of its impacts. These parameters consider both physical and biological data. The physical data emphasizes on climate, soil, water and associated risks such as flood, erosion, seismic and storm water handling. On the other hand, biological data deals with fauna, flora ecosystems, etc.

The project site and its surrounding were surveyed by the ESIA study team to carry out the task. This study, however, does not include assessment on project area of influence as there was no prior plant lay-out available.

Thus, issues/or parameters/ such as project area of influence; core process area; area for supportive facilities; expansion area; protected green belt; alignment/symmetry/ for point and area sources of pollutant emissions, heavy load of traffic on affected roads and surroundings etc. are not treated. This is because the scope of the study is limited on test well drilling. As it is explained above in this chapter, the proposed project site at Ayrobera is a no man land; arid climate; flat land covered with sand and ash. Thus, impacts from site selection and land acquisition are at minimal.

Site analysis

- Findings from document review at Regional and/or Zonal levels do not reveal any directives that prevent the geothermal plant from establishment along the proposed site;
- The inquiry/interview/ we made with legally authorized institution/ Regional & Woreda EPA/ for this particular site do not indicate that the surroundings of the proposed project site is either declared or reserved;

- More than 100% of directly affected households in the area express their willingness for establishment of the plant in the proposed site provided that they earn compensation as per indicated in guidelines and secure equivalent resettlement area near their town;
- All of key stakeholders do not have compliant in the proposed project site. In addition to this, they have also explained that their office do not have any planned development activity in the surrounding of the project sites.
- According to Federal Environmental Guideline of EPA, 2003, the proposed site is not classified as environmentally sensitive;
- No preliminary hydro geological data is obtained to confirm that the proposed site is relatively safe and stable from natural hazards of seismic, subsidence. Further work need to be carried out after during implementation;
- In addition to the above mentioned facts, professional observation and judgment of the study team is that the proposed site is not environmentally sensitive but arid climate for the work force;
- The study team strongly believes and as usually practiced, public disclosure and official reviewing are best instruments for further investigation of few unforeseen dimensions so as to arrive on a sound decision before implementation.

5.3.6 Findings from Relevant Guidelines

For this study major guidelines selected as relevant are: Federal and Regional guidelines of Environmental Protection Authority, EPA: According to these guidelines, geothermal power plant development industries which process mine products are treated under Category I (Schedule III) and they require full EIA. With regard to site selection processes; the federal guideline; environmental impact assessment procedural guideline, May, 2003,(Annex VI) stress that adverse projects shall be sufficiently far or out from environmentally sensitive sites.
From this guideline, description of environmentally sensitive sites relevant to the proposed plant is summarized as follows.

Environmentally Sensitive Areas and Ecosystems

- Areas prone to natural disasters (geological hazards, floods rain storms, earthquakes, landslides, volcanic activity, etc.).
- Wetlands: - flood plains, swamps, lakes, rivers etc.
- Mangrove swamps characterized by one or any combination of the following conditions;
    - With primary pristine and dense growth;
    - Adjoining mouth of major river systems;

- Near or adjacent to traditional fishing grounds;
- Which act as natural buffers against shore erosion, strong winds and storm floods

- Areas of unique socio-cultural history archaeological or scientific importance and areas with potential tourist value

- Areas declared as: National parks, Watershed reserves, forest reserves, wildlife reserves and sanctuaries, sacred areas, wildlife corridors, hot - spring areas

***Potential impacts*:** It can be observed from the discussion of the previous section that potential impacts of the project naturally emanate from major drilling processes and related activities. These impacts are identified as follows:

a. Predicted impacts from project concept formulation (screening);
b. Predicted impacts from site selection and land acquisition;
c. Impacts due to plant lay-out (setting), design aspect;
d. Impacts due to construction and development phase;
e. Impacts from raw material handling, storage and feed supply;
f. Impacts from major plant processes;
g. Impacts from handling, storage and feed supply of hazardous input materials/chemicals/;
h. Impacts from utilities and infrastructure services;
i. Occupational safety of workers (in-plant);
j. Community safety and health (out-plant);
k. Effects and benefits to local community;
l. Impacts from generation and disposal of liquid process-wastes;
m. Impacts from non-condensable gaseous wastes;
n. Impacts from generation and disposal of domestic wastes;
o. Impacts from infra-transport phenomenon;
p. Impacts from resource competition and issues of cleaner production methods;
q. Nature of water resource utilization and its options;
r. Energy source and its utilization;
s. Optimized raw material utilization

For convenience, each of the above impacts on the corresponding sensitive socio-environmental receptors is usually and meaningfully grouped phase-by-phase of the project development. These receptors are then squeezed to few but main categories. Finally, impact evaluation is performed on main receptors for easy decision making.

Summarized environmental receptors include:

- Natural environment: (1) Topography and geological features including seismic, (2) Soil erosion, (3) , Hydrological & seismic situation, (4) Flora, fauna and biodiversity,(5)Protected Area, (6) Global warming

- Pollution control: (1) Air pollution and dust, (2)Water pollution, (3) Waste generation, (4) Bottom sediment, (5) Noise and vibration, (6) Odour

For instance, a representative development project has the following phases: (1) concept formulation (inception) phase; (2) construction phase; (3) operation phase; (4) decommissioning phase etc. In a similar approach the "test well drilling project" can be perceived as having the following phases:

- Pre drilling phase (survey & conceptual modeling);
- Construction phase (civil & non-civil works);
- Drilling phase (development & commissioning phase);
- Testing phase (operation phase);
- Decommissioning phase.

5.3.7 Experience Learnt from Aluto-Langano

The Aluto-Langano geothermal field is located on the floor of the Ethiopian Rift Valley about 200 km south east of Addis Ababa. It is regarded as advanced prospect area. Eight deep exploratory wells were drilled to a maximum depth of 2500 m between 1981 and 1985, of which four are potentially productive. The maximum reservoir temperature encountered in the productive wells is about 350ºC.

A 7.3 MW pilot geothermal plant was installed in 1999 on the basis of the exploration wells that had been drilled. Binary system was installed and operated for many years. However, the plant was not fully operational mainly due to technical limitations inappropriate, field and plant management skills.

Recently, techno-feasibility study of the power development at the Aluto-Langano geothermal field has been conducted as part of FY2009 Studies for Economic Partnership Projects in Developing Countries promoted by the "Ministry of Economy, Trade and Industry of Japan (METI)" and that was entrusted to West Japan Engineering Consultants Inc. (West JEC) through Ernst & Young Shin Nihon LLC and the Japan External Trade Organization (JETRO).

The geothermal power development project is divided into the following two kinds of development: underground geothermal resource development and surface power generation facilities. The outlines of each development are as follows:

(a) Underground geothermal resource Development

The 3D numerical model was constructed based on the geothermal conceptual model. Using this numerical model, 30 years forecast simulations with several development scenarios were carried out. It was concluded that the optimum scenario is 35MW development with steam pressure of 10 bars. In this case, it is forecasted that 8 production wells and 4 reinjection wells will be required at the commissioning of the 35MW power plant. It is also forecasted that 5 make-up production wells and 2 make-up reinjection wells will be necessary to maintain the rated output for 30 years. The produced steam and brine will be separated at a separator station, and the separated steam will then be sent to the power station and the brine to reinjection wells in the southern part of the field. All of the required pipelines and other facilities will be constructed.

(b) Surface power generating facilities
The geothermal power facilities consist of the geothermal fluid transportation system (Gathering System), power plant, transmission and substation. Main specifications of the facility shown below were determined taking account the results of resource evaluation and the pressure drop of pipeline of the geothermal fluid.

- Capacity 35 MW gross × 1 unit
- Power plant type Single flashed steam cycle with condensing turbine
- Steam condition 10 bar(abs)/179.9 Deg. C (saturated) at plant inlet
- Non-condensable gas in steam 8 wt %

Currently, two test wells are drilled each about 1951 meters depth and about 150 meters apart. It generates steam at 1350 and the brine solution is relatively clean. Interview made with the site engineer, Ato Habtamu Germew, revealed that boundary cases and compensation were and still are critical social issues for the last thirty five years. The project area is about 44 Hectare; 33 households were compensated each household gaining about ETB 400,000.00; giving rise a total cost of ETB13, 200,000.00.

As the site recommends that any new geothermal development plants shall pro-actively establish clear boundary map considering future expansion and green belt development. The project shall also secure approval from Regional and Federal Authorities. Copies of approved document with site plan shall be officially issued to the local administrators so as to minimize unnecessary negotiation and unwise cost.

The following table summarizes phase-by-phase, identified impacts of the project on sensitive socio-environmental receptors.

5.4 Social Impact Analysis

5.4.1 Findings from Directly Affected People

The findings of the public consultation have been highly encouraging. The participants were, more or less termed as <directly affected people>, though they are settled very far away from the proposed site, Ayrobera. They were people drawn from the community, women and youth, the elderly and religious leaders, among others. In fact the finding confirms similar positive scenario and view to that end. The issue is thoroughly discussed in the coming chapters.

Photo 5.1: Site Visit

5.4.2 Findings from Other Key Stakeholders' Participation

The assessment follows and employed the concept of the International Association for Impact Assessment (IAIA) which considers social impacts as changes to all aspects of social variable. This among others includes their health and wellbeing, services and facilities, quality of the air and water people use; the level of hazard or risk, dust and noise they are exposed to; physical safety, access to and control over resources. Pertaining to the project site, Ayrobera is the best and only alternative location that is presumed to be rich in thermal power. Fortunately, the site/ is not only inhabitable but hostile to life. If the test well drilling proves positive, the future geothermal production will be a promising venture. Stakeholders view on the appropriateness of the site is fully positive. Starting from the concerned community (Ayrolaf-Gebelaytu kebele) to region, woreda and local officials, the site and the project fit well with nearly no adverse impact affecting the community directly. In general there is no social, economic, or other legal issue that imposes, the implementation of the test well drilling project.

Perception of key stakeholders on the impact: *T*his section discusses the major social impacts identified by stakeholders. The entire household heads interviewed hoped to gain benefits from the establishment of the project. However few respondents worried about the success of the project. This is because that they had bad experience which resulted in not only in failure but also accident.

The two prioritized benefits that the community hoped to secure are the expansion of development projects in the area and access to electric power that may be distributed in the future.

The big majority of interviewed officials expressed their support for establishment of the project by providing with what is required of them. There are no policies, regulations and directives that prevent the test well activity from launching on the proposed site. The only obligation is that project owners go through legal process and procedures as required by the federal and regional governments. In line to this, findings from other stakeholders too, reveal that they didn't have objection, rather happy, in that the unexplored resource of Afar Region in general and Ayrolaf-Gebelaytu kebele in particular is to be exploited. It will be, thus, justifiable to launch the proposed project on Ayrobera site.

5.4.3 Impact on heritages and scenery

Heritages: The other aspect of the impact is concerned with cultural, historical, and natural heritages. In terms of its proper definition of heritages, there have been no heritages located within or close to the site. Thus impact analysis pertaining to this has been left out due to the absence of the elements.

Scenery: The test well drilling activity at Ayrobera site would be situated within the empty deserted section of the kebele. Thus the construction and activity of the proposed test well drilling would not affect the natural and geological features of the area. Rather the effect would be positive. It is positive because the proposed area is so harsh, sandy, and no single vegetation is growing. As the result, no human being prefers to cross the area, let alone living within. Very few temporarily settled pastoralists neighbor the site; however, they are off the site, far away, and found in relatively vegetated areas. In terms of this therefore, the activity and construction of a camp, and other appurtenance buildings such as maintenance workshop, lounges, lodgings, new facilities and infrastructures for example roads, supply of water, energy, would rather boost the amenity of the harsh landscape. This in other words mean, implementing the project would undoubtedly result in significant positive effect.

5.4.4 Change in land use pattern and zoning

It is assumed that the launching of test well drilling would attract other business sectors towards Ayrolaf and Gebelytu in general and Ayrolaf site in particular. This is so, because once the project launched others began to look into business alternative closely tied or associated with the drilling project. The unpopulated vast land of Ayrobera could slowly attract small businesses or pastoralists willing to settle, though in a lesser extent. One pull factor for settlement might be the availability of water supplied within the site.

Overall economic impact: The impact of the project revolve around the socio-economic impacts at higher level, particularly at National and Region level in general and at Dubti woreda level in particular. The impact in these areas has been taken one of the two significant positive effects. The analysis compares the extent of the effect at all levels, in terms of employment, local capital, and increase in capacity of the energy sector.

Other socio economic impact: The socio economic benefits of the project would be immense, explained by direct and indirect, short term and long term. In fact the analysis has covered impacts that are related to adverse social issues. However, a few of the variables are not decisive and thus left out from discussion in this report.

Sources of adverse impacts: Impacts are sourced from different factors, activities and conditions. Identifying the sources of adverse impacts would help to identify the real mechanisms of mitigation and management.

Table 5.2: Major sources of adverse impacts

Major impacts sources	Activities/situation	
Accidents	Personal; equipment, and vehicular	
Personal factors	Lack of skill; worker physical and mental ailments.	
Unsafe activities	Operation without safety and authority.	
Unsafe condition	Absence of safety tools	
Job factors	Make use of below standard equipment; wear and tear of tools and materials	
Items, equipment	Electricity; motors; gases; chemicals, walk ways; ladders, mast and/or derricks;	

Generic impacts will be the major characteristics of the project. This means adverse occupational health and safety impacts related to personal accident or injury all projects particularly that involve construction and production. There are also likely negative impacts derived from workers-management relationships. According to the study team judgment, due to the nature of the project/site nearly all adverse impacts will be related to generic (Table 5.2).

5.4.5 Occupational accident and hazards

During construction phase, heavy equipment would move from Semera town to Ayrobera site. After arrival, the same machines are to move from one corner of the site to the other. Construction of camps and stores, installation of equipment, storage activities, movement of vehicles, and physical activities of workers, among others, are intense. During operation phase too, wells are drilled, gases and vapors are emitted, tools and machines are moving from place to place, and chemicals are loaded and unloaded, or carried from one corner to another, the function of machines and vehicular movements etc., enhanced. All these process and activities are sources of accidents and hazards; what is more, the occurrence of such irregularities is most likely. Possible accidents and hazards associated with test well drilling projects are indicated at Table 5.3.

Table 5.3: Phase, and sources of accident and hazard in test well drilling

Likely Phase	Sources of accident	Sources of hazard
Construction and operation phases	Over exertion,	Burning
Construction and operation phases	Slips and falls	Explosion
Construction	Openings	Ignition
Construction and operation phases	Struck by objects	Fire
Construction	Work in heights	Gases/ vapor
Implementation	Drilling activity	Shock
Construction and operation phases	Equipment movements	
Construction and operation phases	Movements of vehicles	
Operation/Implementation	Operating machines	

The key and most likely adverse impacts of the project therefore are the following:

Injuries: The following are the common types of injury usually sustained by workers during test well drilling: injuries from a violent blow; injuries involving breathing; injuries of scrapped; injuries having jagged or hole by a sharp object; sprain and fracture; burns of skin or eye; and spinal injury etc.

Dust:-Due to the nature of the site, emission of dust is quite uncontrollable. The blowing of wind in and around the site is common which carries tones of dust across the site and travel long way, sometimes violently. The staff and workers around the site will definitely be affected incessantly. In line to this, the occurrence of adverse impact during exposure to dust is critical.

Hearing disorder:-Impact of noise is the other sensitive issue during test well drilling. As experienced elsewhere, for example in Aluto site, noise emitted from during and after drilling is nauseating. Even the blowing of steam after the drilling wells emit incessant noise which can be heard one to two km away. In terms of this, therefore, the adverse impact of the noise particularly on the staff and other workers around the site is serious, and thus labeled as major. As already indicated, as most of these noise sources cannot be prevented, control measures should include the use of personal hearing protection for exposed personnel. The allowable exposure time according to the ILO or Ethiopian standard for different sound level is given in Table 5.4.

Table 5.4: Sound level with allowable exposure time

S/N	Ethiopia/ILO/ standard[dB(A)]	Allowable exposure time (hr)
1	90	8
2	92	6
3	95	4
4	97	3
5	100	2
6	102	1.5
7	105	1
8	110	0.5
9	115	0.25

Source: Ethiopia/ILO/ standard [dB(A)]

Duration of the test well drilling activity is anticipated to last over 12 months. The required number of workers in all phases is about 70-90. The following are presumed impacts that are closely associated in all phases. In general, the staff and temporary workers exposure to unsafe work setting will be moderate; as it is expected that the concerned body will take measure to that end. In addition to exposure to improper equipment will also be moderate. On top of this, exposure to harsh environment would be high.

5.5 Economic Impact

5.5.1 Impact of Road Construction

As the area is totally free from residence and vegetation, there is no need to worry about displacement cost and deforestation risks. In other words, it doesn't result in adverse impact on agriculture, and fertility of the land. In addition, it does not result in displacing or affect private property. In line to this, therefore the cost of constructing the road will be relatively cheap because some of the raw materials are available in the area; what is more the landscape is evenly flat which would make the cost minimal. As the project site is free from any human settlement, the activity of the project will have no impact related to noise and dust, at least on the community.

5.5.2 Impact of project vehicles/transportation

There is generally a higher traffic on the road from Addis Ababa all along Semera town to Djibouti. The road transports heavy trucks carrying imported items to all parts of the country. Thus, as the result of the project activities, traffic will increase in the area mainly during the transportation of the rig and its accessories to the drill site. This additional increase traffic might have some unfavorable impact however it is insignificant. The increased traffic may also lead to an increase in dust, noise and vehicular emissions; however, since there are no communities living around the main road there will be no impact in that respect. This doesn't however mean that there is no adverse impact. During drilling, dust and noise resulting from movements of service trucks most likely affect the entire staff/workers. Since increased traffic activity will be temporary and normality is restored after the drilling is completed, expected impacts would be lesser and lesser.

5.5.3 Impact of the Project on Employment Opportunities

The test well drilling project will create temporary jobs for different activities. Some of the employment opportunities, especially the technical part demands the use of foreign experts while some others can be covered by local workforce. And yet, the large part of operation will be covered by the local community.

The test well drilling project is expected to create an employment opportunity for 13 local professionals and laborers and semi-skilled workers. In addition the project will involve about 10 foreign experts at different stages (see Table 5.6).

Work force and experts' involvement: At this drilling and testing phase of the project a number of professionals and non-professionals will be employed /assigned. Of this, during drilling a total of 121 workers are required. Of this 8 are local professionals, 7 of them are foreign experts. During the testing phase too, 8 highly skilled workers are required. Of the total 121 workers, additional labor force, a minimum of 60 workers is required for the construction of the road from the main road to the site. In general, a total of 129 skilled and non-skilled workers will be involved through-out the phases (Table 5.6).

Table 5.5: Project labor force required

Nº	Labor Force Type	Drilling phase	Testing phase	Total
1	Foreign experts	7	3	10
2	Local experts	8	5	13
3	Laborers and semi-skilled workers	46	-	46
4	Laborers during road construction	60	-	60
	G. total	**121**	**8**	**129**

The community in the potential project site is semi-pastoralist. Due to the recent severe drought, and the incorporation of the fertile land into sugarcane plantation, the community is becoming dependent on wage labor available. In this regard the project will serve as a source of additional income for the

surrounding community. To build a positive image of the project related to the job opportunities, project owner has to give due attention to ensure equity in recruitment and selection. Involving community leaders at the early stage of the recruitment therefore will be best approach to that end. The available job opportunity for the community during test well drilling is mainly labor works. The projects' requirement for unskilled labor indeed meets the need of the local community. This is therefore one of the positive impact in terms of economic benefits of the community.

5.5.4 Impact on Disposable Income and Business Activities

Most development interventions create job opportunities that involve the local community. The additional income that some members of the community earn from the employment will increase their disposable income. Besides, migrant workers who might access the job opportunity will secure adequate money to satisfy their basic needs. This in other way means injecting additional money in the economy. The level of benefit maximized from the increased disposable income and business activity largely depend on readiness of the local community to consume and deliver the required goods and services. In this regard Semera town is expected to benefit far more than the project site kebele and other towns such as Logia and Dubti.

The additional demand created as the result of the test well drilling intervention will bring about development in the local business activities and thereby contribute to the improvement of the economy at the Kebele, Woreda, Region and National level. The project will contribute to the increase in the number and types of business in the area. Each new business creates new job opportunity, additional revenue for the local Government bodies in the form of profit tax and employee income tax.

In addition, the implementation of the test well drilling project is expected to inject cash inflow through job opportunity and enhance marketing for livestock outputs. The project staff might indirectly boost income of the community through exchanging sheep, goats, ox, and milk supplied by the surrounding community. In this regard the implementation of test project will have moderate favorable impact both on increasing the number and types of businesses in the area.

5.5.5 Impact on Cost of Living

When new development project is established in rural communities like Ayrolaf and Geblaytu, one of the major socio economic impacts is the increasing migrant workers appearing around the project site; which indirectly bring about an increase on cost of living. In addition to that, the increase in population, due to migrant workers, may cause a strain on the available resources and thus may result in conflicts. In terms of the test well drilling project in Ayrobera, however, the pressure of migrant workers on the local community will be insignificant. This is because that, most of the facilities and services project workers need may be obtained from Semera town rather than the project Kebele.

Semera is not only near to the project site but also supply better services and facilities needed to the project staff/workers. The impact of migrant workers on the existing services and facilities of Semera will be negligible when compared with the size of laborers employed in the project. Besides, the increase in the demand for facilities and services during the drilling phase will be temporary. Once the drilling operation is over, the demand may return to its previous level. Moreover, the drilling project may not significantly affect housing facilities adversely in the kebele, since the staff/workers will be camping within the site. Consequently, the project's impact on the cost of services and facilities either on the kebele and/or on the local community would be minor.

5.5.6. Impact on Cultural and Social Norms

Ayrobera site is located away from the local villages where the kebele community settled. However there are very few people living within 10 Kilo meter radius from the potential test well drilling site. Thus the establishment and operation of the project will have some kind of impact with limited range of intensity. The impact of migrant workers on the culture, language, religion, and style of life of the community will be insignificant on the nearby few residents and lesser impact on Asboda and Boina villages, the two big settlement villages in the project kebele. Similarly, the impact on socio cultural norms of Semera town will be insignificant too, because the town has already been mixed with migrants for a long time. The issue of gender would not be a point of discussion here. This is because that as already mentioned, the site is devoid of human settlement.

5.6 Conflict History and Minority Issue

Conflict:-The area is not known for witnessing tribal conflict within and/or without. No report of conflict has been reported by respondents during data collection. In addition to that, there is no official recorded data on history of conflict in the area. Possible conflict of interest (claiming the site to be included in their respective kebele) however might arise among the same kebele dwellers when drilling activity begins in the near future. According to Focus Group Discussants, three neighboring villagers began to claim Ayrobera when the news of the drilling project was heard. However, through intermediaries' of all sides, the issue was being discussed. Although the site is characterized by sandy terrain and incessant wind, according to informers, the southern part of Ayrobera is claimed by a tribe called Tiou Henteba. Other people who have settled at the far end (northern part) of Ayrobera also claim that the area belongs to them. Nearly all Kebele residents of Ayrolaf-Gebelaytu are resettled by the Afar Regional government. The settlement area is far away/ opposite the site. And yet according to some respondents, the same resettled people think of benefiting from the future geothermal project, if any. From this angel therefore conflict of economic interest (just to get a kind of benefit from the project) might occur when the actual test well drilling activity begins.

In fact, the tendency of individuals claiming project land (even though the land is no man land and has never been serving for either grazing or settlement), is common among the Afar. The previous study made by the same team (on Master Plan for Geothermal sites in Ethiopia) confirms this very fact, per-se. Any person/s from somewhere might come and claim a plot of land assigned to any project. Since the Afar culture doesn't encourage certificate of any kind for owning/inheriting land, a mere oral claim is taken for granted. In line to this therefore, land claim might arise from three directions. The first is from people who are neighboring or living at the far end of the site. The second claimers might be those who are already settled on the opposite side of the site. The third one could be individual

person/group of people who might claim that the site belonged to their father or grandfathers. Thus the issue need to be given due consideration. The shortest cut is to let the higher body of Afar Regional State process and clear the future land claim that may arise by one or all of the groups mentioned above.

Minority and Indigenous Issues: - In general, minorities (non-Afar) living in Afar face difficulties in possessing land. The Afar believes that their land belongs to no other except the Afar people. Due to this, none-Afar individuals don't have the right to own land. Following observation and informal interviews, in rural areas minority group may be denied of possessing land. Minorities in big tows such as Semera, Dubti and Logia however seemed to have the right to possess land as long as they passed through legal process in their respective Municipality. The best example could be certain non-Afar minority groups, for instance, business people, such as hotel owners have been able to possess land and built houses.

The case of investors is totally different. Land for big investors is processed by the Regional government. Since the federal government also has concern on investment, accessing land for large venture such as modern farming and geothermal projects would be simple, and relatively none bureaucratic. And yet the issue of compensation might be a bit irritating.

Ayrolaf-Gebelaytu residents belonged to mainly to Asobakari, other three tribes, namely, Bedewaita, Mandit, and Hintiba are also residing in the area. In line to this therefore the indigenous people are none other than these four mentioned tribes. In other words, there are no other indigenous people known among the area. The four tribes belonged to the bigger clan-The Afar. The above mentioned tribal groups are more or less treating each other equally and what is more, they are socially and economically tied together. Minority within the Afar are not discriminated. In light of this there is no history of discrimination against any Afar minority group in the kebele.

5.7 Quantitative Evaluation of Identified Impacts

From discussions made above the following impacts are considered useful for quantitative evaluation and then for the corresponding management plan. Here, as much as possible, similar impacts that may occur in different phases of project development are treated together using their generic name. However, few impact parameters such as nature; sensitivity; reversibility etc. are explained using descriptive statements.

Assumption for the scoping result

As the scope of the present study is limited to test well drilling, scoping results of operation phase may not be adequately addressed using the above mentioned parameters, such as generation rate, spatial coverage, intensity etc. Thus, scoping results of operation phase need detailed investigation after production capacity of the power plant is determined. Hence, rate given on operation phase shall be perceived only as indicative value in the context of test well drilling.

Note:

Pre:-During preparation,
Con:-During construction,
Ope:-During well testing
A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown (further examination is needed, and its impact could be clarified as the study progresses)
D+/-: Miner impact is expected.
E : No impact is expected.

Table 5.6: Quantities evaluation of identified impacts

Quantitative evaluation of identified impacts (Scoping)						
Category	No.	Items	Rating: Pre	Rating: Con	Rating: Testing	Basis for rating
Policy framework	1	National policy of the country	A+	......	....	**Pre・Con :** Inter allignment of policies and guidelines needs verivication
	2	International conventions				
	3	Guidelines of financial institutions				***Ope.*** Energy from geothermal power plant is among national priorities
	4	Policy of funding organization				Considered as renewable and also reduces greeen house gas emission
Pollution	5	Air Quality	E	D-	D-	**Pre・Con :** By production test, generation of the containing hydrogen sulfide (H_2S) is expected. In addition, emission gases are discharged by operation of heavy machines during well drilling and facility construction. **Ope :** H_2S is expected to be released along with steam.
	6	Water Quality	E	D-	D-	**Pre・Con :** Muddy water is expected to be generated due to well drilling. **Ope :** Wastewater is expected to be discharged from the facilities.
	7	Waste generation	E	D-	D-	**Pre・Con :** Drilling sludge, construction waste soil, and scrap wood are expected to be generated by well drilling activities. **Ope :** Wastes (sludge, waste oil) are expected to be generated at the facilities.
	8	Soil Pollution	E	D-	D-	**Pre・Con :** Discharging of geothermal fluids and muddy water will contaminate surface soil with heavy metals
	9	Noise/ Vibration	E	D-	D-	**Pre・Con :** Blowout of geothermal fluid by well drilling and noise from operation of heavy machines are expected. **Ope :** Noise from operation of the facilities (power generator, steam turbine, cooling tower, etc.) is expected.
	10	Ground Subsidence	E	E	D-	**Pre・Con**: Collection of geothermal fluid during well drilling and facilities construction is limited. **Ope :** Although ground subsidence is expected by collection of geothermal fluid, detail examination is required.
	11	Offensive Odor	E	D-	D-	**Con * Oper**: Offensive odor is expected due to harmful H2S gas emission **Pre* Con**: Construction of link roads and other facilities are planned
	12	Sediment Quality	E	D-	D-	**Oper**:Discharge of contaminated sludge and slurry is part of the planned activity
Natural Environment	9	Protected Area	E	E	E	No protected area is regestered with in and around project site
	10	Ecosystem/Flora and Fauna	E	D-	D-	***Con* Oper***: Minor negative impacts on local ecosystem and flora and fauna are expected due to disturbance of the land, operation, and existence of the facilities.
	11	Hydrology	E	D-	D-	**Pre・Con :** Surface water or groundwater is planned to be used. **Ope :** The amount of surface water or groundwater planned to be used is limited.
	12	Topography/ Geology	E	D-	D-	**Pre :** Impacts are negligible as large-scale well drilling is not planned. **Con :** The land is expected to be disturbed by construction of facilities (generator building, steam and hot fluid transport pipe, cooling tower, etc.). **Ope :** No activities which may cause impacts on topography/geology are planned.

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Category	No.	Items	Rating			Basis for rating
			Pre	Con	Testing	
Social Environment	13	Involuntary Resettlement	E	E	E	Since there are no residents at the project site, involuntary resettlement would be out of question.
	14	Ethnic Minority/ Indigenous People	E	E	E	There are no indigenous people in the area, and no ethnic minorities except clans within the Afar.
	15	Local economy (the poor)	D+	C+	C+	**Pre :** Creation of employment opportunities are limited at this stage. **Con・Ope :** Positive economic impacts would occur in terms of local employmnet, however limited.
	16	Land use and utilization of local resources /resource competion such as water and energy/	E	E	E	No impacts on land use, utilization of local resources and conflict are expected as the site is left baren and the project will use its own source of water and energy
	18	Infrastructures and social services	E	E	E	Although there are social infrastructures such as health centers, schools and others around the project site kebele, the staffs will use the thses services away from the kebele such as Semera town.
	19	Social institutions and local decision-making institutions	E	E	E	There are no such institutions within the site that could be affected due to the project in all phases.
	20	Misdistribution of benefits	E	E	E	No unequal distribution of benefit and damage is expected during all phases.
	21	Local conflicts of interest	D-	D-	D-	Minor local conflict of interest is expected among villagers to include the site in their repective kebele.
	22	Diffussion of local culture & norm	E	D-	C-	**Co: Op:**Minor impact could occur as limited number of local people interact with project staff. what is more, the limited number of skilled staff (camped) are little access to diffuse among the community.
	23	Increased cost of living	E	D-	C-	**Co; Op:** Minor impact would occur that aggravate cost of living on the area
	24	Landscape	E	D-	D-	**Pre・Con :** Since no large scale construction work is planned, impacts on landscape are temporal and limited. **Ope :** Some impact on landscape is expected by the existence of plant facilities (power generator, steam turbine, cooling tower, etc.).
	25	Gender and children's rights	E	E	E	No impact is expected as the site is dvoid of settlement.
	26	Community saftey and infectious Diseases	E	D-	C-	**Pre, :** There would be no possibility for infectious diseases at this stage. **Co: Ope :** Since the number of workres at the project facilities is limited, impact due to infectious disease would be minor.
Industrial safety	27	Occupational safety and accidents	D-	B-	C-	***Con: Op:*** Since the project site is located at harsh environment; what is more since construction and drilling activities involve accidents occupational safety are required. Accidents are expected during test drilling, facility construction, and operation, respectively. Thus requires special consideration
Socio-economic	28	Contribution to the national economy	E	E	A+	**Ope:** Lack of alternative and renewable power would be addressed; hard currency earned from sale of elric poweris likely expected
Others	29	Climate change	D	D	A+	**Pre・Con :** Since no large-scale construction work is planned, impact on climate change is temporal and limited. **Ope :** This project could contribute to reduce greenhouse gas emission.

Summary of overall findings

As can be observed from results of the identified impacts (Table 5.6), socio-environmental components with rating value greater than-1.25 are considered as having adversely significant impacts. Thus, *pollution, safety and health, waste generation, changes in life pattern are* among the top priorities for the corresponding mitigation measure and management plan that will be dealt in the next chapter. Geothermal technologies in general, test well drilling in particular are environmentally advantageous because there is no combustion process. The potential environmental impacts of conventional hydrothermal power generation are widely known. Several articles and reports have documented various potential impacts from geothermal dry-steam, flash-steam, binary energy, combined energy conversion systems. The general conclusion from all studies is that emissions and other impacts from geothermal plants are dramatically lower than other forms of electrical generation. Thus, the lessons learned from a number of existing geothermal power plants can be used to ensure that future geothermal systems will have similar or even lower environmental impacts.

CHAPTER SIX: MITIGATION MEASURES AND MANAGEMENT PLAN

6.1 Overview

This section presents major adverse effects only on natural and social environment due to significant impacts identified in the previous sections; then provides mitigation measures if possible with alternatives. For harmonized reviewing, these impacts can be presented parallel to the drilling activities but at various project phases.

These phases can be presented as follows;

- Pre drilling phase (survey & conceptual modeling);
- Construction phase (civil & non-civil works);
- Drilling phase (development & commissioning phase);
- Testing phase (operation phase);

Most of identified potential impacts can either be avoided or reduced through mitigation. These mitigation measures are proposed in sequence of: technology/design/ option; careful choice of location; proper timing; suitable season; material and best practices.

Mitigation measures and management plan for air emission depends on practices to be adopted to eliminate or reduce air emissions. Such practices include both prevention practices and pollution control measures, preferably at a lower cost. Prevention and control techniques may include various methods of treatment depending on:

- Regulatory requirements;
- Significance of the source;
- Location of the emitting facility relative to other sources;
- Location of sensitive receptors;
- Existing ambient air quality;
- Technical feasibility and cost effectiveness of the available options for prevention, control, and release of emissions;

Emissions from the test wells, according to the information gathered during the preliminary drillings carried out by Aquater and the relevant field assessment, contain 99% steam and the remaining 1 % is constituted by CO_2, H_2S, ammonia and other non-condensable gases. Furthermore, test well drilling is a short term activity and localized in the project site which is almost no man's land. Therefore, technology option to adsorb emission is considered as not a viable option.

6.2 Social Impact Mitigation Measures and Management

6.2.1 Design for workers' camp

As discussed in the socio impact analysis part of this report, most expected adverse impact of the project would be on the staff/workers of the project. To avoid and/or manage the negative impacts the first step would be to arrange and prepare the project site in a manner that adverse impacts would be easily controlled. To that end, workers' camp needs to be built in a way that fits the harsh environment of the site/area. The following precaution should be considered while building the camp.

Permanent and recurrent places of work should be designed and equipped with:

- Temporary but standardized buildings that are structurally safe, and provide appropriate protection against the harsh Ayrobera climate should be set.
- Surfaces, structures and installations should be easy to clean and maintain, and not allow for accumulation of hazardous compounds;
- The buildings of the camp and temporary offices should be equipped with fire resistant, noise-absorbing materials, following the nature of the project.
- The entire buildings should be equipped with AC and ventilators.

Potable water:

- Adequate lavatory facilities (toilets and washing areas) should be provided according to the number of work force available at the site. Particularly cold shower is highly required since Ayrobera site is so hot almost throughout the year. Toilet facilities should also be provided with adequate supplies of cold running water, soap, and hand drying devices.
- Adequate supplies of potable drinking water should be provided from a fountain with an upward jet or with a sanitary means of collecting the water for the purposes of drinking.
- Water supplied to areas of food preparation or for the purpose of personal hygiene (washing or bathing) should meet drinking water quality standards.

6.2.2 Facility Design for Work Areas

Risk management: To control and/or avoid adverse impacts of the project, the contractor should assign personnel and/or sections. As discussed in Chapter 5 there would be potential adverse impacts but limited to around the site and on workers of the project. The potential for occupational accidents and hazard would be imminent, among others. Health threat, vehicles movements and functioning of machines, fire sound and dust effects have been the treated as sources of adverse impacts. In fact, as long as proper mitigation and monitoring measures taken, the said negative impacts could be controlled.

The risk of fire for example could be controlled following Environmental Health and Safety (EHS) guideline and standards which involve occupational health and safety rules. According to other similar test well drilling projects no damaging fire hazard occurred. However, there is a possibility of fire accident; thus the concerned body should consistently adhere to the prescribed requirements and the readiness of fire extinguishers and related equipment; across all parts of the site, camps and drilling areas, among others.

In terms of traffic accidents too, all prevention methods should be in line with international guidelines (particularly, IFC's Guidelines, 3.4 Traffic Safety). As per the agreement that would be reached between project owner and the contractor, all test drilling phases should be given due emphasis in accordance with relevant statutory requirements, abiding regulations standards.

Similar to the staff camp, work areas are mainly sources of adverse impact. In line to that, drilling spots and associated areas need to be arranged in a way that they would minimize, control and avoid adverse impacts. The following points should be considered to mitigate/manage negative impacts before project implementation.

6.2.3 Health and Safety around the Site

Project owner in general and the contractor in particular need to follow and ensure the stipulations indicated here under during construction phase:

- Availing health and safety equipment such as First Aid kits, protective clothing and boots.
- Controlling huge discharge of dust.
- Implementing noise abatement mechanisms to minimize inconvenience to current staff and site workers.
- Ensuring the cleanness of the site, for instance free from mud and debris; and dumping excavated materials and scraps at a preset and approved location.
- Implementing traffic system for vehicles entering and exiting the site.
- Qualified health professionals with necessary medical tools and drugs should avail 24 hours for emergency, at least victims under serious accident or hazard transferred to an appropriate medical facility.

Space and Exit:

- The space provided for activity of workers should be wide enough for safe execution of all assignments. This refers to all buildings required for the project, for example, offices, laboratories, lodgings and lounges, including storage of materials, among others.
- The number of stores needed for the project is determined by the number of wells to be drilled. One store for each well, according to experience elsewhere, may be required. Stores for silica and bentonite are mandatory. These temporary stores may be constructed from cheaper materials but need to be wide and long enough to accommodate thousands of silica/bentonite sacks. A single stores used for the same propose at Aluto Langano, for example, is nearly 20x10 meter wide and 5mter height. Other standardized stores in some countries are wide enough to accommodate big trucks to facilitate loading and unloading.
- All stores, rooms and halls need passages emergency exits and should be unobstructed at all times. Exits should be clearly marked to be visible in total darkness. The number and capacity of emergency exits should also be wide enough for safe and orderly evacuation of the staff and workers.

Fire precautions:

- The test well drilling camp should be designed to prevent the start of fires through the implementation of fire codes applicable to industrial settings. Other essential measures include:
- Equipping facilities with fire detectors, alarm systems, and fire-fighting equipment. The equipment should be maintained in good working order and be readily accessible. It should be adequate for the dimensions and use of the premises, equipment installed, physical and chemical properties of substances present, and the maximum number of people present.
- Provision of manual firefighting equipment that is easily accessible and simple to use
- Fire and emergency alarm systems that are both audible and visible.
- Following the nature of the test well drilling, workers may be exposed to poisonous smokes/vapors, eye and skin irritating substances. Thus all safety tools should be availed at the camp and check workers use them without failure.

Safe access:

- Passageways for movements of vehicles, machines, and workers within and outside the camp should be segregated and provide for easy, safe, and appropriate access.
- Drilling and other related equipment, tools and installations requiring servicing, inspection, and/or cleaning should have unobstructed, unrestricted, and ready access.
- Hand, knee and foot railings should be availed while working on steam pipes, stairs, ladders, platforms, permanent and interim ramps, etc.
- Hazardous areas during drilling or during testing should be marked to prevent unauthorized access.

Work Environment

As already mentioned, the site is so hot, windy and dusty except few days (in two months) when there is little rain and cooler temperature. Thus, the temperature in all work rooms, rest, eating and sleeping rooms should be at a temperature appropriate for the climatic condition of the area.

- Sufficient fresh air should be supplied for indoor and confined work spaces. Factors to be considered in ventilation design include physical activity, substances in use, and process related emissions. Air distribution systems should be designed so as not to expose workers to heat and suffocation.
- All work areas of the drilling should receive natural light and if there is a need artificial light (which of course doesn't aggravate the hot climate of the site) to promote workers' safety and health, and enable safe equipment operation.
- Emergency lighting of adequate intensity should be installed and automatically activated upon failure of energy to ensure the continuation of the entire drilling activity and/or cooling system, among others.

Noise Mitigation Measure: As already mentioned, the site is relatively far from the neighborhood. And yet, it is likely the impact of sound could be felt throughout the site. Thus, measure for the mitigation should ensure minimize noise caused by vehicle movements, excavations, drilling, heavy machines activities, and pit related works. Therefore two basic measures need to be considered:

- Applying equipment mufflers particularly to heavy construction machines; and,
- Evaluating the level of noise every week particularly by consulting groups (staff of the contractor) that may likely affected by the sound.

Labor rights

In terms of labor and employment too, the contractor as well as project owner will be committed to respect human right issues, national and international policies and conventions involving workers that will be engaged in the project.

Summary of mitigation measure: The above discussions briefed the mitigation measures required for the identified impacts so far discussed. In line to that Table XX summarizes the mitigation measures proposed.

Table 6.1: Mitigation measures for adversly significant impacts

Impact type	*Mitigation measures*
Air pollution	When possible, dust producing activities should be reduced in presence of particularly windy conditions.
	The working area and site roads shall be sprayed with water during and immediately after operations so as to maintain the entire surface wet.
	Heights from which materials are dropped shall be restricted as far as practicable to minimize the fugitive dust arising from unloading /loading.
	Stockpiles of friable material must be properly treated to prevent wind throw and sediment run-off to the rivers during wet weather, alternatively coverings, enclosures or wind fences can be used to protect storage piles or vegetation can be grown on and around the storage piles to limit fugitive dust emission.
Surface and ground water pollution	Sufficient settling ponds equipped with an overflow system, and a further settling basin equipped with filters, this being the final point before the abstraction point for recycled water.
	Good maintenance of these storage ponds and treatment system is required.
	Impose best practice methods of storage, regular monitoring and development of appropriate responses for spills from fuels; chemicals etc.
	As much as possible, drill re-injection well after the first test well is developed.
Waste generation	Appropriate storage of general waste and regular disposal to landfill.
	Storage of mud in lined ponds and of cuttings in dedicated houses.
	Disposal of hazardous waste by a licensed contractor.
	Segregation and monitoring of waste streams in view of reducing, reusing recovering and recycling waste.
	Liaison with the community to identify reuse and recycle options.
	Identification of appropriate site(s) for excavation material disposal, away from sensitive surface or ground water features.
	Implementation of measures to avoid silt run off to surface water from excavated material.
	Regular removal of mud from the settling ponds and treatment of the mud as hazardous waste thus requiring safe disposal to approved landfill site.
	A Waste Management Plan should be developed and adopted by the Contractors
Soil contamination and degradation; (Surface & sub-surface changes in geology; morphology; subsidence; land slide; seismicity etc.)	Landfill and level surfaces after their disturbance in excavation or drilling
	Re-vegetation of disturbed areas by draught resistant plants
	Continuous monitoring of steam cavities and hot springs around the project site
	Set up a network of seismometer around the project area
	As much as possible use environment friendly mud additives for drilling
	Develop immediate clean up strategy for spills
	Construct professionally designed drainage and sufficient settling ponds for cuttings and mud products that have no linkage to surrounding water body
	Hazardous chemicals, oils and lubricants shall be stored in bundle at safe locations
	Spent oils, lubricants and other wastes shall be stored at safe and isolated site until regular disposal

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Impact type	Mitigation measures
Noise and vibration	Workers nearest to high noise source shall be equipped with ear drum safety
	All site employees should be trained to adopt the quietest work practices, where appropriate.
	General working hours should be restricted to avoid/ minimize/ exposure to sensitive receptors;
	Machines and plant equipment that may be in intermittent use should be shut down between work periods or throttled to a minimum.
	stockpiles and other wide structures should be effectively utilized, where practicable, to screen sensitive receptors from noise due to on-site construction activities.
	Plant with directional noise features should be positioned so as to minimize the potential for noise disturbance.
	Appropriate construction methods should be used where possible so as to minimize noise levels at source.
	Advising villagers in advance of particularly noisy work.
Ecology; fauna; flora	Drill mud must be contained in appropriately lined ponds, equipped with overflow and solid retention system. These should be maintained throughout the drilling phase and periodically until the mud are removed. Incidents such as uncontrolled spill /overflow should be avoided through appropriate civil works and working practices
	Brines need to be contained in retention ponds that are sufficiently large and lined with corrosion and heat-resistant material, and contained until reinjection is possible.
	During test well drilling, dev't of re-injection well may not be feasible. In such cases, brine or mud solutions need to be treated physicochemical using flocculants at or nearly normal pH before released to either land fill or soil or water bodies and at a temperature that is not more than 3 °C higher than that of the water into which it is released.
	Retention ponds need to be sufficiently large and properly fenced to protect against accidents.
	Domestic and human waste effluents need to be fully treated (involving at least primary and secondary treatment) before being released into soil and local surface waters, or treated with septic tanks.
	Vegetation and green belt development around the project area (cascade)
	Noise and traffic mitigation measures shall also be maintained here for local fauna and flora
Occupational health and safety	Initial and continuous training of concerned staff prior to working (i.e Human Resource Development,HRS;)
	Design aspects of industrial safety shall be in place such as emergency exit, fire fighting systems etc.
	Assignment of roles and responsibilities to employees
	Strict management on delivery and usage of safety tools
	Identification of locations of concern and most sensitive areas.
	Establish clinic for waterborne diseases and malaria.
	Equip with fire detectors, alarm systems, and fire-fighting equipment.
	Set water points for fire-fighting; powder and foam for chemicals substances.
	Orient staff and workers with the use and mechanism of firefighting
	Minimum exposure time for those workers near hazardous activities.
Employment	Priority to local labor force, particularly, none skilled, and if possible semi skilled
Community safety	Remind/aware community on likely areas of health threats
	Posting signs and/or fencing around hazard areas within the site.
Vehicular and machine movements	Set maximum speed limit for vehicles particularly within the site; monitor and enforce rules and regulations.

6.3 Management Plan

Environmental and Social Management Plan (ESMP) is prepared on the basis of identified impacts and their level of significance. The objective of this ESMP is to identify project specific environmental and social actions that will be undertaken to manage impacts associated with the development and operation of test well drilling. Thus, it focuses on:

- Specific measures that will be taken to prevent, reduce or manage the socio-environmental impacts of the development
- Where it is not possible to specify these at this stage what level of environmental performance will be expected of the operation
- Developing proposals for monitoring and audit of ESIA implementation process.

Significant impacts that are detailed in the previous section shall be mitigated through proposed methods and then subjected to mechanisms of environmental management plan using monitoring and auditing as instrument.

However, in parallel to the general ESMP, a number of specific documents are required. GSE shall develop additional plans, policies and procedures to ensure adequate management and monitoring of social and environmental aspects. It is assumed that these plans will be elaborated by GSE to complement existing Environmental, Health and Safety Management System specifically for the Project. Where relevant and under respective contracts, drilling contractors should be required to implement the corresponding arrangements.

This management plan has been developed to clearly identify mitigation measures that should be implemented to minimize, reduce, or eliminate moderate and major adverse impacts identified in the ESIA. In addition, the ESMP also identifies best management practices (BMPs) and other mitigation measures that will minimize, reduce, or eliminate some negligible and minor impacts that could escalate to become more important if they are not handled properly.

Implementation of the ESMP is usually and effectively practiced through establishment of an Environmental Management Unit (EMU). In particular, implementation of the ESMP requires that:

- The detailed final design (plans and specifications) for the project incorporates all mitigation measures specified in the approved ESIA;
- The contract for the project implementation includes all mitigation measures;
- The drilling contractors' performance is duly monitored for compliance with the ESMP by competent inspectors;

- On completion of the works, inspection takes place to check that the completed work meet all significant environmental requirements before the project is officially accepted;
- The operations stage monitoring program is implemented as specified in the ESMP.

- There is effective reporting mechanism by the EMU (Environmental Monitoring Unit), through Project Implementation Unit, to demonstrate that the ESMP is being properly managed;

During drilling stage, the focus is on ensuring that the drilling contract requirements include basic health and safety requirements as well as mitigation measures are environmentally sound. To a considerable degree, drilling contractors will be responsible for implementing mitigation measures but, in any case, the ultimate responsibility for ensuring that environmental and social protection elements are being carried out properly is of GSE. Most of the impacts which occur during the drilling phase can be reduced or avoided through the application of sound construction management guidelines.

6.4 Institutional arrangement

The project office will ensure that socio-environmentally critical actions are undertaken as per recommended mitigation measures, various standard guideline requirements and applicable Ethiopian legislations. There shall be an assigned high level Management Body for overseeing all environment and safety responses to ensure the implementation of ESMP.

Thus, organizational Unit shall be instituted with defined roles, responsibilities, and authority to implement the ESMP. This Unit will focus on assessing current environmental practices, developing an internal audit system, reviewing environmental monitoring reports, identifying required control measures, initiating public relations campaigns to report, maintaining a clear environmental procedure, and establishing a transparent communication with governmental and non-governmental agencies concerned in environmental management.

The social set up within the Unit will form an important part of the Environmental management. There might not be institutional capacity at the woreda and PA levels for implementation of social development schemes in the project area. Thus, this set up in the Project Office will implement these programs. The Social Officer will coordinate with the Municipality of the Town, the woreda officials and the local community to address the social issues in the project surrounding. Community liaison and implementation of various education, health, employment, and infrastructure schemes proposed will be its important function.

A permanent organizational set up charged with the task of ensuring effective implementation of the Socio-environmental Management Plan shall be established in the Project Office. Thus, it may have a department consisting of Experts from various disciplines to co-ordinate activities concerned with the management and implementation of the socio-environmental mitigation measures of the proposed test well drilling operation. Thus, the following professional mix is recommended to establish Environmental Management Unit (EMU).

- Senior Environmentalist-one;
- Chemical Engineer or Chemist-one;
- Senior Sociologist-one.

6.5 Monitoring and Auditing

Monitoring is required prior to, during and after the drilling is completed. The purpose of this activity is to make periodic checks on the environmental impacts during different phases of the project, comparing them with those foreseen during the first phases of ESIA process. Monitoring provides a very useful feedback, which permits to correct at the right moment any environmental problem due to the project and meanwhile to acquire experience in planning future projects. The Federal EPA, the Regional EPA or Woreda level offices may not have facilities to undertake some part of the monitoring or auditing activities. Therefore, the project owner, GSE, shall establish Socio-environmental Management unit/section to address the issues.

The audit program will include pre-commissioning audits of the facilities focusing on the compliance of equipment and procedures to deliver the specified level of performance to ensure that all socio-environmental requirements are met. The above said monitoring shall be carried out by either creating in-house facilities or by hiring an external consultant. This ESIA study, after its approval, will be submitted to concerned bodies; Federal & Regional EPA, local administrators and communities, etc. Thus, this document shall only serve as a bench mark for auditing. It should be dynamic, interactive and participatory with regulatory bodies, project owner, local administrators, and communities through its institutional arrangement. Limiting values of EPA's guideline discussed in Chapter 3 on industrial emission (or effluent) need to be adapted here in test well monitoring and auditing activities.

Table 6.2: Monitoring and auditing plan

Monitoring and auditing plan for all phases of activities									
No.	Items	Method	Parameters //Indicators//	Frequency			Prime Responsibility		
				Pre	Con	Ope	Pre	Con	Ope
1	Air Quality	Measurement /sampling/	PM/ PM10, CO2, H2S, Temperature, Oxygen level,	Quarterly	Monthly	Weekly	GSE project office	Contractor	GSE project office
2	Water Quality	Surface and ground water sampling	Temperature, pH, Oil content Suspended solids, COD, Heavy metal concentration	Quarterly	Monthly	Monthly	GSE project office	Contractor	GSE project office
3	Waste generation	Audits, photographic documentation, and interviews	Generation, storage, recycling, transport and disposal	Monthly	Weekly	Monthly	GSE project office	Contractor	GSE project office
4	Soil Pollution	Sampling	Moisture content, pH, salinity, Nitrogen, Phosphate, Chloride, Potassium, Sodium Heavy metal content such as Mn, Fe , etc.	Monthly	Monthly	Monthly	GSE project office	Contractor	GSE project office
5	Noise/ Vibration	Measurement Leq	(dB(A))	Monthly	Monthly	Biannually and upon complaints	GSE project office	Contractor	GSE project office
6	Ground Subsidence	Site inspection; seismometer reading around the project area	Changes observed in steam cavities and hot springs around the project site	Quarterly	Monthly	Monthly	GSE project office	Contractor	GSE project office
7	Offensive Odor	Steam sampling	Concentration of NH3; H2S	No need	Monthly	Weekly	GSE project office	Contractor	GSE project office
8	Hydrology	Surface and ground water sampling	Temperature, pH, Oil content; Suspended solids; COD; Heavy metal concentration; Generation rate	Quarterly	Quarterly	Monthly	GSE project office	Contractor	GSE project office
9	Occupational safety	Health and Safety survey	Proper use of PPE & other safety equipments;, presence of safety signs, first aid kit, fire fighting devices, Injury/ illness records. Emergency exits and plans; Accident statistics recording in accordance with ILO standards, including recording of Lost-Day- Accidents per Million-man hours (LDA/MMH)	Quarterly	Weekly	Monthly	GSE project office	Contractor	GSE project office
10	Local economy (the poor)	Econonic survey	Monthly income and level of business activities such as demend and supply trends	End of the phase	Semi-annually	Annually	GSE project office	GSE Project Office,Woreda Economic and Finanace Office	GSE Project Office,Woreda Economic abd Finanace Office
11	Local conflicts of interest	Interview, observation and conflict report	Number of conflict incidents reported	End of the phase	Semi-annually	Quarerly	GSE project office	GSE Project Office,Woreda comm. Reprsentatives	GSE Project Office,Woreda comm. Reprsentatives
12	Diffussion of local culture & norm	Survey and observation	Observed way of life style	End of the phase	Annualy	Annually	GSE project office	Culture & Tourism Office &GSE	Culture & Tourism Office &GSE
13	Increased cost of living	Economic survey	Price trends and scarcity of supply and increased demend	End of the phase	Semi-annually	Semi-annually	GSE project office	GSE & Woreda Economy and Finance Office	GSE & Woreda Economy and Finance Office
14	Community saftey and infectious Diseases	Health and safety survey and reports	Number of infected patients	Monthly	Monthly	Monthly	GSE project office	GSE & Health Office	GSE & Health Office

6.6 Cost for Mitigation and Management

It is understood that test well drilling is a transition (or an intermediate) study having neither techno-economic nor engineering estimate studies that corresponds to this level of ESIA study. Thus, determining complete cost for implementing this ESMP might be unrealistic or misleading except perhaps cost estimate for human resource development in the project office and associated expenses for nearby community mobilization in the task of awareness creation and collective monitoring. For a full-fledged project, it is a common practice that 5 up to 7 % of the total project cost is allocated for ESIA implementation. However, the implementation cost for test well drilling is expected much lower. The following table presents annual cost estimate for ESMP implementation, being conservative and hoping that it serves only as bench mark to be further developed when techno-economic studies are finalized.

Table 6.3: Cost estimate for ESMP implementation (in USD)

No	Item	Unit	Amount	Unit price (Cost/month)	Annual cost
1	Professional fee	Person	3	600.00	7200.00
2	Supportive staff	Person	1	400.00	4800.00
3	Laboratory equipment & chemicals	Pcs	LS	1000.00	12000.00
4	Community mobilization	No of meetings /workshops/	12	2000.00	24000.00
5	Miscellaneous expenses	Ls	LS	300.00	12000.00
6	***Total***				***60000.00***

CHAPTER SEVEN: CONCLUSIONS AND RECOMMENDATION

7.1 Conclusion

This ESIA report is developed as a continuation of the "Master plan study for geothermal power plant development in Ethiopia". The objective of the Master Plan study was prioritization from fifteen potential geothermal sites found in Ethiopia. Accordingly, Tendaho-2, Dubti Woreda, Ayrobera site becomes at the frontier. However, geothermal power plant development by its very nature is complex with high coefficient of uncertainty. On top of that, the cost of well drilling is too high. Thus, it is quite reasonable that the selected site need to be supplemented (verified) by finer scientific investigation and test well drilling within the selected Ayrobera site. It is with this understanding that the scope of the project is limited to "ESIA study for test well drilling".

From the nature of the project, it can be concluded that geothermal energy conversion equipment in general and test well drilling in particular is relatively compact, making the overall footprint of the entire system small. With geothermal energy, there are no atmospheric discharges of nitrogen oxides or particulate matter, no need to dispose of radioactive waste materials, does not require large land area. The available and near-term geothermal energy technologies generally present much lower overall environmental impact than do conventional fossil-fueled, nuclear power plants and even hydropower energy system. For example, the power plant is located above the geothermal energy resource eliminating the need to:

a) physically mining the energy source (the "fuel") in the conventional sense, and in the process, to disturb the earth's surface, and;

b) process the fuel and then use additional energy to transport the fuel over great distances while incurring additional environmental impacts;

There are, however, certain impacts that must be considered and managed if geothermal energy is to be developed as a larger part of a more environmentally sound, sustainable energy portfolio for the future. Most of the potentially important environmental impacts of geothermal power plant development are associated with ground water use and contamination, and with related concerns about land subsidence and induced seismicity as a result of water injection and production into and out of a fractured reservoir formation. Issues of air pollution, noise, safety, also merit some consideration.

Findings of the project from policy perspective were studied by considering a number of elements: alignment of the project from policy perspectives; energy policy of the country verses geothermal; project perspective from guidelines of financial institutions; and alignment of JICA's guidelines with national policies. To this effect, national policies and regulation were reviewed; guidelines of relevant Federal and Regional Offices were studied; sufficient numbers of officials were also interviewed. It was understood that the entire legislative framework applicable to the proposed project is governed by the laws of Federal Democratic Republic of Ethiopia (FDRE). The ESIA study team has also concluded

that the proposed project could be fully materialized in alignment with national regulations and international conventions.

In terms of social aspects, the project brings almost no adverse significant impact upon the neighborhood in general and the community in particular. This is because that the project site is totally deserted, even grazing is unthinkable. What is more, there is no permanent settlement, even around the site. Likely adverse impacts could occur on the projects staff and temporary workers at large. This will happen due to the expected occupation accidents and hazard. In this respect, sources of adverse impacts could be observed particularly in the last two phases. These are related to person factors, unsafe activities, unhealthy weather conditions and job factors. These are explained by ill operations, absence of safety tools, lack of skill, failure of machines and equipment, availability of chemicals and movement of vehicles and machines, among others. This doesn't however mean that all the adverse impacts will 100% occur. As long as proper caution and care taken, and all safety mitigation measures are implemented prior to launching the project, the said adverse impacts would either be avoided or minimized, in one or another way.

Concerning economy, the project will result in a number of favorable benefits. The case in point is the fact that the project will definitely provide job opportunity for the unemployed section of the community; this will be true in all phases of the project. For instance, during construction of roads, and drilling or testing phases, most workers might be temporary. And yet, some other workers could enjoy permanent work if the drilling test result indicates positive. Additional income generated through employment in the form of wage will also result in injecting additional cash flow in the project kebele and the surrounding towns. This in turn will contribute to the expansion of the existing market and boost new small businesses, though not significantly. Semera town is expected to benefit more from additional market related to the project workers. On top of that the Federal, regional and woreda Government Revenue and Custom offices will benefit from the different withholding and profit taxes arising from the flow of cash from the project. In fact, the project may have minor adverse impacts related to heavy traffic, influence on the culture and style of life of the community around the project area.

7.2 Recommendation

In terms of environmental aspects, geothermal power projects are relatively eco-friendly, and are results of comparative analysis and possibilities of accessing Best Available in-process Technology, (BAT). This helps to fix potential environmental problems and thus encourages the realization of the test well drilling project. It is also to be noted that the proposed mitigation measures and management plans serve only as a bench mark for auditing. It is supposed to be dynamic, interactive and participatory with Regulatory Bodies, project owner, local administrators and nearby communities through its institutional arrangement.

In addition to this, justification of the project is adequately demonstrated in terms of: project rational; consistency with national policy; attractive scoping result from stakeholders' feedback in the project site; manageable negative impact; contribution to the national development; access for job opportunities and better livelihoods, among others. Thus, as long as the proposed mitigation measures and institutional arrangements are implemented, the test well drilling project is feasible from socio-environmental perspectives.

Hard and soft copies of approved documents of ESIA study along with agreed up-on auditing plan shall be submitted to the respective legal and administrative institutions in a way that ensures easy access for their auditing purposes. It is with this approach that relevant institutions legally responsible can crosscheck its compliance with existing environmental laws and national standards. As the proposed geothermal project and its pre-requisite test well drilling is classified in Category A of EPA guideline, the status and responsibility of this Unit shall be higher to incorporate the following objectives:

- record project impacts during construction and operation;
- evaluate the effectiveness of the mitigation measures;
- meet legal and community obligations;
- update mitigation measures to further reduce impacts;
- elaborate mitigation measures to deal with unforeseen issues;
- develop mitigation measures to face changes in operations;
- let the international lenders verify that loan requirements are being met.

Pertaining to the social impact assessment, the success of the project will be determined by two measures that project owner and the contractor should consider. The first is to closely work with Afar Regional government and Dubti woreda administration. This is decisive, because they are the two government bodies that could react and respond to those individuals who would try to claim belongingness over the deserted and uninhabited site. Experiences from the region show that individuals who don't have legal right might accidentally claim possession over the deserted project sites. The other recommendation is the need to strictly follow up the mitigation measures as presented in last Chapter. Generic adverse impacts arising from occupation health risks, accidents and hazards will likely occur in all phases of the test well drilling project. Thus, the only means to avoid or control the negative effects would be to assign responsible section that would take serious measure and strictly implement mitigation measures before and during project operation.

For further success of the project, public disclosure and official reviewing are best instruments to further investigate unforeseen dimensions so as to arrive on a sound decision before implementation.

The employment opportunities that will be created by the project should be equally accessible for all, but fairly. To that end, recruitment and selection procedures should be done by the involvement of the elderly, tribe leaders and kebele officials; this approach has been found effective in other projects. Considering those who didn't get prior opportunity of employment would be a plus not only in improving the economic wellbeing of individuals but also in ensuring fairness and secure trust among the community. If possible the application of gender mainstreaming, would be advisable to further

facilitate the existing societal change in the area. Finally it will be wise to visit socioeconomic services of the project kebele. The project could provide support to the schools and water supply that are suffering from a number of challenges. The project could win the maximum cooperation of the community if the existing schools get support and the defective water pump gets repaired.

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APPENDIX-7

Drilling Program

Appendix-7 Drilling Program

A7.1 Well Trajectory

Calculation results of well trajectory are shown in the tables and figures below.

Table A7.1.1 1AY-1 Well Trajectory Calculation Results

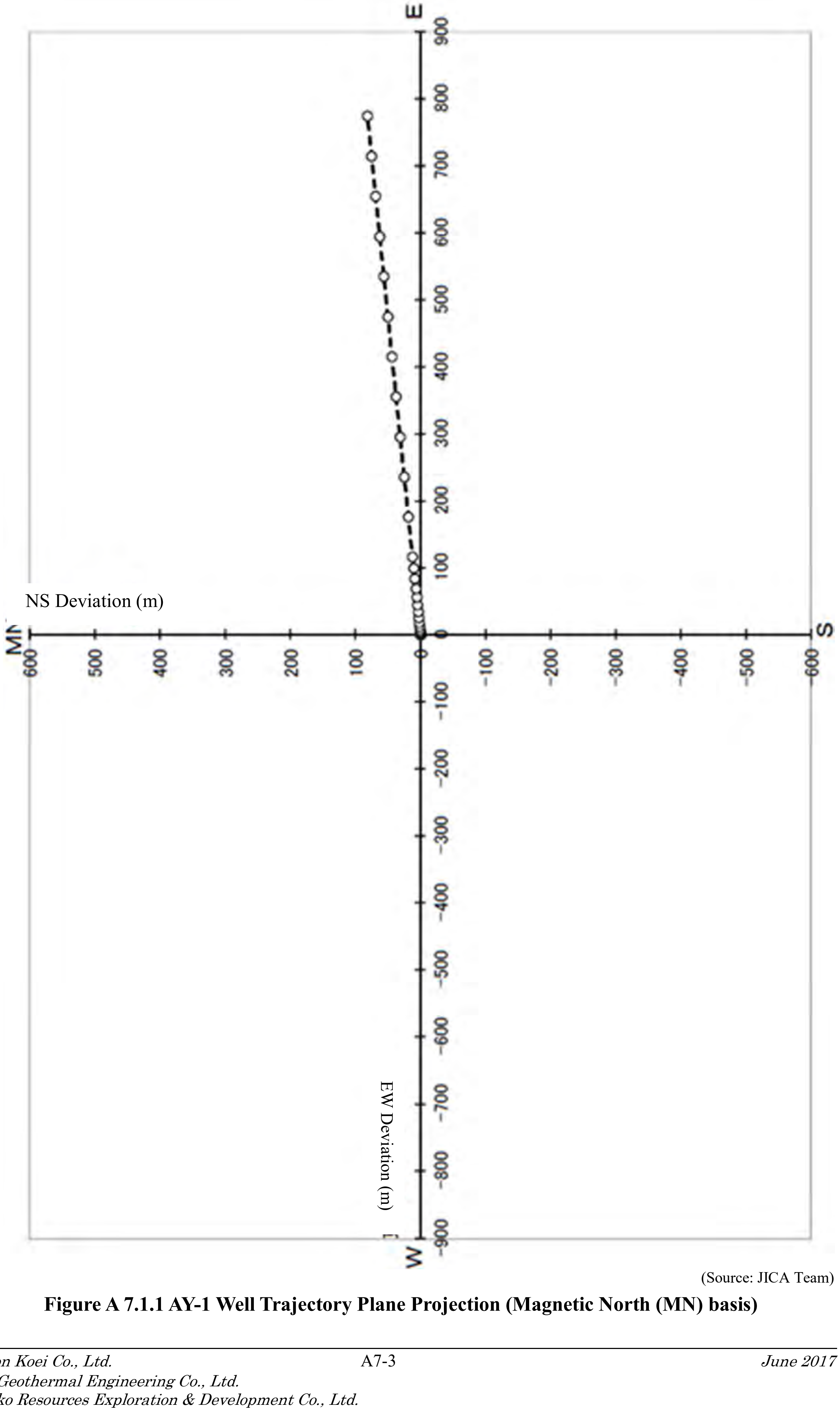
No	Drilling Length	Inclination	Direction			Vertical depth	NS deviation	EW deviation	Direction of well bottom			Deviation	DLS
	m	dd.mm	dd.mm			m	m	m	dd.mm			m	dg/30m
1	0.00	0.00	N	E	84.00	0.00	0.00	0.00	N	E	84.00	0.00	0.00
2	100.00	0.00	N	E	84.00	100.00	0.00	0.00	N	E	84.00	0.00	0.00
3	200.00	0.00	N	E	84.00	200.00	0.00	0.00	N	E	84.00	0.00	0.00
4	300.00	0.00	N	E	84.00	300.00	0.00	0.00	N	E	84.00	0.00	0.00
5	400.00	0.00	N	E	84.00	400.00	0.00	0.00	N	E	84.00	0.00	0.00
6	450.00	0.00	N	E	84.00	450.00	0.00	0.00	N	E	84.00	0.00	0.00
7	480.00	0.30	N	E	84.00	480.00	0.01	0.13	N	E	84.00	0.13	0.50
8	510.00	1.30	N	E	84.00	509.99	0.07	0.65	N	E	84.00	0.65	1.00
9	540.00	3.00	N	E	84.00	539.97	0.19	1.82	N	E	84.00	1.83	1.50
10	570.00	5.00	N	E	84.00	569.90	0.41	3.90	N	E	84.00	3.92	2.00
11	600.00	8.00	N	E	84.00	599.70	0.77	7.28	N	E	84.00	7.32	3.00
12	630.00	9.30	N	E	84.00	629.35	1.24	11.82	N	E	84.00	11.88	1.50
13	660.00	12.30	N	E	84.00	658.80	1.84	17.51	N	E	84.00	17.61	3.00
14	690.00	15.30	N	E	84.00	687.90	2.60	24.73	N	E	84.00	24.86	3.00
15	720.00	18.30	N	E	84.00	716.59	3.52	33.45	N	E	84.00	33.63	3.00
16	750.00	21.30	N	E	84.00	744.77	4.59	43.65	N	E	84.00	43.89	3.00
17	780.00	24.30	N	E	84.00	772.39	5.81	55.31	N	E	84.00	55.61	3.00
18	810.00	27.30	N	E	84.00	799.35	7.19	68.39	N	E	84.00	68.76	3.00
19	840.00	30.30	N	E	84.00	825.58	8.71	82.85	N	E	84.00	83.31	3.00
20	870.00	33.30	N	E	84.00	851.02	10.37	98.66	N	E	84.00	99.20	3.00
21	900.00	36.30	N	E	84.00	875.59	12.17	115.77	N	E	84.00	116.41	3.00
22	1000.00	37.00	N	E	84.00	955.72	18.42	175.27	N	E	84.00	176.24	0.15
23	1100.00	37.00	N	E	84.00	1035.58	24.71	235.13	N	E	84.00	236.42	0.00
24	1200.00	37.00	N	E	84.00	1115.45	31.00	294.98	N	E	84.00	296.60	0.00
25	1300.00	37.00	N	E	84.00	1195.31	37.29	354.83	N	E	84.00	356.78	0.00
26	1400.00	37.00	N	E	84.00	1275.17	43.58	414.68	N	E	84.00	416.97	0.00
27	1500.00	37.00	N	E	84.00	1355.04	49.88	474.53	N	E	84.00	477.15	0.00
28	1600.00	37.00	N	E	84.00	1434.90	56.17	534.39	N	E	84.00	537.33	0.00
29	1700.00	37.00	N	E	84.00	1514.76	62.46	594.24	N	E	84.00	597.51	0.00
30	1800.00	37.00	N	E	84.00	1594.63	68.75	654.09	N	E	84.00	657.69	0.00
31	1900.00	37.00	N	E	84.00	1674.49	75.04	713.94	N	E	84.00	717.87	0.00
32	2000.00	37.00	N	E	84.00	1754.35	81.33	773.79	N	E	84.00	778.06	0.00

※Magnetic north

Table A7.1.2 AY-2 Well Trajectory Calculation Results

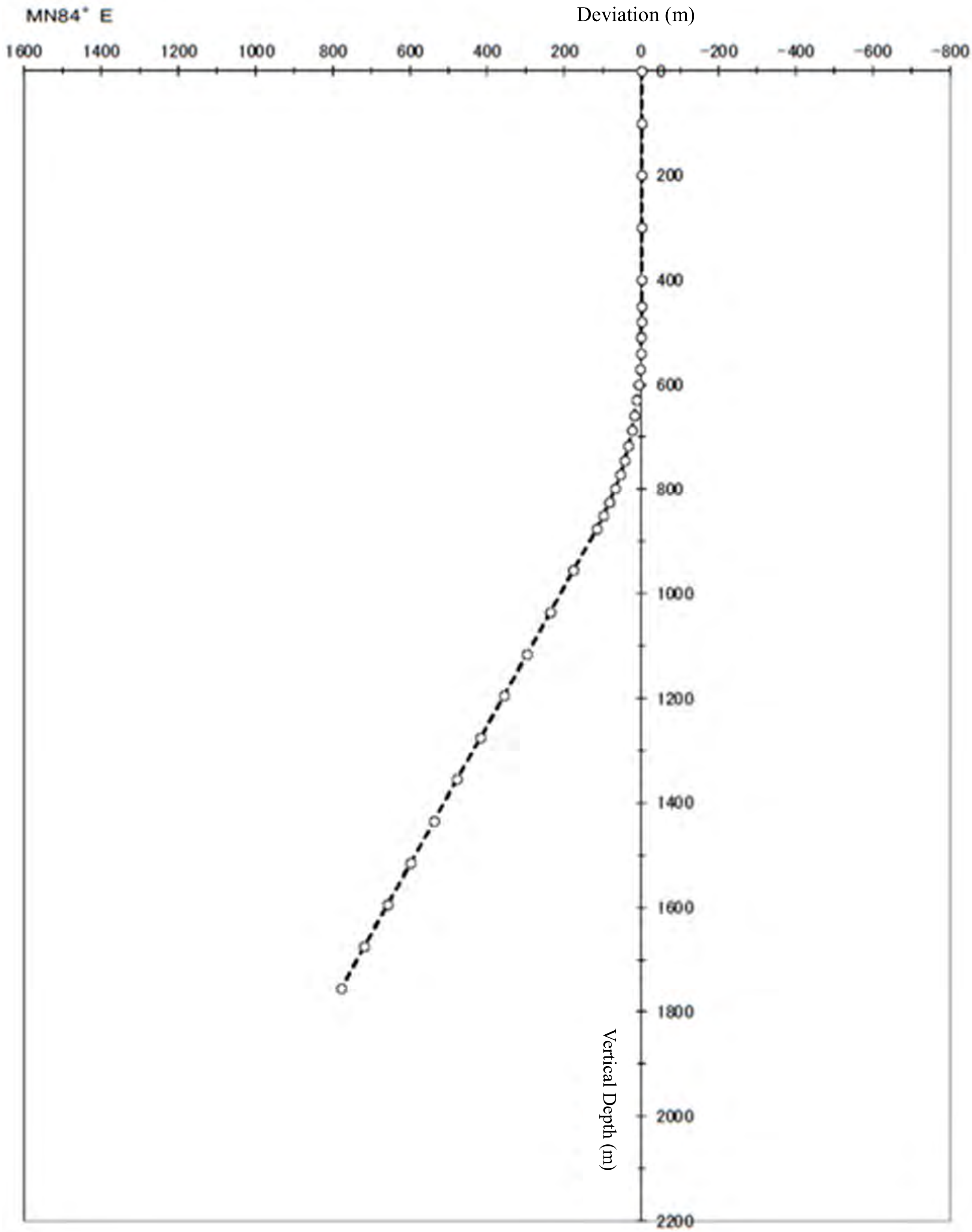
No	Drilling Depth	Inclination	Direction			Vertical Depth	NS Deviation	EW Deviation	Direction of well bottom			Deviation	DLS
	m	dd.mm	dd.mm			m	m	m	dd.mm			m	dg/30m
1	0.00	0.00	N	E	6.00	0.00	0.00	0.00	N	E	6.00	0.00	0.00
2	100.00	0.00	N	E	6.00	100.00	0.00	0.00	N	E	6.00	0.00	0.00
3	200.00	0.00	N	E	6.00	200.00	0.00	0.00	N	E	6.00	0.00	0.00
4	300.00	0.00	N	E	6.00	300.00	0.00	0.00	N	E	6.00	0.00	0.00
5	400.00	0.00	N	E	6.00	400.00	0.00	0.00	N	E	6.00	0.00	0.00
6	500.00	0.00	N	E	6.00	500.00	0.00	0.00	N	E	6.00	0.00	0.00
7	600.00	0.00	N	E	6.00	600.00	0.00	0.00	N	E	6.00	0.00	0.00
8	700.00	0.00	N	E	6.00	700.00	0.00	0.00	N	E	6.00	0.00	0.00
9	800.00	0.00	N	E	6.00	800.00	0.00	0.00	N	E	6.00	0.00	0.00
10	900.00	0.00	N	E	6.00	900.00	0.00	0.00	N	E	6.00	0.00	0.00
11	1000.00	0.00	N	E	6.00	1000.00	0.00	0.00	N	E	6.00	0.00	0.00
12	1100.00	0.00	N	E	6.00	1100.00	0.00	0.00	N	E	6.00	0.00	0.00
13	1200.00	0.00	N	E	6.00	1200.00	0.00	0.00	N	E	6.00	0.00	0.00
14	1230.00	0.00	N	E	6.00	1230.00	0.00	0.00	N	E	6.00	0.00	0.00
15	1260.00	0.30	N	E	6.00	1260.00	0.13	0.01	N	E	6.00	0.13	0.50
16	1290.00	1.30	N	E	6.00	1289.99	0.65	0.07	N	E	6.00	0.65	1.00
17	1320.00	3.30	N	E	6.00	1319.96	1.95	0.21	N	E	6.00	1.96	2.00
18	1350.00	6.00	N	E	6.00	1349.86	4.42	0.46	N	E	6.00	4.45	2.50
19	1380.00	9.00	N	E	6.00	1379.60	8.32	0.87	N	E	6.00	8.36	3.00
20	1410.00	12.00	N	E	6.00	1409.09	13.75	1.45	N	E	6.00	13.83	3.00
21	1440.00	15.00	N	E	6.00	1438.26	20.72	2.18	N	E	6.00	20.83	3.00
22	1470.00	18.00	N	E	6.00	1467.02	29.19	3.07	N	E	6.00	29.35	3.00
23	1500.00	21.00	N	E	6.00	1495.30	39.15	4.11	N	E	6.00	39.36	3.00
24	1530.00	24.00	N	E	6.00	1523.01	50.56	5.31	N	E	6.00	50.84	3.00
25	1560.00	27.00	N	E	6.00	1550.09	63.41	6.66	N	E	6.00	63.76	3.00
26	1590.00	30.00	N	E	6.00	1576.45	77.64	8.16	N	E	6.00	78.07	3.00
27	1620.00	33.00	N	E	6.00	1602.02	93.23	9.80	N	E	6.00	93.74	3.00
28	1650.00	36.00	N	E	6.00	1626.74	110.13	11.57	N	E	6.00	110.73	3.00
29	1700.00	36.00	N	E	6.00	1667.20	139.36	14.65	N	E	6.00	140.12	0.00
30	1800.00	36.00	N	E	6.00	1748.10	197.81	20.79	N	E	6.00	198.90	0.00
31	1900.00	36.00	N	E	6.00	1829.00	256.27	26.93	N	E	6.00	257.68	0.00
32	2000.00	36.00	N	E	6.00	1909.90	314.72	33.08	N	E	6.00	316.46	0.00

※Magnetic north



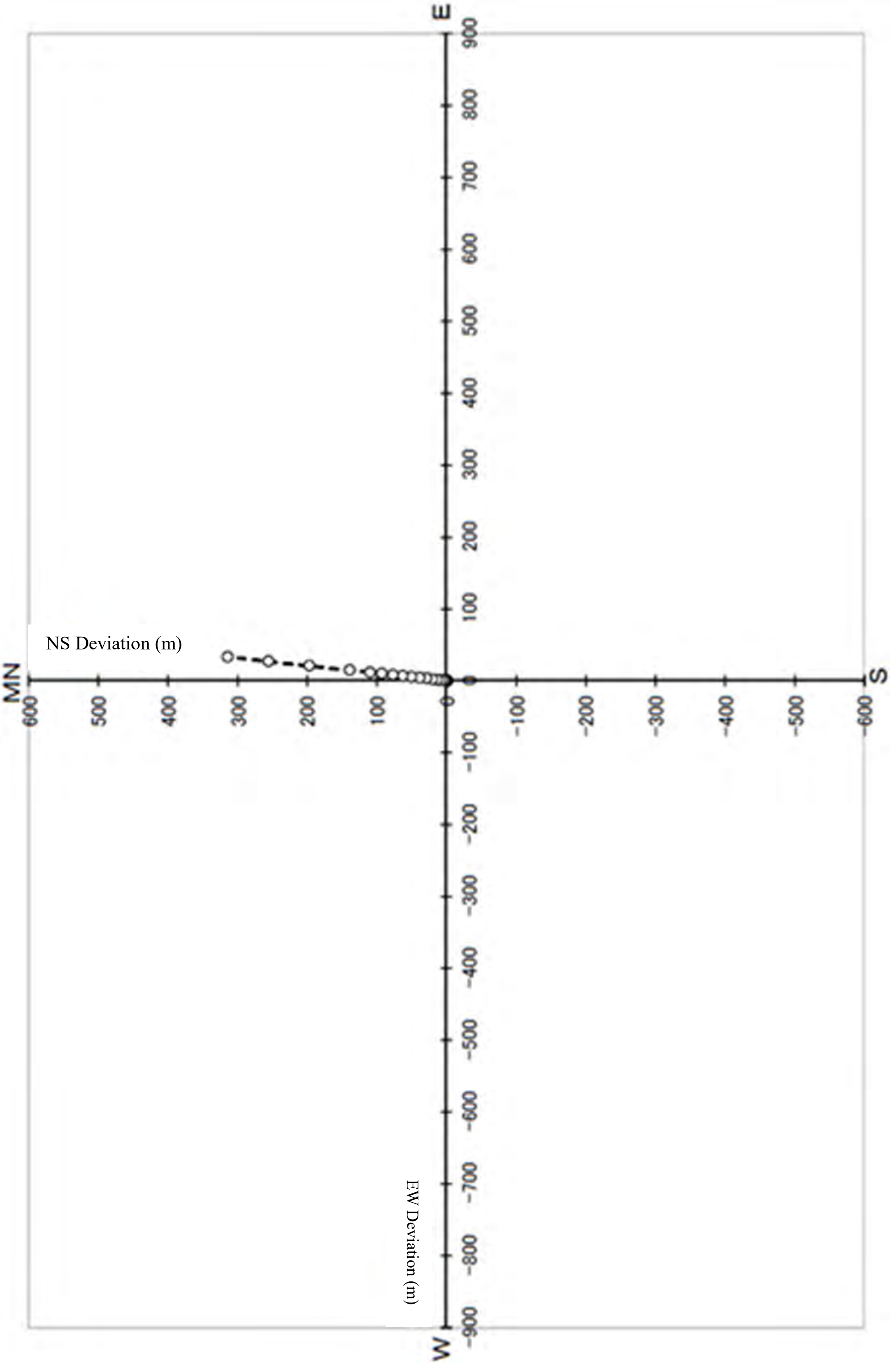
(Source: JICA Team)

Figure A 7.1.1 AY-1 Well Trajectory Plane Projection (Magnetic North (MN) basis)



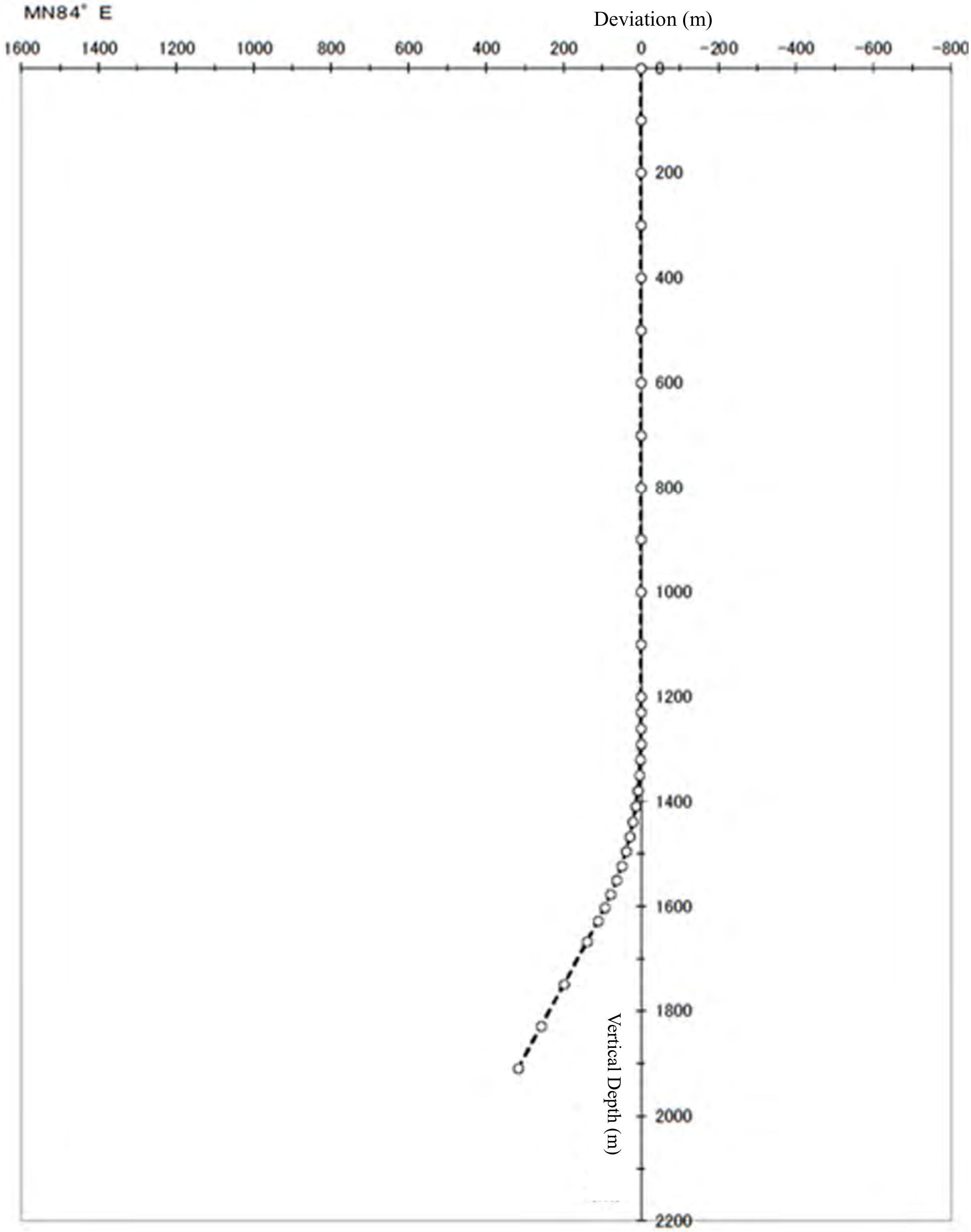
(Source: JICA Team)

Figure A7.1.2 AY-1 Well Trajectory Cross Section



(Source: JICA Team)

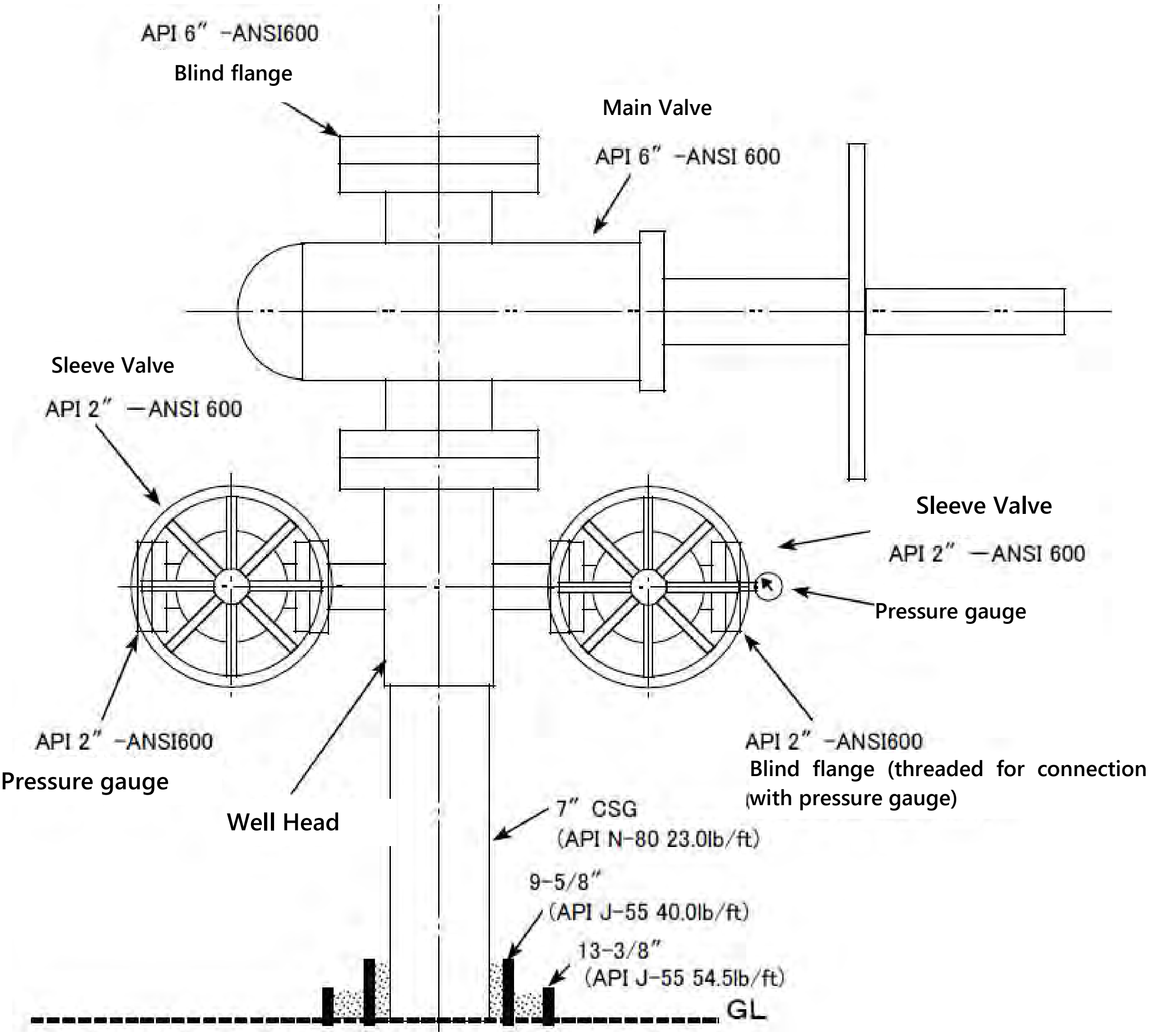
Figure A7.1.3 AY-2 Well Trajectory Plane Projection (Magnetic North (NM) basis)



(Source: JICA Team)

Figure A7.1.4 AY-2 Well Trajectory Cross Section

A7.2 Well Head Equipment



(Source: JICA Team)

Figure A 7.2.1 Well Head Assembly

APPENDIX-8

Minutes of Meetings

MINUTES OF MEETING
ON
DRAFT FINAL REPORT
FOR
DATA COLLECTION SURVEY ON GEOTHERMAL DEVELOPMENT
IN ETHIOPIA

The Draft Final Report Meeting was held on 8th September 2016 at Conference Room, Jupiter International Hotel with the participants listed in the attachment.

After the through discussions, it is agreed on how to go about the next phase of the project which is test well drilling in Ayrobera as recorded in the Record of Discussion attached hereto.

Addis Ababa, 8th September, 2016

Mr. TAKAHASHI Shinya
Team Leader
JICA Survey Team

Mr. KEBEDE Solomon
Director for Geothermal
Geological Survey of Ethiopia

For

Mr. JIN Kimiaki
Chief Representative
JICA Ethiopia Office

RECORD OF DISCUSSION ON DRAFT FINAL REPORT

OF

DATA COLLECTION SURVEY ON GEOTHERMAL DEVELOPMENT

IN ETHIOPIA

The workshop started by opening speech of Mr. Masresha Gebre Selassie,the Director General of Geological Survey of Ethiopia (GSE), followed by presentations of the survey team in accordance with the schedule (attached herewith).

At the end of the whole presentations, the floor was opened for discussions, which was jointly chaired by Mr. Masresha Gebre Selassie and Mr. Solomon Kebede, Director of Geothermal Exploration and Assessment Directorate, GSE. During the discussion session, questions were raised from participants and replies given by the survey team which are concluded as follows:

1. Mr. Solomon from GSE, started the discussion raising two questions:
   a) The study considered a long distance (11 km) water supply from the irrigation canal. Did the team consider other alternatives such as water wells near the project site?
   b) Since the drilling contract is for 2-3 wells, is there any possibility to get contractors for yrobera, especially from foreign countries? Mr. S. Takahashi, the team leader, responded for the first question. He said that, yes the team considered test well options. But, it doesn't have geological information of the area and further information is needed on how much water can be obtained and how many wells are needed. He also added that, based on a previous meeting made with concerned body; there is no problem to use water from irrigation cannel with some amount of payment. Therefore, the team selected water from irrigation.

   Mr. Kawahara from the team replied on the second question that according to the interview survey the team made to drilling companies, there are many companies interested in geothermal industry in East Africa who showed interests together with considerations of drilling risks. But, the cost is a different issue.

2. Mr. Asefaw Teclu, GSE expert questioned that on the contract types presentation it is said that there is no need of engineer. If that is the case, who will supervise the work? Mr. Kitano of the team explained that there are only two contracting parties; i.e the Operator and the Contractor in the IADC contract model that is used for petroleum drilling industry. The Operator will assign "Drilling site supervisor" who is to supervise the drilling contractor. The role of "Drilling site supervisor" is a kind of the role of "Engineer" for civil work construction for which FIDIC contract model is applied. In general, the "drilling site supervisor" assigned by the Operator will act for the benefit of the Operator, whereas the Engineer appointed shall coordinate between the project owner and the contractor.
3. Mr. Fikru from Ethiopia Electric Power (EEP) added a related question with Mr. Asefaw. He asked the possibility of assigning independent engineer.

Mr. Kitano also responded that, it depends on the type of management policy and conditions of contract. But according to International Association of Drilling Contractors (IADC), there are only two contracting parties; the Operator and the Contractor.

4. Mr. Abraham, Drilling Directorate Director of GSE, commented that to hire a rig for drilling of three wells will be expensive. He suggested using existing rig in Ethiopia with some maintenance of spare parts.
   Mr. S. Takahashi responded that procurement of contractors is a better option because time period for repairing the rig, actual drilling capacity, the availability of the existing rig to JICA project and so on is not known. Also the worldwide movement of the development is to involve private companies as much as possible to release financial burdens from governments. He noted the existence of many geothermal project sites in Ethiopia would attract investors' interest, if the project using a drilling contractor is to be successfully completed.

5. Mr. Bayu, GSE expert requested that the necessity of injection wells.
   Mr. S. Takahashi replied that the proposed project is for test well drilling, which is meant to be drilled for the Team to confirm availability of geothermal energy and to estimate how much energy is to be obtained. Once those information is made available, adetail planning of production and injection wells will be made. The proposed project is on the stage before providing injection wells.

6. Mr. Saito, Representative of JICA Ethiopian office, asked the team about the cost of civil works.
   Mr. Kawahara explained that the cost estimate for construction of the well pad and the access road (5-6 km from the main national high way), is around USD 500,000- 600,000 according to the survey of collecting cost information from Ethiopian contractors.

   Mr. Saito also mentioned that JICA headquarters may send its detail planning team at the end of October. He also informed EEP of JICA's possible request to allocate some amount of money for the above mentioned civil works. He also asked GSE about the present status of the Butajira geothermal prospect and expressed JICA's interest to provide support in the area.
   Mr. Solomon confirmed that, even though there are rumors about the interest of private companies on Butajira site, they have not so far entitled to do exploration since new license giving process has totally been stopped. The license giving process will commence under the new institutional set up. But, GSE has planned to do surface exploration in the area by its own budget. Therefore, JICA's technical assistance is highly welcomed.
   Mr. Saito requested GSE for issuing a letter addressed to JICA Ethiopia Office, the letter should state that GSE wishes to have technical assistance from JICA in

conducting geothermal surface survey in Butajira as it is a matter of a national importance.

7. Mr. Masresha forwarded four questions to the team members.
   a) Explaining the presence of lots of investigations in Ayrobera including surveys by JICA, ICEIDA and ARGeo, he questioned whether the team can integrate such findings in order to support the decision of daily based contract.
   b) Which rig type is suitable for this project among the presented rig types and how?
   c) The survey considered one organogram assuming the new institution. It has also indicated the contribution of GSE and EEP. Is it not contradictory? What will happen if the establishment of this new institution is delayed? What is the fate of the project from JICA side?
   d) If you are going to select case-3, which is beneficial for Ethiopia, what is the need of explaining other models (Cases 1, 2 and 4)?

   Response was given by Mr. S. Takahashi, as follows.

   Regarding the question (a): In fact, there are lots of investigations in Tendaho area. But the surveys, especially in Ayrobera area, are limited to surface investigations only. Thus, we cannot be sure what are underground conditions. The contractors also do not want to take any geological risks. If footage or turn-key contracts should be selected in the tender documents, drilling contractors may not show interests in the bidding or they may bid with bigger prices, taking into account such unknown geological risks that may incur a considerable amount of costs. Therefore, daily rate at this moment is considered to be the best option.

   Regarding the question (b): If we procure contractors with rig, they will select the rig type that they have knowledge on how to use. From our side, we cannot instruct the type of the drilling rig, and the selection of the rig type should be left to the contractor.

   Regarding the question (c): The JICA team proposed EEP as counterpart of the project with various experts from various units under it. This project will be a test case for the intended unified organization for geothermal development. EEP can procure employees from other governmental organizations such as GSE, as a form of secondment. If this kind of arrangement is followed, it will be easy for JICA to provide assistance.

   Mr. Saito of JICA added that the proposed PMU for the project is JICA's recommendation. It would be difficult that the project will continue with the maintaining existing separately operated organogram. Relevant experts shall be unified under one unit such as PMU.

   Regarding the question (d): The least cost model for Ethiopian side is selected based on a discussion with various parties. Case- 1, which avoids any cost in the Ethiopia side, cannot be selected because of JICA's principle of "cost sharing by the recipient for the project to be implemented." If other cases, expensive in Ethiopian side, were selected the smooth project implementation is considered to be difficult due to complicated procurement process in EEP.

8. Mr. Fikru affirmed that they will try their best to realize the new institution but, if it is delayed to establish, they have to follow the present mechanism as it has been, but with clear agreement between EEP and GSE. He also asked about the application of daily based contracts verses monitoring of works. He asked more explanation on: who will decide the total number of days? How the evaluation will be? Maintenance problem, how to manage geological matters?
   Mr. Kitano responded that all of the mentioned matters can be discussed to find solutions during the preparation of the tendering document. Geothermal development procurement has its own stages.
   Mr. Salahaddin of GSE added the possibility of referring previous trends in order to calculate the average time.

9. Mr. Assefa, Planning director of GSE recommended that for transparence and accountability purpose, procurement of supervising company by the owner of the project.
   Mr. S. Takahashi explained that Drilling site supervisor team (DSV)which is different from Drilling Service Contractor (DSC) will be hired by JICA budget. It is JICA's decision to hire both under the same contract or different contract for each.

10. Mr. Muhaddin a director of Hydrology department, GSE recommended that using ground water found around Dubti area is better because taking water from irrigation will affect the dam. He said that they conducted survey in the area and willing to share the document.
    Mr. S. Takahashi answered there will be uncertainty in finding groundwater based on his experience in Ethiopia in a water supply project; and he confirmed the availability of the irrigation water through an interview with CEO of Ethiopian Authority of Water Construction Works, who operates and maintains the dam and the irrigation canal.

Generally, the workshop participants have agreed on the contents of the final report presented by JICA study team.

The workshop concluded by closing remarks of Mr. Takeshi Matsuyama, Senior Representative of JICA Ethiopia Office. He thanks all the participants and highlighted on the future continued support of JICA as it places high priorities on the geothermal sector development in Ethiopia and will take initiative in this challenging project.

The workshop was then closed.

JICA Technical Cooperation for Geothermal Development

Data Collection Survey on Geothermal Development in Ethiopia

Workshop on Draft Final Report

Date: 8th September, 2016 (Thursday) Half-day **Venue: Jupiter International Hotel- Cazanchis**

REGISTRATION FORM

No	Name	Organization	Position	Cell Phone	Email	Signature
1.	Feteha Sunkemo	GSE	Reservoir Engineer			
2.	Andualem Eshetu	GSE	Geologist			
3.	Woyeneshet Melesse	GSE	geologist			
4.	Bogu Wedaj	GSE	Engineer			
5.	Hagte Berhanu	ESA	Team leader			
6.	Zemen Abebe	GSE	Geologist			
7.	Andarge Mengiste	>>	Geophysicist			
8.	Firew W.Mariam	EEP	PM, Aluto GP			
9.	Muhuddin Abdela	GSE	Director			
10	Abraham Mulune	GSE	Public Service Directorate			

JICA Technical Cooperation for Geothermal Development

Data Collection Survey on Geothermal Development in Ethiopia

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REGISTRATION FORM

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1.	Tsegaye Woldie	GSE	Geophysicist			
2.	Selamawit Worku	GSE	Geologist			
3.	Kasu Gemu	EEP	Electrical			
4.	Neway Abeje	EEP	Tech. Coordinator			
5.	Masresha Gebreselassie	GSE	Dir. General			
6.	Solomon Kebede	GSE	Director			
7.	Alemu Teclu	GSE	Geochemist			
8.	Enatfenta Melaku	MoMPNG	Director			
9.	Tamiru Mesha	GSE	Director			
10	Getahun Moges	EEA	Director General			

JICA Technical Cooperation for Geothermal Development

Data Collection Survey on Geothermal Development in Ethiopia

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REGISTRATION FORM

No	Name	Organization	Position	Cell Phone	Email	Signature
1.	Salahadin Ali	GSE	Geochemist			
2.	Temesghen Belay	GSE	Geochemist			
3.	Tesfaye Kassa	MoMP&NG	Case Team			
4.	Yared Sinetebeb	GSE	Geologist			
5.	Getenesh Hailegiorgis	GSE	Geophysicist			
6.	Fitsum Abera	GSE	Geophysist			
7.	Bekele Mokonnen	EEP	Mech. Engineer			
8.	Getachew Burussa	G.S.E	Geophysicist			
9.	Assefa Zerihun	GSE	Planning Direct			
10	Silesh W/Yohanne	GSE	PL			

JICA Technical Cooperation for Geothermal Development

Data Collection Survey on Geothermal Development in Ethiopia

Workshop on Draft Final Report

Date: 8th September, 2016 (Thursday) Half-day **Venue: Jupiter International Hotel- Cazanchis**

REGISTRATION FORM

No	Name	Organization	Position	Cell Phone	Email	Signature
1.	TAKESHI MATSUYAMA	JICA	Senior Rep			
2.	GAKU Saito	JICA	Rep			GS.
3.	Addisalem Ambaye	JICA	PO			
4.	Kebede Mengesha	GSE	Geophysicist			
5.	Alcalwald Seif	GSC	Res. Engin			ahoo.com
6.	Gera Teshane	MOMPNG	Senior En. Eng			ane@gmail.com
7.						
8.						
9.						
10						

JICA Technical Cooperation for Geothermal Development

Data Collection Survey on Geothermal Development in Ethiopia

Workshop on Draft Final Report

AGENDA

Date: 8th September, 2016 (Thursday) Half-day **Venue: Jupiter International Hotel- Cazanchis**

Clock Time	Time Period	Activity	Speaker
8:30-10:00		**Registration**	
10:00-10:10	10min	Opening address	GM, GSE
10:10-10:15	5min	On what we have done up to today	S. Takahashi
10:15-10:35	20 min	Resource Assessment Target Selection (for memory Refreshment)	N. Kawahara
10:35- 11:05	30 min	Drilling Program	C. Takahashi
11:05-11:25	**20min**	**Coffee Break**	
11:25-11:30	5min	Introduction to types of drilling contract	T. Kitano
11:30-11:50	20 min	JICA Technical Cooperation in the next stage- test well drilling	S. Takahashi
11:50-11:55	5 min	Time line up to Final Report	S. Takahashi
11:55-12:25	30 min	Discussions	Participants
12:25-12:35	10 min	Closing remarks	JICA representative
Luncheon post meeting			

Geological Survey of Ethiopia (GSE)

Japan International Cooperation Agency (JICA)

DATA COLLECTION SURVEY FOR GEOTHERMAL DEVELOPMENT IN ETHIOPIA

Draft Final Report Workshop

8th September, 2016

Work Conducted up to Today

- S. TAKAHASHI -

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SUMIKO RESOURCES EXPLORATION & DEVELOPMENT CO., LTD.

Background

1. The Master Plan Project placed high priority on Tendaho-2 and Boseti

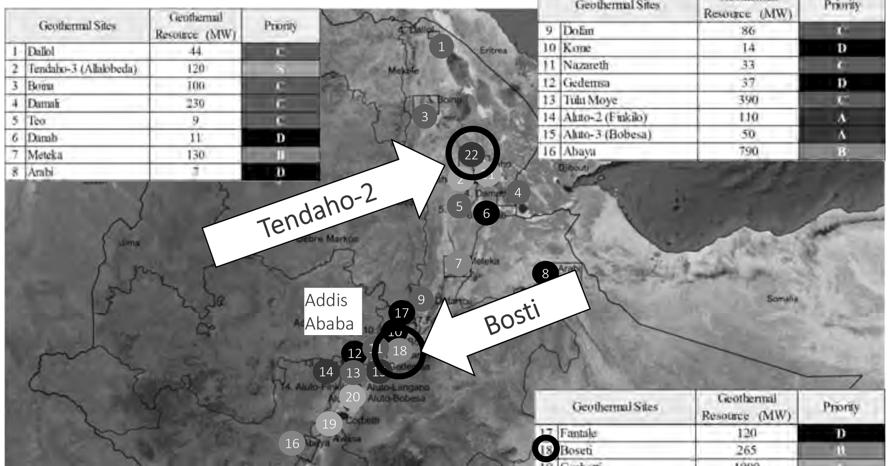
2. GSE requested a Technical Cooperation for Test Well Drilling to JICA (16th September, 2014).

3. JICA launched this survey to verify feasibility of the test well drilling project in Tendaho-2 or Boseti.

Project Site Location

	Geothermal Sites	Geothermal Resource (MW)	Priority
1	Dallol	44	C
2	Tendaho-3 (Allalobeda)	120	S
3	Boina	100	C
4	Damali	230	C
5	Teo	9	C
6	Danab	11	D
7	Meteka	130	B
8	Arabi	7	D

	Geothermal Sites	Geothermal Resource (MW)	Priority
9	Dofan	86	C
10	Kone	14	D
11	Nazareth	33	C
12	Gedemsa	37	D
13	Tulu Moye	390	C
14	Aluto-2 (Finkilo)	110	A
15	Aluto-3 (Bobesa)	50	A
16	Abaya	790	B



	Geothermal Sites	Geothermal Resource (MW)	Priority
17	Fantale	120	D
18	Boseti	265	B
19	Corbetti	1000	S
20	Aluto-1 (Langano)	75	S
21	Tendaho-1(Dubti)	290	S
22	Tendaho-2 (Ayrobera)	180	A

Satellite Image copied from Google

Objective

To examine the feasibility of JICA support for test well drilling

Scope of Work

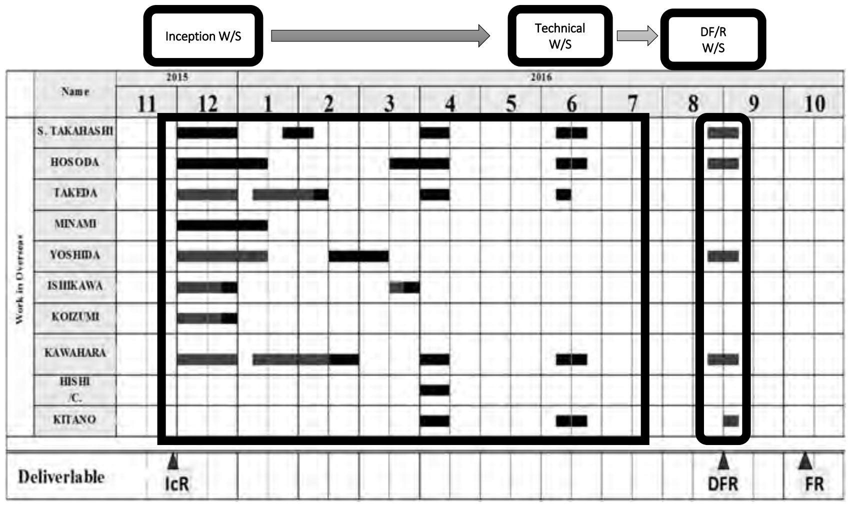
1. To conduct geophysical surveys in Tendaho-2 and Boseti geothermal sites,
2. Select one site for test well drilling,
3. To support GSE for conducting ESIA for test well drilling.

Contents of the Survey

Following surveys were conducted.

Item	Tendaho-2	Boseti
MT/TEM Survey	Newly 80 points	Nil (Existing 30 points)
3D Inversion Analysis	191 points (incl. existing data)	Nil
Gravity Survey	Nil (Existing Data)	1,207 points
Micro-seismic Monitoring	5 points	1 point
Temperature Survey	220 points	(GSE for training)
Reservoir geothermal modeling, and resource analysis	conducted	conducted
Environmental and Social Impact Assessment (ESIA)	ESIA Survey (Existing Data)	Nil

Time Schedule



Agenda for the DF/R Workshop

1. *Works conducted up to today*
2. *GSE training presentation – 2m Depth Temperature Measurement in Boseti*
3. Resource Assessment, Target Selection *(for your memory refreshment)*
4. Drilling Program in the recommended site

(Tea break)

5. Introduction to types of drilling contract
6. JICA Technical cooperation in the next stage
   For test well drilling
   For geothermal surface survey
7. What's the next
8. Discussions

Geological Survey of Ethiopia (GSE)

Japan International Cooperation Agency (JICA)

DATA COLLECTION SURVEY FOR GEOTHERMAL DEVELOPMENT IN ETHIOPIA

Let Us Start !!!!

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FOR GEOTHERMAL DEVELOPMENT
IN ETHIOPIA

Review of Target Selection discussed in the last workshop

Naoki KAWAHARA

NIPPON KOEI CO., LTD.
JMC GEOTHERMAL ENGINEERING CO., LTD.
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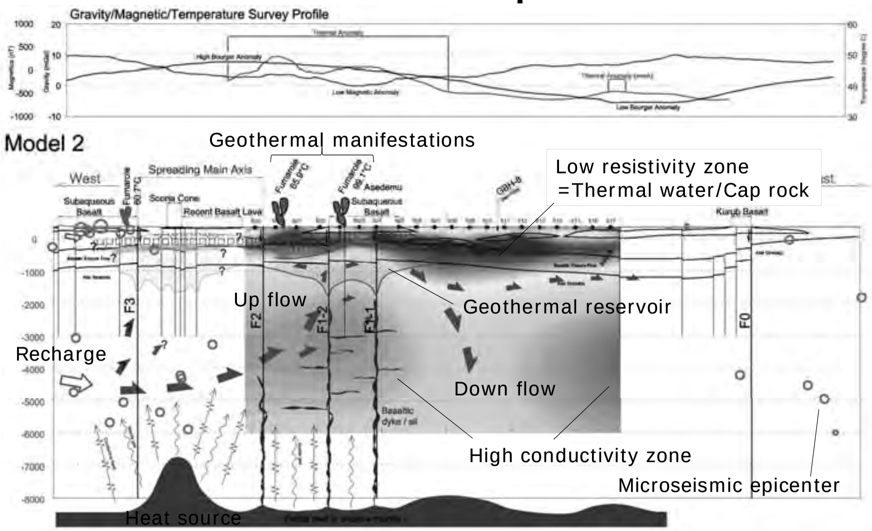
Survey in Tendaho-2 and Boseti

Work item	Tendaho-2	Boseti
Geological Reconnaissance	800km2	600km2
Geochemical Analysis	7 points	2 points
MT/TEM Survey 3D inversion analysis	111+80 points Done	30 points Nil
Gravity Survey	1,963 points	1,207 points
Temperature Survey	220 points	177 points*
Drilling Target	Done	Done

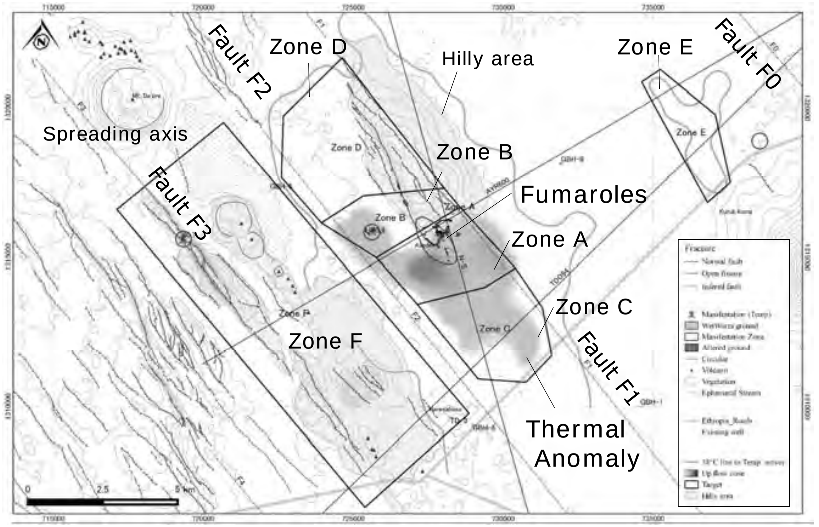
Blue: Conducted in this survey, Black: Conducted in the past study
*Conducted by GSE

■ Test Well Drilling will be implemented in Tendaho-2.

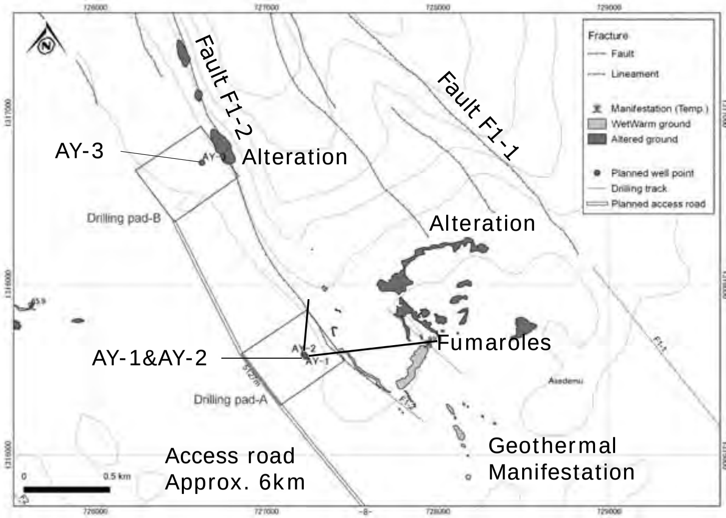
Geothermal Conceptual Model



Drilling Target Zone



Drilling Target



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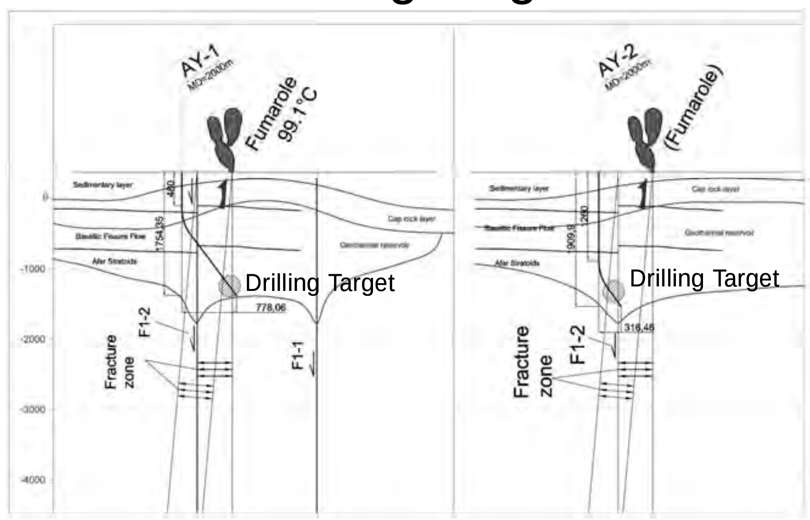
Drilling Target



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DATA COLLECTION SURVEY FOR GEOTHERMAL DEVELOPMENT IN ETHIOPIA

Drilling Plan

Chihiro TAKAHASHI

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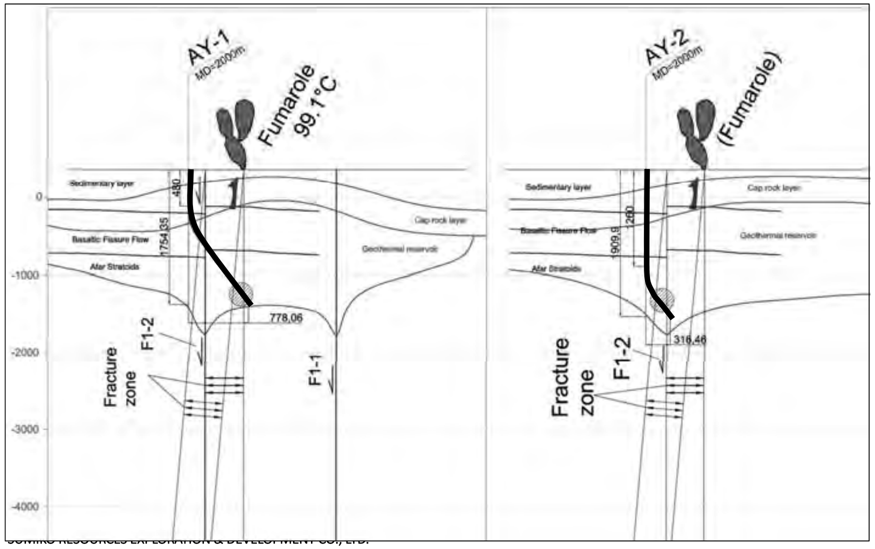
Contents

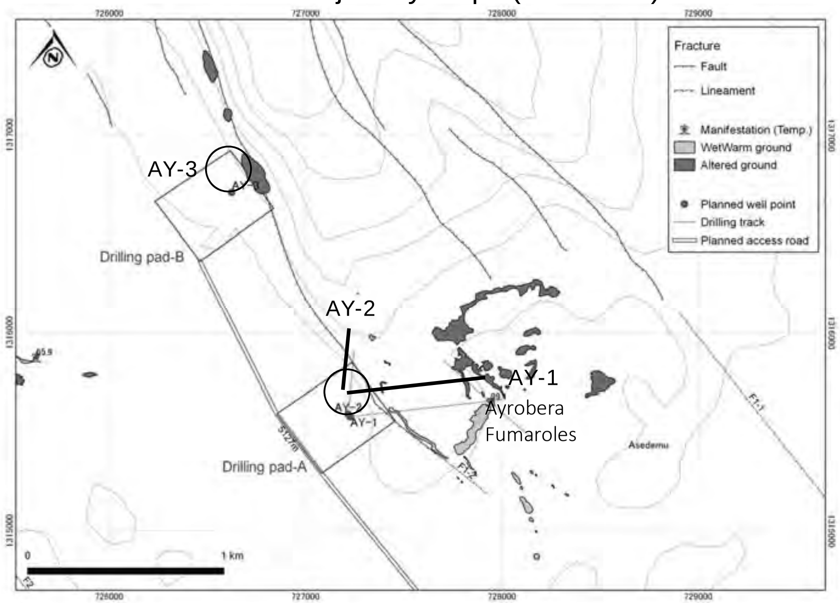
Discussion on Well Trajectory

- Three test wells have been planned.
- The drilling plan will be finalized according to the results of cost analysis and amount of budget.

Trajectory Map (Cross Section View)



Tendaho-2 Trajectory Maps (Plan View)



Trajectory of the Structural Drilling Well in Tendaho-2 Area

Well name	TD(m)	KOP(m)	Target Direction	Well Deviation (m)	Remark (Target Location)
AY-1	2,000	450	MN84°E	778.06	Underneath the highest temperature location in 2m depth
AY-2	2,000	1,230	MN6°E	316.46	Deep part of F1-2 fracture
AY-3	2,000	-	-	-	Vertical well

Casing Program

- Reviewed from Well TD-3 Drilling Report.
- The information from Well TD-3 showed that mud loss has occurred frequently in pit 17-1/2″(drilling section depth: 66~404.5 m) and 12-1/4″(drilling section depth: 404.5~841 m).
- As a countermeasure for mud loss, a total of 11 times cementing have been carried out.

Implementing Record on TD-3 Mud Loss Countermeasure

No.	Bit Size	Drilling Section (m)			Depth of L/C CMT(m)	Times
1st Section	36″	0	～	19	No CMT	0
2nd Section	26″	19	～	66	No CMT	0
3rd Section	17-1/2″	66	～	407	73m,61m,230m,199m,186m,125m, 149m,135m	10
4th Section	12-1/4″	407	～	841	640m	1
5th Section	8-1/2″	841	～	198 9	No CMT	0

Casing Depth of TD-3 and Implementing Record on Top Job Cementing

No.	CSG Size	CSG Set Depth(m)			Top Job Cementing Situation	Remark
1st Section	30″	0	~	19	No Top Job CMT	
2nd Section	20″	0	~	62	No Top Job CMT	
3rd Section	13-3/8″	0	~	404.5	TOC: 14m, use of top job cementing	Poor circulation of mud loss occurred during drilling
4th Section	9-5/8″	0	~	830	TOC: 107 m, use of top job cementing	Mud loss of about 20 kL/h occurred at depths of 580 m and 640 m.
5th section	7″	681	~	1362	—	Small mud loss occurred below the depth of 1,440 m.

Casing Program

- If it is assumed that Tendaho-2 (Ayrobera) has a similar structure of shallow strata with Tendaho-1 (Dubti), mud loss would occur in the same frequency in these two areas.
- On this assumption, the water shut-off of structural drilling wells should be implemented up to 600 m of drilling depth by using 9-5/8″CSG.
- For preventing mud loss recurrence, it is planned to use slurry with lower density in cementing.

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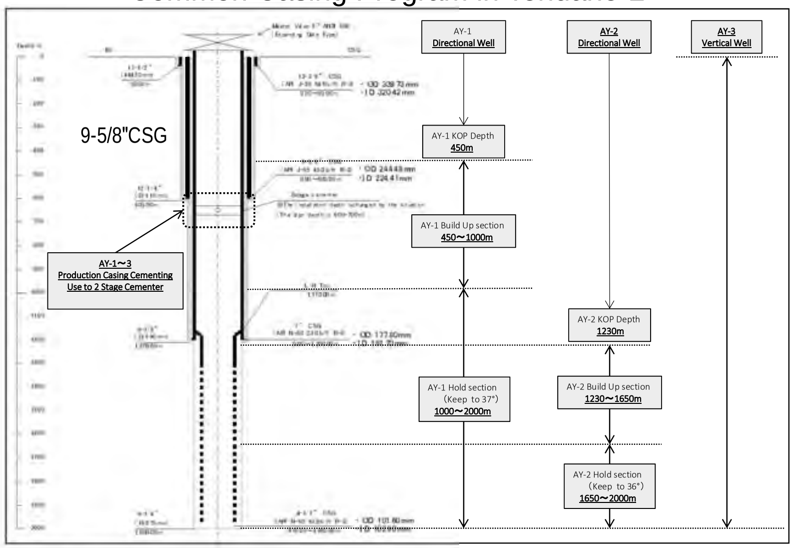
Common Casing Program in Tendaho-2



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Casing Cementing Methods in Tendaho-2 Area

	CSG Size	CSG Grade	Cementing Method	Cement	Slurry Property	Remark
1st section	13-3/8″	J-55, 54.5lb/ft	Inner string Method	Geothermal Well Cement (GWC)	Neat	Use accelerator depending on the situation
2nd section	9-5/8″	J-55, 40.0lb/ft	2 Plug Method	GWC	Low density	This Section estimate many L/C. This Plan choose Light weight Cement.
3rd section	7″	L-80, 23.0lb/ft	2 Stage Cementing Method	GWC	Low density	This Section estimate many L/C. This Plan choose 2 stage cementing and Light weight Cement.
4th section	4-1/2″	L-80, 10.5lb/ft	—	—	—	This Casing installed L/H .No Cementing.

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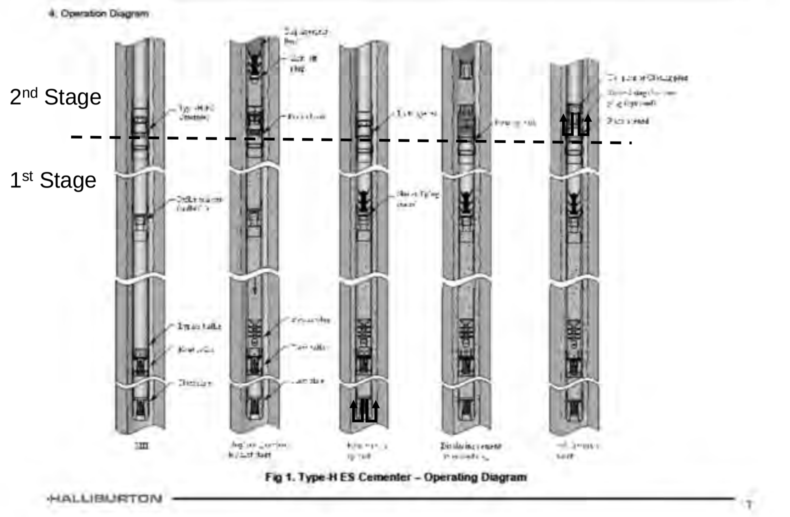
Detail of 2 Stage Cementer Operation Diagram



Discussion on Rig Standards

- Draw works should use rotary rig above 750 hp class.
- Either engine power or motor power can be used as long as there is enough space for materials storage.
- At least two mud pumps with capacity of 120 kL/h or above should be prepared.
- Cantilever mast or bootstrap mast are suggested to be used as both of which can be assembled without using large cranes.
- Use of top driver system (TDS) should be possible but not compulsive. However, it is recommended to use TDS if it can be prepared.
- Mud cooling system should be contained inside the rig equipment.
- Structure used for wellhead equipment assembling should be with necessary height.
- Because drilling work is planned to use rig slide on the same site, it is necessary to build the slide system.

750HP Rotary Drilling Rig by Geo-E

Front Side

Back Side

Boot Strap Type Mast: Rig Up Method

Cantilever Type Mast: Rig Up & Down Method

Top Drive System(TDS) by TESCO

Top Drive System installed Mast

250ton TDS (Type 250HMI)

Water Cooled Mud Cooling System

Mud Cooling Tower (Outside View)

Water Shower System (In side View)

Working Water Shower System

Drilling Water Supply

- Continuous delivery of 2,000 L/min (about 33 L/sec) of water will not be easy.
- Water pond will be constructed in the drilling site to which water is delivered continuously when necessary.
- Comparison of water supply facility was conducted for water well or irrigation canal.

Drilling Water Supply

- Water Pond at Drilling pad : 600 m^3
- Delivery Capacity : q= 0.75 m^3/min×8 hrs
- As a result, drilling water from irrigation canal is recommended.

Water Source	Water Availability	Construction Period	Operation	Maintenance	Re-use of materials	Cost	Evaluation
Water Well	Uncertain	Uncertain	Wells will be located in distances	Relatively difficult	Pump and engine only	High	△
Irrigation Canal	Certain	Certain	Two pumping Station	Easy	Pump, engine, uPVC pipe	High	◎ (Recom-mended)

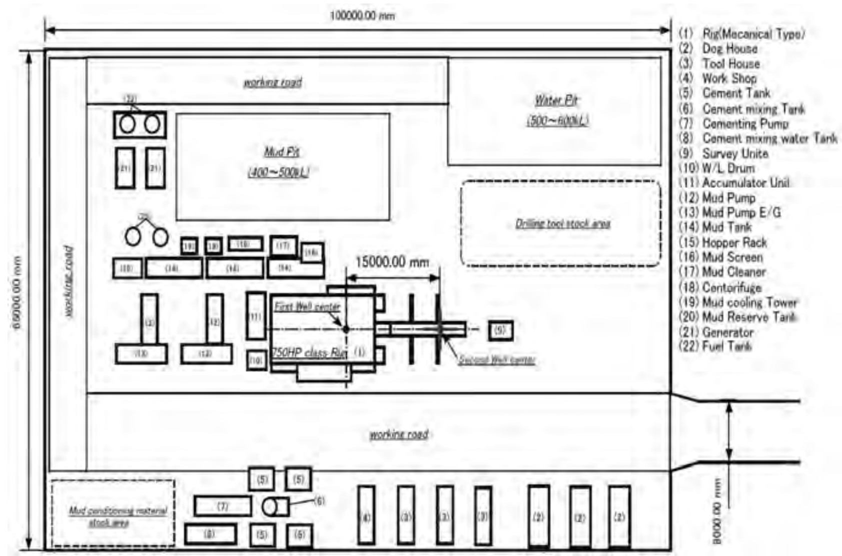
Drilling Water Supply

- ➢ Drilling site is in desert and flat, good for drilling.
- ➢ Access road should be constructed to the site. Access road to TD-3 can be used with repair.
- ➢ Drilling water can be supplied from irrigation area.
- ➢ There are no residences around the site. (Little traces of nomadic are found)

Well Pad Planning

- The drilling device should be 750 hp class rotary rig.
- Water supply pipelines are needed to be built from the irrigation area.
- Drilling waste or mud waste will be stored in a large-scale pit as waste storage.
- AY-1 and AY-2 will be drilled by same drilling rig with sliding for decreasing the cost of site building.
- Well pad of AY-3 is located at a different site, the shape of the site is as same as AY-1 and AY-2.

Well Pad Planning in Tendaho-2



Planned Drilling Work Schedule (AY-1)

① Estimated Term of Construction Work at AY-1.

No.	Work	day	No.	Work	day
1	Rig Up	20.0	11	Logging (Temperature, Electic, FMI etc)	1.0
2	1st section Drilling (17-1/2" 0.00～55.00m)	3.0	12	7" CSG Set	1.0
3	Logging (Temperature & Electic)	0.5	13	7" CSG CMT (Include next section Drilling preparation.)	3.0
4	13-3/8" CSG Set	0.5	14	4th Section Drilling (6-1/4" 1205.00～2000.00m)	23.0
5	13-3/8" CSG CMT (Include next section Drilling preparation.)	2.0	15	Logging (Temperature, Slectic, FMI etc)	1.5
6	2nd Section Drilling (12-1/4" 55.00～605.00m)	16.5	16	Drift Test	1.0
7	Logging (Temperature, Electic, FMI etc)	1.0	17	4-1/2" CSG Set	1.5
8	9-5/8" CSG Set	1.0	18	Water Injection Test (Include Logging at PTS,Fall of Test)	4.0
9	9-5/8" CSG CMT (Include next section Drilling preparation.)	2.5	19	Logging (Temperature Recovery Test: 24h, 48h, 72h)	3.0
10	3rd Section Drilling (8-1/2" 605.00～1205.00m)	20.0	20	Rig Down	14.0
				Total Days	**120.0**

② Sort of Work.

Ⅰ	Rig Up & Rig Down	34.0
Ⅱ	Drilling	62.5
Ⅲ	CSG Set & CSG CMT	12.5
Ⅳ	Logging(Include Well Test)	11.0
	Total Days	**120.0**

Bit Planning for Tendaho-2

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Arigato!

Geological Survey of Ethiopia (GSE)

Japan International Cooperation Agency (JICA)

Data Collection Survey for Geothermal Development in Ethiopia

Survey Result and Recommendation on Type of Contract Method

Tomoyuki KITANO

September 8, 2016

Addis Ababa, Ethiopia

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Table of Contents

1. Commonly-Used Contract Method for Drilling Works

Drilling Contractors' Organization (IADC)

- IADC is an acronym of
  International Association for Drilling Contractors
- Since 1940, the International Association of Drilling Contractors (IADC) has exclusively represented the worldwide oil and gas drilling industry.
- Headquarters is located at Houston, Texas in the United States. Regional offices are established at Washington D.C. in United States, Nijmegen in Netherlands, Dubai in UAE and Bangkok in Thailand.
- Well-known in standard conditions of contracts for underground drilling works.

IADC Drilling Contract Forms

- IADC issues three kinds of model contracts which are suggested to use for the drilling works:
  1) Daywork Drilling Contract
  2) Footage Drilling Contract
  3) Turnkey Contract
- Names of Contract Parties:
  1) Operator (defined as the client)
  2) Contractor (defined as the drilling contractor)

  *No “Engineer” is appointed.

IADC Drilling Contract Principle (1)

- Daywork Drilling Contract :

  The term “Daywork” means Contractor shall furnish the equipment, labor, and perform the services required of Contractor herein, for a specified sum per day under the direction, supervision and control of Operator.

  Except for such obligations and liabilities specifically assumed by Contractor, Operator shall be solely responsible and assumes liability for all consequences of operations by both parties while on a daywork basis, including results and all other risks or liabilities incurred in or incident to such operations.

  Daywork Drilling Contract is basically applied for the Project which the geological risks is high.

IADC Drilling Contract Principle (2)

- Footage Contract :

  The term “Footage” means Contractor shall furnish the equipment, labor, and perform the services required to drill a well, as specified by Operator, to the Contract Footage Depth. While drilling on a Footage Basis.
- Turnkey Contract :

  The term “Turnkey” means Contractor shall furnish the equipment, labor, and perform the services required to drill a well, as specified by Operator, to the Turnkey Depth. While drilling on a Turnkey Basis.

  Footage Depth/Turnkey Depth, where the geological conditions are sufficiently confirmed, are specified by Operator.

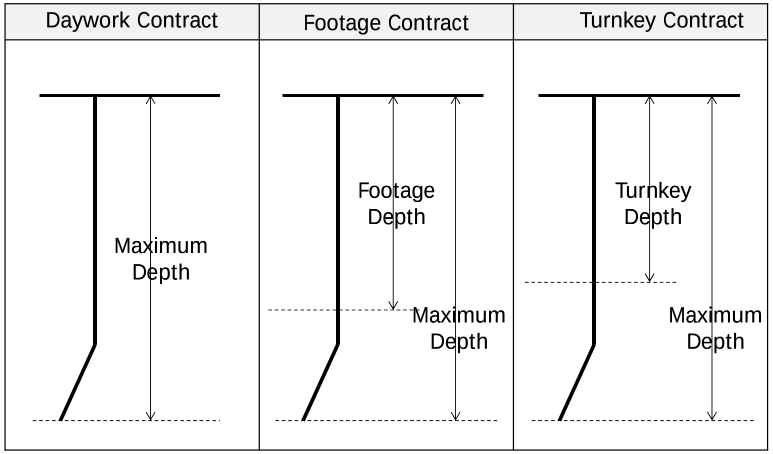
IADC Drilling Contract Principle (3)

- Responsibility under Footage/Turnkey Contract:

  Contractor shall direct, supervise and control drilling operations and assumes certain liabilities to the extent specifically provided for Footage/Turnkey Contract.
- Use of Multiple Type of Contract Method:

  Even the Footage Contract and Turnkey Contract, IADC model contract enables the partial use of daily rate payment. For instance, Footage rate payment or Turnkey price payment is applied to the section where the geological conditions have been sufficiently confirmed and daily rate payment is applied for other sections where geological risks is high.

Maximum Depth, Footage Depth and Turnkey Depth



Features of IADC Conditions of Contract

Items	Payment upon Measurements		Lump Sum Contract
	Daywork (Daily/Hourly)	Footage	Turnkey
Construction Period	Specified	Not specified	Not specified
Depth	Maximum Depth specified	Footage Depth and Maximum Depth specified	Turnkey Depth and Maximum Depth specified
Rate	- Mobilization Fee - Demobilization Fee - Operating Rate - Standby Time Rate - Rate During Repair - Force Majeure Rate - etc.	- Footage Rate - Standby Time Rate - Work Stoppage Rate - Operation Rate (optional) - Drilling Fluid Rate - Reimbursable Rate - etc. (Operating Rate can be applied for the part that daily basis is applied.)	- Turnkey Amount - Standby Time Rate - Work Stoppage Rate - Operation Rate (optional) - Drilling Fluid Rate - Reimbursable Rate - etc. (Operating Rate can be applied for the part that daily basis is applied.)
Payment	Monthly	Upon completion of services of Footage Depth	Upon completion of services of Turnkey Depth
Unforeseeable Conditions	Standby Rate will be applied during suspension.	For Footage Depth, Operating Rate can be applied, if progress becomes very slow.	For Turnkey Depth, no price adjustment is allowed.

2. Integrated Project Management (IPM)

What is Integrated Project Management?

■ Integrated Project Management Services:
IPM service is the total Management which all materials and equipment will be procured by the contractor.

The IPM services offering delivers managed and coordinated Drilling service company and third-party services and products.

IPM-trained Integrated Services Project Manager (ISPM) who leads service delivery and ensures project activity is essential. *(source: Schlumberger company website)*

Cost increase is basically unavoidable.

3. Survey Result and Recommendation

Summary of Interview Survey Result

Company	Preferable Contract Type	Comment from Contractor	Applicability to IPM application
A	Daily	➢ Double/triple cost are assumed in applying lump sum price contract compared with daily rate price contract.	A: Yes
B	Daily/ Lump Sum	➢ Lump sum price (turn-key) contract is acceptable on condition all tasks such as preparatory works, procurement of consumable, et al are involved.	B: Yes
C, D, E, H	Daily	➢ Negative view to adapt lump-sum price (turn-key) contract in view of contractor's risk exposure to unforeseen events in new area since actual geological conditions are not confirmed by himself.	C: Yes D: Yes E: Yes H: No
F, G	Daily	➢ Geothermal drilling project with footage rate contract is known in his country. ➢ Daily rate contract is practically for this project since actual geological conditions are not confirmed by himself.	F: No G: No

Recommendation on Contract Method

■ Type of Contract Method for Drilling Works:
"daily rate", which is the most commonly used method in the geothermal well drilling industry, is suggested to be adapt for the Project since actual geological conditions are not confirmed by drilling company (Contractor).

In applying the daily rate contract, it is essential that the client (Operator) establish construction supervision structure that assigns supervisors and site geologists properly, and check and monitor the drilling work carefully.

Outlook on Application of IPM Service

■ Possibility on Application of IPM Services:
Several contractors, who have experiences in drilling works in East Africa, expressed the possibility to apply IPM service for this Project.

■ "NO" Application of IPM Service:
In case wellhead equipment and casings are to be procured by client, cost reduction is expected. However, client shall assume the coordination among the related activities.

Data Collection Survey for Geothermal Development in Ethiopia

Thank you for your attention.

DATA COLLECTION SURVEY FOR GEOTHERMAL DEVELOPMENT IN ETHIOPIA

Proposed Framework of JICA Technical Cooperation <u>in the Next Stage</u>

- S. TAKAHASHI -

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Over all objectives

Capacity building for smooth development of geothermal energy.

Two key bottle necks for development:

1. Resource evaluation
2. Test well implementation

Project objectives proposed

1. Capacity building of geothermal project management skill
2. Capacity building of management skill of test well drilling works(*drilling skill itself is not included)*
3. Capacity building of geothermal surface survey skill including analysis and reporting

Key considerations for planning

1. <u>A new public organization, exclusively</u> for geothermal development, is expected to be established.
2. The JICA technical cooperation shall be in accordance with this movement

A basic approach for JICA's assistance

One JICA's basic approach:

Cost sharing
by the recipient
for the project to be implemented.

Expected input from both parties

Subject	Japan	Ethiopia
1. Project management	Technical consultants	Establishment of PMU and Staffing
2. Management skill of test well drilling	Major procurement - Drilling site supervising team - Contractors/ suppliers for major works	Local procurement - Civil works and/or others as required
3. Geothermal surface survey skill	- Tools and/or equipment as necessary	- Staffing for geo-scientific surface survey - Tools and/or equipment presently available

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Cost allocation analysis for test well drilling

Work allocation

Work type	Case-1	Case-2	Case-3	Case-4
Civil works	JICA	Ethiopia	Ethiopia	Ethiopia
Water supply	JICA	Ethiopia	JICA	JICA
Drilling Work	JICA	JICA	JICA	JICA
Material Supply	JICA	JICA	JICA	JICA/Ethiopia

Cost Allocation

Party	Case-1	Case-2	Case-3	Case-4
JICA	100 %	81%	93%	89%
Ethiopia	0 %	19%	7%	11%

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Procurement allocation proposed Case-3

By JICA Budget		By Ethiopia Budget	
Prc.-0	a. Technical consultant b. Drilling site supervisor team (DSV)	-	-
Prc.-1	a. Drilling Service Contractor (DSC) with drilling rig b. Major consumable for drilling works	Prc.-1	Civil work contractor - Access road construction, - Drilling pad preparation, - Including maintenance works
Prc.-2	Contractor for water supply facility including equipment, material and O&M during drilling works	Prc.-2	(Consumables that are to be procured in well advance) to be decided.

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Essential Key Point, No.1 !!

Timely execution of the civil works by the Ethiopian C/P

-Access road construction

-Drilling pad construction

Project activities

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Project Activities
1. Project management

Japan Team	Ethiopia Team
Technical consultants	Project management team
Overall project management together with Ethiopia counterparts - Technical management - Schedule management - Procurement management - Others as required	Overall project management - Coordination of national staff - Coordination with national public offices concerned - Undertaking administrative procedures, - Public relations including land acquisitions, compensations and/or others - ESIA monitoring, SHE - Others as required

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Project Activities
2. Test well drilling works

Japan Team	Ethiopia Team
a. To provide assistance for the local procurement and supervision b. Procurement: - DSC together with rig and consumables - Contractor for water supply facility and supervsion	a. Procurement of Contractor for civil works and supervision b. To work together with Japanese team for the main procurement
c. Supervision of drilling works	
d. Geo-scientific survey – observation of cuttings, well logging, production test	

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Project Activities
3. Geo Scientific surface survey

Japan team	Ethiopia team
a. Site selection from either Boseti or Butajira whichever possible and requested. Special note to be drawn to the license matter.	
a. Field survey: Geological survey, geophysical survey, geochemical survey - Geophysical survey may include MT/TEM survey, 2m-depth temperature survey and/or others as necessary. c. Data processing, analysis and reporting d. Training program in Japan or third country/ies e. Others as necessary	

Project Implementation Organogram

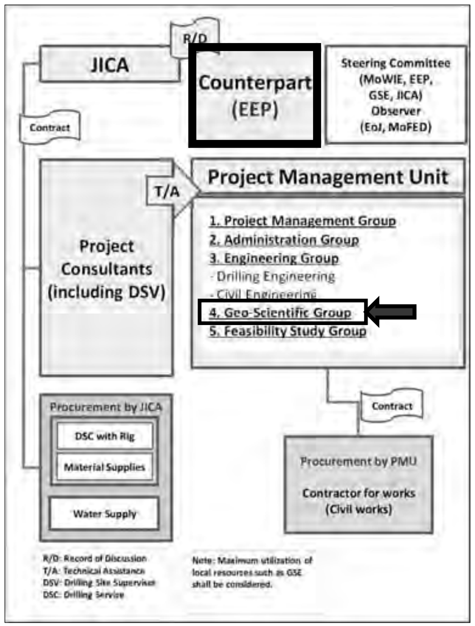
Again, our policy for the planning:

1. A new public organization exclusively for geothermal development is expected to be established.
2. The JICA technical cooperation shall be in accordance with this movement

Project Implementation Organogram (proposed)

Our Counterpart:
EEP

Together with
Geo-scientific group



Role allocation for two groups
1. Project management group
2. Geo-scientific group

Project management group (EEP) – Technical consultants	
Project management group Mainly from EEP	Geo-scientific group Mainly form other offices, such as GSE
Test well drilling site - Procurement of contractors - Supervision of the test well drilling and its related works Administrative activities for the test well drilling work	Test well drilling site - Well geology - Well logging - Production test Surface survey site - Geothermal surface survey - Evaluation Administrative activities for geo-scientific activity
- Feasibility Study for electric power generation project with resource assessment results given	

Essential Key Point, No.2 !!

Smooth Coordination
between
The project management team
&
Geo-scientific team

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Implementation Schedule

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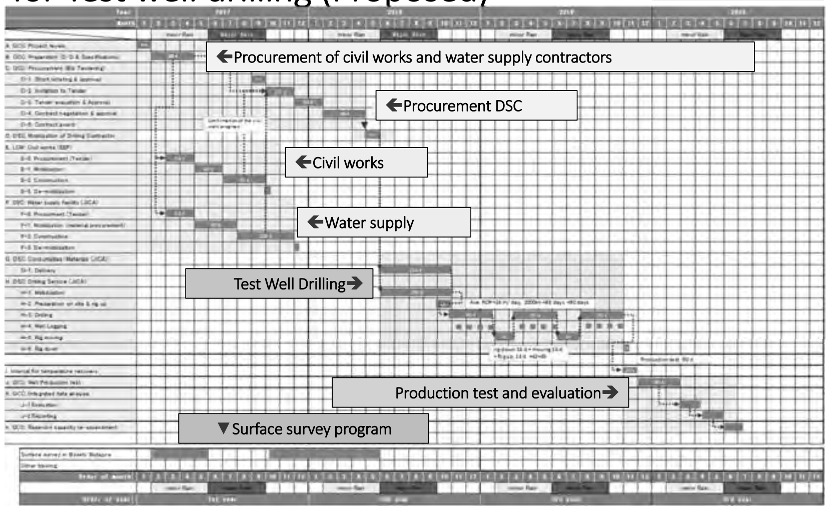
Project Implementation Schedule for Test well drilling (Proposed)

A 3.5 year project



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Time table to the Final Report

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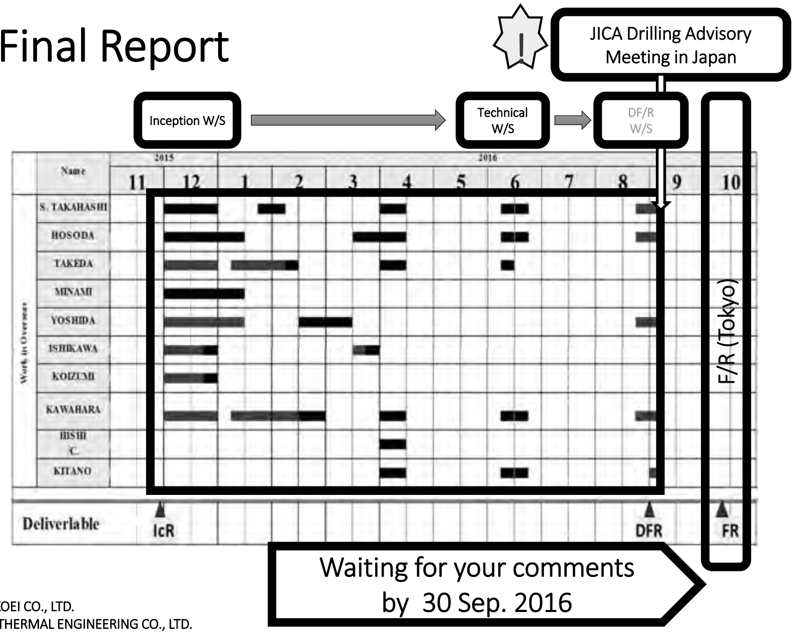
Final Report



Then, what’s the next ???

Aluto Langano, Ethiopia

What’s the Next?

- A discussion and decision for implementation will be made within JICA, including budgetary arrangement.
- JICA will dispatch a detail planning team, towards the end of **October 2016**.
- An agreement may well be reached between the JICA and the Ethiopian counterpart.
- The project is expected to commence in an early part of 2017.

Let’s go for Geothermal !!

Geological Survey of Ethiopia (GSE)

Japan International Cooperation Agency (JICA)

DATA COLLECTION SURVEY
FOR GEOTHERMAL DEVELOPMENT
IN ETHIOPIA

Thank you, Amesege'nallo‘, and Arigoto

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APPENDIX-9

Improvement of Calculating Formulas

for Geothermal Volumetric Assessment

This is an authors manuscript version after accepted by Geothermics, before the proofing process. The final version is available on: http://dx.doi.org/10.1016/j.geothermics.2016.04.011

Improvement of Calculating Formulas for Volumetric Resource Assessment

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ABSTRACT

The USGS volumetric method is used for assessing the electrical capacity of a geothermal reservoir. The calculation formulas include both underground related parameters and above-ground related parameters. While primary variability and uncertainty in this method lay in the underground related parameters, electric capacity calculated is also a function of the above-ground related parameters. Among those parameters, the fluid temperature of the reservoir will be the key parameter for the volumetric method calculation when used with Monte Carlo method, because this temperature is the variable (uncertain) underground related parameter which affects the steam-liquid separation process in the separator - an above-ground related parameter. Conventional calculation methods do not deal with the steam-liquid separation process being affected by fluid temperature as a random variable when used together with Monte Carlo method. In order to fix up this issue, we have derived calculation formulas by introducing "Available Exergy Function", thereby, the fluid-temperature-dependant separation process can be included in the equations together with the fluid temperature as a random variable. This paper presents the electricity capacity calculations formulas that can be used for the volumetric method together with Monte Carlo method. In addition, a comparison is also made between the proposed method and the USGS method. The theoretical background of the proposed formula has eventually proved to be as same as USGS method except for a few parameters adopted.

Keywords: triple point temperature; single flash power plant; steam-liquid separation process at separator; available exergy function; adiabatic heat drop at turbine

1. INTRODUCTION - ISSUES OF THE CALCULATION METHODS BEING AVAILABLE

The USGS (1978) defines the reservoir thermal energy available under a reference temperature by the following equation.

$$q_r = \rho C V (T_r - T_{ref}) \quad \text{[kJ]} \qquad \text{(Eq. 1)}$$

Where q_r is geothermal energy that is stored in geothermal reservoir and is able to be used under reference temperature conditions, ρC is volumetric specific heat, V is reservoir volume, T_r is reservoir temperature and T_{ref} is reference temperature. It describes that the reference temperature (15 ℃) is the mean annual surface temperature and for simplicity is assumed to be constant for the entire United States. A set of calculation equations are presented, on the basis of the second law of thermodynamics, to estimate electric energy to be converted from geothermal energy available under the reference temperature. Parameters required for the calculation of the electric generation capacity by using the USGS method are summarized below.

Table 1 Classification of Parameters for USGS Method (1978)

A. Underground related parameters	**B.** Above-ground related parameters
a-1. Reservoir volume: V [m^3]	b-1. Reference temperature: T_{ref} [℃]
a-2. Reservoir temperature: T_r [℃]	b-2. Utilization factor: η_u[-]
a-3. Volumetric specific heat: ρC [$kJ/m^3 - K$]	b-3. Plant life: L [sec]
a-4. Recovery factor: R_g [-]	b-4. Plant factor: F [-]

While primary variability and uncertainty in this method lay in the underground related parameters, considerations have also been directed to above-ground related parameters. The USGS method defines 'utilization factor' to convert heat energy to electric energy, giving 0.4 (USGS 1978). It was updated to 0.45 by USGS (2008). USGS (1978) states the given utilization factor is applicable only for the case that the reference temperature is 15 ℃ (the average ambient temperature in the United State) and the condenser temperature is 40 ℃. On the other hand, S. K. Garg and J. Combs (2011) pointed out that the utilization factor depends on both power cycle and the reference temperature; the available work (calculated electric energy) is a strong function of the reference temperature. This suggests that type of power cycle has to be defined to obtain valid results when practicing the volumetric method.

We consider here a single flash condensing power cycle as a typical plant. Electric energy to be generated is calculated by well established calculation processes for turbine-separator-condenser performance in accordance to thermodynamics; the electric energy generated is principally dependent on fluid temperature sent to separator together with separator temperature and condenser temperature; a set of each fixed temperature may be given into the calculation process. However, these conventional calculation methods are not applicable when practicing the volumetric method together with Monte Carlo method because the fluid temperature shall be dealt as a random variable due to its uncertainty and the steam-liquid separation process is a fluid-temperature-dependant process. Calculation equations for the volumetric method need to satisfy those two requirements when used with Monte Carlo method. In order to provide this issue with a solution, we have derived calculation formulas by introducing "Available Exergy Function", thereby, fluid-temperature-dependant separation process can be included in a equation together with the fluid temperature as a random variable for the use with Monte Carlo method.

With the concept above, Takahashi and Yoshida (2015 a, 2015 b) proposed a simplified calculation formula, assuming a single flash condensing power cycle of the separator temperature 151.8 ℃ and condenser temperature 40 ℃; the formula includes fluid temperature as a random variable and the function that reflects the fluid-temperature-dependant steam-liquid separation process;

that can be used with Monte Carlo method. We herein refined the proposed method and expand its application to various combinations of separator and condenser temperatures assuming a single flash condensing power cycle.

Discussions on other important subjects of the underground related parameters are out of the scope of this paper. We believe the proposed equations will provide clearer ideas on the reservoir potential once the underground related parameters are properly defined.

2. SUMMARY OF THE PROPOSED CALCULATION EQUATIONS

The key points of the proposal are described below. A detailed explanation on how the equations have been derived are presented in Chapter 3 for verifications by readers.

1. We placed the "triple point temperature" in the equation-2 for the place of the reference temperature of the equation-1 of USGS (1978). The equation-2 represents the heat energy potentially stored in the geothermal reservoir, whereas the equation-1 defines the heat energy available in the reference temperature condition out of the heat energy potentially stored in a geothermal reservoir. This is because the fluid recovered at well head is sent to the power plant before exposed to any of reference conditions.

2. We adopted the concept of the "exergy" at a single flash condensing cycle by the equation-5 or -6 (adiabatic heat drop) in accordance to thermodynamics. This equation is eventually proved to be the same as the one given by USGS (1978) as the "Available Work" (Chapter-11).

3. We defined the "Available Exergy Function" by the equation-7. This represents the ratio of the exergy at a turbine-generation system against the total heat energy recovered at well head. Inclusion of the function in the calculation formula is the key idea of this paper.

4. By using the Available Exergy Function, the electricity to be generated is given by the equation-10. "Exergy efficiency", instead of "utilization factor", is included in the equation to tie up with the "exergy" adopted. This is the base equation from which approximation equations for application are derived.

5. For the separator temperature of 151.8 ℃ and the condenser temperature of 40 ℃ as an example; an approximation of the Available Exergy Function is given first as cubic polynomial as in the equation-21; this polynomial approximation is further simplified by the equation-23 for practical uses; Exergy efficiency is approximated in the equation-25, -26 based on 189 actual performance data; Electricity to be generated is given by the equation-27.

6. A comparison with USGS method is discussed in Chapter 8 and Chapter 11 for further reference. A discussion on the utilization factor defined by USGS is also given in Chapter-11

2.1 Application

We will first present the sets of equations in Table-2. Thereafter, the explanation is given on how those equations have been derived.

2.1.1 Underground Related Conditions

The underground related parameters listed in Table 1 shall be determined first. We referred to the USGS method (1978) for the definitions and applications of those parameters. For the proposed calculation method, those parameters can be random variables for Monte Carlo method as has been practiced in the past. Much attention and examination shall be directed to the determination of those parameters because primary variability and uncertainty lay in the underground related parameters. Discussions on how to determine those parameters are out of scope of this paper.

2.1.2 Geothermal Fluid Conditions for the Proposed Method

We assume the geothermal fluid is the single phase liquid conditions in the reservoir. This is because "a fluid that is all liquid has a smaller entropy value than a two phase fluid with same enthalpy; thus, the available work (exergy) value assuming liquid water is greater than any two-phase mixture of the same enthalpy and is an appropriate reference condition" (USGS 1978). The enthalpy of the fluid in the reservoir usually decreases when it comes up to the wellhead due to the partial or entire flashing, frictions, gravitational forces and/or others. We, however, assume the fluid enthalpy available at the wellhead should correspond to the enthalpy of the single phase liquid in the reservoir. The loss of enthalpy while the fluid comes up to the well head could be included in the recovery factor when practicing the volumetric method.

2.1.3 Above-Ground Conditions for the Proposed Method

A single flash condensing system is assumed, where separator temperature and condenser temperature shall be pre-determined. The combination of separator temperature and the condenser temperature will be the index for selection of the simplified calculation equation presented in Table 2. Discussions on how to determine the separator temperature and the condenser temperature in relation to geothermal fluid characteristics are out of the scope of this paper. The following presentation however may be helpful.

Figure 1 shows the relative power output to be generated by a power plant with the separator pressures ranging from 2 bar-a to 10 bar-a, with two cases of condenser temperatures of T_{cd} =40℃ or T_{cd} =50℃, for the geothermal fluid temperature raging from 200 ℃ to 350 ℃, (assuming $R_g \rho C V$=1 for the calculations of relative outputs). Power output may be maximum when the separator pressure of 5 or 6 bar-a for the fluid temperature of 250 ℃ - 275 ℃. These separator pressures may be recommended for an initial stage of resource evaluation if other conditions should allow to do so. Note that power output will be about 88 % when condenser temperature increases from 40 ℃ to 50 ℃ with the separator pressure of 5 bar-a just for a reference.

http://dx.doi.org/10.1016/j.geothermics.2016.04.011

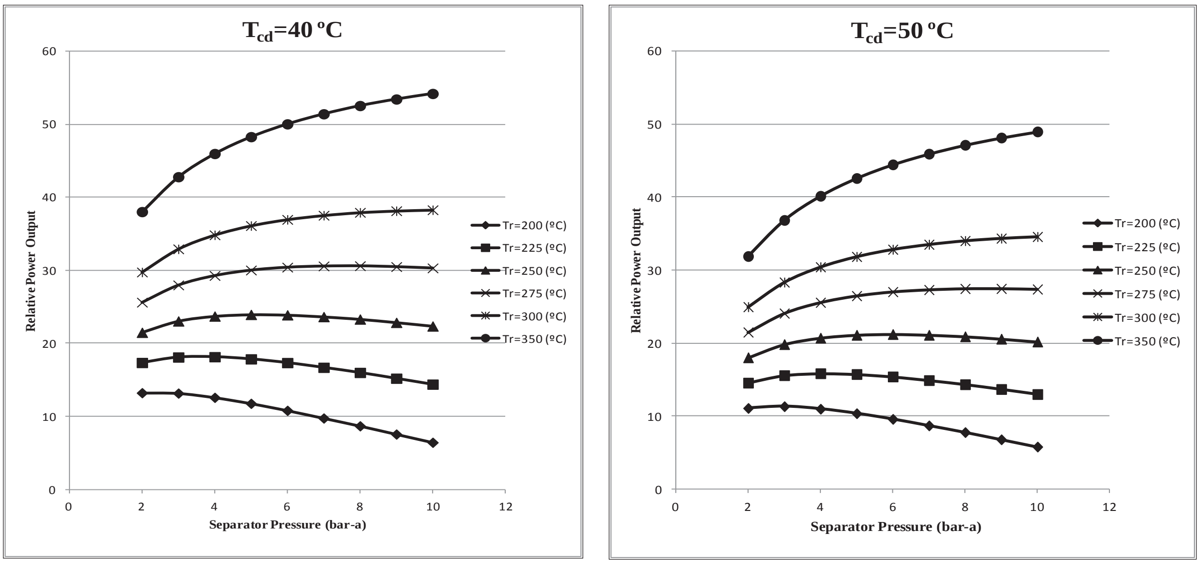

Figure 1 Relative Power Output for Various T_{sp} with T_{cd} =40 ℃ (Left) or T_{cd} =50 ℃ (Right)

2.1.4 A Note on "Reference Temperature" and "Utilization Factor"

For the proposed calculation method, we do not use such generalized temperature names as "reference temperature", "abandonment temperature" or "rejection temperature". Instead, specified temperatures as "triple point temperature", "separator temperature" and "condenser temperature" are used to avoid possible misunderstandings. We do not use 'utilization factor' either, because it is originally defined for the use exclusively in the United State. It is a rather region specific factor. Instead of the "utilization factor", we use plant specific "exergy efficiency" (defined by Equation-24) together with plant specific "exergy" (defined by Equation-5 or -6) at a turbine-generator. A brief observation on the "utilization factor" is given in Chapter 11.1 of this paper for further observation.

2.2 Calculation Equations

The sets of the calculation equations are presented in Table-2. Abbreviations appeared in the table are shown below.

E : Electric energy $[kJ]$
R_g : Recovery factor [-]
V : Reservoir volume$[m^3]$
T_r : Average reservoir temperature [℃]

$\rho C = (1-\varphi)C_r\rho_r + \varphi C_f\rho_f$: Reservoir volumetric specific heat $[\mathrm{kJ}/m^3 - \mathrm{K}]$
φ : Porosity [-]
C_r : Specific heat of rock $[kJ/kg]$
ρ_r : Rock density $[kg/m^3]$
C_f: Specific heat of fluid $[kJ/kg]$
ρ_f: Fluid density $[kg/m^3]$

A calculation equation is uniquely given by selecting a combination of the temperatures of the separator and the condenser. Numerical constants in the equations in Table-2 shall not be modified or changed in any case. These are the products from a series of approximation processes. Coefficients of the turbine-generator efficiency are included in the numerical terms in the equations based on information of actual power plants all over the world.

The average output capacity of the power plant in a designed plant life period is given as follows.

$$W_e = \mathrm{E}/(\mathrm{FL}) \qquad [kJ] \text{ or } [kW]$$

Where; "We" is the average output capacity of the power plant, "F" is the plant utilization factor, "L" is the plant life period (sec).

Table 2 Proposed Calculation Equations for Volumetric Method

Eq.-ID	Conditions				Electric Energy (kJ) Linear Approximation
	Separator		Condenser		
	P (bar-a)	T (℃)	P (bar-a)	T(℃)	
230	2	120.2	0.04	30	(0.19 ± 0.01) * $R_g \rho C V$ * (T_r - 120.2)
240	2	120.2	0.07	40	(0.17 ± 0.01) * $R_g \rho C V$ * (T_r - 120.2)
250	2	120.2	0.12	50	(0.14 ± 0.01) * $R_g \rho C V$ * (T_r - 120.2)
260	2	120.2	0.20	60	(0.11 ± 0.01) * $R_g \rho C V$ * (T_r - 120.2)
370	2	120.2	0.31	70	(0.09 ± 0.01) * $R_g \rho C V$ * (T_r - 120.2)
330	3	133.5	0.04	30	(0.23 ± 0.01) * $R_g \rho C V$ * (T_r - 133.5)
340	3	133.5	0.07	40	(0.20 ± 0.01) * $R_g \rho C V$ * (T_r - 133.5)
350	3	133.5	0.12	50	(0.17 ± 0.01) * $R_g \rho C V$ * (T_r - 133.5)
360	3	133.5	0.20	60	(0.14 ± 0.01) * $R_g \rho C V$ * (T_r - 133.5)
370	3	133.5	0.31	70	(0.12 ± 0.01) * $R_g \rho C V$ * (T_r - 133.5)
430	4	143.6	0.04	30	(0.25 ± 0.02) * $R_g \rho C V$ * (T_r - 143.6)
440	4	143.6	0.07	40	(0.22 ± 0.01) * $R_g \rho C V$ * (T_r - 143.6)
450	4	143.6	0.12	50	(0.19 ± 0.01) * $R_g \rho C V$ * (T_r - 143.6)
460	4	143.6	0.20	60	(0.17 ± 0.01) * $R_g \rho C V$ * (T_r - 143.6)
470	4	143.6	0.31	70	(0.14 ± 0.01) * $R_g \rho C V$ * (T_r - 143.6)
530	5	151.8	0.04	30	(0.27 ± 0.02) * $R_g \rho C V$ * (T_r - 151.8)
540	5	151.8	0.07	40	(0.24 ± 0.02) * $R_g \rho C V$ * (T_r - 151.8)
550	5	151.8	0.12	50	(0.21 ± 0.01) * $R_g \rho C V$ * (T_r - 151.8)
560	5	151.8	0.20	60	(0.19 ± 0.01) * $R_g \rho C V$ * (T_r - 151.8)
570	5	151.8	0.31	70	(0.16 ± 0.01) * $R_g \rho C V$ * (T_r - 151.8)
630	6	158.8	0.04	30	(0.29 ± 0.02) * $R_g \rho C V$ * (T_r - 158.8)
640	6	158.8	0.07	40	(0.26 ± 0.02) * $R_g \rho C V$ * (T_r - 158.8)
650	6	158.8	0.12	50	(0.23 ± 0.02) * $R_g \rho C V$ * (T_r - 158.8)
660	6	158.8	0.20	60	(0.20 ± 0.01) * $R_g \rho C V$ * (T_r - 158.8)
670	6	158.8	0.31	70	(0.18 ± 0.01) * $R_g \rho C V$ * (T_r - 158.8)
730	7	165.0	0.04	30	(0.31 ± 0.02) * $R_g \rho C V$ * (T_r - 165.0)
740	7	165.0	0.07	40	(0.28 ± 0.02) * $R_g \rho C V$ * (T_r - 165.0)
750	7	165.0	0.12	50	(0.25 ± 0.02) * $R_g \rho C V$ * (T_r - 165.0)
760	7	165.0	0.20	60	(0.22 ± 0.01) * $R_g \rho C V$ * (T_r - 165.0)
770	7	165.0	0.31	70	(0.19 ± 0.01) * $R_g \rho C V$ * (T_r - 165.0)
830	8	170.4	0.04	30	(0.32 ± 0.02) * $R_g \rho C V$ * (T_r - 170.4)
840	8	170.4	0.07	40	(0.29 ± 0.02) * $R_g \rho C V$ * (T_r - 170.4)
850	8	170.4	0.12	50	(0.26 ± 0.02) * $R_g \rho C V$ * (T_r - 170.4)
860	8	170.4	0.20	60	(0.23 ± 0.02) * $R_g \rho C V$ * (T_r - 170.4)
870	8	170.4	0.31	70	(0.21 ± 0.01) * $R_g \rho C V$ * (T_r - 170.4)
930	9	175.4	0.04	30	(0.34 ± 0.02) * $R_g \rho C V$ * (T_r - 175.4)
940	9	175.4	0.07	40	(0.31 ± 0.02) * $R_g \rho C V$ * (T_r - 175.4)
950	9	175.4	0.12	50	(0.28 ± 0.02) * $R_g \rho C V$ * (T_r - 175.4)
960	9	175.4	0.20	60	(0.25 ± 0.02) * $R_g \rho C V$ * (T_r - 175.4)
970	9	175.4	0.31	70	(0.22 ± 0.01) * $R_g \rho C V$ * (T_r - 175.4)
1030	10	179.9	0.04	30	(0.35 ± 0.02) * $R_g \rho C V$ * (T_r - 179.9)
1040	10	179.9	0.07	40	(0.32 ± 0.02) * $R_g \rho C V$ * (T_r - 179.9)
1050	10	179.9	0.12	50	(0.29 ± 0.02) * $R_g \rho C V$ * (T_r - 179.9)
1060	10	179.9	0.20	60	(0.26 ± 0.02) * $R_g \rho C V$ * (T_r - 179.9)
1070	10	179.9	0.31	70	(0.23 ± 0.01) * $R_g \rho C V$ * (T_r - 179.9)

3. DERIVING THE PROPOSED EQUATIONS

We will describe hereunder how the proposed calculation equations have been derived. The key abbreviations used correspond to those in Figure 2.

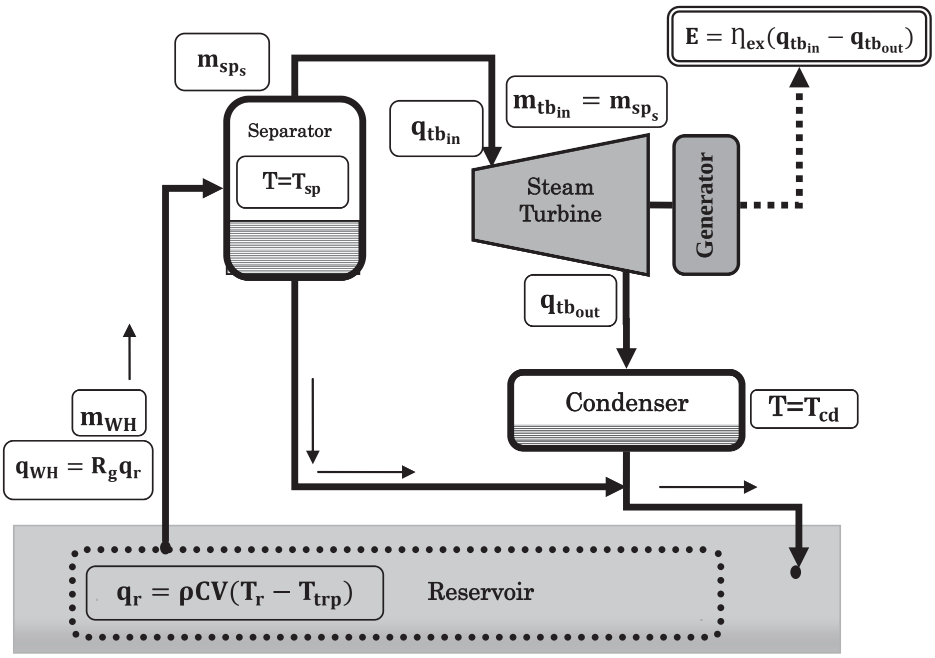

Figure 2 Simplified Single Flash Power Plant Schematic.

3.1 Thermal Energy Potentially Stored in Geothermal Reservoir

The thermal energy potentially stored in a geothermal reservoir is given as follows.

$$q_r = \rho CV(T_r - T_{trp}) \quad \text{[kJ]} \qquad \text{(Eq. 2)}$$

Where T_{trp} is triple point temperature (T_{trp}=0.01℃ for pure water).

Note that we placed T_{trp} (triple point temperature) in the equation Eq. 2 for the position of T_{ref} (reference temperature) of the equation Eq. 1 given by USGS (1978). The equation-2 represents the heat energy potentially stored in the geothermal reservoir, whereas the equation-1 defines the heat energy available in the reference temperature condition out of the heat energy potentially stored in a geothermal reservoir. The process of utilization of the geothermal fluid stored in a reservoir is made through three steps; (i) First, the geothermal fluid having the heat energy potentially stored in the reservoir is recovered at the well head (with recovery factor to be considered. See section 3.2); (ii) Second, the recovered fluid is sent into a energy utilization system before exposed to any of ambient conditions; (iii) Third, the heat energy, after utilized, decreases down to the final state condition. The equation Eq. 1 represents the heat energy made available through these three steps. Here, we consider the heat energy of the geothermal fluid at the first step only, where the fluid is not yet exposed to any of reference conditions such as the ambient temperature; the geothermal fluid retains potentially available heat energy at this step. In accordance to thermodynamics, potentially available heat energy of geothermal fluid of temperature T_r °C is given by the equation Eq. 2 using the triple point temperature. The triple point temperature is the extreme minimum temperature for the reference temperature in thermodynamic. The potentially available heat energy is sent into the geothermal power plant.

3.2 Thermal Energy in the Reservoir, Recovery Factor

Since not all heat energy is recovered, the recovery factor is defined by USGS (1978) as follows.

$$R_g = q_{WH}/q_r \quad \text{[-]} \qquad \text{(Eq. 3)}$$

Where R_g is the recovery factor, and q_{WH} is the heat energy recovered at the well head.

From the equations Eq. 2 and Eq. 3, the heat energy recovered at the well head is expressed by the following equation.

$$q_{WH} = R_g \rho CV(T_r - T_{trp}) \quad \text{[kJ]} \qquad \text{(Eq. 4)}$$

This recovered heat energy is sent into separator through a adiabatic treated fluid transport pipe system without losing its energy to the ambient.

3.3 Electric Power Output from Turbine-generator

Electric power output generated by a steam turbine-generator system is expressed by the following equation using "adiabatic heat drop" between the heats at the turbine entrance and at the turbine exit (DiPippo 2008 or Hirata, et al 2008 or other references on thermodynamics).

$$E = \eta_{ex}\, m_{tb_{in}}(h_{tb_{in}} - h_{tb_{out}}) \qquad \text{[kJ]} \qquad \textbf{(Eq. 5)}$$

or

$$E = \eta_{ex}(q_{tb_{in}} - q_{tb_{out}}) \qquad \text{[kJ]} \qquad \textbf{(Eq. 6)}$$

Where η_{ex} is the turbine-generator efficiency (exergy efficiency), $m_{tb_{in}}$ is the mass of the steam at turbine entrance, $h_{tb_{in}}$ is the specific enthalpy at the turbine entrance, $h_{tb_{out}}$ is the specific enthalpy at the turbine exit, $q_{tb_{in}}$ is the thermal energy of the turbine entrance, $q_{tb_{out}}$ is the thermal energy of the turbine exit.

Note that the $h_{tb_{out}}$ is the heat energy at turbine exit under the condition when the heat at turbine entrance and heat at condenser (final state) are given, the explanation for this will be given in section 4.2.2; that the η_{ex} defined as the turbine-generator efficiency (exergy efficiency) is different from the 'utilization factor' defined by the USGS (1978). Also note that E defined by Eq. 5 is eventually proved to be the exergy energy (Available work) defined by USGS (1978) in Section 11 of the paper.

3.4 Definition of Available Exergy Function

We herein define the following equation. We name it "Available Exergy Function"

$$\zeta = (q_{tb_{in}} - q_{tb_{out}})/q_{WH} \qquad \textbf{[-]} \qquad \textbf{(Eq. 7)}$$

Where ζ is the Available Exergy Function.

This is the ratio of the heat energy that contributes to electric power generation (i.e. exergy) at the turbine-generator against the whole thermal energy recovered at the well head.

3.5 Deriving the Rational Calculation Equation

We reform the equation Eq. 7 to the following equation.

$$(q_{tb_{in}} - q_{tb_{out}}) = \zeta\, q_{WH} \qquad \textbf{[kJ]} \qquad \textbf{(Eq. 8)}$$

Combination of the equation Eq. 6 and Eq. 8 gives the following equation.

$$E = \eta_{ex}\, \zeta\, q_{WH} \qquad \textbf{[kJ]} \qquad \textbf{(Eq. 9)}$$

Further, q_{WH} in the equation Eq. 9 is replaced with the equation Eq. 4, resulting in the following equation.

$$E = \eta_{ex}\, \zeta\, \rho C V (T_r - T_{trp}) \qquad \textbf{[kJ]} \qquad \textbf{(Eq. 10)}$$

The equation Eq. 10 expresses the electric energy generated at a turbine-generator; the electric energy converted from the thermal energy sent into the turbine-generator of the efficiency η_{ex} (exergy efficiency).

4 CALCULATION OF THE AVAILABLE EXERGY FUNCTION

Although the equation Eq. 10 gives the electric energy to be converted from the thermal energy recovered at the well head, the equation is not ready for a practical calculation in field. This has to be expressed as an equation that shall be practically and user-friendlily used.

4.1 Assumptions

In order to convert the equation Eq. 10 to a calculable equation, we assume the following three conditions.

a. Geothermal fluid recovered at well head is assumed to have the enthalpy that corresponds to the enthalpy of the single phase liquid stored in the reservoir (as stated in 2.1),
b. Single flash condensing geothermal power plant is assumed for resource evaluation (as stated in 2.1),,
c. Dry steam sent into the turbine and wet steam exhausted from the turbine is assumed.

4.2 Deriving the Calculable Equation of "Available Exergy Function ζ"

The Available Exergy Function consists of thermal energies (i) at the well head, (ii) at the turbine entrance and (iii) at the turbine exit. Calculation processes of these three thermal energies are explained hereunder step by step.

4.2.1 Geothermal energy recovered at the wellhead (q_{WH})

The geothermal energy at the well head is expressed by the following equation[1].

$$q_{WH_L} = m_{WH_L}\, h_{WH_L} \qquad \textbf{[kJ]} \qquad \textbf{(Eq. 11)}$$

[1] Note that the equation $m_{WH} = q_{WH}/(h_{WH} - h_{ref})$ given by USGS(1978) is valid only when $h_{ref} = 0$.

Where q_{WH_L} is the geothermal energy recovered at the wellhead, m_{WH_L} is the mass of the liquid recovered at the wellhead, h_{WH_L} is the specific enthalpy of the fluid recovered at the wellhead.

4.2.2 Thermal energy at turbine entrance ($q_{tb_{in}}$)

The geothermal fluid recovered at the well head is sent into the separator, separated into steam fraction and liquid fraction; and the steam fraction (dry steam) only is sent into the turbine. The thermal energy of the dry steam sent into the turbine is first given by the equation Eq. 12 and Eq. 13; the Equations Eq. 12 and Eq. 13 are re-written using water/steam separation ratio (Eq. 14), as the equation Eq. 15 below.

$$q_{tb_{in}} = m_{sp_s} h_{sp_s} \quad \text{[kJ]} \quad \text{(Eq. 12)}$$

$$m_{sp_s} = \alpha_{sp_s} m_{WH_L} \quad \text{[kg]} \quad \text{(Eq. 13)}$$

$$\alpha_{sp_s} = (h_{WH_L} - h_{sp_L})/(h_{sp_s} - h_{sp_L}) \quad \text{[-]} \quad \text{(Eq. 14)}$$

$$q_{tb_{in}} = \alpha_{sp_s} m_{WH_L} h_{sp_s} \quad \text{[kJ]} \quad \text{(Eq. 15)}$$

Where $q_{tb_{in}}$ is the thermal energy sent into the turbine, m_{sp_s} is the mass of the steam fraction separated at the separator and sent into the turbine, h_{sp_s} is the specific enthalpy of the steam fraction separated at the separator and sent in to the turbine, α_{sp_s} is the ratio of the steam mass fraction separated at the separator, h_{sp_L} is the specific enthalpy of the liquid fraction separated at the separator.

4.2.3 Thermal energy at turbine exit ($q_{tb_{out}}$)

The dry steam sent into the turbine is losing its thermal energy being converted into electric energy. At the same time the dry steam is becoming to be wet steam. The thermal energy of the wet steam exhausted at the turbine exit is given in the following equation. Note the mass of the steam fraction at the turbine entrance is preserved at the turbine exit.

$$q_{tb_{out}} = m_{sp_s} h_{tb_{out_{SL}}} \quad \text{[kJ]} \quad \text{(Eq. 16)}$$

Where $q_{tb_{out}}$ is the thermal energy at the turbine exit, $h_{tb_{out_{SL}}}$ is the specific enthalpy of the wet steam fraction at the turbine exit.

Dryness of the steam exhausted at the turbine exit is given by the following equation (DiPippo 2008 and/or Hirata et. al 2008).

$$\chi = (s_{sp_s} - s_{cd_L})/(s_{cd_s} - s_{cd_L}) \quad \text{[-]} \quad \text{(Eq. 17)}$$

Where χ is the quality of steam (dryness of steam), s_{sp_s} is the entropy of the steam at the separator, s_{cd_L} is the entropy of the liquid at the condenser and s_{cd_s} is the entropy of the steam at the condenser. Using the equation E. 17, the specific enthalpy of the wet steam fraction exhausted at the turbine exit is given by the following equation.

$$h_{tb_{out_{SL}}} = h_{cd_L} + (h_{cd_s} - h_{cd_L})\chi \quad \text{[kJ/kg]} \quad \text{(Eq. 18)}$$

Where h_{cd_L} is the specific enthalpy of the liquid at the condenser and h_{cd_s} is the specific enthalpy of the steam at the condenser.

Combination of the equations Eq. 16, Eq. 17 and Eq. 18 gives the following equation.

$$q_{tb_{out}} = \alpha_{sp_s} m_{WH_L} h_{tb_{out_{SL}}} \quad \text{[kJ]} \quad \text{(Eq. 19)}$$

4.2.4 The Available Exergy Function (ζ)

Replacing the terms in the equation Eq. 7 (Available Exergy Function) with the equations Eq. 11, Eq. 15 and Eq. 19 gives the following equation.

$$\zeta = \alpha_{sp_s}(h_{sp_s} - h_{tb_{out_{SL}}})/h_{WH_L} \quad \text{[-]} \quad \text{(Eq. 20)}$$

An approximation equation of the Available Exergy Function will be derived by the equation Eq. 20 through specifying the combination of a separator temperature and a condenser temperature.

5 APPROXIMATION EQUATION (AN EXAMPLE) OF AVAILABLE EXERGY FUNCTION

5.1 Step One Approximation to Cubic Polynomial

In order to convert "Available Exergy Function" into a calculable equation, a set of a separator temperature and a condenser temperature has to be selected first. There are a number of combinations of the temperatures; among those one sample approximation equation is derived assuming a typical temperature combination.

a. Separator temperature : 151.8℃ (0.5 MPa)
b. Condenser temperature : 40.0℃ (0.007 MPa)

The correlation between the geothermal fluid temperature and the Available Exergy Function is presented in Figure 3 for this example. Figure 3 shows that the thermal energy contributing to electricity power generation in the turbine ranges from 8% to 16 % for the geothermal fluid temperature ranging from 200 ℃ to 300 ℃.

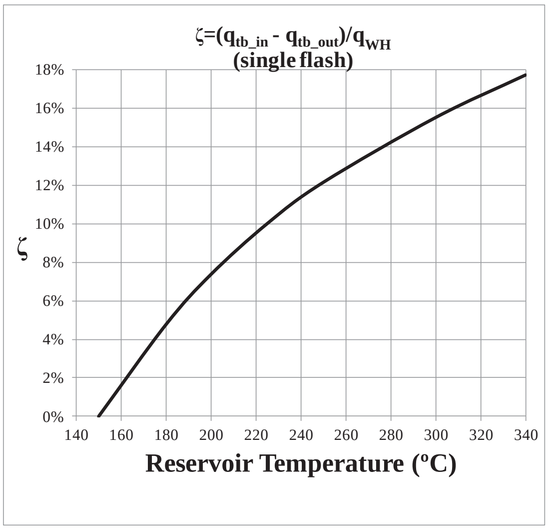

Figure 3 Available Exergy Ratio vs. Fluid Temperature
(for T_{sp}=151.8 ℃, T_{cd}=40.0 ℃)

The approximation equation of the correlation is given by the following cubic polynomial.

$$\zeta = 0.0000000127\,T_r^3 - 0.0000124900\,T_r^2 + 0.0046543806 T_r - 0.4591082158 \qquad \text{(Eq. 21)}$$

Note that the Available Exergy Function shall be zero ($\zeta = 0$) when the fluid temperature equals to the separator temperature according to the definition of the equation (see Eq. 7). For this example of the separator temperature T_{sp}=151.8 ℃ , ζ shall theoretically be zero ($\zeta = 0$). (However, this is not necessarily attained by the approximation although we specified ten digits after the decimal point for the coefficients.)

5.2 Step Two Appropriation to a Practical Equation for the Available Exergy Function

The equation Eq.21 as an approximation equation of the Available Exergy Function, is still somewhat too large to be used as a user-friendly calculation equation. Thus, a simpler and more user-friendly approximation equation is hereunder derived.

Figure 4 shows a lenear correlation between $\zeta(T_r - T_{trp})$ in the equation Eq. 10 on the vertical axis and $(T_r - T_{sp})$ on the horizontal axis. Since when $T_r = T_{sp}$, $\zeta = 0$, the correlation between $\zeta(T_r - T_{trp})$ and $(T_r - T_{sp})$ is expressed by the following equation.

$$\zeta(T_r - T_{trp}) = A(T_r - T_{sp}) \qquad [\,-\,] \qquad \text{(Eq. 22)}$$

Where A is a constant.

For this example of T_{sp}= 151.8 ℃ and T_{cd} =40 ℃ the equation Eq. 22 shall be as follows (Figure 4).

$$\zeta(T_r - T_{trp}) = 0.3155(T_r - 151.8) \qquad [\,-\,] \qquad \text{(Eq. 23)}$$

(For T_{sp}= 151.8 ℃ and T_{cd}=40 ℃ only)

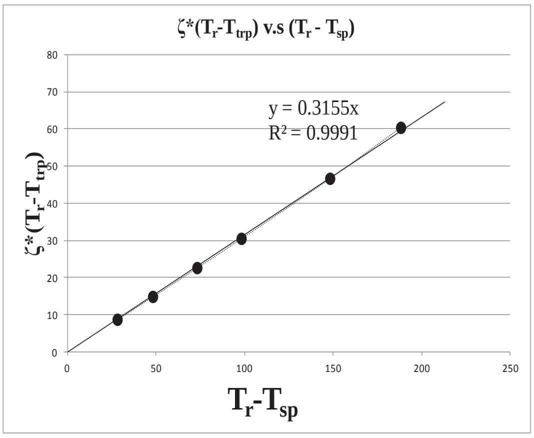

Figure 4 Linear Approximation $\zeta(T_r - T_{trp})$ and $(T_r - T_{sp})$
(for T_{sp}=151.8 ℃, T_{cd}=40.0 ℃)

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6 TURBINE-GENERATOR EFFICIENCY (η_{ex})

The equation Eq. 5 defines the electric energy converted from the thermal energy, using the adiabatic heat-drop concept at a turbine. The equation includes the turbine-generator efficiency (exergy efficiency). The equation Eq. 5 is reformed to the following equation.

$$\eta_{ex} = E/\{m_{tb_{in}}(h_{tb_{in}} - h_{tb_{out}})\} \quad [-] \quad \text{(Eq. 24)}$$

We analyzed the correlation between turbine-generator efficiencies (η_{ex}), and temperature drops ($T_{tb_{in}} - T_{cd}$) of turbine entrance and condenser. We used 189 data of geothermal power plants all over the world (listed in ENAA 2013 in Japanese) resulting in the following correlation.

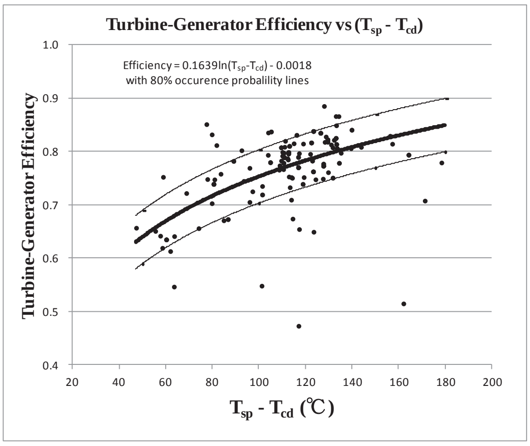


Figure 5 Turbine-Generator Efficiency from 189 data

$$\eta_{ex} = 0.164 \ln(T_{tb_{in}} - T_{cd}) - 0.002 \pm 0.05 \quad [-] \quad \text{(Eq. 25)}$$

Where $T_{tb_{in}}$ is the temperature of the turbine entrance and T_{cd} is the temperature of the condenser.

The actual efficiency of a turbine-generator system depends on many factors that include the efficiency of basic power plant design, resource temperature, concentrations of dissolved gases in the reservoir fluid, the condition of plant maintenance and so on. For this reason, we included an range of ± 0.05 in the approximation equation Eq. 25, which encompasses 153 data among the 189 data (approximately 80% occurrence probability).

For this example of T_{sp}= 151.8 ℃ and T_{cd}=40 ℃, the equation Eq. 25 is as follows.

$$\eta_{ex} = 0.77 \pm 0.05 \quad [-] \quad \text{(Eq. 26)}$$

(For the case of T_{sp}= 151.8 ℃ and T_{cd}=40 ℃ only)

7. A RATIONAL, PRACTICAL AND USER-FRIENDLY EQUATION FOR VOLUMETRIC METHOD

7.1 Approximation For the Example of T_{sp}= 151.8 ℃ and T_{cd}=40 ℃

Replacing $\zeta(T_r - T_{trp})$ and η_{ex} in the equation Eq. 10 with the equations Eq. 23 and Eq. 26 gives the following equation.

$$E = (0.24 \pm 0.02) R_g \rho C V (T_r - 151.8) \quad [kJ] \quad \text{(Eq. 27)}$$

(For the case of T_{sp}= 151.8 ℃ and T_{cd}=40 ℃ only)

The equation Eq. 27 above gives the electric energy converted in the geothermal power plant with separator of T_{sp}= 151.8 ℃ and condenser of T_{cd}=40 ℃. The other factors, i.e. recovery factor (R_g), Volumetric specific heat of the reservoir (ρC), reservoir volume (V) and average reservoir temperature (T_r) have to be given by the practitioners in charge.

7.2 Approximation Equations for Various Sets of Separator Temperatures and Condenser Temperatures

We have derived approximation equations for various sets of separator temperatures and condenser temperatures, so that practitioners may select one or some of those that may suite to their site conditions. The equations are presented in Table-2.

.

8. A COMPARISON WITH THE USGS METHOD

A comparison is made between the proposed method and the USGS method.

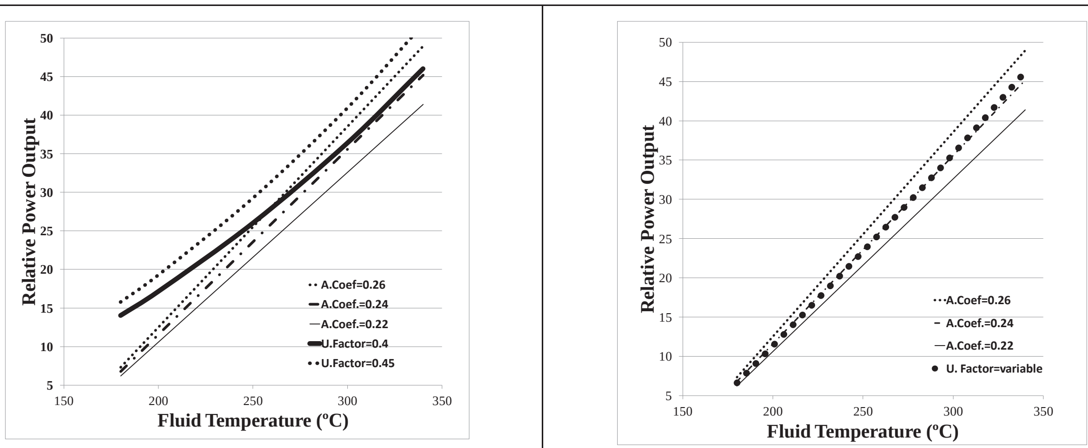
In theory, T_{ref} should be T_{trp} in USGS method when fluid is sent into a geothermal power plant directly. But, here T_{ref} = 15 ℃ is assumed because the utilization factors (0.4 and 0.45) might have been given with the assumption that the T_{ref} is the average ambient temperature of the USGS . The conditions for the comparison is summarized in Table 3.

Table 3 Calculation Conditions for Comparison between USGS method and the Proposed method

	USGS method	Proposed method (for T_{sp} = 151.8 ℃ and T_{cd} = 40 ℃)
Reference Temperature	Ambient temperature (15 ℃)	Triple point temperature for potential heat stored in reservoir (0.01℃)
Separator temperature	Not given	151.8 ℃
Condenser temperature	40 ℃	40 ℃
Factor in equation	Utilization factor (η_u) 0.40, 0.45	Approximation value of Exergy efficiency (η_{ex}) x Available exergy function (ζ) 0.22 (minimum), 0.24 (central value), 0.26 (maximum)
Reservoir related factors	($R_g \rho CV$) = 1 is assumed for this comparison	

Figure 6 (Left) shows that the USGS method gives slightly larger values than those of the proposed method; the USGS method with the utilization factor of 0.4 is in good agreement with the proposed method when fluid temperature is over 250 ℃ approximately.

While the USGS method treated the utilization factor as constant possibly for a practical reason, it shall be variable in theory. The utilization factors as variable is calculated in Section 11.1. We calculated the relative power output using "utilization factors as variable". The relative power output of the USGS method with variable utilization factor is shown in Figure 6 (Right). It demonstrates that the result of the USGS method is on the line of the proposed method with the approximation coefficient of 0.24.



Proposed Method (for T_{sp}=151.8 °C, T_{cd}=40 °C) and USGS method (fixed Utilization factor of 0.40 and 0.45, T_{ref}=15 °C and T_{cd}=40 °C)

Proposed Method and USGS method with variable utilization factor (for both T_{sp} =151.8 °C, T_{cd}=40 °C; only for USGS T_{ref}=15 °C)

Notes: A. Coef.: Approximation Coefficient of the proposed method, U. Factor: Utilization Factor of the USGS method

Figure 6 A Comparison of the Proposed Method with USGS Method

It has become evident that both of the USGS method and the proposed method are on the same theoretical basis (see the section 11.2). The major difference is that the USGS method defines the Utilization factor as a constant, whereas the proposed method deals all factors as dynamic variable factors. Thus, the proposed method is more 'accurate' than the USGS method although the method is expressed by approximation equations. Moreover, the proposed method is much simpler and therefore much more user-friendly, particularly when practiced with Monte Carlo Simulation.

9. NOTES AND DISCUSSIONS

It has been pointed out that the USGS method may have given larger resource estimations than that of reservoir resources actually available on site. Thus, the proposed method may also give excessive resource estimation than actual. In connection with this issue, one may be tempted to calibrate the equations by changing the constants in the equations of the proposed method. However, any of the constants shall not be changed, because the equations in Table-2 do not represent any of thermodynamic implications directly; the separator temperature in the second brackets acts only for zero-point adjustment; the constants in the first brackets are only the resultants of the approximations.

If the calculation results should not agree to the reservoir resource actually available, such reservoir related factors have to be reviewed as recovery factor (R_g), volumetric specific heat of the reservoir (ρC), reservoir volume (V) and average reservoir temperature (T_r). In particular, recovery factor (R_g) and reservoir volume (V) shall have to be examined prudently, because the two factors will give significant impacts on the resource assessment.

10. CONCLUSIONS

The USGS method is widely used for assessing the electrical capacity of a geothermal reservoir. While the under-ground related parameters will have significant impacts on the resource assessment, the electric capacity calculated is a strong function of the above-ground related conditions. The fluid temperature recovered at well head will be the key parameter for the volumetric method calculation when used with Monte Carlo method, because this temperature is the variable (uncertain) underground related parameter which affects the steam-liquid separation process in the separator - an above-ground related parameter. We have derived calculation formulas by introducing "Available Exergy Function", thereby, fluid-temperature-dependant separation process can be included in the equations together with the fluid temperature as a random variable for the Monte Carlo method. It is expected that this calculation method may provide clearer ideas on geothermal resources assessment because the above-ground related parameters are separately defined from the much uncertain underground related parameters. The proposed calculation formulas is proved to be on the same theoretical base of the USGS method (1978). They may thus give larger resource estimation than actually monitored on site if conventional underground related parameters should be selected. However, any of coefficients in the equations of the proposed method must not be changed or adjusted or calibrated. It is the underground related factors that shall be reviewed. In particular, recovery factor and/or reservoir volume have to be reviewed.

11. ADDITIONAL NOTES

11.1 About Utilization Factor of the USGS Method

The utilization factor defined by the USGS (1978) is as follows.

$$\eta_u = E'/W_A \qquad [-] \qquad \text{(Eq. 28)}$$

Where η_u is the utilization factor; W_A is the thermodynamically available energy produced at a thermo-engine, into which all energy of the recovered fluid at well head (originally under the ambient condition in the United State) is assumed to be sent in. E' is the electric power generated at the thermo-engine, into which only the steam fraction separated at the separator is assumed to be sent in.

The USGS has given the constants of 0.40 (USGS 1978) or 0.45 (USGS 2008) to the utilization factor as an empirical factor. However, the factor shall be a variable because W_A and $E'$are given by the following exergy equations, based on the USGS theoretical concept.

$$W_A = m_{WH_L}\{h_{WH_L} - h_{ref_L} - T^K_{ref_L}(s_{WH_L} - s_{ref_L})\} \qquad [kJ] \qquad \text{(Eq. 29)}$$

$$E' = \eta_{ex} m_{sp_s}\{h_{sp_s} - h_{cd_L} - T^K_{cd_L}(s_{sp_s} - s_{cd_L})\} \qquad [kJ] \qquad \text{(Eq. 30)}$$

Where $T^K_{ref_L}$, $T^K_{cd_L}$ are temperature of liquid in reference (i.e. ambient) condition and the condenser in K (absolute temperature) respectively; h_{ref_L}, h_{cd_L} are specific enthalpy of liquid in reference (i.e. ambient) condition and in the condenser respectively; s_{WH_L}, s_{ref_L} , $s_{cd_L}$are specific entropy of the liquid at the well head, in reference (i.e. ambient) condition and in the condenser respectively. The numerical utilization factors calculated by the equation Eq. 28, Eq. 29 and Eq. 30 for the case of T_{sp}=151.8 ℃, T_{cd}=40.0 ℃ and η_{ex}=0.77 are as shown in the table below.

Table 4 Utilization Factors as Variable (for T_{sp}=151.8 ℃, T_{cd}=40.0 ℃, η_{ex}=0.77)

Fluid temperature at Well head (℃)	Utilization factor (variable)
200	0.27
250	0.36
300	0.39
340	0.40

The utilization factor ranges from 0.27 to 0.40 in accordance to the temperatures of the fluid recovered at the well head. If the exergy efficiency η_{ex} could be larger than 0.77, the utilization factor would be larger than those calculated above.

11.2 Theoretical Background of the Proposed method

We presented first the adiabatic heat drop concept for the proposed method in the equation Eq. 5. The specific enthalpy of the turbine exit was expressed by the equations Eq. 16, Eq. 17 and Eq. 18. Among those, combination of the equations Eq. 17 and Eq. 18 gives the following equation.

$$h_{tb_{out_{SL}}} = h_{cd_L} + (h_{cd_s} - h_{cd_L})\{(s_{sp_s} - s_{cd_L})/(s_{cd_s} - s_{cd_L})\}$$

$$= h_{cd_L} + T^K_{cd_L}(s_{cd_s} - s_{cd_L})\{(s_{sp_s} - s_{cd_L})/(s_{cd_s} - s_{cd_L})\}$$

$$= h_{cd_L} + T^K_{cd_L}(s_{sp_s} - s_{cd_L}) \qquad [kJ/kg] \qquad \text{(Eq. 31)}$$

Further combination of the equation Eq. 5 and Eq. 31 gives:

$$\mathbf{E} = \boldsymbol{\eta}_{\mathbf{ex}} \mathbf{m}_{\mathbf{tb_{in}}} \{\mathbf{h}_{\mathbf{tb_{in}}} - \mathbf{h}_{\mathbf{cd_L}} - \mathbf{T}^{\mathbf{K}}_{\mathbf{cd_L}} (\mathbf{s}_{\mathbf{sp_s}} - \mathbf{s}_{\mathbf{cd_L}})\} \quad \textbf{[kJ]} \qquad \textbf{(Eq. 32)}$$

Where $m_{sp_s}=m_{tb_{in}}$, $h_{sp_s}=h_{tb_{in}}$

The equation Eq. 32 has been derived from the concept of the proposed method (adiabatic heat-drop at turbine), whereas the equation Eq. 30 from the USGS method (exergy exergy). The electric energy outputs of the two methods have become eventually to be expressed by the same equation. Thus, the two methods have been proved to be on the same theoretical basis

12. ACKNOWLEDGMENTS

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APPENDIX-10

An Outline of Countermeasures against Scale

Appendix-10 An Outline of Countermeasures Against Scale

A.10.1 Purpose of this appendix

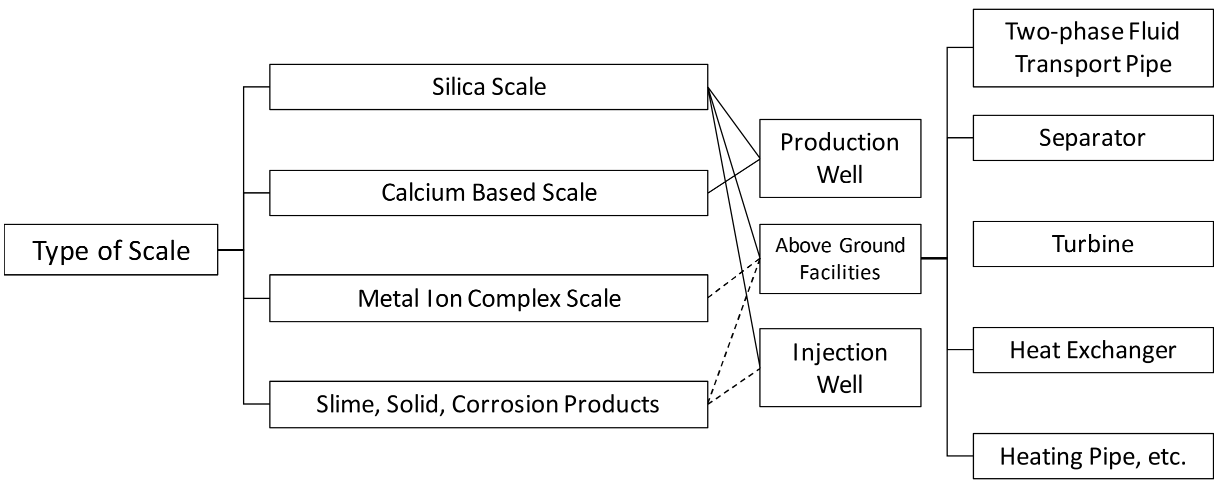
A considerable amount of costs is sometimes spent to countermeasures against scale during operation period of geothermal power generation plants. We describe here an outline of countermeasures against scale because this is a key factor for stable and continuous operation of a geothermal power plant, though this subject may be out of cope of the present Data Collection Survey that has been aimed for examine a justification for a JICA support to Ethiopia in conducting geothermal test well drilling.

Detail plan for countermeasure operations shall be proposed based on concrete information that should be obtained from the geothermal test well drilling.

A.10.2 Possibility of scaling from geothermal fluid to be produced in Tendaho geothermal site.

Geothermal fluid of Tendaho area may well contain carbon dioxide (CO_2) with considerable high content because the area is underlain by Alkaline rock group. Due to this reason, Calcium carbonite scale in geothermal wells during plant operation. Further, hot spring in Tendaho-3 contain a relatively high concentration of Silica 316 ppm (pH=8.8, EC=2,900 μS/cm), 318 ppm (pH=9.2, EC=2,860 μS/cm) according to the Mater Plan (2015); this may imply a possibility that the geothermal fluid that may be obtained from the geothermal well may well contain a high concentration of Silica that will form Silica scale in the power plant.

Various types of scales may disturb smooth operation of various portion of the power plant as shown in Figure-1.



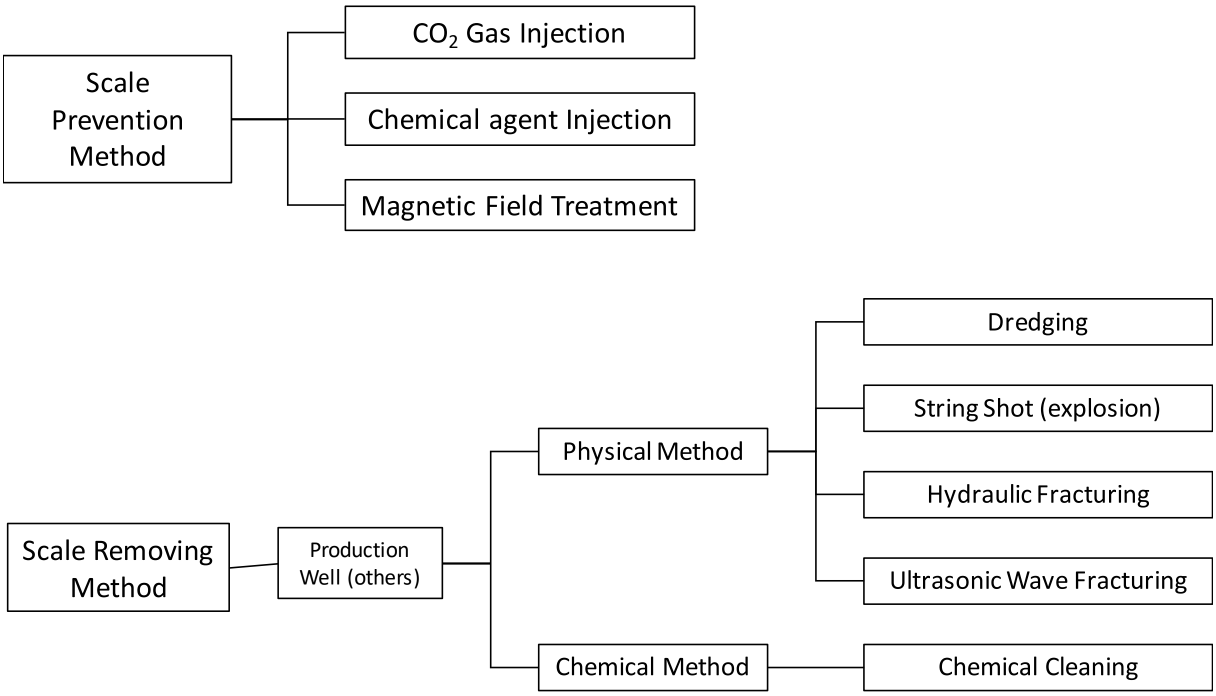
(Source : Geothermal power generation hand book (2011, in Japanese))
Figure A.10.1 Portions affected by scales

A.10.3 Countermeasures against scaling

(1) Calcium Carbonate Scale – Countermeasures of Prevention and Removal

Calcium carbonate scale is formed wells when CO_2 separates from the geothermal fluid as the fluid is depressurized while coming up in production well; the Calcium carbonate scale therefore often is formed at and around boiling depth of production wells. Figure 10.2 shows a general countermeasure of prevention and removal of Calcium carbonate scale.

There are three options indicated in the Figure 10.2; among those, injection of chemical agents is effective in many cases. Polycyclic acid type of chemical agents is known to be used in many power plants. Removal of calcium carbonate scale may be attained either by physical removal methods and chemical removal methods as shown in Figure A 10-2. As for physical removal method, dredging by a drilling rig and/or coiled tubing equipment against scale in geothermal wells; cleaning using jet water and/or pig for SGAS facility. As for chemical agents, agents are injected into geothermal wells and/or pipe system to resolve the scale in them.



(Source : Geothermal power generation hand book (2011, in Japanese))

Figure A.10.2 Countermeasure for Prevention and Removal – Calcium Carbonate Scale

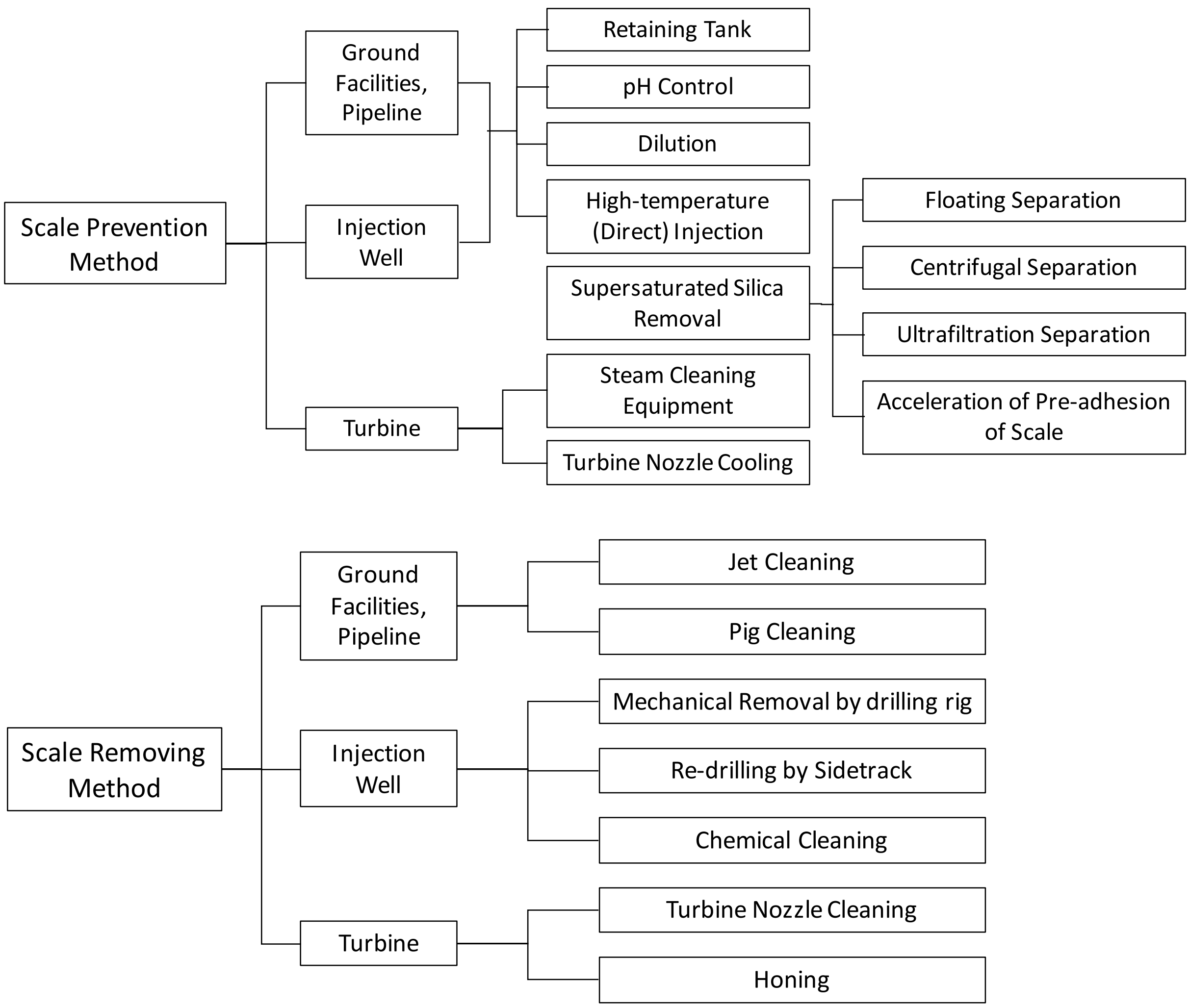
(2) Countermeasures for prevention and removal - Silica Scale

Silica scale is one of the serious problems against smooth operations of geothermal power plants, that impose a considerable part of O & M cost. Since silica scale is formed as silica concentration in geothermal fluid increase while liquid-steam separation process, the scale often concentrates in SAGS, turbine and/or re-injection wells. The scale is sometimes formed in production wells that produce two phase fluid of high-dryness.

Figure 10.3 shows a general countermeasure for prevention and removal of silica scale formation.

For prevention, high temperature re-injection method and pH adjustment method have most commonly been used. Polymer type inhibiters are also sometimes used.

For removal, physical methods and chemical methods are used as for the case of calcium carbonate scale. As for physical methods, dredging by drilling rig is applicable for scale removal in the geothermal wells or in the geothermal reservoir of the periphery of geothermal wells; cleaning by jet water and/or pig method will be used for the scale removal in SAGS. Cleaning by jet water or honing are used for the silica scale removal on turbine when periodical services. As for chemical method, there are examples that re-injection wells are cleaned by chemical agents.



(Source : Geothermal power generation hand book (2011, in Japanese))

Figure A.10.3 Countermeasure for Prevention and Removal – Silica Scale

A.10.4 Countermeasures against scale formation in Tendaho-2

A detail examination and planning shall be proposed once the characteristics of geothermal fluid should be identified through test well drilling works. Subjects to be examined are described, but not limited to, as follows.

（1） Countermeasures for scale formulation prevention

- Options for permanent facility for polyacrylic acid type inhibitors to be injected into production wells shall be examined for the prevention countermeasure against calcium carbonate scale formulation.
- Such countermeasures as high-temperature direct reinjection method, pH adjustment methods or retaining tank method shall be examined as application for silica scale prevention. In case, removal of saturated silica shall be considered.
- Steam scrubbing system or turbine nozzle cooling facility may be considered for scale prevention to turbine system.

（2） Countermeasure of scale removal

- Physical methods are proposed because timely supply of chemical agents may not be maintained due to such remote area as Tendaho.
- Scale in geothermal wells should be counter-measured by dredging or side track drilling. The subject on how equipment should be procured shall be worked out with expected cleaning frequency that shall be planed based on the information on characteristics of geothermal chemistry to be obtained by analysing the geothermal fluid to be obtained from the test well drilling.
- Cleaning by jet water or pigging equipment for SAGS; nozzle cleaning or honing for turbine set will be used. The subject on how the equipment should be procured (time-to-time procumbent or permanently equipped) shall also examined based on information of characteristics of geothermal chemistry to be obtained. Advice from turbine manufacturer may be useful for this decision.

A.10.5 O&M management system during operation of Tendaho-2 geothermal power station

Another geothermal development project is now on a process to drilling in Tendaho-1 with financial assistance of AFD to EEP, who will the project owner. It may be an efficient arrangement for EEP if both power station (AFD Tendaho-1 and JICA Tendaho-2) should be maintained by one maintenance system. Considerations on such arrangement shall be made once the frequency of scale countermeasures are proposed after chemical properties of the geothermal fluid should be obtained from the geothermal test wells.

A.10.6 Feasibility Study of Tendaho-2 geothermal power station

As stated in the first paragraph, a considerable amount of costs is sometimes spent to countermeasures against scale during operation period of geothermal power generation plants. The Master Plan (2015) has proposed that the Tendaho-2 should be the highest priority among the geothermal green fields in Ethiopia mainly based on the financial analysis. The cost estimation included O&M cost based on past experiences and information collected.

On top this general approach taken by the Master Plan, a feasibility study shall be conducted with concrete information based on test well drilling results. The F/S shall include technical and financial analysis of countermeasures against possible scale formulations with a firm and concrete information about geochemistry of geothermal fluid to be obtained.

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APPENDIX-11

Civil Works

(Access Road, Drilling pad, and Pipeline)

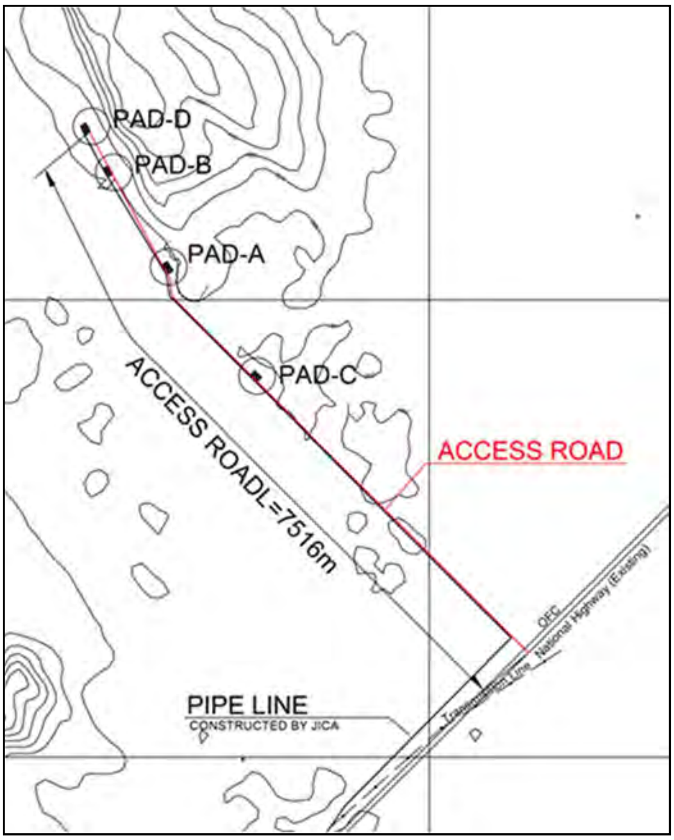
Appendix-11 Civil Works

A11.1 Access Road

An access road with total length of 7.5 km will be prepared from existing national road to drilling pad D via drilling pad A, B and C. Specification of the access road is as below.

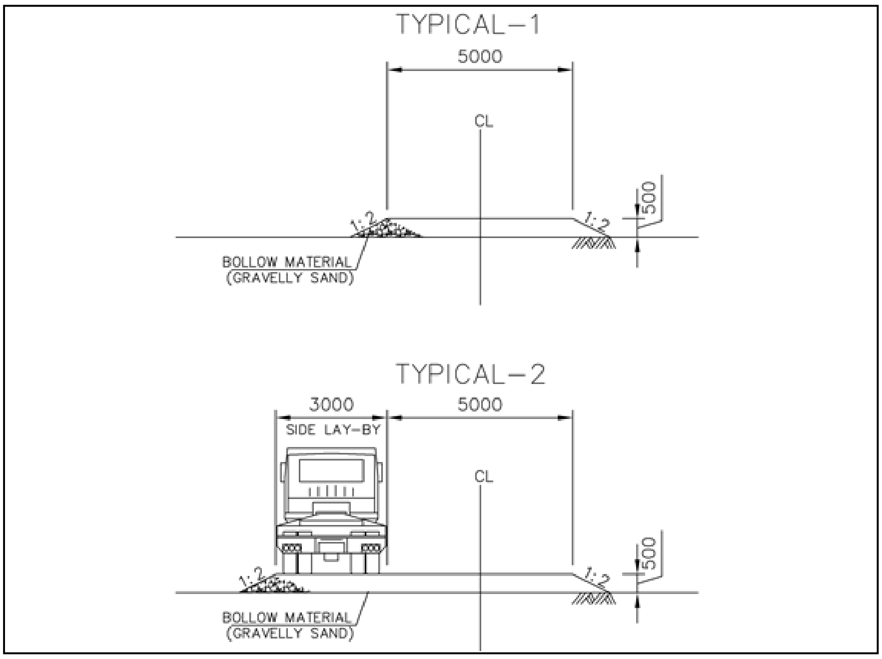
- Road with 5.0 m width is designed in consideration of the heavy vehicle passage.
- Gravel road without asphalt pavement will be used as it is trial drilling.
- Considering the underlain soft alluvium, embankment with thickness of 50 cm for road and rolling compaction in accordance with suitable soil bearing capacity will be necessary.
- For purpose of alternate passage, passing place with 3 m length will be prepared every 3 km.
- Pipe culvert will be built at the place where surface water is probably generated when it rains for fast dewatering.

Location and profile of the access road is shown in the figures below, and design drawing of the access road can be found in the Appendix.



Source: JICA Survey Team

Figure A11.1.1 Location of the access road



Source: JICA Survey Team

Figure A11.1.2 Profile of the access road

A11.2 Drilling pad

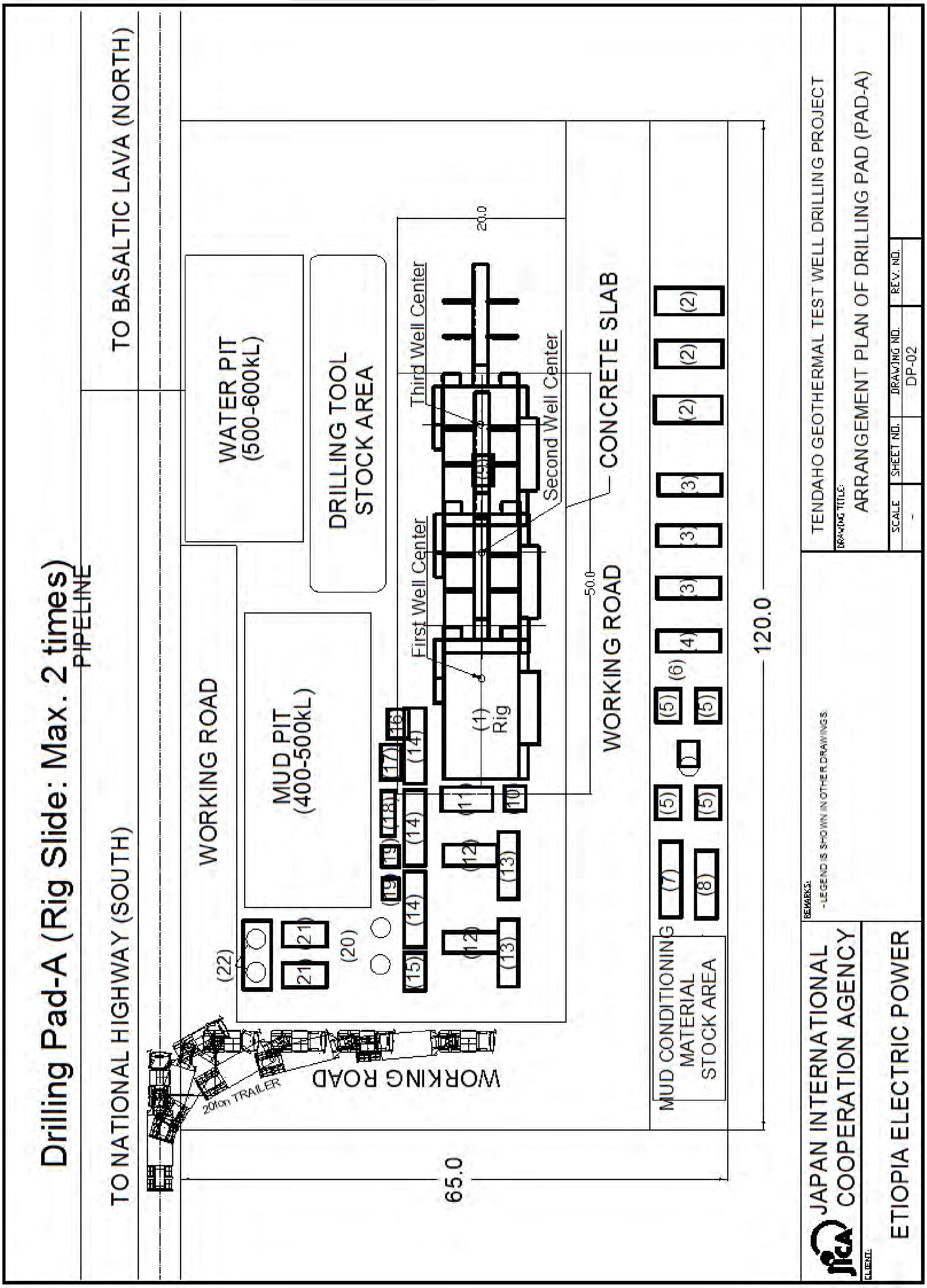
The method of drilling pad and drilling targets selection has already been discussed based on the drilling decision tree (Figure 6.1.1 of main text). Four drilling pads have been planned and designed based on the consideration of all possible cases. The area of each drilling pad is determined based on the times of rig sliding which has also been determined using decision tree. Area of each drilling pad can be found in Table A11.2.1. Specifics of each drilling pads are described as below, and the layout drawing of drilling pad A is shown in Figure A11.2.1. The location map and layout drawings of all drilling pads can be found in Appendix.

- For prevention of rig subsidence during assembling, reinforced concrete slab will be installed. Area of the slab will be changed corresponding to the times of rig sliding (Table A11.2.1).
- Water pit with volume of about 600 m^3 will be built for storing water sent by the pipeline which will be described later.
- Besides the rig sliding times, the entering of large trailer is also necessary to be considered when determining the drilling pads area.

Table A11.2.1 Area of drilling pads

Site	Maximum rig sliding times	Site area	Class of rig assembling
A	2 回	130×65 m	50×20 m
B	1 回	115×65 m	35×20 m
C	0 回	100×65 m	20×20 m
D	1 回	115×65 m	35×20 m

Source: JICA Survey Team



Source: JICA Survey Team

Figure A11.2.1 Layout of drilling pad A

A11.3 Pipeline

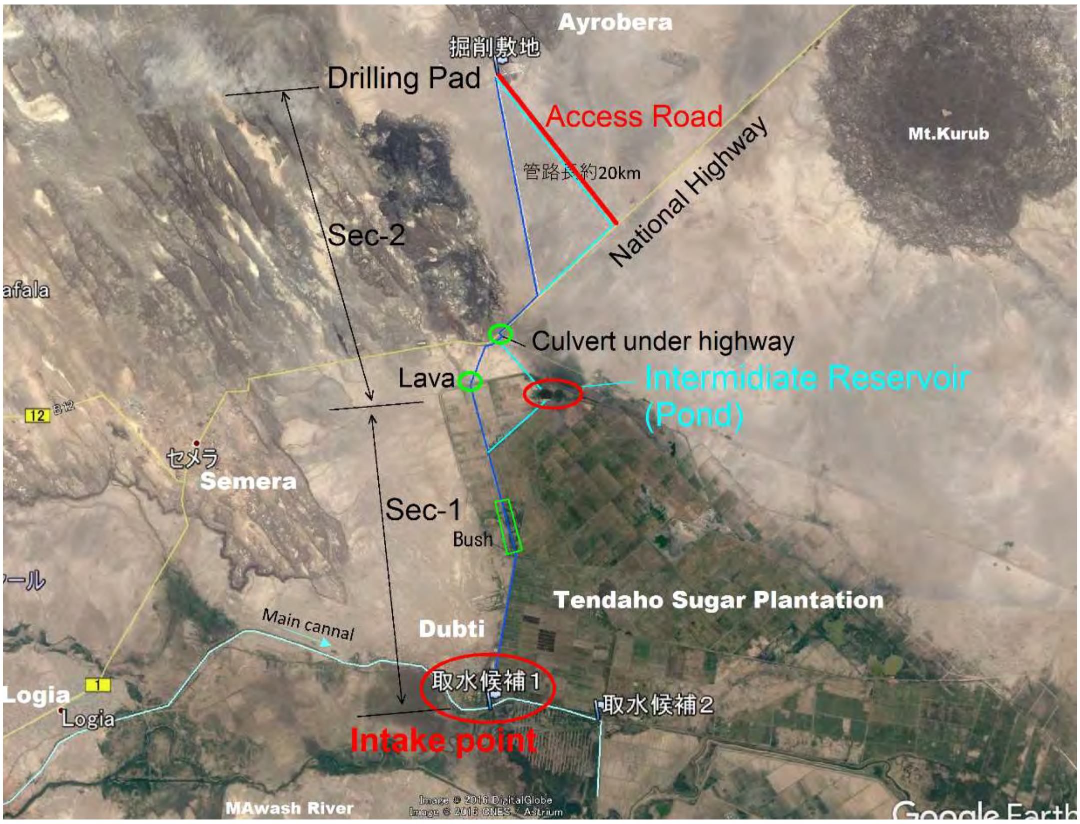
For the water supply for the test-well drilling, water pipeline is planned from the main canal (MC) in the Dubti irrigation area owned by Tendaho Sugar Factory, that is the nearest water resource (Figure A11.3.1).

The summary of the pipeline is the followings;

- Quantity of necessary water: 0.75 m^3/min (possible to continue drilling for 7 hours when lost circulation occurs)
- Pipeline and Pump: 2 lines and sets including backup

A11.3.1 Site Condition

The distance form MC to the proposed drilling pad is more than 20km, and the elevation of the drilling pad is higher than that of the Dubti irrigation area. Therefore, it is impossible to carry water by one pump, and necessary to set a reservoir and other pump at one or more intermediate point. For this reason, pond located in the north of the irrigation area is examined to utilize as a reservoir, and alignment is divided into two sections; section-1 from MC to the pond, and section-2 from the pond to the drilling pad.



Source: JICA Survey Team

Figure A11.3.1 Summary of Water Supply

The pond located in the north of the irrigation area can be first found in the satellite photograph available in Google Earth taken in October, 2011 as shown in Figure A11.1.2. According to local people, the pond used to be the sand quarry for the Tendaho dam, and has more than 10m in depth. Significant drawdown of water level of the pond cannot be observed in the satellite photographs taken form October, 2011 to June, and the reservoir area is estimated around 146,000m[2].

Source: Google Earth added by JICA Survey Team

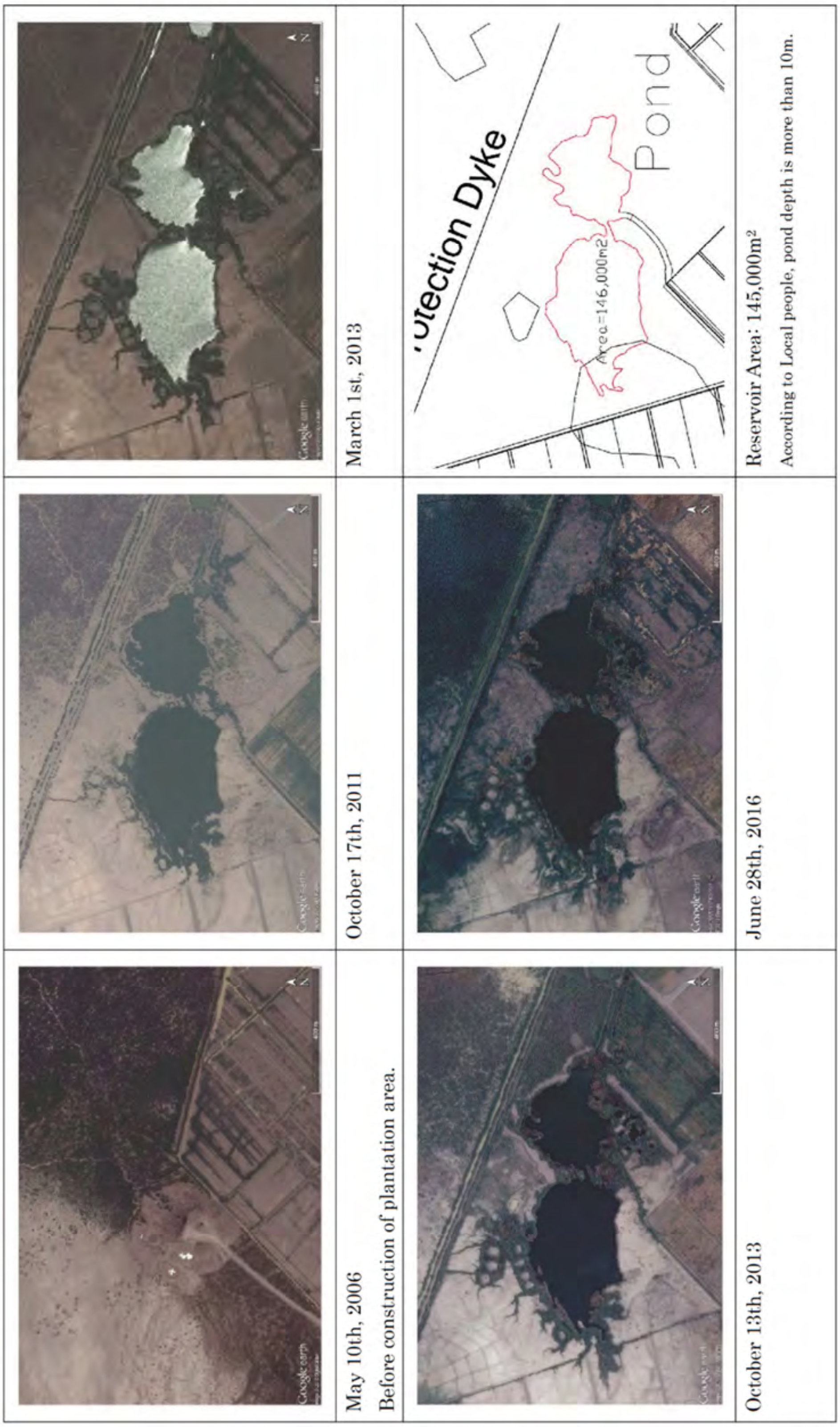


Figure A11.3.2 Pond in Chronological Order

Figure A11.1.3 shows water flow oath from MC to the pond through the primary canal-1 (PC1) and the secondary canal-1-5 (SC1-5). The water flow rate is calculated based on the dimension of canal and drainage gradient as shown in Table A11.2.1. While the project needs 0.75m^3/min of water flow rate, enough amount of water discharge with 19.0 m^3/min from PC1 flows into the pond.

Source: JICA Survey Team

Figure A11.3.3 Water Flow from Main Canal to Pond

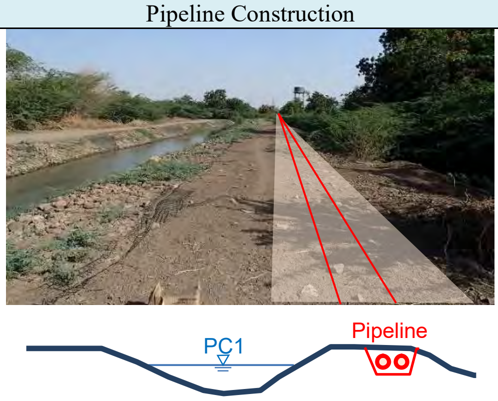
Table A11.3.1 Flow rate from Main Canal to Pond

Sec.	Canal	Canal Width (m)	Canal Depth (m)	Flow Rate (m3/min)	Remarks
1	PC1: MC~SC1-3	5.0	1.0	**149.0**	Design discharge is 163.8 m3/min.
2	PC1: SC1-3~SC1-5	3.0	1.0	**65.2**	
3	SC1-5: SC1-5~Bend point	2.0	1.0	**39.1**	
4	SC1-5: Curve ~ Pond	2.0	0.6	**19.0**	

Source: JICA Survey Team

Based on the above, Table A11.1.2 discusses the water supply system in section-1 from MC to the pond. In both two alternatives, the project must pay for water use with ETB 1.00/m^3 to the Tendaho Sugar Factory, the owner of the irrigation area.

Table A11.3.2 Water Supply in Section-1 form Main Canal to Pond

Item	Pipeline Construction	Utilization of Existing PC1 and SC1-5
Conceptual Image		 Full view of PC1
Summary	Pipeline is newly laid down under ground, and pump is set and send water.	Utilizing the irrigation canal, water is delivered to the pond. SC1-5 is dredged because damage is found in some section.
Economy	The construction for pipeline and pump needs expensive cost with around USD 1 mil.	Cost for dredge work estimates around USD 40,000, and is very economical.
Workability	- It is necessary to laid down the pipe on the ground at the intersection of SC and the tertiary canal (TC). - Because the work occupies the farm road in the irrigation area under construction, it causes disturbance for Tendaho Sugar Factory, farmers and local residents. The work is possibly blocked by local residents. - The pipeline must be removed in the irrigation area after the completion of the project.	- The work area is limited because it utilize the existing canal, and can shorten the construction period. - The dredge work can be acceptable for Tendaho Sugar Factory and local residents because it does good to the irrigation project. - There is nothing to be removed in the irrigation area after the completion of the project.
Sustainability	- It is necessary to protect the aboveground pipeline from destruction by local residents. - Because local residents uses MC and PC1 for washing and bathing, the pipeline and pump must be maintain properly. - It is necessary to take care of interfusion of sand and dust to the pump when flooding, and clogging of pipeline due to dirty water.	- Because the pump isn't set in this section, water flow gauge is adapted in SC1-5, and is utilized for monitoring of water flow rate and calculation of water charge. - If necessary, the project asks Tendaho Sugar Factory to adjust the water gate in Figure A11.1.3. (necessary height: 2.6cm)
Interview Survey Result	Tendaho Sugar Factory It doesn't not make sense that pipeline is newly laid down along PC1 and SC1-5. Ethiopian Design & Supervision Works Corporation When construction of pipeline, the project must pay attention to the existing underground water pipeline to local village.	Tendaho Sugar Factory Because the pond is not utilized by the irrigation project, the project can utilize it for water supply. Ethiopian Design & Supervision Works Corporation The corporation can collaborate supervision and maintenance works of water supply in the irrigation area.
Evaluation	**Poor**	**Good**

Source: JICA Survey Team

Based on the above comparison, water had better to be delivered using and maintaining the existing canal of PC1 and SC1-5 from MC to the pond under the cooperation of Tendaho Sugar Factory. In section-1, the dredging work is planned in a part of SC1-5 connecting to the pond. In section-2, water pipeline with pump is designed to connect form the pond to the drilling pads.

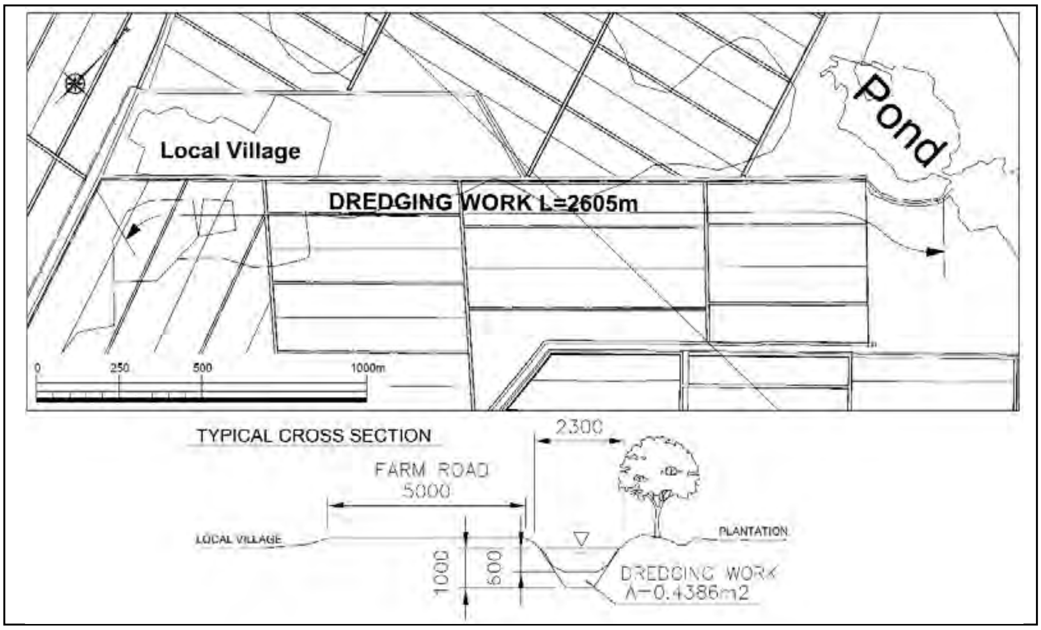
A11.3.2 Dredging Work in Section-1

Even though there is enough quantity of water flow at present, sedimentation of debris and erosion by overflow can be observed in SC1-5 connecting to the pond as shown in Figure A11.3.4. To secure sustainable flowing water, the rehabilitation work is implemented at this portion.

Source: JICA Survey Team

Figure A11.3.4 Sedimentation of Debris (left) and Erosion by Overflow (right) in SC1-5

Location of the rehabilitation work and volume of dredging work are shown below. The dredging work improves to the original canal cross section based on the design drawings of the irrigation canal shared by Ethiopian Design and Supervision Works Corporation as shown in Figure A11.3.5. The soil volume of the work is estimated 1,143 m^3 as shown in Table A11.3.5.



Source: JICA Survey Team

Figure A11.3.5 Plan View and Typical Cross-Section of Dredging Work in SC1-5

Table A11.3.3 Summary of Dredging Work

Sec.	Canal	Distance (km)	Dredge Soil V (m3)	Remarks
1	SC1-5	2.605	**1,143**	Rehabilitation to the original design

Source: JICA Survey Team

A11.3.3 Water supplying work in Section-2

(1) Design process

Design process of water supplying facilities is shown in Figure A11.3.6. Water flow rate is designed as 0.75 m^3/min considering that water pit is 600 m^3 and drilling will be continued for 5 hours during lost circulation is occurring. Three cases of pump number (1 pump, 2 pumps and 3 pumps), which will be installed between water intake pond and drilling pad, are considered. The most suitable case will be decided by comparing the economic efficiency of different pump and pipeline specification and their cost.

Section flow	⇒ 0.75m^3/min in consideration of total mud water leakage
Assumption of caliber and pump	⇒ Case study: Caliber: 6.8 inch / Pump number: 1~3
Measurement on pipeline laying location and on-site confirmation Sec-3. SC1-5	⇒ Reference point measurement and profile leveling
Hydraulic gradient and flow rate calculation	⇒ Confirm if the flow rate is less than 2.0 m/s
Determining of pump	⇒ Based on section loss of head and measurement results
Economic efficiency	⇒ Comparing the cost of pipeline and pump
Pipeline design	⇒ Drawing and number calculation

Source: JICA Survey Team

Figure A11.3.6 Layout of drilling pad A

(2) Determining of pump specification

When determining the pump specification, the pump need to meet the resistance of water level differences and pipe or valve based on the flow rate and calibre mentioned above. Head loss of the pipeline route can be figured out by using Hazen–Williams equation, and actual pump head can be obtained from measurement results, and furthermore, the total pump head can be calculated.

- Hazen–Williams equation

$$H(m)=5.4755\times10^{-3}\times C^{-1.85}\times D^{-4.87}\times Q^{1.85}\times L$$

H: Head of loss, C: coefficient of flow velocity, D: pipe diameter (m), Q: flow amount (m^3/min), L: Pipe length (m)

Table A11.3.4 Coefficient of flow velocity

Pipe Diameter	C
6 inch (150mm)	140
8 inch (200mm)	150

Source: JICA Survey Team

The candidate location of pipeline, pump and water pit is shown in Figure A11.3.7. Pipeline will be laid along the existing national road and planned access road for the sake of maintenance. For crossing through the national road, culvert will be used. In case 1, one pump will be installed at the location 15 km away from water intake pond. In case 2, a junction water pit and pump will be set at the middle of water intake pond and drilling pad. In case 3, a junction water pit and pump will be at the location with the lowest elevation, and another junction pond and pump will be set at the middle of rest section.

Source: JICA Survey Team

Figure A11.3.7 The candidate location of pipeline, pump and water pit

The results of hydraulic head calculation and economic efficiency comparison of each cases is shown in Table A11.3.5.

Considering the economy and durability against water hammering pipe with diameter of 8 inch is selected. As to the number of pump and water pit, case 2 has been adopted for the sake of economy and maintenance convenience.

Table A11.3.5 Results of hydraulic head calculation and economy comparison

Hydraulic Head Calculation

Water		Lake	20~30°C
Pipe type		HDPE	JIS K6741 or equivalent
Flow velocity coefficient (d=150mm) C=		140	MAFF standards
(d=200mm) C=		150	
Pump	Location	Indoor (inside pump house)	
	Absorption total pump head	2.00	m
	Discharge quantity	0.75	m^3/min

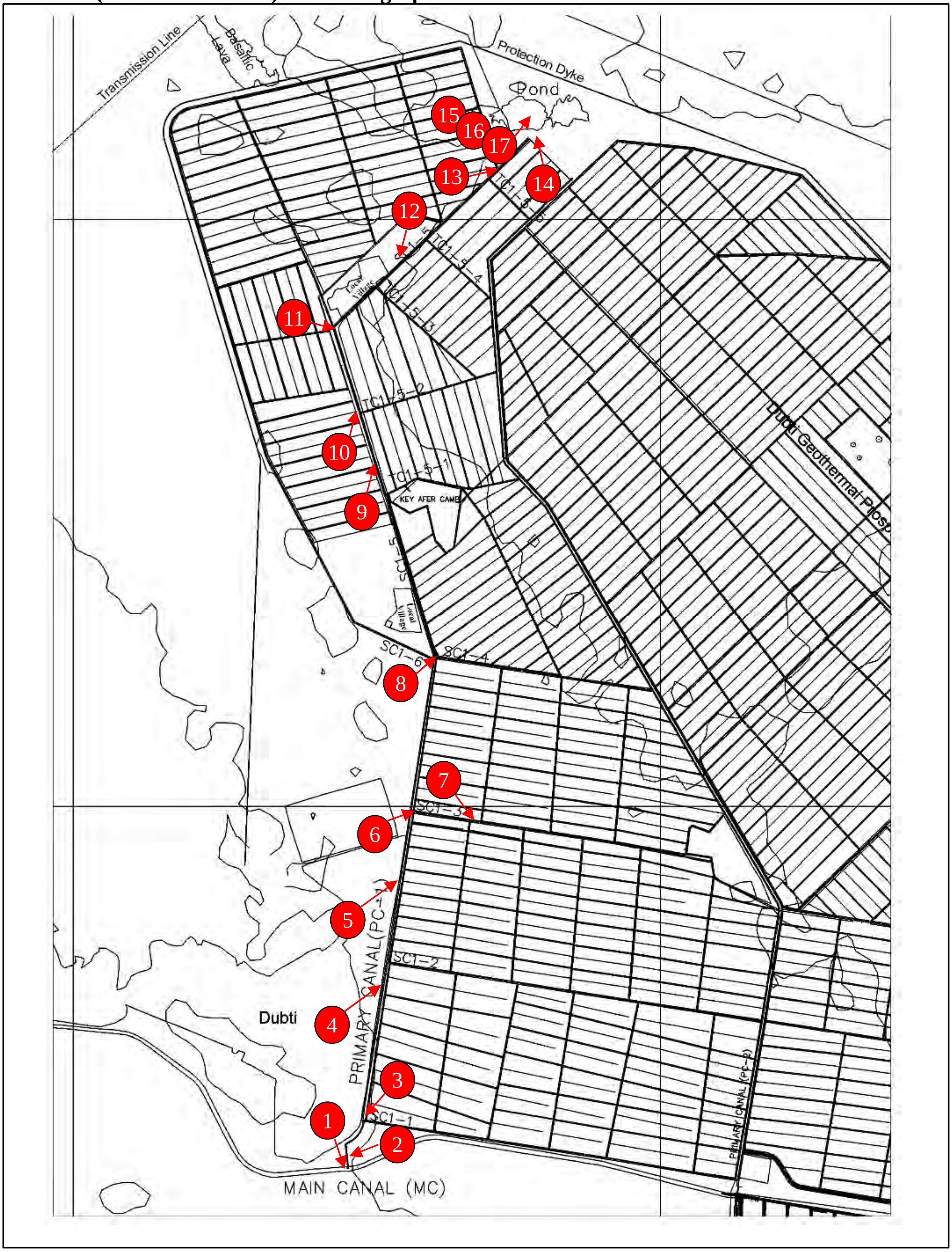
Calculation by using Hazen–Williams equation

Case	Diameter	Section length	Pump number	Head loss	Actual pump head	Discharging location elevation difference (m)	Total pump head		Flow rate	Power	Approximate cost of one system (USD)				
	(m)	(m)		(m-H2O)	(m)		(m-H2O)	(Mpa)	(m/s)	(kW)	Pipe	Pump	Power cost	Pit building	Total
6"-case1	0.15	15,237	1	54.0	13.8	2.0	**69.8**	0.70	0.71	8.53	563,769	59,130	37,358	-	**660,258**
6"-case2	0.15	7,337	2	26.0	7.5	2.0	**35.5**	0.35	0.71	4.34	271,469	23,478	19,003	-	**658,159**
	0.15	7,860		27.8	6.3	2.0	**36.1**	0.36	0.71	4.42	290,820	23,478	19,350	10,560	
6"-case3	0.15	6,273	3	22.2	6.1	2.0	**30.3**	0.30	0.71	3.71	232,101	16,522	16,243	-	**669,342**
	0.15	6,220		22.0	9.1	2.0	**33.2**	0.33	0.71	4.06	230,140	16,522	17,771	10,560	
	0.15	2,744		9.7	-0.3	2.0	**11.4**	0.11	0.71	1.39	101,528	11,304	6,092	10,560	
8"-case1	0.20	15,237	1	11.7	13.8	2.0	**27.5**	0.27	0.40	3.36	610,142	16,522	14,719	-	**641,383**
8"-case2	0.20	7,337	2	5.6	7.5	2.0	**15.1**	0.15	0.40	1.85	293,799	11,304	8,102	-	**657,483**
	0.20	7,860		6.0	6.3	2.0	**14.3**	0.14	0.40	1.75	314,742	11,304	7,672	10,560	
8"-case3	0.20	6,273	3	4.8	6.1	2.0	**12.9**	0.13	0.40	1.58	251,193	11,304	6,922	-	**680,902**
	0.20	6,220		4.8	9.1	2.0	**15.9**	0.16	0.40	1.95	249,070	12,174	8,529	10,560	
	0.20	2,744		2.1	-0.3	2.0	**3.8**	0.04	0.40	0.46	109,879	8,696	2,014	10,560	

Source: JICA Survey Team

Site Photographs

Section-1 (Main Canal-Pond) Site Photograph



Source: JIAC Survey Team

Figure Location Map of Site Photographs in Section-1 (Main Canal-Pond)

Section-1 (Main Canal – Pond)

1. Main canal (MC).
   Canal drawing water from Awash River near Tendaho dam.
   Water is mixed with floating dust and sand.

2. Primary Canal-1 (PC1).
   Canal is covered with geo-textile (filter fabrics) and geomembrane (impermeable fabrics)

3. Water gate.
   First water gate in PC1 just before SC1-1.
   Gate width is 2m.

4. PC1.
   Canal has 5m in width and 1m in depth
   Canal is covered with.

5. PC1.
   Total length of PC1 is about 4km from MC to SC1-5.

6. Water gate near SC1-3.
   Gate width is 2m. Downstream PC1 from the gate is no surface treatment such as geo-textile and geomembrane with 3m in width.

<table>
<tr>
<td>
7. Agricultural farm.
March when the survey conducted is slightly agricultural off-season. According to Tendaho Sugar factory, the water usage is 30-40% against the maximum usage.</td>
<td>
8. PC1.
PC1 is diving into three SC at this point; SC1-4, SC1-5, and SC1-6.
SC1-5 is connecting to the pond.</td>
</tr>
<tr>
<td>
9. .SC1-5.
Deep Bushes on the right bank of the canal, and the canal is close to farm land, so it seems to be difficult to construct pipeline on right bank.</td>
<td>
10. SC1-5.
Canal has 2m in width and is excavated ditch without surface treatment.</td>
</tr>
<tr>
<td>
11. Bend point of SC1-5.
At this point, the canal changes flow direction from north to east.
Connection pipe underground toward north is not found.</td>
<td>
12. SC1-5.
The canal flows to east and ends at the pond.
There are farm land and tertiary canal.</td>
</tr>
</table>

13. SC1-5.
    Due to depositing debris and waterweed, overflow has occurred.

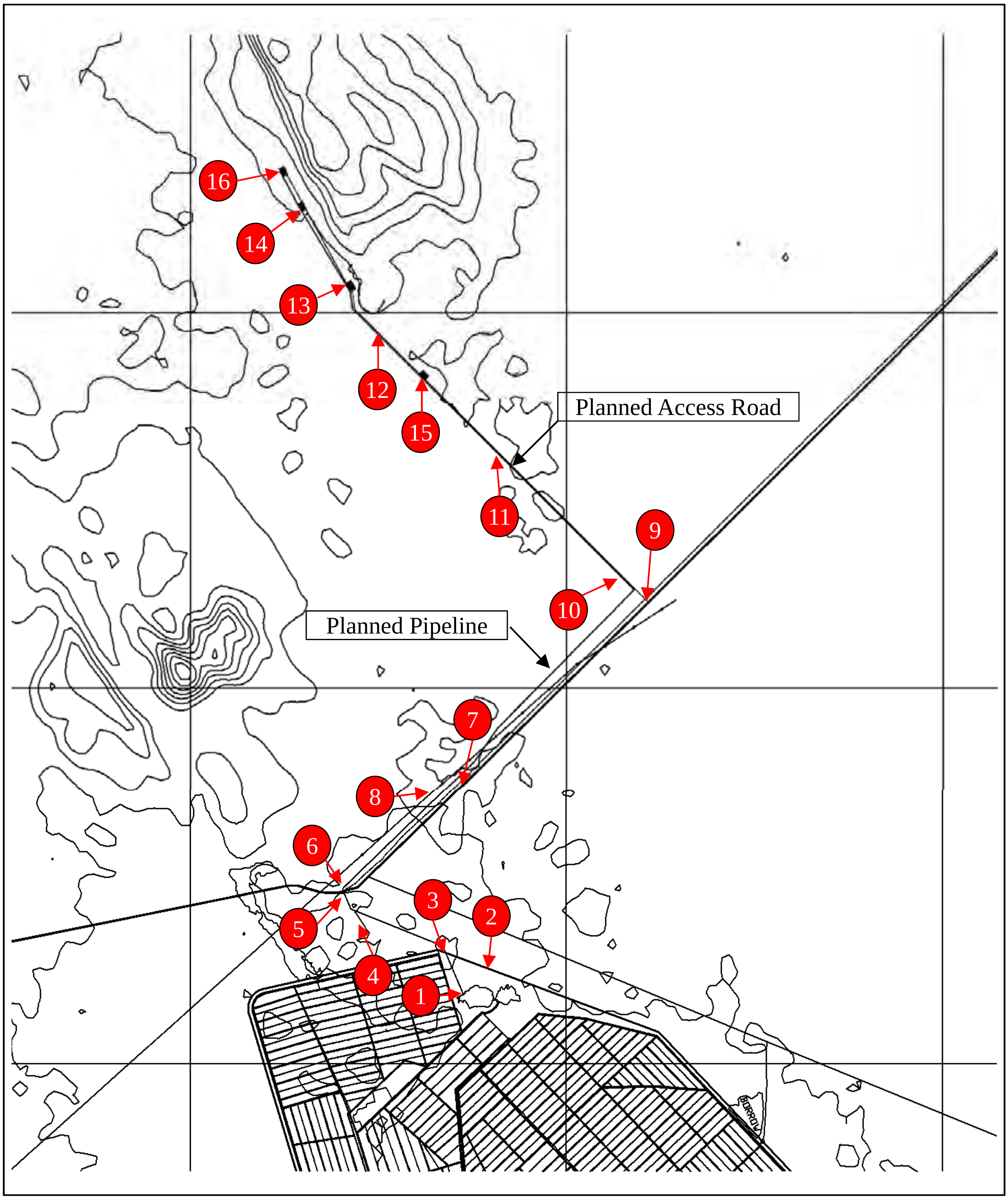
14. SC1-5.
    Because of close to the pond, flow rate here is very slow.
    Waterweed grows in the canal.

15. Pond in north of the irrigation area.
    Connecting point to east part of the pond can be confirmed.

16. Joint site verification with Mr.Ashebir Kochito, General Manager, Tendaho Sugar Factory (right).
    According to him, the pond is filled with excess water from the canal, and not utilized by the factory.

17. Full view of pond.
    Water color is clear blue, and cannot be found floating dust and debris.
    According to local residents, original topography of the pond is quarry for the construction of Tendaho dam, and water depth of the pond is more than 10m.

Section-2 (Pond to Drilling Pad)



Source: JIAC Survey Team

Figure Location Map of Site Photographs inSection-2 (Pond-Drilling Pad)

Section-2 (Pond – Drilling Pad)

1. North edge point of the pond planned pump station.

2. Protection dyke surrounding north part of the irrigation area..

3. Overview of the protection dyke.

4. Overview of the planned pipeline alignment from the dyke to the culvert.

5. South inlet of the culvert crossing the national highway. OFC is laid down in the culvert.

6. North inlet of the culvert crossing the national highway. OFC is laid down in the culvert.

7. National highway near the site

8. Old trace of Excavation for OFC.

9. Planned start point of the access road from the existing national highway.

10. Planned point of relay pump station and water pit.

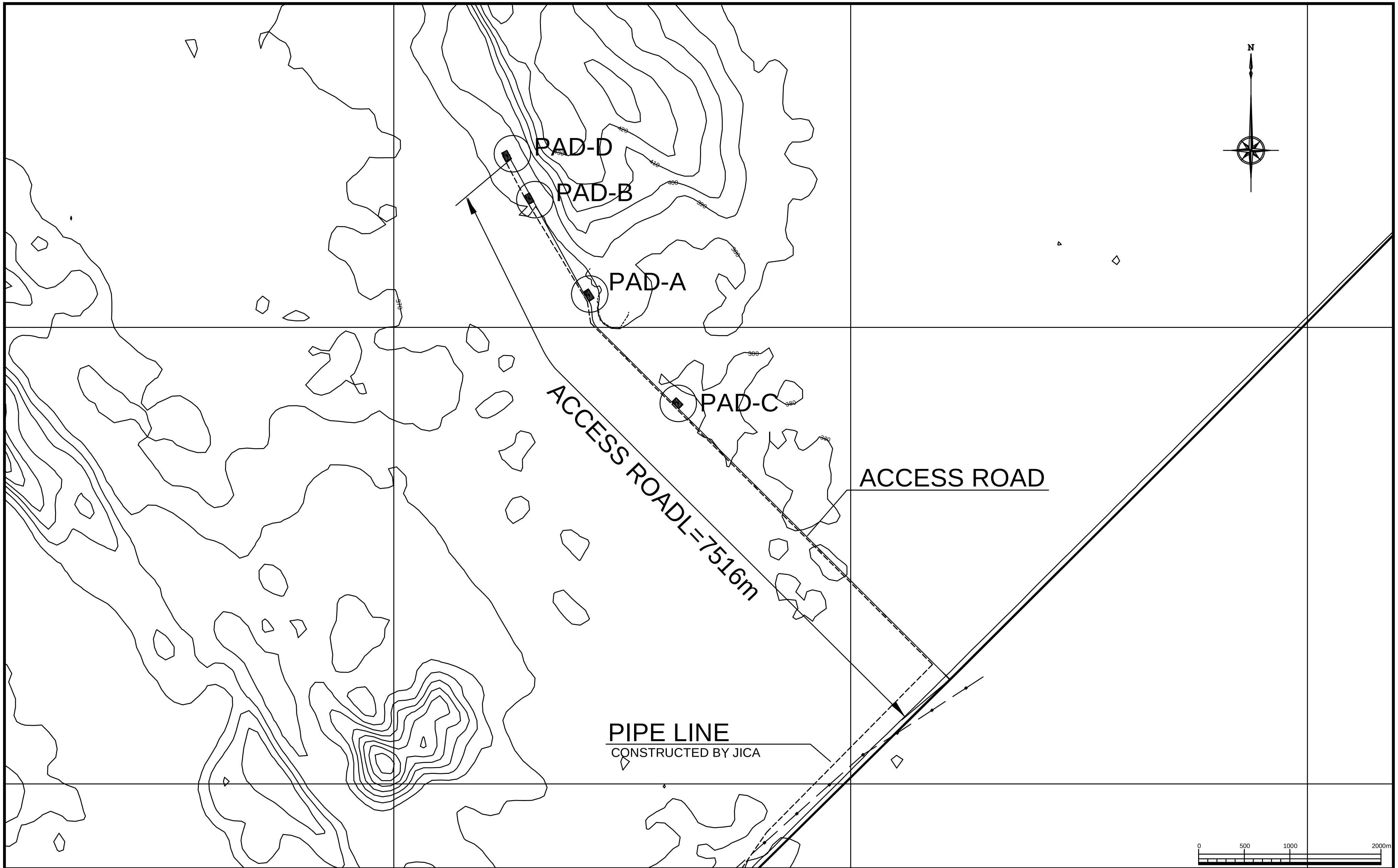
11. Ephemeral water stream on the planned access road and pipeline.

12. Ephemeral water stream on the planned access road and pipeline.

	
13. Site condition of planned drilling pad-A in front of hilly basaltic lava plateau.	14. Site condition of planned drilling pad-B near white-colored hill composed of altered ground.
	
15. Site condition of planned drilling pad-C near warm/wet ground with geothermal glass.	16. Site condition of planned drilling pad-D near another white-colored hill composed of altered ground.

Drawings

1. ACCESS ROAD

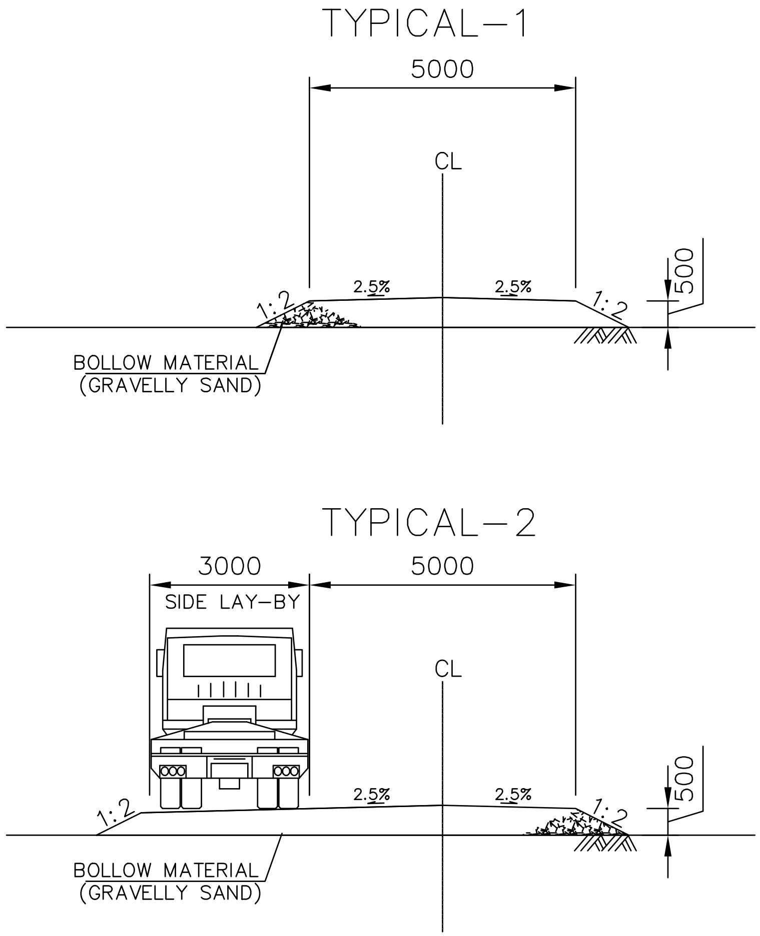


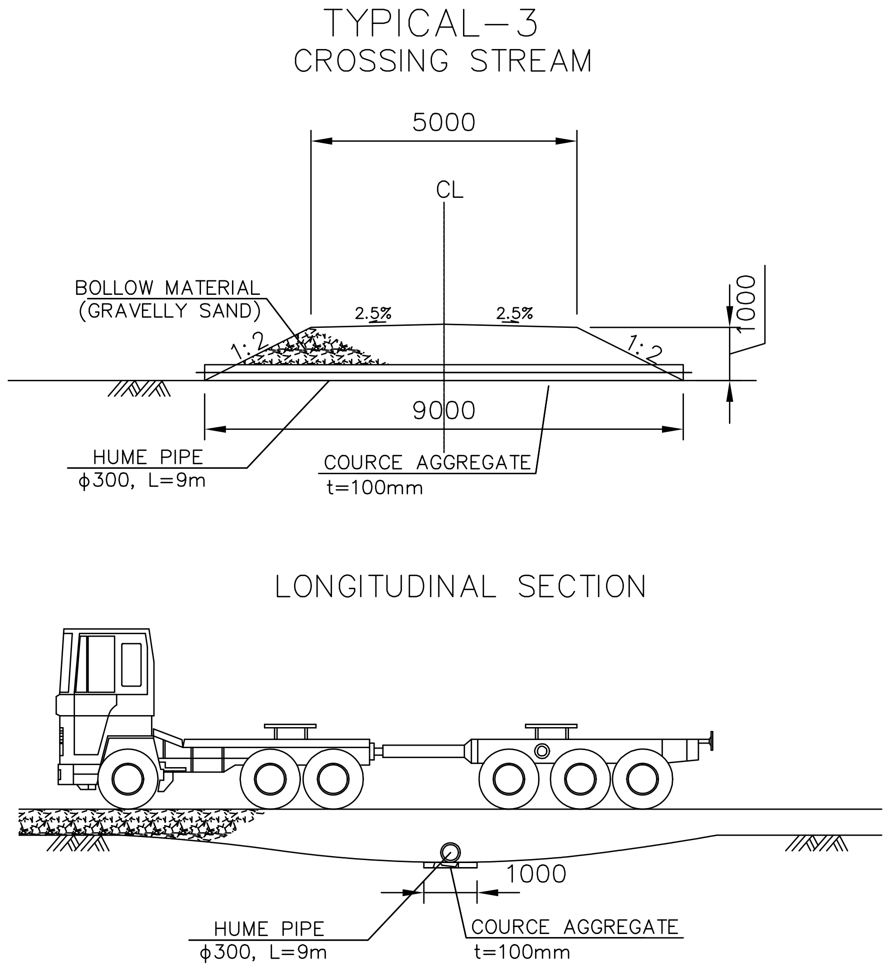
JAPAN INTERNATIONAL COOPERATION AGENCY	TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT
CLIENT: ETIOPIA ELECTRIC POWER	DRAWING TITLE: FULL VIEW OF ACCESS ROAD AND DRILLING PAD
REMARKS:	

SCALE	SHEET NO.	DRAWING NO.	REV. NO.
1:40,000		AR-01	

TYPICAL CROSS SECTION

(SCALE 1:100)





JAPAN INTERNATIONAL COOPERATION AGENCY	REMARKS:	TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT
CLIENT: ETIOPIA ELECTRIC POWER		DRAWING TITLE: TYPICAL CROSS SECTION (ACCESS ROAD)

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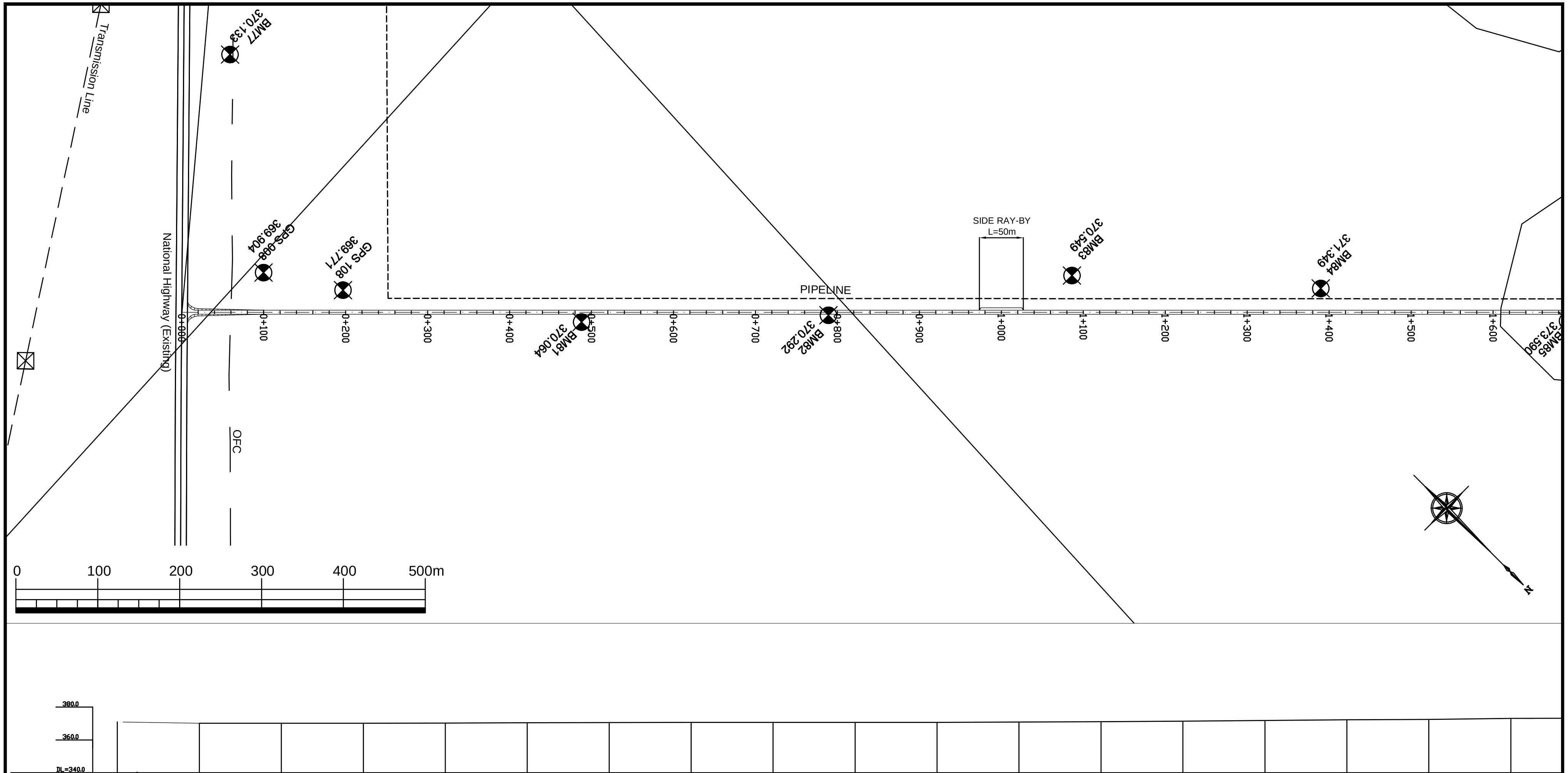

VERTICAL GEOMETRY	i=−1.508% L=100.000		i=0.183% L=1600.000															
FINISH ELEVATION	371.13	370.17	370.11	370.20	370.32	370.46	370.60	370.68	370.68	370.67	370.73	370.87	371.15	371.42	371.85	372.31	372.51	373.10
EXISTING ELEVATION	371.13	369.67	369.61	369.70	369.82	369.96	370.10	370.18	370.18	370.17	370.23	370.37	370.65	370.92	371.35	371.81	372.01	372.60
STATION	0+000	0+100	0+200	0+300	0+400	0+500	0+600	0+700	0+800	0+900	1+000	1+100	1+200	1+300	1+400	1+500	1+600	1+700
HORIZONTAL GEOMETRY	L=1700.00																	

JAPAN INTERNATIONAL COOPERATION AGENCY

CLIENT:

ETIOPIA ELECTRIC POWER

REMARKS:

TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

DRAWING TITLE:

PLAN AND PROFILE OF ACCESS ROAD STA.0+000-1+700

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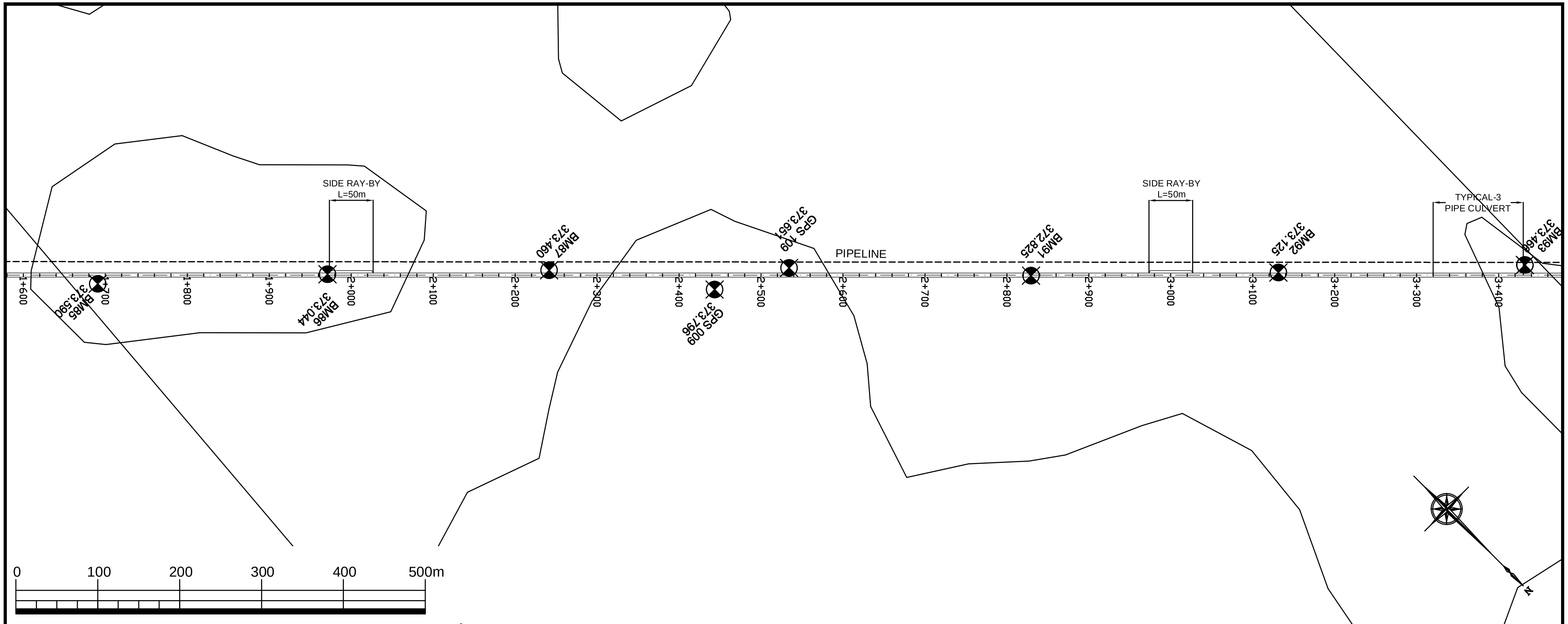

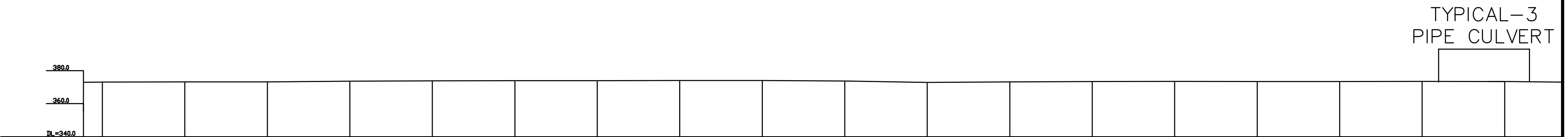

VERTICAL GEOMETRY	i=0.024% L=1620.000																	L=110.000		
FINISH ELEVATION	373.10	373.25	373.30	373.64	373.90	373.97	373.96	374.10	374.13	373.79	372.90	373.28	373.47	373.53	373.45	373.47	373.51	373.49	373.45	373.30
EXISTING ELEVATION	372.60	372.75	372.80	373.14	373.40	373.47	373.46	373.60	373.63	373.29	372.40	372.78	372.97	373.03	372.95	372.97	373.01		372.77	
STATION	1+700	1+800	1+900	2+000	2+100	2+200	2+300	2+400	2+500	2+600	2+700	2+800	2+900	3+000	3+100	3+200	3+300	3+320	3+400	3+430
HORIZONTAL GEOMETRY	L=1700.00																			

JAPAN INTERNATIONAL COOPERATION AGENCY

CLIENT:

ETIOPIA ELECTRIC POWER

REMARKS:

TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

DRAWING TITLE:

PLAN AND PROFILE OF ACCESS ROAD STA.1+700-3+400

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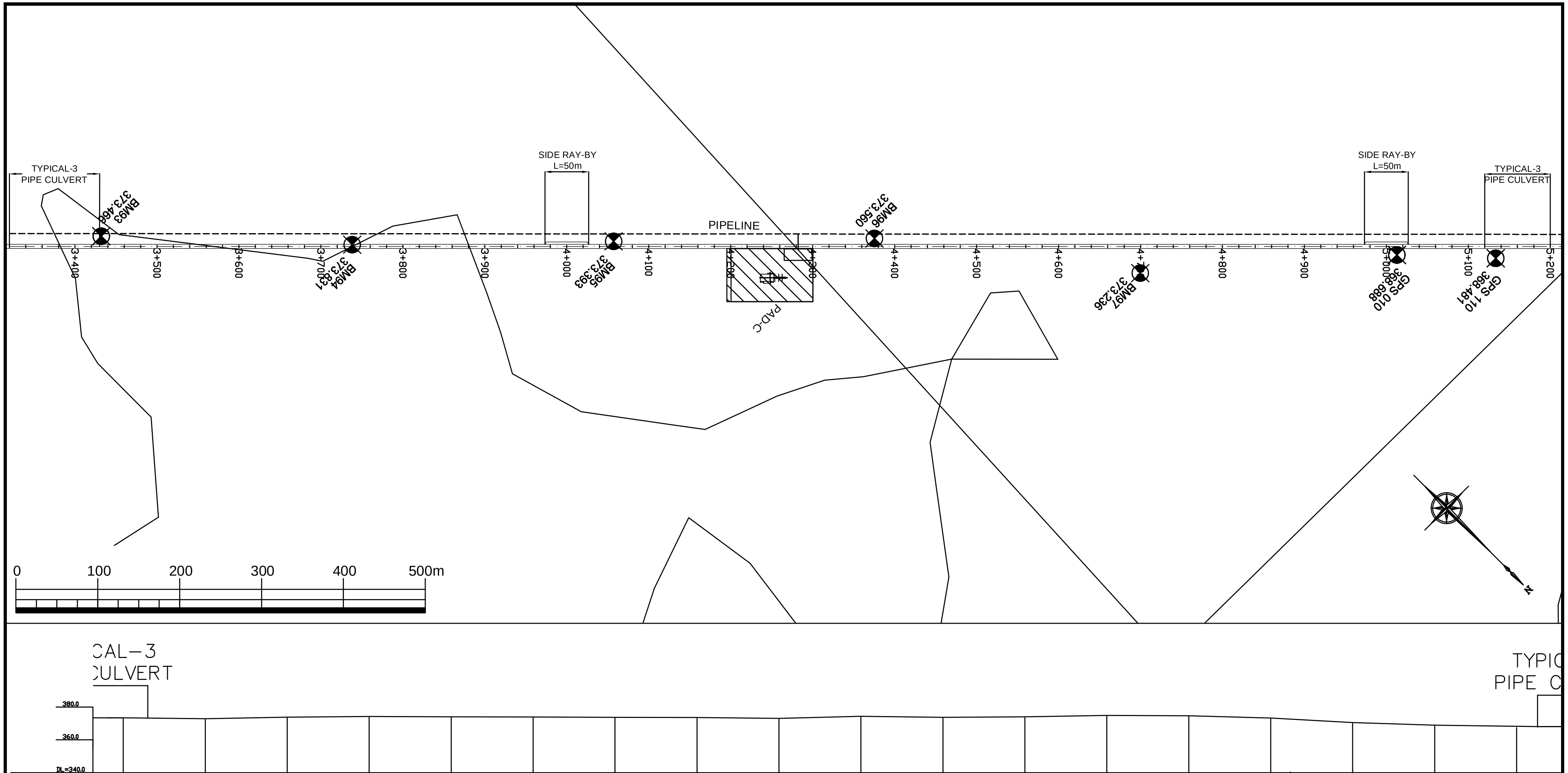

VERTICAL GEOMETRY: 110.000 | i=0.052% L=1170.000 | i=-1.294% L=520.000 | L=8

STATION	3+400	3+430	3+500	3+600	3+700	3+800	3+900	4+000	4+100	4+200
FINISH ELEVATION	373.45	373.30	372.91	373.90	374.28	374.05	374.03	373.82	373.65	373.19
EXISTING ELEVATION	372.77		372.41	373.40	373.78	373.55	373.53	373.32	373.15	372.69

STATION	4+300	4+400	4+500	4+600	4+700	4+800	4+900	5+000	5+100	5+120
FINISH ELEVATION	374.38	373.75	374.08	374.92	374.78	373.32	370.62	369.03	368.01	368.19
EXISTING ELEVATION	373.88	373.25	373.58	374.42	374.28	372.82	370.12	368.53	367.51	

HORIZONTAL GEOMETRY: L=1700.00

JAPAN INTERNATIONAL COOPERATION AGENCY

CLIENT:

ETIOPIA ELECTRIC POWER

REMARKS:

TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

DRAWING TITLE:

PLAN AND PROFILE OF ACCESS ROAD STA.3+400-5+100

SCALE	SHEET NO.	DRAWING NO.	REV. NO.
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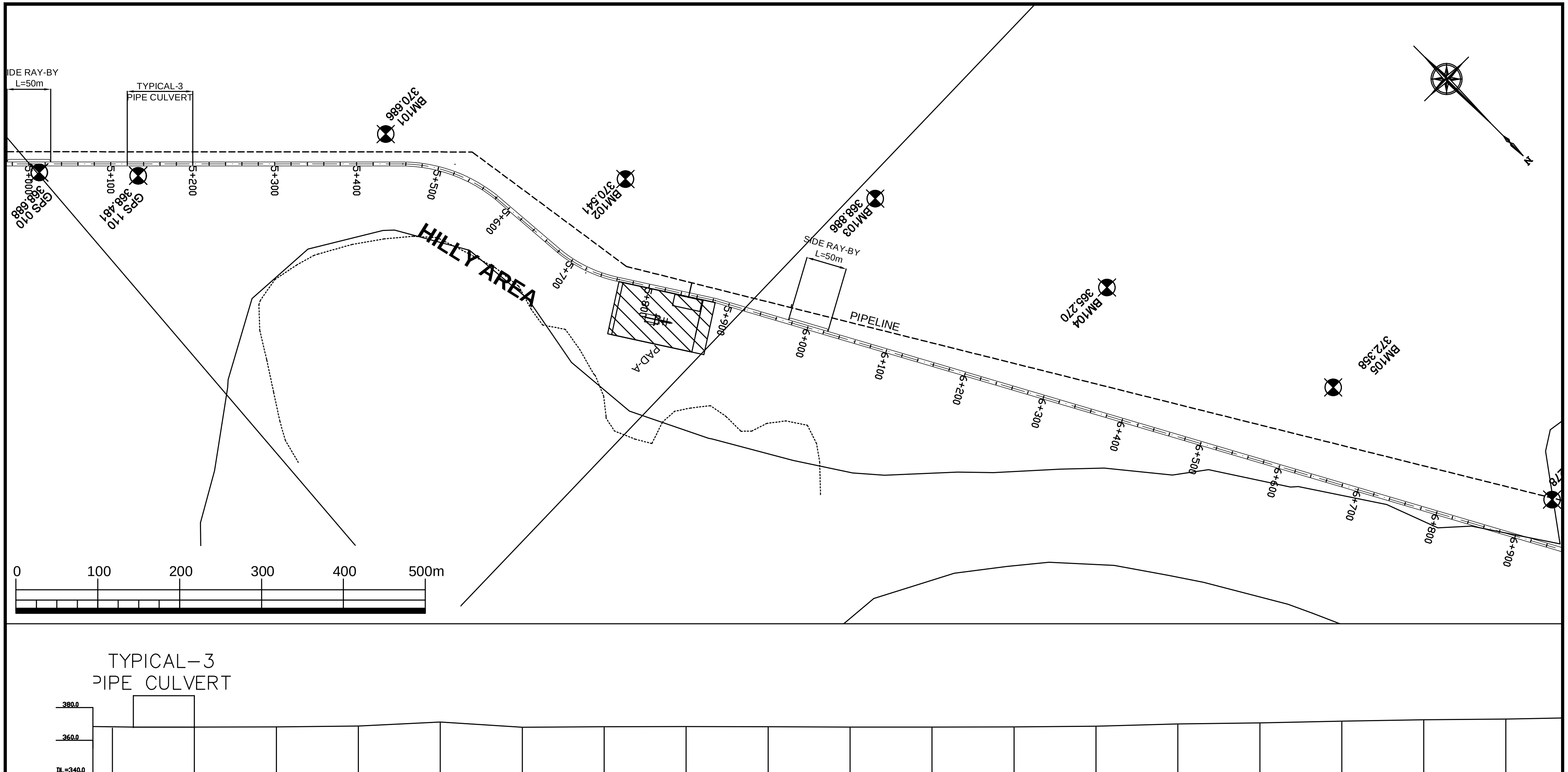

VERTICAL GEOMETRY	L=80.000			i=1.023% L=300.000					i=−0.527% L=600.000							i=0.699% L=700.000			
FINISH ELEVATION	368.01	368.19	368.19	368.26	368.75	371.26	368.07	368.35	368.50	368.41	368.17	368.10	368.27	368.65	370.01	370.73	371.76	372.57	372.99
EXISTING ELEVATION	367.51		367.53	367.76	368.25	370.76	367.57	367.85	368.00	367.91	367.67	367.60	367.77	368.15	369.51	370.23	371.26	372.07	372.49
STATION	5+100	5+120	5+200	5+300	5+400	5+500	5+600	5+700	5+800	5+900	6+000	6+100	6+200	6+300	6+400	6+500	6+600	6+700	6+800
HORIZONTAL GEOMETRY	L=360.00					L=120.00 R=120.00	L=100.00	L=80.00 R=80.00	L=100.00				L=1040.00						

JAPAN INTERNATIONAL COOPERATION AGENCY

REMARKS:

CLIENT:

ETIOPIA ELECTRIC POWER

TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

DRAWING TITLE:

PLAN AND PROFILE OF ACCESS ROAD STA.5+100-6+800

SCALE	SHEET NO.	DRAWING NO.	REV. NO.
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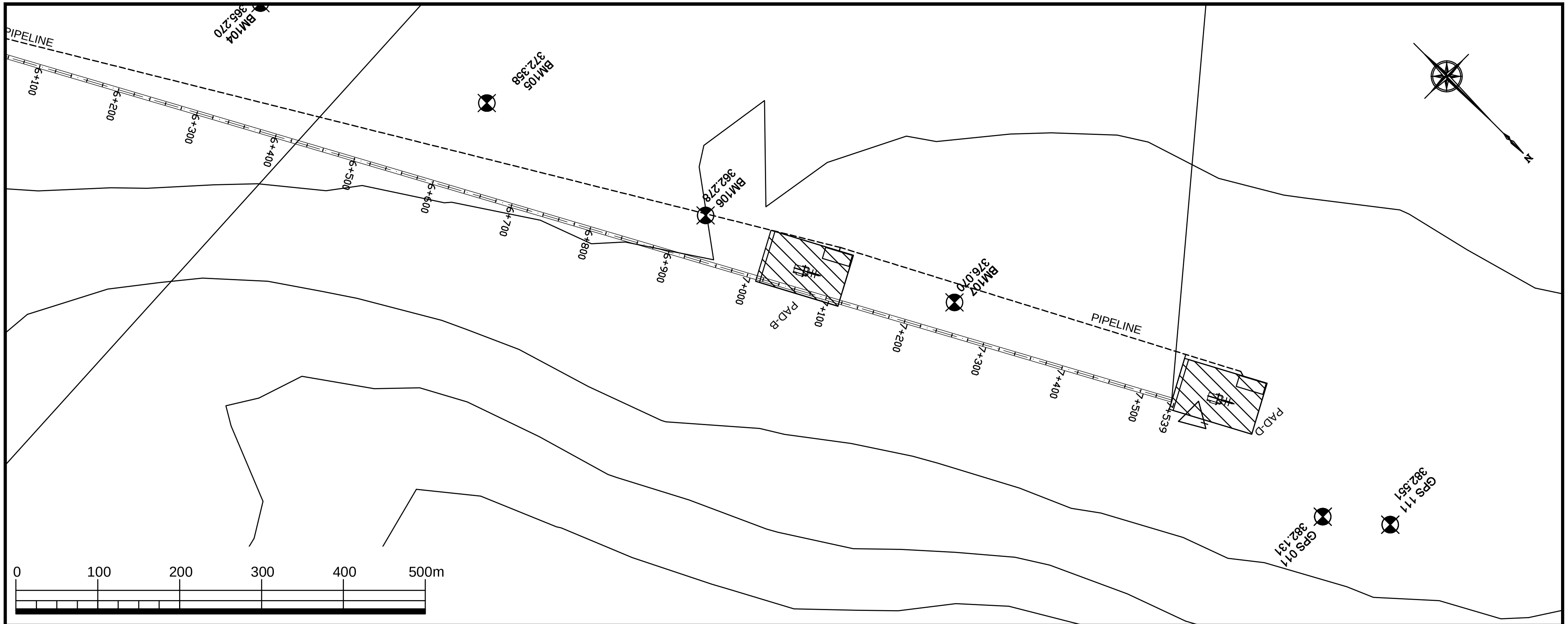


VERTICAL GEOMETRY	i=0.645% L=739.000								
FINISH ELEVATION	372.99	374.03	374.44	375.21	376.11	376.97	377.55	377.70	377.76
EXISTING ELEVATION	372.49	373.53	373.94	374.71	375.61	376.47	377.05	377.20	
STATION	6+800	6+900	7+000	7+100	7+200	7+300	7+400	7+500	7+539
HORIZONTAL GEOMETRY	L=739.00								

380.0
360.0
DL=340.0

JAPAN INTERNATIONAL COOPERATION AGENCY

REMARKS:

CLIENT:

ETIOPIA ELECTRIC POWER

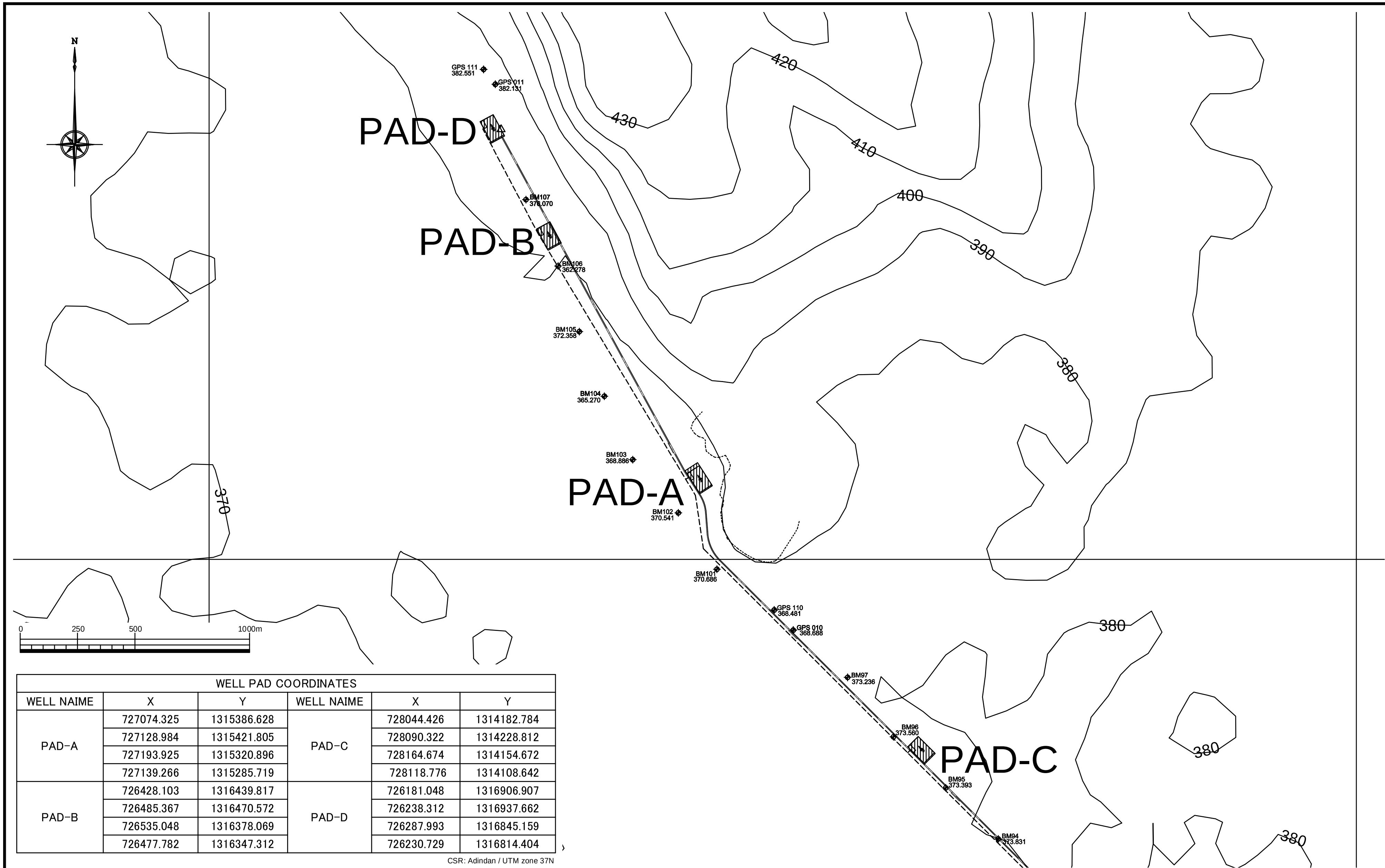
TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

DRAWING TITLE:

PLAN AND PROFILE OF ACCESS ROAD STA.5+100-7+539

SCALE	SHEET NO.	DRAWING NO.	REV. NO.
1:5000		AR-07	

2. DRILLING PAD



WELL PAD COORDINATES

WELL NAIME	X	Y	WELL NAIME	X	Y
PAD-A	727074.325	1315386.628	PAD-C	728044.426	1314182.784
	727128.984	1315421.805		728090.322	1314228.812
	727193.925	1315320.896		728164.674	1314154.672
	727139.266	1315285.719		728118.776	1314108.642
PAD-B	726428.103	1316439.817	PAD-D	726181.048	1316906.907
	726485.367	1316470.572		726238.312	1316937.662
	726535.048	1316378.069		726287.993	1316845.159
	726477.782	1316347.312		726230.729	1316814.404

CSR: Adindan / UTM zone 37N

JAPAN INTERNATIONAL COOPERATION AGENCY

CLIENT:

ETIOPIA ELECTRIC POWER

REMARKS:

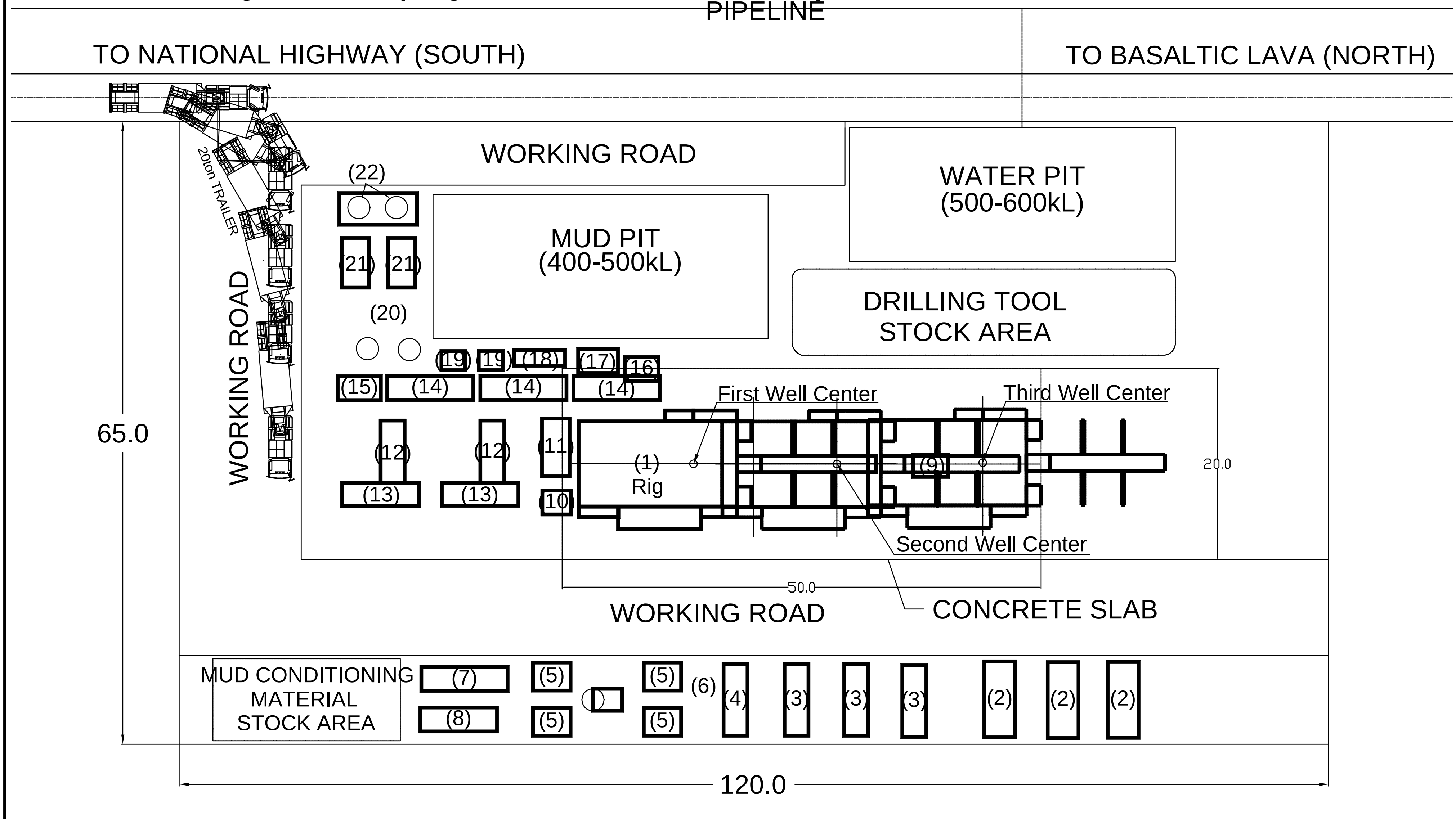
TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

DRAWING TITLE:

LOCATION OF DRILLING PAD

SCALE	SHEET NO.	DRAWING NO.	REV. NO.
1:5,000		DP-01	

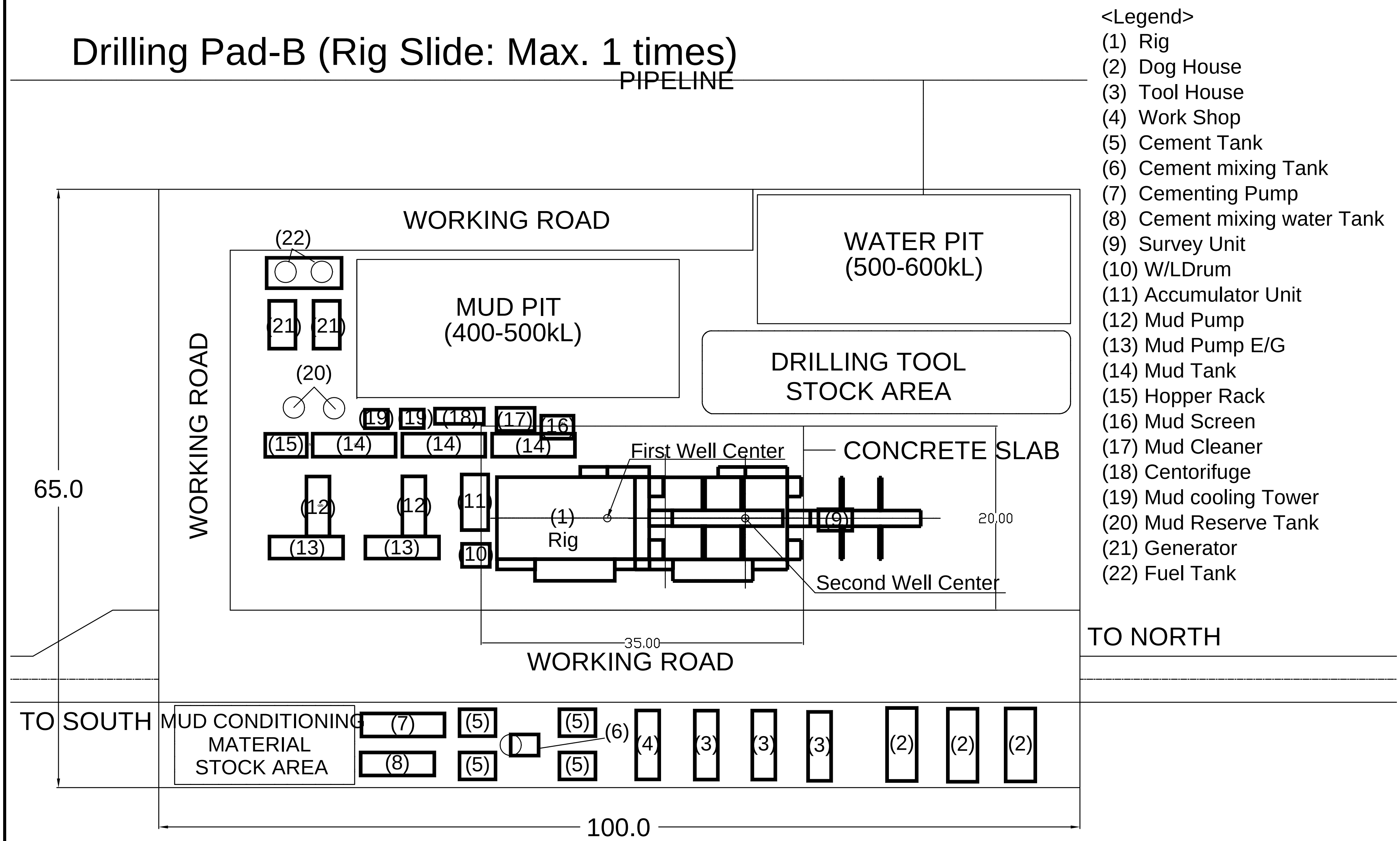
Drilling Pad-A (Rig Slide: Max. 2 times)



JAPAN INTERNATIONAL COOPERATION AGENCY	REMARKS: - LEGEND IS SHOWN IN OTHER DRAWINGS.	TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT
CLIENT: ETIOPIA ELECTRIC POWER		DRAWING TITLE: ARRANGEMENT PLAN OF DRILLING PAD (PAD-A)

SCALE	SHEET NO.	DRAWING NO.	REV. NO.
-		DP-02	

Drilling Pad-B (Rig Slide: Max. 1 times)



JAPAN INTERNATIONAL COOPERATION AGENCY

CLIENT: ETIOPIA ELECTRIC POWER

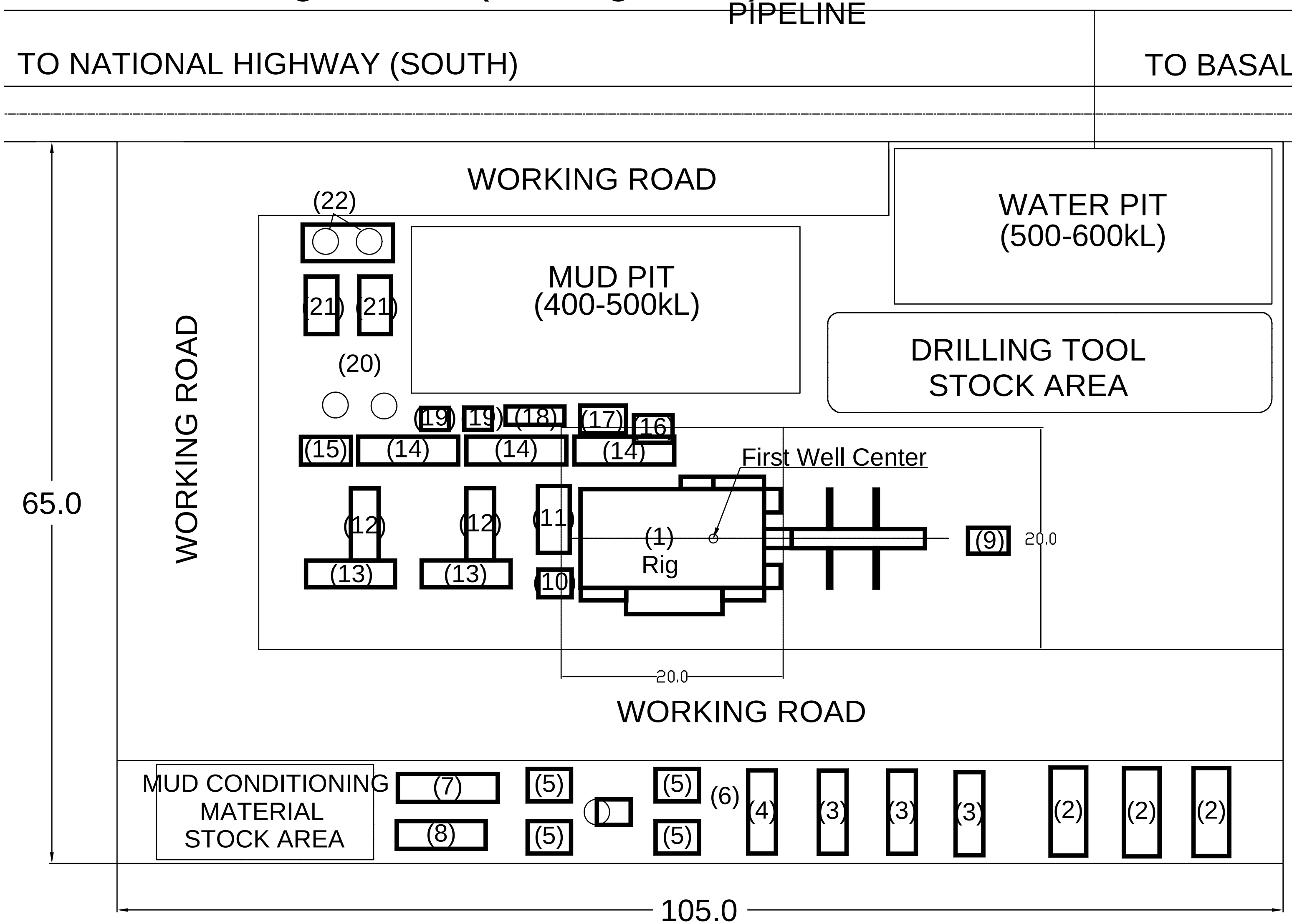
REMARKS:

TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

DRAWING TITLE: ARRANGEMENT PLAN OF DRILLING PAD (PAD-B)

SCALE	SHEET NO.	DRAWING NO.	REV. NO.
-		DP-03	

Drilling Pad-C (No Rig Slide)



<Legend>
(1) Rig
(2) Dog House
(3) Tool House
(4) Work Shop
(5) Cement Tank
(6) Cement mixing Tank
(7) Cementing Pump
(8) Cement mixing water Tank
(9) Survey Unit
(10) W/LDrum
(11) Accumulator Unit
(12) Mud Pump
(13) Mud Pump E/G
(14) Mud Tank
(15) Hopper Rack
(16) Mud Screen
(17) Mud Cleaner
(18) Centorifuge
(19) Mud cooling Tower
(20) Mud Reserve Tank
(21) Generator
(22) Fuel Tank

JAPAN INTERNATIONAL COOPERATION AGENCY

CLIENT: ETIOPIA ELECTRIC POWER

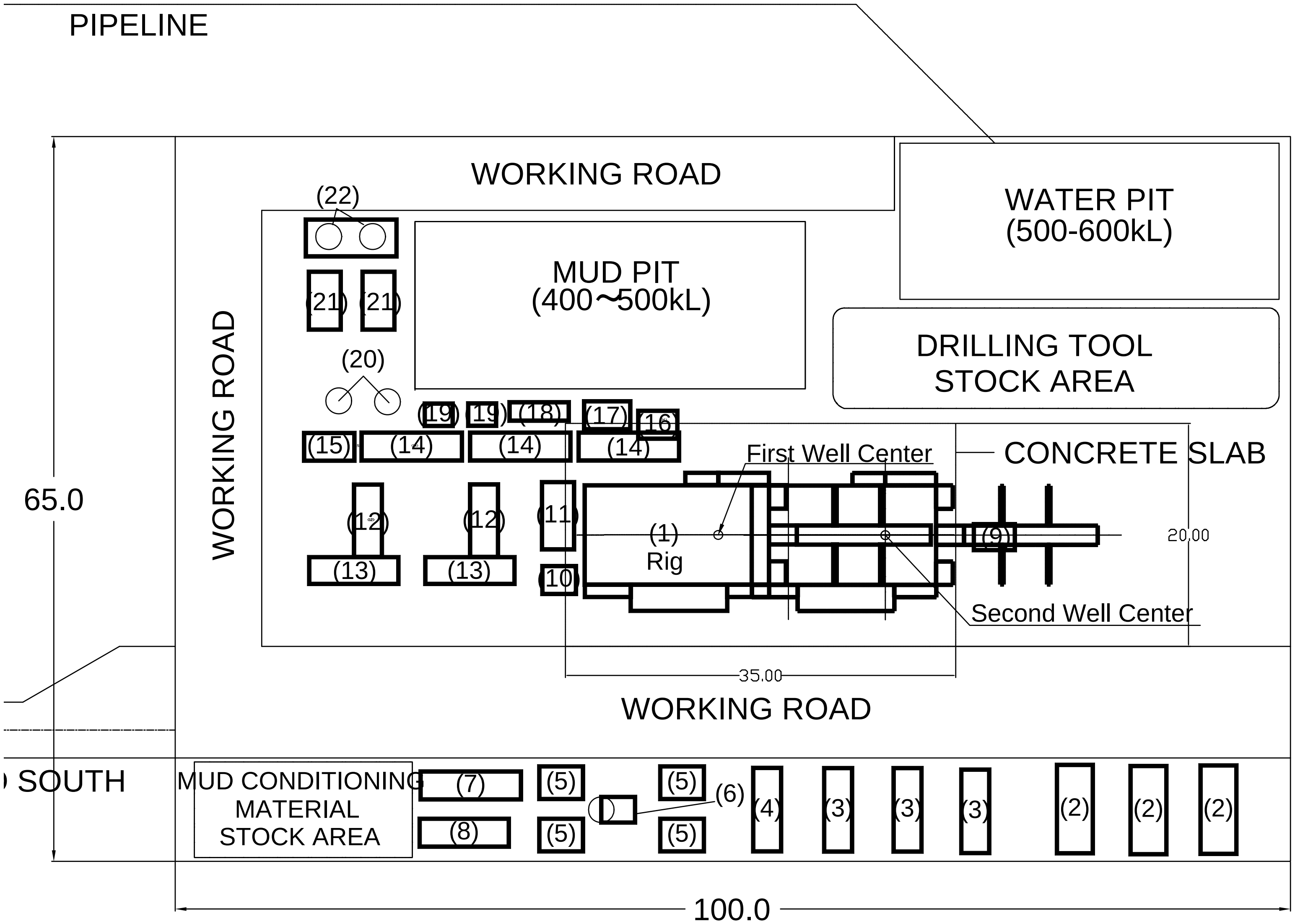
REMARKS:

TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

DRAWING TITLE: ARRANGEMENT PLAN OF DRILLING PAD (PAD-C)

SCALE	SHEET NO.	DRAWING NO.	REV. NO.
-		DP-04	

Drilling Pad-D (Rig Slide: Max. 1 times)



<Legend>
(1) Rig
(2) Dog House
(3) Tool House
(4) Work Shop
(5) Cement Tank
(6) Cement mixing Tank
(7) Cementing Pump
(8) Cement mixing water Tank
(9) Survey Unit
(10) W/LDrum
(11) Accumulator Unit
(12) Mud Pump
(13) Mud Pump E/G
(14) Mud Tank
(15) Hopper Rack
(16) Mud Screen
(17) Mud Cleaner
(18) Centorifuge
(19) Mud cooling Tower
(20) Mud Reserve Tank
(21) Generator
(22) Fuel Tank

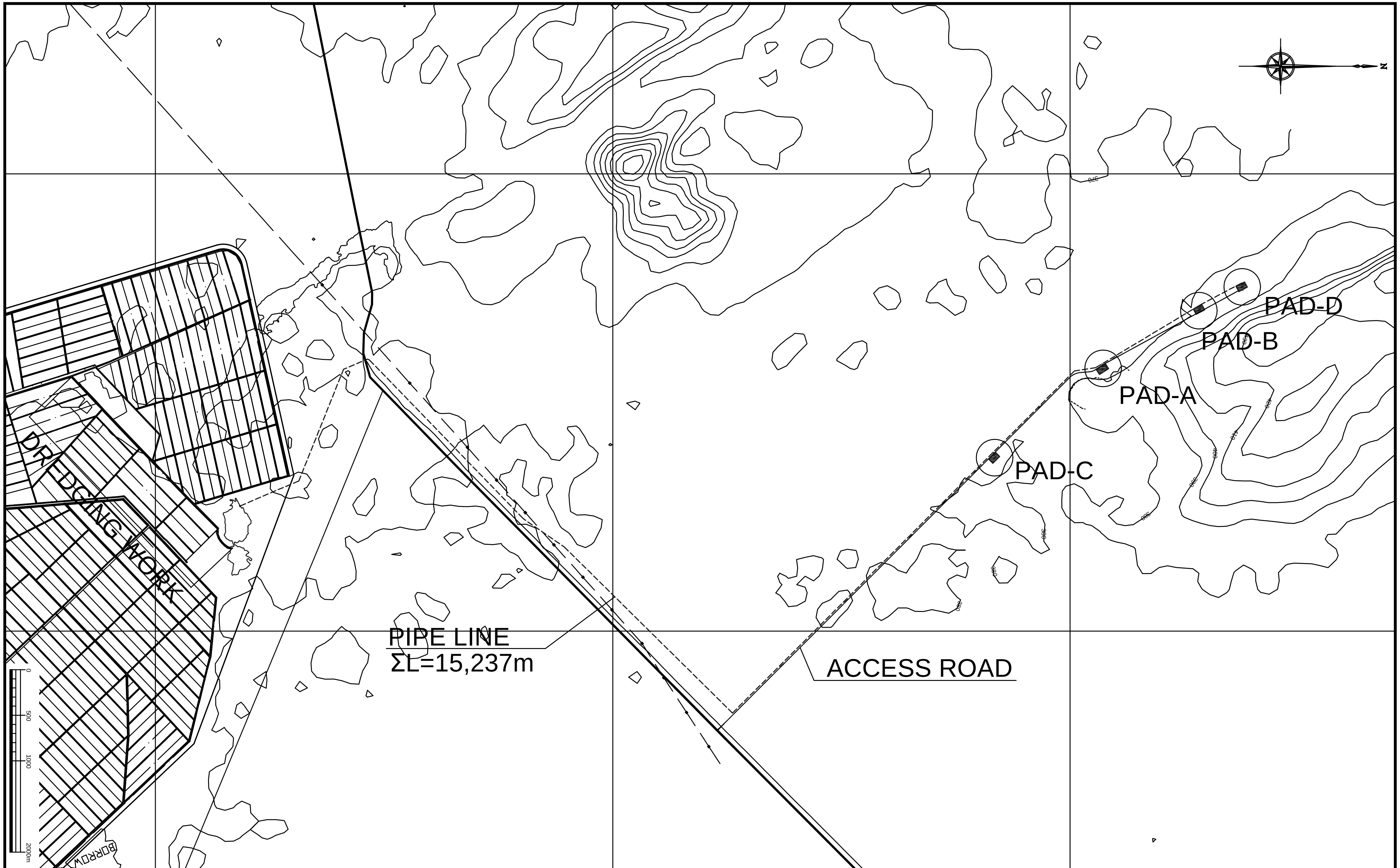
JAPAN INTERNATIONAL COOPERATION AGENCY	REMARKS:
CLIENT: ETIOPIA ELECTRIC POWER	

TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

DRAWING TITLE: ARRANGEMENT PLAN OF DRILLING PAD (PAD-D)

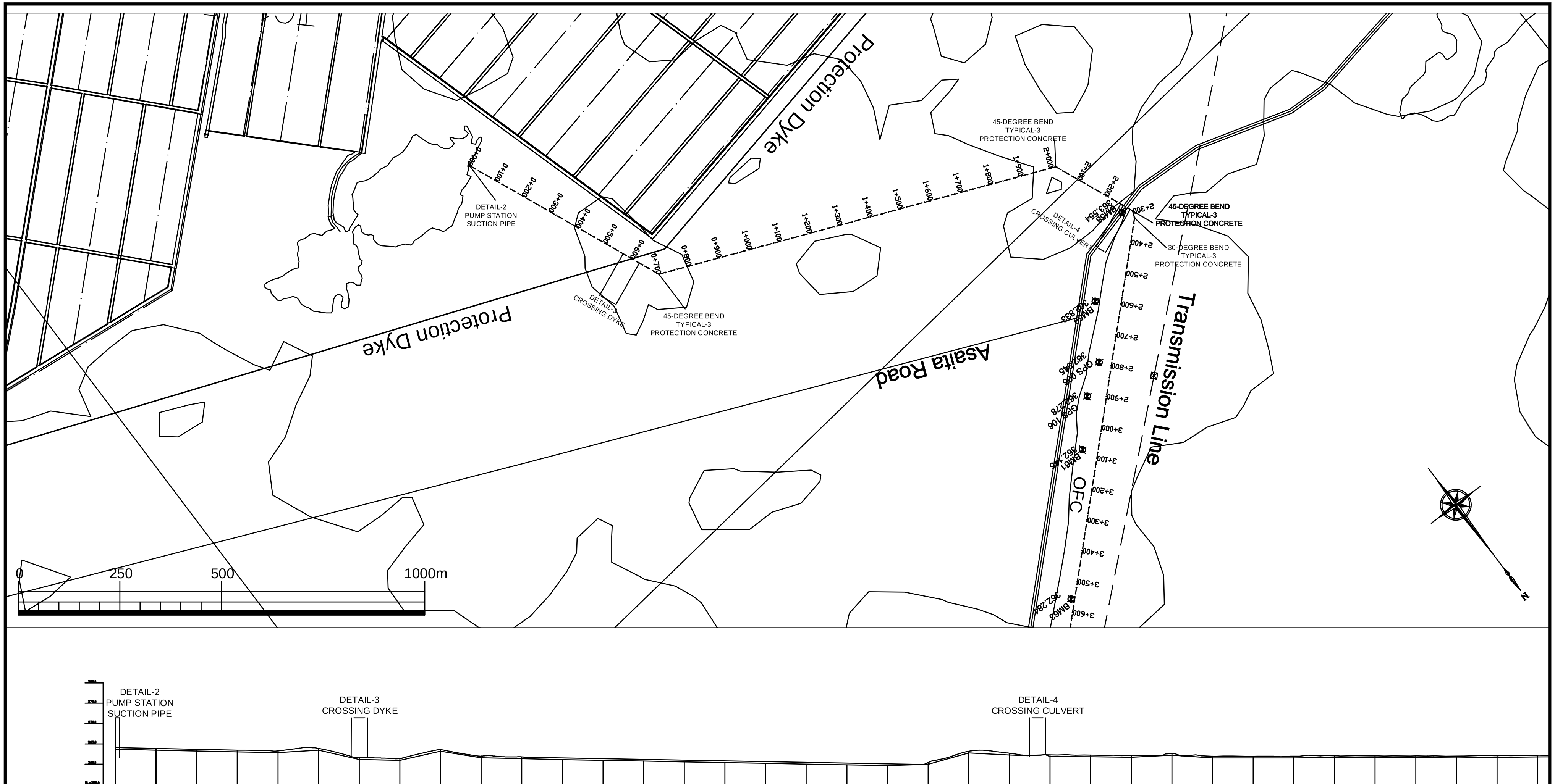
SCALE	SHEET NO.	DRAWING NO.	REV. NO.
-		DP-05	

3. WATER SUPPLY SYSTEM



JAPAN INTERNATIONAL COOPERATION AGENCY	REMARKS:	TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT
CLIENT: ETIOPIA ELECTRIC POWER		DRAWING TITLE: FULL VIEW OF PIPELINE WORKS

SCALE	SHEET NO.	DRAWING NO.	REV. NO.
1:40,000		PP-01	



STATION	EXISTING ELEVATION	FINISH ELEVATION
0+000	364.11	363.69
0+100	363.89	363.46
0+200	363.67	363.25
0+300	363.47	363.05
0+400	363.28	362.85
0+500	363.88	363.45
0+600	361.58	361.15
0+700	361.36	360.94
0+800	363.61	363.18
0+900	361.99	361.56
1+000	361.78	361.36
1+100	361.54	361.12
1+200	361.36	360.94
1+300	361.18	360.75
1+400	361.00	360.57
1+500	360.81	360.39
1+600	360.63	360.21
1+700	360.45	360.02
1+800	360.27	359.84
1+900	360.08	359.66
2+000	360.39	359.97
2+100	363.18	362.76
2+200	362.70	362.27
2+300	362.29	361.86
2+400	362.24	361.82
2+500	362.13	361.70
2+600	362.66	362.23
2+700	361.95	361.53
2+800	361.95	361.53
2+900	361.97	361.54
3+000	362.08	361.66
3+100	362.05	361.62
3+200	362.03	361.61
3+300	361.98	361.56
3+400	362.11	361.68
3+500	362.20	361.77

VERTICAL GEOMETRY: i=−0.210% L=400.000; i=0.600% L=100.000; i=−1.255% L=200.000; i=2.240% L=100.000; i=−0.2675% L=1200.00; i=2.790% L=100.00; i=−0.450% L=155.000; CROSSING CULVERT; i=−0.030% L=1000.00

HORIZONTAL GEOMETRY: 45-DEGREE BEND; 45-DEGREE BEND; 45-DEGREE BEND; 30-DEGREE BEND

JAPAN INTERNATIONAL COOPERATION AGENCY

CLIENT:

ETIOPIA ELECTRIC POWER

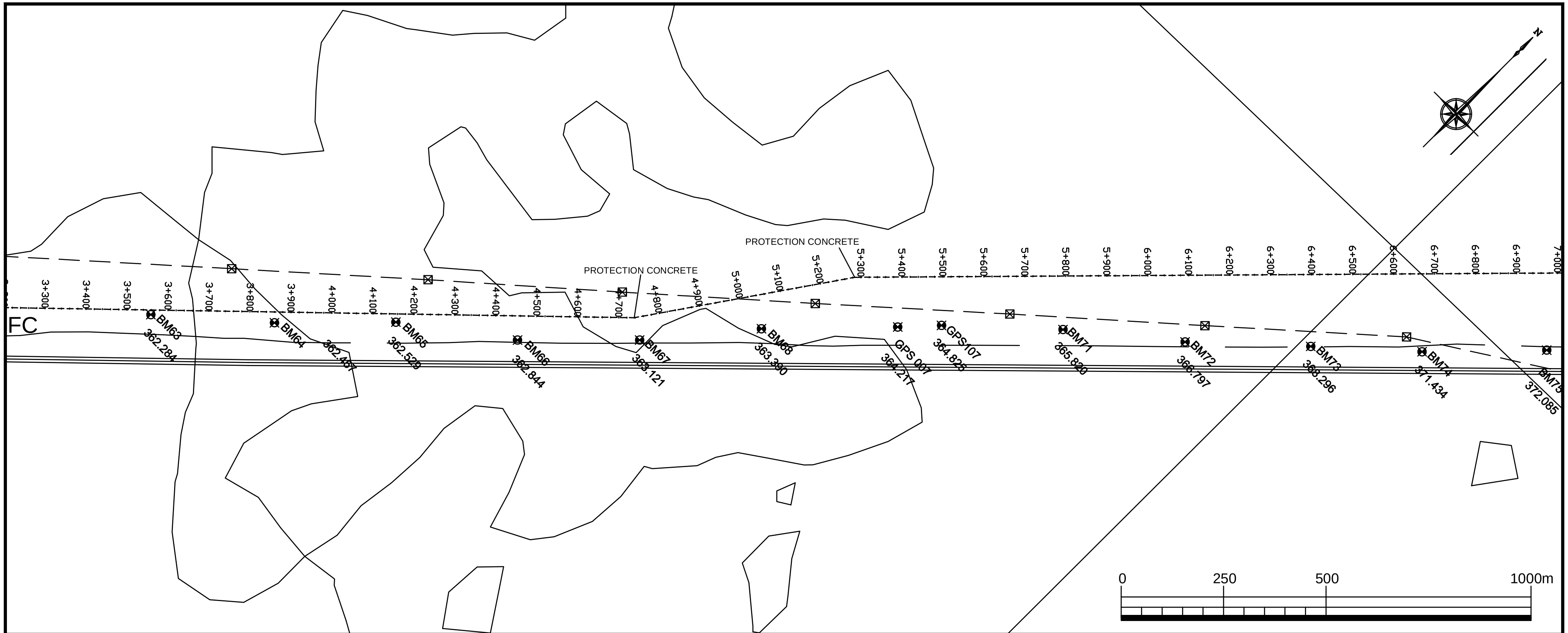
REMARKS:

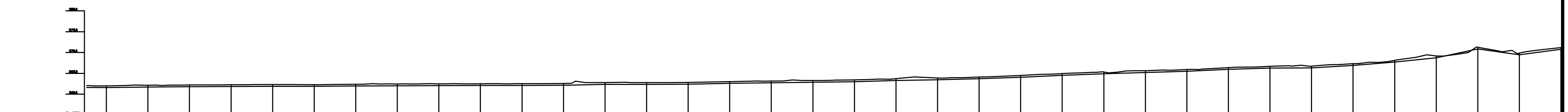
TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

DRAWING TITLE:

PLAN AND PROFILE OF PIPELINE STA.0+000-3+300

SCALE	SHEET NO.	DRAWING NO.	REV. NO.
1:10,000		PP-02	





Vertical geometry	i=0.281% L=3300.00 (3+300 – 6+600); i=-1.410% L=100.00 (6+600 – 6+700)

Station	Finish elevation	Existing elevation
3+300	361.56	361.98
3+400	361.68	362.11
3+500	361.77	362.20
3+600	361.81	362.24
3+700	361.87	362.30
3+800	361.84	362.27
3+900	361.93	362.36
4+000	362.01	362.44
4+100	362.04	362.47
4+200	362.06	362.48
4+300	362.08	362.50
4+400	362.13	362.55
4+500	362.35	362.77
4+600	362.33	362.76
4+700	362.37	362.80
4+800	362.57	363.00
4+900	362.71	363.13
5+000	362.85	363.28
5+100	362.97	363.40
5+200	363.29	363.71
5+300	363.45	363.87
5+400	363.68	364.11
5+500	364.03	364.45
5+600	364.50	364.93
5+700	364.86	365.29
5+800	365.18	365.60
5+900	365.48	365.91
6+000	365.93	366.35
6+100	366.25	366.67
6+200	366.28	366.70
6+300	366.87	367.30
6+400	367.67	368.10
6+500	368.71	369.13
6+600	370.83	371.25
6+700	369.42	369.85
6+800	370.75	371.18

Horizontal geometry	R=400 (4+600 – 4+900); R=500 (5+200 – 5+400)

JAPAN INTERNATIONAL COOPERATION AGENCY

CLIENT:

ETIOPIA ELECTRIC POWER

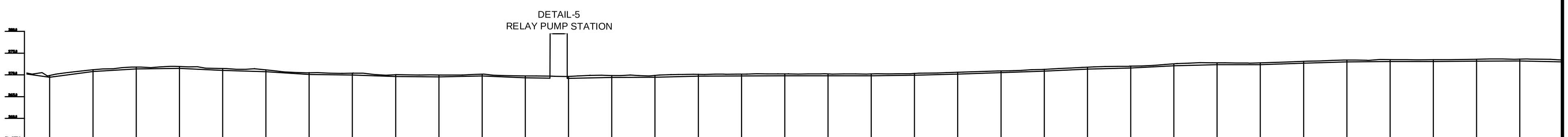
REMARKS:

TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

DRAWING TITLE:

PLAN AND PROFILE OF PIPELINE STA.3+300-6+700

SCALE	SHEET NO.	DRAWING NO.	REV. NO.
1:10,000		PP-03	



VERTICAL GEOMETRY	.410% 00.00	i=-0.019% L=1200.00															
FINISH ELEVATION	369.42	370.75	371.36	371.49	371.02	370.70	370.05	369.93	369.59	369.52	369.71	369.29	369.19	369.37	369.43	369.67	369.73
EXISTING ELEVATION	369.85	371.18	371.78	371.91	371.45	371.13	370.47	370.36	370.01	369.95	370.14	369.71	369.62	369.80	369.85	370.10	370.16
STATION	6+700	6+800	6+900	7+000	7+100	7+200	7+300	7+400	7+500	7+600	7+700	7+800	7+900	8+000	8+100	8+200	8+300
HORIZONTAL GEOMETRY													WATER PIT				

VERTICAL GEOMETRY	i=0.181% L=2200.00																	
FINISH ELEVATION	369.76	369.77	369.77	369.88	370.16	370.48	370.83	371.32	371.56	372.08	372.33	372.32	372.66	372.96	373.06	373.03	373.13	373.18
EXISTING ELEVATION	370.19	370.19	370.19	370.31	370.59	370.90	371.25	371.75	371.98	372.51	372.75	372.74	373.08	373.38	373.49	373.45	373.56	373.60
STATION	8+400	8+500	8+600	8+700	8+800	8+900	9+000	9+100	9+200	9+300	9+400	9+500	9+600	9+700	9+800	9+900	10+000	10+100
HORIZONTAL GEOMETRY																		

JAPAN INTERNATIONAL COOPERATION AGENCY

CLIENT:

ETIOPIA ELECTRIC POWER

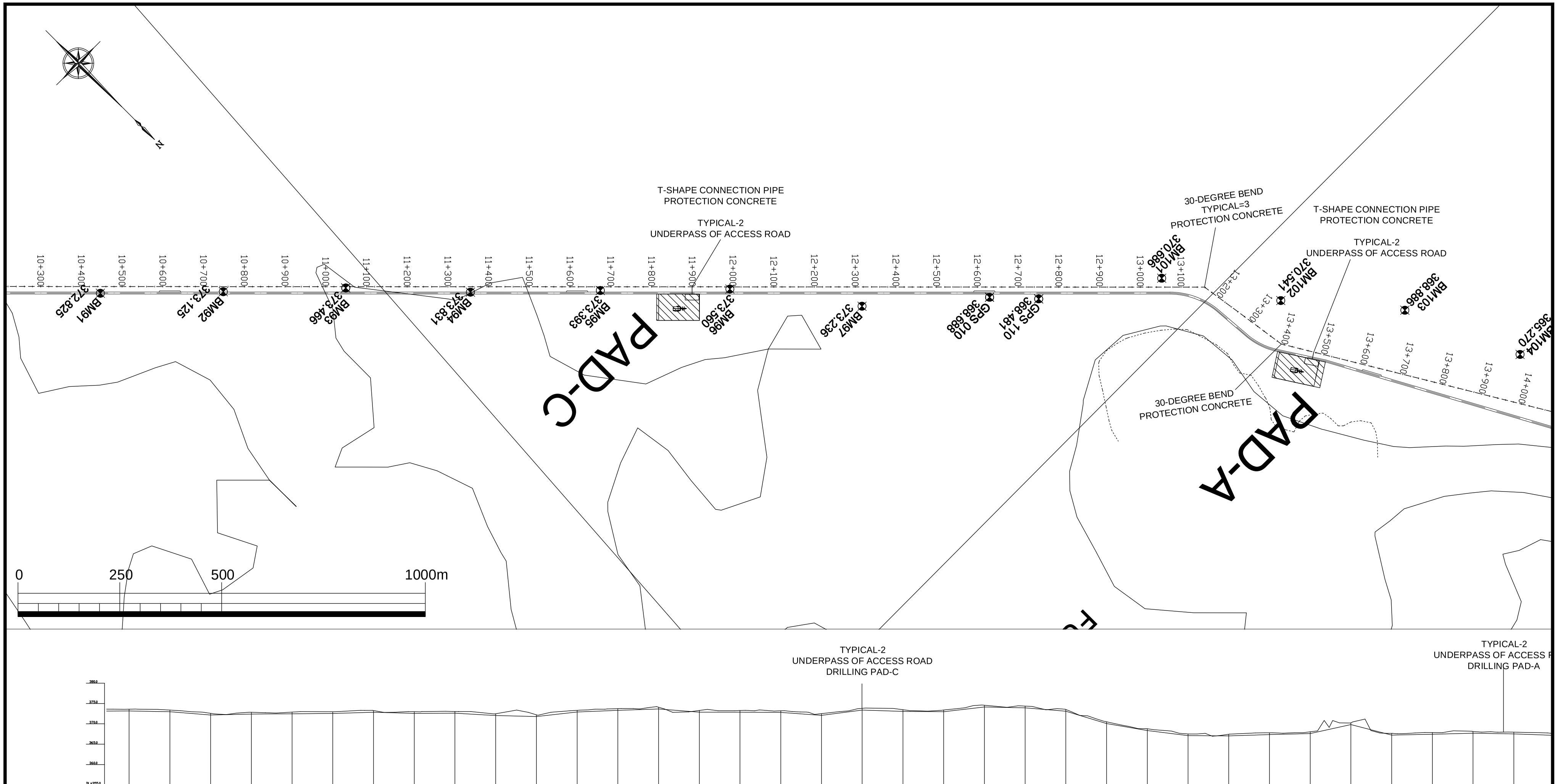
REMARKS:

TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

DRAWING TITLE:

PLAN AND PROFILE OF PIPELINE STA.6+700-10+100

SCALE	SHEET NO.	DRAWING NO.	REV. NO.
1:10,000		PP-04	



STATION	FINISH ELEVATION	EXISTING ELEVATION
10+100	373.18	373.60
10+200	372.96	373.39
10+300	372.15	372.58
10+400	372.40	372.83
10+500	372.45	372.88
10+600	372.54	372.96
10+700	372.84	373.27
10+800	372.56	372.98
10+900	372.61	373.04
11+000	372.04	372.47
11+100	371.79	372.21
11+200	372.9	373.33
11+300	373.33	373.75
11+400	373.67	374.09
11+500	372.87	373.29
11+600	372.86	373.29
11+700	372.79	373.21
11+800	372.07	372.50
11+900	373.40	373.82
12+000	373.05	373.48
12+100	372.97	373.40
12+200	374.15	374.58
12+300	373.94	374.36
12+400	373.12	373.54
12+500	370.06	370.49
12+600	368.35	368.78
12+700	367.09	367.52
12+800	367.03	367.45
12+900	367.35	367.77
13+000	367.61	368.03
13+100	369.82	370.24
13+200	367.22	367.65
13+300	367.44	367.86
13+400	367.69	368.12
13+500	367.52	367.95

VERTICAL GEOMETRY: i=−0.139% L=1000.00; i=0.295% L=800.00; i=−1.187% L=600.00; i=0.930% L=300.00; i=−0.575% L=400.00; i=−(

HORIZONTAL GEOMETRY: T-SHAPE PIPE; 30-DEGREE BEND; 30-DEGREE BEND; T-SHAPE PIPE

JAPAN INTERNATIONAL COOPERATION AGENCY

REMARKS:

CLIENT:

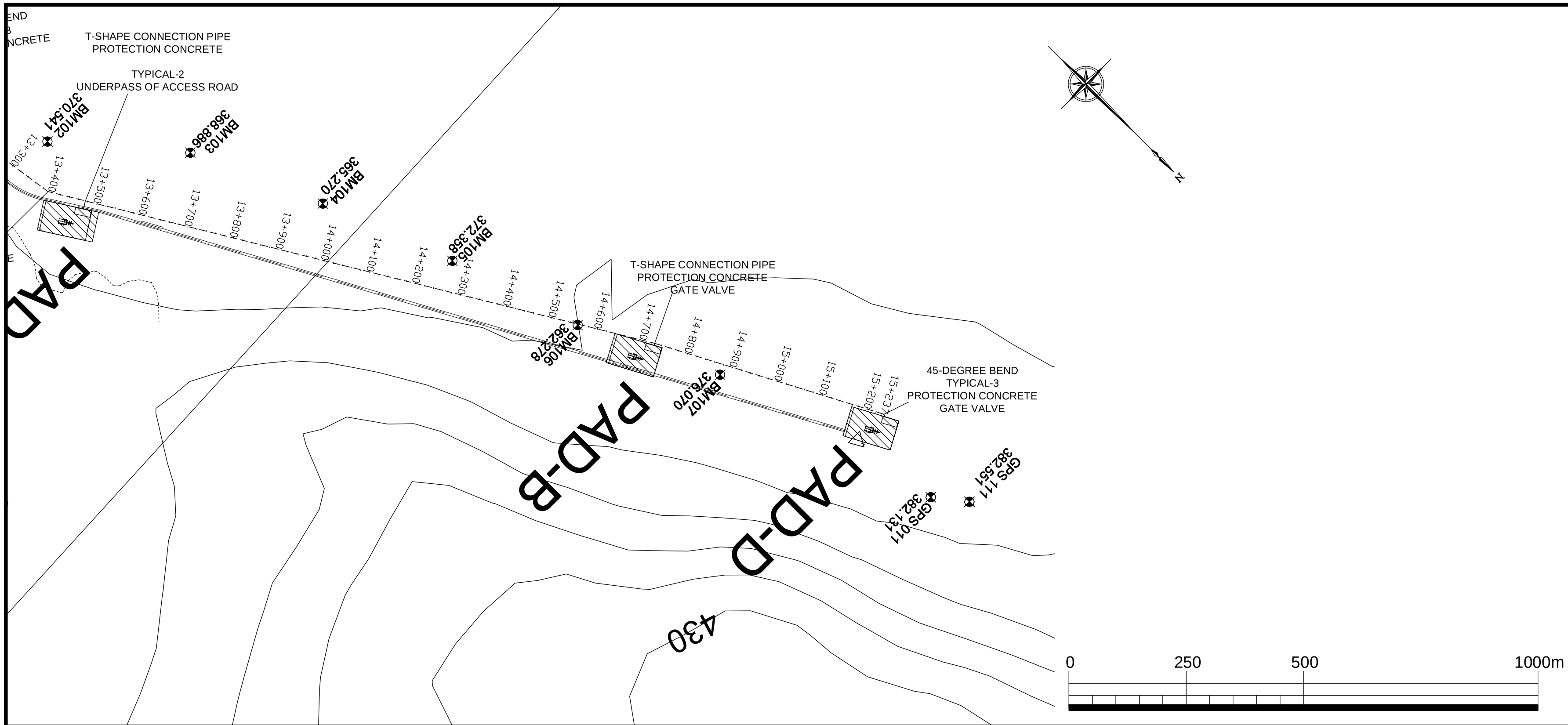
ETIOPIA ELECTRIC POWER

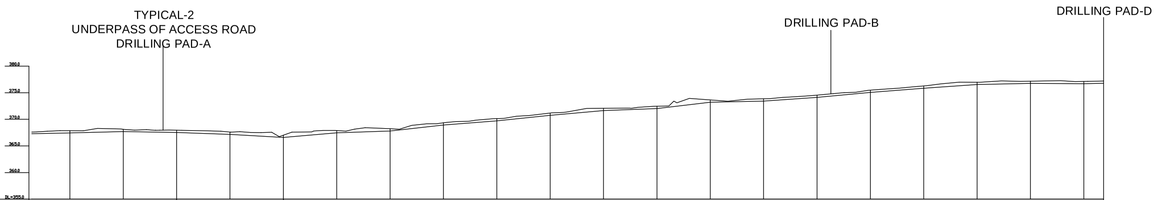
TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

DRAWING TITLE:

PLAN AND PROFILE OF PIPELINE STA.10+100-13+500

SCALE	SHEET NO.	DRAWING NO.	REV. NO.
1:10,000		PP-05	





VERTICAL GEOMETRY	i=−0.575% L=400.00				i=−0.460% L=200.00		i=0.662% L=1537.00														
FINISH ELEVATION	367.44	367.69	367.52	367.17	366.60	367.47	367.80	368.91	369.71	370.74	371.63	372.02	373.23	373.44	374.13	375.06	375.84	376.55	376.75	376.70	376.77
EXISTING ELEVATION	367.86	368.12	367.95	367.60	367.02	367.89	368.23	369.34	370.14	371.17	372.06	372.45	373.65	373.86	374.55	375.49	376.27	376.98	377.17	377.12	377.20
STATION	13+300	13+400	13+500	13+600	13+700	13+800	13+900	14+000	14+100	14+200	14+300	14+400	14+500	14+600	14+700	14+800	14+900	15+000	15+100	15+200	15+237
HORIZONTAL GEOMETRY	ND 30-DEGREE BEND	T-SHAPE PIPE													T-SHAPE PIPE						45-DEGREE BEND

JAPAN INTERNATIONAL COOPERATION AGENCY

REMARKS:

CLIENT:

ETIOPIA ELECTRIC POWER

TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

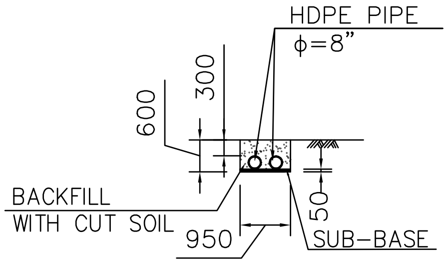
DRAWING TITLE:

PLAN AND PROFILE OF PIPELINE STA.13+500-15+237

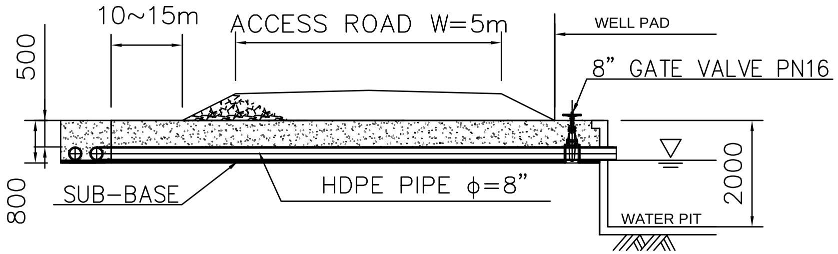
SCALE	SHEET NO.	DRAWING NO.	REV. NO.
1:10,000		PP-06	

TYPICAL CROSS SECTION

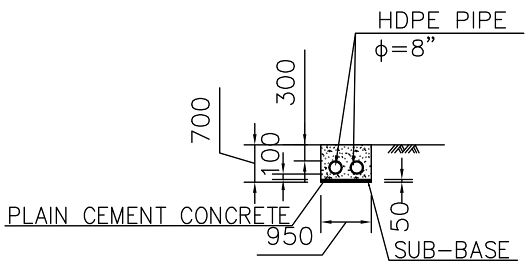
TYPICAL-1
SCALE1:100



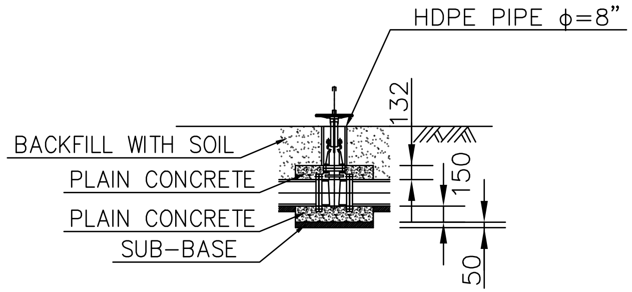
TYPICAL-2
UNDERPASS OF
ACCESS ROAD
SCALE1:100



TYPICAL-3
BEND PORTION
PROTECTION CONCRETE
SCALE1:100



DETAIL-1
GATE VALVE
SCALE1:50



JAPAN INTERNATIONAL COOPERATION AGENCY

CLIENT:

ETIOPIA ELECTRIC POWER

REMARKS:

TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

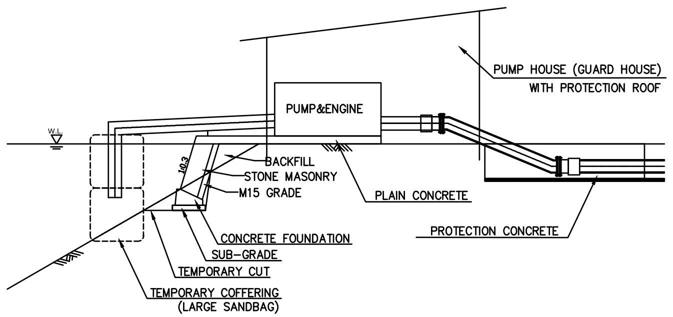
DRAWING TITLE:

TYPICAL CROSS SECTION (PIPELINE)

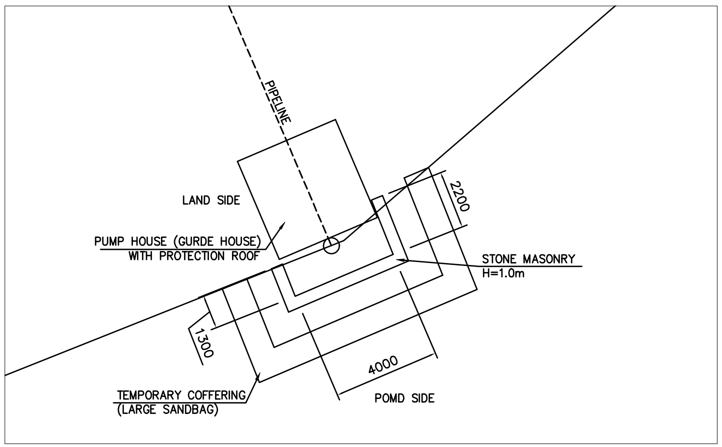
SCALE	SHEET NO.	DRAWING NO.	REV. NO.
-		PP-07	

DETAILS OF PIPELINE
(SCALE 1:100)

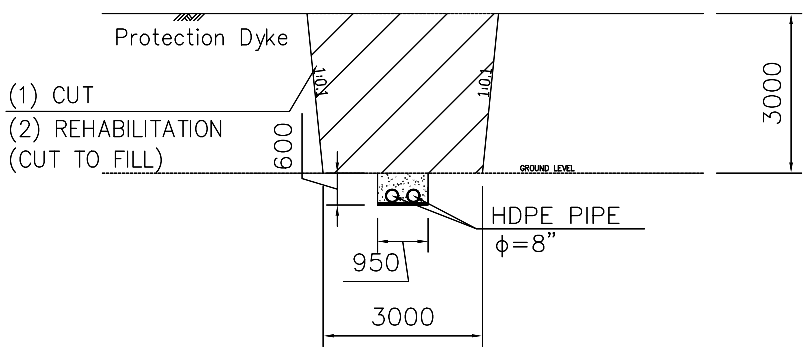
DETAIL-2
PUMP STATION & SUCTION PIPE
CROSS-SECTION VIEW
SCALE1:100



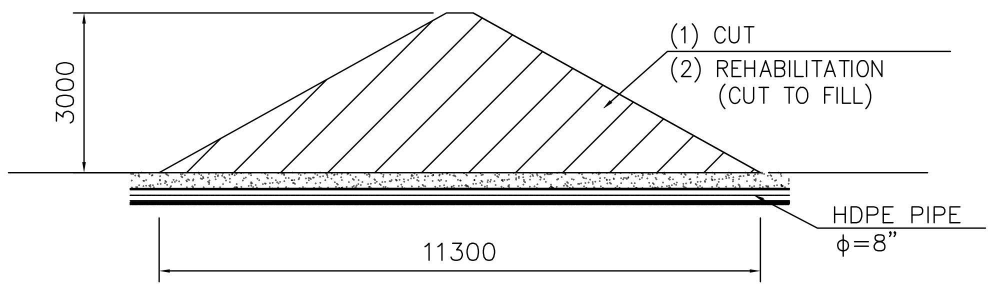
PLANE VIEW
SCALE1:200



DETAIL-3
CROSSING PROTECTION DYKE
CROSS-SECTION VIEW
SCALE1:100



LONGITUDINAL CROSS-SECTION VIEW
SCALE1:100



JAPAN INTERNATIONAL COOPERATION AGENCY

CLIENT:

ETIOPIA ELECTRIC POWER

REMARKS:

TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT

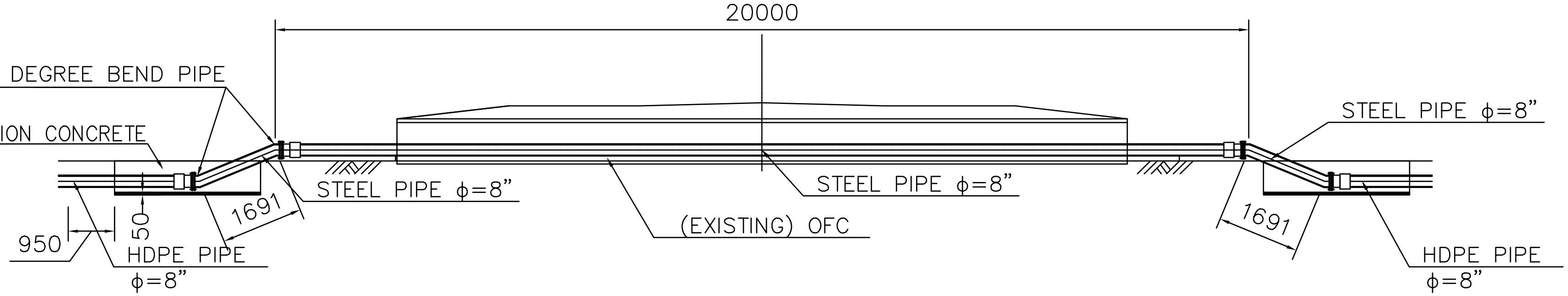
DRAWING TITLE:

DETAILS OF PIPELINE WORKS

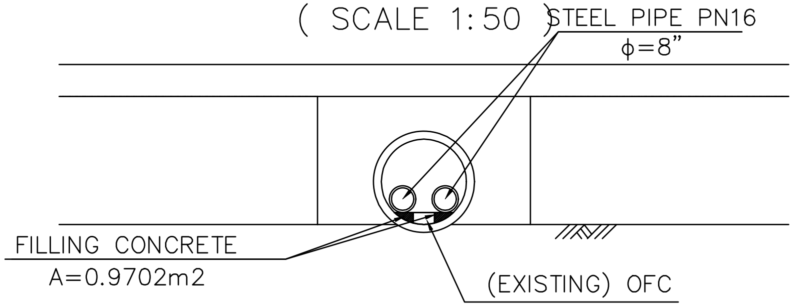
SCALE	SHEET NO.	DRAWING NO.	REV. NO.
-		PP-08	

DETAIL–4
CROSSING CULVERT

CROSS–SECTION VIEW
(SCALE 1:100)

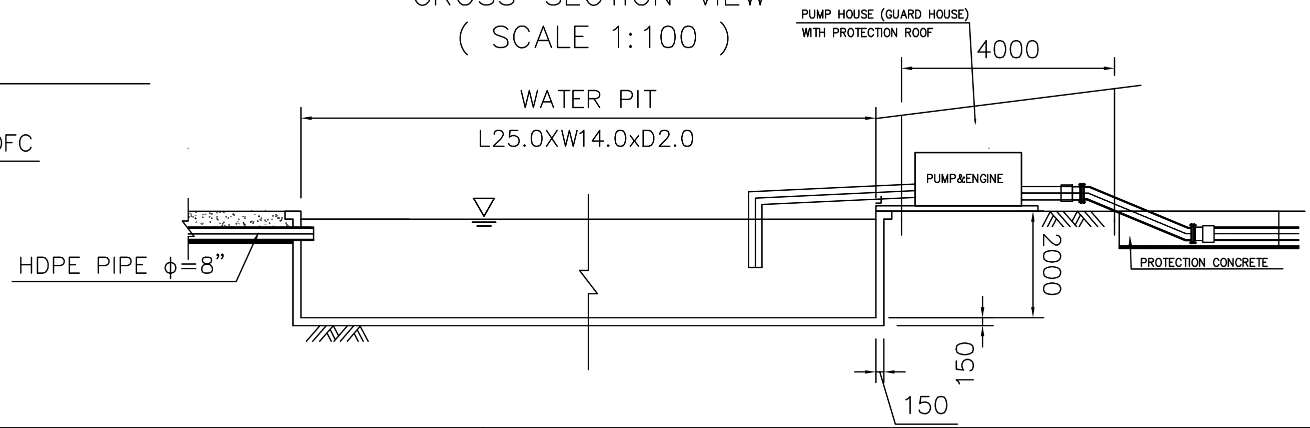


FRONT VIEW
(SCALE 1:50)



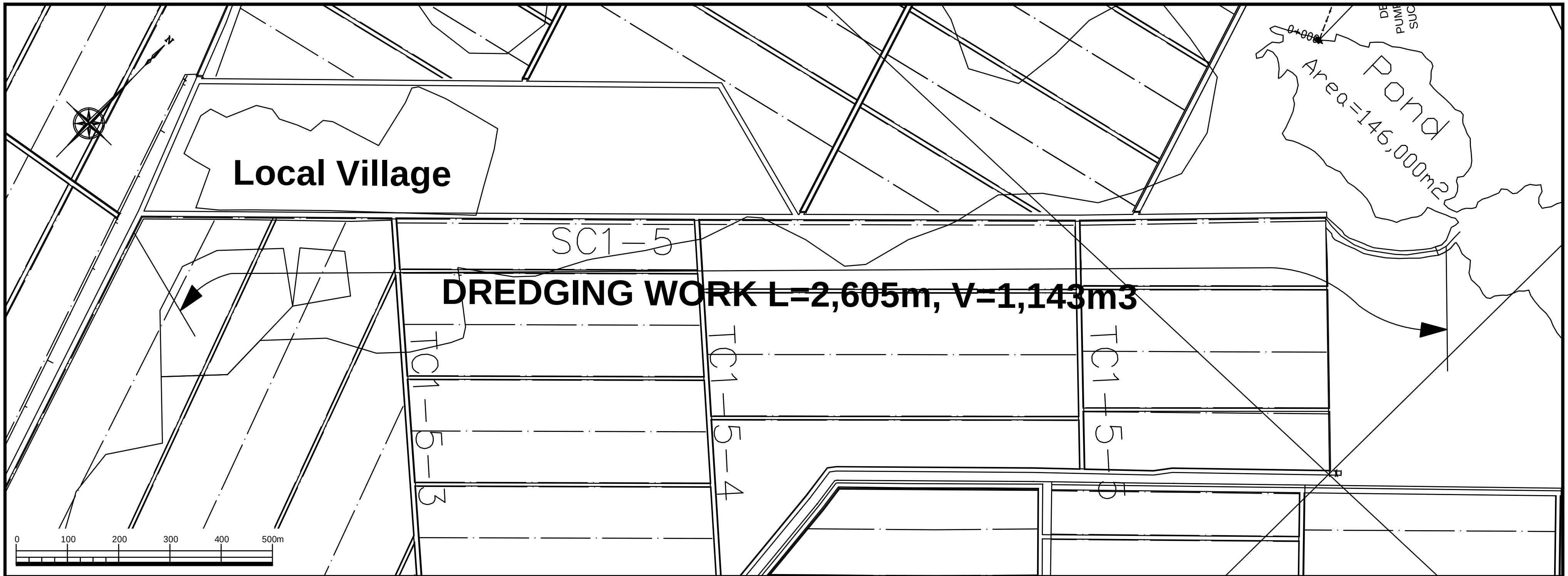
DETAIL–5
RELAY PUMP STATION

CROSS–SECTION VIEW
(SCALE 1:100)

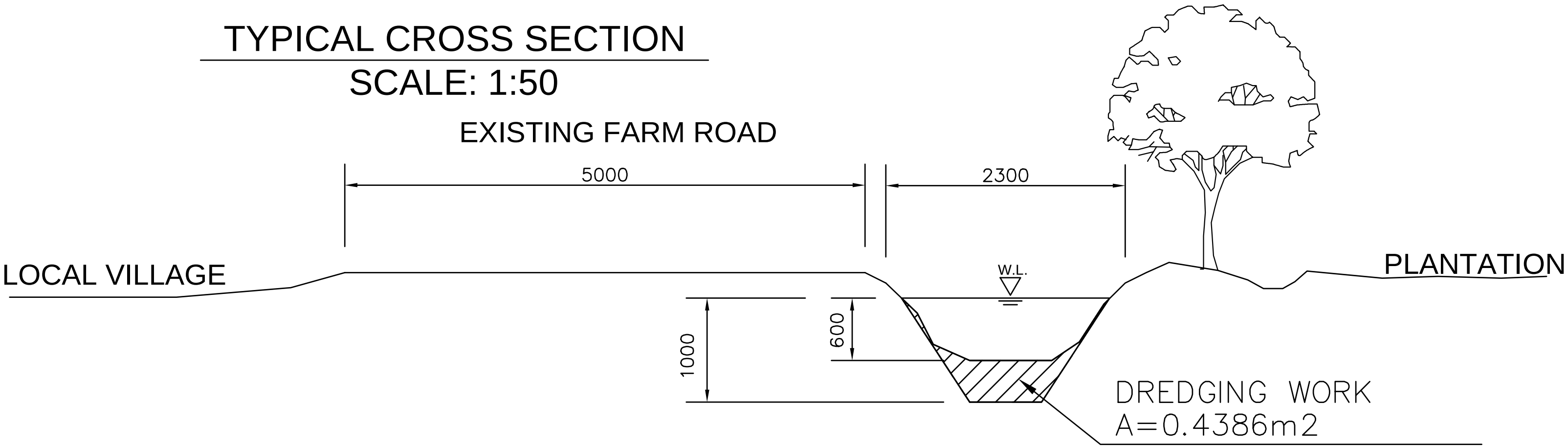


JAPAN INTERNATIONAL COOPERATION AGENCY	REMARKS:
CLIENT: ETIOPIA ELECTRIC POWER	

TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT			
DRAWING TITLE: DETAILS OF PIPELINE WORKS			
SCALE	SHEET NO.	DRAWING NO.	REV. NO.
-		PP-09	



TYPICAL CROSS SECTION
SCALE: 1:50



JAPAN INTERNATIONAL COOPERATION AGENCY	REMARKS:	TENDAHO GEOTHERMAL TEST WELL DRILLING PROJECT
CLIENT: ETIOPIA ELECTRIC POWER		DRAWING TITLE: DREDGING WORK IN SC1-5

SCALE	SHEET NO.	DRAWING NO.	REV. NO.
-		PP-10	

Quantity Calculation

ACCESS ROAD AND DRILLING PAD CONSTRUCTION

Item No.	Item	Description	Unit	Qty
P0	**Mobilization and demobilization**		L.S.	1
P1	**Road Construction**			
P1.1	Clearing and Grubbing		Ha	3.848
P1.2	Gravel Wearing course and Shoulder constructed from gravel taken from cut or borrow pits		m3	22,999
P1.3	Concrete Pipe Culvert		m	18.0
P2	**Drilling Pad Construction**			
P2.1	Clearing and Grubbing		Ha	2.828
P2.2	Cut and Borrow to Fill		m2	28,275
P2.3	Cut to Spoil (for Mud Pit)	W15xL35xD1m	m2	2,100
P2.4	Cut to Spoil (for Water Pit)	W14xL35xD2m	m3	4,341
P2.5	Cast in situ concrete (Plain Concrete for Water Pit)	Thickness=15cm	m3	733
P2.6	Cast in situ concrete (Reinforced Concrete for Rig Base)	Thickness=15cm	m3	420
P2.7	Steel Reinforcement for Structure (Steel bar D13)		ton	8.00
P2.8	Steel Reinforcement for Structure (Steel bar D10)		ton	10.03
	Total (P0+P1+P2)			
P3	**Contingencies**			
P3.1	Contingency		%	10.0
P3.2	Quality Control		%	5.0
P3.3	Work Charged Establishment		%	20.0
P3.4	Agency Charge		%	8.0

Technical Specification

Item No.	Ref. No.	DESCRIPTION
P0		**Mobilization and demobilization**
	Item 12.01	General Requirements and Provisions
	Item 13.01	Contractor's Establishment on Site
	Item 16.01~07	Social, Health, Safety and Environmental Protection and Mitigation Measures
P1		**Access Road Construction**
P1.1	Item 21.01	Clearing and Grubbing
		The clearing of the site and grubbing necessary for the construction of the permanent works in accordance with these Specifications; and the removal and disposal of materials resulting from clearing and grubbing. This work shall also include the preservation from injury or defacement of all vegetation and objects
P1.2	Item 54.01 a)	Gravel Wearing course and Shoulder constructed from gravel taken from cut or borrow pits
		Gravel wearing course from natural gravels. The gravel wearing course shall be constructed to the dimensions and cross sectional profiles shown on the Drawings.
P1.3	Item 32.03 c)	Concrete Pipe Culvert
		The construction of in-situ drainage culverts for new works, together with inlet and outlet structures, and other appurtenant structures at the locations and to the dimensions shown on the Drawings or as directed by the Engineer. All concrete works for culverts shall be in line with the requirements of Divisions 8200, 8300, 8400 and T8000 of Series 8000 in ERA standard.
P2		**Drilling Pad Construction**
P2.1	Item 21.01	Clearing and Grubbing
		The clearing of the site and grubbing necessary for the construction of the permanent works in accordance with these Specifications; and the removal and disposal of materials resulting from clearing and grubbing. This work shall also include the preservation from injury or defacement of all vegetation and objects
P2.2	Item42.01 b) (iii)	Cut and Borrow to Fill
		The work in connection with the excavation, stockpiling and use (or otherwise) of soil and rock within the
P2.3	Item 42.03	Cut to Spoil (for Mud Pit)
		The work in connection with the excavation, stockpiling and use (or otherwise) of soil and rock within the
P2.4	Item 42.03	Cut to Spoil (for Water Pit)
		The work in connection with the excavation, stockpiling and use (or otherwise) of soil and rock within the
P2.5	Item 84.01 a)	Cast in situ concrete (Plain Concrete for Water Pit)
		The placing, curing and testing of concrete used in the works where plain concrete (Class C 30/20 concrete) is specified.
P2.6	Item 84.01 a)	Cast in situ concrete (Reinforced Concrete for Rig Base)
		The placing, curing and testing of concrete used in the works where reinforced concrete is specified.
P2.7	Item 83.01 a)	Steel Reinforcement for Structure (Steel bar D13)
		The furnishing and placing of steel reinforcement in concrete structures (Rig base)
P2.8	Item 83.01 a)	Steel Reinforcement for Structure (Steel bar D10)
		The furnishing and placing of steel reinforcement in concrete structures (Rig base)

Quantity Calculation for Access Road

A1.1 Clearing and Grubbing Road Land.

	Length		Width		A (m2)	
Main Road	7516.24	*	5.0	=	37581.20	
Side Lay-by	300.00	*	3.0	=	900.00	
Total			ΣA	=	**38481.20**	m2
				=	**3.85**	Ha

No. of Side Lay-by is 6.

A1.2 Fill of Borrowed Material and Compaction

	Length	*	A			=	V (m3)	
Main Road	7516.24	*	3.0			=	22548.72	
	Length	*	Width	*	Thickness	=	V (m3)	
Side Lay-by	300	*	3.0	*	0.5	=	450.00	
					ΣV	=	**22998.72**	m3

Course Aggregate for Hume Pipe

	Length	*	Width	*	Thickness	=	V (m3)	
Course Aggregate	9	*	1.0	*	0.1	=	0.90	
			V	*	No.			
	ΣV	=	0.90	*	2.0	=	**1.80**	m3

Setting of Hume pipe

Item	Length	*	No.	*		=	L (m3)	
Length	9	*	2	*		=	18.00	m
					ΣL	=	**18**	m

Hume pipe

Item	Length	*	No.	*		=	L (m3)	
Pipe Length	9	*	2	*		=	18.00	m
					ΣL	=	**18**	m

Quantity Calculation for Drilling Pad

Site Clearing

PAD	Narrow Side	*	Wide Side	=	A (m2)	
PAD-A	65	*	120	=	7800	
PAD-B	65	*	105	=	6825	
PAD-C	65	*	105	=	6825	
PAD-D	65	*	105	=	6825	
Total			ΣA	=	**28275**	m2
				=	**2.8275**	Ha

Soil Excavation for Mud Pit

PAD	Narrow Side	*	Wide Side	*	Depth	=	V (m3)	
PAD-A	15	*	35	*	1	=	525	
PAD-B	15	*	35	*	1	=	525	
PAD-C	15	*	35	*	1	=	525	
PAD-D	15	*	35	*	1	=	525	
					ΣV	=	**2100**	m3

Soil Excavation for Water Pit

PAD	Narrow Side	*	Wide Side	*	Depth	=	V (m3)	
PAD-A	14.3	*	35.3	*	2.15	=	1085.30	m3
PAD-B	14.3	*	35.3	*	2.15	=	1085.30	m3
PAD-C	14.3	*	35.3	*	2.15	=	1085.30	m3
PAD-D	14.3	*	35.3	*	2.15	=	1085.30	m3
					ΣV	=	**4341.194**	m3

Plain Concrete for Water Pit

Item	Narrow Side	*	Wide Side	*	Thickness	=	V (m3)	
Slab	14.3	*	35.3	*	0.3	=	151.44	m3
	Length	*	Depth	*	Thickness			
Wall	98.6	*	2	*	0.15	=	29.58	m3
	Length							
Edge	98.6	*	0.15	*	0.15	=	2.22	m3
					No. Pad		4	
					ΣV	=	**732.94**	m3

Concrete Basement

PAD	Narrow Side	*	Wide Side	*	Thickness	=	V (m3)	
PAD-A	20	*	50	*	0.15	=	150	m3
PAD-B	20	*	35	*	0.15	=	105	m3
PAD-C	20	*	20	*	0.15	=	60	m3
PAD-D	20	*	35	*	0.15	=	105	m3
					ΣV	=	**420**	m3

Steel Bar D13

PAD	Length	*	No.					
PAD	19.9	*	101	=	2009.9	m		
	Length	*	No.					
Total Length	2009.9	*	4	=	8039.6	m		
			ΣL	=	8039.6	m	D13	0.995 kg/m
			Weight	=	**8.00**	ton		

Steel Bar D10

PAD	Length	*	No.				Wide Side
PAD-A	49.9	*	168	=	8383.2	m	50

PAD-B	34.9	*	117	=	4083.3	m		35	
PAD-C	19.9	*	68	=	1353.2	m		20	
PAD-D	34.9	*	117	=	4083.3	m		35	
			ΣL	=	**17903.0**	m	D10	0.56	kg/m
			Weight	=	**10.03**	ton			

WATER SUPPLY SYSTEM CONSTRUCTION

Item No.	Item	Description	Unit	Qty
P0	**Mobilization and demobilization**		L.S.	1
P1	**Water Supply System**			
P1.1	Clearing and Grubbing	Work Space Width=3m	Ha	4.571
P1.2	Soil Excavation for Pipeline		m3	8,708.27
P1.3	Laid down of HDPE Water Pipe	8" dia.	m	30,438.00
P1.4	Material Cost of HDPE Pipe	8" dia.	m	30,438.00
P1.5	Cut to Fill (Backfill with Cut Material)		m3	6,490.86
P1.6	Connection of Suction Pipe		m	34.40
P1.7	Material Cost of Suction Pipe		m	34.40
P1.8	Stone Masonry Soil Retaining Wall (Suction Pipe)		m3	8.55
P1.9	Temporary Coffering with Large Sandbag		m3	30.89
P1.10	Installation of Water Pump		ea.	4
P1.11	Material Cost of Water Pump	including Generator	ea.	4
P1.12	Pump House (Water Pump Station)		ea.	2
P1.13	Cut to Fill (Rehabilitation of Protection Dyke)	Soil Embankment	m3	53.10
P1.14	Material Cost of 45-degree Bend Pipe	8" dia. HDPE Pipe	ea.	8
P1.15	Protection Plain Concrete		ea.	25
P1.16	Laid down of Steel Pipe Crossing Culvert	8" dia. Steel Pipe	m	46.76
P1.17	Material Cost of Steel Pipe with Flinge	8" dia. Steel Pipe	m	46.76
P1.18	Material Cost of 30-degree Bend Pipe	8" dia. HDPE Pipe	ea.	6
P1.19	Cut to Spoil (for Water Pit)	W14xL35xD2m	m3	1,085.30
P1.20	Cast in situ concrete (Plain Concrete for Water Pit)	Thickness=15cm	m3	183.24
P1.21	Material Cost of T-shape Connection Pipe	8" dia.	ea.	6
P1.22	Intallation of Gate Valve	8" dia. Gate Valve	ea.	8.0
P1.23	Material Cost of Gate Valve	8" dia. Gate Valve, PN16	ea.	8.0
P1.24	Flow Test		times	2.0
P1.25	Maintenance and Operation		month	12.0
P1.26	Fuel for Diesel Engine		Litter	13,608.0
P1.27	Dismantle of Water Pump	including Generator	ea.	4.0
P1.28	Cut to Spoil (for Dredging Work)		m3	1,142.55

Technical Specification

Item No.	Ref. No.	DESCRIPTION
P0		**Mobilization and demobilization**
	ERA Item 12.01	General Requirements and Provisions
	ERA Item 13.01	Contractor's Establishment on Site
	ERA Item 16.01~07	Social, Health, Safety and Environmental Protection and Mitigation Measures
P1		**Water Supply System**
P1.1	ERA Item 21.01	Clearing and Grubbing
		The clearing of the site and grubbing necessary for the construction of the permanent works in accordance with these Specifications; and the removal and disposal of materials resulting from clearing and grubbing. This work shall also include the preservation from injury or defacement of all vegetation and objects designated to remain.
P1.2	ERA Item 54.01 a)	Soil Excavation for Pipeline
		Gravel wearing course from natural gravels. The gravel wearing course shall be constructed to the dimensions and cross sectional profiles shown on the Drawings.
P1.3	-	Laid down of HDPE Water Pipe
		- Laid down and fixing HDPE pipe in excavated ditch - Laid down bend and T-shape pipe at indicated points, and connect to pipes - Sub-base with 5cm in thickness under HDPE pipe - Connection of each pipes by fusion splicing
P1.4	-	Material Cost of HDPE Pipe
		- Pipe Type: HDPE Pipe (High-Density Polyethylene Pipe) - Diameter: 8 inches (200mm) - Maximum Allowable Pressure: 0.8MPa
P1.5	ERA Item 44.01 a)	Cut to Fill (Backfill with Cut Material)
		All work in connection with the construction of backfill within the pipeline alignment using soil or rock excavated from the pipe line in accordance with Division 4200 and conforming with the lines, grades, cross-section and dimensions shown on the Drawings, or as instructed by the Engineer.
P1.6	-	Connection of Suction Pipe
		- Connection suction pipe to pump - Set pipe stand at the top pf masonry wall - Put suction pipe at more than 1.0m in depth
P1.7	-	Material Cost of Suction Pipe
		- Steel pipe with 8-inch in diameter - Including 90-degree bend pipe, foot valve, flanges, adjuster, filter, etc.
P1.8	EEP Spec.	Stone Masonry Soil Retaining Wall (Suction Pipe)
	Ref.4820 4.01	- Stone masonry wall for foundation of suction pipe
P1.9	-	Temporary Coffering with Large Sandbag
		- Making coffer dam to dry up around planned site of masonry wall - Size of large sandbag is 1m cubic meter - Including dismantle of the sandbags
P1.10	-	Installation of Water Pump
		- Fixing water pump and generator on concrete slab in pump house - Connection pump to generator, suction pipes, main pipeline
P1.11	-	Material Cost of Water Pump
		- Total Pump Head: 20m - Flow Rate: 0.75m3/min - Handled Fluid: Clear Water (Lake Water) - Total Pump Head for Suction: -6m - Use Place: Outdoor (Inside pump house) - Including generator with necessary capacity - Including necessary accessary such as casing, flange, etc.
P1.12	EEP Spec.	Pump House (Water Pump Station)
	Bill No.3	- Store 2 sets of pump and generator - Steel wire fence with 2m in height (No brick wall for aeration) - Protection roof, lockable door
P1.13	ERA Item 44.01 a)	Cut to Fill (Rehabilitation of Protection Dyke)
		All work in connection with the construction of backfill within the pipeline alignment using soil or rock excavated from the pipe line in accordance with Division 4200 and conforming with the lines, grades, cross-section and dimensions shown on the Drawings, or as instructed by the Engineer. - Rehabilitation of excavated protection dyke with 3m high.
P1.14	-	Material Cost of 45-degree Bend Pipe
		- HDPE pipe with 8-inch in diameter - Maximum Allowable Pressure: 0.8MPa
P1.15	ERA Item 84.01 a)	Protection Plain Concrete
		The placing, curing and testing of concrete used in the works where plain concrete (Class C 30/20 concrete) is specified. - Placing plain concrete instead of backfill to fix pipe at bend parts.
P1.16	-	Laid down of Steel Pipe Crossing Culvert
		- Placing and fixing steel pipe with 8-inch in diameter in and around existing culvert.
P1.17	-	Material Cost of Steel Pipe with Flinge

		- Steel pipe with 8-inch in diameter - Including 22-1/2-degree bend pipe and flanges, etc.
P1.18	-	Material Cost of 30-degree Bend Pipe
		- HDPE pipe with 8-inch in diameter - Maximum Allowable Pressure: 0.8MPa
P1.19	ERA Item 42.03	Cut to Spoil (for Water Pit)
		The work in connection with the excavation, stockpiling and use (or otherwise) of soil and rock within the site.
P1.20	ERA Item 84.01 a)	Cast in situ concrete (Plain Concrete for Water Pit)
		The placing, curing and testing of concrete used in the works where plain concrete (Class C 30/20 concrete) is specified. - Placing plain concrete for slab and wall of water pit.
P1.21	-	Material Cost of T-shape Connection Pipe
		- HDPE pipe with 8-inch in diameter - Maximum Allowable Pressure: 0.8MPa
P1.22	-	Intallation of Gate Valve
		- Gate valve with 8-inch in diameter - Laid down gate valve and connect to pipes - Installation of hand hole for hand wheel of gate valve
P1.23	-	Material Cost of Gate Valve
		- Gate valve with 8-inch in diameter - Including hand wheel, flange, etc
P1.24	-	Flow Test
		- Comissioning pump and testing flow rate - Adjusting pump and pipes after test
P1.25	-	Maintenance and Operation
		- Dispatch a guard man at two pump stations for 24 hours everyday throughout drilling work period (12 months) - Start pump in order to fill water in water pit at both intermeadiate reservoir and drilling pad - Delivery and supply fuel into generator
P1.26	-	Fuel for Diesel Engine
		- Diesel oil for generator
P1.27	-	Dismantle of Water Pump
		- Dismantle of 4 sets of water pump from pump stations after completion of drilling work.

Quantity Calculation for Pipeline Construction

P1.1 Clearing and Grubbing Road Land.

	Length		Width		A (m2)	
	Length	*	Width	=	A (m2)	
Pipeline Alignment	15237	*	3.0	=	45711.00	
Total			ΣA	=	**45,711.00**	m2
				=	**4.57**	Ha

P1.2 Soil Excavation for Pipeline

Length of All Alignment			L	=	15237	m
Connection to Pad-A and C	20	*	2.0	=	40	m
Connection to Pad-B	5	*	1.0	=	5	m
Connection to Pad-D	7	*	1.0	=	7	m
			ΣL	=	15,289	m

Subtraction			Length	
Length of Crossing Culvert Portion	L	=	35	m
Length of Intermediate Reservoir	L	=	35	m
	ΣL	=	70	m

Total Length of Alignment to be excavated	ΣL	=	15,219	m

	Length		Width		Depth			
(a) Voulume of Excavation	15,219	*	0.95	*	0.60	=	8674.83	m3

(b) Surplus Volume for Underpass of Access Road Portions in Pad-A and C

Underpass of Access Road	L	=	20	m
Connection to T-shape Pipe	L	=	50	m
	ΣL	=	70	m
Pad-A and C	n	=	2	
	ΣL	=	140	m

Length		Width		Depth			
140	*	0.95	*	0.2	=	26.60	m3

(c) Surplus Volume for Connection to Pad-B and D

	Length		Width		Depth			
Pad-B	5	*	0.95	*	0.6	=	2.85	m3
Pad-D	7		0.95	*	0.6	=	3.99	m3
					V	=	6.84	m3
Total Volume of Soil Excavation	(a+b+c)				ΣV	=	**8708.27**	m3

P1.3 Laid down of HDPE Water Pipe

P1.4 Material Cost of HDPE Pipe

Length of All Alignment			L	=	15237	m
Connection to Pad-A and C	20	*	2.0	=	40	m
Connection to Pad-B	5	*	1.0	=	5	m
Connection to Pad-D	7	*	1.0	=	7	m
			ΣL	=	15,289	m

Subtraction			Length	
Length of Crossing Culvert Portion	L	=	35	m
Length of Intermediate Reservoir	L	=	35	m
	ΣL	=	70	m

Sub-total Length of Alignment per each	ΣL	=	15,219	m

	The number of lines			n	=	2		
	Total Length of Alignment			ΣL	=	**30,438** m		
P1.5	**Cut to Fill (Backfill with Cut Material)**							
	Total Length of HDPE Pipe			ΣL	=	15,219 m		
		Area		No.				
	Volume of HDPE Pipe	0.049	*	2	*	15,219	=	1494.51 m3
	-OD=0.25, 2 lines							
	Sub-Base	0.0475	*	15,219	=	722.90 m3		
	Volume of Backfill	8708.27	-	1494.51	-	722.90	=	**6490.86** m3
P1.6	**Connection of Suction Pipe**							
P1.7	**Material Cost of Suction Pipe**							
	Length of Suction Pipe per each	L	=	4.30 m				
	The number of Pumps	n	=	4				
	Sub-total Length	ΣL	=	17.2 m				
	The number of lines	n	=	2				
	Total Length of Alignment	ΣL	=	**34.4** m				
P1.8	**Stone Masonry Soil Retaining Wall (Suction Pipe)**							
		Length	*	Area	=	V (m3)		
	Volume of Stone Masonay	7.5	*	1.1399	=	8.55 m3		
	*including Concrete Slab in Pump Station			ΣV	=	**8.55** m3		
P1.9	**Temporary Coffering with Large Sandbag**							
		Length	*	Area	=	V (m3)		
	Volume of Coffer Dam	15.444	*	2.00	=	30.89 m3		
				ΣV	=	**30.89** m3		
P1.10	**Installation of Water Pump**							
P1.11	**Material Cost of Water Pump**							
	The number of Water Pumps	n	=	**4**				
P1.12	**Pump House (Water Pump Station)**							
	The number of Water Pump Sta.	n	=	**2**				
P1.13	**Cut to Fill (Rehabilitation of Protection Dyke)**							
				Area				
	Volume of Embankment	3.000	*	17.70	=	53.10 m3		
				ΣV	=	**53.10** m3		
P1.14	**Material Cost of 45-degree Bend Pipe**							
	The number of Bend Pipes	n	=	**8**				
	Sta.0+700							
	Sta.2+010							
	Sta.2+300							
	Sta.15+237							
P1.15	**Protection Plain Concrete**							
	The number of Work Places	n	=	**16**				
	Sta.0+000							
	Sta.0+700							
	Sta.2+010							

Sta.2+260
Sta.2+280
Sta.2+300
Sta.2+320
Sta.4+700
Sta.5+300
Sta.7+900
Sta.11+900
Sta.13+160
Sta.13+400
Sta.13+480
Sta.14+720
Sta.15+237

			Length	*	No.	=	V (m3)	
Volume of Plain Concrete	0.5193	*	3	*	16	=	24.93	m3
					V	=	**24.93**	m3

P1.16 Laid down of Steel Pipe Crossing Culvert

P1.17 Material Cost of Steel Pipe with Flange

Length	L	=	23.382	m
The number of lines	n	=	2	
Total Length of Alignment	ΣL	=	**46.8**	m

P1.18 Material Cost of 30-degree Bend Pipe

The number of Bend Pipes	n	=	**6**

Sta.2+320
Sta.13+160
Sta.13+400

P1.19 Cut to Spoil (for Water Pit)

	Narrow Side	*	Wide Side	*	Depth	=	V (m3)	
Excavation Volume	14.3	*	35.3	*	2.15	=	1085.30	m3
					ΣV	=	**1085.30**	m3

P1.20 Cast in situ concrete (Plain Concrete for Water Pit)

Item	Narrow Side	*	Wide Side	*	Thickness	=	V (m3)	
Slab	14.3	*	35.3	*	0.3	=	151.44	m3
	Length	*	Depth	*	Thickness			
Wall	98.6	*	2	*	0.15	=	29.58	m3
	Length							
Edge	98.6	*	0.15	*	0.15	=	2.22	m3
					ΣV	=	**183.24**	m3

P1.21 Material Cost of T-shape Connection Pi	n	=	**6**

Sta.11+900
Sta.13+480
Sta.14+720

P1.22 Intallation of Gate Valve

P1.23 Material Cost of Gate Valve	n	=	**8**

Sta.11+900
Sta.13+480
Sta.14+720
Sta.15+237

P1.24	Flow Test						
	The number of tests	n	=	**2**			
P1.25	Maintenance and Operation						
	Drilling Work Period including Rig Shift			**12**	month		
P1.26	Fuel for Diesel Engine						
	Fuel Consumption Rate			2.1	Litter/hour		
	Drilling Work Period			270	days		
	Diesel Oil for Generator	V	=	**13,608**	Litter		
P1.27	**Dismantle of Water Pump**	n	=	**4**			
P1.28	**Cut to Spoil (for Dredging Work)**						
		Area	*	Wide Side	=	V (m3)	
	Excavation Volume	0.4386	*	2605	=	1142.55	m3
				ΣV	=	**1142.55**	m3

Specifications (Access Road and Drilling Pad)

Annex 8 Specification

Specification for the design of the access road and drilling pads for JICA Geothermal Development Support Project in Ethiopia

1. Project site

   Semera, Afar Region

2. Access road to drilling pads

2.1. General descriptions

The access road shall connect from the National road 12 to the drilling pad-D through pad-A, pad-B, and pad-C.

Length of the road shall be 7,539m.

General layout and typical cross sections of the road are shown in Figure-1.

The road shall be of single track with the nominal width 5 m in principle, associated with widened double truck stretches of the nominal width 8 m for dual traffic for side ray-by. The widened stretches shall be constructed approximately at every 1 km of the access road.

The road shall be constructed following the Standard Technical Specification and Methods of Measurement for Roadworks of ERA published in July 2014. The bearing capacity of the access road shall be enough CBR specified in the standard for the transportation by 20 ton class trailers. The road shall be paved with compacted pebble.

Concrete pipe culvert with 300mm in diameter shall be placed under the road material at narrow streams where deemed necessary.

2.2. Specifications and work volumes

Specifications and the work volumes for the access road construction are shown in Table-1.

3. Drilling pad construction

3.1. General description

Total four drilling pads shall be constructed. The drilling pad is a land lot where a drilling rig is erected and the drilling works are undertaken.

Construction of a drilling pad consists of (i) leveling and compacting of four land lots of 6,500m2 for pad-B and pad-D, 6825m2 for pad-C, and 7,800 m2 for pad-A, (ii) placing basement concrete on 400m2 in pad-C, and 700 m2 for pad-B and pad-D, 1000m2 in pad-A, and excavating two pits of 500m3 and 600 m3 at each drilling pad for mud pit and water pit respectively.

General layout of a drilling pad-A is as shown in Figure 3.

3.2. Specifications and work volumes

The specification and work volumes of the drilling pad construction is as shown in the Table-2. The concrete shall be of base-concrete quality with Fc not less than 24 N/mm2 with reinforcing bar of D13 @ 200mm and D10 @ 300mm.

4. Cost estimation

Based on information from local contractors, a preliminary cost estimation is as shown in Table 3.

The cost estimation for the access road is about 528 thousand USD whereas the cost estimation for the drilling pad is about 712 thousand USD.

The total cost of the civil works to be undertaken by EEP shall be 1,395 thousand USD.

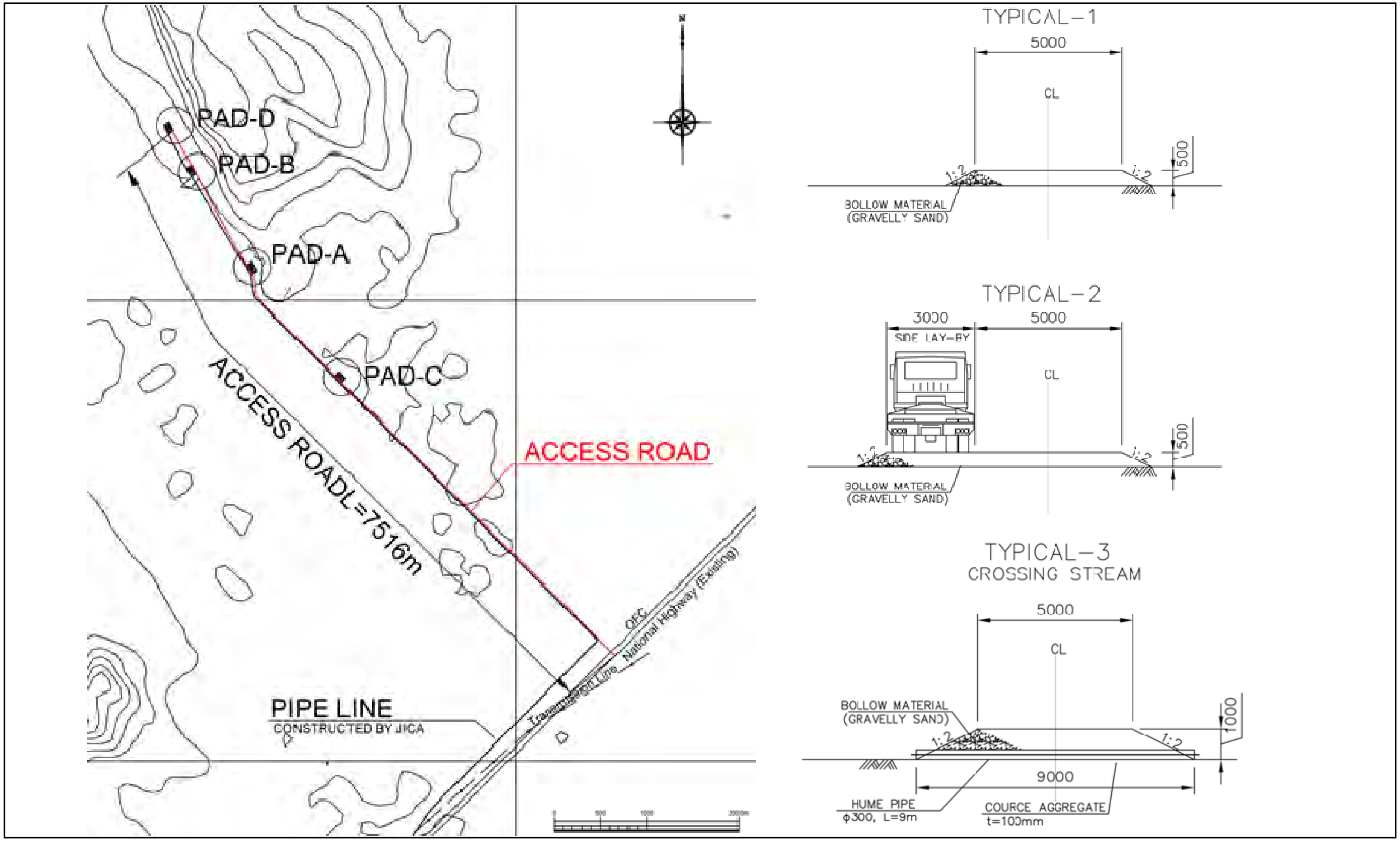


Figure-1 General layout and typical cross sections of the access road

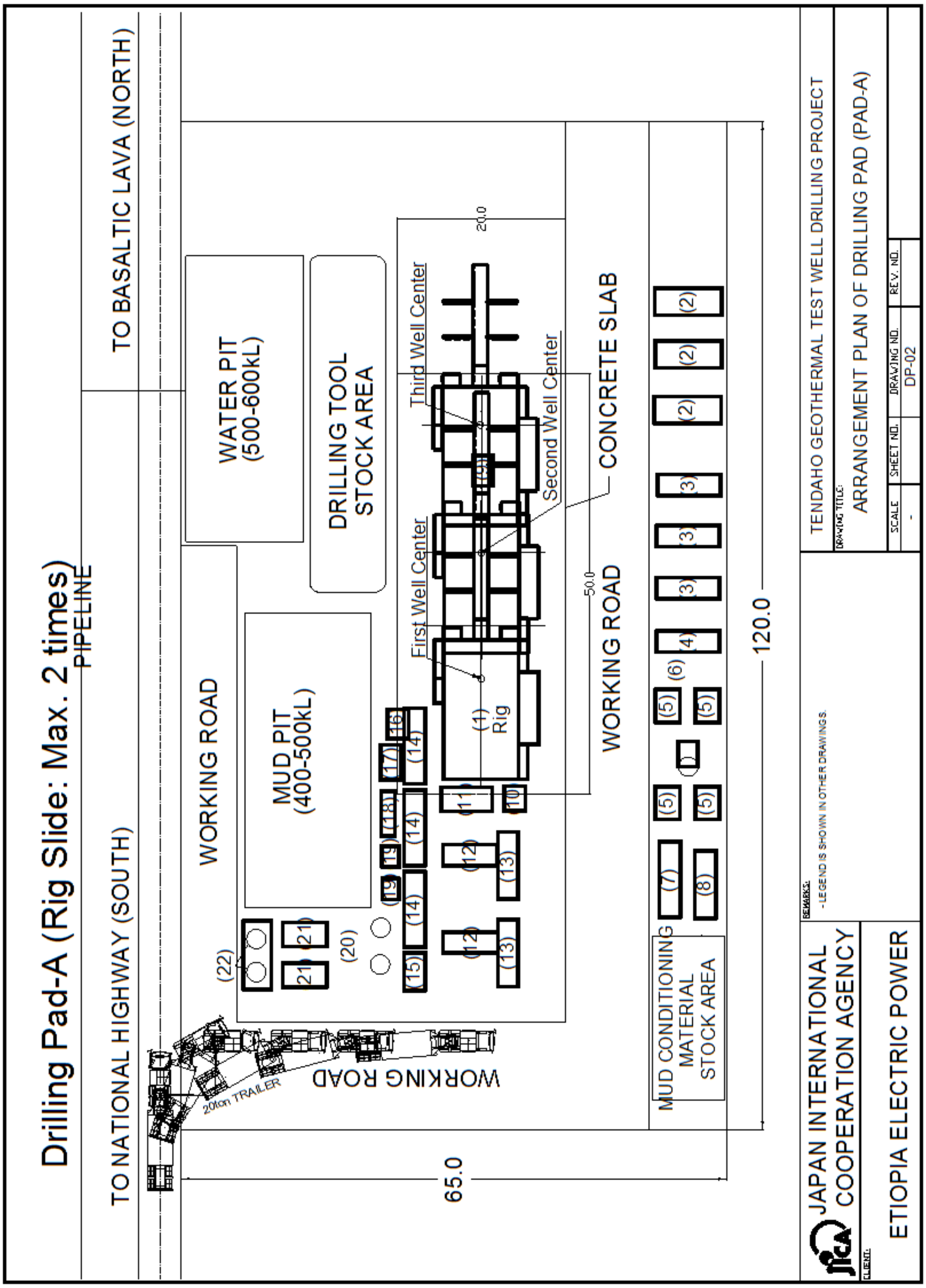


Figure-3 General layout of the drilling pad

Table-1 Specifications and work volume estimated for the access road

Item	Road Construction	Unit	Q'ty	ERA Standard
P1.1	Clearing and Grubbing	Ha	3.848	Item 21.01
P1.2	Gravel Wearing course and Shoulder constructed from gravel taken from cut or borrow pits	m3	22,999	Item 54.01 a)
P1.3	Concrete Pipe Culvert	m	18.0	Item 32.03 c)

Table-2 Specifications and work volume estimated for the drilling pad construction

Item	Drilling Pad Construction	Description	Unit	Q'ty	ERA Standard
P2.1	Clearing and Grubbing		Ha	2.828	Item 21.01
P2.2	Cut and Borrow to Fill		m2	28,275	Item42.01 b) (iii)
P2.3	Cut to Spoil (for Mud Pit)	W15xL35xD1m	m2	2,100	Item 42.03
P2.4	Cut to Spoil (for Water Pit)	W14xL35xD2m	m3	4,341	Item 42.03
P2.5	Cast in situ concrete (Plain Concrete for Water Pit)	Thickness=15cm	m3	733	Item 84.01 a)
P2.6	Cast in situ concrete (Reinforced Concrete for Rig Base)	Thickness=15cm	m3	420	Item 84.01 a)
P2.7	Steel Reinforcement for Structure (Steel bar D13)		ton	8.00	Item 83.01 a)
P2.8	Steel Reinforcement for Structure (Steel bar D10)		ton	10.03	Item 83.01 a)

Table 3. A preliminary cost estimation

Item No.	Item	Description	Unit	Cost Estimate			
				Qty	Unit Price (ETB)	Unit Price (USD)	Price (USD)
P0	**Mobilization and demobilization**		L.S.	1	3,500,000	155,383	**155,383**
P1	**Road Construction**						**527,814**
P1.1	Clearing and Grubbing		Ha	3.848	44,055	1,956	7,526
P1.2	Gravel Wearing course and Shoulder constructed from gravel taken from cut or borrow pits		m3	22,999	508	23	518,684
P1.3	Concrete Pipe Culvert		m	18.0	2,007	89	1,604
P2	**Drilling Pad Construction**						**711,784**
P2.1	Clearing and Grubbing		Ha	2.828	44,055	1,956	5,530
P2.2	Cut and Borrow to Fill		m2	28,275	400	18	502,109
P2.3	Cut to Spoil (for Mud Pit)	W15xL35xD1m	m2	2,100	606	27	56,497
P2.4	Cut to Spoil (for Water Pit)	W14xL35xD2m	m3	4,341	303	13	58,397
P2.5	Cast in situ concrete (Plain Concrete for Water Pit)	Thickness=15cm	m3	733	962	43	31,303
P2.6	Cast in situ concrete (Reinforced Concrete for Rig Base)	Thickness=15cm	m3	420	962	43	17,937
P2.7	Steel Reinforcement for Structure (Steel bar D13)		ton	8.00	50,000	2,220	17,757
P2.8	Steel Reinforcement for Structure (Steel bar D10)		ton	10.03	50,000	2,220	22,255
	Total (P0+P1+P2)						**1,394,982**

Specifications (Water Supply System)

SECTION III
TECHNICALSPECIFICATIONS

Specification of the Water Supply System for JICA Geothermal Development Support Project in Ethiopia

1 Project site

Semera, Afar Region

2 Water Supply System

2.1 General Descriptions

The water supply system shall connect from the pond in the Semera irrigation area to the drilling pad-A, B, C, and D. The system includes 2sets of pipeline and water pump for backup.

Length of the pipeline shall be 15,237m. General layout and typical cross sections of the pipeline are shown in Figure-1.

The pipeline shall be of HDPE (high-density polyethylene) pipe with 8-inch diameter in principle, and divided into two sections; from the pond to sta.7+900, and from sta.7+900 to the farthest drilling pad-D. The pump shall be set at the begging point of the sections, and shall have a capacity of total pump head with 20m.

The construction work of the pipeline shall follow the drawings and the specification. It is the responsibility of the Contractor to route all piping. Piping shall be routed in such a way so as not to interfere with other piping, OFC (optical fiber cable), electrical line or tower. Pipeline routing shall be in accordance with the guidelines presented in the Drawings. Minor changes due to differences in equipment, size or configurations will be permitted provided that such changes do not interfere with other work. Any major deviations from the layouts shown on the Drawings will be considered substitutions and shall require approval as such. All piping layouts shall be subject to approval by the Engineer prior to installation.

2.2 Specifications and Work Volumes

Specifications and the work volumes for the access road construction are shown in Table-1.

3 Cost Estimation

Based on information from local contractors, a preliminary cost estimation is as shown in Table 3.

The cost estimation for the water supply system is about USD 1.9 million. The total cost of the work shall be financed by JICA.

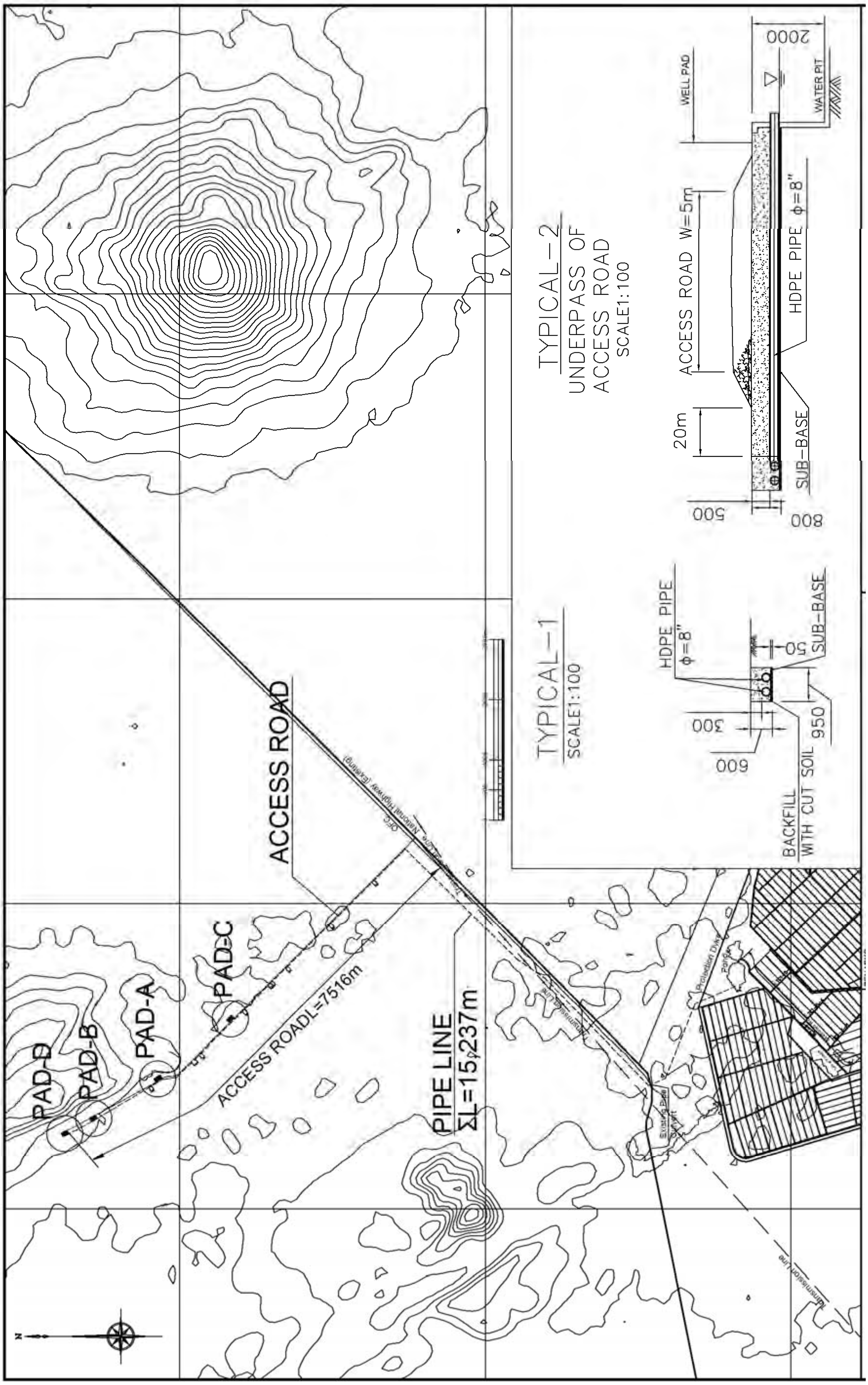


Figure-1 General Layout and Typical Cross-section of the Water Supply System

Table-2 Work Volume Estimated for the Water Supply System

Item No.	Item	Description	Unit	Qty	Standard
P0	Mobilization and demobilization		L.S.	1	ERA Item 12.01 ERA Item 13.01 ERA Item 16.01~07
P1	Water Supply System				
P1.1	Clearing and Grubbing	Work Space Width=3m	Ha	4.571	ERA Item 21.01
P1.2	Soil Excavation for Pipeline		m3	8,708.27	ERA Item 54.01 a)
P1.3	Laid down of HDPE Water Pipe	8" dia.	m	30,438.00	-
P1.4	Material Cost of HDPE Pipe	8" dia.	m	30,438.00	-
P1.5	Cut to Fill (Backfill with Cut Material)		m3	6,490.86	ERA Item 44.01 a)
P1.6	Connection of Suction Pipe		m	34.40	-
P1.7	Material Cost of Suction Pipe		m	34.40	-
P1.8	Stone Masonry Soil Retaining Wall (Suction Pipe)		m3	8.55	EEP Spec. Ref.4820 4.01
P1.9	Temporary Coffering with Large Sandbag		m3	30.89	-
P1.10	Installation of Water Pump		ea.	4	-
P1.11	Material Cost of Water Pump	including Generator	ea.	4	-
P1.12	Pump House (Water Pump Station)		ea.	2	EEP Spec. Bill No.3
P1.13	Cut to Fill (Rehabilitation of Protection Dyke)	Soil Embankment	m3	53.10	ERA Item 44.01 a)
P1.14	Material Cost of 45-degree Bend Pipe		ea.	8	-
P1.15	Protection Plain Concrete		ea.	13	ERA Item 84.01 a)
P1.16	Laid down of Steel Pipe Crossing Culvert	8" dia.	m	70.00	-
P1.17	Material Cost of Steel Pipe with Flange	8" dia.	m	70.00	-
P1.18	Material Cost of 30-degree Bend Pipe		ea.	6	-
P1.19	Cut to Spoil (for Water Pit)	W14xL35xD2m	m3	1,085.30	ERA Item 42.03
P1.20	Cast in situ concrete (Plain Concrete for Water Pit)	Thickness=15cm	m3	183.24	ERA Item 84.01 a)
P1.21	Material Cost of T-shape Connection Pipe	8" dia.	ea.	6	-
P1.22	Installation of Gate Valve	8" dia. Gate Valve	ea.	8.0	-
P1.23	Material Cost of Gate Valve	8" dia. Gate Valve	ea.	8.0	-
P1.24	Flow Test		times	2.0	-
P1.25	Maintenance and Operation		month	12.0	-
P1.26	Fuel for Diesel Engine		Litter	13,608.0	-
P1.27	Dismantle of Water Pump	including Generator	ea.	4.0	-

Table 2. A Preliminary Cost estimation

Item No.	Item	Description	Unit	Qty	Cost Estimate	
					Unit Price (USD)	Price (USD)
P0	**Mobilization and demobilization**		L.S.	1	155,383	**155,383**
P1	**Water Supply System**					**1,744,757**
P1.1	Clearing and Grubbing	Work Space Width=3m	Ha	4.571	1,956	8,940
P1.2	Soil Excavation for Pipeline		m3	8,708.27	13	117,141
P1.3	Laid down of HDPE Water Pipe	8" dia.	m	30,438.00	7	213,297
P1.4	Material Cost of HDPE Pipe	8" dia.	m	30,438.00	38	1,163,469
P1.5	Cut to Fill (Backfill with Cut Material)		m3	6,490.86	6	40,725
P1.6	Connection of Suction Pipe		m	34.40	7	241
P1.7	Material Cost of Suction Pipe		m	34.40	162	5,580
P1.8	Stone Masonry Soil Retaining Wall (Suction Pipe)		m3	8.55	42	360
P1.9	Temporary Coffering with Large Sandbag		m3	30.89	6	193
P1.10	Installation of Water Pump		ea.	4	6,659	26,637
P1.11	Material Cost of Water Pump	including Generator	ea.	4	14,650	58,602
P1.12	Pump House (Water Pump Station)		ea.	2	89	178
P1.13	Cut to Fill (Rehabilitation of Protection Dyke)	Soil Embankment	m3	53.10	6	332
P1.14	Material Cost of 45-degree Bend Pipe	8" dia. HDPE Pipe	ea.	8	263	2,104
P1.15	Protection Plain Concrete		ea.	25	43	1,065
P1.16	Laid down of Steel Pipe Crossing Culvert	8" dia. Steel Pipe	m	46.76	14	655
P1.17	Material Cost of Steel Pipe with Flinge	8" dia. Steel Pipe	m	46.76	115	5,363
P1.18	Material Cost of 30-degree Bend Pipe	8" dia. HDPE Pipe	ea.	6	263	1,578
P1.19	Cut to Spoil (for Water Pit)	W14xL35xD2m	m3	1,085.30	13	14,599
P1.20	Cast in situ concrete (Plain Concrete for Water Pit)	Thickness=15cm	m3	183.24	43	7,826
P1.21	Material Cost of T-shape Connection Pipe	8" dia.	ea.	6	263	1,578
P1.22	Intallation of Gate Valve	8" dia. Gate Valve	ea.	8.0	7	56
P1.23	Material Cost of Gate Valve	8" dia. Gate Valve, PN16	ea.	8.0	718	5,744
P1.24	Flow Test		times	2.0	1,000	2,000
P1.25	Maintenance and Operation		month	12.0	3,000	36,000
P1.26	Fuel for Diesel Engine		Litter	13,608.0	1.33	18,124
P1.27	Dismantle of Water Pump	including Generator	ea.	4.0	5,327	21,310
P1.28	Cut to Spoil (for Dredging Work)		m3	1,142.55	13	15,369
Total (P0+P1)						**1,900,140**

Reference Station Survey Results

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
JICA SURVEY TEAM
DATA COLLECTION SURVEY FOR GEOTHERMAL DEVELOPMENT IN ETHIOPIA

Client NIPPON KOEI CO. LTD			
Project Name : **Dubti-Ayroberra Pipeline and Access Road**		Nature of control points : Iron bar in bridge parapet	
Project Type :- **DESIGN**		Establishment date :- February 2017	
Control point ID : **GPS001**			
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N		Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m		False Northing: 0.0000m
Latitude: 011:43:35.82334N		**Northing: 1296958.7057**	
Longitude: 041:05:12.32615E		**Easting: 727340.297**	
		Height: 373.299	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm			

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5″		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45′	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on bridge parapet near the intake. The station is located by the side of the primary canal.

GPS Survey by

TerraVision Trading Services PLC
+251-011-279-2819, 0911-126397/0913-178935,
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JICA SURVEY TEAM
DATA COLLECTION SURVEY FOR GEOTHERMAL DEVELOPMENT IN ETHIOPIA

Client NIPPON KOEI CO. LTD			
Project Name : **Dubti-Ayroberra Pipeline and Access Road**		Nature of control points :Concrete pillar	
Project Type :- **DESIGN**		Establishment date :- February 2017	
Control point ID : **GPS101**			
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N		Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m		False Northing: 0.0000m
Latitude: 011:43:41.11970N		**Northing: 1297121.3875**	
Longitude: 041:05:11.88633E		**Easting: 727325.7706**	
		Height: 373.005	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm			

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5"		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45'	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar about 100m north of GPS001. The station is located by the side of the primary canal.

GPS Survey by

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Client NIPPON KOEI CO. LTD			
Project Name : **Dubti-Ayroberra Pipeline and Access Road**		Nature of control points :Concrete pillar	
Project Type :- **DESIGN**		Establishment date :- February 2017	
Control point ID : **GPS002**			
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N		Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m		False Northing: 0.0000m
Latitude: 011:44:38.34653N		**Northing: 1298883.0501**	
Longitude: 041:05:24.47693E		**Easting: 727694.0493**	
		Height: 370.554	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm			

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5"		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45'	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar. The station is located by the side of the gravel road.

GPS Survey by

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Client NIPPON KOEI CO. LTD		
Project Name : **Dubti-Ayroberra Pipeline and Access Road**	Nature of control points :Concrete pillar	
Project Type :- **DESIGN**	Establishment date :- February 2017	
Control point ID : **GPS102**		
Coordinate System: Universal Transverse Mercator (UTM) Zone 37N	Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m	False Northing: 0.0000m
Latitude: 011:44:41.35179N	**Northing: 1298975.5513**	
Longitude: 041:05:25.08134E	**Easting: 727711.668**	
	Height: 370.541	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm		

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5"		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45'	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar about 100m north of GPS002. The station is located by the side of the gravel road.

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Client NIPPON KOEI CO. LTD		
Project Name : **Dubti-Ayroberra Pipeline and Access Road**	Nature of control points :Concrete pillar	
Project Type :- **DESIGN**	Establishment date :- February 2017	
Control point ID : **GPS003**		
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N	Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m	False Northing: 0.0000m
Latitude: 011:45:45.55464N	**Northing: 1300951.253**	
Longitude: 041:05:35.98682E	**Easting: 728027.254**	
	Height: 368.656	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm		

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5"		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45'	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar. The station is located by the side of the gravel road.

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JICA SURVEY TEAM
DATA COLLECTION SURVEY FOR GEOTHERMAL DEVELOPMENT IN ETHIOPIA

Client NIPPON KOEI CO. LTD			
Project Name : **Dubti-Ayroberra Pipeline and Access Road**		Nature of control points :Concrete pillar	
Project Type :- **DESIGN**		Establishment date :- February 2017	
Control point ID : **GPS103**			
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N		Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m		False Northing: 0.0000m
Latitude: 011:45:48.91592N		**Northing: 1301054.6967**	
Longitude: 041:05:36.59070E		**Easting: 728044.7716**	
		Height: 368.886	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm			

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5"		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45'	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar about 100m north of GPS003. The station is located by the side of the gravel road.

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DATA COLLECTION SURVEY FOR GEOTHERMAL DEVELOPMENT IN ETHIOPIA

Client NIPPON KOEI CO. LTD			
Project Name : **Dubti-Ayroberra Pipeline and Access Road**		Nature of control points :Concrete pillar	
Project Type :- **DESIGN**		Establishment date :- February 2017	
Control point ID : GPS004			
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N	Datum: Adindan		Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m		False Northing: 0.0000m
Latitude: 011:47:01.34765N	**Northing: 1303276.7574**		
Longitude: 041:05:18.43177E	**Easting: 727478.2945**		
	Height: 365.800		
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm			

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5"		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45'	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar. The station is located by the side of the gravel road across the canal.

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JICA SURVEY TEAM
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Client NIPPON KOEI CO. LTD		
Project Name : **Dubti-Ayroberra Pipeline and Access Road**	Nature of control points :Concrete pillar	
Project Type :- **DESIGN**	Establishment date :- February 2017	
Control point ID : **GPS104**		
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N	Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m	False Northing: 0.0000m
Latitude: 011:47:04.95591N	**Northing: 1303387.4029**	
Longitude: 041:05:17.31192E	**Easting: 727443.5582**	
	Height: 365.27	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm		

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5"		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45'	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar about 100m north of GPS004. The station is located by the side of the gravel road across the canal.

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Client NIPPON KOEI CO. LTD				
Project Name : **Dubti-Ayroberra Pipeline and Access Road**			Nature of control points :Concrete pillar	
Project Type :- **DESIGN**			Establishment date :- February 2017	
Control point ID : **GPS005**				
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N		Datum: Adindan		Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m			False Northing: 0.0000m
Latitude: 011:48:15.91431N		**Northing: 1305562.3793**		
Longitude: 041:04:51.15158E		**Easting: 726635.2026**		
		Height: 363.800		
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm				

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5"		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45'	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar. The station is located by the side of the track/dirt road past the plantation residence condominium.

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FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
JICA SURVEY TEAM
DATA COLLECTION SURVEY FOR GEOTHERMAL DEVELOPMENT IN ETHIOPIA

Client **NIPPON KOEI CO. LTD**		
Project Name : **Dubti-Ayroberra Pipeline and Access Road**	Nature of control points :Concrete pillar	
Project Type :- **DESIGN**	Establishment date :- February 2017	
Control point ID : **GPS105**		
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N	Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m	False Northing: 0.0000m
Latitude: 011:48:15.94140N	**Northing: 1305562.5181**	
Longitude: 041:04:48.06802E	**Easting: 726541.8301**	
	Height: 363.883	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm		

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5"		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45'	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar about 100m west of GPS005. The station is located by the side of the track/dirt road.

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Client NIPPON KOEI CO. LTD		
Project Name : **Dubti-Ayroberra Pipeline and Access Road**	Nature of control points :Concrete pillar	
Project Type :- **DESIGN**	Establishment date :- February 2017	
Control point ID : **GPS006**		
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N	Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m	False Northing: 0.0000m
Latitude: 011:49:23.40979N	**Northing: 1307640.184**	
Longitude: 041:05:17.00940E	**Easting: 727402.3035**	
	Height: 362.345	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm		

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5"		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45'	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar. The station is located by the side of the National Highway close to the culvert.

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Client NIPPON KOEI CO. LTD		
Project Name : **Dubti-Ayroberra Pipeline and Access Road**	Nature of control points :Concrete pillar	
Project Type :- **DESIGN**	Establishment date :- February 2017	
Control point ID : **GPS106**		
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N	Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m	False Northing: 0.0000m
Latitude: 011:49:25.47524N	**Northing: 1307704.381**	
Longitude: 041:05:20.17623E	**Easting: 727497.7105**	
	Height: 362.278	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm		

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5″		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45′	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar about 100m east of GPS006. The station is located by the side of the National Highway.

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Client NIPPON KOEI CO. LTD			
Project Name : **Dubti-Ayroberra Pipeline and Access Road**		Nature of control points :Concrete pillar	
Project Type :- **DESIGN**		Establishment date :- February 2017	
Control point ID : **GPS007**			
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N		Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m		False Northing: 0.0000m
Latitude: 011:50:22.13322N		**Northing: 1309458.929**	
Longitude: 041:06:18.16025E		**Easting: 729240.1594**	
		Height: 364.217	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm			

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5″		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45′	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar. The station is located by the side of the National Highway.

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Client NIPPON KOEI CO. LTD			
Project Name : **Dubti-Ayroberra Pipeline and Access Road**		Nature of control points :Concrete pillar	
Project Type :- **DESIGN**		Establishment date :- February 2017	
Control point ID : **GPS107**			
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N		Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m		False Northing: 0.0000m
Latitude: 011:50:24.58504N		**Northing: 1309537.3079**	
Longitude: 041:06:20.57433E		**Easting: 729313.0395**	
		Height: 364.825	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm			

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5"		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45'	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar about 100m east of GPS007. The station is located by the side of the National Highway.

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Client NIPPON KOEI CO. LTD			
Project Name : **Dubti-Ayroberra Pipeline and Access Road**		Nature of control points :Concrete pillar	
Project Type :- **DESIGN**		Establishment date :- February 2017	
Control point ID : **GPS008**			
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N		Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m		False Northing: 0.0000m
Latitude: 011:51:17.59443N		**Northing: 1311179.2906**	
Longitude: 041:07:16.09293E		**Easting: 730981.4969**	
		Height: 369.904	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm			

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5″		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45′	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar. The station is located by the side of the National Highway.

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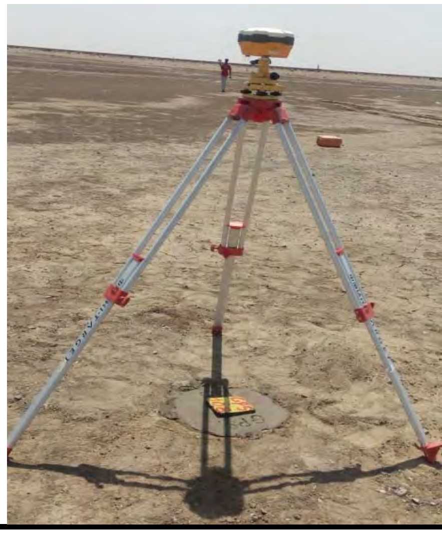
Client NIPPON KOEI CO. LTD			
Project Name : **Dubti-Ayroberra Pipeline and Access Road**		Nature of control points :Concrete pillar	
Project Type :- **DESIGN**		Establishment date :- February 2017	
Control point ID : **GPS108**			
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N		Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m		False Northing: 0.0000m
Latitude: 011:51:20.32754N		**Northing: 1311262.8925**	
Longitude: 041:07:14.35186E		**Easting: 730928.149**	
		Height: 369.771	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm			

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5"		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45'	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar about 100m north of GPS008. The station is located by the side of the National Highway.

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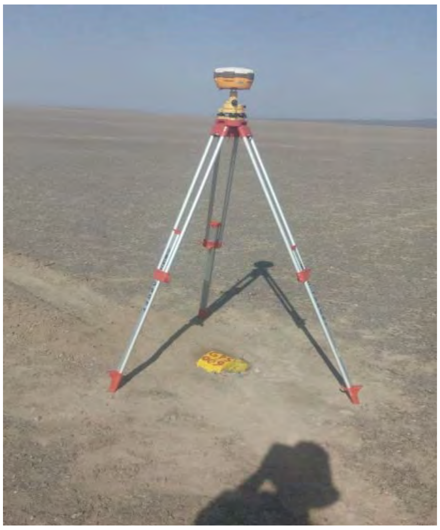
Client NIPPON KOEI CO. LTD		
Project Name : **Dubti-Ayroberra Pipeline and Access Road**	Nature of control points :Concrete pillar	
Project Type :- **DESIGN**	Establishment date :- February 2017	
Control point ID : **GPS009**		
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N	Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m	False Northing: 0.0000m
Latitude: 011:52:13.36327N	**Northing: 1312881.2199**	
Longitude: 041:06:23.26269E	**Easting: 729369.1688**	
	Height: 373.796	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm		

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5″		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45′	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar. The station is located on the sand plain off the National highway to the north.

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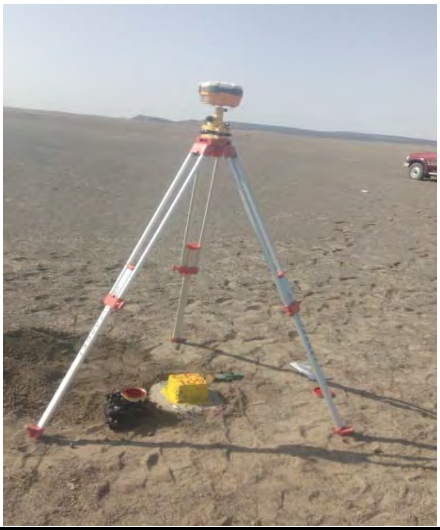
Client NIPPON KOEI CO. LTD			
Project Name : **Dubti-Ayroberra Pipeline and Access Road**		Nature of control points :Concrete pillar	
Project Type :- **DESIGN**		Establishment date :- February 2017	
Control point ID : **GPS109**			
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N		Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m		False Northing: 0.0000m
Latitude: 011:52:14.87286N		**Northing: 1312926.9938**	
Longitude: 041:06:20.54157E		**Easting: 729286.4446**	
		Height: 373.651	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm			

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5″		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45′	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar about 100m north of GPS009. The station is located on the sand plain off the National highway to the north.

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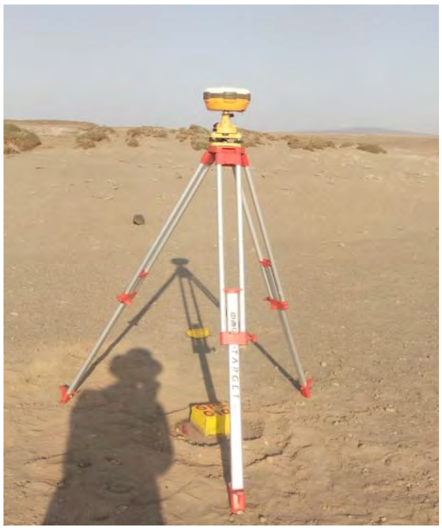
Client NIPPON KOEI CO. LTD		
Project Name : **Dubti-Ayroberra Pipeline and Access Road**	Nature of control points :Concrete pillar	
Project Type :- **DESIGN**	Establishment date :- February 2017	
Control point ID : **GPS010**		
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N	Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m	False Northing: 0.0000m
Latitude: 011:53:12.71187N	**Northing: 1314691.646**	
Longitude: 041:05:23.48106E	**Easting: 727545.7739**	
	Height: 368.688	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm		

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5″		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45′	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar. The station is located on the sand plain off the National highway to the north.

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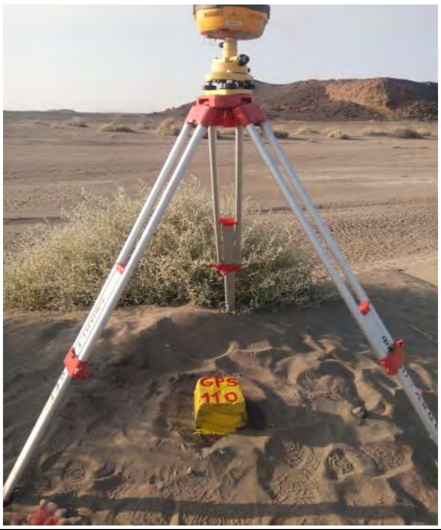
Client NIPPON KOEI CO. LTD		
Project Name : **Dubti-Ayroberra Pipeline and Access Road**		Nature of control points :Concrete pillar
Project Type :- **DESIGN**		Establishment date :- February 2017
Control point ID : **GPS110**		
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N	Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m	False Northing: 0.0000m
Latitude: 011:53:15.59959N	**Northing: 1314779.7843**	
Longitude: 041:05:20.77750E	**Easting: 727463.271**	
	Height: 368.481	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm		

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5"		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45'	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on concrete pillar about 100m north of GPS010. The station is located on the sand plain off the National highway to the north.

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Client NIPPON KOEI CO. LTD		
Project Name : **Dubti-Ayroberra Pipeline and Access Road**		Nature of control points : drillied point on rock outcrop
Project Type :- **DESIGN**		
Control point ID : **GPS011**		Establishment date :- February 2017
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N	Datum: Adindan	Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m	False Northing: 0.0000m
Latitude: 011:54:30.40910N	**Northing: 1317070.0427**	
Longitude: 041:04:41.19437E	**Easting: 726247.9069**	
	Height: 382.131	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm		

Point Monograph	Photograph
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5"		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45'	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on rock outcrop (lava flow). The station is located on the rocky, hilly terrain north of the plain.

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Client **NIPPON KOEI CO. LTD**				
Project Name : **Dubti-Ayroberra Pipeline and Access Road**			Nature of control points : drillied point on rock outcrop	
Project Type :- **DESIGN**				
Control point ID : **GPS111**			Establishment date :- February 2017	
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N		Datum: Adindan	Ellipsoid: Clarke 1880 Modified	
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m		False Northing: 0.0000m	
Latitude: 011:54:32.53785N		**Northing: 1317135.0881**		
Longitude: 041:04:39.51336E		**Easting: 726196.5377**		
		Height: 382.551		
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm				

Point Monograph	**Photograph**
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5"		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45'	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on rock outcrop (lava flow) about 100m north of GPS011. The station is located on the rocky, hilly terrain north of the plain.

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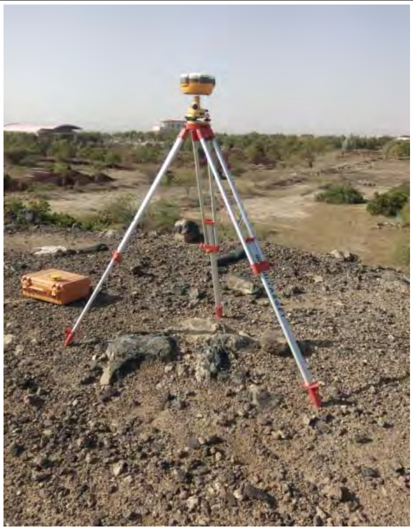
Client NIPPON KOEI CO. LTD				
Project Name : **Dubti-Ayroberra Pipeline and Access Road**			Nature of control points : Iron bar in Rock Outcrop	
Project Type :- **DESIGN**			Establishment date :- February 2017	
Control point ID : **EMA**				
Coordinate System: Universal Transverse Mercator (UTM), Zone 37N		Datum: Adindan		Ellipsoid: Clarke 1880 Modified
Central Meridian : 39.0000deg E	False Easting: 500,000.0000m			False Northing: 0.0000m
Latitude: 011:46:42.82079N		**Northing: 1302640.257**		
Longitude: 041:00:26.05172E		**Easting: 718628.634**		
		Height: 419.935		
SC. factor=**0.999606447**	Ele. factor =**0.999682350**		Comb. Factor= **0.9992889221**	
Horizontal & Vertical Accuracy: 5mm +1ppm & 10mm +2ppm				

Point Monograph	**Photograph**
	

GPS Survey General Information	Device Type	Operation Mode	Rec. Per.		Unit No.
	Hi-Target V30 Receiver	Static	5″		1
	Last Observation date	Min. Observation period	Weather	Operator	Checked
	Feb-17	45′	Sunny	KIRUBEL MICHAEL	TESFAYE G/YOHANES

Point Description:-The GPS reference point is on rock outcrop. The station is located in Semera in the compound of Agda Hotel near the water reservoir.

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