CHAPTER D9. TURKANA: SUB-PROJECT OF INTRODUCTION OF SOLAR POWER SYSTEM IN WATER PUMP FACILITIES IN LODWAR WATER AND SANITATION COMPANY

D9.1 Outline of the Sub-project

D9.1.1 General Outline of the Sub-project

The general outline of the sub-project is summarized below.

Table AD9.1.1 General Outline of the Sub-project of Introduction of Solar Power Pump System in Lodwar Water and Sanitation Company (LOWASCO)

1. Objectives	1) to raise special fund that is to be exclusively utilised for repair and maintenance of hand pumps in pastoralist communities as preparedness, accumulated from present water fee collection system with reduced O/M cost of pumps 2) To improve financial condition of the water service providers with introduction solar power pumping system, by reduction of consumption of fuel		
2. Number of Beneficiaries	LOWASCO(5,300HH) and hand pump users in pastoralist communities		
3. Implementation Organization	JICA ECoRAD Project, LOWASCO		
4. Project Contents			
1) Project Outline	1) Installation of solar power pumping system 2) Improvement of management system of LOWASCO for operation and maintenance of water facilities 3) Establishment of new management system for repair and maintenance of hand pump		
2) Facility / Activity	*Facilities/Activities*	*Implementator*	
	1) Solar power system 2) Borehole cleaning 3) Provision of stand-by pump set 4) Improvement of management system of water service provider 5) Establishment of new system for management of special fund 6) Monitoring	1) Contractor 2) Contractor 3) Contractor 4) Project Team / LOWASCO / DWO 5) Project Team / LOWASCO / DWO 6) Project Team / DWO	
3) Organization for O&M	LOWASCO		
4) Procurement Period	1.5 months from August to October, 2014		

Source: JICA Project Team

This sub-project aims at:

i) raising a special fund that was to be exclusively utilised for repair and maintenance of hand pumps in pastoralist communities as preparedness, accumulated from present water fee collection system with reduced O/M cost of pumps of water service provider, and,

ii) improving financial condition of the provider with introduction solar power pumping system, by reduction of electricity charges to the Kenya Power and Lighting Company Ltd. (KPLC) and consumption of fuel for diesel engines.

D9.1.2 Basic Concept of the Sub-project

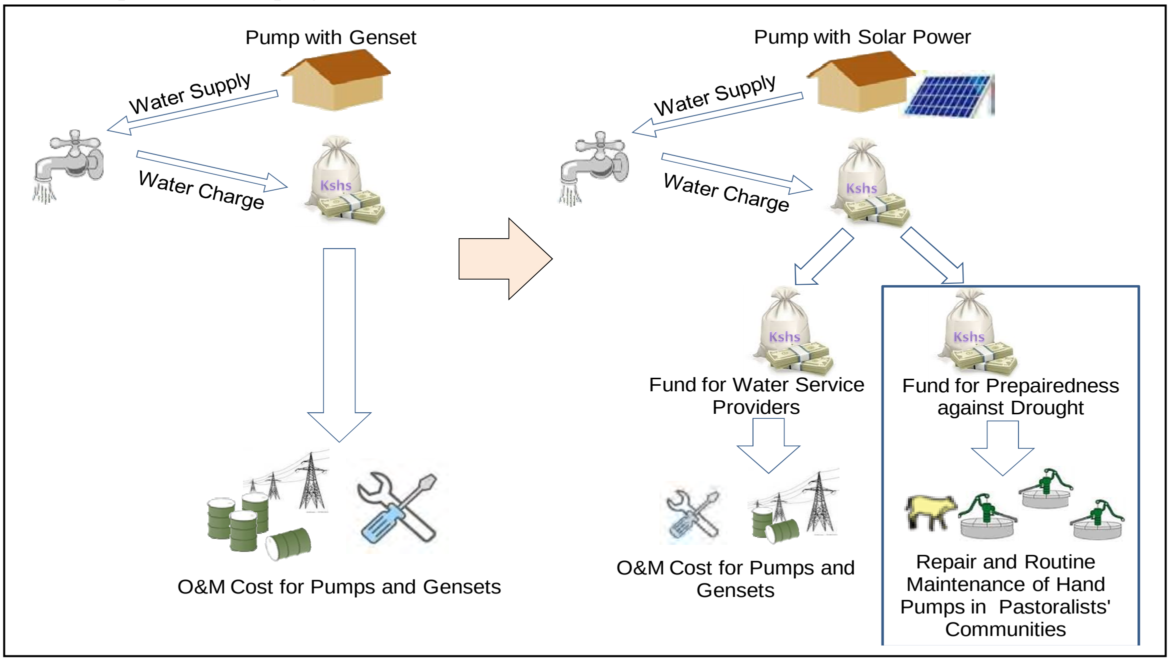
The current scarcity of water occasioned by drought and in any case failure of the anticipated rains might have high negative impact on access to water for both livestock and human. Presently, the government is responsible in undertaking some immediate actions, according to drought early warning bulletins. The actions to be taken by rapid response teams includes 1) urgent repairs of malfunctioning water points, 2) procurement of fast moving spare parts for hand pump and genset, 3) provision of fuel subsidy to all motorized water points, 4) water tankering/trucking at water stressed areas, and 5) repair of all government water tracks/bowsers to enable water tracking. Due to limitation of available fund, such actions for emergency cases are not ensured at present.

However, such emergency measures that are undertaken only during the alert, alarm and emergency stage are not able to solve vulnerability of the pastoralists' communities against drought. The most important is "preparedness" during the normal stage before drought. Critical boreholes shall not be rehabilitated during alert/alarm nor emergency stages, but be repaired in the normal stage (preparedness stage) as a routine repair and maintenance works. Prevalent arrangement of the WUA for their management is collecting membership fees for their financial source for a part of their operation cost, even though most of the routine maintenance and repair works have depended on external supports. The maintenance and repair works to be done during the normal stage include 1) repair of broken-down hand pump, 2) replacing parts, such as rubber packing, cylinder, etc, 3) rehabilitation of broken-down borehole, and so on.

On the other hand, there are several water service providers in urban area in the County. The core business of these providers is the provision of efficient and affordable water and sanitation services to the residents of their areas of jurisdiction as defined in the service provision agreements between the providers and the government (Rift Valley Water Service Board). They operate water sources mainly boreholes with diesel engine driven motor pump. These providers also have hand pump maintenance service scheme without any charge from the borehole management, utilising the water tariff collected from their water service delivery. However, both providers have not been able to spare enough fund for borehole pump repairs having a list of borehole with outstanding maintenance and rehabilitation issues.

A solar power pumping system needs high initial investment, but no operation cost is required and is almost maintenance free, while a diesel generator’s power pumping system requires continuous expenses for fuel consumption. Total O&M costs of solar power pumping system are much lower than that of pumps with genset. The solar system has a big economical advantage to reduce operation cost. On the other hand, water fee collection will be continued at the same tariff of the present agreement, which will result in producing surplus of funds. It is therefore expected that water service provider can have enough operations fund for sustainable use of the pumping system. And the excess of such operation fund can be diverted as a special financial source for the routine maintenance and repair cost in the pastoralists" communiqués as the "preparedness" described above.

The concept of the sub-project is sketched below.



Source; JICA Project Team

Figure AD9.1.1 Draft Concept of Sub-project of Improvement of Drought Resilience with Introduction of Solar Power Pumping System to Water Service Providers

D9.1.3 Plan and Design of Solar Power System

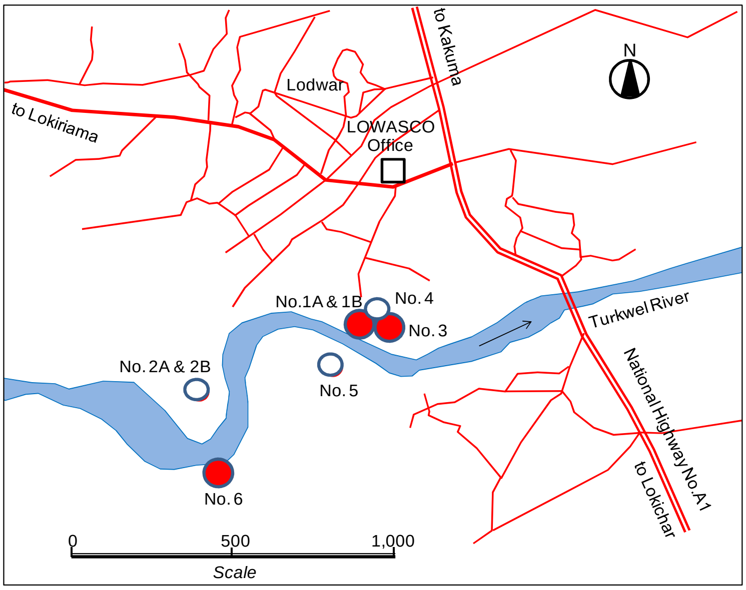
Following the purpose of the natural resources management in the project, the introduction of the solar pump system at Lodwar Water and Sanitation Company (LOWASCO) was proposed LOWASCO serves not only domestic water users in the area but also livestock in the county. Taking into consideration the ECoRAD target area, the providers included in this sub-project are listed below, and the location map is shown in the below Figure AD9.1.2.

Regarding provision of new pump, existing pump in Borehole No.1A had been replaced with new pump which was prepared for a stand-by pump in the initial plan; the existing pump was not a good condition in terms of efficiency.

Table AD9.1.2 Scope of Upgrading Works for Water Facilities of LOWASCO

Site	BH No.1A	BH No.3	BH No.6
Installation of solar power system	Yes	Yes	Yes
Borehole rehabilitation	Yes	Yes	No
Provision of new pump	Yes	No	No

Source: JICA Project Team



Source: JICA Project Team

Figure AD9.1.2 Location Map of LOWASCO Boreholes

Outlines of existing conditions of the proposed three boreholes are shown in the following tables.

Table AD9.1.3 Data of Existing Pump System of LOWASCO Boreholes

	BH No.1A	BH No.3	BH No.6
Location			
Total Depth of Borehole	18 m	21 m	20 m
Water Rest Level	4 m	-	-
Existing Pump	Grundfos SP46-12 18.5 kW	Grundfos SP46-12 18 kW	Grundfos SP17-20 11 kW
New Pump	Grundfos SP46-7 11.0 kW	-	-
Year of Pump Installation	1984	NA	2005
Pump Setting Depth	13 m	NA	NA
Casing Size	8”	8”	6”
Riser Pipe size	4”	4”	3”
New Pump Discharge	49 m^3/hr	60 m^3/hr	19 m^3/hr

Source: JICA Project Team

The proposed solar power system for the existing three boreholes in LOWASCO was planed and designed as below.

(1) Equipment and Borehole Cleaning at Borehole No.1A

The solar panels and inverter system are adequately sized to power an existing Grundfos SP46-12 18.5 kW 3-phase submersible pump installed at site. The pump was connected to the existing main power supply via a changeover switch between solar and mains power.

Technical specifications of the equipment to supply and install are as follows.

(i) Solar Panels

144 nos. 195 W, 24V, crystalline PV solar modules to provide a maximum of 28,080 W output and a reserve capacity over the rated power requirement of the pump. Eighteen pieces each shall be wired in series to provide the voltage requirement of the pump and 8 strings (of 18 panels each) shall be in parallel.

(ii) Inverter System/ Control Unit

The controllers Lorentz PS25K2 is used for converting the DC power from the solar panels into the 3phase AC power required to run the pump. It has an integrated MPPT (Maximum Power Point Tracking) which maximizes power use from PV modules. The unit shall be housed in a damp proof stainless steel enclosure. The controller is fitted with PS Data Modules which provides real-time and stored information on key pump metrics. The data module can be used with a bluetooth connection for contactless pump control, data monitoring and extraction to a Pump Scanner Android Application.

(iii) Mild Steel Tower for Solar Panels

Four meter high mild steel support structure for mounting the solar panels designed to withstand associated loads including wind loading.

(iv) Borehole cleaning – included:

a. Mobilization of the borehole truck, air compressor and personnel to the site in Lodwar
b. Pulling out of the existing borehole pump to allow installation of the flushing tools
c. Borehole cleaning including desilting and flushing of the borehole screens
d. Borehole camera inspection using an underwater borehole camera
e. Submission of report in disc form

(v) Installation –included:

a. Transport of equipment to the site,
b. Lifting of the existing pump from the borehole
c. Reinstalling the pump with the existing pipes
d. Erection of the 4 m support tower for the solar panels and positioning of the solar modules on the structure.
e. Cable connections between existing pump controller, manual changeover switch and the solar modules (within an assumed distance of 20 m from the pump house)
f. Commissioning and testing with water delivered to the surface

(2) Equipment and Borehole Cleaning at Borehole No.3

The solar panels and inverter system were adequately sized to power an existing Grundfos SP46-12 18.5 kW 3-phase submersible pump already installed at site. The pump was connected to existing mains power supply via a changeover switch between solar and mains power. Technical specifications of the equipment to supply and install are as follows.

(i) Solar Panels

144 nos. 195 W, 24V, crystalline PV solar modules to provide a maximum of 28,080 W output and a reserve capacity over the rated power requirement of the pump. Eighteen pieces each shall be wired in series to provide the voltage requirement of the pump and 8 strings (of 18 panels each) shall be in parallel.

(ii) Inverter System/ Control Unit

The controllers Lorentz PS25K2 is used for converting the DC power from the solar panels into the 3-phase AC power required to run the pump. It has an integrated MPPT (Maximum Power Point Tracking) which maximizes power use from PV modules. The unit is to be housed in a damp proof stainless steel enclosure. The controller is fitted with PS Data Modules which provides real-time and stored information on key pump metrics. The data module can be used with a bluetooth connection for contactless pump control, data monitoring and extraction to a Pump Scanner Android Application.

(iii) Mild Steel Tower for Solar Panels

Four meter high mild steel support structure for mounting the solar panels designed to withstand associated loads including wind loading.

(iv) Borehole cleaning – to included:

a. Mobilization of the borehole truck, air compressor and personnel to the site in Lodwar
b. Pulling out of the existing borehole pump to allow installation of the flushing tools
c. Borehole cleaning including desilting and flushing of the borehole screens
d. Borehole camera inspection using an underwater borehole camera
e. Submission of report in disc form

(v) Installation –to included:

a. Transport of equipment to the site,
b. Lifting of the existing pump from the borehole
c. Reinstalling the pump with the existing pipes
d. Erection of the 4 m support tower for the solar panels and positioning of the solar modules on the structure.
e. Cable connections between existing pump controller, manual changeover switch and the solar modules (within an assumed distance of 20 m from the pump house)
f. Commissioning and testing with water delivered to the surface

Source: JICA Project Team

Figure AD9.1.3 Photos of Solar System in LOWASCO

(3) Equipment and Borehole Cleaning at Borehole No. 6

The solar panels and inverter system were adequately sized to power an existing Grundfos SP17-20 11 kW 3-phase submersible pump already installed at site. The pump was connected to existing mains power supply via a changeover switch between solar and mains power. Technical specifications of the equipment to supply and install are as follows.

(i) Solar Panels

90 nos. 195 W, 24 V, crystalline PV solar modules to provide a maximum of 17,550 W output and a reserve capacity over the rated power requirement of the pump. Eighteen pieces each shall be wired in series to provide the voltage requirement of the pump and 5 strings (of 18 panels each) shall be in parallel.

(ii) Inverter System/ Control Unit

The controllers Lorentz PS15K2 is used for converting the DC power from the solar panels into the 3-phase AC power required to run the pump. It has an integrated MPPT (Maximum Power Point Tracking) which maximizes power use from PV modules. The unit is to be housed in a damp proof stainless steel enclosure. The controller is fitted with PS Data Modules which provides real-time and stored information on key pump metrics. The data module can be used with a bluetooth connection for contactless pump control, data monitoring and extraction to a Pump Scanner Android Application.

Source: JICA Project Team

Figure D9.1.4 Inverter System and Control Unit

(iii) Mild Steel Tower for Solar Panels

Four meter high mild steel support structure for mounting the solar panels designed to withstand associated loads including wind loading.

(vi) Installation – included:

a. Transport of equipment to the site,
b. Lifting of the existing pump from the borehole
c. Reinstalling the pump with the existing pipes
d. Erection of the 4 m support tower for the solar panels and positioning of the solar modules on the structure.
e. Cable connections between existing pump controller, manual changeover switch and the solar modules (within an assumed distance of 20 m from the pump house)
f. Commissioning and testing with water delivered to the surface

(4) PS Communicator

All the controllers shall be supplied c/w a PS communicator that will facilitate far range control via GPRS. The PS communicator combines with “Pump Manager” to offer cost effective full management and monitoring system for your pump system. The PS Communicator sends data from the pump across the cellular (mobile) data network to a secure central web server application called Pump Manager. The Pump Manager application can be accessed from any web connected device anywhere in the world making access to information and control of your solar pumps simple and convenient. As the connection is two ways the pump can be programmed, speed controlled or switched off, providing full remote control. The Pump Manager application also monitors the status of the Lorentz pumps systems and will alert the user if there are any unexpected events.

(5) Stand-by Pump Unit

In the plan, one stand-by pump unit was included for use on either borehole 1A or borehole 3 in case of broken down in near future. Then during installation, a pump at borehole No.1A was broken. Thus this stand-by pump was immediately used at the site. The pump was a premium quality Grundfos SP46-7 centrifugal borehole pump made of stainless steel internal components with water lubricated rubber bearings and pressure equalizing diaphragm.

The pump was directly coupled onto a sealed, liquid cooled 2-pole asynchronous 18.5 kW (25 HP) 3ph DOL Grundfos electric motor.

D9.1.4 Economical Evaluation and Comparison for Total Costs for 2 Systems

Solar power pumping system needs vast initial investment, but no operation cost is required and almost maintenance free, while the existing pumping system requires continuous expense for power supply from KPLC and fuel consumption of stand-by diesel generators during brownout period. Total O&M costs of solar power pumping system are much lower than that of existing pumps. The solar system has big economical advantage to reduce operation cost. On the other hand, water fee collection will be continued at the same tariff of the present agreement, which will result in producing surplus of fund. It is therefore expected that water service provider can have enough operation fund for sustainable use of the pumping system. And an excess of such operation fund can be diverted to a special financial source for the routine maintenance and repair cost in the pastoralists' communiqués as the "preparedness".

Tariff of power supply form KPLC is complicated and duration of brownout is subject to various conditions in Lodwar Town. In the evaluation, the following conditions and assumptions are applied.

1) Pumps run for 24 hours a day and 7 days a week
2) Solar power system runs for 10 hrs a day

3) Power supply cost is Kshs.16 per kWh, rising at a rate of 1% per year
4) Annual running cost for solar system is assumed at Kshs.20.000, rising at a rate of 10% per year
5) Life of both systems is assumed at 10 years
6) Energy costs calculated with the following conditions

Table AD9.1.4 Conditions for Energy Cost Calculation

Pump and Motor	Conditions for Cost Calculation
BH-1A and BH-3 (18.5 kW motor)	1) Power absorbed at pump shaft, P2=17.3 kW which translates to 93.5% loading on motor
	2) Efficiency at 100% load 82.8% therefore efficiency at 93.5% by interpolation = 82.97%
	3) Power absorbed by the motor from the power supply, P1 =P2/Ƞ 20.85 kW
	4) Energy Costs E = c x h x P
BH-6 (11 kW motor)	1) Power absorbed at pump shaft, P2= 10.2 kW which translates to 92.73% loading on motor
	2) Efficiency at 100% load = 82.7% therefore efficiency at 92.73% by interpolation = 82.4%
	3) Power absorbed by the motor from the power supply, P1 =P2/Ƞ = 12.38 kW
	4) Energy Costs, E = c x h x P

Source: JICA Project Team

The calculation of cost saving is shown in Table BD9.1.1, and summarized below.

Table AD9.1.5 Summary of Economical Evaluation for 3 Pumping Systems

(Unit: Kshs)

Description	BH-1A	BH-3	BH-6
Supply and installation of solar power system	4,654,281	4,654,281	3,298,925
Annual energy cost without project	2,915,328	2,831,232	1,737,984
Annual energy cost with project	1,943,552	1,887,488	1,158,656
Annual cost saving	971,776	943,744	579,328

Remarks: Supply and installation cost exclude related cost such as borehole cleaning and monitoring system, etc.
Source: JICA Project Team

As shown in the above table, total savings on cost of solar power pumping system is about 30% of the total annual energy cost without the project condition. It is also concluded that initial investment cost recovery (pay back period) is estimated theoretically to be within about 3-4 years.

D9.2 Sub-project Activities

D9.2.1 Agreement between County Government and LOWASCO

The general concept for the proposed plan had been discussed since March 2014 with Turkana County Government, LOWASCO and DWOs. However, an agreement needed more discussion to decide concrete plan and rules, such as 1) who will manage the fund, and 2) how the fund will be efficiently utilized. The discussion, detailed planning and engineering design continued from March to June 2014, and Memorandum of Understanding (MOU) was signed between Turkana County Government and LOWASCO with witness of the project and water office on 23rd June, 2014 (refer to Attachment D9-1).

D9.2.2 Supply and Installation Works of Solar Power System

The contract for supply and installation of the solar power system was signed on 15th August 2014 with Davis & Shirtliff, and the contractor commenced preparatory works in Nairobi in August 2014. In Lodwar, LOWASCO also started preparatory works on site including ground preparation and arrangement of stock pile of solar panels and related materials.

Then the contractor has installed 3 solar system at Borehole No.1A, 3, and 6 successfully by middle of October 2014. These systems started their operation as soon as the facilities were installed. The monitoring system with internet and Bluetooth devices are operated at the same time.

D9.2.3 Technical Training of LOWASCO Staff

In December 2014, five LOWASCO officers were invited to Davis & Shirtliff in Nairobi, and had a technical training course for solar system for 5 days.

In the training, the following topics were included. All the trainees absorbed all the necessary knowledge in term of solar system in those 5 days.

- Theoretical basic knowledge of solar system
- Diagnostic skill for mechanical troubles
- Actual repairing skills
- Monitoring method of solar system

D9.3 Results and Observation

D9.3.1 Evaluation of Saved Expenditure

At each solar system, the monitoring device with electric data logger system was equipped. By the monitoring system, various items can be monitored, such as operation hours, power consumption (kWh), current and voltage generated by solar system, current discharge of water pumped up, irradiation, etc. The Project Team collected the data from the monitoring system and evaluated the operation of the solar system. Since the monitoring work is in a middle of the course and there are still several unclear matters in the monitoring system, monitoring results which had been collected and analysed so far was shown below.

The following table is a result of power consumption in October – December 2014, and the detail data is given in Figure BD9.3.1.

Table AD9.3.1 Total Power Consumption by Solar System

(Unit: kWh)

	BH 1A	BH 3	BH6	Total
(a) Actual*	5,848	5,715	1,452	13,016
(b) Expected**	11,692	9,768	5,720	27,180
Difference (%) = (a)/(b)	50%	59%	25%	47.9%

* Actual: Power consumption was calculated based on the actual record of operation hours of solar system in the monitoring system.

**Expected: Power consumption was calculated based in the assumption operation hours, i.e. 8 hours/day.

Source: JICA Project Team

According to the data above, it was found that actual usage of solar system was only a half of the expected. There are several possibilities of the causes of such ineffectiveness.

The Project Team is trying to figure out the reason and cause in the system, and to rectify the problems.

So far the following matters are pointed out:

- The installed solar system in the Project should be switched off and the KPLC electric system switched on manually by the operator. Since the operators were instructed to turn on at 8:00am and turn off at 5:00pm, it seemed that the solar systems was not turned on/off properly within the instructed time according to the monitoring records. The solar systems were sometimes turned on at 10:00-11:00am and switched off before 5:00pm always. In the records, it was observed there were a lot of non-operational days in which the solar system did not turned on at all.

- Through interviews with pump operators, it was established that they believed that solar system has less power than KPLC power supply. Thus they hesitated to turn-on at the time when the sun is not at good position for generating power. But this still could not explain why they did not operate the system for a whole day.
- There was mis-recording in the monitoring system sometimes, by PS communicator, of operational hours and other data. It was a fact that the Project Team experienced some recording trouble during detail observation works. It was transmission problem in which the internet monitoring system was down and current conditions of the solar system could not be monitored for several days.

To give incentive to LOWASCO to reduce KPLC's excess electricity bill due to the above mentioned human-error, the 3 parties, the county government, LOWASCO and JICA team, discussed and agreed that amount of refund money from LOWASCO to the county government was set at Ksh.900,000 per year as a fixed rate no matter how much LOWASCO decreases the KPLC's electricity bill (refer to Attachment D9-2).

D9.3.2 Fund Raising for Existing Borehole Maintenance

One of main objectives of the Sub-project was to establish a fund raising system from LOWASCO's solar pumping system for maintenance of existing water facilities.

In Turkana, the project installed three sets of the solar power system in boreholes controlled by the Lodwar Water and Sanitation Company (LOWASCO). Due to the installation of the solar system, LOWASCO's electricity bills were decreased. Consequently, the company could save some sort of operation costs. Based on an agreement which was made between LOWASCO and the county government, assisted by the project, a part of such benefit from the solar power system would be transferred and used in the repairing and maintenance activities by the county government on the existing boreholes.

Payment for the half-year, from November 2014 to April 2015, an amount of kSh450,000 was paid by LOWASCO to the Diocese of Lodwar who have a maintenance contract with the county government. Such financial support from LOWASCO to the county government in terms of borehole repairing is expected to be continued for the next 15 to 20 years.

Source: JICA Project Team

Figure AD9.3.1 Photo of Fund Transfer Ceremony at Turkana

D9.4 Lessons Learnt and Recommendation

From the experiences of the Project, following lessons learnt and recommendation were pointed out.

- In Northern Kenya, where sunny days are dominant throughout the year, it is a suitable place for utilisation of solar power system. The strength of radiation is also suitable for the system in this region. Furthermore, the recurrent drought, which is known as the biggest risk to life in Northern Kenya, is a preferable condition for a solar power system. It means that the solar power system is quite a rare system which can convert the negative impact of drought into a useful power source for the humanity.
- In Turkana, Lodwar Water and Sanitary Company (LOWASCO) was selected as a counterpart entity for the sub-project activity. The following points were noted as advantages in comparison with the case in Marsabit where the solar power pumping systems were installed in community boreholes managed by communal water users' associations:
  a) Water fee collection system in LOWASCO had been established before the sub-project implemented. Thus there were no any problem of water fee collection technically, and water fee collection had been made smoothly.
  b) Since education level and capability of staff in LOWASCO were much higher than that of communal water users' committees, technical training for solar power system was easily accepted by the staff.
  c) In LOWASCO, there was a certain financial audit system by the county government. Thus there was low possibility of misappropriation of money which was saved by the solar power pump system.
- In the installed solar power systems, the power source had to be switched manually, by a pump operator, from Kenya Power and light Company (KPLC) power source to the solar power modules. The operator did not sometimes did not change the power sources in proper timing in the morning, then KPLC electricity power source was used even under very fine weather condition. This was y reflected in the KPLC's high monthly bill.. In order to avoid such human error, an automatic power source changing system is recommended to be applied in future if funds are available.
- In the Project, PS communicator (a remote monitoring and information system via internet) was installed as a trial for verification of its function. However it was found that there were a lot of errors during operation and monitoring period in this PS communicator system. It was therfore decided that this information system cannot be recommended for use for monitoring purpose in the facilities.

Tables

Table BD1.2.1 Evaluation of Factors Limiting Development Potential of Water Pan

Area[*1]			Factor							Suitability Rating (no.)[*3]				Evaluation[*4] by potential
			Slope	Soil type	Soil depth	Runoff[*2]	Evaporation	Frosion hazard	Catchment land use	Good	Fair	Poor	Point	
1	Forole-Diribsoi -Godoma triangle	Assessment Rating	< 8% G	C,SC,SL,SCL G	ve D>6m,oc S<1m G	50mm G	>2200mm P	m-hs-S&G P	Range P	4	0	3	8	Middle
2	Middle & lower slopes of Marsabit	Assessment Rating	5-16% F	C,CL,cr-C G	D-ve D 3-o 6m G	80mm G	<2200mm F	s-S,h-G F	FR,arable F	3	4	0	10	High
3	Western slopes of the Hurri Hills	Assessment Rating	gen.< 5% G	fg-SCL F	m D 1-3m F	40mm G	<2200mm F	l-S,m-G F	uu-Range G	3	4	0	10	High
4	Eastern slopes of the Hurri Hills	Assessment Rating	< 5% G	cr-C P	D 3-6m G	40mm G	<2200mm F	s-S,h-G P	uu-Grazing G	4	1	2	9	High
5	East Turkana Basin lowlands	Assessment Rating	<10%,-16% G	vgC/CL,SL,S P	S-mD ovD <1->6m F	25mm P	>2600mm P	l-m-S,h-G P	Range P	1	1	5	3	Low
6	Hedad plain, Karole and Kaisut deserts	Assessment Rating	flat, < 1% G	LS,SCL,SL,S v-ge P	va S - D, <1m - 6m F	35mm F	>2600mm P	st-S P	Range P	1	2	4	4	Low
7	Eastern slopes of Mt. Kulal highlands	Assessment Rating	<10% G	G	(F o) G	40mm G	>2200mm P	F	G	5	1	1	11	High
8	Foothills of southern border	Assessment Rating	<10% G	F	F	40mm G	>2200mm P	F	F	2	4	1	8	Middle
9	Eastern side of Mt.Marsabit area	Assessment Rating	<2% G	F	P (or F)	25mm P	>2600mm P	G	G	3	1	3	7	Middle
10	Rest of the Study area	Assessment Rating	gen.< 2% G	CL,C,lt-cr-C ge P	ve D - D, oc S G	20mm P	>2600mm P	l-S,l-G F	Range P	2	1	4	5	Low
Abbreviation			G: Good F: Fair P: Poor gen.: generally	C: Clay L: Loam S: Sand cr: cracking	D: Deep S: Shallow ov: over, ve: very m: moderately oc: occasionary va: variously			S: Sheet erosion G: Gully erosion	Range: Rangeland uu: under- -utilized				Good: 2 Fair: 1 Poor: 0	Low: - 5 Middle: 6 - 8 High: 9 -

Note:
*1: Areas 1 to 6 are derived from original report.
*2: Runooff is estimated at 10% of MAR (Mean Annual Rainfall).
*3: Suitablilty Rating by No. and point is done by the JICA Project Team.
*4: Evaluation is done by the JICA Project Team.

Source: JICA Project Team

Table BD1.2.2 Grazing Area and Capacity of Water Pan

	Unit	Hurri Hills	Hedad	Remarks
(1) Grazing Area around a water pan				
Moving distance	km/day	10.0	10.0	a (assumption)
Interval of waterting	days	2.0	2.0	b (assumption)
Max. radius for grazing around water pan	km	10.0	10.0	c = a * b / 2
Grazing area around a water pan	sq.m	314,000,000	314,000,000	d = (c * 1,000)^2 * 3.14
	ha	31,400	31,400	e = d / 10,000
Utilization rate for conservation of pasture	%	100%	100%	f (assumption)
Effective grazing area	**ha**	**31,400**	**31,400**	**g = e * f**
(2) Data for Grazing Area				
Required area for grazing per 1 cattle	ha/head/ i days	0.8	1.1	h (assumption)
Grazing days	days	85.0	75.0	i
Required area for grazing 1 cattle for 2months*	ha/head/2month	0.6	0.9	j = h * 60 / i
Holding capacity: Number of livestock to be grazed at 1 water pan for 2 months	**heads/2months**	**55,604**	**35,682**	**k = g / j**
(3) Required Water				
Unit water requirement per head	liter/head/day	16.4	16.4	l (assumption)
Water requirement for consumption	**cu.m for 2 months**	**54,715**	**35,111**	**m = k * l / 1,000**
(4) Loss by evaporation and Percolation				
Average depth of water pan	m	2.5	2.5	n (assumption)
Surface/bottom water area	m2	21,886	14,044	o = m / n
a) Percolation	mm/day	5	5	p (assumption)
	m/day	0.0050	0.0050	q = p / 1,000
	cu.m/day	109	70	r = o * q
	cu.m/2month	*6,566*	*6,320*	*s = r * (30*3)*
b) Evaporation	mm/year	2,200	2,200	t (assumption)
	m/year	2.20	2.20	u = t / 1,000
	cu.m/year	48,149	30,898	v = o * u
	cu.m/2months	*8,025*	*7,724*	*w = v * (3*12)*
c) Total loss	**cu.m/2months**	**14,591**	**14,044**	**y = s + w**
Total Capacity of Water Pan	**cu.m**	**69,305**	**49,155**	**z = m + y**

* Note) Assumption: A water pan can keep water for 2 months.

Source: JICA Project Team

Table BD6.2.1 VES Results and Interpretation (1)

No	Site Code	Village name	Location	Depth to Expected Formation (m)	True Resistivity in Ohms (Ω)	Expected formation	Remarks
1	N1-2	Kaabilikeret	Milimatatu	0 – 6.3 6.3 – 33.0 33 - 130 Below 130.0	59.9 19.0 6.8 15.0	Loam soils Fractured volcanics Highly weathered/fractured volcanics (aquiferous) Weathered to fresh volcanics	· Well defined aquifer 40-120m · Good recharge · Groundwater potential medium to high
2	N2-2	Lokwakel	Milimatatu	0 – 2.3 2.3 – 8.1 8.1 – 21.0 21 - 120 Below 120.0	162.1 23.7 14.0 20.0 9.9	Sandy top soils Alluvial sands Weathered volcanics Highly weathered volcanics Weathered volcanics/ clays	· Well defined aquifer 40-80m & 100m · Good recharge · Groundwater potential medium to high
3	N3-2	Ngaukon	Kangakipur	0 – 3.3 3.3 – 16.1 16.1 – 82.0 Below 82.0	213.0 5.3 1.5 5.2	Dry top soils Compact sub soils Weathered volcanics Fractured volcanics	· Deep weathering · Well defined aquifers 40-80m & 100-120m · Groundwater potential medium to high
4	N4-1	Kaituko	Kanakurdio	0 – 2.5 2.5 – 6.4 6.4 – 26.0 26.0 - 100 Below 100.0	26.0 7.1 5.0 13.0 4.7	Loam soils Alluvial sands Weathered volcanics Highly weathered volcanics (aquiferous) Decomposed basalts	· Good recharge · Shallow aquifer 16-30m and deep aquifer 63-100m · Thick clays beyond 100m · Groundwater potential medium
5	W1-1	Natwol	Lokichoggio	0 – 2.5 2.5 – 5.1 5.1 – 16.2 16.2 – 82.0 Below 82.0	53.0 25.0 38.0 9.1 17.0	Top silty soils Alluvial sands Compact sediments Highly weathered/fractured volcanics (aquiferous) Weathered to fresh basement	· Deep weathering · Good recharge · Ground water potential medium to high
6	W2-2	Nakeruman	Lokichoggio	0 – 2.5 2.5 – 10.0 10 – 34.0 34 – 80.0 Below 80.0	300.0 62.9 40.0 91.0 50.0	Top soils Loose sub soils Weathered volcanics Relatively fresh volcanics Highly weathered/fractured volcanics (aquiferous)	· Well defined aquifers 25-40m, 63-80m & 100-130m · Groundwater potential medium-high · Good recharge
7	W3-1	Oropoi	Oropoi	0 – 3.3 3.3 – 20.0 20 - 110 Below 110.0	570.0 45.0 92.0 240.0	Sandy top soils Loose sediments Alluvial sands Weathered to fresh basement	· Deep weathering · Good recharge · Ground water potential medium-high
8	W4-3	Loreng	Kakuma	0 – 3.2 3.2 – 8.2 8.2 – 20.0 20 – 84.0 Below 84.0	101.0 21.0 48.0 36.0 5.0	Sandy soils Weathered sediments Compact sediments Alluvial sands Decomposed volcanics/clays	· Deep weathering · good recharge · stable formation · Groundwater potential medium-high
9	W5-1	Nakoros	Kakuma	0 – 2.4 2.4 – 12.0 12 – 101.0 Below 101.0	30.0 68.0 9.0 18.0	Loam soils Compact sediments Saturated sediments Weathered to fresh volcanics	· Deep weathering · Good recharge · Ground water potential medium-high
10	W6-4	Kokurio	Loritit/Oropoi	0 – 2.5 2.5 – 5.1 5.1 – 33.0 33 – 125.0 Below 125.0	49.0 120.0 9.9 21.0 34.0	Sandy over burden Compact sediments Weathered sediments Saturated sediments Weathered to fresh volcanics	· Deep weathering · Shallow aquifer 25-40m · Deep aquifer 60-110, · Good recharge · Groundwater potential medium-high
11	C1-1	Kangirisae	Kerio	0 – 1.9 1.9 – 6.4 6.4 – 21.0 21 – 50.0 50 - 110 Below 110.0	11.0 7.3 3.2 43.0 30.0 101.0	Top silty soils Weathered sub-surface soils Alluvial sands Compact sediments Highly weathered/loose sediments (aquiferous) Weathered to fresh basalts	· Deep weathering 32m · Excellent recharge · Ground water potential medium
12	C2-2	IDP camp	Central	0 – 2.5 2.5 – 6.4 6.4 – 45.0 45 - 100 Below 100.0	380.0 1200.0 4.8 7.5 78.0	Sandy soils Compact sub-surface soils Alluvial sands Highly weathered sediments(aquiferous) Weathered to fresh basalts	· Good recharge · Crystalline limestones that could compromise water quality · High ground water potential
13	C3-3	Natapar Angidomou	Eliye	0 – 2.1 2.1 – 5.2 5.2 – 33.0 33 - 130 Below 130.0	198.0 145.0 220.0 440.0 1200.0	Top silty soils Highly weathered sub-surface soils Alluvial sands Weathered sediments (aquiferous) Weathered to fresh basalts	· Well defined aquifers 25-40, 63-130m · Medium-high groundwater potential · Area needy
14	C4-1	Losagam	Kerio	0 – 1.9 1.9 – 6.4 6.4 – 21.0 21 – 50.0 50 - 110 Below 110.0	11.0 7.3 3.2 43.0 30.0 101.0	Top silty soils Weathered sub-surface soils Alluvial sands Compact sediments Highly weathered/loose sediments (aquiferous) Weathered to fresh basalts	· Deep weathering 32m · Excellent recharge · Ground water potential medium
15	C5-3	Chokchok	Central	0 – 4.0 4.0 – 25.0 25 – 55.0 55 - 110 Below 110.0	67.0 4.1 7.5 3.6 12.0	Sandy soils Alluvial sands Compact sediments Highly weathered sediments (aquiferous) Weathered to fresh basalts	· Well defined aquifer 63-100m · Good recharge · Groundwater potential medium

Source: JICA Project Team

Table BD6.2.2 VES Results and Interpretation (2)

No	Site code	Village name	Location	Depth to expected formation (m)	True Resistivity in Ohms (Ω)	Expected formation	Remarks
16	L1-1	Kakromosing	Lokiriama	0 – 3.3 3.3 – 25.0 25.0 – 60 60 - 100 Below 100.0	329.0 38.0 27.0 55.0 34.0	Sandy top soils Alluvial sands Highly weathered volcanics Highly weathered/fractured basement (aquiferous) Decomposed basement	· Community proposed site · Deep weathering · Good recharge · High groundwater potential
17	L2-4	Lotilo	Urum	0 – 3.1 3.1 – 13.3 13.3 – 70.0 Below 70.0	197.0 23.8 17.0 60.0	Sandy top soils Weathered volcanics Saturated weathered volcanics Weathered to fresh volcanics	· Luxuriant acacia · Fractured basalts · Deep weathering 32m · Deeper aquifers 63- 100m · Good recharge · Groundwater potential medium
18	L3-1	Kalokutany /EreAmoru Arengam	Lorengippi	0 – 2.1 2.1 – 13.0 13.0 – 32.0 32.0 - 100 Below 100.0	70.0 510.0 230.0 50.0 80.0	Loose sandy soils Compact sand sediments Moist alluvial sands Saturated sediments (aquiferous) Weathered to fresh basement	· Well defined aquifers 32-100m · Excellent recharge · Ground water potential high · Community proposed site
19	L3-4	Lokiriamet	Lorengippi	0 – 2.1 2.1 – 5.0 5.0 – 20.0 20.0 - 64.0 Below 64.0	38.2 67.0 25.0 34.0 140.0	Overburden Weathered gneisses Highly weathered gneisses Fractured gneisses (aquiferous) Weathered to fresh Basement	· Deep weathering · Good recharge · Groundwater potential medium - high
20	L4-6	Kaidir	Namoruputh	0 – 2.5 2.5 – 6.6 6.6 – 22.0 22 – 82.0 Below 82.0	126.0 49.0 76.0 37.0 110.0	Loam soils Sub soils Compact basalts Highly weathered/fractured volcanics (aquiferous) Fresh Basement	· Well defined aquifer 40-80m only · Good recharge · Groundwater potential medium-high
21	S1-3	Lochor Edome	Lokichar	0 – 3.3 3.3 – 11.0 11.0 – 34.0 34 - 90 Below 90.0	74.9 28.0 56.0 150.0 240.0	Top soils Weathered sub-surface soils Highly weathered gneisses Weathered/fractured basement (aquiferous) Weathered to fresh basement	· Shallow weathering 10m · Well defined aquifer 20-32m · Good recharge · Medium ground water potential
22	S2-5	Kakali	Lokichar	0 – 4.1 4.1 – 22.0 22 – 53.0 Below 53.0	220.2 19.0 36.0 166.0	Top sandy soils Alluvial sands Highly weathered/fractured gneisses (aquiferous) Weathered to fresh Basement	· Deep weathering 20m · Fractured gneisses · Good recharge · Medium-high groundwater potential
23	S3-1	Lolupe	Lochwaangikamatak	0 – 2.1 2.1 – 5.2 5.2 – 21.0 21 – 64.0 Below 64.0	40.0 88.0 38.0 65.0 280.0	Top silty soils Compact sub-surface soils Weathered gneisses Slightly weathered basement (aquiferous) Fresh Basement System	· Fractured quartzite · Favorable dip angles · Good recharge · Ground water potential medium
24	S3-4	Loreng	Lochwaangikamatak	0 – 2.0 2.0 – 8.0 8.0 – 25.0 25 - 110 Below 110.0	280.0 188.8 70.0 95.0 510.0	Sandy top soils Alluvial sands Weathered sandstones Saturated sediments (aquiferous) Weathered to fresh basement	· Well defined aquifer 20-100m · Good recharge · Medium groundwater potential
25	S4-2	Nakejuamosing	Lochwaangikamatak	0 – 2.5 2.5 – 6.3 6.3 – 25.0 25 – 90.0 Below 90.0	62.0 49.0 32.6 27.8 130.0	Top silty soils Weathered sub-surface soils Weathered gneisses Highly weathered basement Weathered to fresh basement	· Well defined aquifer 20-80m · Fractured gneisses · Groundwater potential high
26	S5-1	Ngimamki	Lochwaangikamatak	0 – 3.2 3.2 – 8.1 8.1 – 19.0 19.0 – 50.0 Below 50.0	590.0 66.6 24.0 29.0 240.0	Sandy top soils Weathered sub-surface soils Alluvial sands Highly weathered basement (aquiferous) Weathered to fresh basement	· Well defined aquifers 16-50m & 80-100m · Good recharge · Ground water potential medium-high · Proposed site by community
27	E1-3	Lopii	Lokori	0 – 2.7 2.7 – 10.1 10.1 – 50.0 50 – 130.0 Below 130.0	325.0 52.6 38.0 17.0 30.0	Sandy top soils Weathered sediments Alluvial sands Highly weathered volcanics Weathered to fresh basalts	· Good recharge · Aquifer 80-100m · Massive volcanics beyond 100m · Groundwater potential low-medium
28	E2-2	Kaaruko	Lokori	0 – 3.1 3.1 – 22.0 22 - 100 Below 100.0	119.8 70.0 25.0 78.0	Lateritic soils Weathered volcanics Highly weathered volcanics(aquiferous) Weathered to fresh basalts	· Good recharge · Well defined aquifers 25-40m & 63-90m · Groundwater potential low-medium

Source: JICA Project Team

Table BD6.3.1 Results of Water Quality Analyses

No	SAMPLING SITE NAME	CHEMICAL TESTS (ANIONS)						CHEMICAL TESTS (CATIONS)			
		TOTAL ALKALINITY (Mg/L $CaCO_3$)	CHLORIDE (Mg/L Cl)	FLUORIDE (Mg/L F)	SULPHATE (Mg/L SO_4)	NITRATE (Mg/L NO_3)	NITRITE (Mg/L NO_2)	CALCIUM (Mg/L Ca)	MAGNESIUM (Mg/L Mg)	IRON (Mg/L Fe)	MANGANANESE (Mg/L Mn)
1	Lokwakel	**872**	152	1.15	140	0.26	0.007	72.0	27.84	0.06	0.002
2	Kaituko	**2304**	**330**	1.01	240	0.70	**0.053**	8.0	10.56	**0.43**	0.102
3	Natwol	**708**	20	0.43	3	0.64	0.003	60.8	ND	0.24	<0.001
4	Nakeruman	432	62	0.00	0	0.0	**0.034**	38.4	42.24	0.01	0.500
5	Ngasoge	476	12	0.52	1	0.52	0.002	19.2	18.24	0.14	<0.001
6	Nakarimon	408	34	1.10	14	0.18	0.002	27.2	24.96	0.18	<0.001
7	Nakoros	**604**	30	0.93	40	0.86	0.012	9.6	24.96	0.08	0.003
8	Kokurio	448	68	1.16	5	0.14	0.003	6.4	ND	0.23	<0.001
9	Kangirisae	368	**1700**	1.08	**925**	0.31	0.017	28.8	ND	0.16	0.019
10	Losagam	**968**	**980**	0.97	**570**	0.18	0.013	19.2	1.92	0.04	0.010
11	Chokchok	**668**	**564**	1.01	325	1.10	0.023	9.6	12.48	0.05	0.002
12	Kakromosing	**884**	34	0.57	80	0.01	0.006	38.4	15.36	0.00	0.009
13	Lotilo	436	78	0.77	96	0.32	0.008	11.2	2.88	0.03	0.018
14	Kalokutany	356	16	0.52	2	0.01	0.016	16.0	60.48	0.05	0.100
15	Lokiriamet	468	10	0.40	8	0.02	0.017	25.6	26.88	0.02	0.400
16	Kaidir	480	**1044**	0.62	310	0.18	0.005	17.6	38.40	0.20	0.046
17	Lochor Edome	**780**	54	0.90	82	0.02	**0.032**	96.0	ND	0.30	0.300
18	Kakali	**660**	30	0.99	13	3.20	0.009	20.8	25.92	**1.08**	0.040
19	Lolupe	**664**	16	0.46	23	0.01	0.030	49.6	30.72	0.24	0.040
20	Nakejuamosing	460	16	0.41	17	1.02	0.001	11.2	50.88	0.21	<0.001
RECOMMENDED STANDARDS (KEBS)		-	250	1.5	400	50	0.3	150	100	0.3	0.5
WHO Standards		**500**	250	1.5	450	50	0.1	100	100	0.3	0.1
European Union		-	25	1.5	250	50	0.1	100	100	0.3	0.1

No	SAMPLING SITE NAME	PHYSICAL TESTS						HEAVY METAL	OTHER PARAMETER
		TURBIDITY (NTU)	TOTAL SUSPENDED SOLIDS (Mg/L)	TDS (Mg/L)	pH	EC (μS/cm)	TOTAL COLIFORM	ARSENIC (Mg/L As)	TOTAL HARDNESS (Mg/L$CaCO_3$)
1	Lokwakel	2.07	1	**1156.3**	7.4	1865	ND	ND	296
2	Kaituko	**6.70**	4	**3713.8**	7.4	**5990**	ND	ND	64
3	Natwol	0.40	**<1**	688.2	7.3	1110	ND	ND	148
4	Nakeruman	0.54	**<1**	495.0	7.7	976	ND	ND	272
5	Ngasoge	0.30	**<1**	488.6	7.0	788	ND	ND	124
6	Nakarimon	0.30	**<1**	492.9	7.6	795	ND	ND	172
7	Nakoros	0.20	3	689.6	7.2	1080	ND	ND	128
8	Kokurio	0.20	<1	607.6	8.1	980	ND	ND	8
9	Kangirisae	**8.50**	5	**3552.6**	7.5	**5730**	ND	ND	44
10	Losagam	2.71	3	**4330.7**	7.8	**6985**	ND	ND	56
11	Chokchok	2.46	**<1**	**1705.0**	7.7	**2750**	ND	ND	76
12	Kakromosing	0.22	**<1**	995.1	7.4	1605	ND	ND	160
13	Lotilo	0.27	**<1**	760.1	7.9	1226	ND	ND	40
14	Kalokutany	1.03	**<1**	288.0	7.5	712	ND	ND	292
15	Lokiriamet	1.02	**<1**	364.8	7.6	912	ND	ND	176
16	Kaidir	0.33	**<1**	**4464.0**	7.8	**7200**	ND	ND	204
17	Lochor Edome	1.13	**<1**	751.6	7.6	1879	ND	ND	228
18	Kakali	0.20	**<1**	782.4	7.3	1262	ND	ND	160
19	Lolupe	1.25	**<1**	560.0	7.7	1400	ND	ND	248
20	Nakejuamosing	0.60	**<1**	503.4	7.1	812	ND	ND	240
RECOMMENDED STANDARDS (KEBS)		5.0	15 TCU	1000	6.5-8.5	-	-	0.01	300
WHO Standards		5.0	5	1500	6.5-8.5	**2500**	-	0.05	500
European Union		4.0	20	1500	-	-	-	0.05	-

WHO Standards Source: Appendix 2.10, Ewaso Ng'iro North Catchment Area June, 2008

European Union Standards source : Based on Table 6.1, in Twort, Law & Crowley, 1985

Source: JICA Project Team

Table BD6.4.1 Summary of Questionnaire Interview Result on Borehole Management (1/4)

No	BH site	Sub-Location	1. Distance from the nearest parmanent settlement	2. Distance from the nearest temporary settlement during use	3. The number of temporary settlement that use the BH water	4. No. of beneficiaries		5. Representation from the WUA to the DMC/DC	6. WUA having experiences of managing other BH	7. Organisation					
						herds (no. of animals)	domestic (HH)			7-1. Committee was formed	Informal WUA committee	appointed responsible persons but not committee	assigned watchman/ guards	assigned operator	7-3. roles of the appointed persons and how to operate
s	Nasogae	Oropoi	13-15 km	1Km	70	10000	70-100	NO	Yes	√					To ensure proper usage of the borehole. To resolve conflicts arising during use. To regulate the use of the borehole(watering of livestock) and domestic use. Setting rules and regulation governing borehole use. Reporting of any technical problem.
s	Nakalimon	Loreng	2 km	2 km	10	1000	10	NO	No	√					To ensure that boreholes around the area are operational. To ensure proper use of the boreholes. Ensuring that every year the borehole is registered under the maitenance body. Reporting of technical problem to relevant people. Setting rules and regulations on borehole use.
s	Nakoros	Morungole	0.5-1 km	5-8km	50-70	5000	50-70	NO	NO		√				They ensure that there is proper use of the borehole. They regulate the watering of livestock and domestic use e and resolve conflict arising from borehole use. They report to relevant people when there is a technical problem.
s	Natwol	Lokichoggio	10-12 km	6-8 km	30	10000	30	No	NO			√			To regulate the use of borehole by livestock and human. To oversee general use of the borehole. To set rules and regulations governing use of the borehole. Reporting of any technical problem to the concerned
s	Nakeruman	Lokariwon	16-20 km	10-15 km	0	20000	100	NO	NO			√			Governing the use of the borehole. Ensuring proper use and operating. Regulating the use of the borehole by various households. Train people on how to use it instead of misuse. Reporting any problem to CDC for further action.
s	Kaituko	Kaeris	18-20 km	0.5-1 km	50-60 HH	3000 shoats	50-60 HH	No CDC since it was not a pilot sub location	No	yes	0	3	0	0	they ensure that there is proper use of the borehole. And water their livestock sytematically
s	Lokwakel	Milima Tatu	25 Km	7 Km	120	4000	120	Yes, 3 members	Yes	√					Ensuring timely registration with the diocese. Custodian of WUA money. Ensuring proper use of the borehole. Reporting any technical breakdown to diocese.
s	Kangirisae	Kangirisae	15 Km	1Km	50-100	3000	50-100	No	No			√			They are incharge of day to day supervision of the borehole. To ensure that the water trough is clean.
s	Losagam	Kerio	10-15 km	1Km	15	500	15	Yes, 1 member	No	√					Supervising borehole operation. Contribution of registration fee. Reporting of mechanical problems to relevant authorities. Collection of fee. General incharge of the borehole. Locking of the borehole and ensure proper use.

Table BD6.4.1 Summary of Questionnaire Interview Result on Borehole Management (2/4)

No	BH site	8. O&M					
		8-1. Technical problem	8-1. Non-technical problem	8-2. Daily care and maintenance of BH	8-3. Maintenance when the BH is not in use (including security)	8-4. repairing work done (problem and who repair)	8-5. Further plan for O&M and management for sustainable use of the BH
s	Nasogae	None	The water trough is left dirty and nobody bothers to clean.	Washing of the water trough was initiated recently after the JICA team sinsitizing about hygiene and sanitation.	Checking technical hitches. Locking when not in use.	None	There is monthly contribution of Ksh. 50 per house hold for future registration. The borehole is registered with the diocese of Lodwar for maintenance and repair.
s	Nakalimon	The borehole was found not pumping water. The handle is loose	None	Washing of the water trough daily . Ensuring the tap is locked after use to avoid misuse.	Locking	None	Yes, we have planned and decided that every household should be contributing Kshs. 50 a month for future O&M.
s	Nakoros	None	None	Since it ws not yet in use (at the time of interview), there was no daily care but rules have been put in place. Every household should be ready to contribute Kshs. 50 towards registration with the diocese.	When not in use it should be locked and every commmunity member should be responsible to ensure there is no misuse.	None	We plan to be having monthly contribution per household to ensure ther are no problems of registration in future. We also want to appoint two people who will be incharge of the management of the borehole.
s	Natwol	The handpump is loose, water cannot be pumped	There has been a problem in collecting fee because of insecurity and migration.	No, because the borehole is not in use and the place is deserted.	Locking the borehole	None	Fencing of the borehole and monthly contribution
s	Nakeruman	None	None	No, Because it is locked and the area is deserted due to insecurity	It is always locked when not in use (Nakeruman is not secure for the moment but we plan when people migrate back to be locking after use.)	None	Plans are in place to fence it and charge fifty shillings per household but we have not implemented because of migration.
s	Kaituko	No technical prol	none	Daily washing of the water trough	since there is no handpump to we advise the people using it to ensure that water is not contaminated	No repair work has ever been done	No further plan.
s	Lokwakel	None	None	Locking the borehole after use. Washing the water trough.	Locking the borehole	None	We are planning to mobilize the community on monthly contribution for future O&M. During wet season, the borehole should be locked to allow livestock to use rain water.
s	Kangirisae	None	None	The trough is cleaned daily and also handpump is cleaned	Locking the borehole	None	They are still contributing to register with the Diocese of Lodwar
s	Losagam	Use of force and energy to pump water.	None	Washing of animal trough. Locking the borehole.	We lock it to ensure children don't misuse it.	None	No plan, but we are discussing among ourselves to start contributing money towards the end of the two years.

Table BD6.4.1 Summary of Questionnaire Interview Result on Borehole Management (3/4)

No	BH site	Sub-Location	1. Distance from the nearest parmanent settlement	2. Distance from the nearest temporary settlement during use	3. The number of temporary settlement that use the BH water	4. No. of beneficiaries		5. Representation from the WUA to the DMC/DC	6. WUA having experiences of managing other BH	7. Organisation					
						herds (no. of animals)	domestic (HH)			7-1. Committee was formed	Informal WUA committee	appointed responsible persons but not committee	assigned watchman/ guards	assigned operator	7-3. roles of the appointed persons and how to operate
s	Chokchok	Nawoitorong	20km	0.5km	40 hh	600-700 shoats	40 hh	NO	NO	YES	0		3		To make general use of the borehole, linking the community with diocese of Lodwar and reporting cases of mechanical breakdown, they ensure that is locked whenever it is not in use
s	Kokorio	Loritit	35km	1km	80-90 hh	2500-3000 shoats	80-90 hh	No,only appointed 4 people to manage	No	yes		4			To ensure propper use of the borehole and ensuring that the borehole is not locked when not in use. supervising watering of livestock and reporting cases of mechanical breakdown
s	Kakali	Lokichar	6 KM	500 Metres	31	An average of 2325	31	NO	NO	√			√		Chairman- overall watch of the borehole and communicating borehole problems to relevant institutions, Treasurer - keeping money, Secretary - keeping records
s	Lochor edome	Lokichar	5.5 km	0.2-0.5 km	around 100 hh	an average of 1500	around 100 hh	NO	NO	√		√	√		Chairman- decides who uses the borehole at a particular time and to resolve any arising conflicts Treasurer - keeping money and collecting contributions, Secretary - keeping records
s	Nakejuamosin	Lochwaangika matak	25 km	0.5 km	15-37 hh	average of 100 per hh	15-37 hh	NO	NO	√	√				Chairman - to supervise the usage of the borehole. Secretary - keeping records.Treasurer - collecting money from the water users
s	Lolupe	Lochwaangika matak	1 km	300 metres	20-48 hh	average of 30-50 per hh	20-48 hh	Yes, 4 members	NO	√			√		Chairman - checking weather there is a problem with the borehole, Secretary - writing down any problems and presenting to the chairman, Treasurer - collecting money and keeping list of people who have contributed.
s	Kalokutany	Lorengkippi	3.5 km	No temporary settlement	100-300 hh	average of 100 per hh	NONE	Yes, 3 members	Yes	√					Chairman - arranging and chairing meetings, Secretary - writing reports, Treasurer - keeping money
s	Lokiriemet	Lorengkippi	16 km	No temporary settlement	150-250 hh	average of 50-100 per hh	NONE	Yes, 6 members	Yes	√					Chairman - chairing meetings, Secretary - Taking minutes during meetings, Treasurer - keeping contributions
s	Kakromosing	Lokiriama	7-8 km	300m	10-15 hh	average 50-100 per hh	10-15 hh	No	No		√	√			Chairman; Oganising how people use the BH and securing it from improper use. Treasurer; Collecting contributions
s	Lotilo	Urum	3 km	500 Metres	40-50 hh	average of 150-200 per hh	40-50 hh	No	NO	√	√				Chairman; checking the condition of the BH and how people are using.Secretary; Recording and keeping the register of the users.Treasurer; Supporting the chairman in checking the condition of the BH.
s	Kaidir	Namoruputh	7 Km	300 metres	9 HH	average of 30-50 per hh	9 HH	No	No	√		√			Checking how people are using the borehole, Mobilising community members for contributions, Keeping records on who contributes money, Informing relevant people incase of any problems

Table BD6.4.1 Summary of Questionnaire Interview Result on Borehole Management (4/4)

No	BH site	8. O&M					
		8-1. Technical problem	8-1. Non-technical problem	8-2. Daily care and maintenance of BH	8-3. Maintenance when the BH is not in use (including security)	8-4. repairing work done (problem and who repair)	8-5. Further plan for O&M and management for sustainable use of the BH
s	Chokchok	No technical pro	None	Daily washing of water trough. Locking the borehole after use.	We lock it when nobody is using	No repair done	No further plan but we are planning to start contribution towards the end of the second year
s	Kokorio	there was a time when the borehole was not working the hand pump was loose	No problem	Daily washing of the water trough and locking of the borehole	We normally lock it when not in use	Yes,handpump could not pump water because it was loose but it was repaired by diocese	we have no further plans but we plan to start our registration fee for towards the end of the second year
s	Kakali	Bearings	Reduced fee collection during rains because people use nearby stagnant water instead of borehole	Cleaning of water trough, safety in handling chain and pump. Locking borehole	Locking	Bearing- the WMC contacted Doicese of Lodwar after which they came to repair	Put strict rules for monthly contributions for future maintenance.If one does not make monthly contributions then he/she should not be allowed to use borehole.
s	Lochor edome	None	Some people not willing to contribute money	Cleaning of water trough, collection of monthly funds. Training community members the right way to use the hand pump.	Community member assigned to watch over the borehole when not in use.	None	Collection and saving of monthly funds for future maintenance
s	Nakejuamosin	None	None	Checking the bolts whether there is any which is loose, directing community members how to pump, locking the borehole while not in use	Locking the borehole	None	Collection of monthly funds for future maintenance
s	Lolupe	Difficult to pump	None	locking borehole while not in use	Locking the borehole	None	monthly contributions for future maintenance
s	Kalokutany	None	None	Checking the borehole regularly to confirm the condition	Locking	None	No plan yet
s	Lokiriemet	None	None	Locking the borehole	Locking when not in use	None	No plan yet
s	Kakromosing	None	None	Training community members the right way to use the hand pump., Cleaning the animal trough after use. Nobody should use the BH without prior permission from the chairman	Locking when not in use. Security patrol around the BH	None	Monthly Contributions
s	Lotilo	Broken chain	None	Cleaning water trough, No one is allowed to bath near the borehole	The chairman checks on the borehole regularly	Replacing the chain, Repair work was done by the Diocese of Lodwar	None
s	Kaidir	None	None	Making sure the BH is pumped correctly and Cleaning the animal trough. New members in the community are supposed to make contributions.	The selected persons check on the borehole regularly	No repair work done	Plan to start collecting fee for the next registration

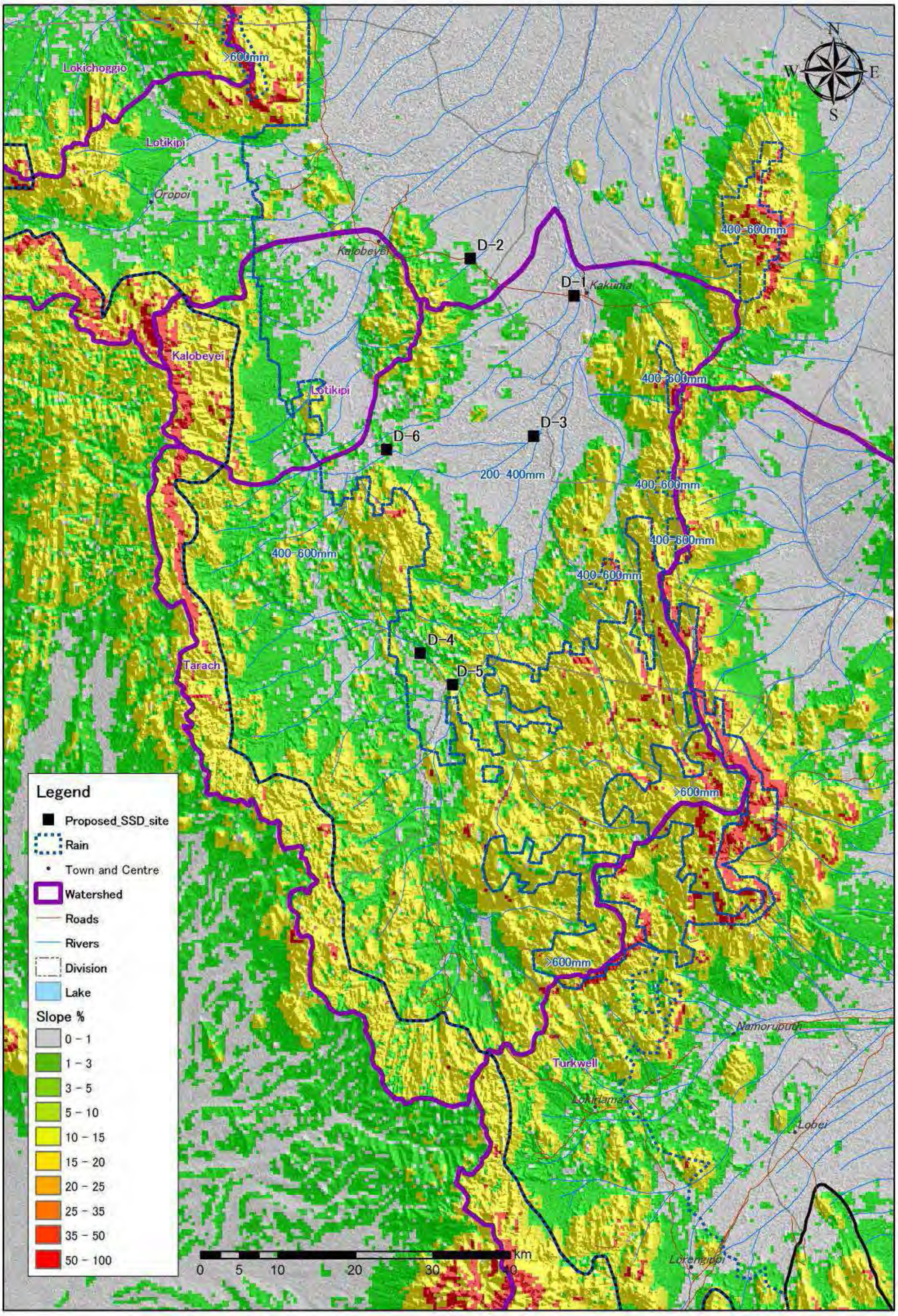
Source: JICA Project Team

Table BD9.1.1 Cost Saving of LOWASCO Pumps by Introduction of Solar Power System

		B/H-1A	B/H-3	B/H-6	Total
(A) Without Project					
(1) Motor power (kW)		18.5	18.0	11.0	
(2) Loading on motor (%)		93.5	93.5	93.5	
(3) Power absorbed at pump shaft (kW)	= (1) x (2)	17.3	16.8	10.3	
(4) Efficiency (%)		83.0	83.0	83.0	
(5) Power absorbed by motor (kW)	= (3) / (4)	20.8	20.2	12.4	
(6) Operation hour per day (hrs/day)		24	24	24	
(7) days in a year (days)		365	365	365	
(8) Operation hour per year (hrs/year)	= (6) x (7)	8,760	8,760	8,760	
(9) Annual required power (kWh)	= (5) x (8)	182,208	176,952	108,624	
(10) Energy Cost (Kshs/kWh)		16	16	16	
(11) Annual Energy Cost (Kshs/year)	= (9) x (10)	2,915,328	2,831,232	1,737,984	7,484,544
(B) With Project					
(1) Motor power (kW)		18.5	18.0	11.0	
(2) Loading on motor (%)		93.5	93.5	93.5	
(3) Power absorbed at pump shaft (kW)	= (1) x (2)	17.3	16.8	10.3	
(4) Efficiency (%)		83.0	83.0	83.0	
(5) Power absorbed by motor (kW)	= (3) / (4)	20.8	20.2	12.4	
(6) Operation hour per day (hrs/day)		16	16	16	
(7) days in a year (days)		365	365	365	
(8) Operation hour per year (hrs/year)	= (6) x (7)	5,840	5,840	5,840	
(9) Annual required power (kWh)	= (5) x (8)	121,472	117,968	72,416	
(10) Energy Cost (Kshs/kWh)		16	16	16	
(11) Annual Energy Cost (Kshs/year)	= (9) x (10)	1,943,552	1,887,488	1,158,656	4,989,696
Cost Saving (A) - (B)		971,776	943,744	579,328	2,494,848
					(33%)

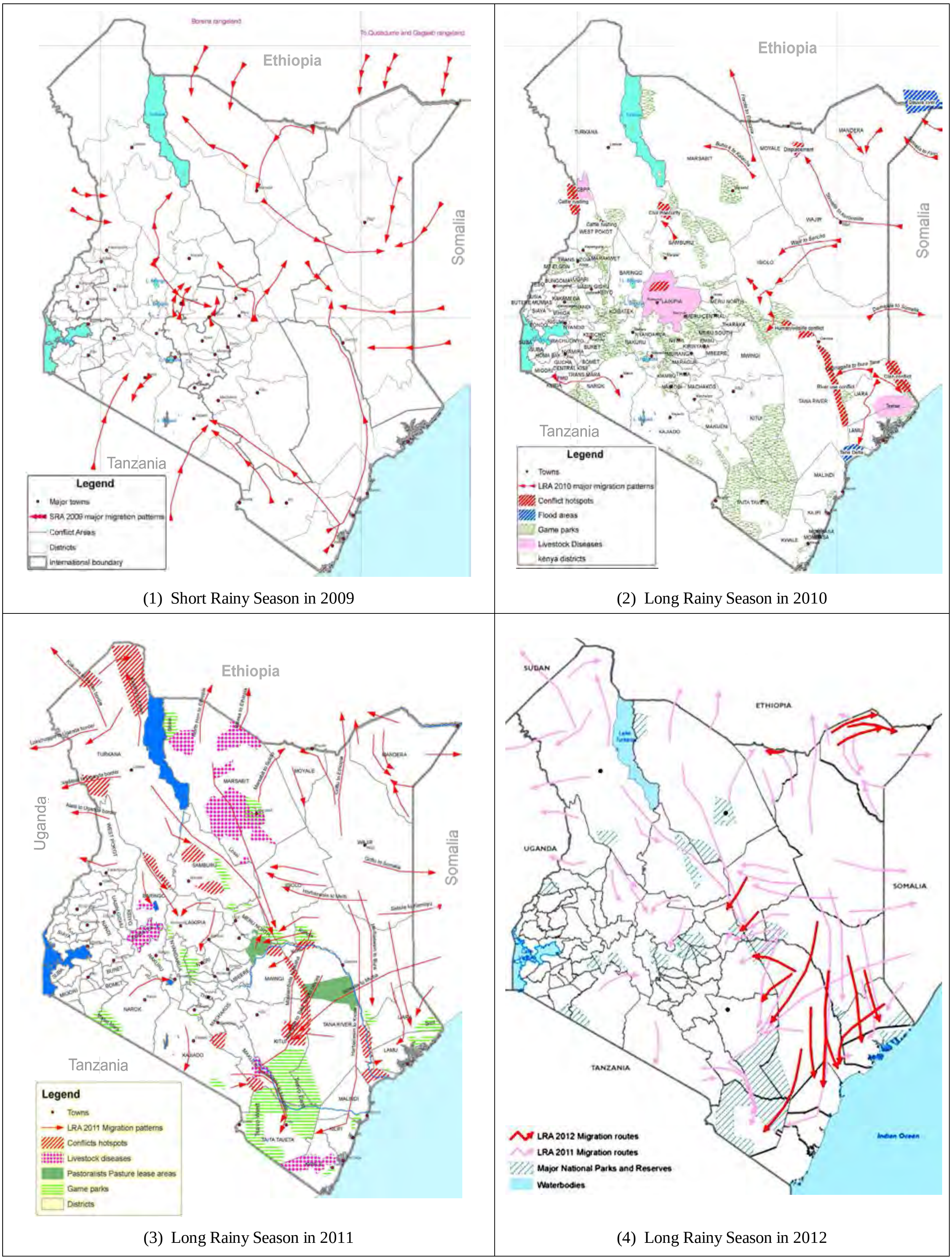
Source: JICA Project Team

Figures



Source: JICA Project Team

Figure BD1.2.1 Proposed Sites for Subsurfce Dam in Turkana County



(1) Short Rainy Season in 2009

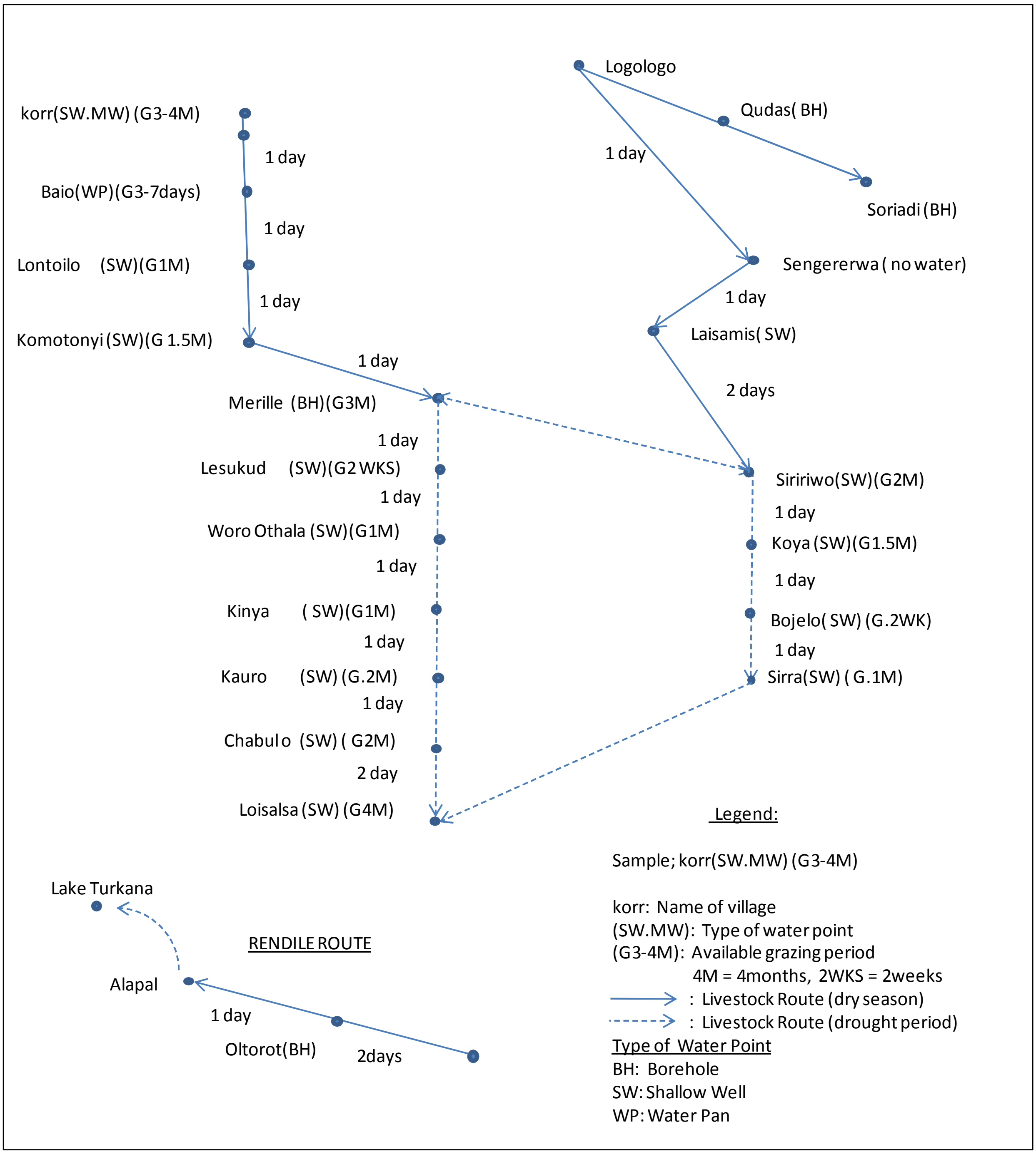
(2) Long Rainy Season in 2010

(3) Long Rainy Season in 2011

(4) Long Rainy Season in 2012

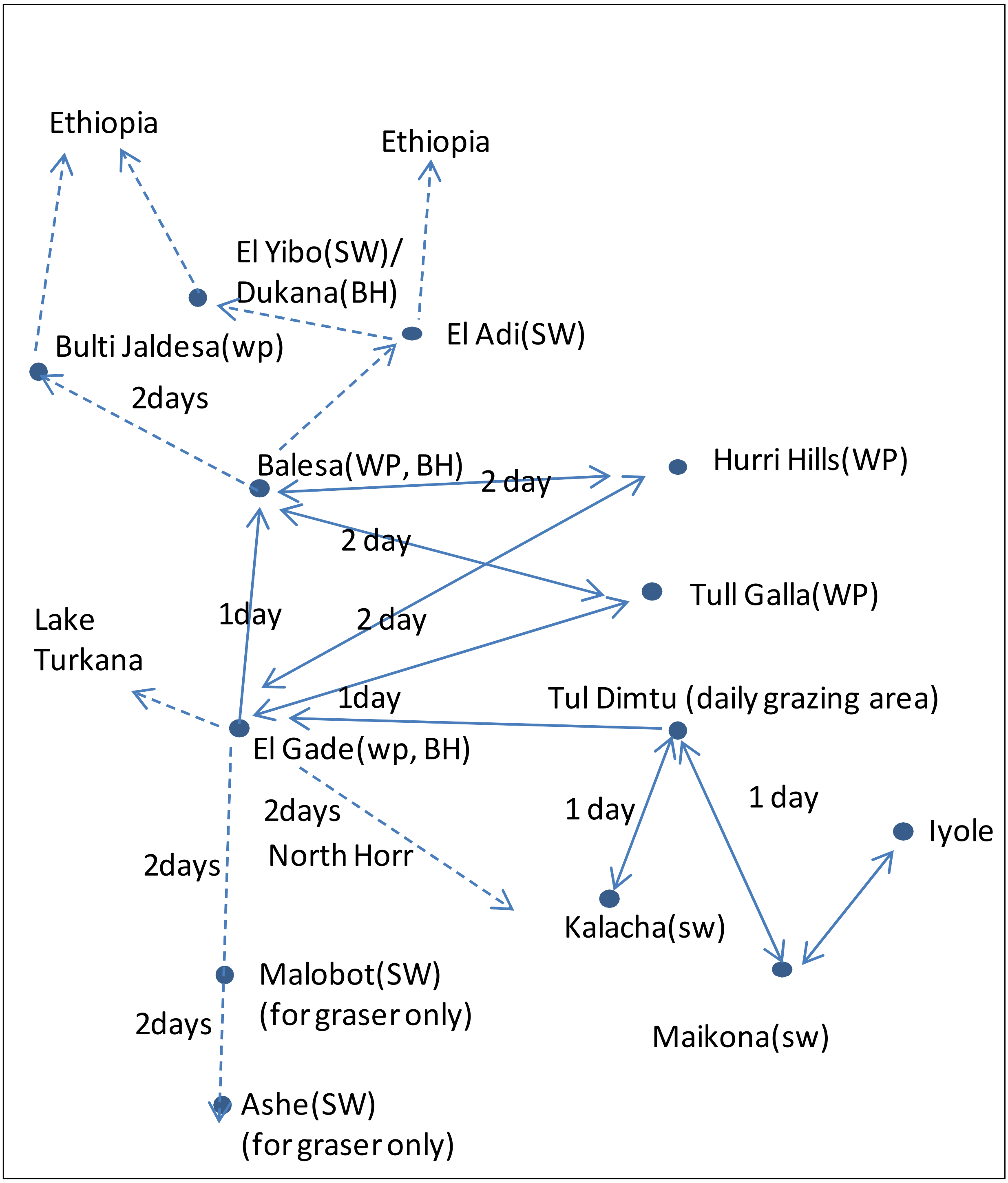
Source: Biannual Food Security Assessments conducted by Kenya Food Security Steering Group

Figure BD1.4.1 Major Migration Routes



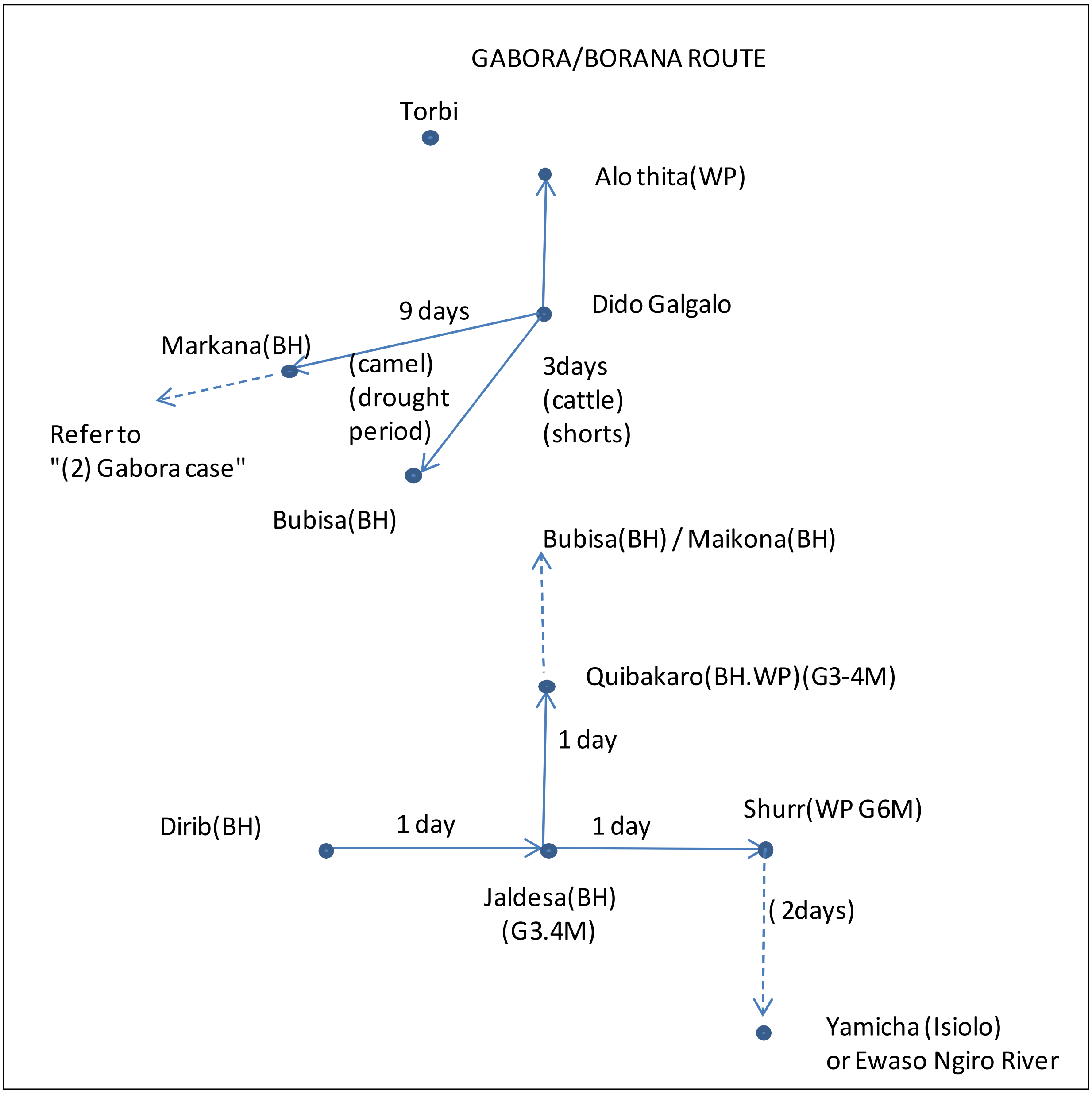
Source: JICA Project Team

Figure BD1.4.2 Livestock Migration Route (1/3) (1) Rendille Case



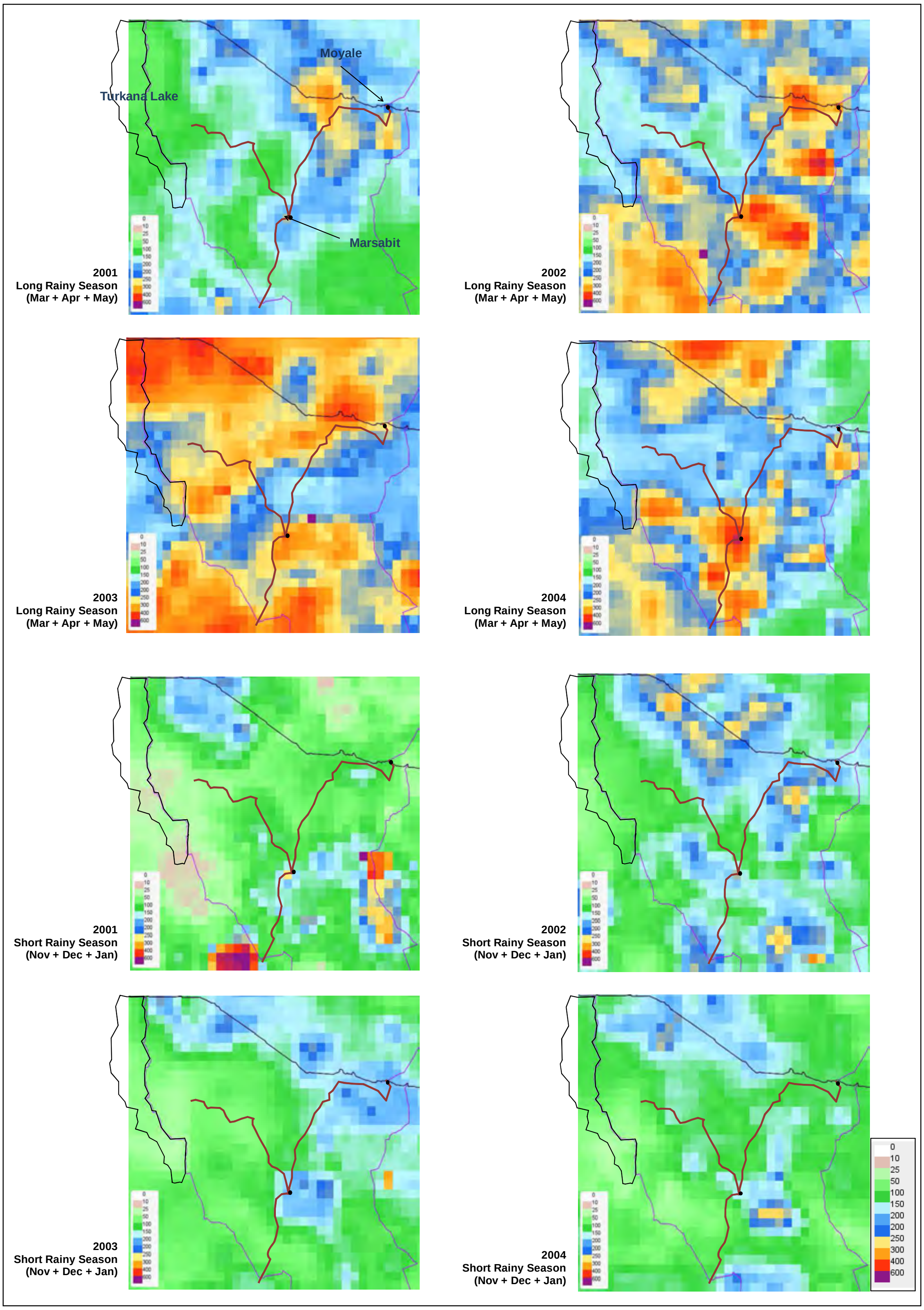
Source: JICA Project Team

Figure BD1.4.2 Livestock Migration Route (2/3) (2) Gabora Case



Source: JICA Project Team

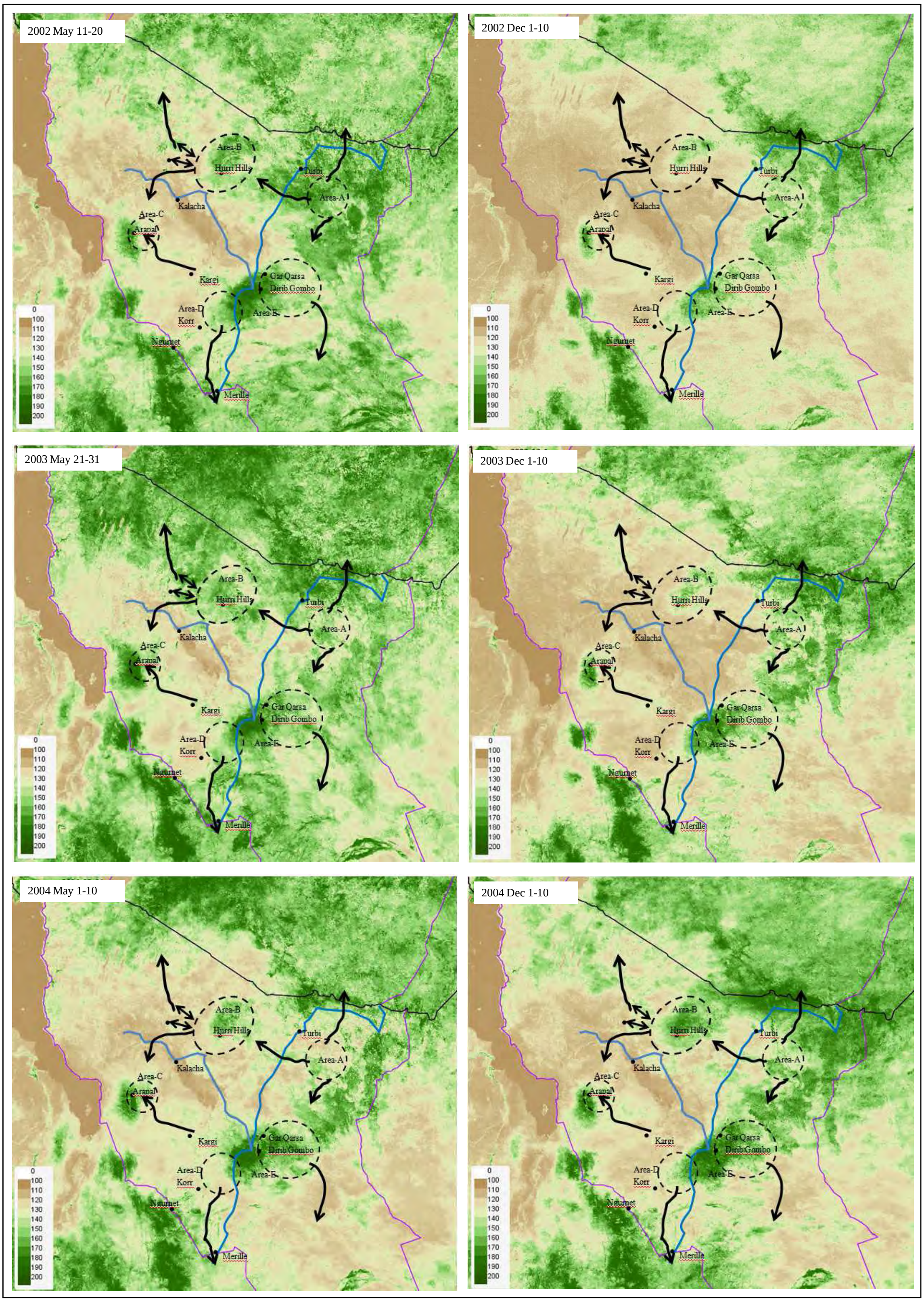
Figure BD1.4.2 Livestock Migration Route (3/3) (3) Borana/ Gabra Case



Note: Rainfall RFE2 = Merged Satellite-gauge Monthly Rainfall produced by NOAA's Climate Prediction Center

Source: Early Warning Explorer (http://earlywarning.usgs.gov:8080/EWX/index.html)

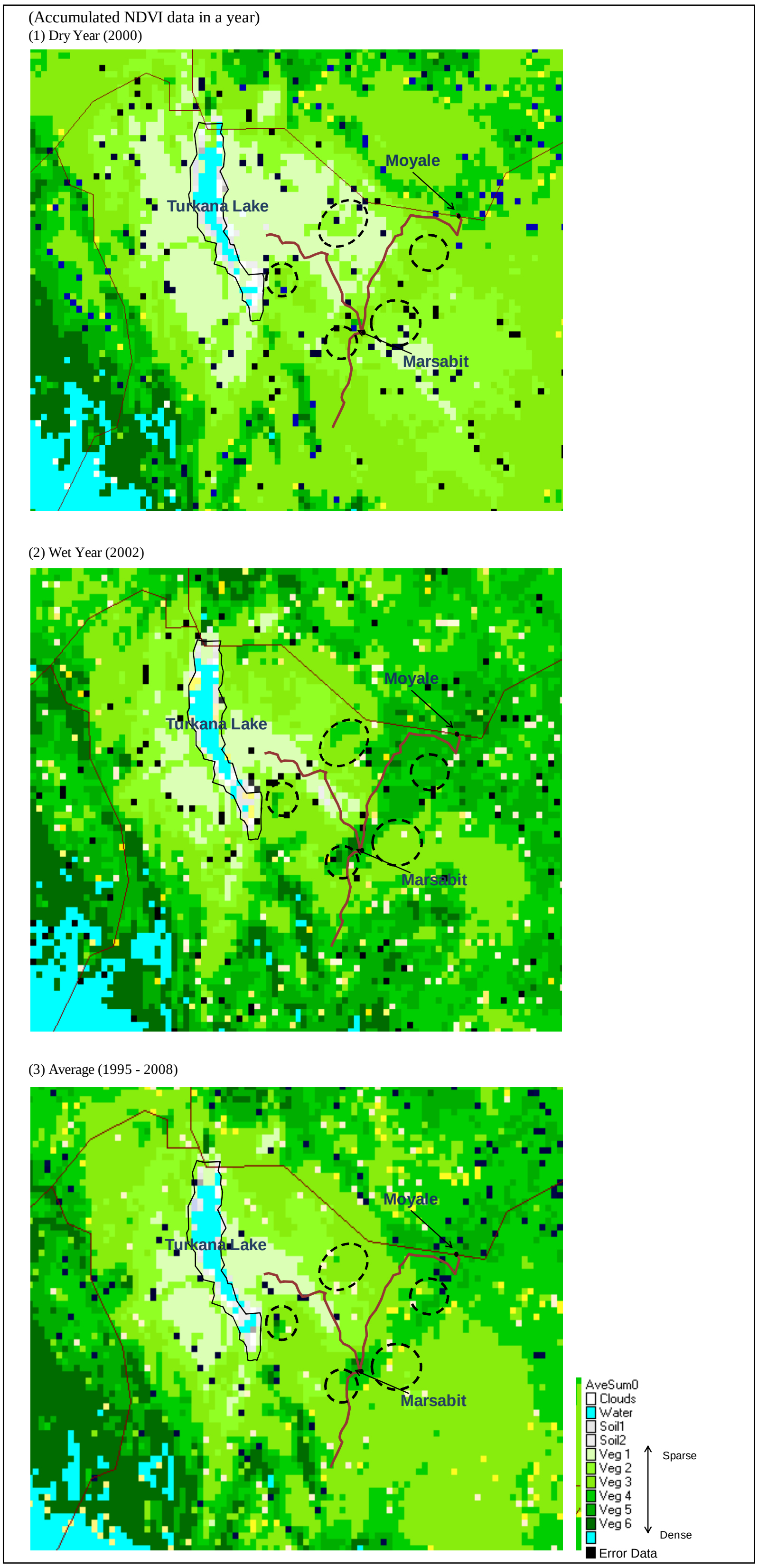
Figure BD1.4.3 Spatial Rainfall Patterns at Marsabit County in Normal Year (2001-2004)



Note: NDVI images were selected to have good vegetation conditions in middle of rainy season in Normal year (2002-2004)

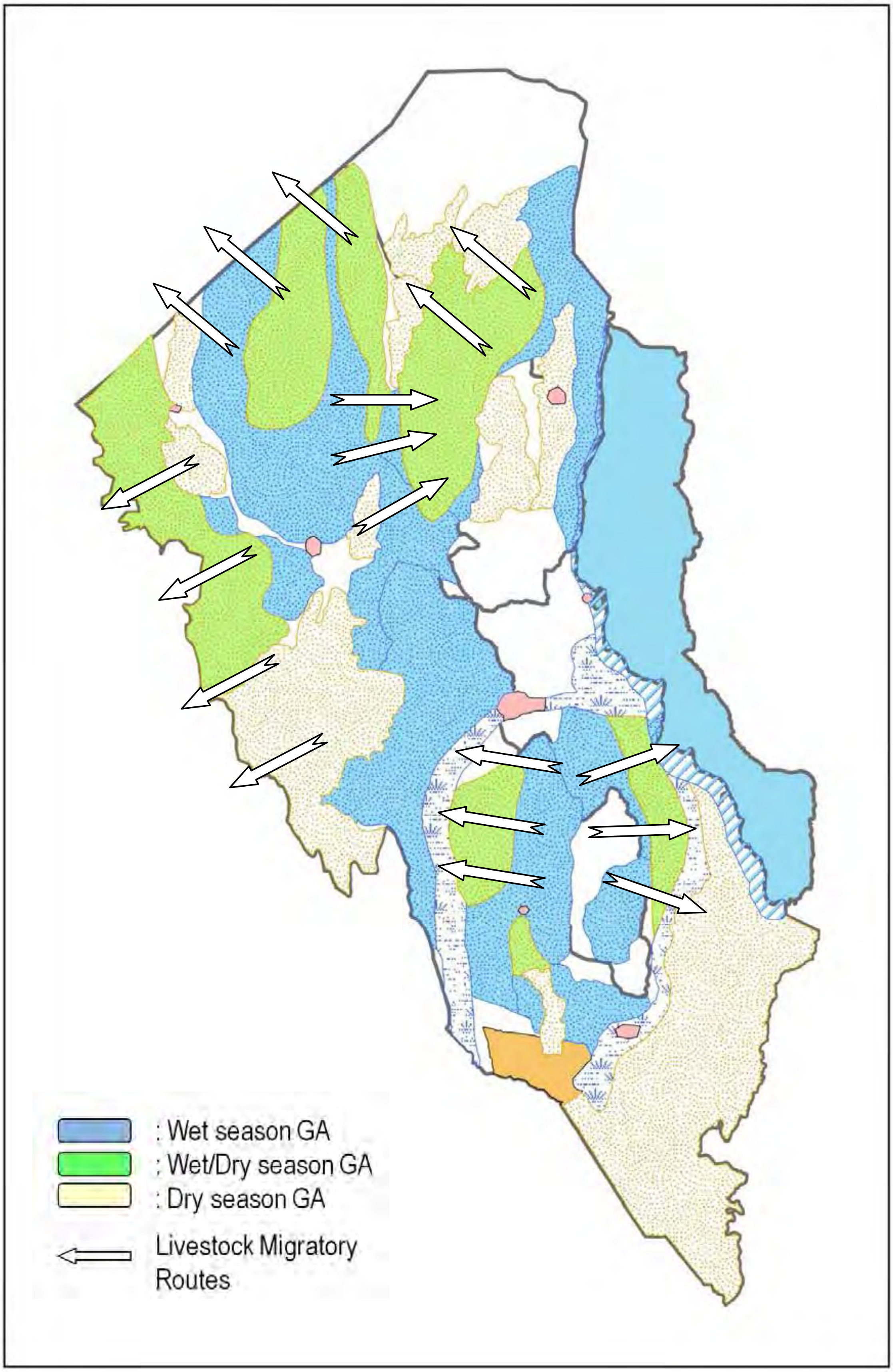
Source: Early Warning Explorer (http://earlywarning.usgs.gov:8080/EWX/index.html), Basic Vegetation Data: eMODIS NDVI 10-days , Edited by JICA Project team

Figure BD1.4.4 Rangeland and Migratory Route in Normal Years



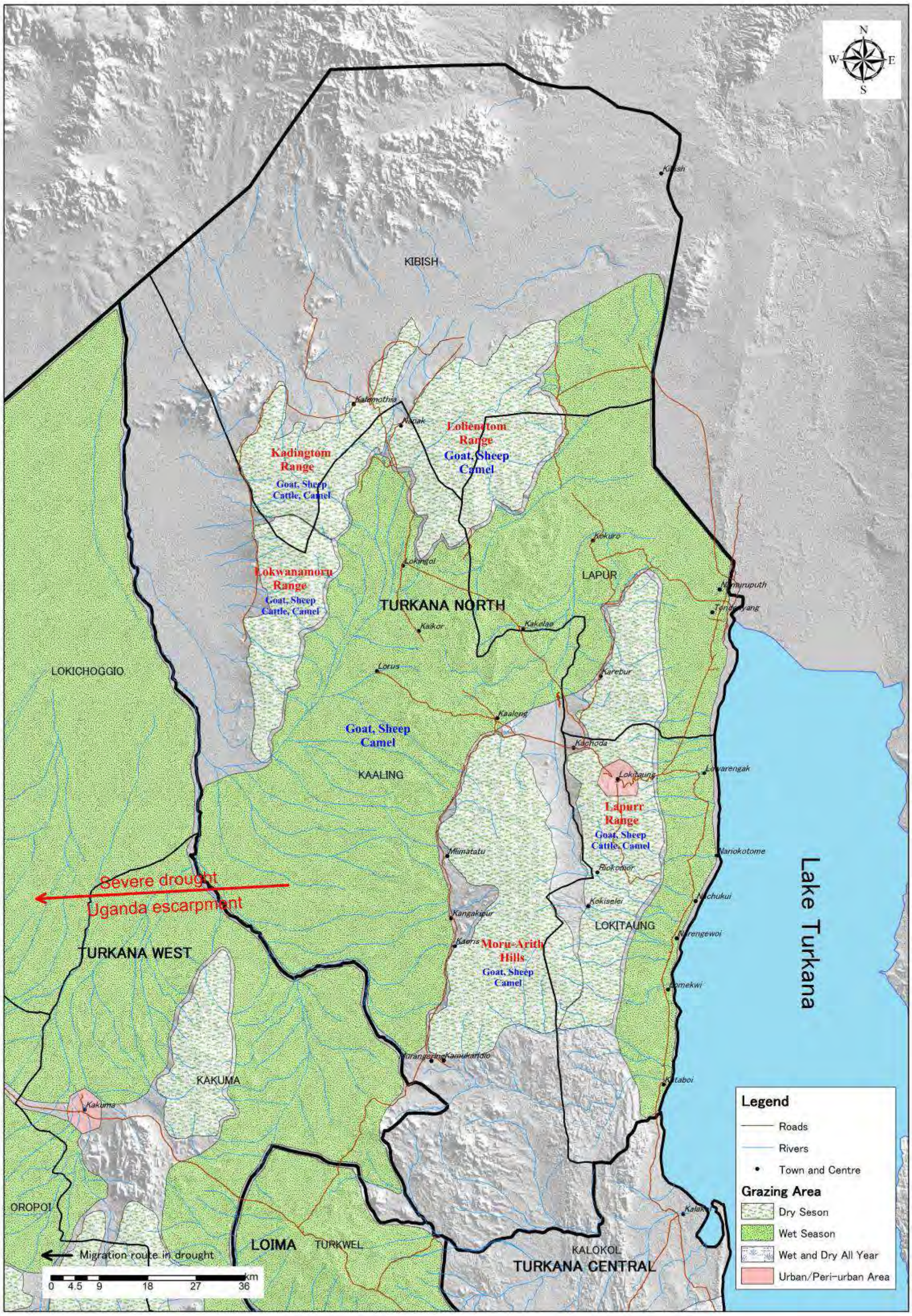
Source: NDVI-G Dataset, December 2004 (Version 4, NOAA-16 calibration) in FEWS-NET (http://earlywarning.usgs.gov/fews/africa/index.php) Calculated by JICA Project team by WinDisp51

Figure BD1.4.5 Pasture Condition Analysis in Marsabit County



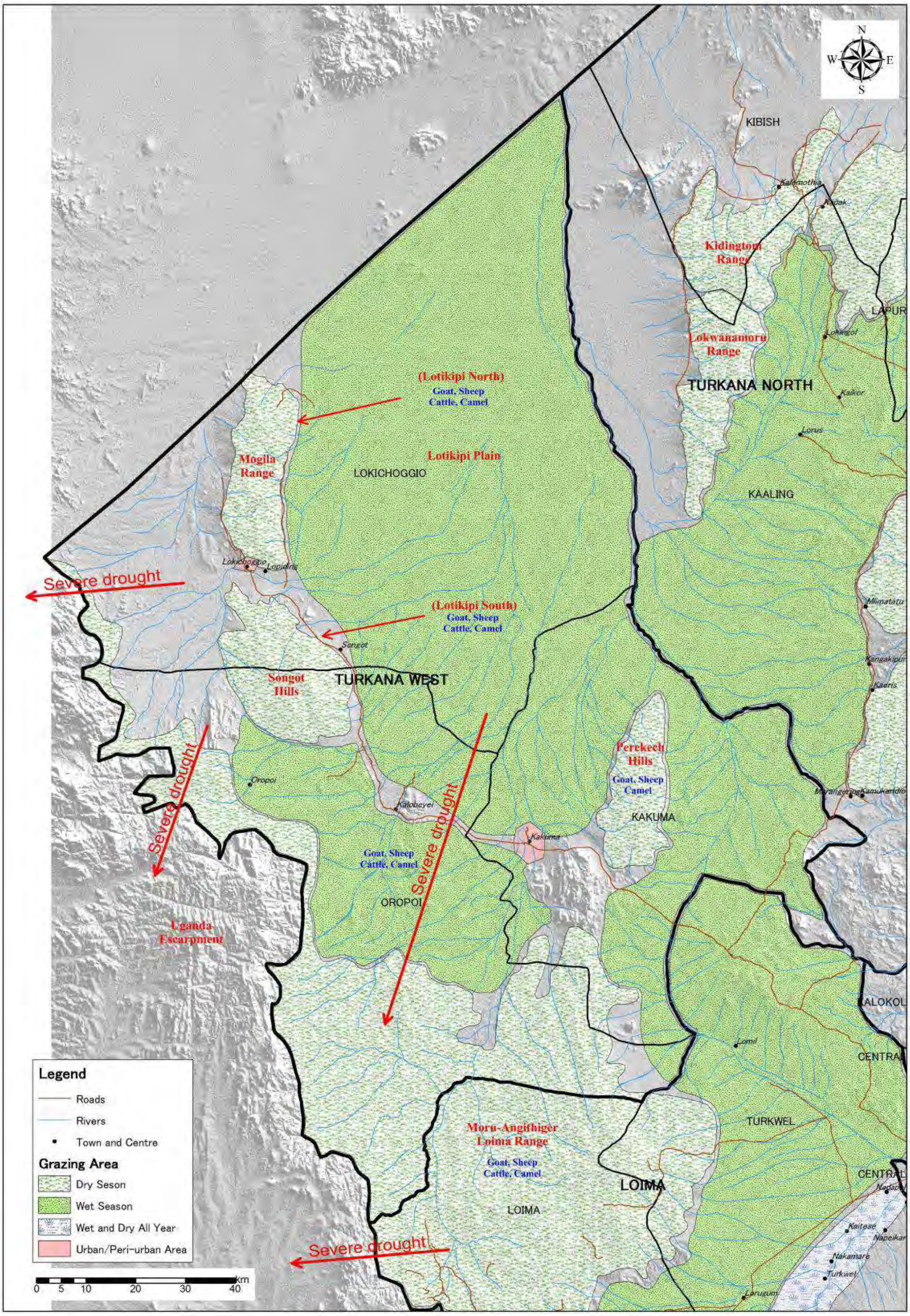
Source: UNICEF and JICA Project Team

Figure BD1.4.6 Grazing Area and Migratory Routes in Drought in Turkana County



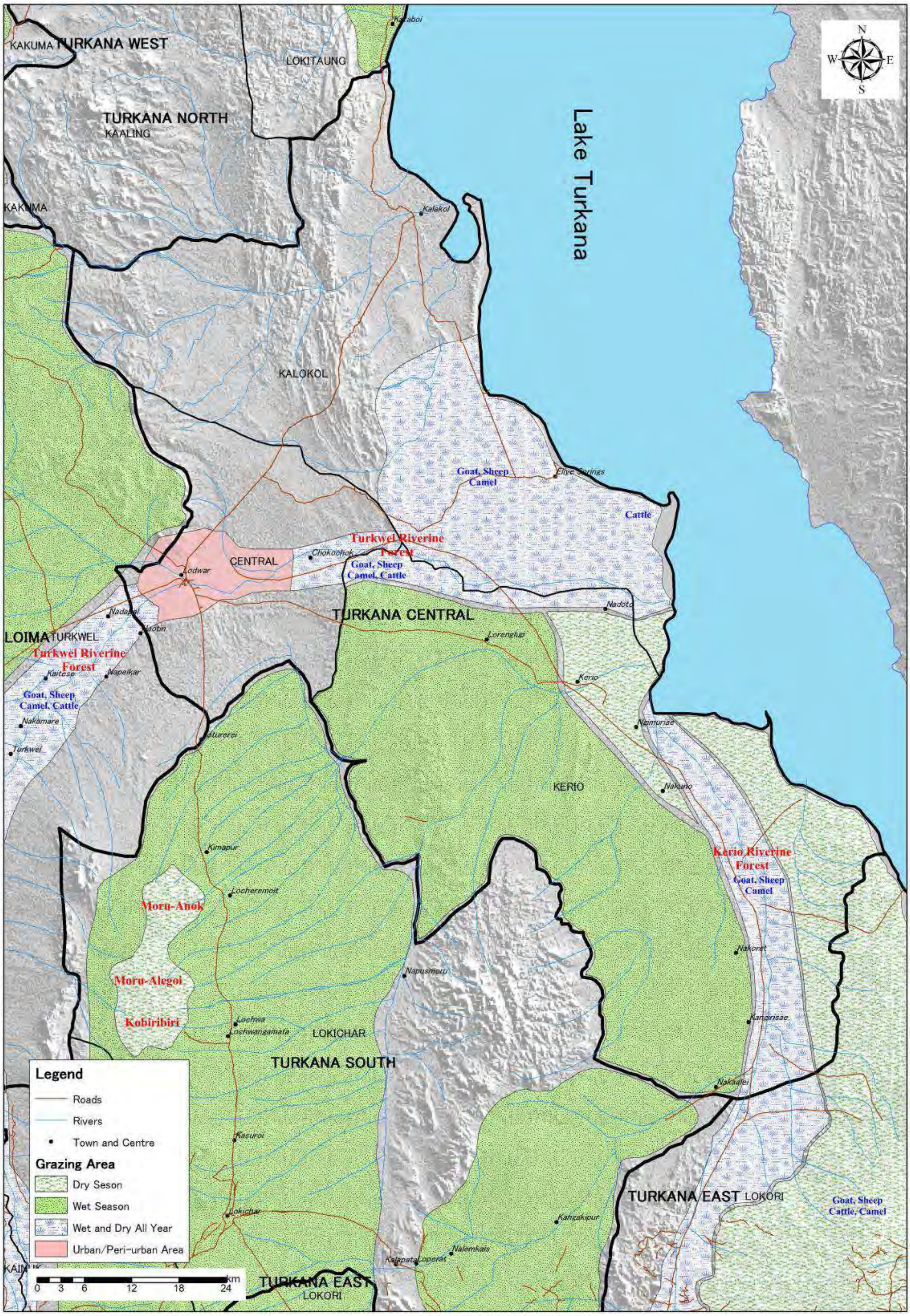
Source: JICA Project Team

Figure BD.1.4.7 Grazing Area in Turkana North District



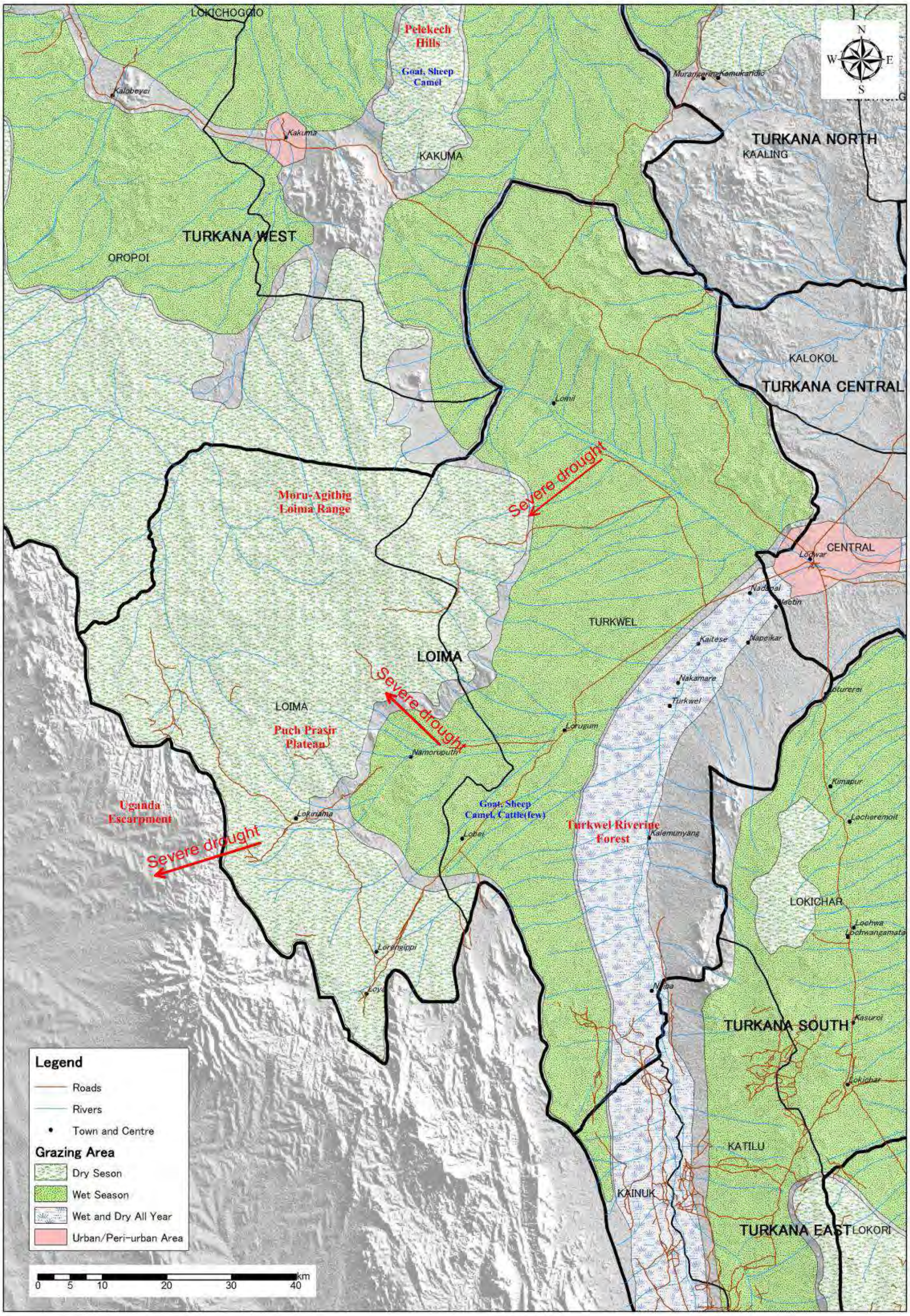
Source: JICA Project Team

Figure BD.1.4.8 Grazing Area in Turkana West District



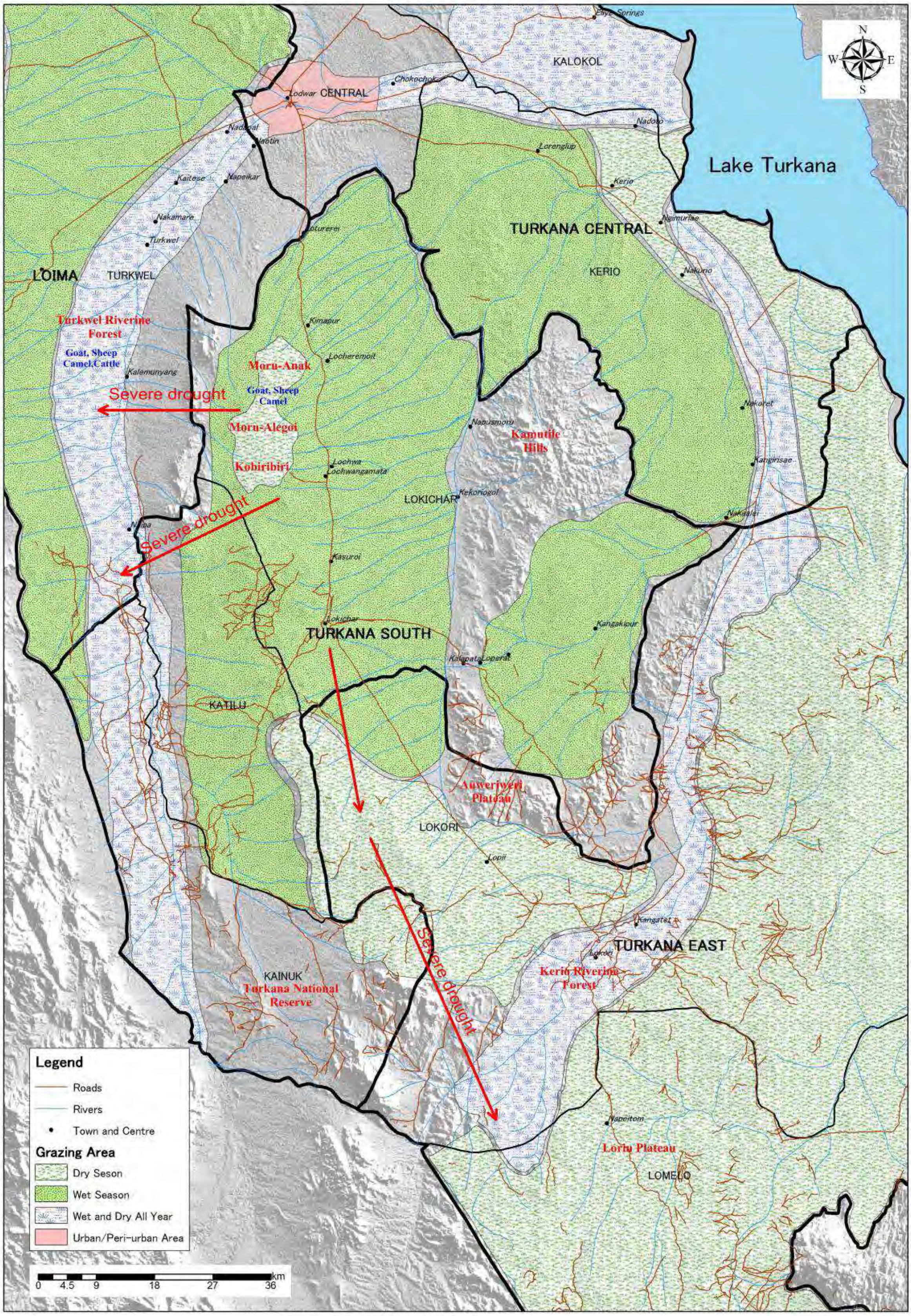
Source: JICA Project Team

Figure BD.1.4.9 Grazing Area in Turkana Central District



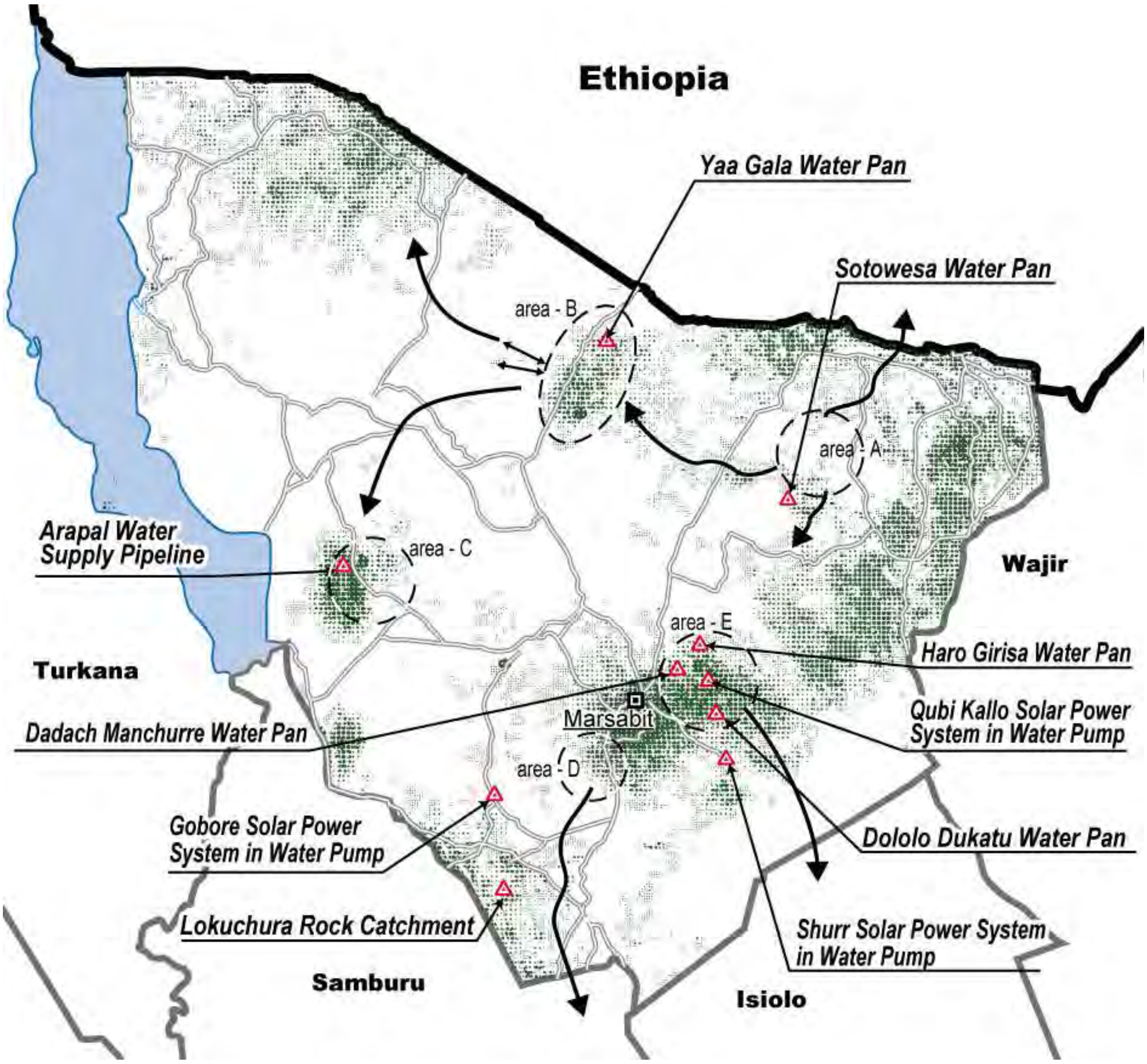
Source: JICA Project Team

Figure BD.1.4.10 Grazing Area in Loima District



Source: JICA Project Team

Figure BD.1.4.11 Grazing Area in South and East District



Legend

Unutilized Grazing Areas

A) Dida Galgalu (Galgalu Plain) area; (Turbi Community)
B) Hurri Hills area (Hurri Hills Community)
C) East side area of Mt. Kulal (Arapal Community)
D) West side area of Mt. Marsabit (Korr/Ballah Communities)
E) East side area of Mt. Marsabit (Dirib Gombo Community)

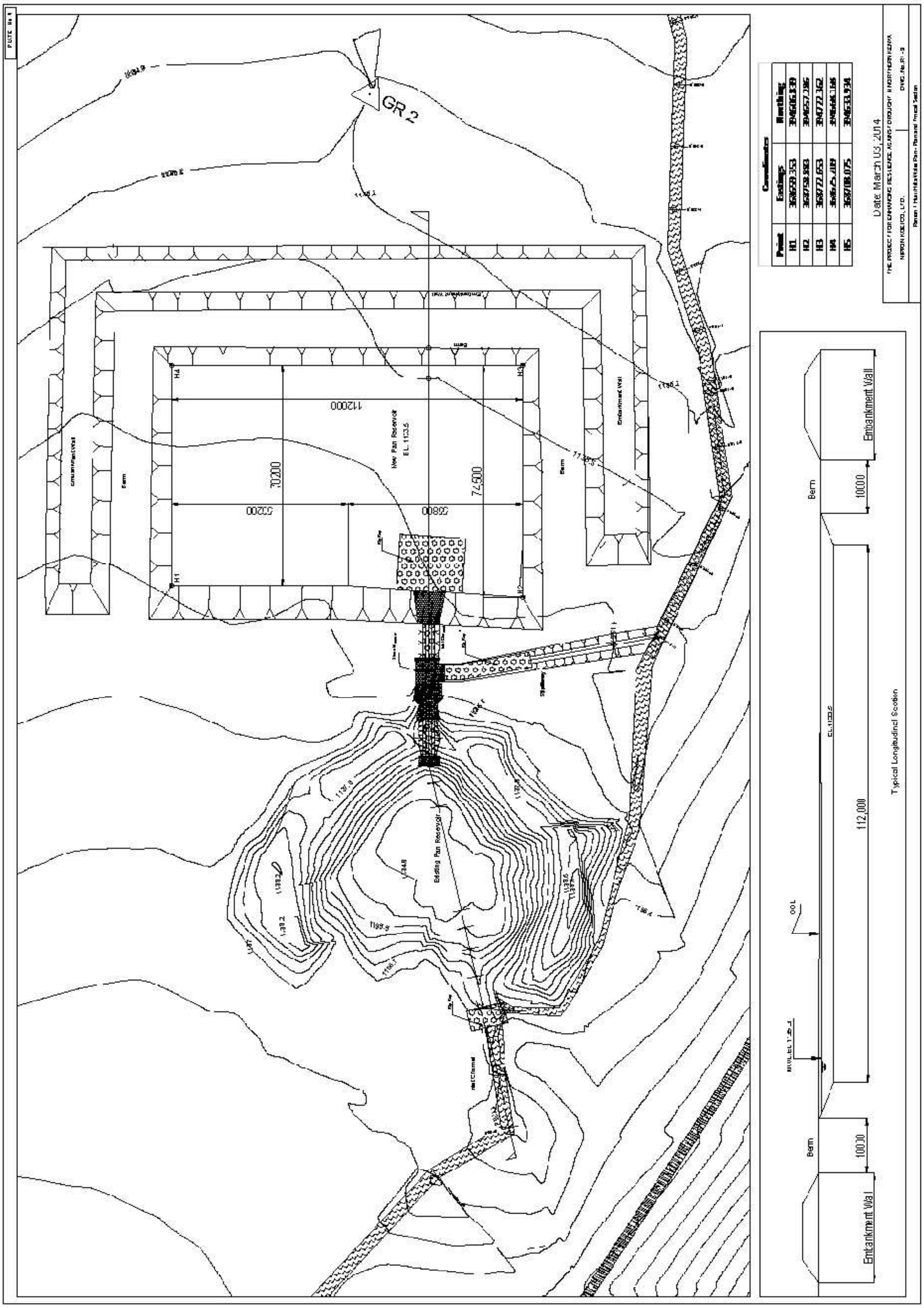
Pastoralist Migratory Routes

Sub-projects for Natural Resources Management under ECoRAD

Base map ; Early Warning Explorer (http://earlywarning.usgs.gov:8080/EWX/index.html), Basic Vegetation Data: eMODIS NDVI 10-days , edited by JICA Project Team

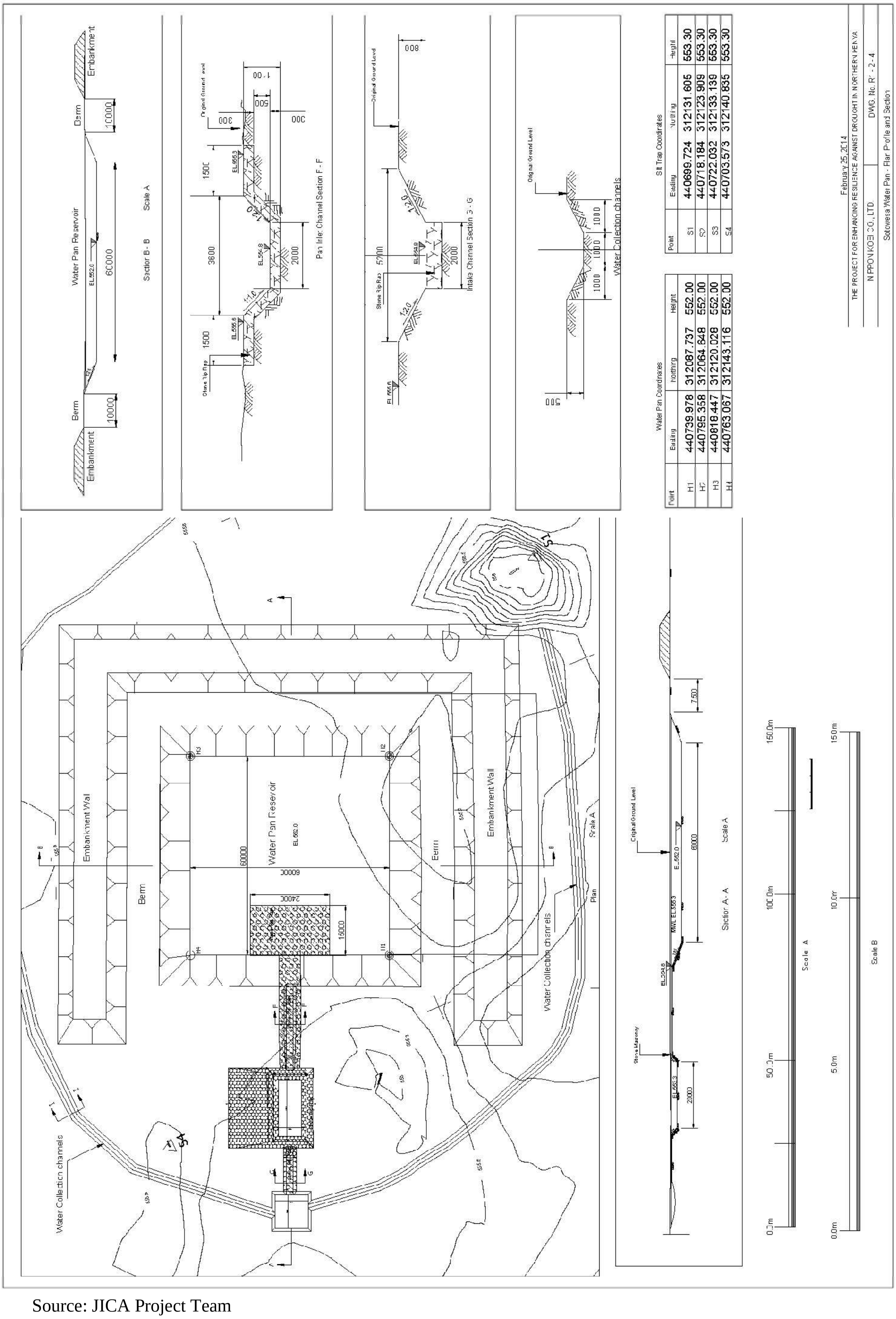
Source: JICA Project Team

Figure BD2.1.1 Location Map of Sub-projects for National Resources Management and Unutilized Grazing Areas in Marsabit County



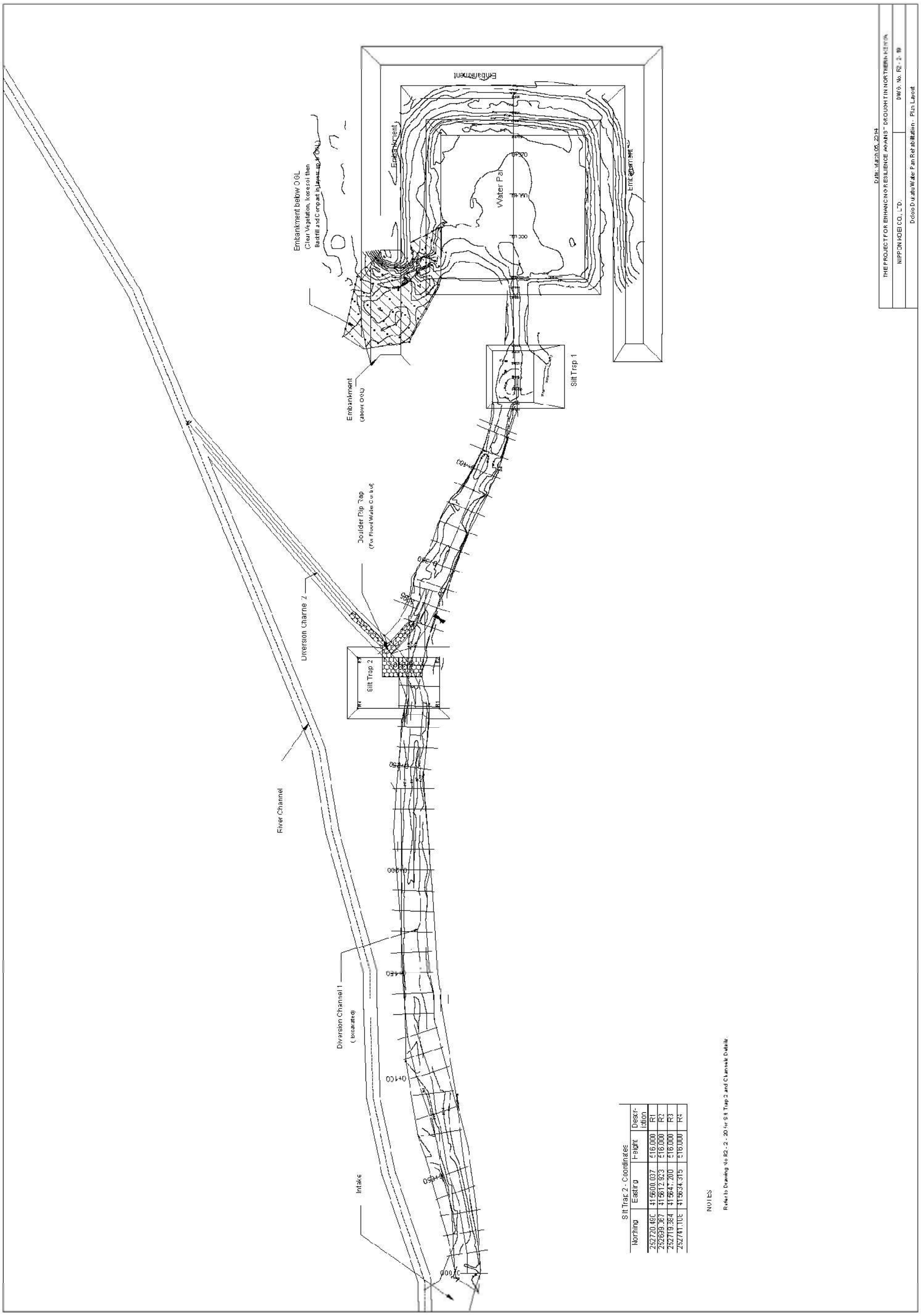
Source: JICA Project Team

Figure BD2.1.2 Plan of Yaa Gala Water Pan



Source: JICA Project Team

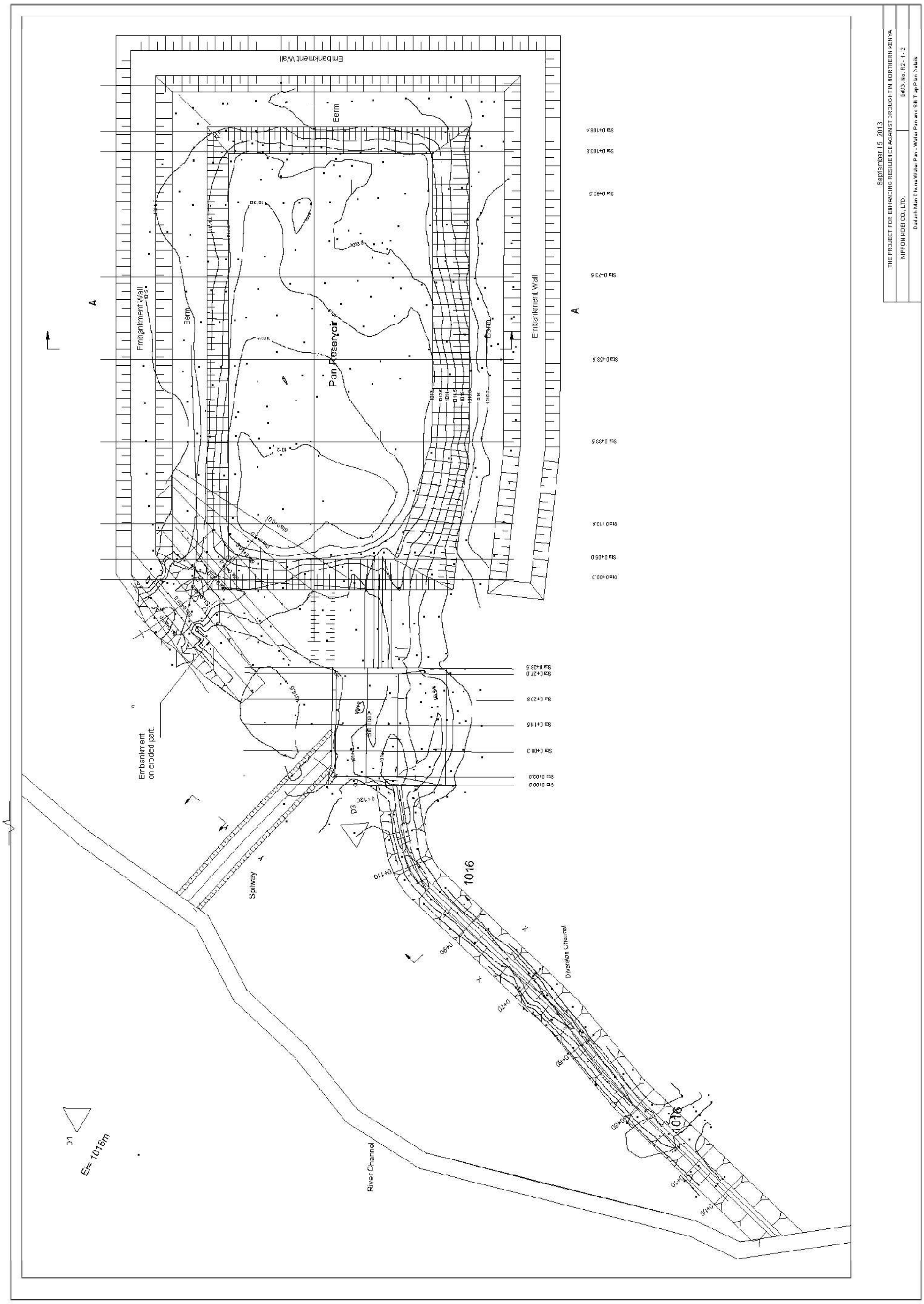
Figure BD2.1.3 Plan of Sotowesa Water Pan



Northing	Easting	Height	Description
252720.490	415600.037	516.000	R1
252699.387	415612.923	516.000	R2
252719.384	415647.200	516.000	R3
252741.106	415634.315	516.000	R4

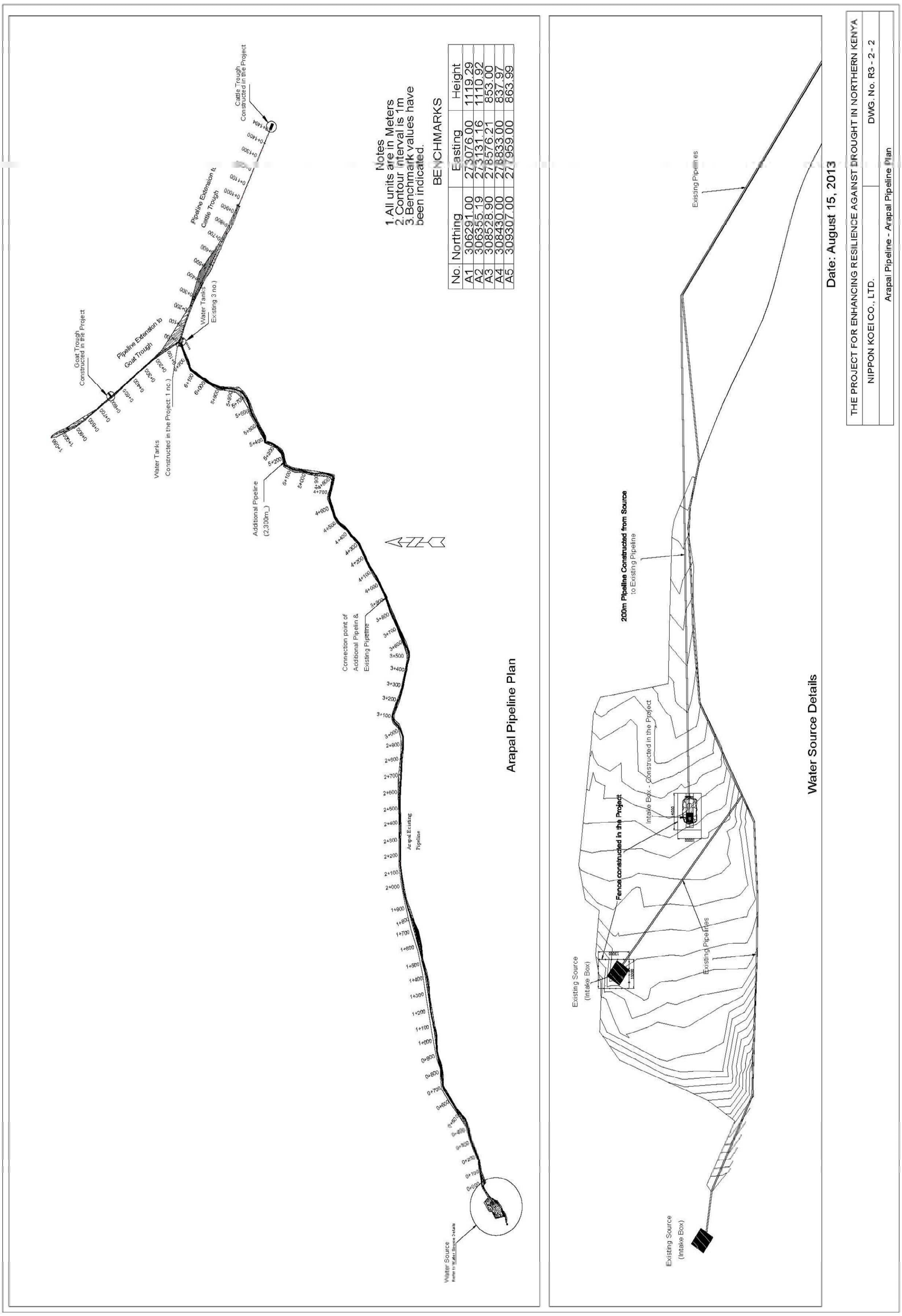
Source: JICA Project Team

Figure BD2.1.4 Plan of Dololo Dokatu Water Pan



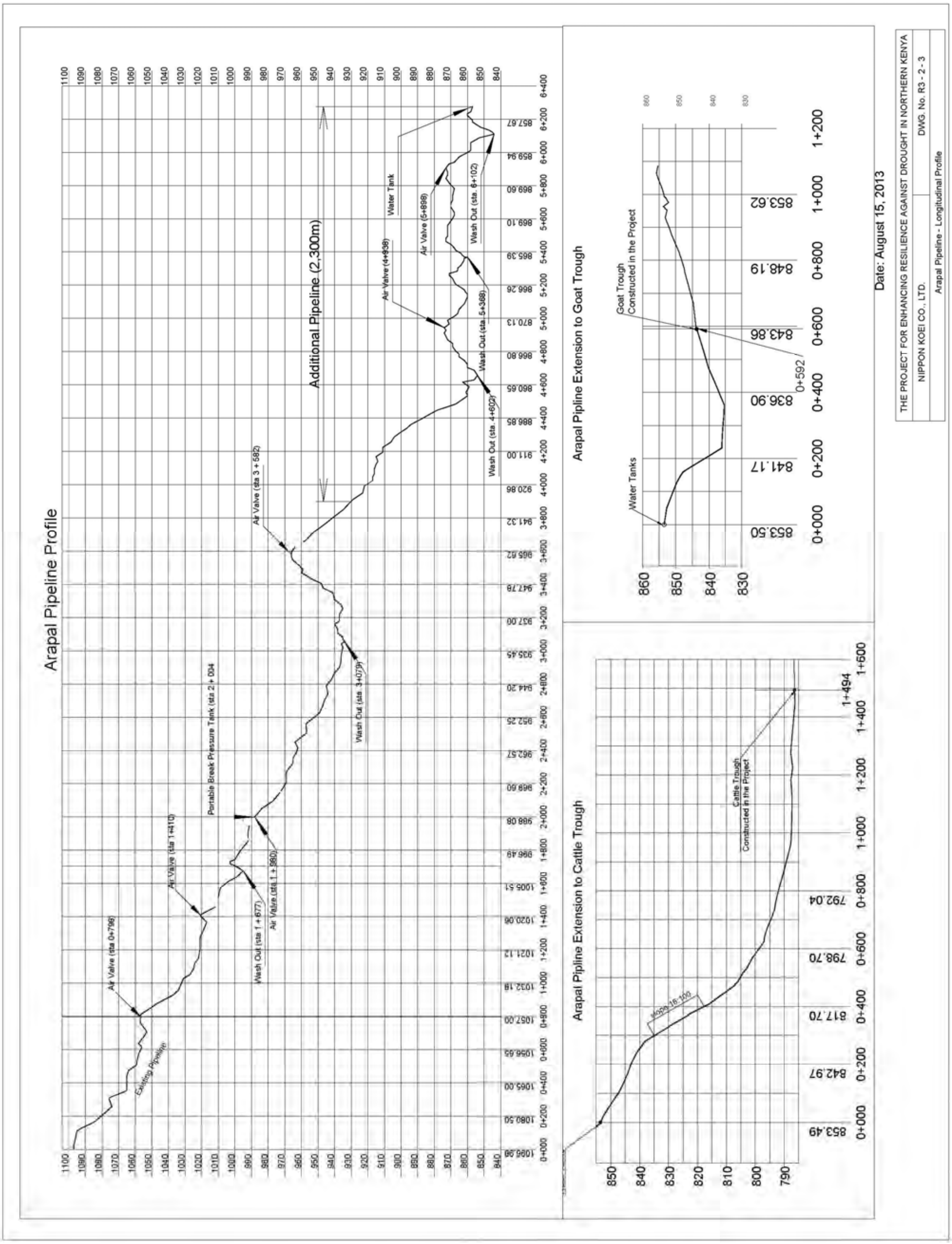
Source: JICA Project Team

Figure BD2.1.5 Plan of Dadach Manchure Water Pan



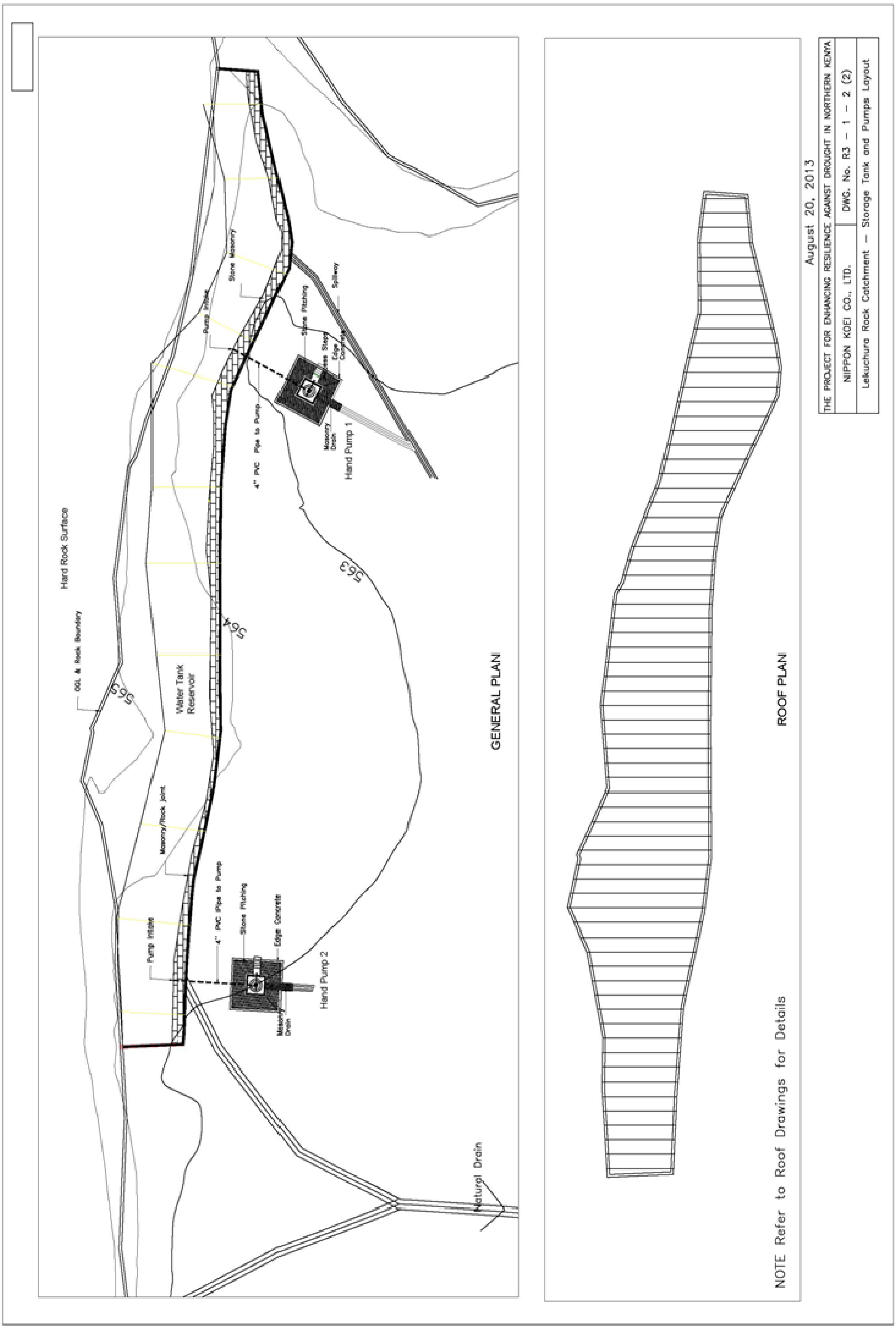
Source: JICA Project Team

Figure BD3.2.1 Plan of Arapal Water Supply Pipeline



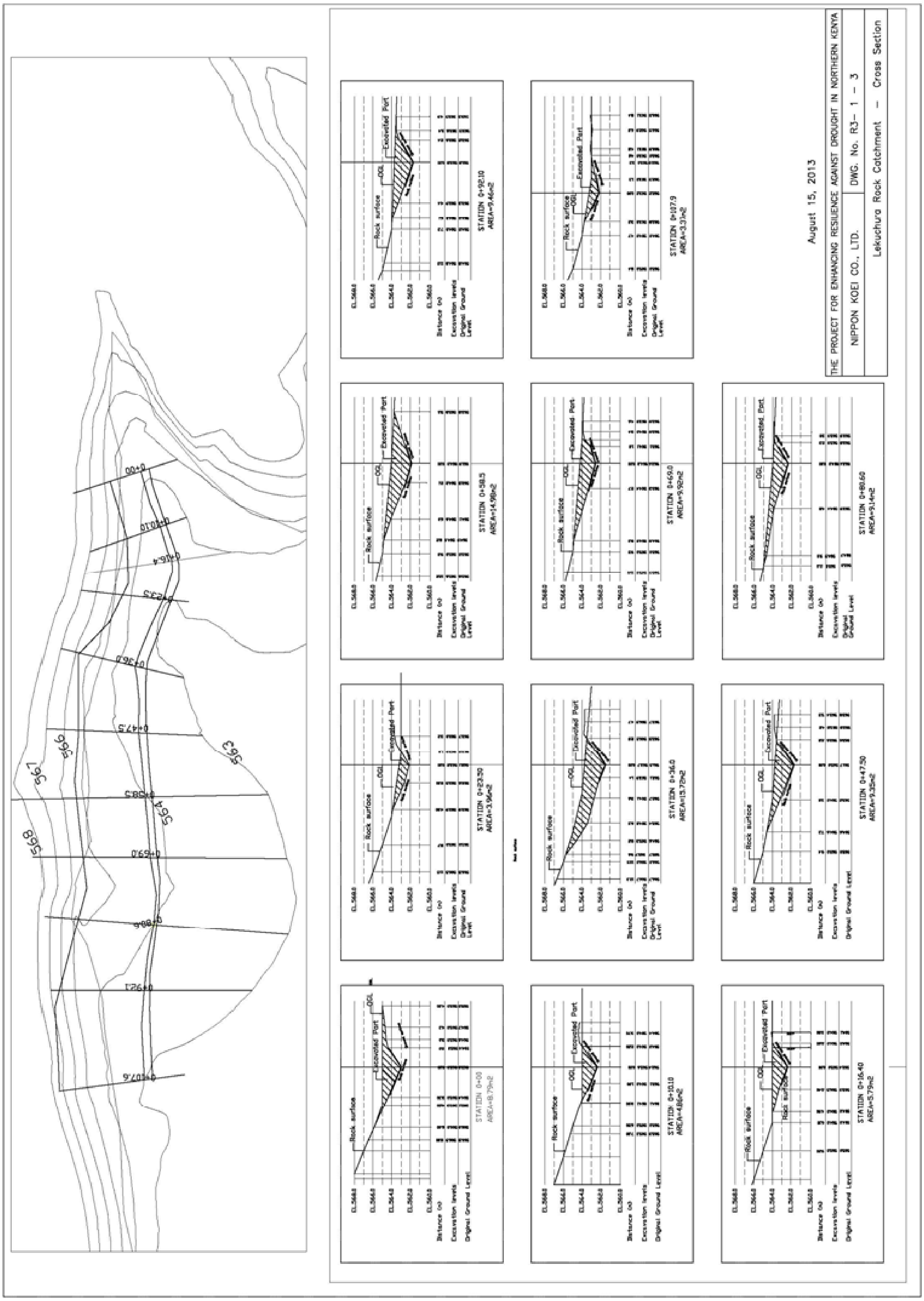
Source: JICA Project Team

Figure BD3.2.2   Longitudinal Profile of Arapal Water Supply Pipeline



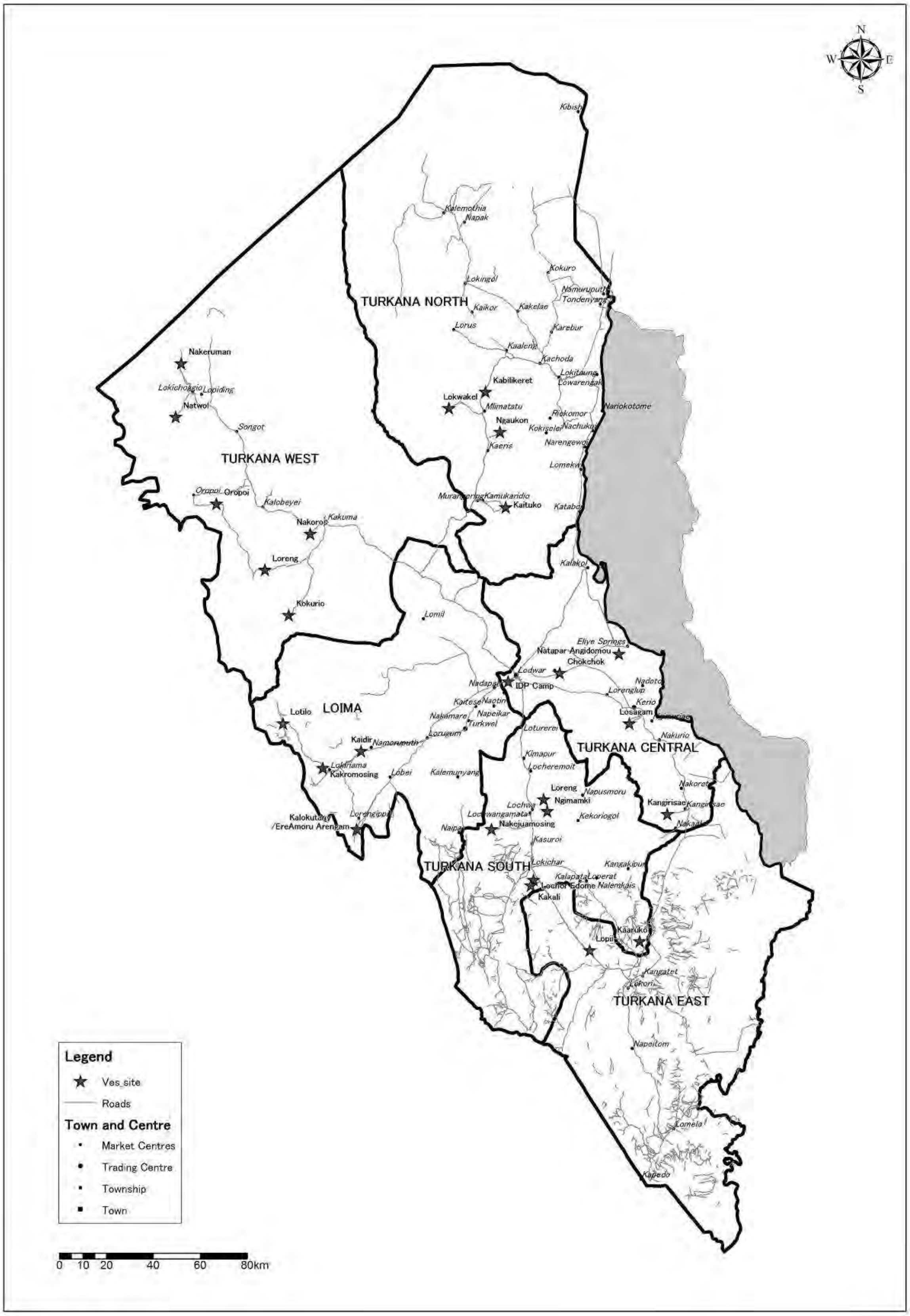
Source: JICA Project Team

Figure BD4.2.1 Plan of Lekchura Rock Catchment



Source: JICA Project Team

Figure BD.4.2.2 Cross Section of Lokuchura Rock Catchment

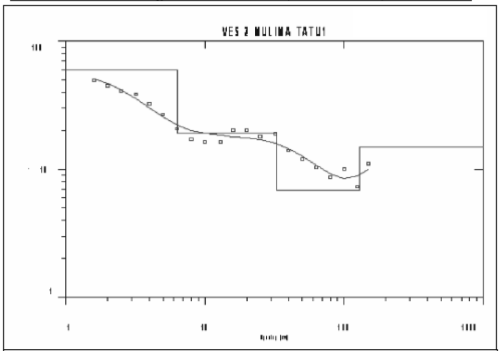


Source: JICA Project Team

Figure BD6.2.1 Electrical Sounding Survey Sites

N1-2 Kaabilikeret

VES 2: Co-ordinates Degrees 035^0 28' 36.1"E; 04^0 12' 45.5"N, Alt 692m ASL



MODEL: VES 2 MULIMA TATU1

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	59.9	6.3	6.3
2	19.0	26.7	33.0
3	6.8	97.0	130.0
4	15.0		

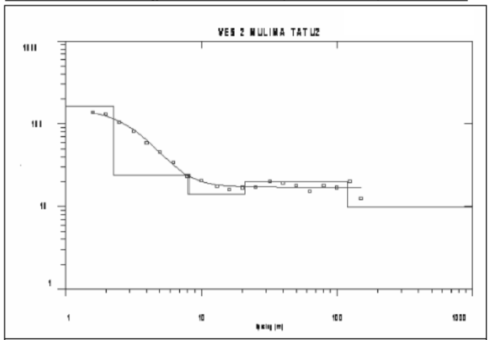
DATASET: VES 2 MULIMA TATU1

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	49.680000
2	2.000000	0.500000	44.740002
3	2.500000	0.500000	40.680000
4	3.200000	0.500000	38.369999
5	4.000000	0.500000	32.470001
6	5.000000	0.500000	26.840000
7	6.300000	0.500000	20.700001
8	8.000000	0.500000	17.200001
9	10.000000	0.500000	16.270000
10	13.000000	0.500000	16.430000
11	16.000000	0.500000	20.070000
12	20.000000	5.000000	20.299999
13	25.000000	5.000000	18.000000
14	32.000000	5.000000	19.000000
15	40.000000	10.000000	14.000000
16	50.000000	10.000000	12.000000
17	63.000000	10.000000	10.400000
18	80.000000	10.000000	8.600000
19	100.000000	25.000000	10.000000
20	125.000000	25.000000	7.300000
21	150.000000	25.000000	11.000000

Recommended drilling site

N2-2 Lokwakel

VES 2: Co-ordinates Degrees 035^0 20' 09.8"E; 04^0 08' 59.2"N, Alt 582m ASL



MODEL: VES 2 MULIMA TATU2

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	162.1	2.3	2.3
2	23.7	5.8	8.1
3	14.0	12.9	21.0
4	20.0	99.0	120.0
5	9.9		

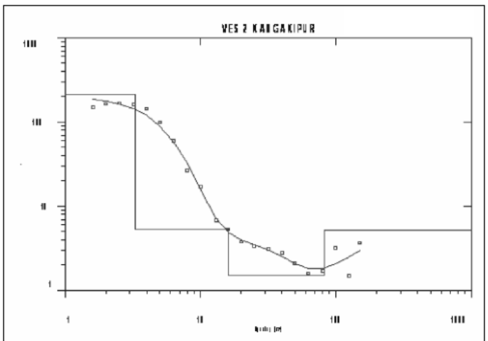
DATASET: VES 2 MULIMA TATU2

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	138.830002
2	2.000000	0.500000	130.389999
3	2.500000	0.500000	105.690002
4	3.200000	0.500000	81.919998
5	4.000000	0.500000	58.950001
6	5.000000	0.500000	45.509998
7	6.300000	0.500000	33.849998
8	8.000000	0.500000	23.400000
9	10.000000	0.500000	20.650000
10	13.000000	0.500000	17.490000
11	16.000000	0.500000	16.059999
12	20.000000	5.000000	17.000000
13	25.000000	5.000000	17.299999
14	32.000000	5.000000	20.000000
15	40.000000	10.000000	19.200001
16	50.000000	10.000000	18.000000
17	63.000000	10.000000	15.300000
18	80.000000	10.000000	18.000000
19	100.000000	25.000000	17.000000
20	125.000000	25.000000	20.000000
21	150.000000	25.000000	12.500000

Recommended drilling site

N3-2 Ngaukon

VES 2: Co-ordinates Degrees 035^0 31' 53.5"E; 04^0 03' 35.0"N, Alt 738m ASL



MODEL: VES 2 KANGAKIPUR

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	213.0	3.3	3.3
2	5.3	12.8	16.1
3	1.5	65.9	82.0
4	5.2		

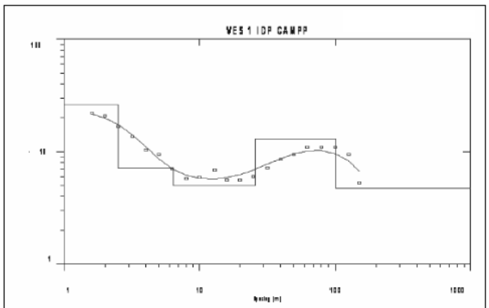
DATASET: VES 2 KANGAKIPUR

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	149.970001
2	2.000000	0.500000	163.850006
3	2.500000	0.500000	169.009995
4	3.200000	0.500000	161.710007
5	4.000000	0.500000	144.440002
6	5.000000	0.500000	99.889999
7	6.300000	0.500000	60.000000
8	8.000000	0.500000	26.600000
9	10.000000	0.500000	17.000000
10	13.000000	0.500000	6.800000
11	16.000000	0.500000	5.300000
12	20.000000	5.000000	3.800000
13	25.000000	5.000000	3.400000
14	32.000000	5.000000	3.100000
15	40.000000	10.000000	2.800000
16	50.000000	10.000000	2.100000
17	63.000000	10.000000	1.600000
18	80.000000	10.000000	1.700000
19	100.000000	25.000000	3.200000
20	125.000000	25.000000	1.500000
21	150.000000	25.000000	3.700000

Recommended drilling site

N4-1 Kaituko

VES 1: Co-ordinates Degrees 035^0 33' 15.4"E; 03^0 46' 11.5"N, Alt 558m ASL



MODEL: VES 1 IDP CAMPP

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	26.0	2.5	2.5
2	7.1	3.9	6.4
3	5.0	19.6	26.0
4	13.0	74.0	100.0
5	4.7		

DATASET: VES 1 IDP CAMPP

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	21.990000
2	2.000000	0.500000	20.889999
3	2.500000	0.500000	16.709999
4	3.200000	0.500000	13.590000
5	4.000000	0.500000	10.390000
6	5.000000	0.500000	9.490000
7	6.300000	0.500000	7.060000
8	8.000000	0.500000	5.800000
9	10.000000	0.500000	5.940000
10	13.000000	0.500000	6.890000
11	16.000000	0.500000	5.620000
12	20.000000	5.000000	5.600000
13	25.000000	5.000000	6.000000
14	32.000000	5.000000	7.200000
15	40.000000	10.000000	8.500000
16	50.000000	10.000000	9.500000
17	63.000000	10.000000	11.000000
18	80.000000	10.000000	11.000000
19	100.000000	25.000000	11.000000
20	125.000000	25.000000	9.500000
21	150.000000	25.000000	5.300000

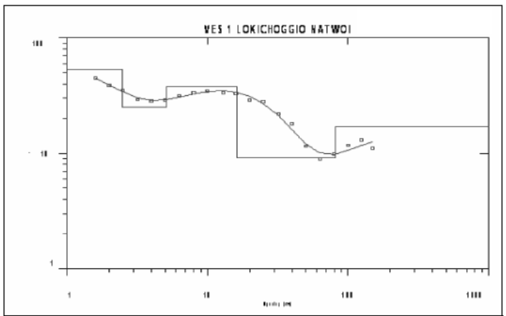
Recommended drilling site

Source: JICA Project Team

Figure BD6.2.2 VES Curves (1)

W1-1 Natwol

VES 1: Co-ordinates Degrees 034⁰ 17' 20.5"E; 04⁰ 06' 59.6"N, Alt 713m ASL



MODEL: VES 1 LOKICHOGGIO NATWOI

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	53.0	2.5	2.5
2	25.0	2.6	5.1
3	38.0	11.1	16.2
4	9.1	65.8	82.0
5	17.0		

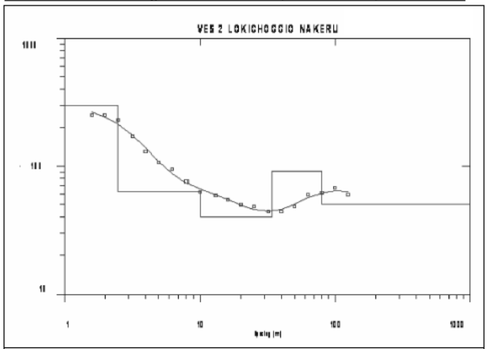
DATASET: VES 1 LOKICHOGGIO NATWOI

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	44.570000
2	2.000000	0.500000	38.990002
3	2.500000	0.500000	35.340000
4	3.200000	0.500000	29.129999
5	4.000000	0.500000	28.260000
6	5.000000	0.500000	29.090000
7	6.300000	0.500000	31.620001
8	8.000000	0.500000	33.400002
9	10.000000	0.500000	34.430000
10	13.000000	0.500000	33.389999
11	16.000000	0.500000	32.919998
12	20.000000	5.000000	29.000000
13	25.000000	5.000000	28.000000
14	32.000000	5.000000	22.000000
15	40.000000	10.000000	18.000000
16	50.000000	10.000000	11.500000
17	63.000000	10.000000	9.000000
18	80.000000	10.000000	9.800000
19	100.000000	25.000000	11.700000
20	125.000000	25.000000	13.000000
21	150.000000	25.000000	11.000000

Recommended drilling site

W2-2 Nakeruman

VES 2: Co-ordinates Degrees 034⁰ 18' 34.9"E; 04⁰ 19' 19.1"N, Alt 696m ASL



MODEL: VES 2 LOKICHOGGIO NAKERUMAN

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	300.0	2.5	2.5
2	62.9	7.5	10.0
3	40.0	24.0	34.0
4	91.0	46.0	80.0
5	50.0		

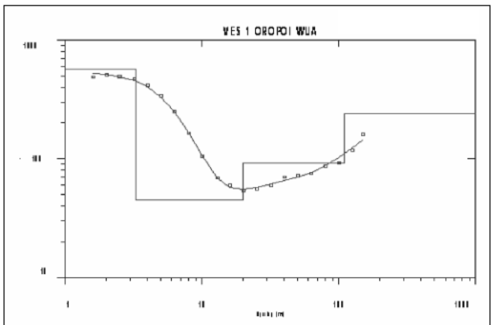
DATASET: VES 2 LOKICHOGGIO NAKERUMAN

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	251.309998
2	2.000000	0.500000	251.460007
3	2.500000	0.500000	228.750000
4	3.200000	0.500000	171.279999
5	4.000000	0.500000	130.869995
6	5.000000	0.500000	106.599998
7	6.300000	0.500000	93.989998
8	8.000000	0.500000	75.800003
9	10.000000	0.500000	62.910000
10	13.000000	0.500000	59.360001
11	16.000000	0.500000	54.599998
12	20.000000	5.000000	50.000000
13	25.000000	5.000000	48.000000
14	32.000000	5.000000	44.000000
15	40.000000	10.000000	44.000000
16	50.000000	10.000000	48.000000
17	63.000000	10.000000	60.000000
18	80.000000	10.000000	62.000000
19	100.000000	25.000000	68.000000
20	125.000000	25.000000	60.000000

Recommended drilling site

W3-1 Oropoi

VES 1: Co-ordinates Degrees 034⁰ 26' 39.6"E; 03⁰ 47' 02.2"N, Alt 783m ASL



MODEL: VES 1 OROPOI WUA

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	570.0	3.3	3.3
2	45.0	16.7	20.0
3	92.0	90.0	110.0
4	240.0		

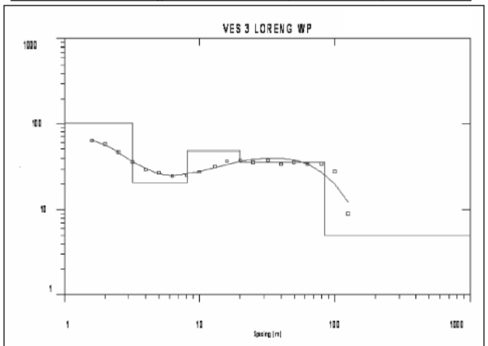
DATASET: VES 1 OROPOI WUA

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	487.519989
2	2.000000	0.500000	508.220001
3	2.500000	0.500000	493.869995
4	3.200000	0.500000	472.250000
5	4.000000	0.500000	415.000000
6	5.000000	0.500000	339.829987
7	6.300000	0.500000	249.240005
8	8.000000	0.500000	164.199997
9	10.000000	0.500000	104.540001
10	13.000000	0.500000	68.900002
11	16.000000	0.500000	59.419998
12	20.000000	5.000000	54.000000
13	25.000000	5.000000	56.000000
14	32.000000	5.000000	60.000000
15	40.000000	10.000000	70.000000
16	50.000000	10.000000	72.000000
17	63.000000	10.000000	75.000000
18	80.000000	10.000000	87.000000
19	100.000000	25.000000	92.000000
20	125.000000	25.000000	118.000000
21	150.000000	25.000000	160.000000

Recommended drilling site

W4-3 Loreng

VES 3: Co-ordinates Degrees 034⁰ 37' 51.2"E; 03⁰ 31' 49.2"N, Alt 737m ASL



MODEL: VES 3 LORENG UP

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	101.0	3.2	3.2
2	21.0	5.0	8.2
3	48.0	11.8	20.0
4	36.0	64.0	84.0
5	5.0		

DATASET: VES 3 LORENG UP

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	62.680000
2	2.000000	0.500000	57.240002
3	2.500000	0.500000	46.660000
4	3.200000	0.500000	36.610001
5	4.000000	0.500000	29.500000
6	5.000000	0.500000	27.150000
7	6.300000	0.500000	25.040001
8	8.000000	0.500000	25.600000
9	10.000000	0.500000	27.850000
10	13.000000	0.500000	32.330002
11	16.000000	0.500000	36.930000
12	20.000000	5.000000	38.000000
13	25.000000	5.000000	36.000000
14	32.000000	5.000000	38.000000
15	40.000000	10.000000	34.000000
16	50.000000	10.000000	36.000000
17	63.000000	10.000000	34.000000
18	80.000000	10.000000	34.500000
19	100.000000	25.000000	28.000000
20	125.000000	25.000000	9.000000

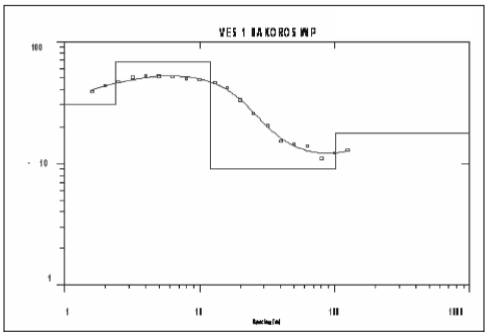
Recommended drilling site

Source: JICA Project Team

Figure BD6.2.3 VES Curves (2)

W5-1 Nakoros

VES 1: Co-ordinates Degrees 034^0 48' 16.1"E; 03^0 40' 02.5"N, Alt 650m ASL



MODEL: VES 1 NAKOROS WP

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	30.0	2.4	2.4
2	68.0	9.6	12.0
3	9.0	89.0	101.0
4	18.0		

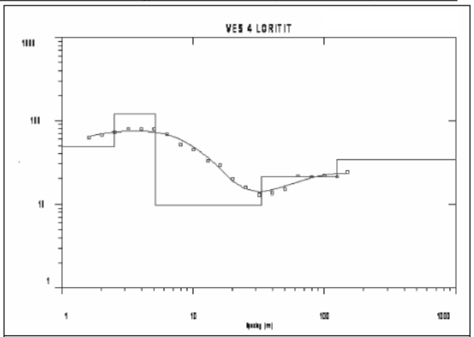
DATASET: VES 1 NAKOROS WP

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	38.549999
2	2.000000	0.500000	43.220001
3	2.500000	0.500000	46.529999
4	3.200000	0.500000	50.770000
5	4.000000	0.500000	52.320000
6	5.000000	0.500000	51.810001
7	6.300000	0.500000	51.330002
8	8.000000	0.500000	49.200001
9	10.000000	0.500000	48.200001
10	13.000000	0.500000	45.580002
11	16.000000	0.500000	41.750000
12	20.000000	5.000000	33.000000
13	25.000000	5.000000	26.000000
14	32.000000	5.000000	20.500000
15	40.000000	10.000000	15.300000
16	50.000000	10.000000	14.500000
17	63.000000	10.000000	14.000000
18	80.000000	10.000000	11.000000
19	100.000000	25.000000	12.200000
20	125.000000	25.000000	13.000000

Recommended drilling site

W6-4 Kokurio

VES 4: Co-ordinates Degrees 034^0 43' 18.4"E; 03^0 21' 26.4"N, Alt 750m ASL



MODEL: VES 4 LORITIT

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	49.0	2.5	2.5
2	120.0	2.6	5.1
3	9.9	27.9	33.0
4	21.0	92.0	125.0
5	34.0		

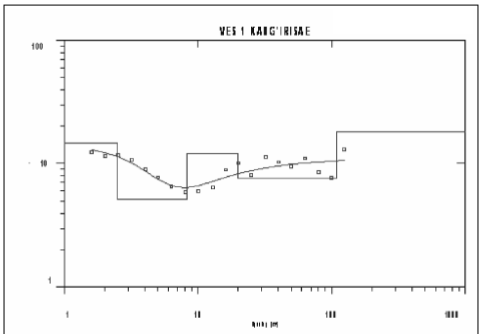
DATASET: VES 4 LORITIT

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	62.400002
2	2.000000	0.500000	67.500000
3	2.500000	0.500000	72.169998
4	3.200000	0.500000	80.000000
5	4.000000	0.500000	79.199997
6	5.000000	0.500000	78.500000
7	6.300000	0.500000	68.070000
8	8.000000	0.500000	51.400002
9	10.000000	0.500000	44.130001
10	13.000000	0.500000	32.799999
11	16.000000	0.500000	28.900000
12	20.000000	5.000000	20.000000
13	25.000000	5.000000	15.500000
14	32.000000	5.000000	13.000000
15	40.000000	10.000000	13.500000
16	50.000000	10.000000	15.000000
17	63.000000	10.000000	21.500000
18	80.000000	10.000000	21.000000
19	100.000000	25.000000	22.000000
20	125.000000	25.000000	21.000000
21	150.000000	25.000000	24.000000

Recommended drilling site

C1-1 Kangirisae

VES 1: Co-ordinates Degrees 036^0 10' 23.7"E; 02^0 35' 39.3"S, Alt 472m ASL



MODEL: VES 1 KANG'IRISAE

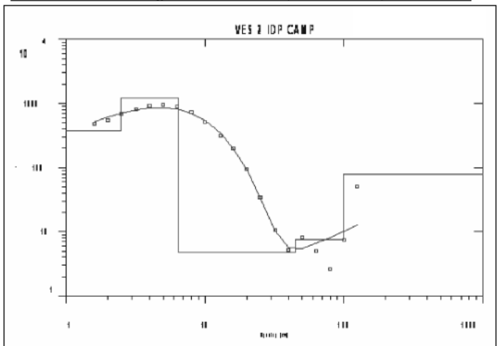
LAYER	RESISTIVITY	THICKNESS	DEPTH
1	14.5	2.5	2.5
2	5.2	5.8	8.3
3	12.0	11.7	20.0
4	7.6	90.0	110.0
5	18.0		

DATASET: VES 1 KANG'IRISAE

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	12.320000
2	2.000000	0.500000	11.520000
3	2.500000	0.500000	11.690000
4	3.200000	0.500000	10.640000
5	4.000000	0.500000	8.910000
6	5.000000	0.500000	7.702000
7	6.300000	0.500000	6.450000
8	8.000000	0.500000	5.800000
9	10.000000	0.500000	5.900000
10	13.000000	0.500000	6.360000
11	16.000000	0.500000	8.830000
12	20.000000	5.000000	10.000000
13	25.000000	5.000000	8.000000
14	32.000000	5.000000	11.300000
15	40.000000	10.000000	10.200000
16	50.000000	10.000000	9.400000
17	63.000000	10.000000	11.000000
18	80.000000	10.000000	8.500000
19	100.000000	25.000000	7.600000
20	125.000000	25.000000	13.000000

C2-2 IDP camp

VES 2: Co-ordinates Degrees 035^0 33' 49.1"E; 03^0 06' 09.5"N, Alt 513m ASL



MODEL: VES 2 IDP CAMP

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	380.0	2.5	2.5
2	1200.0	3.9	6.4
3	4.8	38.6	45.0
4	7.5	55.0	100.0
5	78.0		

DATASET: VES 2 IDP CAMP

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	484.890015
2	2.000000	0.500000	552.000000
3	2.500000	0.500000	677.919983
4	3.200000	0.500000	806.599976
5	4.000000	0.500000	919.260010
6	5.000000	0.500000	956.859985
7	6.300000	0.500000	886.469971
8	8.000000	0.500000	723.299988
9	10.000000	0.500000	507.679993
10	13.000000	0.500000	313.760010
11	16.000000	0.500000	196.729996
12	20.000000	5.000000	94.000000
13	25.000000	5.000000	34.000000
14	32.000000	5.000000	10.500000
15	40.000000	10.000000	5.200000
16	50.000000	10.000000	8.200000
17	63.000000	10.000000	5.000000
18	80.000000	10.000000	2.600000
19	100.000000	25.000000	7.500000
20	125.000000	25.000000	50.000000

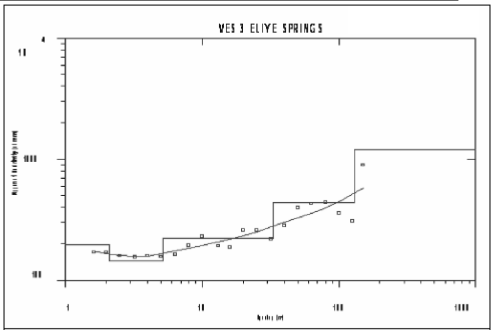
Recommended drilling site

Source: JICA Project Team

Figure BD6.2.4 VES Curves (3)

C3-3 Natapar Angidomou

VES 3: Co-ordinates Degrees 035^0 59' 16.9"E; 03^0 12' 31.1"N, Alt 491m ASL



MODEL: VES 3 ELIYE SPRINGS

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	198.0	2.1	2.1
2	145.0	3.1	5.2
3	220.0	27.8	33.0
4	440.0	97.0	130.0
5	1200.0		

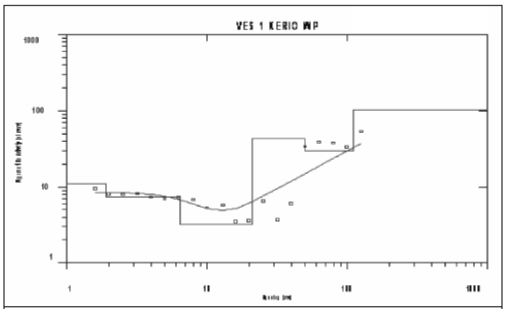
DATASET: VES 3 ELIYE SPRINGS

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	171.479996
2	2.000000	0.500000	171.800003
3	2.500000	0.500000	160.360001
4	3.200000	0.500000	156.149994
5	4.000000	0.500000	159.880005
6	5.000000	0.500000	157.929993
7	6.300000	0.500000	164.300003
8	8.000000	0.500000	195.399994
9	10.000000	0.500000	231.300003
10	13.000000	0.500000	192.919998
11	16.000000	0.500000	189.500000
12	20.000000	5.000000	260.000000
13	25.000000	5.000000	260.000000
14	32.000000	5.000000	220.000000
15	40.000000	10.000000	285.000000
16	50.000000	10.000000	400.000000
17	63.000000	10.000000	430.000000
18	80.000000	10.000000	440.000000
19	100.000000	25.000000	360.000000
20	125.000000	25.000000	310.000000
21	150.000000	25.000000	900.000000

Recommended drilling site

C4-1 Losagam

VES 1: Co-ordinates Degrees 036^0 01' 41.2"E; 02^0 56' 29.5"N, Alt 421m ASL



MODEL: VES 1 KERIO WP

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	11.0	1.9	1.9
2	7.3	4.5	6.4
3	3.2	14.6	21.0
4	43.0	29.0	50.0
5	30.0	60.0	110.0
6	101.0		

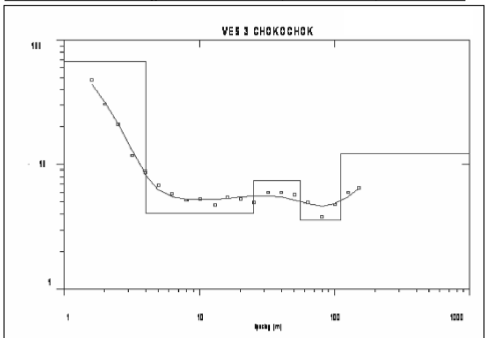
DATASET: VES 1 KERIO WP

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	9.500000
2	2.000000	0.500000	8.100000
3	2.500000	0.500000	8.000000
4	3.200000	0.500000	8.200000
5	4.000000	0.500000	7.400000
6	5.000000	0.500000	7.000000
7	6.300000	0.500000	7.300000
8	8.000000	0.500000	6.800000
9	10.000000	0.500000	5.300000
10	13.000000	0.500000	5.800000
11	16.000000	0.500000	3.500000
12	20.000000	5.000000	3.600000
13	25.000000	5.000000	6.500000
14	32.000000	5.000000	3.700000
15	40.000000	10.000000	6.000000
16	50.000000	10.000000	34.000000
17	63.000000	10.000000	39.000000
18	80.000000	10.000000	38.000000
19	100.000000	25.000000	33.599998
20	125.000000	25.000000	54.000000

Recommended drilling site

C5-3 Chokchok

VES 3: Co-ordinates Degrees 035^0 45' 40.7"E; 03^0 08' 05.5"N, Alt 477m ASL



MODEL: VES 3 CHOKOCHOK

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	67.0	4.0	4.0
2	4.1	21.0	25.0
3	7.5	30.0	55.0
4	3.6	55.0	110.0
5	12.0		

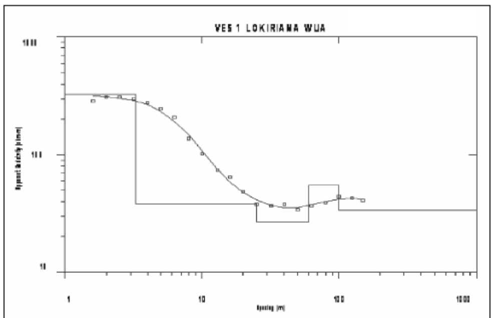
DATASET: VES 3 CHOKOCHOK

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	47.689999
2	2.000000	0.500000	30.389999
3	2.500000	0.500000	20.889999
4	3.200000	0.500000	11.710000
5	4.000000	0.500000	8.760000
6	5.000000	0.500000	6.840000
7	6.300000	0.500000	5.830000
8	8.000000	0.500000	5.200000
9	10.000000	0.500000	5.320000
10	13.000000	0.500000	4.770000
11	16.000000	0.500000	5.460000
12	20.000000	5.000000	5.300000
13	25.000000	5.000000	5.000000
14	32.000000	5.000000	6.000000
15	40.000000	10.000000	6.000000
16	50.000000	10.000000	5.800000
17	63.000000	10.000000	5.000000
18	80.000000	10.000000	3.800000
19	100.000000	25.000000	4.800000
20	125.000000	25.000000	6.000000
21	150.000000	25.000000	6.500000

Recommended drilling site

L1-1 Kakromosing

VES 1: Co-ordinates Degrees 034^0 51' 08.8"E; 02^0 46' 14.8"N, Alt 916m ASL



MODEL: VES 1 LOKIRIAMA WUA

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	329.0	3.3	3.3
2	38.0	21.7	25.0
3	27.0	35.0	60.0
4	55.0	40.0	100.0
5	34.0		

DATASET: VES 1 LOKIRIAMA WUA

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	286.619995
2	2.000000	0.500000	310.119995
3	2.500000	0.500000	309.760010
4	3.200000	0.500000	302.440002
5	4.000000	0.500000	278.040009
6	5.000000	0.500000	246.000000
7	6.300000	0.500000	208.070007
8	8.000000	0.500000	137.399994
9	10.000000	0.500000	102.029999
10	13.000000	0.500000	74.199997
11	16.000000	0.500000	64.239998
12	20.000000	5.000000	48.000000
13	25.000000	5.000000	38.000000
14	32.000000	5.000000	37.000000
15	40.000000	10.000000	38.000000
16	50.000000	10.000000	34.000000
17	63.000000	10.000000	37.000000
18	80.000000	10.000000	39.000000
19	100.000000	25.000000	44.000000
20	125.000000	25.000000	43.000000
21	150.000000	25.000000	41.000000

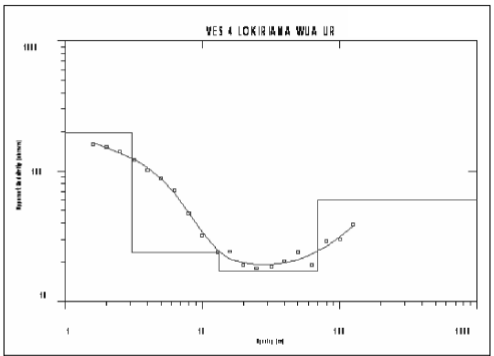
Recommended drilling site

Source: JICA Project Team

Figure BD6.2.5 VES Curves (4)

L2-4 Lotilo

VES 4: Co-ordinates Degrees 034^{0} 41' 59.9"E; 02^{0} 56' 29.6"N, Alt 1000m ASL



MODEL: VES 4 LOKIRIAMA WUA URUM

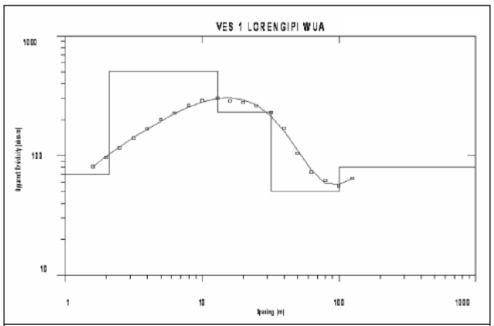
LAYER	RESISTIVITY	THICKNESS	DEPTH
1	197.0	3.1	3.1
2	23.8	10.2	13.3
3	17.0	56.7	70.0
4	60.0		

DATASET: VES 4 LOKIRIAMA WUA URUM

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	161.750000
2	2.000000	0.500000	153.990005
3	2.500000	0.500000	140.729996
4	3.200000	0.500000	121.169998
5	4.000000	0.500000	101.919998
6	5.000000	0.500000	88.449997
7	6.300000	0.500000	71.300003
8	8.000000	0.500000	47.400002
9	10.000000	0.500000	32.110001
10	13.000000	0.500000	23.850000
11	16.000000	0.500000	24.090000
12	20.000000	5.000000	19.000000
13	25.000000	5.000000	18.000000
14	32.000000	5.000000	18.500000
15	40.000000	10.000000	20.500000
16	50.000000	10.000000	23.799999
17	63.000000	10.000000	19.000000
18	80.000000	10.000000	29.000000
19	100.000000	25.000000	30.000000
20	125.000000	25.000000	39.000000

L3-1 Kalokutany

VES 1: Co-ordinates Degrees 034^{0} 58' 56.1"E; 02^{0} 32' 11.3"N, Alt 911m ASL



MODEL: VES 1 LORENGIPI WUA

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	70.0	2.1	2.1
2	510.0	10.9	13.0
3	230.0	19.0	32.0
4	50.0	68.0	100.0
5	80.0		

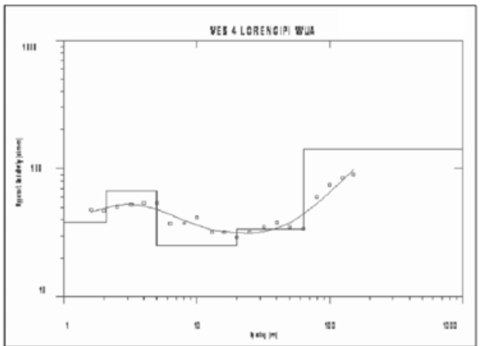
DATASET: VES 1 LORENGIPI WUA

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	81.459999
2	2.000000	0.500000	96.250000
3	2.500000	0.500000	116.370003
4	3.200000	0.500000	140.949997
5	4.000000	0.500000	166.860001
6	5.000000	0.500000	200.020004
7	6.300000	0.500000	227.410004
8	8.000000	0.500000	263.600006
9	10.000000	0.500000	288.269989
10	13.000000	0.500000	302.100006
11	16.000000	0.500000	285.799988
12	20.000000	5.000000	280.000000
13	25.000000	5.000000	260.000000
14	32.000000	5.000000	230.000000
15	40.000000	10.000000	170.000000
16	50.000000	10.000000	105.000000
17	63.000000	10.000000	73.000000
18	80.000000	10.000000	62.000000
19	100.000000	25.000000	56.000000
20	125.000000	25.000000	65.000000

Recommended drilling site

L3-4 Lokiriamet

VES 4: Co-ordinates Degrees 035^{0} 03' 58.1"E; 02^{0} 37' 04.3"N, Alt 812m ASL



MODEL: VES 4 LORENGIPI WUA

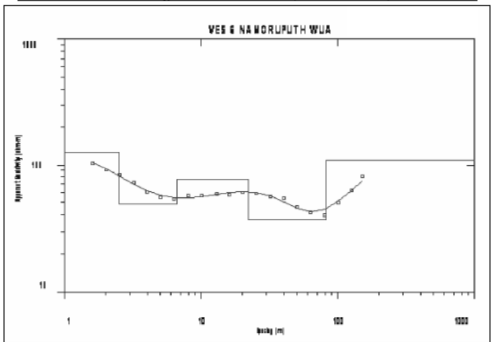
LAYER	RESISTIVITY	THICKNESS	DEPTH
1	38.2	2.1	2.1
2	67.0	2.9	5.0
3	25.0	15.0	20.0
4	34.0	44.0	64.0
5	140.0		

DATASET: VES 4 LORENGIPI WUA

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	47.529999
2	2.000000	0.500000	46.959999
3	2.500000	0.500000	50.299999
4	3.200000	0.500000	52.529999
5	4.000000	0.500000	54.540001
6	5.000000	0.500000	54.560001
7	6.300000	0.500000	37.320000
8	8.000000	0.500000	37.599998
9	10.000000	0.500000	41.310001
10	13.000000	0.500000	32.000000
11	16.000000	0.500000	32.000000
12	20.000000	5.000000	29.000000
13	25.000000	5.000000	32.000000
14	32.000000	5.000000	35.000000
15	40.000000	10.000000	38.000000
16	50.000000	10.000000	35.000000
17	63.000000	10.000000	34.000000
18	80.000000	10.000000	60.000000
19	100.000000	25.000000	75.000000
20	125.000000	25.000000	85.000000
21	150.000000	25.000000	90.000000

L4-6 Kaidir

VES 6: Co-ordinates Degrees 034^{0} 59' 56.6"E; 02^{0} 50' 07.9"N, Alt 751m ASL



MODEL: VES 6 NAMORUPUTH WUA

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	126.0	2.5	2.5
2	49.0	4.1	6.6
3	76.0	15.4	22.0
4	37.0	60.0	82.0
5	110.0		

DATASET: VES 6 NAMORUPUTH WUA

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	104.320000
2	2.000000	0.500000	90.709999
3	2.500000	0.500000	83.470001
4	3.200000	0.500000	71.900002
5	4.000000	0.500000	60.389999
6	5.000000	0.500000	55.160000
7	6.300000	0.500000	53.560001
8	8.000000	0.500000	56.400002
9	10.000000	0.500000	56.340000
10	13.000000	0.500000	58.299999
11	16.000000	0.500000	57.810001
12	20.000000	5.000000	60.000000
13	25.000000	5.000000	59.000000
14	32.000000	5.000000	56.000000
15	40.000000	10.000000	54.000000
16	50.000000	10.000000	46.000000
17	63.000000	10.000000	42.000000
18	80.000000	10.000000	40.000000
19	100.000000	25.000000	50.000000
20	125.000000	25.000000	62.000000
21	150.000000	25.000000	80.000000

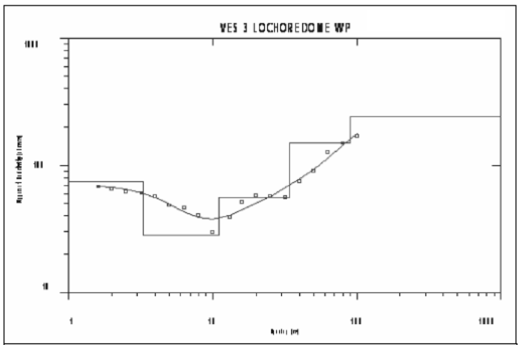
Recommended drilling site

Source: JICA Project Team

Figure BD6.2.6 VES Curves (5)

S1-3 Lochor Edome

VES 3: Co-ordinates Degrees 035^{0} 39' 39.8"E; 02^{0} 20' 37.0"S, Alt 762m ASL



MODEL: VES 3 LOCHOREDOME WP

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	74.9	3.3	3.3
2	28.0	7.7	11.0
3	56.0	23.0	34.0
4	150.0	56.0	90.0
5	240.0		

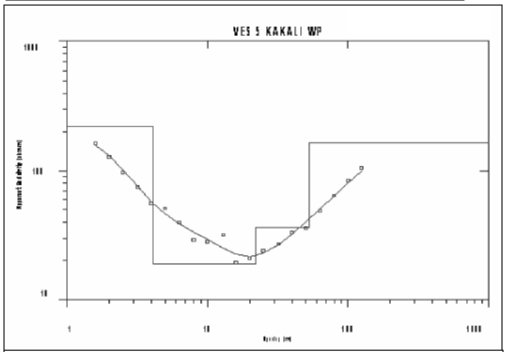
DATASET: VES 3 LOCHOREDOME WP

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	68.309998
2	2.000000	0.500000	65.839996
3	2.500000	0.500000	62.340000
4	3.200000	0.500000	60.750000
5	4.000000	0.500000	57.169998
6	5.000000	0.500000	48.619999
7	6.300000	0.500000	46.369999
8	8.000000	0.500000	40.799999
9	10.000000	0.500000	30.040001
10	13.000000	0.500000	39.220001
11	16.000000	0.500000	51.389999
12	20.000000	5.000000	58.000000
13	25.000000	5.000000	57.000000
14	32.000000	5.000000	56.000000
15	40.000000	10.000000	75.000000
16	50.000000	10.000000	91.000000
17	63.000000	10.000000	128.000000
18	80.000000	10.000000	150.000000
19	100.000000	25.000000	170.000000

Recommended drilling site

S2-5 Kakali

VES 5: Co-ordinates Degrees 035^{0} 39' 01.6"E; 02^{0} 19' 15.2"S, Alt 792m ASL



MODEL: VES 5 KAKALI WP

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	220.2	4.1	4.1
2	19.0	17.9	22.0
3	36.0	31.0	53.0
4	166.0		

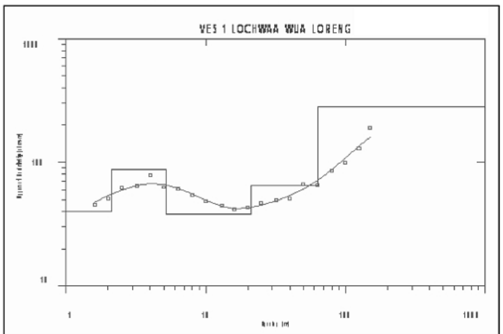
DATASET: VES 5 KAKALI WP

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	164.139999
2	2.000000	0.500000	128.500000
3	2.500000	0.500000	96.440002
4	3.200000	0.500000	75.230003
5	4.000000	0.500000	55.779999
6	5.000000	0.500000	50.980000
7	6.300000	0.500000	39.680000
8	8.000000	0.500000	29.000000
9	10.000000	0.500000	28.020000
10	13.000000	0.500000	31.799999
11	16.000000	0.500000	19.270000
12	20.000000	5.000000	21.000000
13	25.000000	5.000000	24.000000
14	32.000000	5.000000	27.000000
15	40.000000	10.000000	33.000000
16	50.000000	10.000000	36.000000
17	63.000000	10.000000	49.000000
18	80.000000	10.000000	64.000000
19	100.000000	25.000000	84.000000
20	125.000000	25.000000	105.000000

Recommended drilling site

S3-1 Lolupe

VES 1: Co-ordinates Degrees 035^{0} 38' 46.3"E; 02^{0} 35' 42.6"S, Alt 743m ASL



MODEL: VES 1 LOCHWAA WUA LORENG

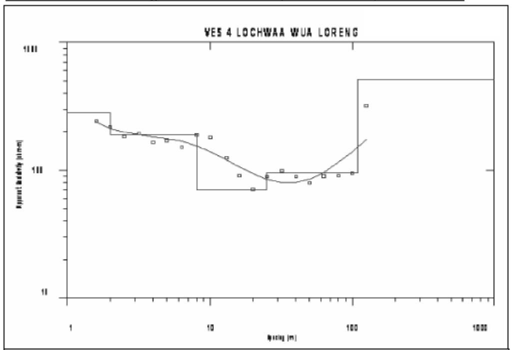
LAYER	RESISTIVITY	THICKNESS	DEPTH
1	40.0	2.1	2.1
2	88.0	3.1	5.2
3	38.0	15.8	21.0
4	65.0	43.0	64.0
5	280.0		

DATASET: VES 1 LOCHWAA WUA LORENG

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	45.360001
2	2.000000	0.500000	50.810001
3	2.500000	0.500000	62.049999
4	3.200000	0.500000	64.209999
5	4.000000	0.500000	78.849998
6	5.000000	0.500000	62.700001
7	6.300000	0.500000	61.130001
8	8.000000	0.500000	54.200001
9	10.000000	0.500000	48.200001
10	13.000000	0.500000	44.520000
11	16.000000	0.500000	41.750000
12	20.000000	5.000000	43.000000
13	25.000000	5.000000	47.000000
14	32.000000	5.000000	49.000000
15	40.000000	10.000000	51.000000
16	50.000000	10.000000	66.000000
17	63.000000	10.000000	65.000000
18	80.000000	10.000000	85.000000
19	100.000000	25.000000	99.000000
20	125.000000	25.000000	130.000000
21	150.000000	25.000000	190.000000

S3-4 Loreng

VES 4: Co-ordinates Degrees 035^{0} 41' 59.3"E; 02^{0} 39' 02.7"S, Alt 664m ASL



MODEL: VES 4 LOCHWAA WUA LORENG

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	280.0	2.0	2.0
2	188.8	6.0	8.0
3	70.0	17.0	25.0
4	95.0	85.0	110.0
5	510.0		

DATASET: VES 4 LOCHWAA WUA LORENG

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	241.380005
2	2.000000	0.500000	216.770004
3	2.500000	0.500000	182.750000
4	3.200000	0.500000	193.389999
5	4.000000	0.500000	164.630005
6	5.000000	0.500000	170.380005
7	6.300000	0.500000	151.279999
8	8.000000	0.500000	188.800003
9	10.000000	0.500000	179.970001
10	13.000000	0.500000	124.500000
11	16.000000	0.500000	90.730003
12	20.000000	5.000000	71.000000
13	25.000000	5.000000	89.000000
14	32.000000	5.000000	99.000000
15	40.000000	10.000000	89.000000
16	50.000000	10.000000	80.000000
17	63.000000	10.000000	90.000000
18	80.000000	10.000000	91.000000
19	100.000000	25.000000	95.000000
20	125.000000	25.000000	320.000000

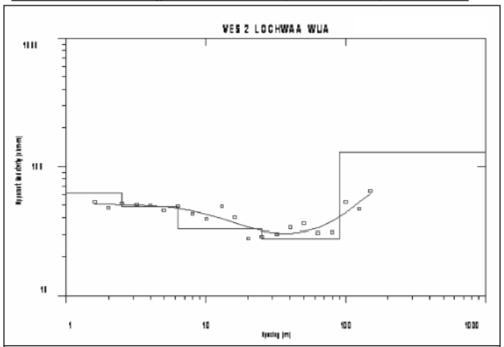
Recommended drilling site

Source: JICA Project Team

Figure BD6.2.7 VES Curves (6)

S4-2 Nakejuamosing

VES 2: Co-ordinates Degrees 035^0 30' 00.1"E; 02^0 32' 09.5"S, Alt 794m ASL



MODEL: VES 2 LOCHWAA WUA

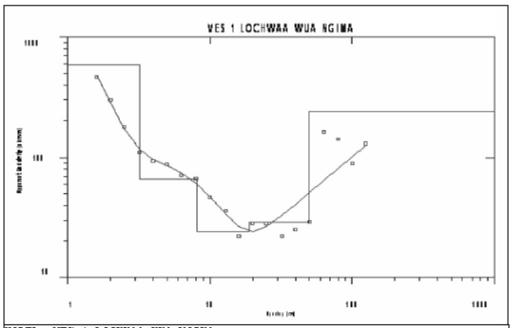
LAYER	RESISTIVITY	THICKNESS	DEPTH
1	62.0	2.5	2.5
2	49.0	3.8	6.3
3	32.6	18.7	25.0
4	27.8	65.0	90.0
5	130.0		

DATASET: VES 2 LOCHWAA WUA

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	52.990002
2	2.000000	0.500000	47.790001
3	2.500000	0.500000	51.500000
4	3.200000	0.500000	50.610001
5	4.000000	0.500000	50.040001
6	5.000000	0.500000	45.820000
7	6.300000	0.500000	48.980000
8	8.000000	0.500000	43.000000
9	10.000000	0.500000	38.799999
10	13.000000	0.500000	49.270000
11	16.000000	0.500000	40.150002
12	20.000000	5.000000	28.000000
13	25.000000	5.000000	29.000000
14	32.000000	5.000000	30.000000
15	40.000000	10.000000	33.799999
16	50.000000	10.000000	36.000000
17	63.000000	10.000000	30.500000
18	80.000000	10.000000	31.000000
19	100.000000	25.000000	53.000000
20	125.000000	25.000000	47.000000
21	150.000000	25.000000	65.000000

S5-1 Ngimamki

VES 1: Co-ordinates Degrees 035^0 42' 46.5"E; 02^0 36' 21.2"S, Alt 676m ASL



MODEL: VES 1 LOCHWAA WUA NGIMA

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	590.0	3.2	3.2
2	66.6	4.9	8.1
3	24.0	10.9	19.0
4	29.0	31.0	50.0
5	240.0		

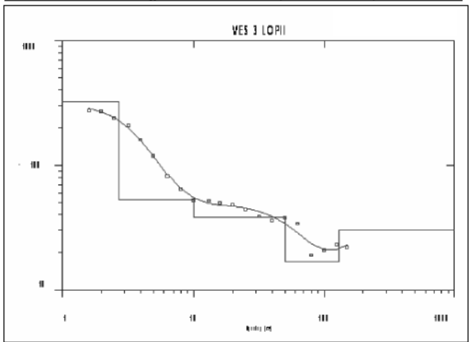
DATASET: VES 1 LOCHWAA WUA NGIMA

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	460.790009
2	2.000000	0.500000	298.420013
3	2.500000	0.500000	178.220001
4	3.200000	0.500000	110.239998
5	4.000000	0.500000	94.239998
6	5.000000	0.500000	88.519997
7	6.300000	0.500000	71.540001
8	8.000000	0.500000	66.599998
9	10.000000	0.500000	46.730000
10	13.000000	0.500000	36.000000
11	16.000000	0.500000	22.000000
12	20.000000	5.000000	28.000000
13	25.000000	5.000000	28.000000
14	32.000000	5.000000	22.000000
15	40.000000	10.000000	25.000000
16	50.000000	10.000000	29.000000
17	63.000000	10.000000	160.000000
18	80.000000	10.000000	140.000000
19	100.000000	25.000000	90.000000
20	125.000000	25.000000	130.000000

Recommended drilling site

E1-3 Lopii

VES 3: Co-ordinates Degrees 035^0 52' 36.4"E; 02^0 04' 18.8"N, Alt 760m ASL



MODEL: VES 3 LOPII

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	325.0	2.7	2.7
2	52.6	7.4	10.1
3	38.0	39.9	50.0
4	17.0	80.0	130.0
5	30.0		

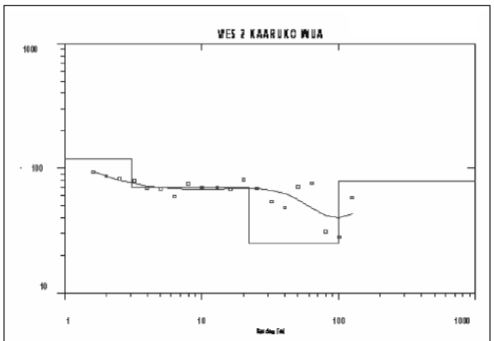
DATASET: VES 3 LOPII

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	275.989990
2	2.000000	0.500000	268.750000
3	2.500000	0.500000	240.789993
4	3.200000	0.500000	207.889999
5	4.000000	0.500000	160.669998
6	5.000000	0.500000	119.650002
7	6.300000	0.500000	81.959999
8	8.000000	0.500000	64.199997
9	10.000000	0.500000	52.580002
10	13.000000	0.500000	51.939999
11	16.000000	0.500000	49.779999
12	20.000000	5.000000	48.000000
13	25.000000	5.000000	44.000000
14	32.000000	5.000000	39.000000
15	40.000000	10.000000	36.000000
16	50.000000	10.000000	38.000000
17	63.000000	10.000000	34.000000
18	80.000000	10.000000	19.000000
19	100.000000	25.000000	21.000000
20	125.000000	25.000000	23.000000
21	150.000000	25.000000	22.000000

Recommended drilling site

E2-2 Kaaruko

VES 2: Co-ordinates Degrees 036^0 04' 04.1"E; 02^0 06' 20.6"N, Alt 586m ASL



MODEL: VES 2 KAARUKO WUA

LAYER	RESISTIVITY	THICKNESS	DEPTH
1	119.8	3.1	3.1
2	70.0	18.9	22.0
3	25.0	78.0	100.0
4	78.0		

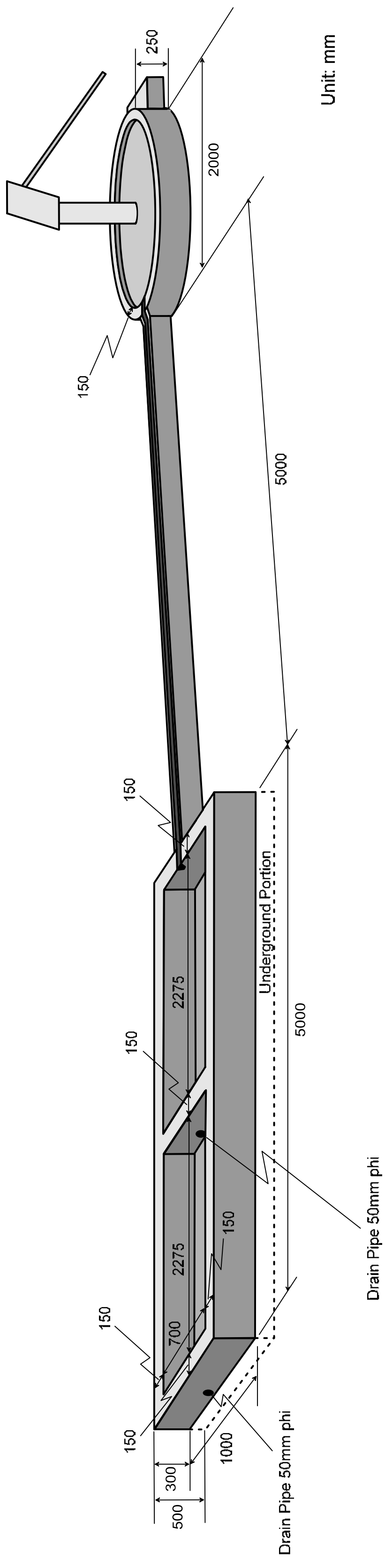
DATASET: VES 2 KAARUKO WUA

NUMBER	AB/2	MN	RESISTIVITY
1	1.600000	0.500000	93.139999
2	2.000000	0.500000	86.730003
3	2.500000	0.500000	82.470001
4	3.200000	0.500000	79.370003
5	4.000000	0.500000	69.000000
6	5.000000	0.500000	68.070000
7	6.300000	0.500000	59.389999
8	8.000000	0.500000	75.199997
9	10.000000	0.500000	70.000000
10	13.000000	0.500000	70.000000
11	16.000000	0.500000	67.449997
12	20.000000	5.000000	81.000000
13	25.000000	5.000000	69.000000
14	32.000000	5.000000	54.000000
15	40.000000	10.000000	48.000000
16	50.000000	10.000000	71.000000
17	63.000000	10.000000	76.000000
18	80.000000	10.000000	31.000000
19	100.000000	25.000000	28.000000
20	125.000000	25.000000	58.000000

Recommended drilling site

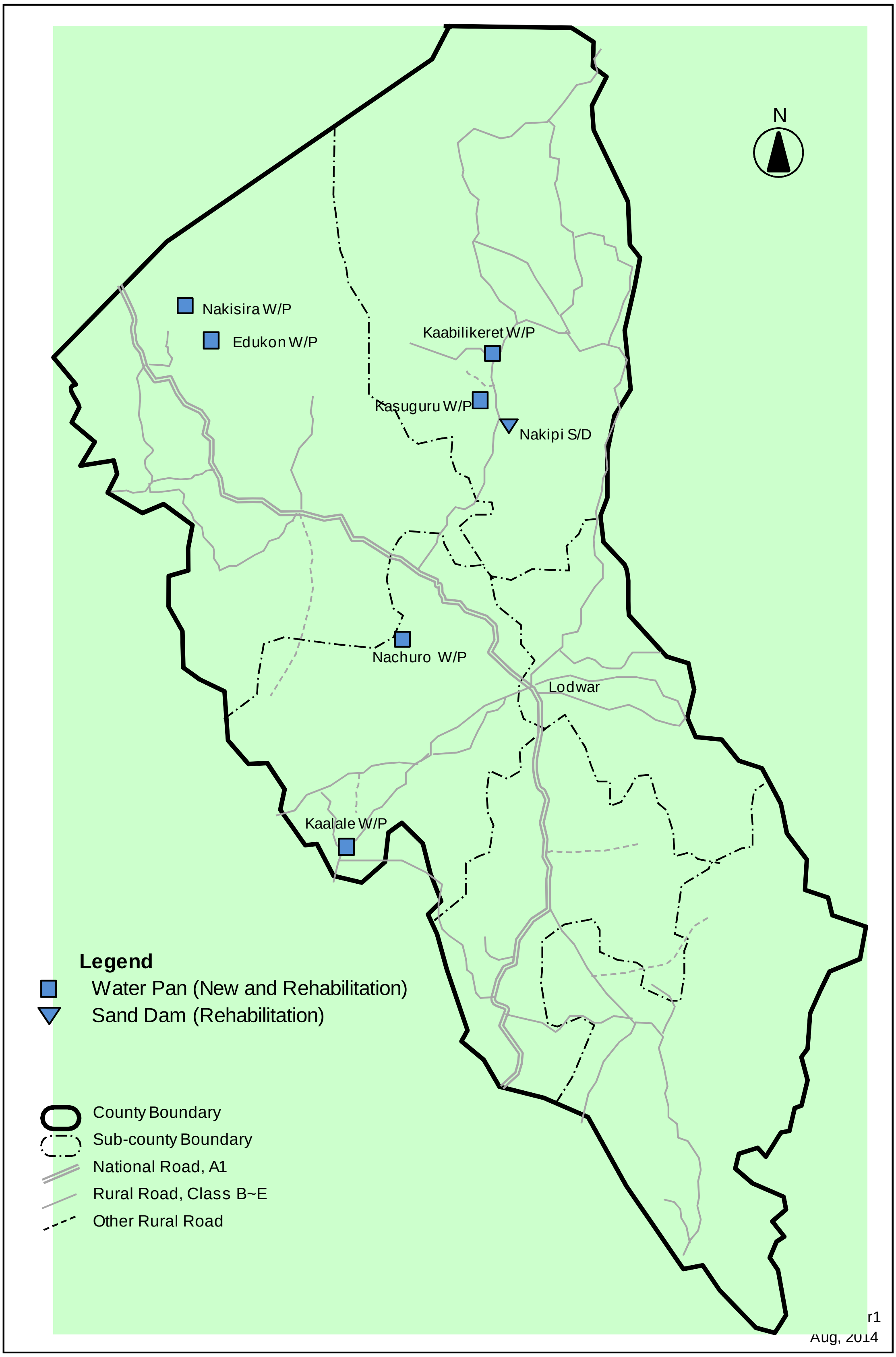
Source: JICA Project Team

Figure BD6.2.8 VES Curves (7)



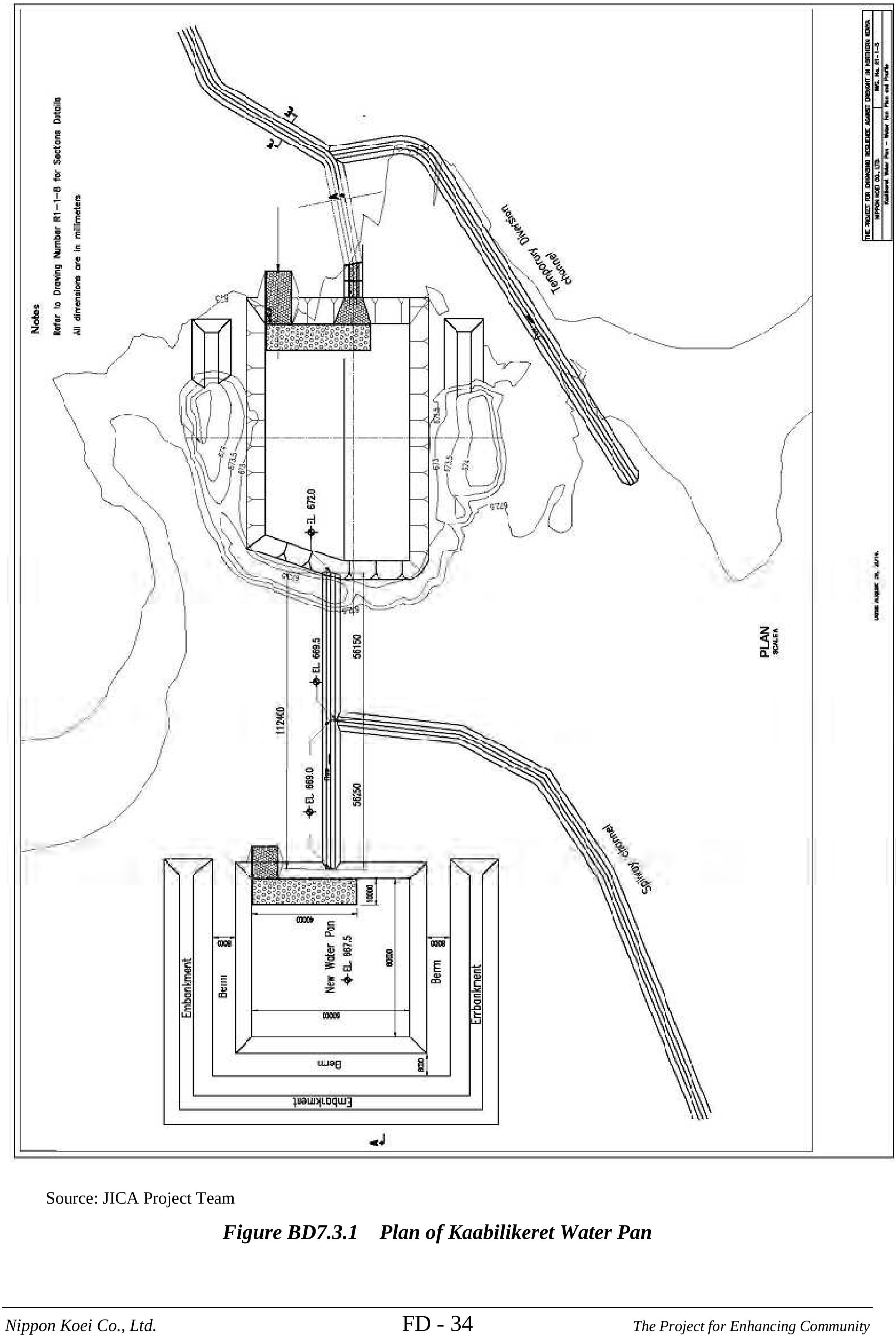
Source: JICA Study Team

Figure BD6.3.1 Basic Design of Hand Pump Apron and Animal Trough



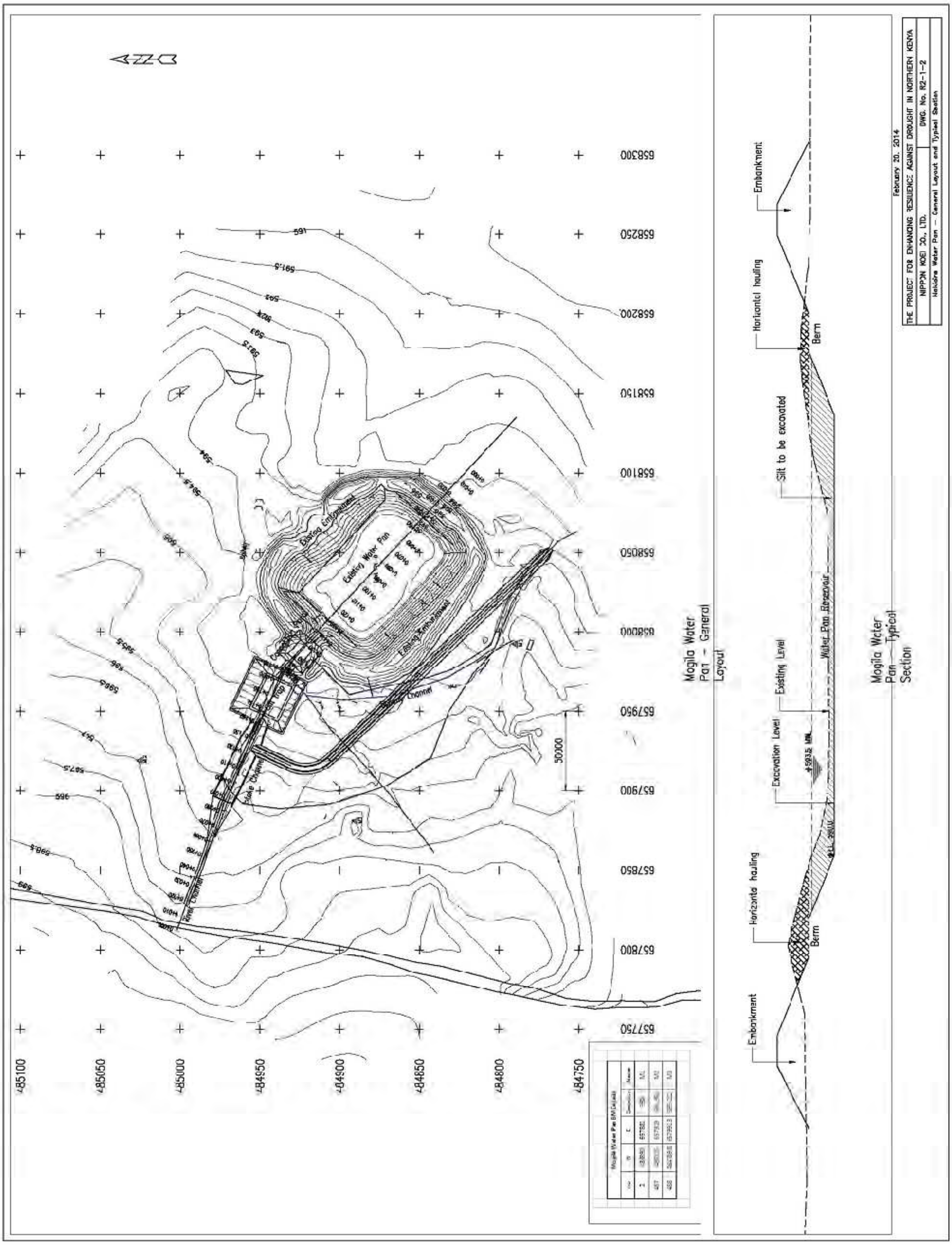
Source: JICA Project Team

Figure BD7.1.1 Location Map of Sub-projects for Construction and Rehabilitation of Water Pan and Sand Dam in Turkana County



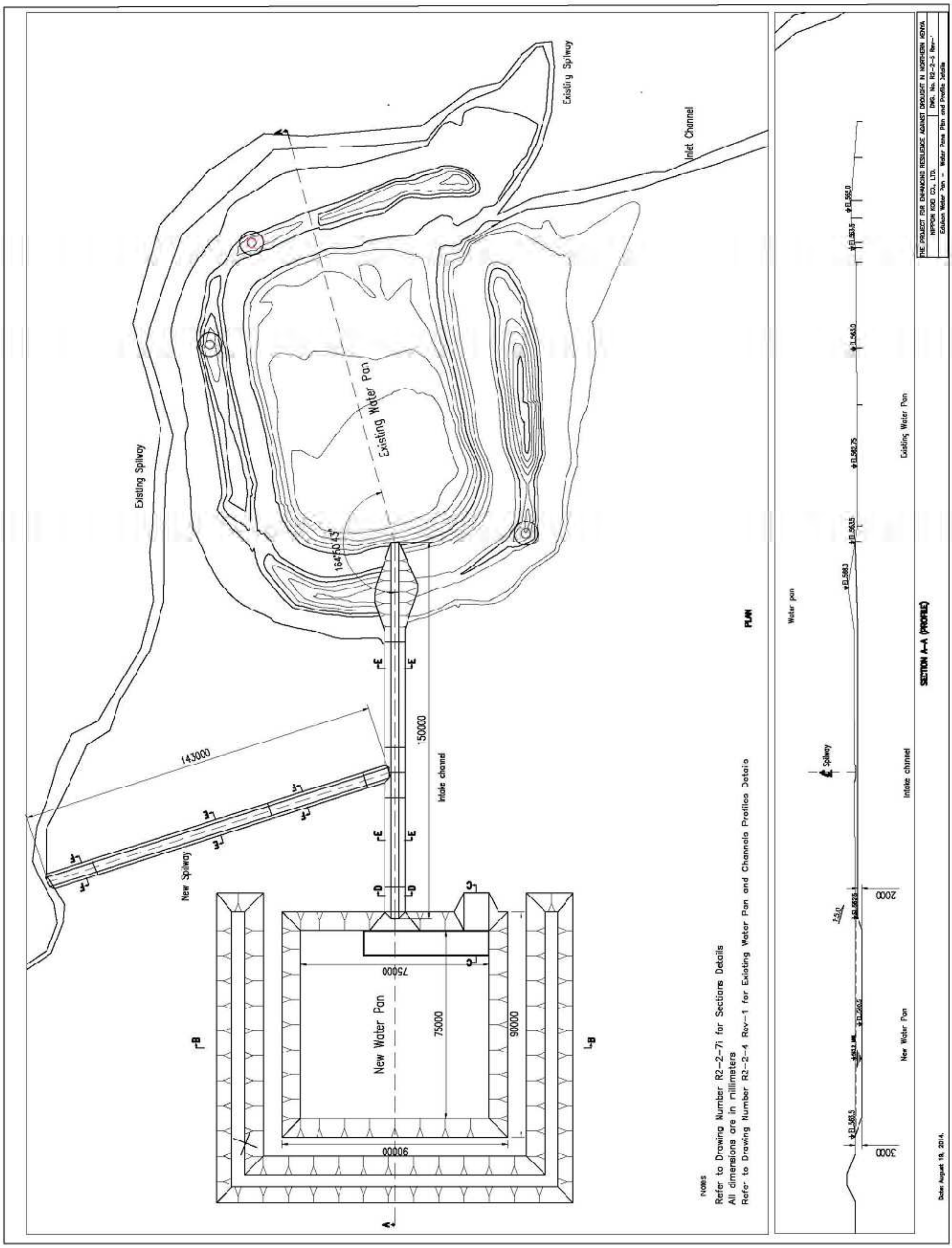
Source: JICA Project Team

Figure BD7.3.1 Plan of Kaabilikeret Water Pan



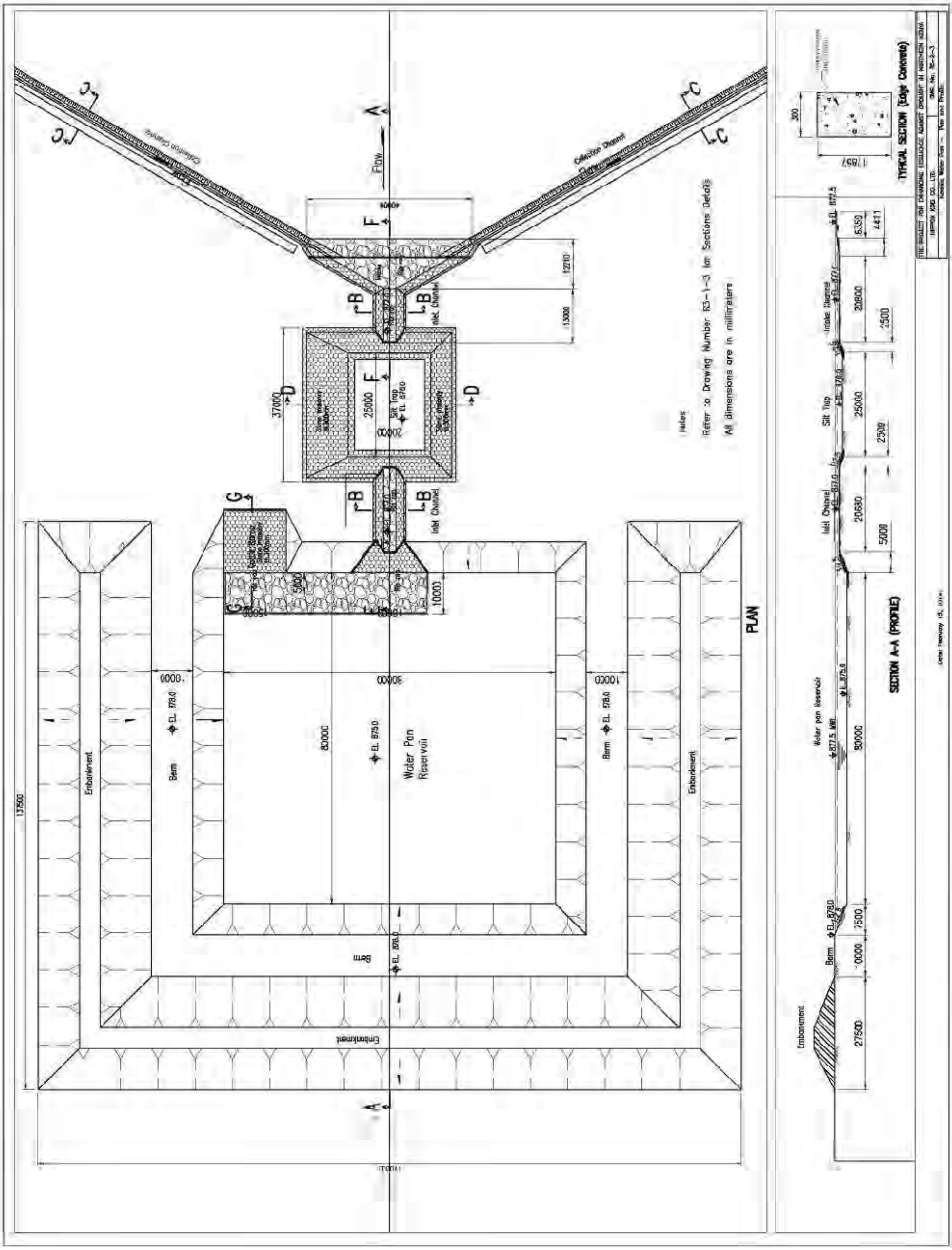
Source: JICA Project Team

Figure B7.3.2 Construction General Layout and Typical Section of Nakisira Water Pan



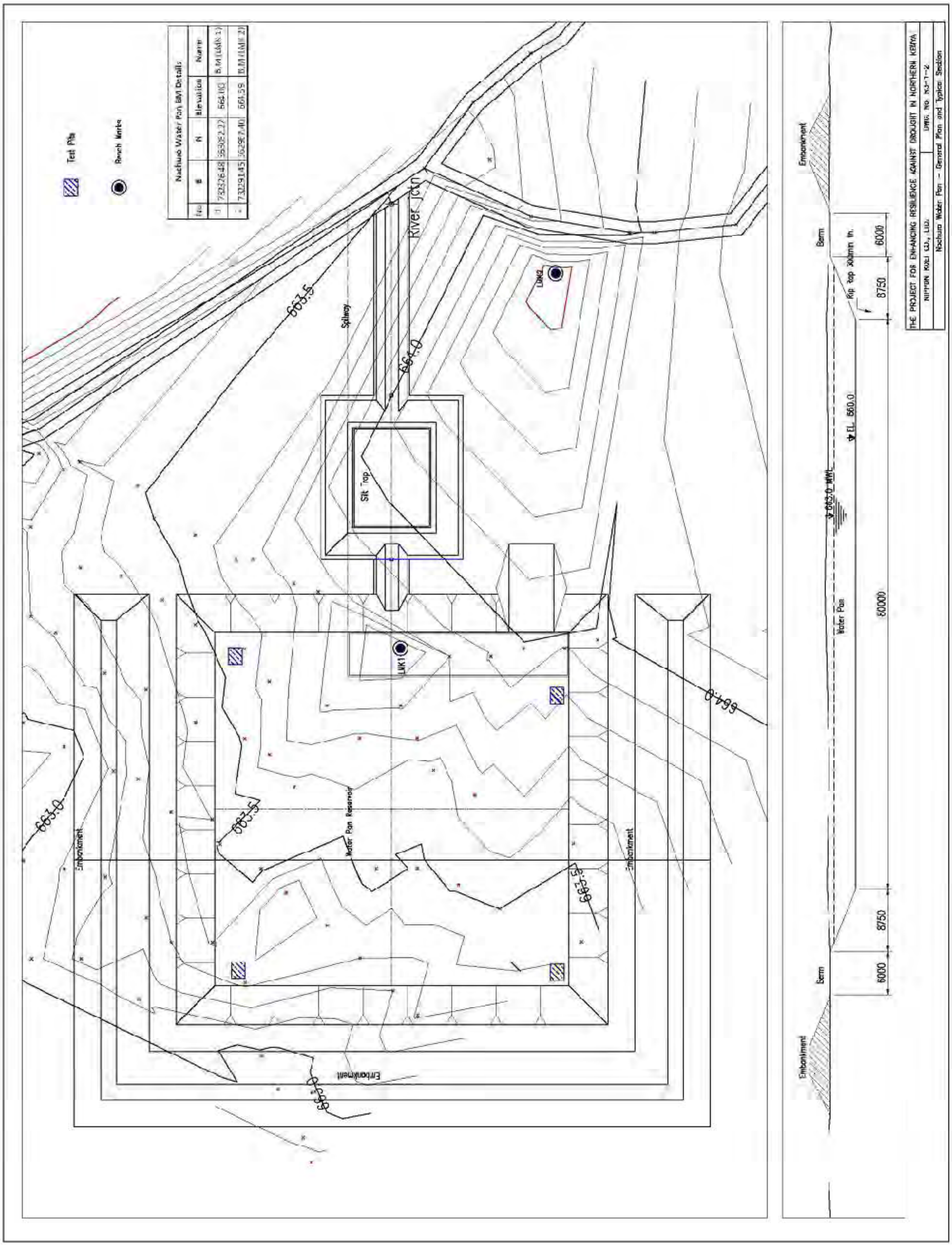
Source: JICA Project Team

Figure BD7.3.3 Plan of Edukon Water Pan



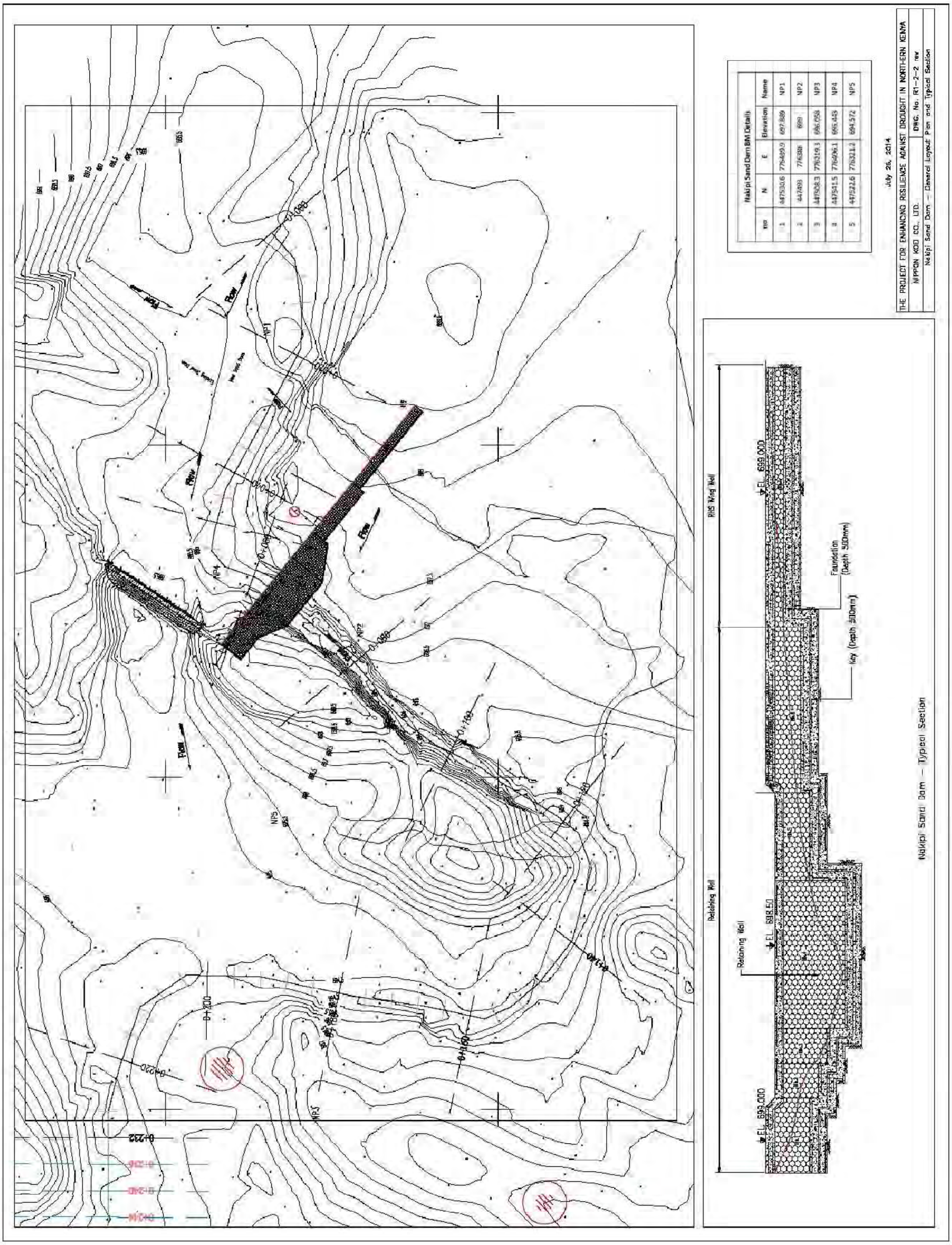
Source: JICA Project Team

Figure BD7.3.4 Plan of Kaalale Water Pan



Source: JICA Project Team

Figure BD7.3.5 Plan of Nachuro Water Pan

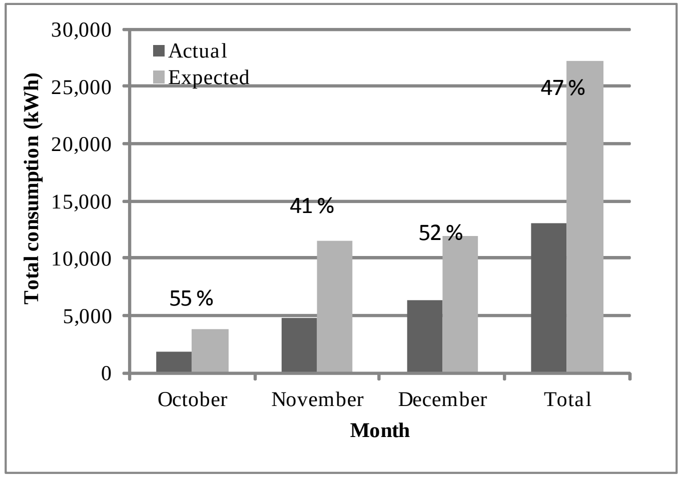


Source: JICA Project Team

Figure BD8.2.1 Plan of Nakipi Sand Dam

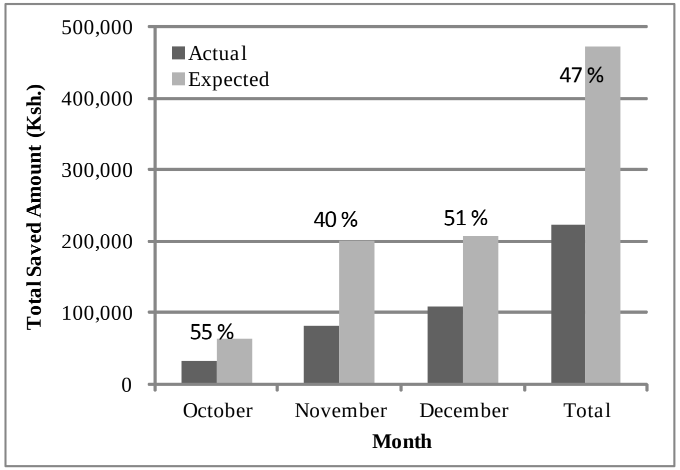
Summary for Total Power Consumption (kWh)

		BH 1A	BH 3	BH6	Total
October	Actual	906	691	233	1,830
	Expected	2,664	740	352	3,756
	Difference (%)	34%	93%	66%	49%
November	Actual	2,128	2,116	579	4,823
	Expected	4,440	4,440	2,640	11,520
	Difference (%)	48%	48%	22%	42%
December	Actual	2,814	2,909	640	6,363
	Expected	4,588	4,588	2,728	11,904
	Difference (%)	61%	63%	23%	53%
Total	Actual	5,848	5,715	1,452	13,016
	Expected	11,692	9,768	5,720	27,180
	Difference (%)	50%	59%	25%	47.9%



Summary for Total Saved Amount (Ksh.)

		BH 1A	BH 3	BH6	Total
October	Actual	15,249	11,622	4,508	31,379
	Expected	44,828	12,452	6,815	64,095
	Difference (%)	34%	93%	66%	49%
November	Actual	35,816	35,603	11,212	82,631
	Expected	74,713	74,713	51,110	200,536
	Difference (%)	48%	48%	22%	41%
December	Actual	47,349	48,948	12,391	108,688
	Expected	77,204	77,204	52,814	207,222
	Difference (%)	61%	63%	23%	52%
Total	Actual	98,414	96,173	28,111	222,698
	Expected	196,745	164,369	110,739	471,853
	Difference (%)	50%	59%	25%	47%



Source: JICA Project Team

Figure BD9.3.1 Summary for Monitoring Results for Solar System