JAPAN INTERNATIONAL COOPERATION AGENCY
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MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT
(MOARD)

THE STUDY
ON
THE INTEGRATED RURAL DEVELOPMENT PROJECT
IN
THE BARINGO SEMI ARID LAND AREA
(MARIGAT AND MUKUTANI DIVISIONS)
IN
THE REPUBLIC OF KENYA

FINAL REPORT

APPENDIX
(WATER SOURCE SURVEY FOR DOMESTIC WATER SUPPLY)

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SUPPLEMENT DATA

WATER SOURCE SURVEY FOR DOMESTIC WATER SUPPLY

1. Introduction

The focus of activity in the water resources survey was the provision of safe and reliable source of water to unserved segments of population. The need for water was urgent, and many requests emerge from PCM and PRA workshops. In fact, most of the villages have no acceptable water source available in the dry season. The primary problem faced in the survey was limitation in the availability of water source. In particular, deep groundwater was in places difficult to detect it. To complete this, Transient ElectromagneticMethod (TEM method) was applied for obtaining reliable information to detect deep aquifer.

Another focus on the survey was on water quality. Water sources are in parts being threatened by contaminants: inclusive ofFluoride, Iron and bacteriological organs. By doing water quality test, degrees and extents of contamination of watersources was clarified.

During the survey, following survey items and contents were completed.

- **Review of Existing Data:**
  In order to clarifying the preset condition of physical background, up-dating themeteo-hydrological information and reviewing existing reports and materials were carried out, in the areas of a) Physiography, b) Meteorology and Hydrology, c) Drought, d) Hydrogeology, e) Groundwater, f) Water quality, g) Existing water facility.

- **Field Reconnaissance Survey:**
  About 137 water points or villages were surveyed in order to collect factualhydro-geographical information concerning to land forms, soil cover, rock type, spring, existing water points, and present condition of water sources. As supplement objectives of survey, "Ground Truth" for photographic information, which had been interpreted from areal photographs, were completed.

- **In-situ Water Quality Survey:**
  Survey was aiming at judging the extent and degree of contamination. 64 water points were visited to check on parameters of Iron (Fe), Manganese (Mn), Nitrate (No3), Ammonium(NH4), Fluoride (F), EC, pH and Temperature (T) in field.

- **Water Sampling and Laboratory Water Quality Test:**
  22 samples were taken from the main water sources, and checked by full wateranalysis for 27 items. It aims to confirm preceding in-situ results, and judging the bacteriological contaminationof water source.

- **Survey on Existing Water Facilities**
  The survey was carried out at 180 water points aiming at obtaining detailed information and up-to date data on different type of water points (or/and constructed water facilities).

The information obtained waswritten in an inventory form for every water point.

- **Geophysical Investigation:**
  Primary objectives of this survey were to determine theaquifer availability of proposed villages and to locate the suitable borehole-drilling sites near by the village center. Secondary objectives of the study were toevaluate aquifer potential, and detect structure of underlying volcanic and sedimentary facies,fault and fracture zones, consequently to clarify the groundwater resources potential. TEM measurements were made at a total of 42 villages (sites) including 479 stations.

In a course of the survey, discussions were made with village communities on the selection of proposed villages for waterresource survey and improvement of water facility.

2. Water Source Survey for Domestic WaterSupply

a) Water Potential

It was prepared in 1994 as the water master plan in the period of 1983-2003, Rift Valley Area: including northern part of Baringo District. The plan includes proposal for development of surface water for water supply using dam reservoirs, Chemenron and Kimao dams, built on two rivers, which were considered to be perennial. However, this plan wasinterrupted without two main components, due to many constraints of being costly, not effective, high operation cost and environmental influence to Lake Baringo. From lessons learnt, it was concluded that bulk abstractions from surface water should be reduced, and water supply program was changed into improvement of surface water resourceavailability at various local sources such as pans, springs and local rivers.

As well, the groundwater potential in the Study Area is not much. In the groundwater potential survey, 42 villagescentered by Mukutani, Arabal and Kiserian Locations were surveyed up to 150 m deep by TEM method. However, only 19 villages can be represented as having some significance of deep aquifers. And, half of them (7 sites among 19 villages) are supposed to be having high saline water. As final result, only 12 are judged as possible sites to develop groundwater by borehole drilling. Summary of groundwater potential is shown below.

Groundwater Potential Survey Results

Location (Sub Location)	Coverage Rate by Safe Water Supply	Coverage by On-going Water Supply Project	Groundwater potential			
			Shallow Aquifer	Deep Aquifer	Water Quality	No of Villages proposed by TEM Survey
Arabal	×	×	△	○	○	7
Eldume	×	△	△	△	△	1
Ilngarua	×	×	○	×	△	0
kapkuikui	×	△	△	×	△	0
Kiserian	×	△	△	△	△	0
Kimalel (kimalel & Sabor)	△	×	×	△	△	0
Kimalel (koriema)	△	×	×	△	△	0
Loboi	×	○	△	○	△	0
Marigat (Endao)	×	×	×	△	△	0
Marigat (Perkerra)	△	×	△	△	△	0
Marigat (Yatoi)	○	×	△	△	△	0
Mukutani	×	×	△	○	○	3
Ngambo (Ngambo)	△	×	○	×	×	0
Ngambo (Sintan)	×	×	○	×	×	1
Salabani	○	×	△	×	△	2
Sandai	×	△	△	△	△	3
Explanation:	○:medium △:low ×:none	○:medium △:low ×:none	○:medium △:low ×:few	○:medium △:low ×:few	○:medium △:low in part ×: low	Total 12 villages

2) Water Quality

About 20 percent of water points were contaminated with high content of Fluoride which is exceeding 3 ppm. Iron concentration is also high in the surface water source in particular those of pans, Molo rivers, Mukutani river, seepage water fromPerikerra river and lake Baringo. Following table shows extent anddegree of (F) and (Fe) contamination in every Locations.

Extent and Degree of (F) and (Fe)

Locations	Pan		River		Groundwater		Lake	
	(F)	(Fe)	(F)	(Fe)	(F)	(Fe)	(F)	(Fe)
Marigat	-	-	○	△	△	△	-	-
Elude & Ngambo	○	×	○	△	-	-	×	×
Salabani	○	○	-	-	-	-	×	×
Loboi/Sandai/Kupkuikui	-	-	△	△	△	○	×	×
Kimalel	△	○	-	-	×	△	-	-
Kiserian /Mukutani	○	-	△	△	△	○	×	×
Arabal	×	×	○	△	-	-	-	-
Explanation								

○: Most of samples within a Kenya Standard (permissible aesthetic quality)
△: Half of samples exceeding Kenya Standard (permissible aesthetic quality)
×: More than half of samples exceeding Kenya Standard (permissible aesthetic quality)
- : no data available

As result from laboratory analysis conducted for 27 parameters including bacteriological items, most of water samples taken from in present water sources were not meet to the Kenya permissible (ordesirable) standard due to high concentration ofTurbidity, Iron (Fe), Manganese (Mn), Sodium (Na), Fluoride(F), Sulfate (SO4). Even treated water of Arabal piped water supply was contaminated bycoliform and faucal coliform bacteria, as below;

Water Quality Analysis of Arabal Piped Water

Parameter		Turbidity	Iron (Fe)	Manganese (Mn)	Sodium (Na)	Fluoride (F)	Sulfate (SO4)	Coliform group	Faecal Coliform
Unit		N.T.U	mg/l	mg/l	mg/l	mg/l	mg/l	/100 ml	-
Kenya permissible (or desirable) quality		5	0.5	1.0	200	3.0	400	not detected	not detected
Kimalel	Kipramoi Spring	28	1.1	0.2	51	0.76	28	>2,400	>2,400
	Kimao Dam	13	1.9	2.2	30	0.66	6.3	>2,400	>2,400
	Keben spring	2	0.46	0.01	165	5	58	>2,400	>2,400
	Egerton Unv.B/H	2	0.4	0.01	150	12	50	>2,400	>2,400
Salabani .	Kampi ya Samaki W/S	22	0.91	0.05	300	1.8	469	nil	nil
	Chemeron Irrigation Canal	24	0.64	0.12	13	1.0	8	>2,400	>2,400
Marigat	Perkerra river	166	10.3	0.6	8.5	0.58	6.7	>2,400	460
	Marigat W/S	5	0.43	0.1	10	0.35	90	nil	nil
Eldume	Molo River	270	3.11	0.3	18	-	28	>2,400	1,100
Ilng'arua	Sesiai UNCEF well	nil	0.38	1	24	1.1	16	nil	nil
Ngambo	Perkerra River	32	1.2	0.05	19	0.94	8	>2,400	1,100
Sandai	Waseges River	910	17.8	1.2	25	0.68	44	>2,400	460
Loboi	Chelaba Spring	2	0.47	0.01	113	4.2	23	>2,400	1,100
Kapkuikui	Katanin canal	7	0.95	0.4	158	5.3	33	>2,400	>2,400
Kiserian	Arabal W/S	3	0.47	0.07	123	0.58	226	>2,400	>2,400
Arabal	Kaseila Spring	2	0.45	0.02	100	0.76	21	>2,400	1,100
	Arabal River	1,900	22	2	48	0.7	40	>2,400	>2,400
Mukutani	Nosukeita River	83	3.33	0.5	50	1.9	21	>2,400	nil
	Mukutani River	73	3.1	1.4	335	5.3	109	>2,400	>2,400
	Lelerai spring	3	0.47	0.01	172	0.92	54	>2,400	>2,400
	Ilpirisati hot spring	8	0.75	0.05	182	1.3	52	>2,400	nil
	Ilpirisati cool spring	6	0.53	0.02	118	0.9	15	>2,400	4

Note: box shaded shows do not to meet the Kenya permissible (or desirable) quality standard.

3) Coverage of Safe Water Supply

The coverage rate was estimated as a percentage of thenumber of users who can access safety water vs. population. In the Study Area, safety water sources for domestic use are limited to less than 10 facilitiesconsisting of five piped water supplies and four boreholes/wells.

Coverage rate of safe water supply were estimated as shown in the following table.

22 percent of population can access safe water (pipe water supply, boreholes and wells). However, this figure does notmean properly that user can reaches to safe water. In fact, most of piped water supply schemes are not functioning satisfactorily, due to poor maintenance and shortage of chemicals such that Kampi ya Samaki pipe water supply system do not add chlorine. As well, Sabor pipe water supply system directly provides the contaminated water with high content of Fluoride (more than 5 ppm) without any treatment. Furthermore, these water facilities are exclusively for people living in town, institutions and trading centers. While in remote area far from town, most villages particularly locating Mukutani Division have no safe water source at all.

Coverage Rate of Safe Water Supply

Division	Location	Sub-Location	Total Population (1999)	*1 Estimated Pop. covered by Safe Water Supply (Oct 200)	*2 Coverage Rate (%*3) (Oct.2000)
Marigat	Marigat	Endao	893	0	25
		Perkerra	4,921	0	
		Yatoi	2,623	2,150	
	Eldume	Eldume	2,174	0	(0)
	Ilng'arua	Ilng'arua	1,279	0	(0)
	N'gambo	N'gambo	2,636	700	17
		Sintaan	1,424	0	
	Salabani	Salabani	1,316	0	68
		Meisori	2,521	2,605	
	Loboi	Chelaba	775	0	(0)
		Maji Ndege	476	0	
	Sandai	Mbechot	926	0	(0)
		Sandai	855	0	
	Kapkuikui	Kapkuikui	444	0	(0)
		Kaptombes	438	0	
	Kimalel	Kimalel	624	200	67
		Sabor	1,194	1,000	
		Koriema	1,466	1,000	
	Sub-total		26,985	7,655	28
Mukutani	Mukutani	Mukutani	1,036	0	0
		Rugus	881	0	
	Arabal	Arabal	2,024	0	(0)
		Ngelecha	717	0	
	Kiserian	Kiserian	2,000	0	(0)
		Logumgum	790	0	
	Sub-total		7,448	0	0
Total			34,433	7,655	22

Note 1):Population data is taken from District Statistical Office as provisional result of 1999's census.

2):Population covered by safe water supply is estimated based on the water facility survey made in Oct-Nov, 2000.

3: ( ) is the provisional figures, indicating areas which will be covered by Ol-Arabal water supply scheme by summer 2015.

a) Alternatives of Water Facility Plan for Verification Projects

Type of water facility prepared for Verification Projects was prudently selected among needs raised in the water resources surveys. In a course of factual activity in field, various facility plans were represented by communities, as well as found out in the reconnaissance survey. At beginning of the survey, these, however, include lots of huge and unrealistic facility plans, such as new construction of gouge-dam, renovation of large dam, diversion works and so forth. Accordingly, these had been screened by giving technical concerns with concrete conditions to be realized. Likewise, they were again selected in view of whether they are acceptable to Verification Projects, which is intended to promote community participation and management with self-help activity.

They were all small-scale schemes, but have a function to meet both chronic short of water supply, poor water quality and requirement of livestock-watering. These plans are of two types of "construction of new water facilities" and "expansion of existing facilities", as follows.

<u>Alternatives of Water Facilities</u>

Construction of new water facilities
(a) **Boreholes [BH]:** Medium potential of middle to deep groundwater to be developed for domestic water supply and cattle watering at Arabal and Mukutani Location.
(b) **Shallow wells [W]:** A potential can be developed along river courses. Hand dug well with a fix bucket/rope abstraction can provide some amount of domestic water.
(c) **Spring improvements [S]:** Non-protected natural spring. is needed to be meet the requirement of domestic supply by improvement.
(d) **Piped water supplies with sources of springs, boreholes [Ps]:** Spring and borehole bearing enough yield are required to be developed as piped water supply system.
(e) **Roof catchment [R]:** School, health center and dispensary wherever have extensive roof cover can be utilized as supplemental water source by roof catchment. This was already applied as Verification Projects at Rugus Primary School..
Expansion of existing water facility
(f) **Fencing pan with public tap and cattle trough [Pf]:** Fencing of pan are required in preventing pollution for cattle entering and trapping silt, but these pans are still not suitable for domestic purpose because they still remain as the high potential risk of contamination.
(g) **Extending pan with out-let facility [Po]:** This type of improved pan is equipped with the out-let facility functioning as a filtering muddy water. This was already applied as Verification Projects at Rugus village.
(h) **Rehabilitation of shallow well [Wr]:** Half of shallow wells have breakdown, They once functioned in good performance of both yield and quality for water supply. These must be rehabilitated.
(i) **Rehabilitation of improved spring [Sr]:** Existing improve-springs are contaminated. Further improvements on them are required by capping spring-eye and widening their collectors and protection areas.
(j) **Extending the local treatment facility for piped water system [Pt]:** Water distributed from these systems are not treated, so that they are being contaminated with high content of Fluoride. Local treatment system is proposed as extended facility on existing piped water system.
(k) **Checking the piped water supply [Pc]:** piped supplies based on springs or other groundwater source must be checked as to whether the existing water supply capacity excess water can be supplied to neighboring Location.
(l) **Restoration of abandoned borehole [BHr]:** Boreholes are abandoned due to high contents of

Fluoride and saline water. If low-cost and easy maintained treatment facility is available to remove them, such boreholes are to be restored.
(m) Metering consumption of supplied water [Pm]: Water tariff on piped water system is charged per respective water stand, hence the water consumption is not controlled, and resulting in far less revenue than the expenses on its maintenance work. The water flow meter is required for appropriate management on existing water supply system.

Apart from water facility plan selected above, sub-surface dam andpiped distribution from surface sources are recommended in existing water supply development plan (DWDP, 1995). And they were supported by its workshop which was held during WRAP study, as below:

- **Subsurface dam:** is now construction at Arabal river as a part of in-take facility of Arabal water supply. It will give us practical experiment on verification whether sub-surface dam is really effective in the Study Area, and further to ASAL area.
- **Piped distribution form surface sources:** Phase II program of Kimao dam is comprising of construction of treatment facility and water distribution system

However, these are judged to be too large to promoteparticipatory project with community with self-help activity, therefore these two were excluded from the Plans.

For respective Sub-Location, several types of facility plan are technically selected for Verification Projects as shown in Table 4.3 inAppendix C, and as below:

<u>Type of Water Facilities in Sub-Location</u>

Sub-Location	Type of Water Facilities and Nos. of Proposed Sites for *4													
	Pop. *1	[BH] *2	[W]	[S]	[Ps]	[R]*3	[Paf]	[Pao]	[Wr]	[Sr]	[Pt]	[Pc]	[BHr]	[Pm]
Endao	893				1	2		6						
Perkerra	4,921					7+(2)								
Yatoi	2,623							3				1		1
Eldume	2,174	1				2			1				2	
Ilng'arua	1,279													
N'gambo	2,636					3+(1)		2	2					
Sintaan	1,424													
Salabani	1,316					3+(2)								
Meisori	2,521							2			1			1
Chelaba	775	1		2				2						
Maji Ndege	476			1		3+(1)								
Mbechot	926													
Sandai	855					2								
Kapkuikui	444							1						
Kaptombes	438							2						
Kimalel	624							3					1	
Sabor	1,194			4		3+(1)		2		1	1			
Koriema	1,466			5	1	5+(2)			1	1	1			

Sub-Location	Type of Water Facilities and Nos. of Proposed Sites for *4													
	Pop. *1	[BH] *2	[W]	[S]	[Ps]	[R]*3	[Paf]	[Pao]	[Wr]	[Sr]	[Pt]	[Pc]	[BHr]	[Pm]
Mukutani	1,036	3		1	2	4+(1)		3	1					
Rugus	881													
Arabal	2,024	7		6	1			5						
Ngelecha	717													
Kiserian	2,000													
Logumgum	790													

Note *1: Information from "Provisional Population Figures" based on 1999 census (Source: District Statistical Office)".
Note *2: Nos. of facility is determined by "Groundwater Potential Survey" completed in this Study.
Note *3: No. of facility is determined by 1993 data of schools and hospital (Source: MOH, Baringo and District Education Office), hence the administrative division of sub-Locations and including Nos. are different from the present. No parenthesis: schools, ():hospital.
Note *4: items [ ] refer to above "box"

As other important issues on the project plan, such that have close relation to the water supply plan: the institutional, financial, social frameworks, and health and hygiene education were not described in this sub-section.

b) Technology Choice and Physical Plan prepared by Location

In selecting the most appropriate technology to apply each type of plan, experiences in WRAP study, DWO offices and "Groundwater Development Project in Rural Districts (JICA, 2000)" are adaptable especially for followingtechnical principals:

- In areas where live stock numbers reachlivestockcarrying capacities, and in areas where no other alternatives, improvement of pan withcattle trough are opted for in addition to boreholes to prevent settling cattle close to boreholes in village center.

- In borehole sites in Arabal and Mukutani, there are supposed to be as low- medium potential of groundwater, hence the handpump are to be applicable.

- Construction of borehole is most common requests fromvillagers, and 12 sites were selected as proposed sites for Verification Projects. Required number of user per borehole indicated in "Design Manual in Kenya (1986)" is being in the ranges of 200 to 500, which should be achieved byadjusting the walking distance. In the WRAP study, number of user per water point were assumed to be 100 as minimum number while 500 as maximum number depending on the cost of thefacility. In the Plan for Verification Projects, the required yield per borehole is estimated with taking a figure of 500 users/hole, which can be converted to a demand of 10cu.m/day. The structure of borehole is applied same type of JICA well, which is used in Rural Waterdevelopment in Baringo and Koibatek Districts

- Hand-pump type are must be chosen by groundwater levels:Afridev or Indian Mark II is for deeper than 40 m, while Indian Mark IIExtra Deep Well or Duba type pump is for 40- 70 m.

- At the remote area and having enoughyields as much as 30 cu.m/day, solar pump may be one of the alternatives. In this case, solar system can employs other functions: for example lighting and desalination and even watetreatment.

- In cases of selecting pump type as above, it must be checked whether there aresufficient opportunities for O/M back-up support.

- High concentration of Fluoride in water source can causes skeletal Flourosis, although it will be selected safe water source, Fluoride contamination still remain in number of existing water sources as serious and widespread problem in the Study Area. As others, Iron and Manganese also affect health indirectly. To mitigate this affection by contaminants, the new treatment technology and method would be applied as long as possible.

APPENDIX A. WATER RESOUCE SURVEY

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Appendix-A Water Resources Survey

1 General

The focus of activity in the Water Resources Survey was the provision of safe and reliable source of water to unserved segments of population. The needs for water was urgent, and many requests emerge from PCM PRA work shop. In fact, most of the villages have no acceptable water source available in the dry season. The primary problem faced in the Survey was limitation in the availability of water source. In particular, deep groundwater was in places difficult to detect it. To complete this, TEM method was applied for obtaining reliable information to detect deep aquifer.
Another focus on the Survey was on water quality. Water sources are in parts being threatened by contaminants: inclusive of Fluoride, Iron and bacteriological organs. By doing water quality test, degrees and extents of contamination of water sources was clarified.
During the Survey, following survey items and contents were completed.

- **Review of Existing Data:** In order to clarifying the preset condition of physical background, up-dating the meteo-hydrological information and reviewing existing reports and materials were carried out, in the areas of a) Physiography, b) Meteorology and Hydrology, c) Drought, d) Hydrogeology, e) Groundwater, f) Water quality, g) Existing water facility.
- **Field reconnaissance survey:** About 137 water points or villages were surveyed in order to collect factual hydro-geographical information concerning to land forms, soil cover, rock type, spring, existing water points, and present condition of water sources. As supplement objectives of survey, "Ground Truth" for photographic information which had been interpreted from areal photographs were completed.
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- **Water sampling and laboratory water quality test:** 22 Samples were taken from the main water sources, and checked by full water analysis for 27 items. It aims to confirm preceding in-situ results, and judging the bacteriological contamination of water source.
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- **Geophysical investigation:** Primary objectives of this survey were to determine the aquifer availability of proposed villages and to locate the suitable borehole-drilling sites near by the village center. Secondary objectives of the study were to evaluate aquifer potential, and detect structure of underlying volcanic and sedimentary facies, fault and fracture zones, consequently to clarify the groundwater resources potential. TEM measurements were made at a total of 42 villages (sites) including 479 stations.

In a course of the Survey, discussions were made with village communities on the selection of proposed villages for water resource survey and improvement of water facility.

2. Data collection and evaluation for existing materials and studies

Up-dating the meteo-hydrological information, and collection and review of existing reports and materials in the context of a) Physiography, b) Metrology and Hydrology, c) Drought, d) Hydrogeology, e)Groundwater, f)Water quality and g) Existing water facility were made in the Survey. The reviews of physical backgrounds are summarized in following sub-sections.

2.1 Physiography

The Study area is divvied into two major physiographic zones and five sub zones as shown in Figure 2-1(Physiographic zone of Study Area), and as follows.

Physiographic zones	Sub-zones	Symbol given in Physiographic zone
Gregory Rift valley	Central Volcano	1a
	Faulted Volcanic Escarpments	1b
	Volcanic Plateau	1c
	Alluviated and Lacustrine	1d
Laikipia Plateau	Western edged of Laikipia Plateau	2a

A zone of "The Gregory Rift valley" has unique feature incorporating to forming the lake Baringo and Bogoria, and is inclusive of distinctive sub-zones of "Central Volcano(1a)", "Faulted Escarpment(1b)", "Volcanic Plateau(1c)" and "Alluviated and lacustrine plain (1d). While, "the Laikipia Plateau" is essentially corresponding with broad outcropped of Miocene phonolitic exclusives, bounded to the west by magnificent series of faulted escarpments bound to the aforesaid "The Gregory Rift valley" These physiographic feature is described as follows respectively:

- **Gregory Rift Valley:** includes a section of the Baringo basin and Baringo-Bogoria 'half-graven' extending from Lake Baringo lake at about 870 m above sea level, up to the Lake Bogoria, where the rift floor elevation rises to about 1100. Faulting trending NW-SE control an array of *en echelon* re-entrants in the alignment of the eastern wall of the rift, which is consequently not every where susceptible to clear definition, particular south of Lake Bogoria. There are bounding fault escarpments trace out curvi-linearments enclosing partly alluviated em-bayments in the adjacent rift valley. The physiographic diversity of "Gregory Rift Valley is described in terms of following paragraphs:
- **Central Volcano:** the low angled 'central composite cone of Korosi volcano (locating northern boundary of Study to Tangulbei Division) is indicated as typical physiographic of "The Central Volcano". Korosi volcano has faults trending NNE and are manifesting as scoria cones. Further along with the this trend, the main fissure system may well extent to the under Lake Baringo as Ol Kokwe Island, which is a submerged salient of the Korosi Volcano.
- **Faulted Volcano Escarpment:** the sub-zone separate the alluvial and Quaternary volcanic median zone of the rift from the plateau which from the outer rift shoulders. Between Lake Bogoria and Laikipia escarpments, there complicated escarpment systems (including Siracho Escarpment, Kahone Range, deeply dissected by Wasages river, and Arabal river (particularly Lower Ol Arabal river systems).

  Karau (1486m) is considered a northern extension of this belt of escarpment, separating

Lake Baringo form the Mukutan-Korosi Basin. The western edge of Karau has been faulted by Pliocene fault.

- **Volcano Plateau:** This locates west and south of Lake Baringo, which includes the Dispei Plateau and Lake Hanington Plateau. the Dispei Plateaux devoid of surface drainage, are broken hilly complex of horsts and grabens, and extend south up to Siraco Escarpment. The Lake Hanington Plateau is charcterised by an grid faulting system and which transect the dominantly trachy-phonolitic lavas, drained by the north-flowing parallel configuration reaching to Loboi form southern watershed.

- **Alluviated and Lacustrine Area**: This area is pronounced by clear distinction on physiographic property between that of Lake Baring and Lake Bogoria depending on different water circulation regimes. The former is favored by fresh water detritiacl pattern , and the later is characterized by saline-alkaline, consisting of evaporite deposition and preservation of organic matter. These surface distribution reflect the depositional environment.

Lake Baringo is at 970 m of elevation and with 22 km long and up to 13 km broad. The lake water is believed to egress at its northern end as groundwater to merge at Kapedo springs to 110 km north

Lake Bogoria is soda lake locating at altitude of about 990 m, and occupy an area ranging 18 km long and 5 km wide, is bounded on the east side by cliffs of Siracho Escarpment rising over 700 km above the lake surface. At the southern end, the numerous hot spring as a geysers. The lake has not exit, although some seepage may occur to the north throughout the Loboi Silts spreading 2 km wide from the northern end of the lake.

Two lake are separated by 20 km wide Loboi plain at height of 975, parts of which are swampy: the ground water is saline, although the Perikerra river has been used for an irrigation scheme. Lacustrine watershed reaches a maximum elevation of 999 m about 4 km north of Lake Bogoria. Geologic evidence shows that two lakes were combined each other during Late Pleistocene. Although this, there is no convincing evidence that Baringo Lake ever sustained a northward over flow by way of the "Lobat pass" where is locating at western flank of Korosi volcano in Tangulbei.

To the north the Mukutan-Komol (Tanbulbei division) Basin extends the eastren side of the rift for about 40 km. It comprises a plain of aggradation, in part palaeolacustrine belt, at about 1200 m, extending up to 10 km wide, flanked by the Aruru-Tangulbei Escarpment to the east and Karau- Chepchuk ridges to the west. At Pleistocene age, the Mukutan and Kabarmel rivers are dammed by volcanoes and river water was pondered in the Basin. The Lower Arabal Basin, below the Ol Arabal gorge, continues this Mukutan feature southward, separated from by the Morilo-Ngarama and Ramaja horsts west of Ngelesha.

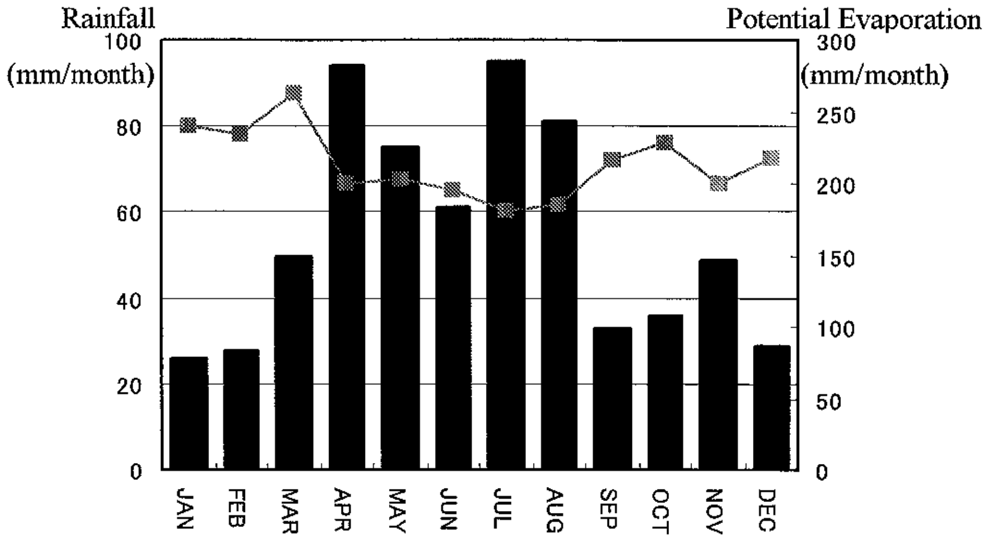
- **Laikipia Plateau:** This covers highest part indicating altitude of 2050 m in the Study area (Negrecha village in Arabal Location locates nearby Neglesha, Sub-Location in Muchongoi Location). This physiographic zone is impressed by vast and monotony of plateau surface, and gently sloping consistently at about 2-4 degrees, and is generally founded on Miocene 'flood' phonolites.

On the 'Rift shoulder' south of Neglecha, rift related to faulting controls the outline of certain minor alluviated through on the plateau, the largest of which is the Upper Ol Arabal Basin.

2.2 Metrology and Hydrology

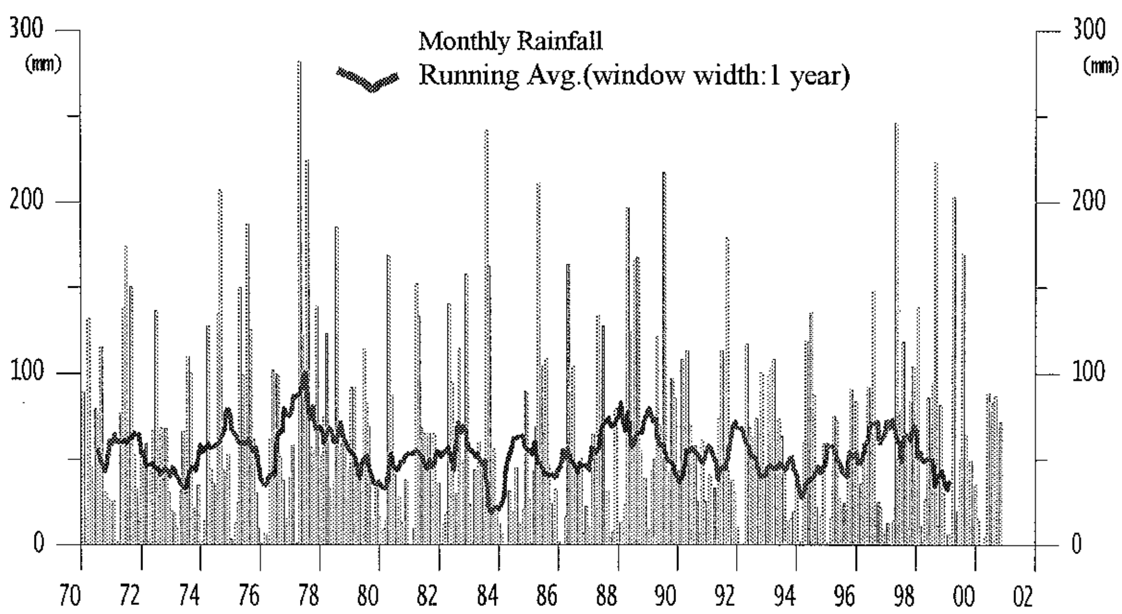
2.2.1 Rainfall

Baringo are ASAL areas with a climatic difference within the Study area in between respective Locations. Annual Rainfall in the Study area is in general about 650 to 800 mm with exemption of Koriema and Sabor Sub-locations, which are indicating as about 800 to 1100 mm/year. As low as 650 mm/year is in the surrounding of Lake Baringo, Ngambo, Kiseilian Location and Rugus Sub-Location. They are two seasons of rainfalls: long rains come from the end of March to the begging of July, and the short rains begin from the end of September to November. In between two



rainy seasons, which is from October to March, is dry period. A few rainfall is received during dry period. Average annual rainfall during 30 years form 1970 to 1999 at Perkerra RRC Meteorological stationary was 650 mm/year.

Changes in monthly total of rainfall amount is given as follows:



2.2.2 Evaporation

Based on pan evaporation data observed in Perikerra Sub-Location, the Study Area would experience high potential evaporation exceeding 2500 mm/year (WRAP, 1994: based on Pan-evaporation record and applying 0.8 of pan coefficient). During half a year, the Area receives low amount of rainfall and has been suffered by the very high evaporation rates. Hence, availability of water in the Area therefore is to be limited. Further, the high evaporation rates also lead to deterioration of both the surface and groundwater quality due to accumulation of salts.

This high value would also causes high water loss from open water sources like as pan and dam. Therefore, effectiveness of such surface-water source is not relied in this Area.

2.2.3 Drainage

In the Study Area, rivers drain inland, finally into the Lake Baringo. Most of rivers have very low and dry-weather flows, hence have being seasonal stream, As perennial or partly parental rivers (perennial river only in upper stream), there are of five rivers: Perkerra, Endao, Waseges, Ol Arabal and Mukutani River. Their divides are located in the surrounding highland to the east and west, and further south up to west of Nakuru. Annual runoff summary of Perikerra and Molo Rivers are given as follows:

River (R.G.S No.)	R.G.S. Location	Area (km^2)	Discharge		Runoff (mm)	Avg. Rainfall (mm)	Runoff Coef.
			Annual Avg. (m^3/sec)	Annual yield (MCM)			
Perkerra (2EE8)	At Kinangoroa,, Eldama, Ravine.	500	1.980	82.6	165	1,300	0.13
Perkerra (2EE7)	At bridge on Mariat, Mogatio tarmac road	1,181	2.620	144.0	122	1,190	0.10
Molo (2EG1)	Nakuru-Eldama bridge, Kanpi ya moto	595	4.570	62.4	105	1,100	0.10

River courses of them were not fully developed with geomorphologic process to keep pace with the Recent volcano-tectonic evolution. Therefore, erosion cycle have not been completed, and rejuvenation can be attributed to faulting system a along particular escapement.

2.2.4 Geological background of drainage

Mukutani, Waseges, Ol Arabal watersheds are originated from Laikipia Plateau and their drainage are aligned only 2 to 3 km east of the main Laikipia Escarpment. They have many interesting features in terms of geologic evolution related to water resources potential, as follows:

- **Mukutani River;** Mukutani Gouge, antecedent east-west drainage channel has been maintained. In the Pliocene time, primary consequent stream draining into the rift, initiated by the rise of the Laikipia Monocline to the east. Fed by a trellis headwater system following the NNE-trends of the rift boundary fault zone, the middle Mukutani maintained its course across a rising crestal horst (Laikiria anticline) throughout the Pliocene age. There is prominent neck at 1830 m at Nandi Dam.
- **Waseges River;** The river flow through Iguamiti breaks and join the mainstream across the escarpment formed by the fault zone. Down strean of Waseges river has incises a tourtuos ravine between the Bechot and Waseges ranges foeming a ridge of Pliestone

trachyphonolites immediately above its entry into the Kisbor Swamp on the Loboi plain.

- **Ol Arabal River;** The river flowed west in the Middle Pliocene age to the Baringo Basin by way of the Moera Pass, now Moera pass is abandonment and a wind gap across the branch of Laikipia Escarpment resulting in regional northward tiling. In the late Pleistocene age a lake is formed over present outcrop of Kapindasum Beds, due to damming up by extrusion of Parraro volcanos to the north.

2.2.5 Lake

In the period of 1987-1988, water level of Lake Baringo has dramatically lowered. Due to receding beyond the lowest of staff gauge, the measurement of water level by MOENR (Kampi Ya Samaki 2EH1 station) had interrupted since 1987. According to observation data at Kampi Ya Samaki, (record of 1989-1995) issued from Kenya Marine Research Institute, its water level had been dropped to 2.5 m during five year. As well, the siltation of lake had been highly progressed, and water turbidity had been worsen. Water depth of lake was measured as 2.5 m in Novbember 1995, at deepest point between Central Island and Kampi Ya Samaki, Because of silttation and heavy turbidity, the water quality had been also worsen, indicating as much as 7 –30 ppm of fluoride concentration. But, such water is still using as domestic water in particular Kampi Ya Samaki, Salabani and Kisirian Locations.

Lake Bogoria has excessively high salinity (more than 20000 micro S/cm), and fluoride, so that their water can not be used as any water supply source.

2.3 Drought year

It may be difficult to define "drought" in time and space in the Study Area. It may take weeks or months of persist dryness before a drought is finally acknowledged, and it may take a similar period of sustained weakness to bring the drought to the end.

Many understanding in development a suitable definition of drought rise especially in this dry weather. The drought may not affect all components of the hydrologic system simultaneously. In the case of the local irrigation water used in Partaro water harvesting scheme in Study Area, the soil moisture maintained from local rainfall on the spot may be important for the deficit of water, whereas water supply systems in Marigat piped water supply conveyed form Perkerra river do not affected by immediate problem. Hence the term of "drought" here is unclear and not an absolute condition.

Typically, item is to identify the drought in terms of three types, as follows:

- Meteorological drought refers to a period of below normal precipitation and above normal temperature;
- Hydrologic draught forces on water supply and might use an index of stream flow and/or groundwater storage, and
- Agricultural drought obviously refers to drought affecting agriculture and forces on soil moisture availability influenced by the local rainfalls.

In the Study, a type of Meteorological drought is conventionally adopted and analyzed with frequency analysis as described below.

2.3.1 Frequency analysis

Frequency analysis does not define the droughts and their seriousness. It only assigns recurrence interval to drought events. an item of annual precipitation is applied to calculate the recurrence interval of drought events (or return period; R.P.). The result of frequency analysis is given below:

requency Analysis for Drought Year							
Order	Year	Annual rainfall	R.P.(year)	Order	Year	Annual rainfall	R.P.(year)
1	1984	271	227.0	16	1982	667	********
2	1980	428	13.5	17	1991	668	********
3	1973	431	12.8	18	1981	692	********
4	1976	476	7.5	19	1970	696	********
5	1995	500	5.8	20	1983	703	********
6	1986	511	5.2	21	1985	714	********
7	1996	540	4.0	22	1974	737	********
8	1972	563	3.4	23	1978	756	********
9	1994	563	3.4	24	1998	760	********
10	1992	565	3.3	25	1975	770	********
11	1987	587	2.9	26	1971	770	********
12	1990	591	2.8	27	1997	781	********
13	1999	638	2.1	28	1989	842	********
14	1979	652	********	29	1988	893	********
15	1993	655	********	30	1977	1085	********

If above category of "Meteorological drought" is reflected in annual area precipitation, most severe drought is taken place in the year 1984 with 227 years of return period during 30 years. A type of "Meteorological drought" was solely selected with specific idea for the yielding from rainwater but water availability. That is, "an extended period of time during which area precipitation was significantly below normal". In recent a year during November 1999 to October 2000, total rainfall is about 435 mm/year. This can be correlated to R.P.12 years as shown below. The set-up the Water Resources Survey the Study Area, this indication on 'Drought' were to be considered.

R.P. Annual Rainfall in Marigat Station			
Year	mm/year	Year	mm/year
2	643.8	3	576.6
4	539.7	5	514.7
6	495.8	7	481.6
8	469.6	9	459.4
10	450.7	11	443.0
12	436.2	13	430.2
14	424.6	15	419.6
16	415.0	17	410.7
18	406.8	19	403.0
20	399.6	21	396.3
22	393.2	23	390.3
24	387.5	25	384.9
26	382.4	27	379.9
28	377.8	29	375.6
30	373.5	35	364.2
40	356.4	50	343.8
60	333.9	70	325.7
80	318.8	90	312.9
100	307.6	150	288.3
200	275.2	300	257.7
400	245.8	500	236.9
700	223.8	1000	210.6

2.4 Hydrogeology

2.4.1 Geologic Members and Stratigraphy

The Study Area, features a variety of volcanic complexes ranging in age from the Miocene to Recent, lave flows and pyroclastic and some intrusive rocks. The eastern shoulder of the Rift Valley, and above the Laikipia Escarpment, extends into the broad expense of the Miocene flood phonolites. In the south-east, there is an area of Pliocene lavas. The surrounding Lake Baringo, Quaternary sediment and superficial sediment are deposited. The geological map is shown in Figure 2-2, and stratigraphy of these rocks are given as follows:

age	Main Component	Sub. Component	Western Shoulder	Median Rift	Eastern Shoulder
Recent	*Alluvial/Colluvial Sedimnets*			*Ilosowuani beds* *Logumukum beds* *Loiminangge deds* *Kapthurin Formation*	
	Fuviolacustrine Sediment	volcaniclastics			
(Recent) Pleistocene-	Trachyte/ basalt Central volcano			Paka volcano Korosi volcano Ol Kokwe	
	Fuviolacustrine / Glaciofluvial Sediment Flood Trachyphonolite and Trachytes	Basalt	Baringo basalt Baringo trachyte Loyamak Trachyphonolite Chemakilani basalt Murgusian basalt	Molo tuffs Koitumet basalts Hannington Trachyphonolite Formation *Kapindasum beds* Kwaibus basalt Emsos mugearite	Mukutan and Mistoni mugearite Karau Volcanics Chepchuk volcanics Chesowanja basalt *Chesowanja sediments(mukutan beds)*
Pliocene	Trachyte shield Volcanoes	Basalt, Sediment	Jamakana Formation Lokwaleibit basalt		Kokwapanga basalt Orus trachyte
	Basalt	Trachyte	Kaparaina basalt	Narokwe basalt	
	Phonolitic Trachytes			Tasiowank and Iguamiti phonolitic trachyte	
Miocene	Phonolites			Alengerr tuffs Kommol volcznics Katomuk tuffs Lapet phonolite Murgomul volcanics	
	Basalts			Sabit trachyte Sambuuru basats	

2.4.2 Aquifer

Tectonic activity, resulting the formation of the Rift Valley system, has develop faults with different magnitude and trends. As well, intense volcanic activity had been suffered, and produced various type of volcanic rocks. In between these volcanics, internal sedimentary basin had been developed. Related to such geologic condition, various types of aquifers are evolved even within the Study Area. Depending upon the formation type bearing the water, They can be classified in to three types: "Thick Sedimentary Deposit (or Aquifer)", "Shallow Alluvial Deposit (or Aquifer) Underlain by Volcanic Formation", and "Weather /or Fractured Zone (or Aquifer) in Thick Formation".

- **Thick Sedimentary Deposit (or Aquifer):** This type of aquifer occurs at a depth ranging between 20 and 50 m with coarse alluvial materiel interbedded by clayey layer and often underlain by saline-water layer. The presence of them are confirmed with the performance data of existing boreholes/geophysical survey in Marigat, Salabani, Ngambo, Kiseirian and Sandai Location, where surrounds to Lake Baringo. In the Endao Sub Location, there is success well drilled by CCF in September 2000. It's aquifer is of gravely layer at depth of about 90 m with fair yield as high as 300 lit/min. However, most of existing wells drilled in this type of aquifer is contaminated by saline water or high Fluoride contents.
- **Shallow Alluvial Deposit (or Aquifer) Underlain by Volcanic Formation:** This aquifer is not as diverse or extensive as other formations, It occurs in patches at the contact zone underlain by volcanic rocks. Aquifer is mainly found either in the overlying sediments/the

contact zone or the weathered fractured/faulted zone in underlying rocks. In the Study Area, they exist Loboi and Mukutani Location, but their yields vary in wide range.

- **Weather /or Fractured Zone (or Aquifer) in Thick Formation:** This aquifer is found along faults zone and accompanied weathering zone which have a space or a loser zone capably bearing and passing groundwater. Accordingly, the detecting the such zone of aquifer is difficult by solely used with geophysical information due to deep position of aquifer even reaching to 200 m. According to the existing record, the zone lying western slope and foothills of Lake Baringo is noted to have either dry or low yielding in particular Koriema Sub-location, Kimarel Sub Location (Eagarton area). While in the eastern slopes of Lake Baringo, where are domain of Arabal Location and Mukutani Location, they in general are judged as "moderate yield". Nearby Arabal Location (extending from Arabal to Muchongoi Location), Rural Water Supply Project In Baringo and Koibatek District (JAPAN grant aid, 1999-2001) has commenced drilling since August 2000 aiming at developing this type of aquifer. Four wells were in success (which are able to withdraw over 5 l/min) out of six drilling trails. Likewise, the shallower ground water near Lake Baringo, is exploitable by developing boreholes, but was being higher Fluoride content inside.

2.5 Groundwater Flow and Recharge

In the Rift Valley, rainfall and availability of permanent water in the rivers away from Lake Baringo decrease generally towards the north. However, some groundwater is flowing from the Laikipia Plateau. Although on the central Laikipia Plateau the water rest level decreases towards the north-east, much groundwater discharges in the opposites direction, due to channeling in fossil valleys on the sub-Miocene surface which is tilted westward: such water would eventually drain into the Rift Valley and supplement groundwater reserves, in particular under area like Loboi plan and the Mukutani Basin.

Rivers following off the Laikipia Escarpment, such as the Ol Arabal and the Mukutani, tend to lose much of their surface water in to escarpment fault zone, and also in to the alluvial gravels soon after they debouch on to the rift floor Therefore, Mukutani basin and other alluvial plan stretching from the foot of escapement has some potential of groundwater resources.

Endao River is in dry at down stream unless it is suffering by heavy rainfall to cause intense flood how is reaching to Lake Baringo. However, there is still in perennial condition at its middle way from mountain channels even in dry season That is to say, groundwater recharge is exclusively taken place within a upper part of watershed. Recharging water is flowing along sub-surface channels and passing through deep fracture zones in the volcanic basement.

In the WRAP-IV study (1997), the development potential of middle-deep groundwater was estimated with use of borehole data, as below:

Sub-location	Available groundwater (cum/year)	Sub-location	Available groundwater (cum/year)
Mukutani	50,000	Perikarra	24,000
Salabaini	12,000	Koriema	14,000
Ngambo	14,000	Sabor	6,000
Eldome	8,500	Sabdai	8,000
Endao	1,4500	Arabal	54,500

All rates mentioned above were estimated with a same rate of 200 cum/year/km^2, but it is far lower than that of surrounding areas such as Tugen Hills, Nginyang Kositei, Kinyachi, Kolowa.

2.6 Water quality

Water type in the Study area is regarding as "Sodium Bicarbonate type and EC (electrical conductivity) is indicating less than 1,000 μS/cm except for that of Lake Baringo, Lake Bogoria and other hot springs. Fluoride content in some sources are high in groundwater, spring water and lake water due to intense tectonic activity within the Rift Valley. However, the surface water flowing into rivers and pondering in pans and dams, fluoride concentration is generally lower than 3.0 mg/l, and is using in domestic and livestock use.

In the Study area, nearly half of piped water is contaminated (WRAP, 1994) by bacteriological organism due to very low residual chlorination levels and being poor operation and maintenance on to water supply systems. For the irrigation purpose, the surface water tends to be not suitable by the low mineral contents.

2.7 Existing water facility

In the Study Area, Both of natural water source and constructed water source are utilized by villagers and some are constructed by government or community and even by NGO, They are several types water facility such as water hole, river, lake, spring, shallow well (hand dug wells), borehole, dam, piped water system, roof catchment and so on.

3. Selection of proposed village for water resources survey

3.1 Coverage of safe water supply

The coverage rate were estimated as a percentage of the number of users who can access safety water vs. population. In the Study Area, safety water sources for domestic use are limited to less than 10 facilities consisting of five(5) piped water supplies and four(4) boreholes/wells. Coverage rate of safe water supply were estimated as shown in the following table.

Division	Location	Sub-Location	Total Population (1999)	*1 Estimated pop. covered by safe water supply (Oct.2000)	*2 Coverage rate (%*3) (Oct.2000)
Marigat	Marigat	Endao	893	0	25
		Perkerra	4,921	0	
		Yatoi	2,623	2150	
	Eldume	Eldume	2,174	0	(0)
	Ilng'arua	Ilng'arua	1,279	0	(0)
	N'gambo	N'gambo	2,636	700	17
		Sintaan	1,424	0	
	Salabani	Salabani	1,316	0	68
		Meisori	2,521	2605	
	Loboi	Chelaba	775	0	(0)
		Maji Ndege	476	0	
	Sandai	Mbechot	926	0	(0)
		Sandai	855	0	
	Kapkuikui	Kapkuikui	444	0	(0)
		Kaptombes	438	0	
	Kimalel	Kimalel	624	200	67
		Sabor	1,194	1000	
		Koriema	1466	1000	
	Sub-total		26985	7655	28
Mukutani	Mukutani	Mukutani	1036	0	0
		Rugus	881	0	
	Arabal	Arabal	2024	0	(0)
		Ngelecha	717	0	
	Kiserian	Kiserian	2000	0	(0)
		Logumgum	790	0	
	Sub-total		7448	0	0
Total			34433	7655	22

Note 1): population data is taken from District Statiscal Office as provisional rusult of 1999's census.
2):population covered by safe water supply is estimated based on the water facility survey made in Oct-Nov, 2000.
3: ( ) is the provisional figures, some part of indicating areas will covered by Ol-Arabal water supply scheme by summer 2015.

22 % of population can access safe water (pipe water supply, boreholes and wells). However, this figure does not mean properly that user can reaches to safe water. In fact, most of piped water supply schemes are not functioning satisfactorily, due to poor maintenance and short age of chemicals such that Kampi Ya Samaki pipe water supply system do not add chlorine. As well, Sabor pipe water supply system directly provides the contaminated water with high content of Fluoride (more than 5 ppm) without any treatment. Furthermore, the these water facilities are

exclusively for people living in town, institutions and trading centers. While in remote area far from town, most villages particularly locating Mukutani Division has no safe water source at all.

3.2 Selection of survey area

In PRA and PCM workshop held in the Study, a lot of needs for safe water supply are appealed from most of participants. Later on, their intentions were confirmed by direct hearing through village representatives in the reconnaissance field survey. Of these, wishes form villages, villagers requests for the siting of groundwater resources were extracted and complied as "Village List" for every Locations, as given below. Total 95 villages were nominated as candidate sites, and priority of them was given as degree of eagerness for subsequent groundwater potential survey.

Besides, from the technical points of view, 95 candidates were further screened to the half numbers of villages (sites) whether is to meet following criteria:

1) **Groundwater potential** (eastern and western slopes of Study Areas are comparatively as high potential by WRAP study, and by antecedent field reconnaissance survey);
2) **Water quality background** (deep groundwater found in the surroundings of Lake Bogoria and Lake Baringo is contaminated by Fluoride and saline water, particularly at Kiserian, N'gambo, Eldume, Sandai, Loboi and Salabani Locations);
3) **Coverage rate by safe water supply** (high priority must be given to low coverage areas, especially to Mukutani Division), and
4) **On-going water supply project** (Ol Arabal and Endao piped water supply projects are under construction. They will supply safe water to part of Loboi, Sandai, Kupkuikui, Elude, Kiserian Arabal, Endao and Salabani by 2001. Their coverage area must be excluded).

Taking relevant existing conditions vs. criteria (see below) into account, Locations of Arabal, Mukutani and Keserian are judged as high priority to be sited for groundwater potential.

Location (Sublocation)	Coverage rate by safe water supply	Coverage by on-going water supply project	Groundwater potential (shallow)	Groundwater potential (deep)	Water Quality
Arabal	+.+	+.+	+	+.+	+.+
Eldume	+.+	+	+	+	+
Ilngarua	+.+	+	+.	-	+
kapkuikui	+.+	+	+	-	+
Kiserian	+.+	+	+ +	+ +	+
Kimalel (kimalel & Sobor)	+	+.+	-	+	+
Kimalel (koriema)	+	+.+	-	+	+
Loboi	+.+	-	+	+.+	+
Marigat (Endao)	+.+	+.+	-	+	+
Marigat (Perikerra)	+	+.+	+	+	+
Marigat (Yatoi)	-	+.+	+	+	+
Mukutani	+.+	+.+	+	+.+	+.+
Ngambo (Nagambo)	+	+.+	+.+	-	+
Ngambo (Sintan)	+.+	+.+	+.+	-	-
Salabani	-	+.+	+	-	+
Sandai	+.+	+	+	+	+
Explantion:	+ + : not covered +: partly covered -: fairly covered		+ +: potential medium +:low -:poor		+ +: fair +: low -: poor

As next step of selection, respective village is further screened in accordance with flowing criteria.

5) Villager's Priority (priority giving by villagers within each Location or Sub Location).

Villager's section is thought to be involving general benefits on the improvement of access to water supply. It implies:

- villagers' convenience;
- time saved;
- energy saved;
- money saved;
- prevention of injury;
- agriculture use, and so on.

In a process of works on selection, all villages appeal willingness to participate the siting survey, and even to planning of water facility, and pay for a burden; a part of construction and management cost in the future. Especially at villages putting on higher priority by themselves, they are very eager to obtain safe water source to grantee their living life within the their walking distance.