ATTACHMENT- 1

Selection of Borehole Sites

Selection of Borehole Sites

1. Preliminary Evaluation of Requested Boreholes Sites

In the earliest period of the Basic Design Study (Study), a preliminary evaluation was done for 100 borehole sites listed on the request by the government of Kenya. As a result, 27 out of 100 were cancelled for the following reasons as shown in Table 1.

- (a) Inaccessibility
- (b) Overlapping with existing drilling plans by other donors
- (c) Problem on land acquisition in private ranch

Other than the originally requested sites, 52 sites were newly identified through the discussions and field reconnaissances jointly conducted by the JICA Study Team and MOWR as listed on Table 2. Accordingly, 125 sites were considered for the basic design study.

In addition, MOWR requested the JICA Study Team Study equipping several borehole sites with motorized pumps and rehabilitating several sites. After the discussions on this matter, eight sites were additional incorporated including four to be equipped with motorized pumps and four to be rehabilitated. Consequently, the total number of objective sites become 133 for the Study as seen in Table 3.

2. Hydrogeological Investigations

(1) Collection and Analysis of Existing Data

The inventory of existing boreholes by MOWR, the list of existing boreholes prepared by each district water office, and the previous study reports were collected and analyzed to clarify the hydrogeological characteristics in the Project Area. Analysis was also made for depth of borehole, static water level, groundwater yield, and water quality. Distribution of existing boreholes in the Project Area is shown in Figure 1. The collected data of existing 404 boreholes are presented in Attachment-4. The number of existing boreholes by districts is summarized below.

Item	Laikipia	Samburu	Baringo	Koibatek	Total
No. of Existing Borcholes	258	68	65	13	404

Water quality data are available for 147 boreholes shown below. These locations are shown in Figure 2. Water quality data for these boreholes are presented in Attachment-5.

ltem	Laikipia	Samburu	Baringo	Koibatek	Total
No. of Existing Boreholes with Water Quality Data	79	38	24	6	147

(2) Field Reconnaissance Survey for Existing Boreholes

A survey including measurements of groundwater level, electric conductivity, pH and water temperature was conducted for 29 of the existing boreholes in the Project Area. These locations are shown in Figure 3. However, measurements were not possible at some boreholes already abandoned or completely sealed up by installation of equipment. For such cases, measurements were made at river or spring which may supply groundwater to the borehole. The results of measurements are shown in Table 4.

(3) Hydrogeological Structure and Evaluation of Aquifer

Geological structures of the Project Area consist of Pre-cambrian metamorphic rocks (more than 600 million years ago), Tertiary and Quaternary volcanic rocks (30 million years ago to present), and Quaternary unconsolidated deposits (river and lake deposits at present). The structures show the following hydrogeological characteristics and are evaluated as aquifers respectively. A conceptual figure of hydrogeological structures in the Project Area is shown in Figure 4.

(a) Pre-cambrian Basement Rocks

The basement rocks are metamorphic rocks mainly consisting of granitegneiss and distributed in Laikipia district in the northeast, Samburu district in the east, and a part of Baringo district. The basement rocks are generally massive without significant cracks and their fresh parts are evaluated as impermeable layers. Aquifers are found as layers of well-developed cracks along faults and fractured zones or weathered surface layers. Such aquifers are found locally with quite limited extent in the basement rocks.

(b) Volcanics

The volcanics are distributed widely in the Project Area: Laikipia district in the west to south, Samburu district in the southwest, and the whole areas of Baringo and Koibatek districts. These consist of Tertiary and Quaternary volcanic rocks composed of basalt-lavas, phenolites, trachytes, etc., with tuffs and volcanic ash.

These volcanics form lava plateau consisting of multi layers as shown in Figure 4. Lava plateau is formed by lava flows with a thickness of 10 to 20 meters overlaying one after another. Confined aquifers exist at contact of layer each other and that of underlaying Pre-cambrian basement. The confined aquifers are distributed widely in the Project Area. Static water level and groundwater yield from the confirmed aquifers varies depending on their confined conditions.

In general, static water level is relatively shallow with abundant yield near Mt. Kenya and the Aberdares. As distant from these mountains, a static water level tends to be deep with less yield.

(c) Quaternary Unconsolidated Deposits

Quaternary unconsolidated deposits containing fresh groundwater are locally observed around rivers and lakes in the Project Area. Groundwater, depending on rainfall amount and thickness of the deposits, is subject to seasonal fluctuation. Static water level is recovered during rainy season but is lowering significantly at the end of dry season. The deposits are distributed locally with limited extent. It is, therefore, necessary to confirm hydrogeological conditions on site for evaluation.

(4) Possible Pumping Yield

Possible pumping yield from borehole depends on aquifer characteristics and capacity of pump installed at borehole. The analysis was done on the basis of boreholes given in the inventory. The results are shown in Figure 5.

(5) Static Water Level

From the inventory of existing boreholes, static water levels vary from 10 to 150 meters and many boreholes have levels 40 to 60 meters or deeper. Static water levels at the proposed borehole sites should be carefully examined for application of hand-pumps with their limitation of the maximum pumping head. Table 5 shows the distributions of unsuccessful boreholes and static water levels of successful boreholes by district.

The table indicates the rates of boreholes unsuccessful and with static water level deeper than 60 m by district are 30% in Laikipia district, 54% in Samburu district and 61% in Baringo and Koibatek districts. Relatively deep static water level is observed around the southern part of Laikipia district near Mt. Kenya and the Aberdares and locations of Quaternary unconsolidated deposits with relatively wide extent. A contour map of static water level in Laikipia district is shown in Figure 6.

(6) Water Quality

The study on water quality is conducted using the water quality data of existing boreholes. Attachment-5 gives the results indicating several items of water quality beyond those guidelines in Kenya for many of the existing boreholes. The study mainly pays attention to Fluoride (F) and Nitrate (NO₃) as described below.

(a) For fluoride, relationships to electric conductivity and aquifer are examined as shown in Figure 7 and 8, respectively. Fluoride content for similar electric conductivity varies by region, namely, groundwater indicates high fluoride content in the volcanics areas of Baringo, Koibatek and a part of Samburu districts, especially in the lowland in the Lift Valley.

Fluoride content is less than the guidelines in most aquifers composed of Quaternary unconsolidated deposits and Pre-cambrian basement rocks. Some higher values are observed in aquifers of volcanies.

(b) Nitrate content is generally less in the whole Project Area, except a part of Samburu district.

Groundwater in Pre-cambrian metamorphic rocks shows poor water quality with high content of dissolved minerals in some places. In general, groundwater quality is good in aquifers of Quaternary unconsolidated deposits and volcanics in Laikipia district. High salt content is observed at a part of Samburu district.

For fluoride content, the Kenyan guidelines accept a content of 3.0 mg/l for exceptional cases like those in the Lift Valley even though the WHO recommended value is 1.0 mg/l.

(7) Electric Soundings

Electric soundings were conducted at 102 locations in the Project Area including 50 in Laikipia district, 24 in Samburu district, 24 in Baringo district and 4 in Koibatek district. Locations of electric soundings are shown in Figure 9. These locations were selected through hydrogeological field reconnaissances prior to the soundings. The results of field data analysis of electric soundings are given in Attachment-7.

(8) Water Quality Tests

The samplings for water quality tests were conducted at 16 locations in the Project Area including 12 of groundwater from boreholes, 2 of rivers, 1 of spring, and 1 of lake. Locations of samplings are given in Table 6 and Figure 3. Water quality tests were done for 19 testing items and the results are shown in Table 7 and a tri-linear diagram shown in Figure 10.

Most water samples indicate characteristics of groundwater originating from volcanics. Some of them give similar content to seawater. Samples showing similar content to rain water were taken from basalt lavas near Mt. Kenya.

3. Evaluation of Possible Borchold Sites from Hydrogeological Viewpoints

On the bases of the results of the hydrogeological studies described above, 133 sites selected for the basic design study were evaluated as shown in Table 8. The results of the evaluation are summarized below. 86 of the possible borehole sites were screened and their locations are shown in Figure 11.

	Possible Site for Handpump		Possible Site for Motorized Pump			Omitted Site		
District	Type-1	Туре-2	Туре-3	Motorized Pump Requeste d	Rehabili- tation Requeste d	No Aquifer	Poor Water Quality	Total No. of Site
Laikipia	28	14	7	1	1	12	1	64
Samburu	14	1	0	1	1	16	0	33
Buringo	12	0	0	1	1	4	10	28
Koibatek	0	2	0	1	1	1	3	8
m . 1	54	17	7	4	4	33	14	133
Total 71		15			47		133	

Note Type-1: SWL ≤ 45 m

Type-2: 45 < SWL ≤ 55 m

Type-3: SWL > 55 m

4. Criteria for Successful Rate of Boreholes

For the purpose of the Project, criteria for successful boreholes are prepared on the basis of the guidelines by JICA due to the absence of such criteria in Kenya. The following criteria are applied.

(a) Groundwater yield: more than 330 l/hour

(b) Water Quality : meeting the Kenya guidelines of potable water quality

Using the criteria above, successful rate of boreholes for the Project is examined in compliance with the results of hydrogeological studies on the condition that drilling points are determined more accurately in the implementation stage.

Table 5 indicates successful rates of boreholes by region estimated from the data of 321 existing boreholes in the Project Area. On this table, Unsuccessful' mean no groundwater is observed or yield is very small at the borehole.

Static water levels at 16% of boreholes are deeper than 55 m that is not suitable to install handpumps. Whereas, all the proposed borehole sites are selected to meet expected static water level up to 55 m depth for installing handpumps. The successful rate of boreholes for the Project is, therefore, obtained from the table as follows.

(Successful Rate) = 1 - (Unsuccessful Rate)

The successful rate of boreholes by region is given below.

District	Division	Successful Rate
Laikipia	Mukogodo	78%
	Romuruti	84%
	Ngarua	76%
	Lamuria	93%
	Central	80%
Samburu	Wamba	30%
	Wamba	30%
Baringo		69%
Koibatek		54%

5. Proposed Number of Boreholes

The results of hydrogeological studies give 71 possible borehole sites for installation of handpumps. The number of sites by district and division is shown below.

District	Division	No. of Proposed Sites
Laikipia	Mukogodo	5
	Rumuruti	5
	Ngarua	. 8
	Lamuria	16
	Central	8
	Sub-total	42
Samburu	Wamba	. 4
	Lorroki	7
	Kirisia	4
	Sub-total	15
Baringo	Kipsalaman	2
	Tangulbei	3
	Mukutani	1
	Mochongoi	5
	Kolowa	1
	Sub-total	12
Koibatek	Mumberes	1
	Mogotio	1
	Sub-total	2
	Total	71

For these 71 sites, proposed number of boreholes was examined taking present supply ratio, population density and successful rate of boreholes into consideration.

(1) Population

The latest official population census in Kenya was conducted in 1989 and the population projections to the year 2000 were provided in 1996. Referring this population projections, the population projections in the Project Area were done by sub-location to the year 2000 for the purpose of the Study.

The population projections by district are shown below. Population density in the Project Area is shown in Figure 12.

District	1990	1995	2000	Area (km²)	Density (person/km²)
Laikipia	245,221	310,440	381,698	9,178	42
Samburu	114,762	136,976	155,056	20,808	7
Baringo	264,754	300,888	329,392	8,567	38
Koibatek	128,935	147,758	168,204	2,387	70

(2) Present Supply Ratio

Present supply ratio by water supply facility is estimated approximately as described below.

(a) Piped Water Supplies

Supplied population by piped water supplies were estimated on the basis of available data obtained from Project Status Report, Water Resources Assessment Project, Aftercare Study for NWMP.

(b) Small Scale Water Supplies

Actual situations of small scale water supplies like point sources were not clarified due to insufficient data. For the purpose of the Study, supplied population by small scale water supplies are estimated approximately from potentials of water sources. The estimation of supply capacity is made on the basis of groundwater yield from the inventory of boreholes prepared by MWR since most of the Project Area covered with ASAL relies on groundwater for domestic use. Supplied population is calculated using estimated supply capacity of water source and unit water consumption assumed at 15 $\ell/c/day$.

Supplied population and supply ratio are estimated by sub-location and compiled by district as shown below. Distribution of supply ratio in the Project Area is shown in Figure 13.

District	Supplied Population	Population in 2000	Supply Rate	
Laikipia	147,723	381,698	38%	
Samburu	58,105	155,056	37%	
Baringo	79,976	329,392	24%	
Koibatek	63,334	168,204	39%	
Total	349,318	1,034,350	34%	

(3) Proposed Number of Boreholes

The proposed number of boreholes were determined by:

- (a) Proposed borehole is equipped with handpump
- (b) Supplied population by one borehole is estimated as follows.

· Unit water consumption: 15 l/c/day (from Kenya guidelines)

· Pumping rate : 675 l/hour (from JICA guidelines)

When borehole yield is less than 675 ℓ /hour, pumping rate is assumed as the same as borehole yield.

· Operation hours : 8 hours/day

For example, supplied population is 360 persons for borehole with pumping rate of 675 ℓ /hour.

 $(675 \ell/\text{hour}) \times (8 \text{ hours/day})/(15 \ell/\text{c/day}) = 360 \text{ persons}$

- (c) First, each borehole is proposed for the selected 71 sites under the following conditions.
 - · Supply ratio is less than 70% in sub-location where site is located.
 - Successful rate of boreholes by region is more than 50%.

As a result, each borehole is proposed at 59 out of 71 sites.

- (d) Second, borehole is additionally proposed for the site where supplied population is many and hydrogeological conditions are good. The conditions are as follows.
 - Concentration of proposed boreholes to some sub-locations should be avoided. Drilling points at site should also be selected within an area where the same hydrogeological conditions are expected. Number of additional boreholes is, therefore, limited to one per site.
 - Population density of sub-location is more than 7 persons/km², namely, an area within 4 km from borehole point covers more than 360 persons that is equivalent to supplied population per borehole with handpump.

- From the hydrogeological evaluation, it is expected that borehole yield will be more than 1 m³/s and static water level is 45 meters depth or less.
- · After provision of one borehole, supply ratio of sub-location is still lower than 70%.

As a result, each one borchole is additionally proposed at 31 out of 59 sites.

The number of proposed boreholes are 90 in the Project Area. The results are summarized in **Table 9** and the list of proposed boreholes is given in **Table 10**. The Proposed boreholes in the Project Area are shown in **Figure 14**.

The number of proposed boreholes by district and division is presented below.

District	Division	No. of Sites	No. of Proposed Boreholes	
Laikipia	Mukogodo	5	8	
•	Rumuruti	5	8	
	Ngarua	8	11	
	Lamuria	16	14	
	Central	8	11	
	Sub-total	42	52	
Samburu	Wamba	4	0	
	Lorroki	7	13	
	Kirisia	4	3	
	Sub-total	15	16	
Baringo	Kipsalaman	2	4	
_	Tangulbei	3	5	
	Mukutani	1	2	
	Mochongoi	5	7	
	Kolowa	1	2	
	Sub-total	12	20	
Koibatek	Mumberes	1	1	
	Mogotio	1	1	
	Sub-total	2	2	
	Total	71	90	

Table 1 Preliminary Evaluation of Requested Borchole Sites

Table Desire Common Co	No. Name of Site	Inaccess- bility	Overlapping	Land Acquisition	Evaluation	No. Name of Site		Overlapping		Evaluation
Mateodo Division	Laikipla District	Ultit!		Acquistion		Lorroki Division	Dillity		Wodnisidou	
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S. Mithiga-1								0		0
6 Mithles-2							<u> </u>		<u> </u>	<u> </u>
7 Kinamba T.C.										<u>o</u>
S. Marweku										0
9 Ngelesha x 0 0 x sub-total										× ×
Lumuria Division		×			×					5
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3 Nogulai										- <u>X</u> -
4 Matanya O										
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Wamba Division										
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the second secon	sub-total				7					73
x: cancelled, O; screened						x: cancelled, O:se	record			

Table 2 Additional Borehole Sites Requested

District Division	Name of Site	District	Division	Name of Site
aikipia		Barinngo		
Romurati	1 Gatundia		Kipsaraman	1 Sibilo
	2 Machuguru			2 Ngaratuko
	3 Mifugo			3 Yatya
	4 Kite			4 Barsemoi
	5 Salama			5 Lokodowobet
	6 Muruku			
	7 Mutara		Mukutan	1 Motutani
Ngarua	1 Naigera		Muchogoi	1 Kasiela
	2 Cheleta			2 Sinoni
	3 Kiambogo		-	3 Kabindasim
	4 Mwenje			4 Kamailel
	5 Kagaa			
			Nginyang	1 Katugumok
Lamuria	1 TharuaWaichekeheri			2 Chepilat
	2 Lamuria T.C			
	3 Thome Kiburuti		Kolowa	1 Barpelo
	4 Thome T.C			
	5 Ngobit T.C	Sub-tot	tal of Baringo	13
	6 Imenti-2			
	7 Withare	Koibatek		
	8 Kihata		Eldama Ravine	1 Tolmo
Central	1 Nturukuma		Mogotio	1 Kipsogon
	2 Rugutu			2 Radat
	3 Endana			<u></u>
	4 Mukima	Sub-tot	al of Koibatek	3
Sub-total of Laikipia	a 24		Total	52
Samburu				
Wamba	1 Dikir			
	2 Wamba-3			
Lorroki	1 Maralal-1			
	2 Maralal-2			
	3 Upper Kisima dam			
	4 Logorate			
	5 Mbaribon school			
	6 Sora adur			
	7 Lepetidet school			
Kirisia	1 Lpartuk-2	· · · · · · · · · · · · · · · · · · ·		
	2 Ilpartuk			
	3 EastLoikas			
Sub-total of Sambu	ru 12			

Table 3 Selected Borehole Sites for Hydrogeological Investigations (1/3)

Lalkipla District

Mukogodo Divis	lon
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Site No.	Location	Electric	No.	Borebole
/O	· · · · · · · · · · · · · · · · · · ·	Soundines		Type
(Original)				
1	Anenduguru		1	В
2	Lorbitosa		1	В
3	Muranairusha	•	1	В
4	Musual	•	1	В
5	Aljijo	•	1	В
6	Olkinyei	•	1	В
7	Ewaso = 1		1	В
8	Ilpolei	•	1	В
9	Kurikuri-1	•	1	В
10	Saramba	•	1	В
11	Ilogwesi	•	1	В
12	Kimanjo T.C.	•	1	В
13	Tora	•	1	В
14	Doldol		1	С
	Sub-total		14	

Rumaruti Division

Site No.	Location	Electric Soundings	No.	Borchole Type
(Original)				
15	Three Point	•	1	В
(Additiona	I)			<u> </u>
16	Gatundia		1	В
17	Machuguru	•	1	В
18	Mifugo	•	1	В
19	Kite	•	1	В
20	Salama		1	В
21	Muruku		1	В
22	Mutara		1	В
	Sub-total		8	<u> </u>

Ngarua Division

Site No.	Location	Electric Soundings	No.	Borehole Type
(Original)				
23	Kamigi	•	1	В
24	Kiambogo-1	•	1	В
25	Eighteen Rubere	•	1	В
26	Ol Ngarua Sec.	•	1	В
27	Mithiga-1	•	1	В
28	Mithiga-2	•	1	В
29	Kinamba T.C	•	1	В
(Additiona	ıl)			
30	Naigera	•	1	В
31	Cheleta	•	1	В
32	Kiambogo-2		1	В
33	Mwenje		1	В
34	Kagaa	<u> </u>	1	В
	Sub-total		12	

Lamuria Division

Location

Site No.

		2089/11052		<u> 1705 </u>
(Original)				
35	Kijabe	•	1	В
36	Segera	•	1	В
37	Njoguini	•	1	В
38	Matanya	•	1	В
39	Lamuria	•	1	Α
40	Wamura	•	1	В
41	Imenti-1	•	1	В
42	Imenti-2	•	1	В
43	Withare	•	1	В
44	Tigithi-1	•	1	В
45	Tigithi-2	•	1	В
46	Sweet Waters	•	ī	В
(Additional)			
47	Tharua Waichekeheri	•	1	В
48	Lamuria T.C.	•	1	В
49	Thome Kiburuti	•	1	В
50	Thome T.C.	•	1	В
51	Ngobit T.C.		1	В
52	Imenti-3	•	1	В
53	Withare		1	В
54	Kihata		1	В
	Sub-total		20	

Borehole

Electric

Central Division

Site No.	Location	Electric Soundings	No.	Borchole Type	
(Original)	1.51.5				
55	East Laikipia	•	1	В	
56	Rugutu-1	•	1	В	
57	Ngenia	•	1	В	
58	Muireri	•	1:	В	
59	Muramati	•	1	В	
60	Naibor	•	1	В	
(Additiona)				
61	Nturukuma		1	В	
62	Rugutu-2		1	В	
63	Endana		1	В	
64	Mukima		1	В	
	Sub-total		10		

Total of Laikipia

64

Samburu District

Site No.	Location	Electric Soundings	No.	Borehole Type
(Original)				
65	Wamba-1	•	1	Α
66	Wamba-2	•	1	В
67	Koiting		1	В
68	Matakwen	•	1	В
69	Ngotim	•	1	В
70	Sesia	•	1	В
71	Lous	•	1	В
72	Lolkuniyani	•	1	В
(Additiona	d)			
73	Dikir		1	В

73	Dikir	1 1	15
74	Wamba-3	1	В
	Sub-total	10	

Site No.	Location	Electric Soundings	No.	Borehole Type
(Original)				
75	Lonkewan	•	1	В
76	Amaiya	•	1	В
77	Kisima Town	•	1	В
78	Nauneri	•	1	В
79	Lmisigiyoi	•	1	В
80	Baawa	•	1	В
81	Baawa		1	C
82	Mbarigon	•	1	В
(Additions				
83	Upper-Kisima Dam		1	В
84	Logorate		1	B
85	Mbaribon school		1	В
86	Sora Adur		1	В
87	Lepetidet school	T	1	В
	Sub-total		13	

Site No.	Location	Electric Soundings	No.	Borzhole Type
(Original)			<u> </u>
88	L Partuk-1	•	1	В
89	Sirata Oirobi	•	1	B
90	Nkejemuny	•	1	В
91	Seiya	•	1	В
92	Malaso		1	В
(Addition	nal)			
93	Lpartuk-2	•	1	В
94	Maralal-1	•	1	В
95	Maralal-2	•	1	В
96	llpartuk		1	В
97	East-Loikas		1	B
	Sub-total		10	T

Total of Samburu

Table 3 Selected Borchole Sites for Hydrogeological Investigations (3/3)

Baringo District

Kipsaram	an Division			
		Fleetric		Borchole
Site No.	Location	Countines	NO.	Type

Site No.	Location	Soundings	No.	Type
(Addition:	al)			
98	Sibilo	•	1	_ <u>B</u>
99	Ngaratuko	•	1	В
100	Yatya	•	1	В
101	Barsemoi		1	В
102	Lokodowobet		1	В
	Sub-total		5	

Kolowa	TA:	vici	ΔH
IN 010 W &	17	1115	on

Site No.	Location	Location Electric No.		Well Type
(Original)				
123	Kolowa	•	1	В
124	Tilingwa	•	i	B
(Additiona)			
125	Barpelo	•	1	В
	Sub-total		3	

Tanonibei Division

Site No.	Location	Electric Soundings	No.	Borekole Type
(Original)				
103	Churo-1	•	1	A
104	Churo-2	•	1	В
105	Komol		1	В
106	Seronin	•	1	B
107	Nangarwa-1	•	1	В
108	Nangarwa-2	•	1	В
109	Nyaunyau		1	С
	Sub-total		7	

Total of Baringo

28

Koibatek District

Mukutani Division

Site No.	Location	Electric Soundings	No.	Borchok Type
(Original)			l	
	Kiserian	•	1	В
111	Narkwe	•	1	В
(Additiona	d)			
112	Mukutani	•	1	В
	Sub-total		3	

Eldama Ravine Division

Site No.	Location	Electric Soundiags	No.	Well Type
(Original)				
(Original) 126	Mumberes		1	B
127	Trongo	•	1	В
(Additional)			
128	Telmo		1	В
	Sub total		3	

Muchongoi Division

Site No.	Location	Electric Soundings	No.	Well Type
(Original)				
113	Cheruniny	•	1	В
114	Nyimbei		1	В
(Additiona	<u> </u>			
115	Kasiela	•	1	В
116	Sinoni	•	1	В
117	Kabindasim	•	1	В
118	Kamailel		1	В
	Sub-total		6	

Mogotio Division

Site No.	Location	Electric Soundings	No.	Well Type
(Original)				
129	Ararae	•	1	В
130	Emening	•	1	A
131	Legetwel		1	С
(Additiona)			. :
132	Kipsogon		1	В
133	Radat		1	В
	Sub total	1	5	

Nginyang Division

Site No.	Location	Electric Soundings	No.	Well Type
(Original)				
119	Seretian	•	1	В
120	Oro	•	1	Α
(Additiona	<u>J)</u>			
121	Katugumok	•	1	В
122	Chepilat	•	1	В
	Sub-total		4	

Total of Koibatek

R

Note:

A means borehole site to be equipped with motorized pump. B means borehole site to be equipped with hand pump. C means rehabilitation site.

means electric soundings are executed.

Table 4 Water Quality Measurements

No.	Date of	District	Water	Division	Location (Village)	Latitude	Longitude	Temp.	EC (#S/cm)	PH	remarks
M-1	measurement 31 Jul. 98	Samburu	resources River	Lorroki	Kiroriti	36.4808	0.8525	21.1	200	8.3	Antaiya R.
M-2		Samburu		Lorroki	Baawa	36.8014	0.9861	20.0	776	7.9	W-1
M-3	1 Aug. 98	Samburu	Pond	Lorroki	Baawa	36.4810	0.8528	21.0	697	8.1	
M-4	1 Aug. 98	Samburu	Exist.W	Lorroki	Kisima	36.7611	0.9444	21.5	904	9.2	W-2
M-5	3 Aug. 98	Samburu	Exist.W	Wamba	Wamba	37.3250	0.9750	26.5	866	7.3	<u>W-3</u>
M-6	3 Aug. 98	Samburu	Exist.W	Wamba	Wamba	37.3250	0.9625	28.1	3930	7.0	W-4
M-7	4 Aug. 98	Samburu	Exist.W	Kirisia	Maralal	36.7278	1.0583	22.0	1381	7.2	W-5
M-8	5 Aug. 98	Baringo	Pond	Mukutani	Narokwe	35.7583	1.2135	32.0	6140	7.8	by rain
M-9	5 Aug. 98	Baringo	River	Muketani	Mukutani	36.2417	0.6333	27.5	1680	9.0	W-6
M-10	6 Aug. 98	Baringo	River	Kolowa	Barpelo	35.9027	1.1248	32.0	180	8.6	Barpero R.
M-11	6 Aug. 98	Baringo	Exist.W	Nginyang	Kositei	36.0083	0.9833	37.7	1320	8.1	W-7
M-12	6 Aug. 98	Baringo	Exist.W	Kolowa	Kolowa	36.8083	1.1861	32,0	630	7.6	W-8
M-13	7 Aug. 98	Baringo	River	Kipsaraman	Sibilo	35.9006	0.7017	26.2	593	8.8	W-9
M-14	7 Aug. 98	Baringo	River	Nginyang	Nginyang	36.0139	0.9500	29.9	231	8.7	Ngiyang R.
M-15	8 Aug. 98	Baringo	Exist.W	Tangulubei	Tangulubei	36.3083	0.7944	31.1	999	8.0	W-10
M-16	8 Aug. 98	Baringo	Spring	Tangulubei	Churo	36.4067	0.7700	27.1	573	8.7	
M-17	9 Aug. 98	Baringo	Lake	(Lake Bari	ngo Club)	36,0250	0.6167	26.7	635	8.3	W-16
M-18	9 Aug. 98	Baringo	River	Kiserian	Logumukum	36.0861	0.0083	19.2	98	8.0	W-11
M-19	9 Aug. 98	Baringo	Spring	Muchongoi	Chebinyiay	36.2103	0.4252	34.5	577	9.1	
M-20	10 Aug. 98	Koibatek	Dug.W	Torongo	Torongo	35.6148	0.1318	16.8	3590	5.6	a bandoned
M-21	12 Aug. 98	Laikipia	Exist.W	Mukogodo	Ildigili	37.0097	0.4875	24.7	1105	5.6	W-12
M-22	13 Aug. 98	Laikipia	Exist.W	Mukogodo	Mukogodo	37.1750	0.3722	22.2	403	7.1	
M-23	13 Aug. 98	Laikipia	River	Mukogodo	Mukogodo	37.1750	0.3722	18.3	865	8.4	
M-24	13 Aug. 98	Laikipia	Spring	Lamuria	Ngogit	36.6508	-0.0658	17.7	605	7.9	
M-25	14 Aug. 98	Laikipia	Exist.W	Lamuria	Sirima	36.6500	-0.0667	20.4	676	7.6	W-13
M-26	14 Aug. 98	Laikipia	Exist.W	Lamuria	Sirima	36.7250	0.0500	22.0	867	9.1	
M-27	15 Aug. 98	Laikipia	Exist.W	Mukogodo	Ilngwesi	37.2938	0.3097	19.2	788	7.2	
M-28	15 Aug. 98	Laikipia	Exist.W	Central	Segera	37.0083	0.1542	22.2	697	7.7	W-14
M-29	16 Aug. 98	Laikipia	Exist.W	Ngarua	Kinamba	36.3250	0.4389	20.4	472	7.7	W-15

Table 5 Unsuccesful Borehole Ratio and Depth Static Water Level

					Number of Borenoics			
District	Division	Unsuccessful		Depth (Depth of Static Water Lovel (D)	,el (℧)		Total
		(Ratio)	55m≦D	45m≦D<55m	35m≦D<45m	0m≤D<35m	Unknown	
Laikipia	Mukogodo	3	0	1	,	6	1	14
,)	(21.4%)	(0.0%)	(7.1%)	(7.1%)	(64.3%)	1	(100%)
	Rumuruti	11	19	17	8	14	-	69
		(15.9%)	(27.5%)	(24.6%)	(11.6%)	(20.3%)	I	(100%)
	Ngama	4	9	2	F	4	ı	17
	3	(23.5%)	(35.3%)	(11.8%)	(5.9%)	(23.5%)	1	(100%)
	Lamuria	2	4	2	9	18	ı	32
		(6.3%)	(12.5%)	(6.3%)	(18.8%)	(56.3%)	1	(100%)
	Central	16	11	10	11	34	ı	82
,		(19.5%)	(13.4%)	(12.2%)	(13.4%)	(41.5%)	•	(100%)
Samburu	Wamba	18	, ;		0	9	1	26
		(69.2%)	(3.8%)	(3.8%)	(0.0%)	(23.1%)		(100%)
	Kinsia/Lorroki	æ	2	0	2	10		17
		(17.6%)	(11.8%)	(0.0%)	(11.8%)	(58.8%)		(100%)
Baringo		10	3	2	1	10	7	33
		(30.3%)	(9.1%)	(6.1%)	(3.0%)	(30.3%)	(21.2%)	(100%)
Koibatek		14	4	3	0	-	6	31
		(45.2%)	(12.9%)	(9.7%)	(0.0%)	(3.2%)	(29.0%)	(100%)
				<u> </u>				

Table 6 Water Sampling Points for Laboratory Tests

No.	Date of sampling	District	Division	Location (Village)	Type of water resources	rematks
W-1	1 Aug, 98	Samburu	Lortoki	Kiroriti	Existing well	Chainese team(1998)
W-2	1 Aug, 98	Samburu	Lorroki	Kisima	Existing well	Catholic mission (1992)
W-3	2 Aug, 98	Samburu	Wamba	Wamba	Existing well	C-7910(1976)
W-4	3 Aug, 98	Samburu	Wamba	Wamba	Existing well	Chainese team(1998)
W-5	4 Aug, 98	Samburu	Kirisia	Mararal	Existing well	C-9068(1989)
W-6	5 Aug, 98	Baringo	Mukutan	Mukutani	Seasonal river	Mukutani river
W-7	6 Aug, 98	Baringo	Nginyang	Kositei	Existing well	C-3470(1967)
W-8	7 Aug, 98	Baringo	Koloa	Koloa	Existing well	AIC(1997)
W-9	8 Aug, 98	Baringo	Kipsaraman	Sibilo	Dug well	
W-10	9 Aug, 98	Baringo	Tangulubei	Tangulubei	Existing well	CDN(1997)
W-11	10 Aug, 98	Koibatek	Mogotio	Mogotio	Permanent river	Molo river
W-12	11 Aug, 98	Laikipia	Mukogodo	lindigiri	Existing well	
W-13	12 Aug, 98	Laikipia	Lamuria	Sirima	Spring	
W-14	13 Aug, 98	Laikipia	Central	Segera	Existing well	
W-15	14 Aug, 98	Laikipia	Ngarua	Kinamba	Existing well	C-10621
W-16	15 Aug, 98	Baringo			Lake	Lake Baringo

Chainese team: Kenya/China technical co-op borehole drilling project

AIC: African inland church mission

CDN: Catholic diocese of Nakuru water programme

Table 7 Results of Water Quality Tests

Š	District	Division	Location	Water	Temp.	EC	粗	Color	Color Turbidity	δ, (§	HCO,	MA (1)	Mg (f/gm)	Fe (mg/l)	ж (гаал)	sN (f/gm)	<u>ে ই</u> ১ 🕞	SCT. SCT. (Nagar)	F 7 (1/2022)	NO, (1887) (0	(1/8m)	C (T/Sm)	(mg/l)
;		;- - - -	(vulage)	Veli	1	848	7.7	06%	-		188	智	110	8.0			39.8	590	1.1	55. 4.	7 8	83	Ş
-M	Samouru	Lorroki	Kisima	Well	20.1	919	9.2	8,	72	2	147	niì	0.5	72	3.7	141	13	સ્	3.5	20	292	175	겯
× ×	Sambimi	Wamba	Wamba	Well	20.0	778	7.5	×30	2	18	238	1.2	145	78	6.3	42.5	8	1380	13	2	386	8	376
***************************************	Samburu	Wanba	Wamba	Well	20.0	3760	6.9	8	17	32	144	4.1	ä	-3	10.8	370	307.5	1445	0.7	3	8	8	434
W.S	Sambiirii	Kirisia	Mararal	Well	20.1	1419	6.8	16	12	11	162	0.5	140		10.5	135	1225 1	1130	6.0	0.1	73	360	214
¥ 8	Baringo	Mukutan	Mukutani	River	20.1	1517	9.1	11	14	62	466	0.1	6.4	r,	8	96	7.5	1060	7	17	380	8	73
7.73	Ratingo	Noinvano	Kositei	Well	20.3	1032	8.1	>30		33	278	ā	23	ISI.	9.3	8	6.5	835	4.7	1.1	165	8	æ
W.R	Baringo	Koloa	Koloa	Well	20.2	525	7.4	27	S	15	161	4.0	Œ		8.7	27.5	31.8	88	7	0.7	1370	8	SS S
W.0	Baringo	Kinsaraman	Sibilo	Well	20.3	573	8.7	>30	3	15	99	7 a	14.9	0.8	14	27.5	20.5	82	27	8.0	4	8	156
W.10	1	Tangulubei	Tangulubei	Well	20.0	839	7.9	>30	1	*	191	μŢ	13.4	72	8.5	31	24.5	\$	1.4	4.0	3	8	491
W-11	<u> </u>	Mocotio	Mogotio	River	20.4	8%	7.9	4	5	128	84	0.1	5	& %	7.5	12.5	9.0	285	0.2	72	73	22.5	77
W-12	┼—	Mukogodo	Dadigiri	Well	20.0	1048	7.7	>30	73	107	194	Ęď	115	0.4	IJ	62.5	37.6	8	1.3	1.2	308.7	8	434
W-13	<u> </u>	Lamuria	Sirima	Spring	20.3	730	7.7	>30	1	171	208	'n	2	0.3	12.5	62.5	17	2	1.5	0.6	144.1	8	197
W-14	1	Central	Segera	Well	20.1	969	7.8	×30	2	33	187	ā	\$4	0.3	В	8	19.2	515	0.3	0.2	82.3	37.5	47
W-15	ļ	Ngarua	Kinamba	Well	20.2	486	8.2	>30	71	8	170	酒	8	0.1	Я	8	10.2	175	1.4	0.1	61.7	17.5	泪
W-16	↓			Lake	20.3	645	7.8	7	4	239	161	0.1	15	œ œ	સ	6.5	5.2	410	ر جو	4.18	102.9	8	73
	1	Ę	The transfer of the contract of the second o	del ai palane	************	١.																	

Temp.: Temperature of water samples in laboratory test

: Value exceeding guideline for constituents of health significance

• [5555555]

: Value exceeding guideline for permissible aesthetic quality

LAIKIPIA DISTRICT

Mukocodo Division

No.	Location Location	No.	Туре	Presence of aquifer	Water quality	Depth (m)	SWI.	Yeild (m3,h)	Evaluation	Remarks
i	Anenduguru	i	В	×					×	1
2	Lorbitosa	1	В	0	O	80	40	3.7	⊚	C-3434
3	Muranairosha	1	В	×					×	
4	Musual	1	В	×					×	l
5	Aljijo	1	В	×					×	
6	Olkinyei	1	В	×					×	
7	Ewaso - 1	1	В	0	0	80	25	1.5	0	C-1813
8	Ilpolei	1	В	0	0	90	25	1.8	0	C-371
9	Kurikuri-1	1	В	×					×	
10	Saramba	1	В	×					×	
11	llngwesi	1	В	×					×	
12	Kimanjo T.C.	i	В	0	0	110	25	4.0	©	C-3420
13	Tura	1	В	0	0	130	30	0.5	- Ø	C-2479
14	Doldol	1	С	T			I]	
	Total	14							T	

Rumuruti Division

No.	Location	No.	Туре	Presence of aquifer	Water quality	Depth (m)	SWL (m)	Yeild (m3,h)	Evaluation	Remark
15	Three Point	1	В	×					×	
16	Gatundia	i	В	×					×	
17	Machuguru	1	В	×					×	
18	Mifugo	1	В	0	0	120	40	4.0	0	C-1921
19	Kite	1	В	0	0	130	40	3.0	0	C-1899
20	Salama	1	В	0	0	130	45	0.5	0	C-1381
21	Muruku	1	В	0	0	120	40	3.0	O	C-42
22	Mutara	1	В	0	0	180	45	3.0	0	C-1143
	Sub total	8			1		1			

Nearua Division

Nα	Location	No.	Туре	Presence of aquifer	Water quality	Depth (m)	SWL (m)	Yeild (m3/h)	Evaluation	Remarks
23	Kamigi	1	В	0	0	110	70	8.0	Δ	C-1977
24	Kiambogo-1	1	В	0	0	130	45	0.5	0	C-3916
25	Eighteen Rubere	1	В	0	0	110	20	5.0	0	C-10621
26	Ol Ngarua Sec.	1	В	0	0	100	40	0.5	0	C-3916
27	Mithiga-1	1	В	0	×				×	
28	Mithiga-2	1	В	0	0	110	70	8.0	Δ	C-1977
29	Kinamba T.C	1	В	0	0	110	20	5.0	0	C-10621
30	Naigera	1	В	0	0	160	50	2.5	•	C-913
31	Cheleta	i	B	0	O	150	50	2.5	•	C-37
32	Kiambogo-2	1	В	0	0	130	50	0.5	•	
33	Mwenje	1	В	0	0	110	20	5.0	©	
34	Kagaa	1	В	×	I				×	
	Sub total	12								

Note: Type

Aquifer type

Presence of Aquifer

Water quality Evaluation

A: Motorized pump, B: Hand pump, C: Rihabilitation

A: Sedimentary deposit, B: Volcanics, C: Basement rocks

O: recognized x: not recognized

O: permissible (F < 3.0 mg/l), \times not suitable (F > 3.0 mg/l) \odot : Hand pump (Afridef), \odot : hand pump (Indian Mark II),

Table 8 Evaluation of Sites from Hydrogeological Viewpoints (2/5)

LAIKIPIA DISTRICT

Lamuria Division

No.	Location Location	No.	Туре	Presence of squifer	Water quality	Depth (m)	SWL (m)	Yeild (m3/h)	Evaluation	Remarks
35	Kijabe	1	B	0	0	100	30	5.0	0	C-1984
36	Segera	1	В	0	0	80	20	2.0	0	,
37	Njoguini	1	В	×					×	
38	Matanya	1	В	0	0	150	60	3.8	Δ	C-1563
39	Lamuria	1	A	0	0	130	40	2.5	0	C-593
40	Waniura	1	В	0	0	180	50	3.5	Δ	C-932
41	Imenti-1	1	В	0	0	80	40	6.0	0	C-2023
42	Imenti-2	1	В	0	0	100	45	6.0	0	
43	Withare	1	В	0	0	120	40	3.0	0	C-1984
44	Tigithi-1	1	В	0	0	150	60	3.8	Δ	C-1563
45	Tigithi-2	1	В	0	0	150	60	4.6	Δ	C-1015
46	Sweet Waters	1	В	0	0	130	60	3,8	Δ	C-1563
47	Tharua Waichekeheri	1	В	0	0	120	50	2.0	•	C-1015
48	Lamuria T.C.	1	В	0	0	120	50	2.0	•	C-1015
49	Thome Kiburuti	1	B	0	0	150	50	2.5	•	C-1562
50	Thome T.C.	1	В	0	0	150	50	2.5	•	C-1562
51	Ngobit T.C.	1	В	0	0	80	40	2.0	•	
52	Imenti-3	1	В	0	0	120	30	3.0	©	C-1791
53	Withare	1	В	0	0	80	20	2.0	0	
54	Kihata	1	В	0	0	150	50	2.5	•	C-1562
	Sub total	20								

Central Division

No.	Location	No.	Туре	Presence of aquifer	Water quality	Depth (m)	SWL (m)	Yeild (m3/h)	Evaluation	Remarks
55	East Laikipia	1	В	0	• 0	100	30	3.0	0	C-233
56	Rugutu-1	1	В	0	0	100	40	1.3	0	C-2803
57	Ngenia	1	В	0	0	80	50	5.0	•	C-1679
58	Muireri	1	В	0	0	100	55	6.0	•	C-1679
59	Muramati	1 1	В	0	0	100	55	6.0	•	C-1679
60	Naibor	1	В	0	0	120	50	1.0	•	C-2375
61	Nturukuma	i	В	0	0	100	45	6.0	0	C-694
62	Rugutu-2	1	В	0	0	130	60	1.7	Δ	
63	Endana	1	В	0	0	150	60	4.5	Δ	
64	Mukima	1	В	0	0	100	45	6.0	O	
	Sub total	10	T						T****	

Note: Type Aquifer type Presence of Aquifer

Water quality Evaluation A: Motorized pump, B: Hand pump, C: Rihabilitation

A: Sedimentary deposit, B: Volcanics, C: Basement rocks

O: recognized x: not recognized

O: permissible (F < 3.0 mg/l), \times not suitable (F > 3.0 mg/l) \odot : Hand pump (Afridef), \odot : hand pump (Indian Mark II),

 Table 8
 Evaluation of Sites from Hydrogeological Viewpoints (3/5)

SAMBURU DISTRICT

Wamba Division

No.	Location	No.	Туре	Presence of aquifer	Water quality	Depth (m)	SWL (m)	Yeild (m3/h)	Evaluation	Remarks
65	Wamba-1	1	Λ	0	0	50	15	1.5	Δ	C-3827
66	Wamba-2	1	В	0	0	120	30	5.0	0	Chinese team
67	Koiting	1	В	×					×	
68	Matakwen	1	В	×					×	
69	Ngotim	1	В	×			I		×	
70	Sesia	ī	В	×					×	
71	Lpus	1	В	×					×	
72	Lolkuniyani	1	B	0	0	100	40	1.0	0	
73	Dirkir	1	В	×					×	
74	Wamba-3	1	В	0	0	120	30	5.0	0	
	Sub total	10]					[

Lorrold division

No.	Location	No.	Турс	Presence of aquifer	Water quality	Depth (m)	SWL (m)	Yeild (m3/h)	Evaluation	Remarks
75	Lonkewan	1	8	×					×	
76	Amaiya	1	В	0	0	100	40	2.0	0	
77	Kisima Town	1	В	0	0	100	30	1.0	0	C-1806
78	Nauneri	1	В	0	0	100	30	1.0	0	C-1806
79	l_misigiyoi	1	В	0	0	100	40	2.0	0	C-8990
80	Baawa	i	В	0	О	120	40	2.0	0	
81	Baawa	1	C							
82	Mbarigon	1	В	×					×	
83	Upper-Kisima Dam	1	В	×			l		×	
84	Logorate	1	В	×		· · · ·			×	
85	Mbaribon school	1	В	O	0	120	40	3.0	0	C-9753
86	Sora Adur	1	В	×	T		T		×	
87	Lepetidet school	1	В	0	0	100	30	1.0	0	C-1806
	Total	13	•					}		

Kirisia Division

No.	Location	No.	Туре	Presence of aquifer	Water quality	Depth (印)	SWL (m)	Yeild (m3/h)	Evaluation	Remarks
88	L Partuk-1	1	В	×					×	
89	Sirata Oirobi	1	В	0	0	130	40	2.5	0	C-3833
90	Nkejemuny	1	В	0	O	130	40	2.5	0	C-3834
91	Seiya	1	В	×			1		×	
92	Malaso	1	В	×					×	
93	Lpartuk-2	1	B	0	Ô	130	50	1.0	•	
94	Maralal-1	1	В	0	0	110	30	1.5	©	
95	Maralarl-2	1	В	×					×	
96	Lipartuk	1	В	×					×	
97	East-Loikas	1	В	×					×	
	Sub total	10								

Note: Type

A: Motorized pump, B: Hand pump, C: Rihabilitation

Aquifer type

A: Sedimentary deposit, B: Volcanics, C: Basement rocks

Presence of Aquifer

O: recognized x: not recognized

Water quality Evaluation O: permissible (F < 3.0 mg/l), \times not suitable (F > 3.0 mg/l) \odot : Hand pump (Afridef), \odot : hand pump (Indian Mark II),

Table 8 Evaluation of Sites from Hydrogeological Viewpoints (4/5)

Baringo District

Kipsalaman Division

No.	Location	No.	Туре	Presence of equifer	Water quality	Depth (m)	SWL (m)	Yeild (m3/h)	Evaluation	Remarks
98	Sibilo	1	В	0	0	50	20	1.5	0	
98 99	Ngaratuko	1	В	O	×				×	
100	Yatya	1	В	0	×				×	
101	Barsemoi	í	В	0	×				×	
	Sub total	4								

Tangulbei Division

No.	Location	No.	Туре	Presence of aquifer	Water quality	Depth (m)	SWL (m)	Yeild (m3/h)	Evaluation	Remarks
102	Churo-1	1	A	0	0	110	40	5.0	Δ	
	Churo-2	- i	В	0	0	130	15	5.0	6	
104	Komol	1	В	×				Ţ	×	
105	Seronin	1	B	×					×	
106	Nangarwa-1	1	В	0	0	130	45	2.5	©	
	Nangarwa-2	1	В	0	0	130	45	2.5	0	
	Nyaunyau	1	С							
	Sub total	7								

Mukutan Division

No.	Location	No.	Туре	Presence of aquifer	Water quality	Depth (m)	SWL (m)	Yeild (m3/h)	Evaluation	Remarks
109	Kiserian	1	В	0	0	80	20	1.0	0	C-6365
110	Narkwe	1	В	0	0	100	30	1.0	0	C-6362
111	Mututani	1	В	0	×				×	
112	Lokodowobet	1	В	0	0	80	20	1.0	0	
	Sub total	4		<u> </u>					- 	

Muchogoi Division

	MINEROPOR DIVERSION	•								·
No.	Location	Na	Туре	Presence of aquifer	Water	Depth (m)	SWL (m)	Yeild (m3/b)	Evaluation	Remarks
113	Cheruniny	1	В	0	0	50	20	1.5	0	
114	Nyimbei	1	В	0	.0	100	20	2.0	0	
115	Kasiela	1	В	0	0	110	30	2.0	0	
116	Sinoni	i	В	0	0	100	30	2.0	0	
117	Kabindasim	1	В	0	0	- 110	30	2.5	•	
118	Kamailel	1	В	0	0	110	30	2.5	0	
	Sub total	6	1							

Nginyang Division

No.	Location	No.	Туре	Presence of aquifer	Water quality	Depth (m)	SWL (m)	Yeild (m3/h)	Evaluation	Remarks
119	Seretian	1	В	×					×	
120	Oro	1	В	0	×				×	
121	Katugumok	1	В	0	×				×	
	Chepilat	1	В	0	0	110	40	2.0	0	C-6364
	Sub total	4		1			T		T	

Kolowa Division

No.	Location	No.	Туре	Presence of aquifer	Water quality	Depth (m)	SWL (m)	Yeld (क3/b)	Evaluation	Remarks
123	Kolowa	1	В	0	0	60	15	1.5	0	
124	Tilingwa	1	В	×					×	
125	Barpelo	1	В	0	0	100	20	2.0	•	
	Sub total	3	T	1						

Note: Type

Aquifer type
Presence of Aquifer
Weter applies

Water quqlity Evaluation A: Motorized pump, B: Hand pump, C: Rihabilitation

A: Sedimentary deposit, B: Volcanics, C: Basement rocks

O: recognized x: not recognized

O: permissible (F < 3.0 mg/l), \times not suitable (F > 3.0 mg/l) \odot : Hand pump (Afridef), \odot : hand pump (Indian Mark II),

Table 8 Evaluation of Sites from Hydrogeological Viewpoints (5/5)

KOIBATEK DISTRICT

Eldama Ravine Division

	FURNISHED FART LINE TALL TOTAL	4								
No.	Location	No.	Туре	Presence of aquifer	Water quality	Depth (m)	SWL (m)	Yeild (m3,h)	Evaluation	Remarks
126	Mumberes	1	В	0	0	120	50	1.0	•	
127	Trongo	1	В	0	0	200	40	3.0	0	
128	Tolmo	1	В	×					×	
	Sub total	3								

No.	Location	No.	Турс	Presence of aquifer	Water quality	Depth (m)	SW1. (m)	Yeild (m3/h)	Evaluation	Remarks
129	Ararae	1	В	0	0	120	50	4.0	•	C-285
130	Emening	1	A	0	0	150	73	8.0	Δ	C-616
131	Kipsogon	1	В	0	×			·	×	
132	Radal	1	В	O	×				×	
133	Legetwet	1	С							I
	Sub total	5								

Note: Type

Aquifer type

Presence of Aquifer Water quality

Evaluation

A: Motorized pump, B: Hand pump, C: Rihabilitation

A: Sedimentary deposit, B: Volcanics, C: Basement rocks
O: recognized ×: not recognized
O: permissible (F < 3.0 mg/l), × not suitable (F > 3.0 mg/l)

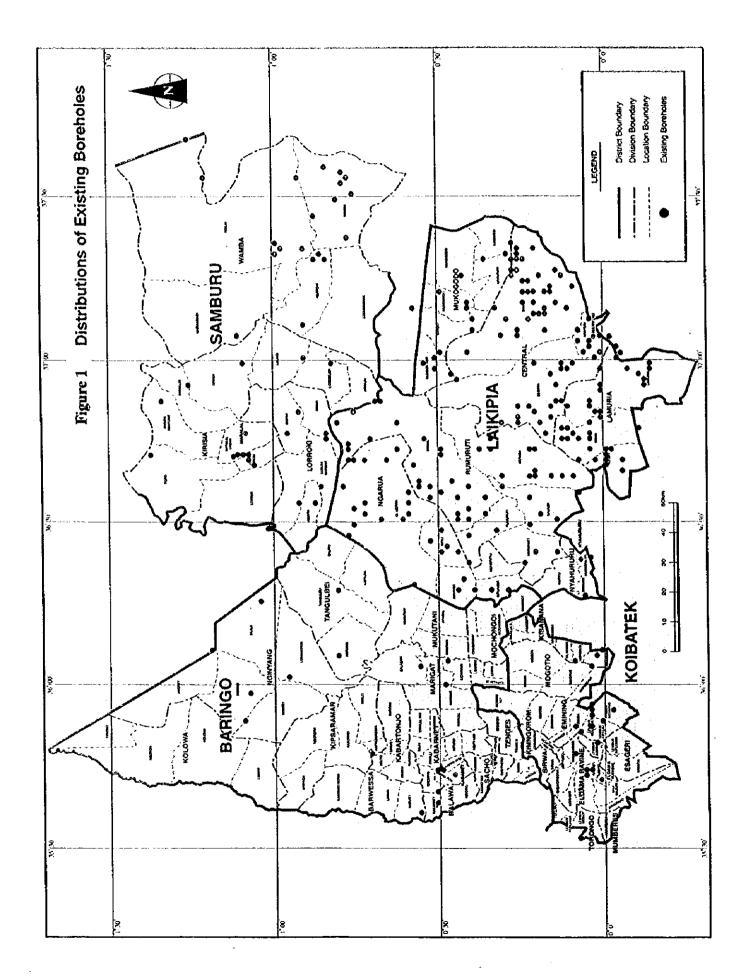
O: Hand pump (Afridef), •: hand pump (Indian Mark II),

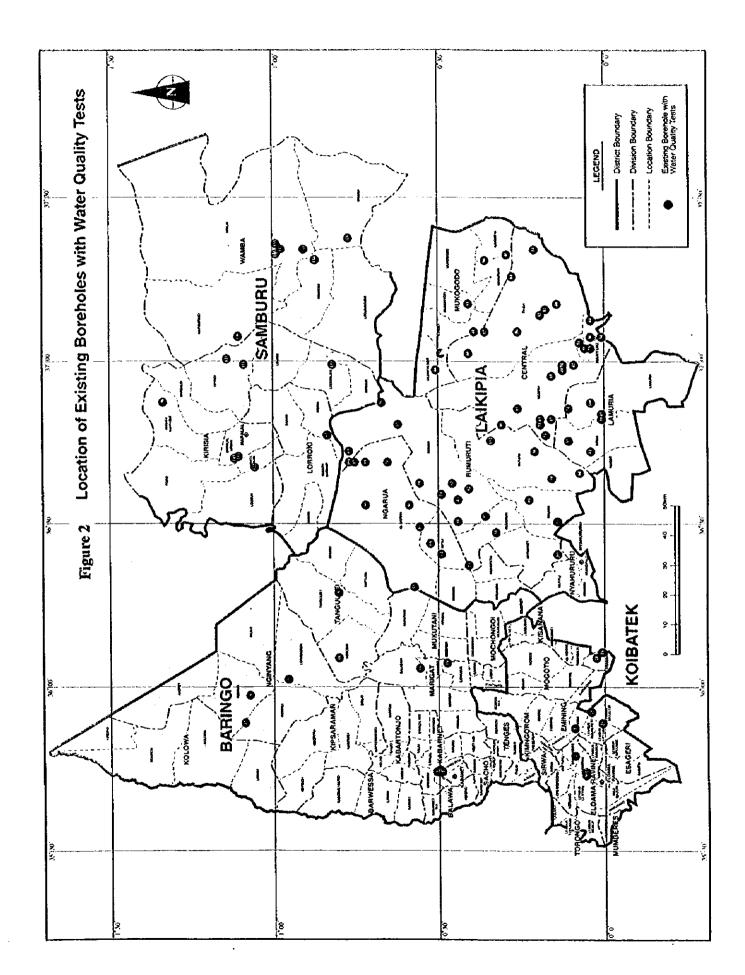
Table 10 Number of Proposed Borcholes by Site

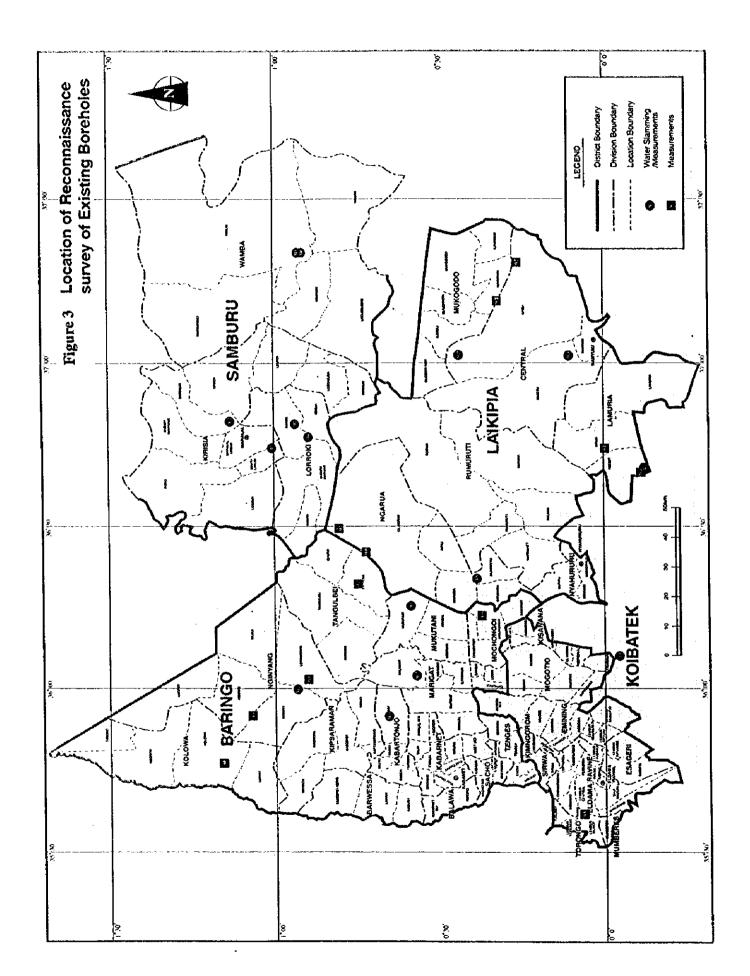
Name of Site	District	Division	Location	Sub-Location	Depth	GWL	Yeld	Type	No. of			Q	Sapply	Unit (m.7.6)	
	<u> </u>				(m)	(m)	(ar 3 p)		Ma.	AM To	otu -	(w3.p)	(m)(d)	(m3/d)	(p=154
2 Lobbosa	i aldę iz	Mckngodo	Oloborsoli	Fn 350	100	40	2.0	(IP-)	1	1	2	0.675	10.800	0.015	:
7 Fx250-1	i aikipia	Mikogodo	Irdişêrî	ipolei	80	25	1.5	1(P-)	1	1	2	0.675	10.800	0.015	
8 Ilpolei	laikiyla	Mukozodo	Irdigiri Taliana	ipolel Turn	100 110	25 25	1.8 4.0	{{P·1 }{P·1	1 1	1 1	2 2	0.675 0.675	10.800 10.800	0.015 0.015	
12 Kimanjo 13 Tur•	Laikipia Laikipia	Mukogodo Mukogodo	hdigirl Oloborsoli	Tura Ewaso	140	30	0.5	HP-1	1		i	8.500	4.000	0.015	
la Mifugo	lakipia	Rannanti	Socian	Socian	130	40	4.0	11P 1	ì		i	0.675	5.400	0.015	
19 Kae	Laikipia	Resoureti	Mannanet	Siron	130	40	3.0	HP-1	1	1	2	0.675	10 800	0.015	
30 Salama	Laikipia	Romareti	Salama	Salama	130	45	0.5	HP-1	1		ı	0.500	4.000	0.015	
21 Muruku	Lakipia	Rumuruti	Salama	Muruku	120	40	3.0	HP-1	1	1	2	0.675	10.800	0.015	
22 Militara	Laikipia	Rumusuti	Murara	Mutara	189	45	3.0	HP-1	1	1	2	0.675	10.800	0.015	
24 Kumbogo-i	Laikipia	Ngania	Ghuanba	Thigo	130	45	0.5	KP-1	1	_	l	0.500	4.000	0.015	
25 Eliphicea Rubere	Laikipia	Ngarua	Kinamba	Mutiga	110	20 40	5.0	HP-1	1	1	2	0.675	10.800	0.015	
26 Ol Ngania Sec.	Laikipia Laikipia	Ngarua	Giuanba Kinamba	Thigo Mwenje	100 110	20	0.5 5.0	HP-1 HP-1	1 1	1	1 2	0.500 0.675	4,000 10,800	0.015	
29 Kinamba T.C. 10 Nalgera	Laikipia Laikipia	Ngarua Ngarua	Muhotetu	Muhotetu	160	50	2.5	HP-2	i	•	ī	0.675	5.400	0.015	
) Cheleta	Lakipia	Ngarua	Muhotetu	Muhoteta	150	50	2.5	HP-2	ì		i	0.675	5.400	0.015	
2 Kambogo-1	Lakipia	Ngarua	Giuanba	Thigo	130	50	0.5	HP-2	ì		1	0.500	4.000	0.015	
U Mwenje	Laŭkipia	Ngarua	Kinamba	Mwenje	110	20	5.0	HP-1	1	1	2	0.675	10.800	0.015	
5 Kijabe	Laškipia	Lamuria	Sima	Muhonia	100	30	5.0	HP-1	ŀ		1	0.675	5.400	0.015	
6 Segesa	Lakiph	Eamin's	Ngobit	Wiyumiterie	80	20	2.0	HP-1	ì	1	2	0.675	10.800	0.015	
7 Njoguni	Lakipia	Lamuria	Sirma	Muhoniz	150	50	3.0	HP-2	0		0	0.675	0.000	0.015	
0 Wamura	Laikiçia	Lamuria	Ngoot	Wiyumirene	180	50	3.5	HP-2)		1	0.675	5,400	0.015	
i kacati	Lakipia	Lamuria	Ngobit	Wiyumberie	80	40	6.0	HP-1	1	1	2	0.675	10.800	0.015	
2 hnenti 2	Laikipia Laikipia	Laonuria	Ngobit	Wryumirerie Muhonia	100 120	45 40	6.0 3.0	HP-1 HP-1	1		2	0.675 0.675	10.800 0.000	0.015 0.015	
3 Withare 5 Tighi 2	Lakipla Lakipla	Lamuria Lamuria	Sinna Lamuria	Matanya	150	55	4.6	HP-2	3		1	0.675	5.400	0.015	
6 Sweet Waters	Lakipia	Lamoria	Lamuria	Matanya	130	55	3.5	KP-2	1		1	0.675	5.400	0.015	
7 Tharua Wakheke	Lakipa	Languria	Lamuria	Lamuria	120	50	2.0	HP-2	ī		1	0.675	5,400	0.015	
8 Lamuria T.C.	Lakipa	Lameria	Lamuria	Lamuria	140	50	2.0	RP-2	1		1	0.675	5.400	0.015	
9 Thome Kiburu	lakipia	Lamuria	[amuria	Matanya	150	50	2.5	HP-2	1		1	0.675	5.400	0.015	
1 Ngobit T.C.	Lakipia	Lamuria	Sirona	Muhonia	80	40	20	HP-1	0		0	0.675	0.000	0.015	
2 knenti 3	Lakipia	Larguria	Simz	Muhonia	120	30	3.0	HP-1	0		0	0.675	0.000	0.015	
53 Withare	Lakipia	l amuria	Sima	Muhonia	80	20	2.0	HP-1	0		0	0.675	0.000	0.015	
54 Kihata	Laikiyia	Lamuria	Lamuria	Matanya	120	45	25	HP-1	1		1	0.675	5.400	0.015	
55 East Laikšpia	Laikipia	Central	Daiga	Ethi Program	100 190	30 40	3.0 1.3	KP-1 KP-1	1 1	1	2	0.675 0.675	19.500 19.500	0.015	
56 Rugutu-1 52 Novemb	(akipia (akipia	Central Central	Segra Dalga	Rugusu Ehi	80	50	5.0	HP-2	i	1	2	0.675	10.800	0.015	
57 Ngrala 58 Muliteri	Laikipia	Central Central	Daiga	Umanbe	100	55	6.0	HP-2	i	•	1	0.675	5.400	0.015	
59 Muramati	Lakipia	Central	Daiga	Umanbe	100	55	6.0	HP-2			1	0.675	5.400	0.015	
50 Naibor	Laikipia	Central	Segra	Nalbor	120	50	1.0	HP-2		1	2	0.675	10.800	0.015	
1 Narukuma	Laikipia	Central	Nanyuki	1.36	100	45	6.0	HP-1	0		0	0.675	0.000	0.015	
S& Mukima	Laikipia	Central	Daiya	Umanbe	100	45	6.0	HP-1	1	1	2	0.675	10.800	0.015	
% Wamba 2	Samburu	Wamba	Wamba	Wamba	120	30		HP-1	0		9	0.675	0.000	0.015	
72 Lolkuniyani	Samburu	Wamba	Ngali	Liksin	100	40		HP-1	0		0	0.675	0.000	0.015	
73 Dakir	Samburu	Wamba	Ngaroni	Ngaroni	60	30		HP-1	0		0	0.675	0.000	0.015	
14 Wazaba-3	Samburu	Wamea	Wamba	Wamba	120	30 40		HP-1 HP-1	0 1		0	0.675 0.675	0.000 5.400	0.015	
76 Amalya 21 Minhan Tanan	Samburi	Logoki Logoki	Amiya Kisima	Amziya Logicatoria	100 100	30		HP-1		ì	2	0.675	10.800	0.015	
77 Kishna Town 78 Nameri	Samburu Samburu	Lonoki	Baawa	Nauneri	100	30		HP-1	1	•	1	0.675	5.400	0.015	
79 Lmsîgiyoî	Samburu	Lorroki	Kisima	Linsigiyoi	100	40		HP-1	i	1	2	0.675	10.800	0.015	
SO Baawa	Sambuni	Lorroki	Baawa	Baawa	120	40		HP-1	1		1	0.675	5.400	0.015	
S Mbarigon School	Samburu	Lorroki	Kisima	Mbarigon	130	40	3,0	HP-1	1	1	2	0.675	10.800	0.015	
87 Lepetidel School	Samburu	Logoki	Baawa	Lichoriti	100	30		HP-1	1	1	2	0.675	10.800	0.015	
89 Sirata Oirobi	Samburu	Krisia	Sirata Oirobî	Sirata Oirobi	130	40		HP-1	0		0	0.675	0.000	0.015	
90 Nkjejemuny	Samburu	Kirista	Sirata Oirobi	Nicjejemomy	130	40		HP-1	0		0	0.675	0.000	0.015	
94 Maralal I	Samburu	Krsia	Maralal	Milmani	110			MP-1]	1	2	0.675	30.800	0.015 0.015	
96 Lpartuk-3	Samburu	Krisia	Maralal	Epartuk	130			HP-2		1	2	0.675 0.675	5,400 19,800	0.015	
98 Sibilio	Baringo	Kipsalaman	Shio	Sièile Bartziew	50 50			HP-1		i	2	0.675	10.800	0.015	
01 Barsemol 03 Churo-2	Baringo Baringo	Kipsalaman Tangalbei	Kaboskel Charo	Charo	130			HP-1		i	2	0.675	10.800	0.015	
06 Nangarwa-1	Baringo Baringo	Tanguloci	Tangulbei	Tanguibei	130			HP-1		•	ī	0.675	5,400	0.015	
07 Nangarwa-2	Baringo	Tangulbei	Kapraya	Kaptaya	130			HP-1		1	2	0.675	10.800	0.015	
12 Lodowobbet	Baringo	Mukatani	Kiserian	Kiserian	80			HP-1		1	2	0.675	10.800	0.015	
13 Chebininy	Barango	Mochongoi	Chebininy	Kasiela	50			HP-1			1	0.675	5,400	0.015	
14 Nyimbei	Baringo	Mochongoi	Mochongoi	Mochongoi	100			HP-1			1	0.675	5.400	0.015	
15 Kasicia	Baringo	Mochocgol	Araba!	Arabal	110			HP-1		1	2	0.675	10.800	0.015	
16 Sinoni	Barmao	Mochongol	Mochongoi	Kapkechir	100			HP-1			1	0.575	5,400	0.015	
17 Kabindasim	Baringo	Mochongol	Arabal	Arabal	50			HP-1		1	2	0.675	10,800	0.015 0.015	
25 Barpelo	Baringo	Kolowa	Koicwa	Barpelo Momberes	100			HP-1 HP-2		1	2	0.675 0.675	19.800 5.400	0.015	
26 Muniberes	Kobatek Kobatek	Ministeres Mogotio	Mumberes Simot	Mumberes Mugurin	130 120						,	0.675	5.400	0.015	
29 Ararae															

注) Type of Handpump HP-1 HP-2

: equipped with Afridev Handpump (SWL<45m) : equipped with India Mark II Handpump (SWL>45m)







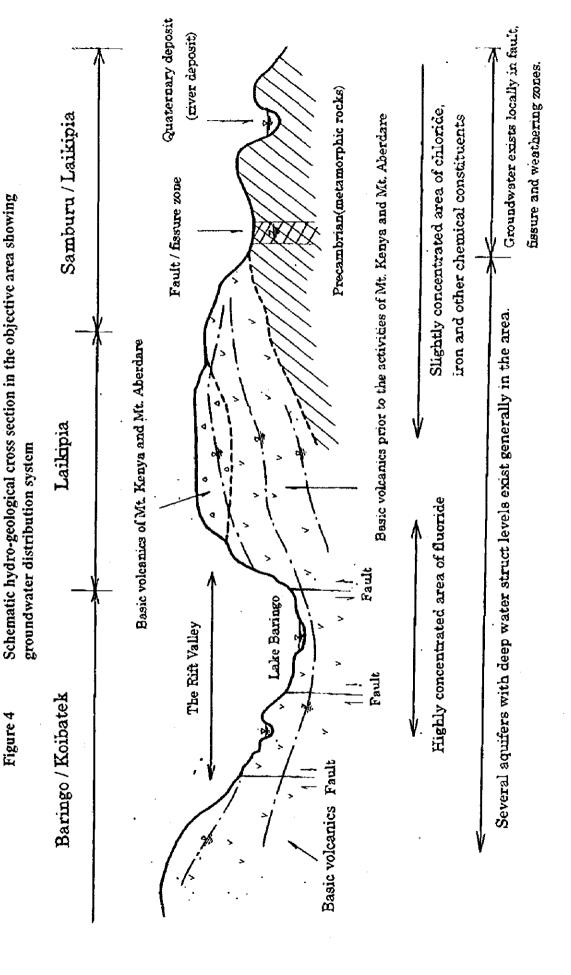
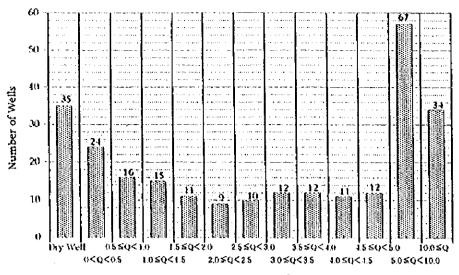
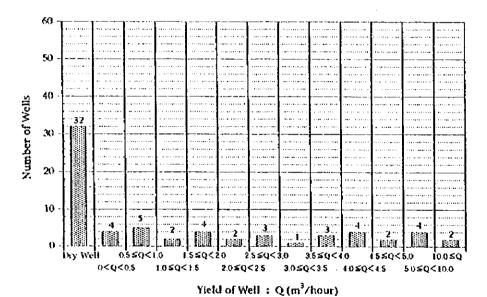


Figure 5 Yield of Existing Brothels

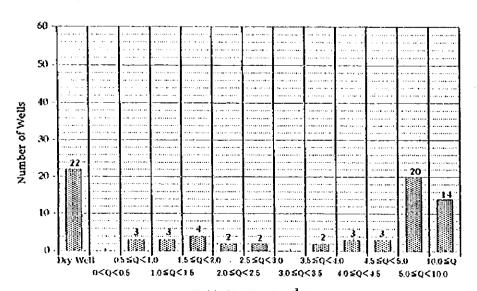


Yield of Well: Q (m3/hour)

Lalkipia District



Samburu District



Yield of Welt: Q(m³/hour)
Baringo/Kolbatek District

. Figure 6 Contour Map of Static Water Level of Groundwater in Laikipla District

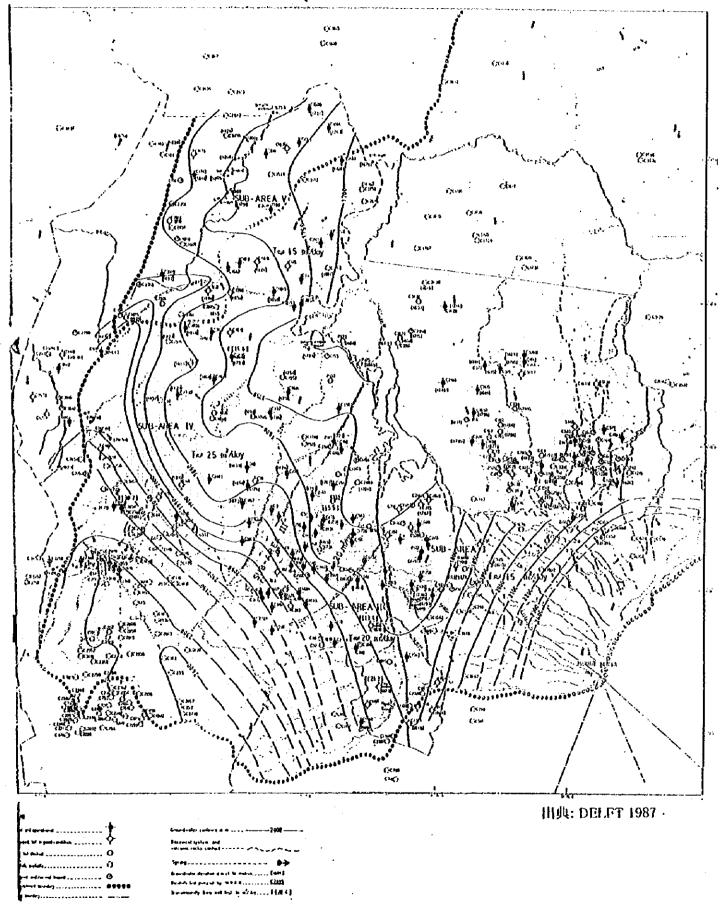


Figure 7 Relationship between Fluorine Content and Electric Conductivity

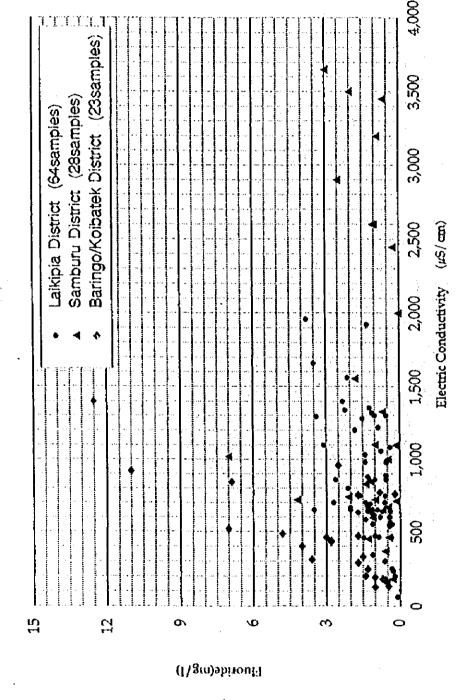
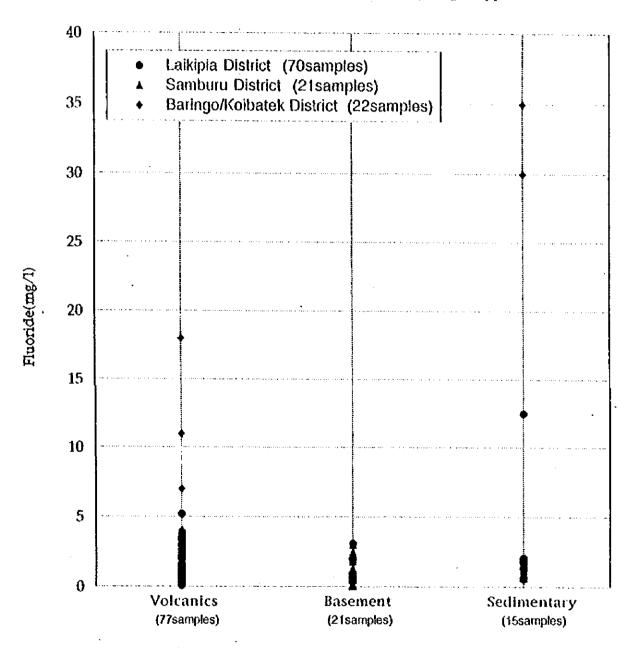
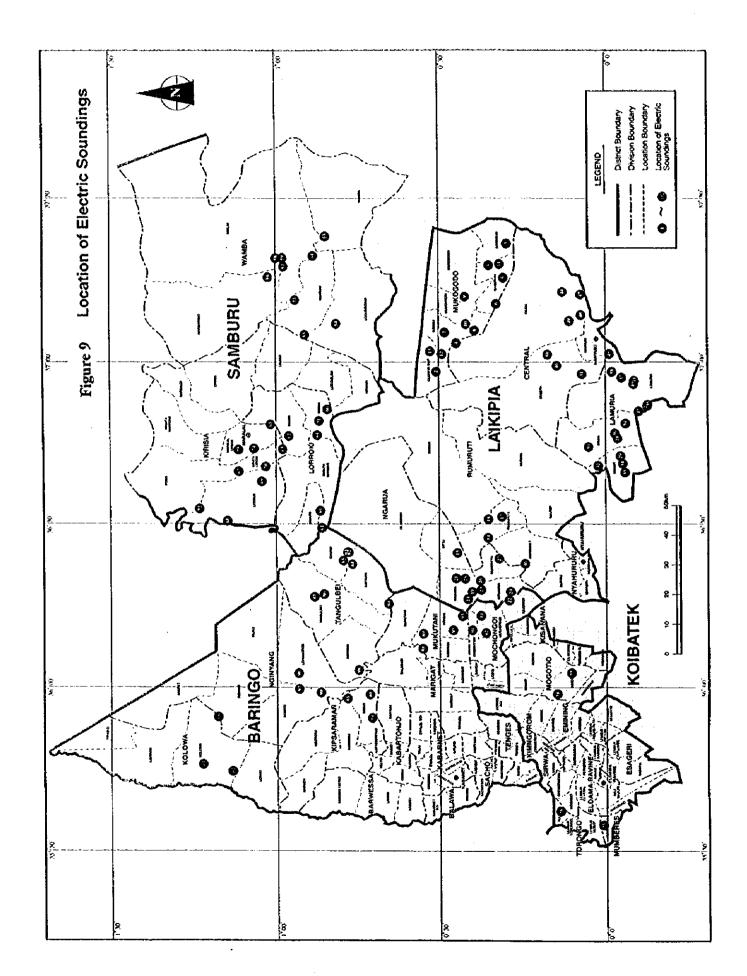
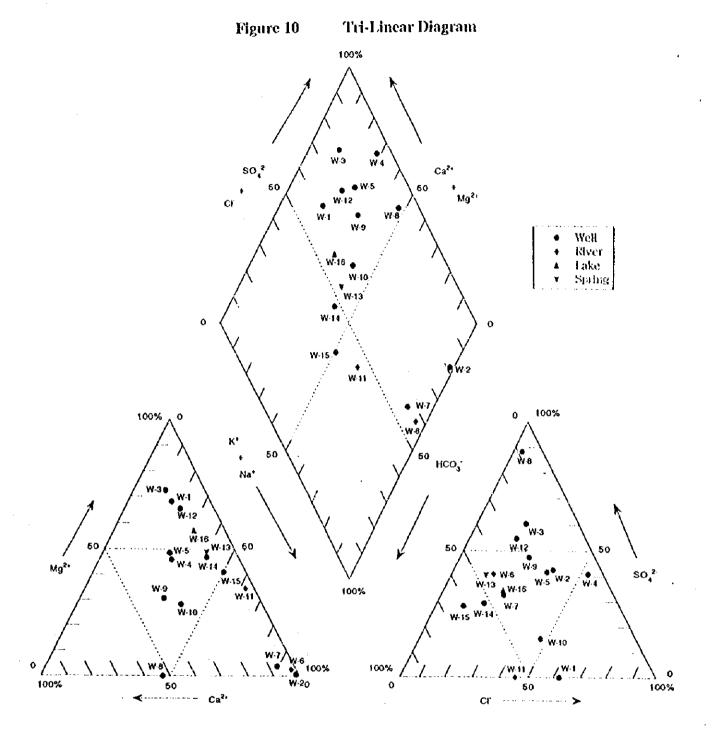


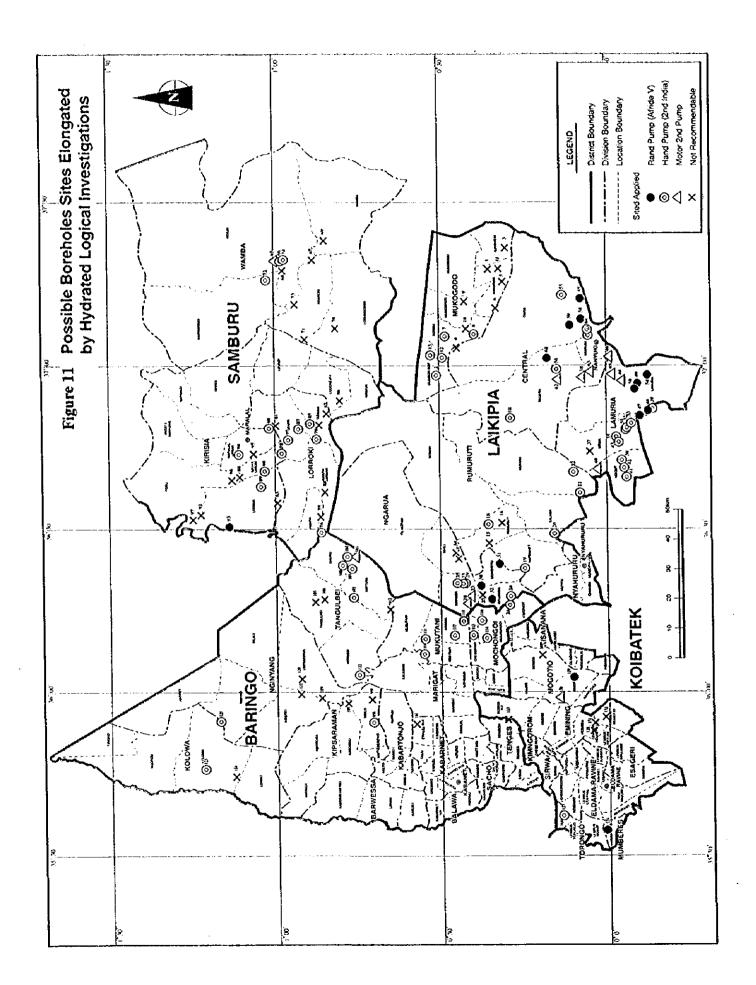
Figure 8 Fluorine Content by Anger Type

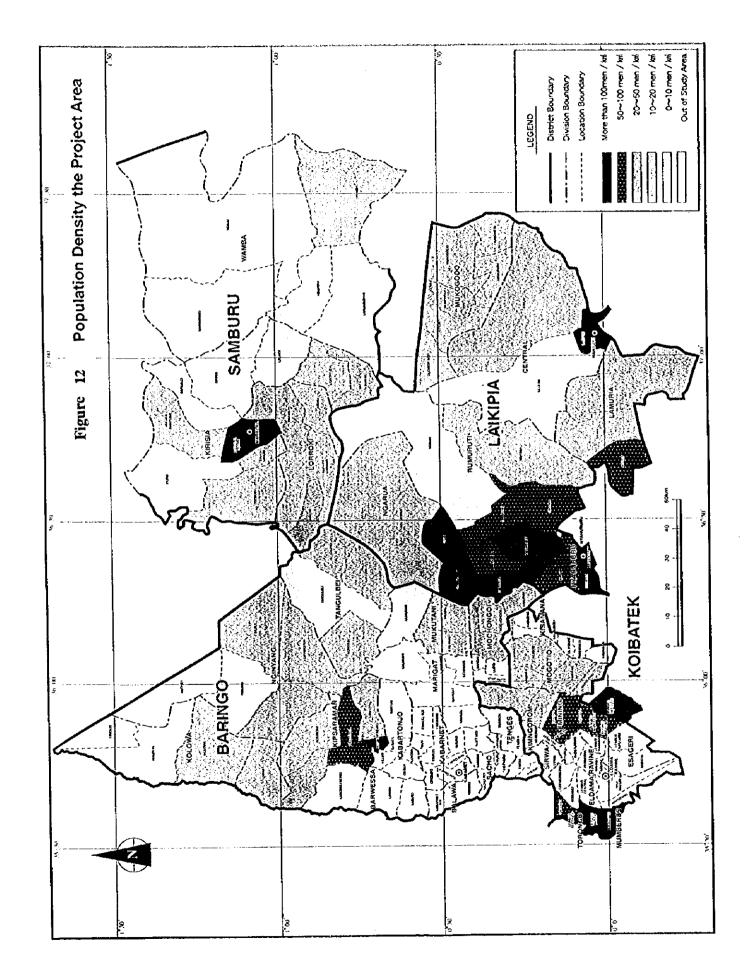


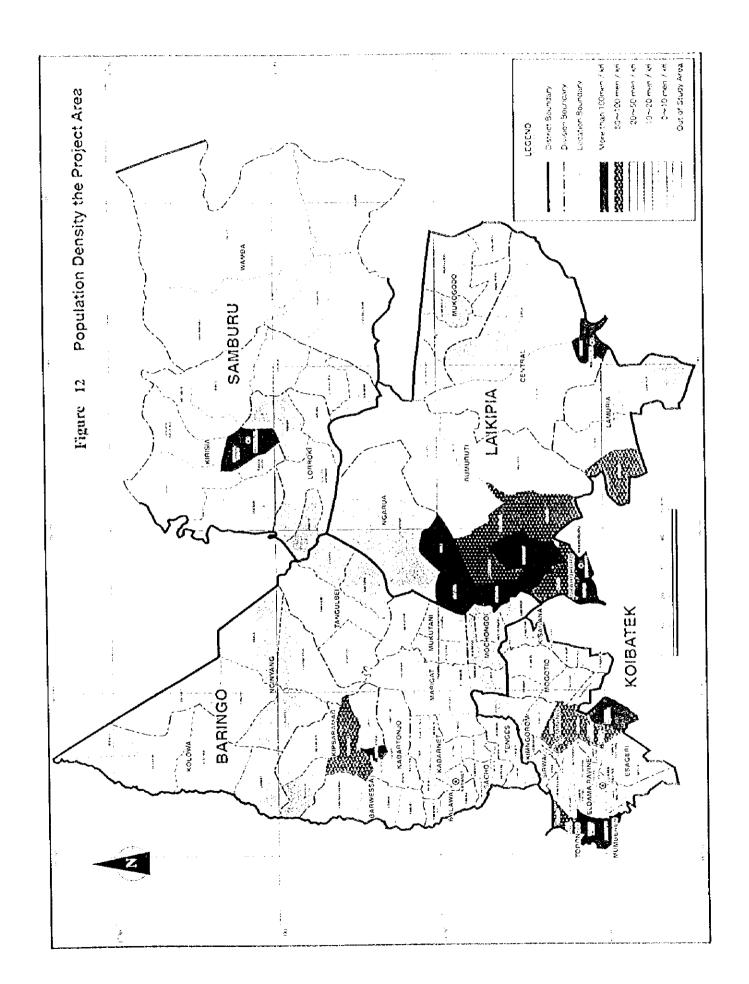
Type of aquifer

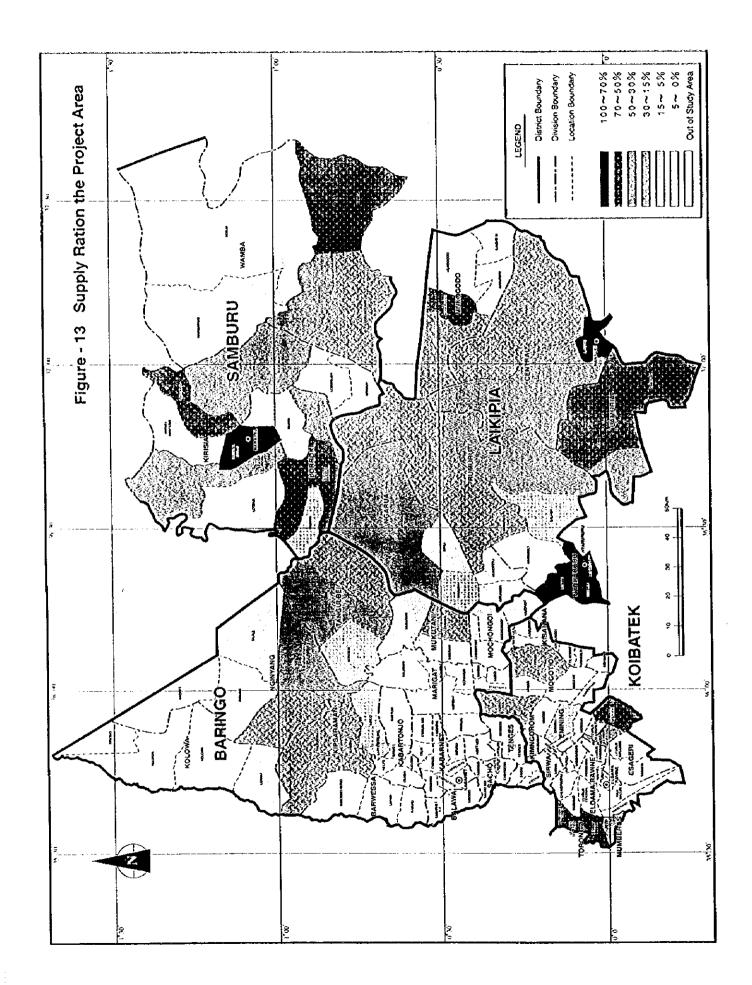


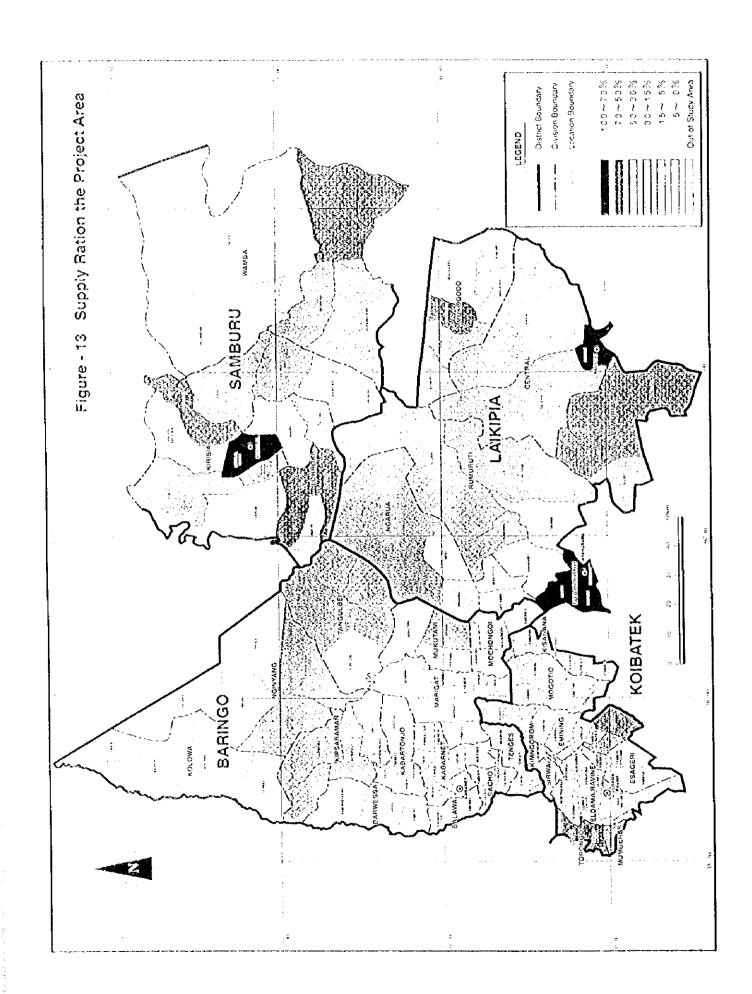


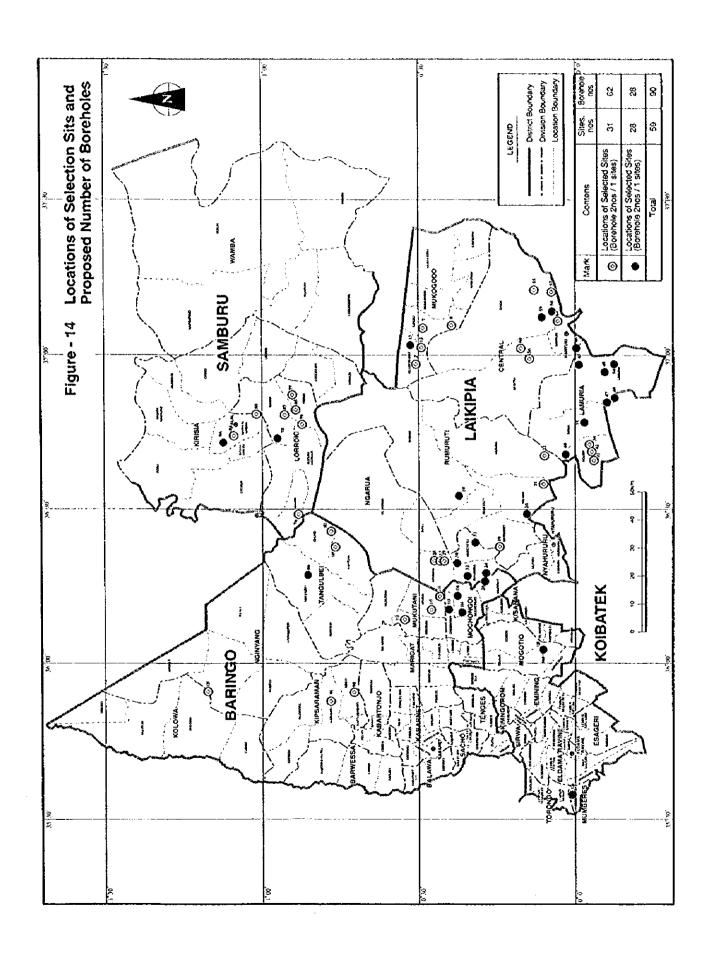












ATTACHMENT- 2

Study on Motorized Pump

Study on Motorized Pump

1. Outline of Motorized Pump

(1) Present Conditions

In the Project Area, electricity is not provided except in urban areas. Existing motorized pumps for boreholes are generally operated with a diesel engine and generator. At present, a submergible pump in combination with a diesel engine and generator is popular equipment installed at boreholes in the Project Area.

Other than the submergible pump, motorized pump operated by connecting its drive shaft with a V-belt to a diesel engine is also found in the Project Area. But such pumps are already old and many of them are out of order. This type of pump is suitable for the maximum pumping head of 30 m only.

A solar powered pump is also an alternative but not popular in the Project Area due to its quite high price.

(2) Procurement Conditions

Motorized pumps are imported. Major suppliers have their branches in the major local cities and service shops near the respective branches. Spare parts and services are supplied through this suppliers network.

2. Conditions for Introduction of Motorized Pump

For introduction of a motorized pump, operation and maintenance aspects in rural areas should be carefully examined. There are problems with operating and maintaining motorized pumps in rural areas in Kenya. GOK, who provides motorized pumps to rural communities, can not look after operation and maintenance due to financial constraints. In many case motorized pumps are handed over to water communities which do not have sufficient technical knowledge or financial sources to operate and maintain them properly.

When water communities are in charge of operation and maintenance of motorized pumps, they need to have technical and mechanical knowledge of operation and maintenance. They also need to have financial resources for fuel, spare parts, salaries for operators and technicians, etc., which are mainly dependent on water charge collection from beneficiaries.

There is an example of successful introduction of a motorized pump in the Project Area. The following factors for successful operation and maintenance were revealed through interview to the existing water committee established in the community.

- Beneficiaries are many.
- Leaders of water committee have sufficient capability for management.
- Water charge collection is properly done in the community.
- Water communities has other income sources beside water tariffs and deposits such incomes to its bank account to cover operation and maintenance costs and replacements costs in the future.

The basic design study proposes enlightenment activities for establishment of water committee for each proposed facility to enhance proper operation and maintenance by community level. However, the above-mentioned conditions of the existing water community suggest that successful introduction of motorized pump depends on the ability of community and its leaders even though enlightenment activities are provided.

3. Application of Motorized Pump in the Project Area

(1) Possible Sites

As described in the selection of possible borehole sites, the possible borehole sites for motorized pump are 11 locations including 7 from hydrogeological evaluation and 4 from additional request by MOWR.

(2) Conclusions of the Study

At 9 out of 11 sites, except Wamba in Samburu district and Emining in Koibatek district, water communities near the respective sites are not sufficiently organized for operation and maintenance for water supply facility at present. It takes a long time to establish proper water communities having sufficient ability for successful introduction of motorized pump by means of enlightenment and full-scale aftercare. However, the enlightenment activities proposed by the Project do not cover full-scale aftercare due to limitation of the implementation period.

At the other two sites, Wamba and Emining, there are existing water supply facilities managed by MOWR. When proposed boreholes are used for reinforcement of water sources for existing facilities, problems on operation and maintenance of motorized pumps are not expected under management by MOWR. However, their urgencies are no justified since no future facility plans are prepared at present. In addition, it is not recommended to select these two sites in view of successful rate of boreholes for the Project due to low yield in Wamba and poor water quality in Emining evaluated by the hydrogeological studies.

Consequent to the considerations above, the 11 sites for motorized pumps are not proposed for the Project.

ATTACHMENT- 3

Study on Wind Pump

Study on Wind Pump

1. Outline of Wind Pump

(1) Outline

A wind pump is operated by circular motion of rotator transferred to vertical motion of rod. The rotator diameter ranges from 3.7 to 7.4 m and the tower to fix rotator is 7 to 10 m heigh. The maximum pumping head of a wind pump is around 200 m.

A wind pump is operated using natural energy. The operation cost for a wind pump is, therefore, cheaper than that for motorized pump requiring electricity or fuel. The maintenance of wind pump is also easier because of its simplified mechanics. Wind pumps have been utilized in agricultural farms in Kenya since colonial times. From the late 1970's, a manufacturer in Nairobi has been producing and selling the wind pumps in Kenya, and as well as the neighbouring countries. The manufacturer has supplied 285 units to catholic missions, NGO's, projects by World Bank, UNDP and doner countries for the period from 1979 to 1997.

(2) Procurement Conditions

The manufacturer in Nairobi has around 20 staffs and previous supply records suggest that it products one wind pump per month. The manufacture provides training of periodical maintenance of the wind pump for rural people at installation and an intensive training program for 2 weeks in Nairobi. The manufacturer does not have any local branch and needs to despatch staffs for spare parts supplies and services on request.

2. Application of Wind Pump

The relationships of rotator diameter, pumping head, and pumping capacity provided by the manufacturer are presented below.

(Unit: m3/day)

Dia. of Rotator		3.7 m			4.9 m			6.1 m			7.4 m	
Wind Velocity (m/s)	2-3	3-4	4-5	2-3	3-4	4-5	2-3	3-4	4-5	2-3	3-4	4-5
Head 10 m	10	28	59	21	71	150	39	107	227	61	167	354
20 m	5	14	29	10	35	75	19	53	113	30	83	177
40 m		7	15	5	18	37	10	27	57	15	42	89
80 m		3	7	3	9	19	5	13	28	8	21	44
120 m			5		6	12	3	9	19	5	14	29
160 m			4		4	9		7	14	4	10	22
200 m			3			7		5	11		8	17
240 m						6		5	9		7	14

To operate the wind pump requires an average wind velocity of least 2 to 3 m/s.

Operation records of wind pumps in Kenya were reported by the British ODA and the Swedish engineering firm in 1980's. A summary of operation records near Nanyuki is shown below. It seems to correspond with the relationships mentioned above.

Dia. of Rotator (m)	Dia. of Pump (inches)	Head (m)	Average Wind Velocity (m/s)	Average Pumping Volume (m³/day)
7.4	3.75	55	3.9	30.4
7.4	3.75	63	4.2	32.6
3.7	3.75	28	3.4	12.1

The following table gives pumping capacity at head of 60 meters for wind velocity of 2.5 to 3.5 m/s.

Average Wind Velocity		Dia. of F	Rotator	
	3.7 m	4.9 m	6.1 m	7.4 m
2.5 m/s	0 m³/day	4 m³/đay	8 m³/day	12 m³/day
3.0 m/s	2 m³/day	8 m³/day	12 m³/day	20 m³/day
3.5 m/s	4 m³/day	12 m³/day	20 m³/day	32 m³/day

According to the Design Manual for Water Supply in Kenya, the average wind velocity is less than 3 m/s in the Project Area except the surroundings mountainous areas such as Nanyuki, Nyahururu and the western part of Baringo and Koibatek districts. Wind pump with rotator more than 4.9 m diameter provides pumping volume equivalent to that of handpump, but it costs around five times that of India

Mark II Extra Deep Type. Wind pump is, therefore, regarded as an alternative to motorized pump but not to handpump.

Under average wind velocity of 3 m/s and 60 meters pumping head, a wind pump with rotator diameter of 3.7 m has a cost per unit pumping volume equivalent to 60% of that of a motorized pump for daily water demand of 4 m³/day. Whereas, the ratio becomes 80% for wind pump with rotator diameter of 7.4 meters operated to lift water for daily demand of 14 m³/day under the same wind and head conditions.

However, the previous reports indicate that cost effectiveness of wind pump becomes lower than that of motorized pump for average wind velocity less than 3 m/s. So the cost effectiveness of a wind pump is mostly dependent on wind velocity. Precise wind records are, therefore, required for proper design of a wind pump.

3. Application of Wind Pump in the Project Area

The available meteorological data show the average wind velocity by month varies from 2.6 to 3.6 m/s at Rumuruti in Laikipia district.

Average	Wind	Velocity	(m/s)
THILL	141770	ACIOCICA	тшуэт

District	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Laikipia	Rumuruti	3.1	3.3	3.6	3.4	3.2	2.9	2.8	2.6	2.8	3.1	3.1	3.1	3.1

Whereas, it is reported the existing wind pump at Njoguini in Laikipia district does not work efficiently for the period from January to March due to very weak wind. Such wind conditions do not correspond with the wind records at Rumuruti. This suggests wind velocity in the Project Area is quite variable by place.

4. Conclusion

To install a wind pump successfully, it is necessary to evaluate operational efficiency of wind pump on the basis of local wind regime at the site prior to installation. However, such local wind regime near the borehole site is not available in the Project Area. Therefore, evaluation of operational efficiency of a wind pump is not possible. Consequently, installation of a wind pump is not proposed for the Project.

ATTACHMENT- 4

The Existing Borehole Data

The Existing Borehole Data (1/8)

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The Existing Borehole Data (6/8)

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Division	RUMURUTI	RUNURUTI	RUMURUTI	Drinker (Dr.) T.	DIVIDIT.	District Control	HOMOHO!!	HUMURU	HUMUHU	RUMURUTI	RUMURUT	RUMURUTI	PUNURUTI	RUMURUT.	RUMURUTI	FUMURUTI	HOMORUTI	HOMOHO	uneu/table	Charles Co.	(Manufacha)	The state of the s	about the view	Cheurtable	uneuftschie	cheuthore	uneutable	uneutable	unevilleble	ureutable	Cheuffable	- Constitution	cheuteble	unsultable	-Charles	unautable																
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The Existing Borehole Data (7/8)

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The Existing Borehole Data (8/8)

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