CHAPTER III EXISTING WATER SUPPLY IN THE STUDY AREA

3.1 General Conditions

3.1.1 Overview

In the study area, several types of water supply systems are under operation. They are 1) ministry water supplies operated by the MLRRWD, 2) community self-help water projects and 3) water supplies operated by other institutions.

In the National Water Master Plan, the Government of Kenya has set up targets to supply potable water to a reasonable distance to the people by the year 2010 by augmenting and implementing water supply projects throughout the country. To achieve this target as early as possible, the government placed emphasis on assisting communities in developing their own self-help water supply schemes in rural areas. These self-help schemes are intended to be supplementary to the Ministry Water Supplies which cover mainly urban centers.

Ministry Water Supplies generally adopt a simple combination of conventional treatment with chlorination. On the other hand, most self-help schemes have no treatment process with emphasis on developing water supply systems free from maintenance. Raw water extracted from rivers and springs is distributed by gravity to the consumers. Major facilities constructed are merely intake weirs and distribution pipes. Customers receive water from their individual taps, which are not metered. They are not charged for water consumption except for an initial membership fee. These self-help schemes, are cost effective in terms of construction, operation and maintenance, and have become one of the common water supply systems in the study areas.

This situation has resulted in competition between Ministry Water Supplies and Community Water Supplies. Many customers prefer Community Water Supplies because of the lower cost of water. In some townships, service coverage by Ministry Water Supplies has significantly decreased due to the customers' shift to Community Water Supplies.

The government has also placed emphasis on constructing a number of water kiosks or communal water points on the outer fringes of the supply areas. Many types of such water points have been constructed in the country, particularly in the 1980s. After several years of operation, however, most of them have been disconnected and closed because of serious operational problems (lack of maintenance, water wastage, vandalization, etc.). In the study area, there were only three (3) operational water kiosks in an Isiolo town which were being operated by women's consumer groups.

3.1.2 Service Coverage

The table below shows the population served and the service coverage by each type of water supply (based on information obtained from DWE).

Table 3.1-1 Population Served and Coverage

Town	Population (1996)	Population Served & Coverage Ratio			Total
		Ministry WS	Community W/S	Others	
Meru	174,426	20,152	19,852	0	40,004
(%)		12%	11%	0%	23%
Nkubu	4,730	2,405	1,680	0	4,085
(%)		51%	36%	0%	86%
Isiolo	28,685	28,862	0	0	28,862
(%)		100%	0%	0%	100%
Chuka	33,727	4,720	0	not known	4,720
(%)		14%	0%	-	14%
Chogoria	28,333	1,890	2,975	not known	4,865
(%)		7%	11%	-	17%
Maua	37,597	3,255	2,910	4,600	10,765
(%)		9%	8%	12%	29%
Tigania	153,911	11,802	not known	not known	11,802
(%)		8%	-	-	8%
Total	461,409	73,088	31,338	4,600	109,026
(%)		16%	7%	1%	24%

Note:
1) Population estimated for the study area
2) Out of the design population served (5,600) of the community supplies, 30% are considered residents in the supply area of the Ministry supply.
3) Becauses of data sources, contradiciton between population and population served is seen.
4) Although two spring systems exist, their coverages are unknown.
5) Coverage of water scheme run by the Mission to supply mainly to the hospital is not known.
6) There are seven (7) self-help and two (2) institutional water schemes in the area.

Source: DWO

The coverage ratio for the whole study area is still at a low level of 25%. Out of the seven schemes, only Isiolo and Nkubu have high coverage ratios, ie, 90% - 100%. Self-help schemes have contributed significantly to service coverage in the rural areas. The majority of the residents, however, continue to depend upon traditional spring and river sources, and walk long distances to fetch water. ***Figures 3.1-1*** to ***3.1-7*** show the administrative areas and the areas covered by water supplies.

To confirm the above information and investigate people's behavior with respect to water use, the Study Team conducted a questionnaire survey on potable water and sanitary education, visiting 700 households in the area.

According to the survey, most of the population use river water and community water supplies. The river is often preferred because it is culturally accepted, it is reliable and no payments are required. River water is used without restriction especially to water animals. A problem with river water is the increasing pollution from factories and agricultural activities located upstream.

The level of service and reliability has a lot to do with the social and cultural values of a given community. For example, in our sample 22.6 % of households depend on community water supplies, while 14.7% on Ministry Water Supplies. In the study area with the exception of Isiolo, communities have developed their own water supplies, therefore they attach greater importance to their own water systems.

Ministry water supplies are not popular because they were designed basically for drinking at a low rate of 30 lpcd. The problem is that humans are not the only ones who use the water from the piped scheme, it is also used for animals, especially grade cattle which have high water requirements. This high demand for water means that water must be rationed making the system unreliable. Therefore there has been a tendency for people to shift from Ministry Schemes to community managed schemes due to lower costs and greater reliability.

3.1.3 Water Use Practice and Per Capita Consumption

People's behavioral patterns for water use were also monitored during the Public Awareness Survey carried out by the Study Team.

Generally, people in the survey areas walk long distances in order to collect water. Only 26.0 % get water immediately from the tap, the rest walk on average over 2 km to get water. Perenial rivers are commonly used as alternative sources during dry seasons because they are more reliable. Other sources used during dry seasons include hand dug wells, Ministry and Community Water Supplies.

Water is mostly used for drinking, washing, bathing, watering animals and plants. Three quarters of the population regularly practice bathing.

The results of surveys also indicate that when water is collected from a source, the unit consumption per head is low, merely 10 lpcd as shown in table below.

Table 3.1-2 Collected Water Consumption

Town	Water Collected (litres/day)	Population	Unit Consumption (lpcd)
Meru	5,240	555	9.4
Nkubu	2,340	223	10.5
Isiolo	3,860	474	8.1
Chuka	6,140	593	10.4
Chogoria	4,500	430	10.5
Maua	5,220	495	10.5
Tigania	6,600	634	10.4
Total	33,900	3,404	10.0

Source: JICA Study Team

As regards unit water consumption by those who depend on piped water supply, attempts were made to gather information on water consumption from metered records. However, due to the many defective meters left without maintenance, the data obtained was limited to the following 16 subscribers in Meru, Isiolo and Nkubu towns.

Table 3.1-3 Unit Water Consumption (Metered Records)

Water Consumption (m3/month)	Nos. of households	Nos. of consumers	Unit Consumption (lpcd)
8	1	8	33
9	1	12	25
10	1	2	167
11	1	6	61
12	6	51	47
18	1	8	75
25	1	11	76
26	1	5	173
27	1	7	129
30	1	6	167
55	1	3	611
	16	119	**82**

Source: DWO

The table above suggests that unit water consumption (working meters) is estimated at around 80 lpcd, similar to the design standard set up by MLRRWD.

3.1.4 Service Level and Accounted-for Water

Accounted-for water in each water supply (MLRRWD) is presented in table below.

Table 3.1-4 Accounted-for Water

Town	Water Production (1996)	AFW	Ministry W/S UFW	Unit Consump.
Meru	997,798	905,065	92,733	117
Nkubu	65,647	47,384	18,263	13
Isiolo	948,361	802,073	146,288	76
Chuka	135,050	133,225	1,825	77
Chogoria	not known	not known	not known	not known
Maua	59,640	47,514	12,126	40
Tigania	657,000	423,400	233,600	98
Total	2,863,496	2,358,661	504,835	81

Note: 1) Total values do not consider Chogoria.
2) AFW: Accounted-for water, UFW: Unaccounted-for water
Source: DWO

As the flow records are not available in every town, the above information obtained from DWO contains some inaccurate or assumed data. From this table, AFW ratio is averaged at 82% (=2,358,661m3/2,853,496m3). However, revealed by the Water Loss Survey, carried out under the Study, many unregistered connections prevail in Meru town (20% of customers were not registered) and UFW ratio accounts for 70% of the water production. Further, the Bulk Flow Measurement Survey in Meru suggests that almost twice as much water (approximately 2,000,000 m3/year instead of 997,798 m3/year in the table above) is being distributed to the consumers.

3.1.5 Willingness to Pay for Water

The Public Awareness Survey provides information on customer's willingness to pay. Regardless of their socio-economic status, 36.7% did not pay for water. In our survey area, we found, in answer to a verbal questionnaire, that when water tariffs are high, fewer consumers are willing to pay for water services. For example, when the tariff was 5 Ksh per day, roughly equivalent to the current tariff, 22% were willing to pay, when the tariff was 10 Ksh per day only 6.9% were willing to pay, when the tariff was 30 Ksh per day 2.7% were willing to pay and finally, when they were required to pay more than 50 Ksh per day, only 1.9% were willing to pay.

When asked whether they were satisfied with water services, 62.8% were not satisfied with the services. Unreliability was the main cause for dissatisfaction. For those who said that they were not satisfied, we went on further to find out whether, if the problems were solved, they would be willing to pay for water. The result was that almost all households were willing to pay for a reliable supply.

3.2 Inventory of Existing Water Supply Systems

3.2.1 Ministry Water Supplies

This section focuses on salient features of the existing water supply systems in the study area, operated and managed by the District Water Offices.

(1) Meru Water Supply

The figure below shows a schematic flow diagram of the existing water supply system in Meru town.

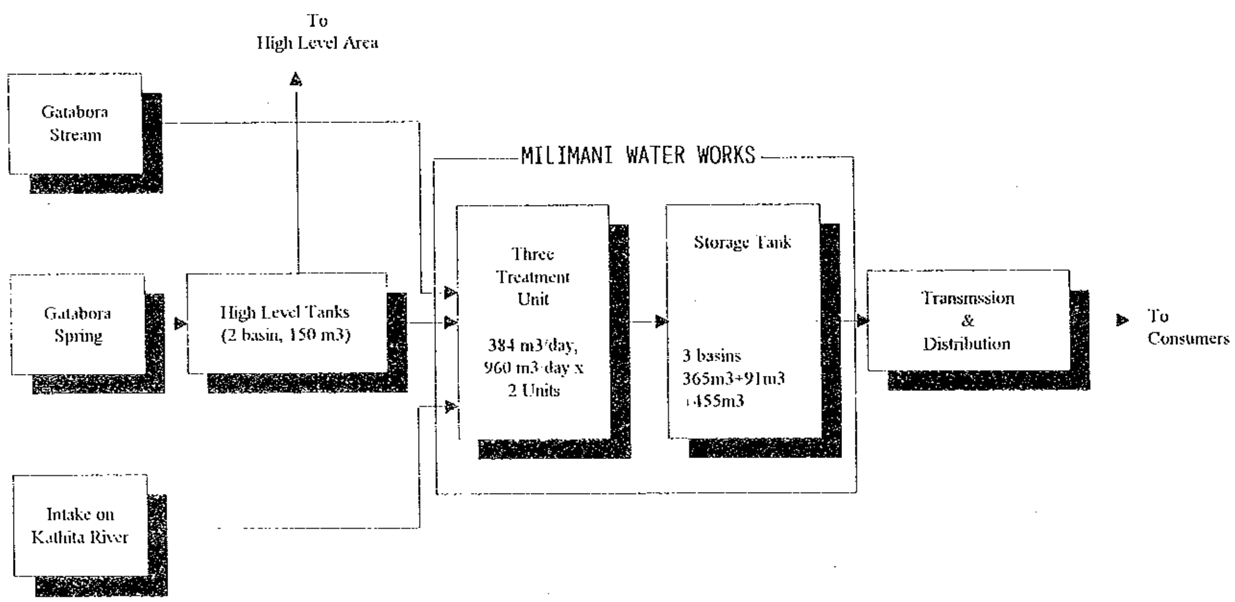


Figure 3.2-1 Schematic Flow Diagram of Water Supply System in Meru

1) History

The establishment of Meru water supply dates back to colonial days in 1952. Water supply facilities were first constructed at Milimani, on a hillside west of the town. It takes raw water from the Gatabora stream. The treatment process adopted was two (2) composite type units, consisting of coagulation, sedimentation and filters. These facilities have been abandoned and have not been in operation since 1992 due to their relatively small production capacity (225 m3/day x 2 units).

The first expansion was undertaken by the Government of Kenya in 1987. Under the expansion, additional filter units were constructed to increase the production capacity to 1,250 m3/day in total. At the same time, intake facilities were also expanded at upstream locations on the Kathita river and in the Gatabora spring.

Due to rapid population growth in Meru town, the inevitable expansion of treatment facilities was launched by the GOK in 1992, and completed in 1995. The treatment process adopted was similar to the original process, i.e., two (2) composite units with a production capacity of 1,920 m3/day in total. Production capacity of the whole treatment plant was significantly increased to 3,170 m3/day. However, the plant currently produces 6,240 m3/day to supply water to the town, and the process is grossly overloaded.

2) Raw Water Intake and Transmission

The existing water supply system in Meru town depends on both the Kathita river water and the Gatabora spring. The Kathita river, originating on Mt. Kenya, gathers water from its tributaries, and runs eastward through the southern fringe of the town center. It has a catchment area of 167 km2. Its river flow rate recorded at Marianti, slightly downstream of the intake site varies from 1.13 m3/s in dry season to 2.29 m3/s in wet season.

At the intake site, an intake weir and a diversion chamber were constructed. The river water diverted from this chamber flows through a 300 mm diameter pipe. All the water is transmitted to the treatment plant at Milimani.

The decrease of the river flow during dry seasons does not affect significantly the intake rate from the weir. The Flow Measurement Survey carried out at the end of the dry season in 1996 recorded 10,000m3/day at the intake site.

The other source is the Gatabora spring, 3km north from the town center, located at the southern edge of Meru Forest Park. Its yield varies according to the season ranging from 1,500m3/day to 2,000m3/day. The facilities constructed are a weir and a 200 mm diameter raw water transmission. All the raw water is transmitted to the High Level Tanks located 2km from the spring. From there, one third (500m3/day) is transmitted to the treatment plant for backwashing, while the remaining (1,000m3/day) is delivered to the high level zone in the town.

At the raw water tank, chlorine is dosed for disinfection. Chlorinated water is then supplied to the population residing at this relatively high elevation. According to the technical staff in the district water office, this direct supply covers a wide area of 9km2 with 400 customer connections, one fifth of the total connections in the town.

3) Water Treatment Plant

Raw water is transmitted to the treatment plant at flows not less than 10,000m3/day, i.e., 10,000m3/day from the Kathita river and 500m3/day from the Gatabora spring. All the river water is treated while the Gatabora spring water is mainly used for backwashing. At the receiving chamber, alum is dosed as coagulant at a rate of 20kg/day or 2mg/l only in the rainy season, when slightly turbid water is expected. This dosing rate is not sufficient although further detailed surveys are required. Settled water then flows into the filters. Three storage reservoirs constructed within the premises of the treatment plant have a capacity of 1,008m3 in total. On the way to the storage reservoirs from the filter units, post-chlorine is dosed at a rate of 10kg/day for disinfection during rainy seasons.

4) Distribution Pipe Network

The distribution pipe network has been expanded gradually, reflecting municipal development. In the 1950s when the water supply was first established, asbestos cement pipes were laid as distribution mains while galvanized steel pipes were used as service pipelines. In the 1970s, PVC (polyvinyl chloride) pipes instead of asbestos cement were mainly installed. The distribution system consists of two zones, high level and low level zones.

Distribution mains with a diameter of 200mm, 150mm, 100mm and 75mm were laid in the 1970s, covering the populated area of the municipality. Since then, no large scale expansion has been carried out. The total length of the distribution mains is 13.5km at present as summarized below:

Table 3.2-1 Distribution Pipelines

Diameter (mm)	Length (m)	Materials	Year of Installation
1) Distribution mains			
200	500	PVC	1970s
150	500	AC	1956
150	500	PVC	1970s
100	6,000	PVC	1970s
75	6,000	PVC	1970s
2) Service mains			
40	3,000	PVC	1970s
25	4,000	PVC	1970s
13	54,500	GI	1956-1970s

Source: DWO

5) Service Pipelines and Connections

Half inch service pipelines have been predominantly installed from the beginning. The pipe materials used have been shifting from GI to PVC. Total length of the system extends to approximately 60 km, but is not sufficient to supply water to the residents on a continuous basis.

Service connections have been gradually increasing in the last decade from 1,909 connections in 1986 to 2,519 connections in 1996. This number is not including 990 disconnected services due mainly to nonpayment. People are likely to shift from the Ministry Water Supply to more reliable Communal Water Projects which have been developed in the periurban areas of the municipality. Nevertheless, they still believe that the Ministry's water supply is the best because it is treated.

Table 3.2-2 Nos. of Connections (Meru)

Year	Nos. of Individual Connections	Connections (flat rate)	Total	Disconnected	Responsible organization
1990	2,001	0	2,001		Municipality
1991	2,090	0	2,090		ditto
1992	2,123	122	2,245		District office
1993	2,182	139	2,321		ditto
1994	2,205	146	2,351		ditto
1995	2,235	272	2,507		ditto
1996	2,247	272	2,519	990	ditto

Source: DWO

(2) Nkubu Water Supply

1) History

Nkubu water supply system was developed in 1952 with a production capacity of 400m3/day which consists of two treatment streams.

2) Intake Facilities

The plant entirely depends on raw water from the Thingithu River, which is perennial. The extracted raw water is conveyed to the treatment plant through two parallel pipelines of 150mm and 100mm, laid in 1952 and 1976 respectively.

3) Treatment Facilities

The treatment process consists of a flocculation basin, sedimentation basins, filters and a storage tank (22.5m3). Production capacity is 400 m3/day (2 units of 200 m3/day). Chlorine is dosed merely in the rainy season. Due to its location at the bottom of the Thingithu valley, pumping to supply is necessary (pumpset capacity 16 m3/hr).

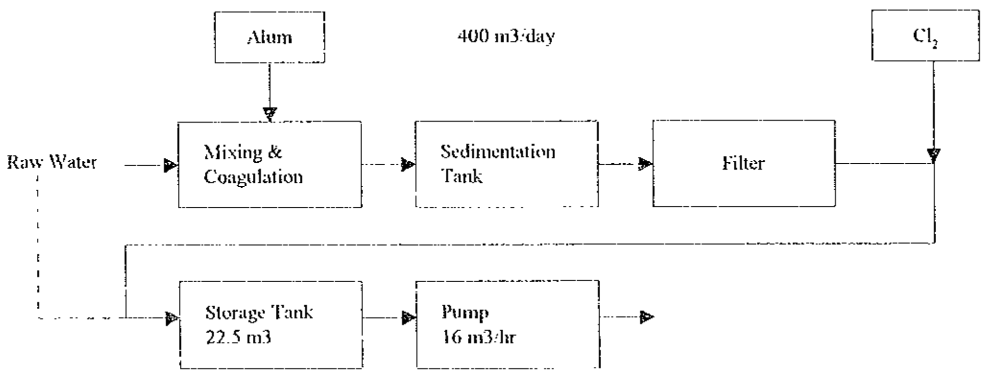


Figure 3.2-2 Treatment Process in Nkubu

4) Distribution Facilities

The design capacity of the distribution network established in Nkubu is for supplying 300 persons. By the end of July 1996, the number of customer connections had increased to 325 in total or equivalent to 1,625 people served. It is obvious that its design period has already elapsed. Service pipelines have been added thereafter, but the limited conveyance capacity of the network is creating a serious water shortage in the service area.

Table 3.2-3 Nos. of Connections (Nkubu)

Year	Nos. of Connections
1990	270
1991	295
1992	313
1993	291
1994	328
1995	345
1996	325

Source: DWO

(3) Isiolo Water Supply

1) History

There is an old abandoned treatment plant constructed during the 1950s. Surface water was diverted from the Isiolo river by pumping. The plant was located within the District Water Office compound in the southeast of the town near the air strip. The old system had a production capacity of about 400m3/day to supply water to the center of the town by pumping. These facilities were abandoned in 1980 when a new treatment plant was constructed upstream on the Isiolo river.

The 1980 expansion was carried out under financial aid of the Norwegian Government. The treatment plant constructed has a production capacity of 2,800m3/day. River water is diverted from the intake weir through a 10" (inch) raw water transmission pipe to the treatment plant by gravity. The treatment process consists of 4 mixing chambers, 2 series of sedimentation basins, 3 filters, and 1 storage reservoir. Treated water after chlorination is distributed to the town area by gravity. The entire system is principally supplied by gravity flow, except for the backwashing where pumping using power is required to an elevated tank of 224 m3 storage capacity and for supplying the School of Infantry.

Due to rapid population growth, the southern area near the treatment plant does not receive sufficient water particularly during dry seasons. Within the service area, there are three (3) Kiosks (public taps) maintained and operated by women's consumer groups. They sell water to several households nearby the Kiosks.

2) Raw Water Intake and Transmission

Intake facilities were constructed in 1980 together with the treatment plant. The Raw water transmission pipeline is 250mm in diameter and has a length of 2.8km.

Upstream of the intake, many farmers extract river water for furrow irrigation. During dry season, this situation becomes worse. River flow decreases to a minimum level with no overflow over the intake weir.

3) Treatment Facilities

Due to source constraints, raw water reaching the treatment facilities is often two thirds of the design intake rate. The water production rate decreases accordingly. The following schematic flow chart illustrates the treatment process adopted.

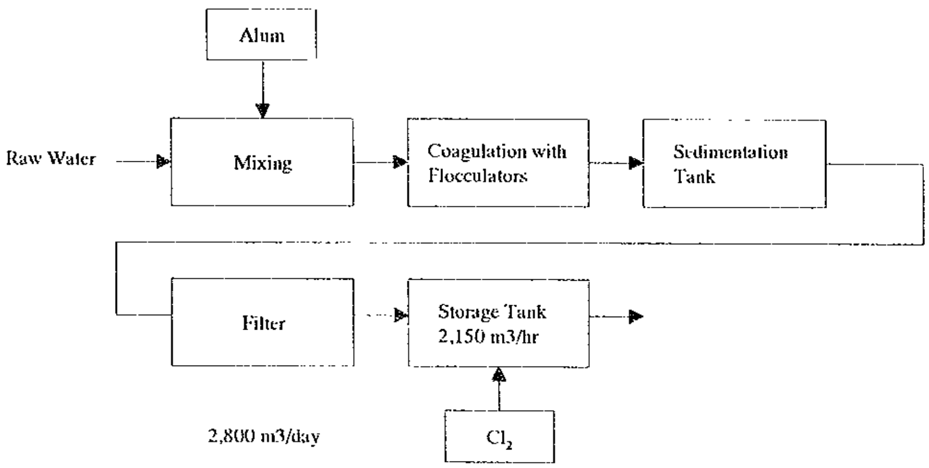


Figure 3.2-3 Treatment Process in Isiolo

Raw water extracted from the river, first flows into 4 mixing chambers where alum is dosed. After coagulation and flocculation, water enters into two series of sedimentation basins which have a retention time of 3 hours. Settled water is then transmitted to filters (3 basins) through interconnecting pipes. Chlorine is dosed at a storage reservoir which has a capacity of 2,150 m^3, or equivalent to 18 hour storage of water production.

Although the water supply system is principally gravity flow, several pump sets have been installed at the treatment works for the purpose of back washing, chemical mixing and treated water distribution to a small high level zone. Most of the pumps are out of order except the high lift pumps which were installed in 1984 for supplying water to the School of Infantry.

4) Distribution Pipe Network

The distribution network in Isiolo was developed in 1982, just after completion of the treatment works. Pipe diameters of distribution mains range from 75mm to 250mm. Pipe materials are all of PVC. The table below shows the length of pipeline installed to date.

5) Service Pipelines and Connections

Pipe materials used for service pipelines are mainly of PVC. In the past 6 years, the number of connections increased from 1,729 in 1990 to 2,771 in 1996 or 10 % per annum.

Table 3.2-4 Nos. of Connections (Isiolo)

Year	Nos. of Connections
1990	1,729
1991	1,911
1992	2,126
1993	2,321
1994	2,499
1995	2,679
1996	2,771

Source: DWO

(4) Chuka Water Supply

Chuka township's water supply system was built in 1970 to supply residents. It extracts surface water from the Tungu river which flows through the forest on the eastern slope of Mt. Kenya. The intake of this supply is located deep in the forest to secure good quality water and therefore there is no need for full treatment. Simple chlorination is done at the Receiving Tanks. In May 1996, however, a sedimentation basin was added to provide clarified water. All the system from intake to distribution is by gravity flow. The following figure shows a flow diagram of the treatment process.

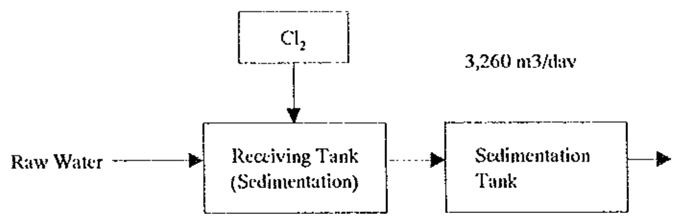


Figure 3.2-4 Treatment Process in Chuka

It is reported that chlorine is normally dosed at the rate, 7kg/day or 2.5 mg/l. After pre-chlorination, raw water enters the settling basin. Post chlorination is not practiced. Settled water is distributed through a 6" distribution main.

Distribution pipelines constructed in 1976 consist of relatively small diameter pipes of 2" and 1". They are however too small to form part of the network. Pipe materials are of PVC. There are three storage reservoirs in the pipe network.

The number of service connections have also gradually increased from 446 in 1990 to 590 in 1996.

Table 3.2-5 Nos. of Connections (Chuka)

Year	Nos. of Connections
1990	446
1991	450
1992	485
1993	500
1994	525
1995	560
1996	590

Source: DWO

(5) Chogoria Water Supply

Chogoria town is served from Mwimbi water supply that takes water from the Mutonga River. The water treatment plant, 2 km from the intake, receives water through a new 150 mm diameter raw water transmission main. The treatment process consists of a sedimentation tank and a filter. All these facilities are located in Meru District.

The Mwimbi water supply commissioned in 1975, has a production capacity of 500m3/day. It was intended to supply treated water to the southern part of Meru district including Igoji, and Chogoria. However in April 1992, Tharaka Nithi

District was newly established, separating these sub-locations from Meru District. Nevertheless, operation and maintenance of the treatment facilities have remained the under responsibility of Meru District Water Office.

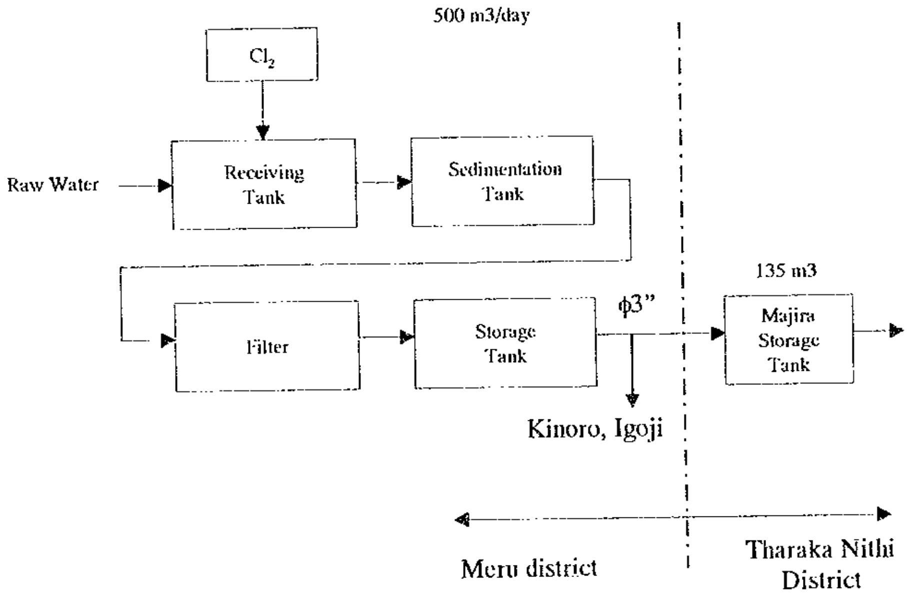


Figure 3.2-5 Treatment Process in Chogoria

The distribution mains constructed in 1975 have a total length of 19 km. Most of the pipelines are of PVC and relatively small, ranging from 4" (100mm) to 1" (13mm) in diameter. Chogoria area receives treated water through one distribution pipeline, 3" (75mm) in diameter. There are several offtakes from this main on the way to Chogoria to supply to Kiangua, Kinoro and Igoji in Meru District and, as a result, very little water over reaches Chogoria.

Table 3.2-6 Distribution Pipelines (Chogoria)

Diameter (mm)	Length (m)	Materials	Year of Installation
1) Distribution mains			
100	12,500	PVC	1975
80	2,000	PVC	1980
60	2,500	PVC	1982
50	500	PVC	1982
40	1,000	PVC	1982
25	500	PVC	1982
2) Service mains			
13	-	PVC	-
20	-	PVC	-

Source: DWO

The 1992 administrative demarcation has created a serious situation in Chogoria town and its environs. Because of it's location at the end of the distribution mains, the quantity of water reaching the town has reduced significantly since then. Many people are suffering from critical water shortage and have to rely on poor quality river water. This may be the explanation for the gradually reducing number of connections in Chogoria town as shown below.

Table 3.2-7 Nos. of Connections (Chogoria)

Year	Nos. of Connections
1990	600
1991	400
1992	420
1993	350
1994	300
1995	270
1996	270

Source: DWO

According to the information provided by DWE, there were 1,200 service connections in 1984, nearly five times larger than the present value. The serious water shortage in the area has forced customers to use river water.

(6) Maua Water Supply

Maua town is located in Nyambene District which was separated from Meru District in April 1992. Maua water supply covers only the populated area of Maua township. The service area covered by the present water supply system is around

2 km2. The water source is Mboone river which runs through the town center originating from the Nyambene Hills. The present intake point is just downstream of the river origin. The flow rate of the river fluctuates seasonally with 2,700 m3/day recorded in the dry season. The intake rate also ranges from a low of 400m3/day in dry seasons to a high of 480m3/day.

The intake facilities were constructed in 1956 and were expanded in 1986. From the intake, two pipelines installed in 1956 and 1994 convey raw water to the treatment works.

The treatment plant, constructed in 1956, consists of one sedimentation basin, one filter and one storage reservoir. Chlorine is dosed only in the rainy season when the raw water is turbid. The treatment process is portrayed schematically in the figure below:

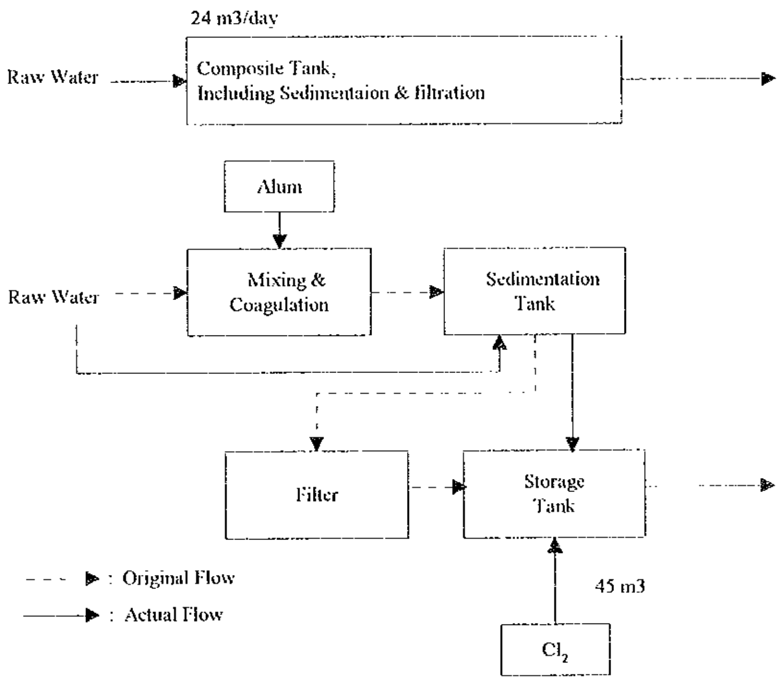


Figure 3.2-6 Treatment Process in Maua

The distribution pipelines have a similar background of expansion as the treatment works. After construction in 1956, they were rehabilitated with some minor augmentation in 1994.

The higher areas are served with untreated water by a 75mm pipe directly from the intake which was also installed in 1994. Pipeline lengths installed are listed in the table below.

Table 3.2-8 Distribution Pipelines (Maua)

Diameter (mm)	Length (m)	Materials	Year of Installation
1) Distribution mains			
75	1,300	AC	1956
75, 50, 40, 25	2,000	PVC/GI	1994
2) Service mains			
40	200	GI	1956
40	500	PVC	1994

Source: DWO

To cope with an increasing number of customers, the DWO has installed additional service connections. However, it is obvious that the limited production capacity of the treatment works is not sufficient to supply water to the new customers, which has resulted in serious water shortages.

Table 3.2-9 Nos. of Connections (Maua)

Year	Nos. of Connections
1990	160
1991	170
1992	196
1993	-
1994	270
1995	412
1996	465

Source: DWO

Due to the constraints of the Ministry supplies a number of community supply schemes have been developed in the surrounding areas. As described in the foregoing subsection, population served by the community based and/or institutional schemes (20% service coverage) are far larger than those served by Ministry water supply (merely 9% service coverage).

(7) Tigania Water Supply

In the vast Tigania rural area, there are two water supply systems developed and interconnected to each other by distribution pipelines. They are (1) Mikorwe system constructed in 1977 and, (2) Michii Mikuru System constructed in 1989.

The water sources for these systems are springs, located on the western slopes of the Nyambene Hills. The Mikorwe system has a ground reservoir, 1.5 km south west from the spring. The spring has a yield of 2,200 - 2,300 m3/day. From which, 1,700 - 1,800 m3/day is extracted for distribution. Currently no chlorine dosage is exercised.

The Michii Mikuru spring has a yield of 1,800 - 2,100 m3/day, slightly smaller than the Mikorwe spring. Neither chemical dosing equipment nor storage tanks are facilitated near the spring.

At the time of construction of the Michii Mikuru system, distribution mains were also constructed. But no significant expansion has been made since then. The table below lists the total length of distribution pipelines.

Table 3.2-10 Distribution Pipelines (Tigania)

Diameter (mm)	Length (m)	Materials	Year of Installation
1) Distribution mains			
200	9,650	PVC	1989
2) Service mains			
150	1,100	PVC	1977
100	7,000	PVC	1977
75	6,500	PVC	1977
50	23,000	PVC	1977
50	16,000	PE	1977

Source: DWO

To cover the wide spread service area, seven storage tanks have been constructed, connected to the distribution network. Total storage capacity is around 400 m3. The system does not achieve continuous water supply and on the edge of the service area, many inhabitants are suffering from severe water shortages.

Due to the growing water demand in the area, service connections are increasing in number, year by year. This also has adverse effects on existing customers.

Table 3.2-11 Nos. of Connections (Tigania)

Year	Nos. of Connections
1990	1,083
1991	1,220
1992	1,304
1993	1388
1994	1,509
1995	1,602
1996	1,686

Source: DWO

3.2.2 Community Water Supplies

Many local community based water supply schemes that were initiated in the seventies and eighties are today faced with serious technical, operational and maintenance problems. These problems have become so severe that some of the water supply schemes have actually collapsed. Many of the water supply schemes are poorly designed, their service areas overlap, and their development is neither co-ordinated nor integrated. The water supply schemes are developed and run by different organisations and without proper co-ordination and supervision by the MLRRWD.

Administrative boundaries and supply areas of Community water supplies in Meru, Nkubu, Chogoria, Maua and Tigania are shown in ***Figures 3.2-7*** to ***11***.

(1) Meru

Our field survey conducted during Feasibility Study Stage indicated the existence of about 100 community water supply schemes in Meru. Twenty were visited and studied in depth. ***Table 3.2-12*** gives the summary of each scheme.

(2) Other Towns

1) Nkubu

The township of Nkubu is served by the MLRRWD Nkubu water supply scheme. The supply is however inadequate and this has resulted in the development of other community schemes to serve mainly the peri-urban and rural areas.

The survey of community based water supply schemes identified five (5) main supply schemes in Nkubu are summarized in ***Table 3.2-13.***

2) Isiolo and Chuka

There were no community based water supply schemes in these areas, although there were several individual institutional boreholes in Isiolo.

Table 3.2-14 Institutional Boreholes within Isiolo

Owner	Depth (m)	WRL (m) Static	WRL (m) Dynamic	Yield (m3/hr)
Isiolo Barracks	54.9	37.5	28.5	4.7
Veterinary Dept.	97.4	50.0	34.4	10.9
Isiolo Airstrip	184.0	46.6	18.0	30.0
Ngare Mala	48.0	58.0	10.9	-
Isiolo District	-	-	-	-
Hospital	-	-	-	-

Source: DWO

3) Chogoria

The survey of community based water supply systems in Chogoria identified 4 schemes, which are summarized in ***Table3.2-15.***

4) Maua

The water schemes covered in Maua are generally located in the North and South of Maua town. Some schemes have had a slow implementation tempo due to funding limitations. The oldest schemes are Maua Methodist Hospital and Mboone Water Schemes which were commissioned in the 1940s and 1977 respectively. Only a few of the projects were solely financed by the local community. The majority have had assistance from the NGO - Plan International. The Maua Methodist Hospital water supply was funded by the church. The majority of these schemes have their sources in streams within Nyambene forest. Salient features of these schemes are summarized in ***Table 3.2-16.***

5) Tigania

There are more than 13 community water projects in Tigania the sources for which are either streams or springs with their catchments in Nyambene forest. There are a few special cases where the community has been allowed to tap their water supply from a MLRRWD pipeline. However, in such cases the individual connection households pay a flat monthly levy to the MLRRWD.

Several projects in the area have been constructed by the Catholic Diocese of Meru. These schemes mainly supply water through designated communal standpipes. The communities have implemented committees for each communal water point for collection of water charges. The Catholic Diocese is responsible for operating its own watering point. Details of the 11 Schemes studied in Tigania are given in ***Table3.2-17***.

(3) Main Findings

The study found that community water supplies play an important role in supplementing government efforts in provision of water. The coverage for community schemes is higher than government schemes, and in most cases there is an overlap of projects especially in Meru. Some of the projects are not registered, and the MLRRWD have thus little information on number of people served or quantities abstracted. This has been caused by the large number of NGOs which have supported the initiation of these projects, they include Plan International, Catholic Diocese of Meru, NCCK, Methodist church, etc.

Community water projects suffer from organizational and management deficiencies. All community water supplies are managed by water committees, whose membership range from 7-13 members. Most of the officials were men, registration with the Ministry of Culture and Social Services (MOCSS) is necessary and all committees had operational bank accounts. Double membership is common, to safeguard against water rationing which is commonly practiced in the study area.

None of the projects initiated by the local communities charge for water on a consumption basis, which is not conducive to efficiently managed and operated schemes. Committees lack training in O/M and do not have effective tariff structures. Funds are collected when the system breaks down. This leads to untimely maintenance operations resulting in wastage from unattended leakage. The projects thus lack funds for expansion and repairs and maintenance are not done on time. On the other hand, some community water supplies operated by NGOs and the church mostly in Tigania and Maua charge for water on a flat rate basis.

Water is predominately used for irrigation in Meru, while water is mainly used for domestic purposes in Tigania and Maua. The irrigation in Meru has brought about misuse of water by farmers. In Tigania and Maua water is used for domestic purposes such as drinking, washing clothes and bathing.

Table 3.2-18 Type of Usage

Area	Type of Usage		
	Domestic	Irrigation	Institutional
Meru	30%	60%	10%
Maua	65%	10%	25%
Tigania	80%	10%	10%

Source Data collection from monitoring of CWS

Women are marginalised in the management of water supplies, except where the water project belongs to a women's group. This is brought about by women's limited access to education and training and due to lack of appropriate technology to ease their workload at home.

Table 3.2-19 Women's Participation in CWS

Area	Committee Members	
	Men	Women
Meru	211	34
Maua	71	9
Tigania	-	10

Source: Data collection on CWS

Experience with community water supplies indicate that where women are active members on the water committee, they make special efforts in problem solving, involving fee collection and financing of repairs. Most of them hold positions as treasurers.

Communities lack technical know how to design water schemes. Most of the schemes were designed by MLRRWD. Due to financial constraints and lack of technical know how, the committees often alter the designs, ending up with undersized pipes, which result in low pressure experienced by the schemes.

The Management of community water schemes lack technical staff to supervise the construction. The committees hire local tradesmen to construct the schemes but do not hire skilled, or professional staff to supervise the works.

In most of the community water schemes, initial investment came from the communities themselves through membership fees and harambee contributions. The majority of the funding however was received from Donors such as Plan

International, CARE, Catholic Diocese of Meru and the Methodist church as shown in the table below.

Table 3.2-20 Contribution

Area	No. of Scheme	Members' contribution	NGOs' contribution
Maua	8	3,000,020	11,000,490
Tigania	8	3,180,000	23,240,000
Meru	22	4,913,000	2,437,000

Source: Data from survey of CWS

Water quality was not seen as an important aspect when developing community water supplies, and none of the schemes treat the water. There is therefore a need to introduce health education.

There was a low willingness to connect to the MLRRWD water supply system. The main reason was that community water supply systems were set up to provide water for small scale irrigation. Amalgamation of the system with the MLRRWD system will introduce regulation that dictate against irrigation (Meru). There is also a fear that communities would loose control if the MLRRWD were to be merged with the community water schemes. The community however was willing to accept metres or any charges for water, if the management is left in the hands of the beneficiary community

3.3 Organization and Institution of Water Related Authorities

3.3.1 General Condition of Water Supply Organization in Kenya

The Ministry of Land Reclamation, Regional and Water Development (MLRRWD) was reorganized in January 1993, integrating the functions of the following three ministries.

- Ministry of Water Development,

- Ministry of Reclamation and Development of Arid, Semi-Arid and Waste Land, and

- Ministry of Regional Development.

Major functions of MLRRWD are enumerated below:

(1) Reclamation of Arid and Semi-Arid lands,

(2) Water master plan implementation,

(3) Water policy formulation & implementation,

(4) Water supply systems development & implementation,

(5) Water abstraction control & management,

(6) Water quality and pollution control, and

(7) Irrigation and dam construction projects.

MLRRWD currently look after and manage the following organization:

(1) Lake Victoria Development Authority

(2) Coast Development Authority

(3) Uaso Nyiro River Basin - North Development Authority

(4) Uaso Nyiro River Basin - South Development Authority

(5) Bura Irrigation Scheme

(6) Turkana Disrict Rehabilitation Project

(7) National Irrigation Board.

MLRRWD has the overall responsibility for planning, conserving and operating water supplies throughout the country with a view to providing safe and clean water to all nationals. The Ministry administers the Water Act (Cap 372) through the Water Apportionment Board (WAB) of which the Director of Water Development is the Technical Advisor. The organization of the MLRRWD is shown in ***Figure 3.3-1.***

The Director of Water Development controls six divisions, KEWI, the eight provincial water offices and 60 District Water Offices. The Water Resources Division carries out assessment, conservation and usage, pollution control of water, and registration of water rights in cooperation with the WAB. The Planning and Design Division is in charge of studies, planning and design of water management and development. The Implementation Division executes construction of infrastructural facilities such as dams, pipelines, treatment works, sewers, irrigation canals and groundwater boreholes. The Operation and Maintenance Division is responsible for operation and maintenance of water supply and sewerage systems including operation policy. The Research Division is responsible for formulation of water research policies and action plans related to water resources and wastewater engineering. The Monitoring and Coordination Division coordinates all external and internal organizations under the direction of the Director. KEWI is responsible for training of employees in the Ministry and local authorities or other agencies in the country.

Apart from the MLRRWD, the National Water Conservation and Pipeline Corporation (NWCPC) fulfils the water works mainly to urban centers including Mombasa, Kapsabet, Kakamega, Embu, Nyeri and Machakos. Large cities such as Nairobi, Kisumu, Nakuru, and Eldoret have independent water supply maintained and operated by their respective municipalities.

Besides the organizations mentioned above, many community based and/or privately owned water supplies are operated in the Republic of Kenya. They include self-help community water projects and institutional water schemes (run by religious groups, NGOs, etc.). The MLRRWD, however, monitors these activities, and are involved in water right issues and providing technical advice on design, operation and maintenance.

Operation and maintenance of the existing water supply systems (owned by MLRRWD) are carried out by the Provincial Water Office and the District Water Office under the direction and control of the Deputy Director of Operation & Maintenance. ***Figures 3.3-2*** and ***3.3-3*** show organization charts of the Easter Provincial Water Office and District Water Office in Meru.

3.3.2 System Operation and Maintenance

(1) Flow and Quality Control

In general, water supplies in the study area adopt gravity flow for water transmission and distribution. Pump sets are installed only at Nkubo and in Isiolo for lifting backwash-water to the elevated tank and for supplying the School of Infantry. Flow meters installed at the inlet and outlet of the treatment works are not working or in most cases not even installed. Hence, flow control is usually undertaken at the waterworks by gate valve operation. When raw water is extremely turbid, they are obliged to stop the operation by closing gate valves.

The treatment processes adopted differ from area to area. Generally, operation of the treatment facilities requires knowledge of water supply engineering and experience. Due to shortages of funds, chemicals are not being dosed regularly.

In the distribution network, break pressure tanks have been constructed. These are to protect the pipelines from the excessive pressures. According to the survey conducted at Meru, high pressures were not measured. Due to absence/damage of the flow control devices, excess water was frequently overflowing from the break pressure tanks.

Water shortage is serious in most of the water supply systems and water rationing is frequently taking place. The areas suffering from water rationing are tabulated below.

Table 3.3-1 Areas Suffering Water Shortage

Town	Areas
Meru	Northern parts of the supply area
Nkubu	None
Isiolo	LMD (Livestock marketing division, upstream area between the treatment works and Kulanawe area
Chuka	Lower town
Chogoria	All the area except areas near the Majira storage tank
Maua	None
Tigania	Kianjai, Akhithi, Maithene, Uringu, and upper parts of Muthara

Source: DWO

(2) Leakage Control

Each water supply system has several plumbers and pipe fitters. According to the district water engineers, leakage control is carried out by them. These activities are, however, characterized as passive leak detection. When leakage is found, they visit the site and repair them. Intensive active leakage control is not exercised yet.

All the water supply officers expressed their concern over shortage of equipment, materials and vehicles. As indicated in the following table, vehicles maintained by each office are apparently insufficient in view of the present service area covered by water supply systems.

Table 3.3-2 List of Vehicles Retained by Water Supplies

Towns		Nos.	Conditions
Meru			
	Folk Jembe (hole)	3	Working
Nkubu		none	
Isiolo			
	Vehicles	2	Grounded and not working
	Dosers	8	Unserviceable
Chuka		none	
Chogoria		none	
Maua		none	
Tigania			
	Motor cycle	1	Working

Source: DWO

(3) Storage

1) Chemicals

Each DWO has store houses for chemicals and equipment for delivery to water supplies. Engineers in each water supply request the delivery of material as required. Delivery is controlled by the DWO, however, chemicals (alum, chlorine) are not dosed on a continuous basis. A reconnaissance survey revealed that stocks at site, as shown below, were chronically depleted.

Table 3.3-3 Storage of Chemicals

Town	Alum	Chlorine	Soda	Frequency	Remarks
Meru	100 kg	300 kg	-		Immediately
Nkubu	100 kg	100 kg	-		
Isiolo	40 tons of alums, chlorine and soda		-	Monthly	Immediately
Chuka	-	2 tons	-	Yearly	
Chogoria	-	100 kg	-		
Maua	-	100 kg		6 Months	
Tigania	-	-	-	-	

2) Materials

To operate and maintain water supply facilities, stocks of pipes, valves, fittings and meters are indispensable. In this regard, none of the water supplies keep sufficient materials as indicated below.

Table 3.3-4 Storage of Materials

Town	Meters	Calibrators	Pipes	Valves
Meru	-	-	-	-
Nkubu	-	-	-	-
Isiolo	nil	-	50-200 mm x 204 m	75-100 mm x 3 sets
Chuka	-	-	75-250 mm x 26 m	-
Chogoria	-	-	50-150 mm x 34m	-
Maua	-	-	-	-
Tigania	-	-	-	-

Source: DWO

3) Laboratory

As described in the previous section, chemicals for coagulation and disinfection are not always dosed at a desirable rate. This appears to be due to a shortage of available funds. Laboratories of the WTPs or DWOs have insufficient equipment to operate the plants normally. An outline of the water testing conducted at the WTPs is summarized below.

Table 3.3-5 Water Testing

Town	Daily	Weekly	Monthly	Yearly	Remarks
Meru	Turbidity	-	-	-	
	Residual Chlorine	-	-	-	
Nkubu	-	Alkalinity	Bio-chemical	-	
Isiolo	pH	Alkalinity	Bio-chemical	-	-
	Turbidity	-	-	-	
	Residual Chlorine	-	-	-	
	Jar Testing	-	-	-	-
Chuka	-	-	-	-	No laboratory
Chogoria	-	-	-	-	No laboratory
Maua	Residual Chlorine	-	-	-	
Tigania	-	-	-	-	No laboratory

As suggested in the table above, laboratory testing is not intensively carried out. The following table also suggests slightly weak institutional capacity for laboratory testing.

Table 3.3-6 Organization for Laboratory Testing

Town	Nos. of Staff
Meru	2 operators
Nkubu	1 chemist
Isiolo	2 laboratory technitians
Chuka	1 pollution controller
	1 chemical attendant
	1 operator
Chogoria	No staff
Maua	1 operator
Tigania	No staff

4) Training

Training of technical staff and engineers is being carried out by KEWI (Kenya Water Institute). The following information on training was obtained from DWOs.

Table 3.3-7 Training

Town	Frequency	Scope	Place
Meru	occasionally	WS operation	Kenya Water Institute
Nkubu	one staff two years ago	WS operation	Kenya Water Institute
Isiolo	occasionally	WS operation	Kenya Water Institute
Chuka	two staff at least every year	WS operation	Kenya Water Institute
Chogoria	none	-	-
Maua	none	-	-
Tigania	none	-	-

Source: DWO

As seen in the table, staff have an opportunity to attend operator training courses held in Nairobi. However, it is notable that nobody from Nyambene has attended a course.

5) Problems Identified

All the problems described above may originate from shortages of financial and human resources.

Insufficient chemicals, meters, tools and equipment normally required for maintenance and operation have resulted in a lack of proper maintenance. Further , as revealed in the Water Loss Survey in Meru town, there are many unmetered connections. Moreover, where water meter have been installed, they are mostly defective. All unmetered supplies and customers with defective meters are charged on a flat rate tariff basis, not on a water consumption basis. As a result, people do not conserve water.

Shortages of experienced staff, technicians and engineers is also serious in every scheme. On-the-job training is considered most efficient to acquire an appropriate level of water supply engineering experience.

3.3.3 Financial Management

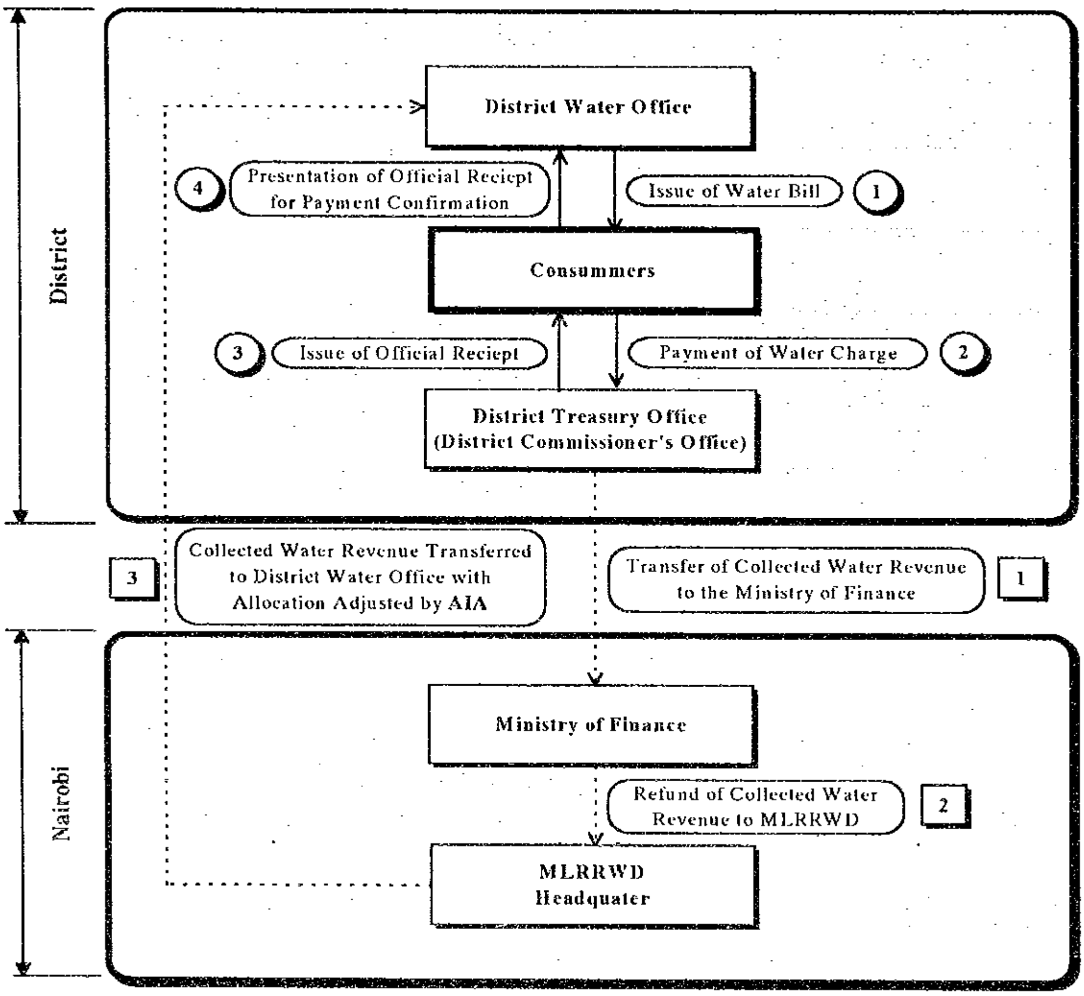
(1) Billing and Bill Collection

The flow of billing and bill collection in Kenya is briefly described as follows. The District Water Office (DWO) first reads water meters at the end of the month. Water bills which are prepared by the DWO on the basis of water meter readings are then distributed to consumers at the beginning of the month. The consumers should then pay water charges within the same month to the District Treasury Office (DTO), which is administratively under the District Commissioner's Office (DCO). In case the consumers do not pay the water charges for two continuous months, DWO then has the legal authority to disconnect the water supply to such consumers. In this case, additional charges are then required for reconnection.

After water charges have been collected by the DTO, the revenue is transferred to the Ministry of Finance similarly to all other public charges in the country, and then fully refunded to MLRRWD without being put in the general account of the national government. The water revenue refunded to MLRRWD is then allocated to each DWO and is used exclusively for operation and maintenance of the water supply systems. However, the amount of the water revenue allocated differs in each DWO, since the amount is adjusted by AIA (appropriation in aid) by MLRRWD with the ratio ranging from a minimum of 65% to more than 100% of the water revenue collected. In order to balance the gaps in operation and maintenance costs of the water supply systems among the DWOs regionwide.

Regarding salaries of personnel at DWO, it should be noted that the operation and maintenance costs of the DWO do not include salaries of engineers and administrative officers, but only those of subordinate staff. This is because the salaries of engineers and administrative officers are considered as a sort of subsidy by MLRRWD.

The more detailed flow of billing and bill collection in MLRRWD is presented in the figure below.



Source: JICA Study Team

Legends:

(1) Flow of Consummer's Payment Procedures

[1] Flow of Collected Water Revenue

Note: AIA stands for "Appropriation in Aid", which is one of the forms of subsidy, in this case, given to the District Water Office by MLRRWD when allocating the collected water revenue, in order to balance the gaps in operation and maintenance costs among the District Water Offices regionwide, with the ratio of AIA ranging from 65% at minimum to more than 100%.

Figure 3.3-4 Flow Diagram of Billing and Bill Collection in MLRRWD

During the period of the field survey, the following were found to be the major issues caused by the current institutional and financial situation of the MLRRWD.

1) Many consumers being provided water at a flat rate due to water meters not being installed or broken,

2) Existence of leakage from the facilities,

3) Existence of the illegal connections,

4) Lack of water meters,

5) Insufficient maintenance of the water meters,

6) Many consumers not willing to make payment due to dissatisfaction with supplies, and

7) Insufficiency in the distributions of bills and meter reading.

(2) Water Tariff Structure

Water charges should be determined on the basis of water consumption measured by meter reading. When there are no water meters or the water meter is broken, water charges are set at a flat rate. When the water meter is broken, previous water consumption records are available, the water charge is estimated and charged by assessing the average water consumption from the past records.

Table 3.3-8 illustrates the current water tariff structure in Kenya as of October, 1996.

Table 3.3-8 Water Tariff Structure in Kenya

Classification	Rate
I. Where no meter is installed, a monthly charge of	90 Ksh
II. Where a meter is installed:	
Where the amount of water sold through a meter in any one month;	
1. does not exceed 10m3	90Ksh
2. is more than 10m3 but does not exceed 30m3, charge per m3 in excess of 10m3	12Ksh
3. is more than 30m3 but does not exceed 60m3, charge per m3 in excess of 30m3	15Ksh
4. exceeds 60m3 but does not exceed 100m3, charge per m3 in excess of 60m3	20Ksh
5. exceeds 100m3, charge per m3 in excess of 100m3	30Ksh
III. Where water is sold through a meter at a kiosk, charge per m3	7Ks
IV. Where water is sold by retail at a kiosk per unit of 20 liters or part of, charge per unit	0.5Ksh
V. For bulk sale to an undertaker for resale, charge per m3	6Ksh

Source: The Water Act, Kenya Gazette Supplement No.5, 27th January, 1995

(3) Financial Situation

1) Financial Situation of Kenyan Government

With regards to the financial situation of the Kenyan government, it should be noted that the financing of domestic development has been dependent largely on external resources in the past years. These have been mostly provided in the form of grants through international organisations and donor countries.

As presented in ***Table 3.3-9***, it is clearly recognised that a large portion of the capital expenditure - the government investment - has been covered by external grants, approximately accounting for 66% on average during the fiscal years between 1990/91 and 1995/96. In particular, the amount of external grants in the fiscal year of 1992/93 even exceeded that of capital expenditure with the grant ratio of 103.9%.

This financial structure can be explained by the Government's weak financial capabilities for implementing development projects. Therefore, some development projects which are considered to be urgently required to meet the basic human needs of the people in the country will still be dependent on external resources, unless the financial reforms currently being attempted by the Kenyan government is successfully settled.

Considering the lack of capital resources and the financial deficit in the country, it is recommended that urgent development projects be considered for grant aid through external resources, particularly when the viability of the project is found to be financially low, but has high socio-economic benefits for the related communities or areas.

Table 3.3-9 Out-Turn of Revenue and Expenditure of Kenya Government 1998/91-1995/96

(Unit: K£million)

	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	Total
Current Revenue	2,420.36	2,852.04	3,454.71	5,050.85	6,120.53	7,176.50	-
Current Expenditure	2,722.96	2,814.54	3,884.17	5,822.31	5,850.11	6,735.65	-
Current Surplus	▲ 302.60	37.50	▲ 429.46	▲ 771.46	270.42	440.85	-
Capital Revenue	16.19	1.99	21.37	10.92	40.61	15.55	-
Capital Expenditure (A)	**554.86**	**453.78**	**423.71**	**569.25**	**725.83**	**1,166.88**	**3,894.31**
Net Lending	79.28	24.02	76.28	35.90	29.53	52.17	-
External Grants (B)	**208.25**	**231.85**	**440.40**	**458.54**	**661.45**	**562.25**	**2,562.74**
Grant Ratio (B) / (A)	**(37.5%)**	**(51.1%)**	**(103.9%)**	**(80.6%)**	**(91.1%)**	**(48.2%)**	**(65.8%)**
Overall Deficit	▲ 712.30	▲ 206.46	▲ 467.68	▲ 907.15	217.12	▲ 200.40	-

Source: Economic Survey 1995 and 1996

Note: Numbers in the fiscal year of 1995-96 are estimated

2) Financial Situation of MLRRWD

The Development and recurrent expenditures of MLRRWD in the fiscal year of 1996/1997 are presented in ***Table 3.3-10***. As shown below, the share of appropriations in aid in development expenditure is found to be almost equal for both MLRRWD (56.4%) and the national total (57.2%). However, the share of development expenditure in MLRRWD (69.4%) is quite large compared to that of the national total (22.2%). It implies that development expenditure of MLRRWD is quite dependent on the external resources, as observed for the Kenyan government as a whole.

Table 3.3-10 Development and Recurrent Expenditures of MLRRWD 1996/1997

(Unit: K£)

	National Total		MLRRWD	
	Estimated Amount	Share	Estimated Amount	Share
Development Expenditure	2,170,264,074	22.2%	195,729,869	69.4%
Appropriations in Aid	(1,240,706,384)	(57.2%)	(110,318,849)	(56.4%)
Net Expenditure	(929,557,690)	(42.8%)	(85,411,020)	(43.6%)
Recurrent Expenditure	7,616,647,592	77.8%	86,284,500	30.6%
Appropriations in Aid	(390,099,450)	(5.1%)	(7,134,110)	(8.3%)
Net Expenditure	(7,226,548,142)	(94.9%)	(79,150,390)	(91.7%)
Total Expenditure	9,786,911,666	100.0%	282,014,369	100.0%
Appropriations in Aid	(1,630,805,834)	(16.7%)	(117,452,959)	(41.6%)
Net Expenditure	(8,156,105,832)	(83.3%)	(164,561,410)	(58.4%)

Source: Development Estimates, and Estimates of Recurrent Expenditure for the Year 1996/1997
Note: The figures of "Appropriations in Aid" include both grants and loans

3) Financial Situation of Water Supply Schemes in the Study Area

Regarding the financial data used in the following tables, it should be noted at the beginning that some figures do not accurately reflect the realities of the field operation, due mainly to the following two reasons: (a) poor management in data documentation and (b) appropriation in aid not being included.

An annual financial statement by water supply schemes in the study area is summarised in the table shown below. According to the table, the major findings characterising the financial situation of each water supply scheme in the study area are presented as follows:

a) The total revenue collected covers all the O&M costs in the study area; however, there is a deficit in Nkubu, Chuka and Chogoria,

b) The major source of revenue in the study area is from metered connections (89.2%); however, due to broken or faulty meters, this is mostly estimated using flat rates or average assessments, as in Chuka (59.2%), Chogoria (93.8%) and Tigania,(62.9%),

c) The revenue recovery ratio in the study area is 61.4% in total, although the ratio was found to be even lower in Chuka (39.1%) and in Chogoria (28.1%),

d) The major O&M expenditures in the study area are personnel emolument for subordinate staffs (49.2%) and chemicals (31.1%), and

e) Besides personnel emolument, there are no other O&M costs in Tigania.

Table 3.3-11 Annual Financial Statement by Water Supply Scheme in the Study Area

(Unit: Kshs)

Item	Water Supply Scheme							Total
	Meru	Nkubu	Isiolo	Chuka	Chogoria	Maua	Tigania	
REVENUE								
New Connection Fee	1,522	1,135	13,500	15,621	-	3,978	9,660	45,416
	(0.0%)	(0.1%)	(0.1%)	(0.6%)	-	(0.4%)	(1.0%)	(0.2%)
Reconnection Fee	2,957	1,200	33,229	10,750	1,000	8,200	6,600	63,927
	(0.0%)	(0.1%)	(0.3%)	(0.4%)	(0.6%)	(0.9%)	(0.7%)	(0.2%)
Revenue from Metered Connection	8,664,203	870,263	11,118,452	1,087,663	9,563	918,062	337,305	23,005,511
	(96.7%)	(99.7%)	(99.6%)	(39.8%)	(5.6%)	(98.7%)	(35.4%)	(89.2%)
Revenue from Flat Rate/Average Assessment	291,180	-	-	1,615,634	161,007	-	600,030	2,667,851
	(3.2%)	-	-	(59.2%)	(93.8%)	-	(62.9%)	(10.3%)
Total Revenue Earned/Billed (A)	8,959,862	872,598	11,165,172	2,729,668	171,570	930,240	953,595	25,782,705
	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)
Total Revenue Collected (B)	3,719,323	410,390	9,117,143	1,067,522	49,295	917,710	554,257	15,834,640
Revenue Recovery Ratio (B/A)	(41.5%)	(47.0%)	(81.7%)	(39.1%)	(28.1%)	(98.7%)	(58.1%)	(61.4%)
Revenue not Collected	▲ 5,240,539	▲ 462,208	▲ 2,048,029	▲ 1,662,146	▲ 122,275	▲ 12,530	▲ 399,338	▲ 9,948,065
O&M COSTS								
Fuels	5,042	435,779	234,871	-	-	-	-	675,692
	(0.4%)	(39.9%)	(9.8%)	-	-	-	-	(9.0%)
Chemicals	379,459	66,358	1,730,436	154,159	-	5,259	-	2,335,700
	(28.8%)	(6.1%)	(72.6%)	(11.0%)	-	(2.2%)	-	(31.1%)
Maintenance, Repair, Spares	33,375	98,644	-	292,372	90,000	-	-	514,391
	(2.5%)	(9.0%)	-	(20.8%)	(14.7%)	-	-	(6.9%)
Transport and Utilities	4,722	10,230		191,700	77,500	-	-	284,152
	(0.4%)	(0.9%)	-	(13.7%)	(12.6%)	-	-	(3.8%)
Personnel Emolument	896,246	482,215	419,460	764,420	445,190	238,356	446,563	3,692,450
	(68.0%)	(44.1%)	(17.6%)	(54.5%)	(72.7%)	(97.8%)	(100.0%)	(49.2%)
Total O&M Costs	1,318,923	1,093,226	2,384,767	1,402,651	612,690	243,615	446,563	7,502,435
Revenue Collected minus O&M Costs	2,400,400	▲ 682,836	6,732,376	▲ 335,129	▲ 564,395	674,095	107,694	8,332,205

Source: Monthly Operation, Maintenance and Financial Monitoring Report 1994-1996 (MLRRWD)
Note : Revenue from flat rate includes the one from average assessment

As indicated in the table below, revenue collected from the sale of water in the study area averages at 2.64 Kshs/m3, which exceeds O&M costs of 1.25 Kshs/m3 by 1.39 Kshs/m3. However, in Nkubu, Chuka and Chogoria, the revenue can not even cover O&M costs and the short falls are 5.29 Kshs/m^3, 0.27 Kshs/m3 and 156.34 Kshs/m3, respectively.

Table 3.3-12 Unit Revenue and O&M Costs by Water Supply Scheme

Scheme	Annual Water Produced (m3)	Annual Water Revenue Collected (Kshs)	Annual O&M Costs (Kshs)	Unit Rate Water Revenue (Kshs/m3)	Unit Rate O&M Costs (Kshs/m3)	Cost Coverage (Kshs)
Meru W/S	1,622,484	3,719,323	1,318,923	2.29	0.81	1.48
Nkubu W/S	129,103	410,390	1,093,226	3.18	8.47	▲ 5.29
Isiolo W/S	1,507,652	9,117,143	2,384,767	6.05	1.58	4.47
Chuka W/S	1,249,846	1,067,522	1,402,651	0.85	1.12	▲ 0.27
Chogoria W/S	3,610	48,295	612,690	13.38	169.72	▲ 156.34
Maua W/S	102,760	917,710	243,615	8.93	2.37	6.56
Tigania W/S	1,373,736	554,257	446,563	0.40	0.33	0.08
Total	5,989,191	15,834,640	7,502,435	2.64	1.25	1.39

Source: Monthly Operation, Maintenance and Financial Monitoring Report 1994-1996 (MLRRWD)

The costs for Chogoria are distorted by the low volume of water supplies and to the lowest ratio of revenue recovery (28.1%) found in the study area.

Based on the above existing financial conditions of the water supply schemes, the financial situation of the study area can be briefly summarized in the following major remarks, which mainly relate to institutional matters of MLRRWD.

a) The average billing/m3 of water produced from ***Table 3.3-12*** comes to only 30% of the minimum tariff of KShs 9.0/m3, implying 70% losses. This is in close agreement to the unaccounted water ratio found during the Pilot Survey at Meru of 70%. Substantial increase in revenue can therefore be achieved by reducing this figure. This together with universal metering is therefore a prerequisite to cost recovery, and

b) In terms of the cost recovery, it would be also a prerequisite that drastic improvement in efficiency of meter reading and bill collection should be undertaken.

3.4 Initial Environmental Examination

3.4.1 Laws and Regulations on Environmental Aspects

The Kenyan government has well established national policies and strategies, covering economic development and population growth. However, aware of the need to protect the natural environment from unsustainable development, the Government, in 1994 formulated the National Environment Action Plan (NEAP).

Enforcement of Environmental Impact Assessments (EIA) and the establishment of environmental legislation are recommended in the NEAP; however, it has not yet been legislated. The Environmental Management and Co-ordination Act is now being discussed by parliament.

3.4.2 Water Quality of Existing Water Sources

Water quality standards for drinking water in Kenya follow closely those established by the World Health Organization (WHO). The Design manual for water supplies in Kenya stipulates bacteriorological and chemical water quality requirements. Water quality analysis is performed by the Water Quality and Pollution Control Laboratory. Chemical quality testing is performed on approximately 27 constituents, in addition to bacteriological examination.

A water quality survey for the proposed water resources was conducted under dry season conditions in Sep. 1996 and in the wet season during Mar. 1997 respectively. The survey in September 96 took samples from upstream of intakes at the proposed intake sites and from downstream of the respective towns. Downstream sampling was included to survey the influence of wastewater. Some projects which use spring water were sampled only at the intake and downstream. In the case of Meru town, water from Mujini springs was also sampled to check the water quality. The wet season samples were taken only from each of the proposed intake sites. Additionally, samples were taken from 20 community water supply schemes in Meru, one in Maua, and two in Tigania. Twenty seven chemical quality parameters and two bacteriological quality parameters were assessed. The water quality results are attached in ***Table 3.4-1 to 3.4-2*** and selected parameters are summarized in the following table. Although high coliform counts were recorded in the wet season, the water quality results at the intake sites show suitability as raw water sources for subsequent treatment.

Table 3.4-3 Water Quality Summary at Intake Sites

Parameters	Meru		Nkubu		Isiolo		Chuka		Chogoria		Maua		Tigania	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Turbidity	0.8	0.4	1.7	1.4	1.2	1.3	1.3	1.2	1.0	0.5	2.0	0.6	0.8	0.2
BOD	4	5	1	5	5	3	4	2	6	10	1	6	1	5
Coliform	210	0	160	300	525	50	110	20	110	10	185	25	50	10

Source: Water Quality Survey

Spot water quality monitoring was also conducted in Meru, Nkubu, and on Isiolo existing works. The samples recorded higher values of turbidity than the samples taken in September 1996, but indicate suitability for raw water sources for water supply schemes.

3.4.3. Screening and Scoping for Environmental Impact Assessment (EIA)

There are many guidelines existing such as those by the World Bank and so on. JICA however, also has their own guidelines. The Kenyan EIA guideline regulation is currently being discussed by parliament. Both guidelines use a check list method for screening and scoping and they are similar. Screening and scoping for the EIA for this Study has therefore been based on the JICA guideline, and modified appropriately to conform to the draft Kenyan guidelines.

The projects consist of 7 individual schemes which have no relation with each other. Components of each project basically are composed of an intake, transmission pipeline, water treatment facilities and distribution pipeline network. Surface water will be abstracted from rivers, however, alternatives such as groundwater, and springs have also been studied in the case of Isiolo water supply.

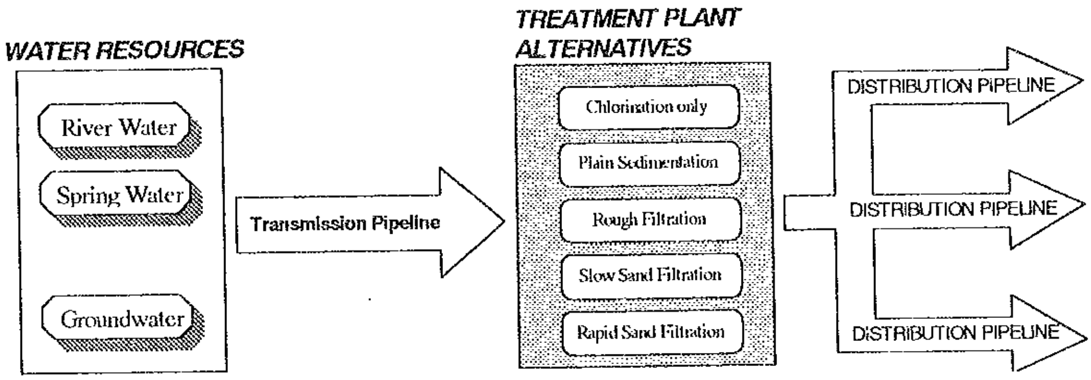


Figure 3.4-1 Schematic Project Components of the Projects

A screening check list for all the sites is provided below. This indicates the environmental concerns applicable to each site. Items identified as of definite concern "yes", or as questionable "?" are discussed by the Initial Environmental Examination (IEE).

Table 3.4-4 Screening Check List in Seven Town

ITEMS	Meru			Nkubu			Isiolo			Chuka			Chogoria			Maua			Tigania		
	Yes	No	?	Yes	No	?	Yes	No	?	Yes	No	?	Yes	No	?	Yes	No	?	Yes	No	?
1 Resettlement			●	●					●			●	●					●			●
2 Economic Activity	●			●					●	●			●					●			●
3 Transport		●			●			●			●			●			●			●	
4 Separation of Community		●			●				●		●			●			●			●	
5 Cultural Heritage		●			●			●			●			●			●			●	
6 Water Right and Common Right			●			●	●					●			●			●			●
7 Sanitation	●			●			●			●					●	●			●		
8 Waste Disposal		●			●				●		●			●			●			●	
9 Dangers		●			●			●		●			●				●			●	
10 Topography and Geology		●			●				●		●			●			●			●	
11 Soil Erosion			●	●			●				●			●				●		●	
12 Groundwater		●			●				●		●			●			●			●	
13 Lake, Marsh and River			●			●	●					●			●			●			●
14 Coastline and Sea		●			●			●			●			●			●			●	
15 Flora and Fauna			●			●			●			●			●		●				●
16 Weather		●			●			●			●			●			●			●	
17 Landscape		●			●				●		●			●			●			●	
18 Air Pollution		●			●			●			●			●			●			●	
19 Water Pollution	●			●			●			●			●			●			●		
20 Soil Contamination		●			●			●			●			●			●			●	
21 Noise and Vibration		●			●			●			●			●			●			●	
22 Land Subsidence		●			●				●		●			●			●			●	
23 Offensive Odor		●			●			●			●			●			●			●	

All the projects' components consist of small scale structures the impacts of which will not be serious. Environmental impacts during the construction stage will mainly affect the human environment. Most of the impacts are not serious, however careful attention needs to be paid to sensitive issues such as the Flora and Fauna in Mt. Kenya area. Environmental problems during the operation stage are divided into 3 groups shown below.

(1) Land acquisition problem may cause resettlement of residents, and degradation of the regional economy. This impact may be minor, nevertheless estimation of resettlement and regional economic activity scales will be necessary in the EIA.

(2) The wastewater problem is composed of water pollution and sanitation problems. No town ensures that adequate wastewater facilities are provided even now. A quantitative estimation for the wastewater volumes will be requested for the EIA.

(3) Several projects such as Isiolo, and Maua would appear to have limited raw water potential, and it will be necessary to clarify this. Information on groundwater potential is also insufficient. A detailed survey of the groundwater in Isiolo will be carried out in the next stage, and the EIA will reflect on its results.

Scoping for the EIA aims to clarify the potential environmental impacts through the IEE exercise.

Environmental impacts are evaluated at four levels, from the most serious level (A) to almost no impact (D). The check list result for seven projects is attached below. There are some alternatives for the water resources in Isiolo and EIA scoping includes all alternatives.

Table 3.4-5 IEE Check List in Seven Towns

No. Items	Meru	Nkubu	Isiolo	Chuka	Chogoria	Maua	Tigania
1. Human Environment							
1 Resettlement	D	D	D	D	D	D	D
2 Economic Activity	C	C	C	C	C	C	C
3 Transport	C	C	C	C	C	C	C
4 Separation of Community	D	D	D	D	D	D	D
5 Cultural Heritage	D	D	D	D	D	D	D
6 Water Right and Common Right	C	D	C	D	C	C	D
7 Sanitation	C	C	C	C	C	C	C
8 Waste Disposal	D	D	D	D	D	D	D
9 Dangers	D	D	D	D	D	D	D
2. Natural Environment							
1 Topography and Geology	D	D	D	D	D	D	D
2 Soil Erosion	C	C	D	D	D	D	D
3 Groundwater	D	D	C	D	D	D	D
4 Lake, Marsh and River	C	D	D	D	D	D	D
5 Coastline and Sea	-	-	-	-	-	-	-
6 Flora and Fauna	C	C	C	C	C	C	C
7 Weather	D	D	D	D	D	D	D
8 Landscape	D	D	D	D	D	D	D
3. Environmental Pollution							
1 Air Pollution	D	D	D	D	D	D	D
2 Water Pollution	B	B	B	B	B	B	B
3 Soil Contamination	D	D	D	D	D	D	D
4 Noise and Vibration	D	D	D	D	D	D	D
5 Land Subsidence	D	D	D	D	D	D	D
6 Offensive Odor	D	D	D	D	D	D	D

Evaluation Key : A Serious impact expected
B Minor impact expected
C Uncertain (may become clear on investigation)
D Almost no impact expected, no need for EIA

CHAPTER IV DESIGN CRITERIA AND WATER DEMAND PROJECTIONS

4.1 Design Criteria

4.1.1 Per Capita Consumption and Service Levels

The per capita consumption rates recommended in the 1986 MOWD Design Manual were found by the consumer survey to be reasonable for metered connections. It was also found however that consumption of up to 5 times higher is to be expected if meters are not connected. This is an important finding since it supports the MLRRWD's current policy to introduce full metering to its supplies and, assuming full metering is affected, it supports the use of design manual consumption rates, as given below, for design.

Table 4.1-1 Design Water Consumption Rates

Category			unit	Demand
Individual connections	Rural	High potential land	l/c/d	60
		Medium potential land	l/c/d	50
		Low potential land	l/c/d	40
	Urban	High class housing	l/c/d	250
		Medium class housing	l/c/d	150
		Low class housing	l/c/d	75
Water Kiosks/communal water points	Rural		l/c/d	10
	Urban		l/c/d	20
Schools		Boarding	l/c/d	50
		Day school with WC	l/c/d	25
		Day school without WC	l/c/d	5
Hospitals		Regional	l/bed/d	400
		District	l/bed/d	200
		Other	l/bed/d	100
		Out patients	l/patient/d	20
Dispensary/Health centre			m3/day	5
Hotels		High class	l/bed/d	600
		Medium class	l/bed/d	300
		Low class	l/bed/d	50
Offices			l/c/d	25
Bars			l/day	500
Shops			l/day	100
Unspecified industry			m3/ha/d	20

Results of the consumer survey also indicated that, assuming good reliability of water supplies, higher affordability and connection levels than suggested in the MOWD Design Manual could be expected at the current tariff level. However, in order to achieve greater cost recovery, it will be necessary to increase the current tariff levels in the future, which will have the effect of reducing this high level of affordability. For the present purposes therefore, the MOWD design guidelines for levels of individual connections, as given below, have been used:

Table 4.1-2 Service Levels as Percent of Individual Connections within Service Areas

Category		Initial	Intermediate	Design Horizon
Rural	High	20%	40%	80%
	Medium	10%	20%	40%
	Low	5%	10%	20%
Urban	High	100%	100%	100%
	Medium	100%	100%	100%
	Low	10%	30%	50%

4.1.2 Water Quality

The MLRRWD policy is to supply water for drinking purposes to levels similar to the World Health Organization water quality guidelines. These standards have therefore been adopted for this study.

4.1.3 Water Sources

(1) Quality

In order to achieve the required water quality standards with low operating costs, good quality raw water is required. Borehole water, springs and intakes in protected forests are occasionally problematical in Kenya due to high levels of iron, manganese and fluoride, but they are generally of good quality and require low levels of treatment. They are therefore usually preferred. Catchments that contain agricultural land however are characterised by high erosion rates during rainy seasons. This results in high turbidity levels in addition to significant levels of bacteriological and chemical pollution. Intakes on rivers flowing through agricultural land are not therefore favoured if an alternative better quality source is available.

Nevertheless, wherever intakes are located, it is necessary to provide appropriate catchment protection to ensure against future deterioration of raw water quality.

(2) Reliability

For the purposes of this study the safe yield of surface water sources has been estimated in accordance with the procedures suggested in the Kenya National Water Master Plan, as the difference between the 95% daily low flow and the minimum daily flow. The minimum daily flow being the proposed downstream maintenance flow for the river.

The 95 % daily low flow and the river maintenance flow for each proposed intake site have been obtained from an analysis of existing gauging stations in the vicinity, and by correlation of catchment characteristics, supported by flow measurements is the intake sites. The safe yield of surface water sources in given in ***Table 4.1-3***.

4.1.4 Intakes

Intake design has been governed by the need to reduce operation and maintenance activities to a minimum. Features include the intake being located at right angles to direction of flow with inlet velocities of less than 0.1 m/s, at a level well above the stream bed level. A submerged entry provides protection against floating material, and coarse screens will protect against the entry of large submerged objects. Fine screens, which require regular cleaning will be located at the downstream end of the raw water pipe at the entry to the treatment plant. The intake will include a flushing device to clear the intake chamber, and any accumulated silt upstream of the intake. Where a weir is required to ensure a minimum depth of flow at the intake location, a Crump Weir, which has good silt transport characteristics will be used where space allows.

The raw water pipeline will be designed to ensure a minimum velocity of 0.75 m/s to avoid siltation in the pipeline. To maintain this minimum velocity during the initial years of the project, higher flows than necessary to meet demand will be passed through the pipeline. Any excess flow will be diverted back to the river using an overflow chamber located at the inlet to the treatment works.

The difficult and rocky terrain which many of the raw pipelines will traverse will require the use of steel, or ductile iron pipes.

4.1.5 Water Treatment

The required level of water treatment for each scheme will depend upon the raw water quality, as discussed in Chapter V. The design philosophy however will remain the same: to provide the simplest and minimum level of treatment required to meet the water quality standards.

(1) Mixing and Flocculation

Where chemical treatment is required, simple hydraulic mixing and flocculation will be provided.

(2) Sedimentation

Due to their relative ease of operation, horizontal sedimentation tanks are proposed. Plain sedimentation without chemical coagulation, requires a surface loading rate of 0.75 m3/m2/hr (Smethurst, & IWEM). For chemical coagulation, a higher rate of 1.0 m3/m2/hr is usual, but it is suggested that by using the more conservative loading rate of 0.75 m3/m2/hr, it should be possible to reduce or eliminate the use of chemicals during periods of good quality raw water. Normal desludging will be hydraulically, but manual desludging of the tank will be required at intervals dependent upon the raw water quality. A minimum of two such tanks will therefore be required so that one can remain in operation while the second is desludged manually. The floor of the tanks will be designed to facilitate desludging.

(3) Filtration

Conventional rapid sand filters using a conservative loading rate of 5 m3/m2/hr are proposed. The design will be similar to current practice in Kenya to which operators have been trained and are familiar. Backwashing will be by water without air scour, but at a sufficient rate to ensure filter bed expansion of a minimum of 20%. Due to the need to backwash filters, and to occasionally replace filter sand, the loading and number of filters at each plant will be designed to allow full flows through the works while one filter is not in use.

Roughing filters shall be designed using similar loading rates and appurtenances to rapid sand filters to enable them to be upgraded in future should this be found necessary due to deterioration raw water quality.

(4) Disinfection

Disinfection will be by use of tropical chloride of lime or calcium hypochlorite solution, using gravity drip feeders at a rate sufficient to provide a residual level of 0.5 mg/l free chlorine after 30 minute contact time.

(5) Clear Water Storage

Storage at the outlet of treatment plants is required to provide chlorine contact time if this can not be provided within the transmission system before the first supply connections. In the case of pumped supplies, it is required to provide the necessary wet well storage for pumping. It is also strategically a useful location to provide some of the required storage for the distribution system. The amount of storage will depend upon the particular circumstances, and will tend to vary from a minimum of 30 minutes storage at average water demand.

(6) Buildings and site works

Each treatment plant will be provided with an administration building that will include office, workshop, store, laboratory and washroom sized appropriately for the plant.

When rapid sand filters are used, a chemical building and pumping station will be included. Storage facilities sufficient for about 3 months chemical usage will be provided, together with appropriate chemical handling, mixing and dosing plant.

The treatment plant sites shall be provided with adequate access, lighting to facilitate night time operation, and security fencing.

4.1.6 Water Distribution

The distribution systems will be designed using the following principals:

(1) Distribution pipelines *from* storage reservoirs to be designed with a peak factor of 2.

(2) Transmission mains delivering *to* storage reservoirs to be designed to pass the projected average daily water demand, plus the peak flow to any areas supplied directly from the pipeline.

(3) Pressures to be kept as low as practicable to limit losses by the inclusion of suitably located break pressure tanks, with a minimum pressure of 6m.

(4) Careful alignment of pipelines to avoid high and low points, and the location of service connections at high points to aid release of air and drainage from kiosks.

4.1.7 Storage

Storage will be provided at strategic locations throughout the supply area. For *rural* areas, the reservoirs will be for balancing peak flows and will be sized to provide a capacity amounting to 12 hours average water demand for the area it supplies. For *urban* areas, supplied by gravity, an additional 12 hour storage will be provided as an emergency supply.

4.2 Human and Livestock Projections

4.2.1 Population

Baseline population and historic growth rates for the different schemes are given in Section 2.3 above. Future population projections were estimated after consideration of these baseline figures together with a review of a number of past studies and reports and have also taken a number additional factors into account, including:

(1) District Development Plans

(2) National Master Water Plan

(3) Water Resources Assessment Project for Meru and Isiolo Districts

(4) Analysis of past census results and trends

(5) Views of District Planning Officers

(6) Population pressures

(7) Land potential and land costs

(8) Inward and outward migration

(9) Government population policies

The growth rates adopted for future projections varied with the particular circumstances.

Generally, based on the analysis of historic data, growth rates were found to be influenced by the degree of urbanization within the supply area. Urban areas were found to be growing at an average of 5.0% per annum in the supply areas, whereas rural areas were growing at a slower rate of 2.8% per annum. Also, based partly on historic evidence, and also on Government policy, it was assumed that the current very high growth rates will slow down over the design horizon but, due to resultant population pressure on rural land, the reduction in growth would be felt mostly in the rural areas, and that the urban areas would continue to grow at similar rates to present.

In the case of Chuka, the District Planning Office had already made very high initial projections of 12% growth per annum, due to the establishment of new District Offices in the town. The intense construction activity in the area would appear to suggest that the use of this figure is justified, and this has therefore been adopted, but for the urban areas only. For similar reasons, a higher than average growth rate was also assumed for the urban area of Maua. In this case however, as the location of the new District Headquarters offices is actually outside the supply area, a more moderate growth rate of 7% was adopted.

Growth rates were assumed to vary gradually over the plan horizon using the figures given below:

Table 4.2-1 Annual Population Growth Rates

Scheme	Year	Rural			Urban		
		High Potential	Medium Potential	Low Potential	High Class	Medium Class	Low Class
General	1997	3.0%	2.5%	2.0%	5.0%	5.0%	5.0%
	2000	2.5%	2.0%	1.0%	5.0%	5.0%	5.0%
	2010	2.0%	1.0%	1.0%	5.0%	5.0%	5.0%
Chuka	1997	3.0%	2.5%	2.0%	11.5%	11.5.0%	11.5%
	2000	2.5%	2.0%	1.0%	12.0%	12.0%	12.0%
	2010	2.0%	1.0%	1.0%	7.0%	7.0%	7.0%
Maua	1997	3.0%	2.5%	2.0%	7.0%	7.0%	7.0%
	2000	2.5%	2.0%	1.0%	7.0%	7.0%	7.0%
	2010	2.0%	1.0%	1.0%	7.0%	7.0%	7.0%

The resultant projections are given in ***Appendix K*** and are summarised below:

Table 4.2-2 Population Projections

Project \ Year	1989	1997	2000	2010
Meru	125,191	165,980	183,527	251,668
Nkubu	6,882	9,471	10,648	15,611
Isiolo (3)	27,987	38,518	45,544	65,471
Chuka *(1)*	31,265	41,502	46,238	64,433
Total	62,784	81,034	88,861	116,577
Chogoria	25,148	32,134	34,920	44,376
Maua	3,223	5,537	6,763	13,344
Tigania (2)	51,826	63,891	68,891	83,121

Notes (1) *Chuka intake and treatment plant to be sized for a larger area than required to serve the Municipal area alone.*
(2) *Figures for new Tigania scheme only.*
(3) *Includes allowance for seasonal migration*

Annual details of the population forecasts for each land and housing category are given in ***Appendix K***.

4.2.2 Schools, Institutions, Commercial and Industrial Growth

Growth projections for educational establishments, institutions, commercial premises and industry have been based on the following criteria:

(1) The proportion of pupils to population will decline slightly from the present high level of 32%, due to the projected decline in growth rate to 30%.

(2) The proportion of boarding schools, schools with and without WCs will remain constant throughout the design horizon.

(3) Institutional, commercial and industrial activity will grow in direct proportion to population growth.

(4) All educational establishments, commercial premises, and institutions will receive water connections.

(5) Industries located within urban areas will receive water connections. However rural industries, such as coffee factories, will continue to use untreated water from local streams for their water processing requirements.

4.2.3 Livestock

Existing livestock ownership levels have been estimated using the results of the WRAP livestock census conducted in Meru District during 1988. This indicated approximately

200 livestock units per 1000 population. The socio economic survey indicated a similar figure for the permanent residents of Isiolo. However, after consultation with the District Offices, a much higher figure was adopted to allow for the nomadic nature of the surrounding areas, and where large herds of livestock seasonally migrate to the town. Details are given in ***Appendix K***.

Livestock population projections have been based on WRAP's scenario 1, which assumed that increasing pressure on land will constrain future growth of livestock to around 2 % per annum.

However, with fully metered water supplies, the use of potable water for watering livestock will be limited, with many households preferring to take their livestock to local streams. A figure of 15% of the livestock water demand being supplied from the metered supply has been suggested as being a reasonable allowance.

4.3 Water Demand Projections

Water demand projections based on the design criteria and population projections given in Sections 4.1 and 4.2 respectively are detailed for each category of consumer and for each year over the design horizon in ***Appendix K***, and are summarised below:

Table 4.3-1 Total Water Demand Projections for 2000 and 2010

Project Year	Meru m3/d	Nkubu m3/d	Isiolo (3) m3/d	Chuka (1) m3/d	Chogoria m3/d	Maua m3/d	Tigania (2) m3/d
2000	13,188	1,142	6,692	2,192	1,578	719	2,125
2010	22,725	1,915	10,671	4403	2,886	1,493	3,778

Note (1) *Chuka supply area only*
(2) *New Tigania supply area only*
(3) *Includes allowance for seasonal migration*

Table 4.3-2 Breakdown of 2010 Water Demand

Project	Meru m3/d	Nkubu m3/d	Isiolo m3/d	Chuka (1) m3/d	Chogoria m3/d	Maua m3/d	Tigania (2) m3/d
Domestic	17,311	1,577	5,626	3,659	2,371	1,181	3,193
Livestock	306	25	258	100	61	16	127
Industry	3,627	91	234	206	106	83	64
Institution	779	87	4,792	160	239	54	184
Health	217	73	120	55	71	46	51
Commerce	485	63	140	223	36	114	159