APPENDIX M

BASIC PLAN

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURE

1. CONDITION OF BASIC PLANNING

1.1 SERVICE LEVEL

(1) Water Supply Methods

Water supply methods were classified into the following levels:

a) Individual house connection
b) Yard connection
c) Public standpipe
d) Well
e) Rainwater harvesting

To improve sanitary conditions, it would be desirable to employ the individual house connection method. However, to provide as many residents as possible with a supply of water with limited funds, it would be preferable to use the yard connection, public standpipe, or well method all of which are inferior to the house connection method.

Judging from the conditions of the existing water supply facilities in Kibungo Prefecture, the public standpipe method would be adopted in areas having piped water supply systems.

The well method would be adopted in areas where shallow well construction would make it possible to utilize the high quality groundwater.

In the sparsely populated mountainous areas where proper water sources are not available, the rainwater harvesting method would be adopted.

The maximum distance from the beneficiary area to the proposed public standpipe and/or well shall be less than 1 km.

(2) Water Supply Systems

The water supply plan would be established by classifying the water supply systems into the following four levels:

a) System-1
The public standpipe method using surface water. In this system, the surface water will be treated and distributed through pipes and supplied to users via public standpipes. One standpipe would cover approximately 200 families.

b) System-2
The public standpipe method using groundwater. This system will distribute high quality groundwater requiring no treatment through pipes. The service level should be one standpipe for approximately 150 persons.

c) System-3
The well method. The maximum yield of one well would be 10 m3/day including the consumption of the public facilities. One well is estimated as able to supply water to approximately 75 households.

d) System-4
The rainwater supply method. Water is collected by roof catchment. The service block for System 4 would be per household.

1.2 TARGET YEAR

The Project's target year is the year 2000 on the basis of the national development policy.

1.3 PLANNED SERVICE AREA

The planned service area of Phase III Basic Plan is classified as Zone E which was discussed in Section 3.2 of Appendix L.

2. PROPOSED WATER SUPPLY AREA AND SYSTEMS

2.1 SELECTION OF WATER SUPPLY SYSTEMS

The following 4 systems would be adopted as a water supply system in Phase III Basic Plan.

System 1:	Piped water supply system with treatment facilities and public standpipe
System 2:	Small scale piped water supply system by groundwater with pump facilities and public standpipe
System 3:	Shallow wells with manual pump
System 4:	Rainwater harvesting

The service area and population served of communes by each system are tabulated in Table M.1. It is standing out that the southern area of Kibungo Prefecture, which has not yet developed or improved comparatively, has a large population served.

2.2 POPULATION, AREA AND WATER DEMAND OF PHASE III PLANNING AREA

(1) Future Population

Kibungo Prefecture's population forecast for the year 2000 was based on the average annual population growth rate that was derived from the 1982 to 1988 population growth rates for each Commune. The calculated average annual population growth rate for Kibungo Prefecture is 3.3%. Kibungo Prefecture's year 2000 population was estimated as being 653,500.

Future population density in 2000 is shown in Figure below.

Future Population and Growth Rate

Commune	Population (1988)	Growth Rate (%)	Population (2000)
BIRENGA	43,400	2.8	60,400
RUKIRA	36,000	4.3	59,400
RUSUMO	64,100	6.5	136,200
SAKE	40,800	3.8	63,700
MUGESERA	46,100	2.2	60,000
KIGARAMA	39,600	2.3	52,000
KABARONDO	32,000	3.2	46,500
KAYONZA	26,000	1.8	32,200
RUTONDE	31,000	2.2	40,300
MUHAZI	38,500	3.0	55,100
RUKARA	35,500	2.5	47,700
TOTAL	433,000	3.3	653,500

Source: The Study Team, 1990

Each commune's population forecasts and each secteur's forecast for the year 2000 are listed in DATA BOOK.

(2) Population of Phase III Planning Area

The studied zone area which is defined as given in Section 3 of Appendix L for each secteur and the studied population and area covered by each water supply system are listed in Table M.1.

(3) Water Demand of Phase III Planning Area

1) Unit of Water Demand Calculation

The water supply unit for the Rural Drinking Water Supply Manual (Draft) of the Director General of Water in MINITRAPEE was adopted for estimating the water demand. The unit of Water Demand is given in Table M.2.

Based on MINITRAPEE's Unit of Water Demand given above, the design water demand of the Basic Plan of the Phase III Project was calculated with the following modifications:

- Where a piped system will be adopted, the domestic water consumption shall be 130/liters/household/day (including livestock consumption), and 90 liters/household/day (including livestock consumption).

- Water use by schools shall be based on 5 liters/student/day. 10 liters/student/day would be excessive.

The total domestic water consumption was estimated based on the number of households that was derived by dividing the year 2000's forecasted population by six (the average number of persons per family).

The total public water consumption was estimated by taking the actual number of hospital beds and the number of school children in August 1991 and multiplying the resultant number by the growth rates for the year 2000.

In System 4 (rainwater harvesting) installation areas, where System 2's per household initial cost and operation and maintenance cost will be too high, it is planned to secure a minimum water consumption of 3 liters/person/day during dry seasons.

2) Planned Water Supply

a) Average Daily Water Consumption
Based on the unit water supply amount, the average daily water consumption was calculated using the population figure and number of public facilities in each Sector.

The average daily water consumption of each water supply area was obtained from the ratio of the water supply area to the area of the Sector.

b) Maximum Daily Water Consumption
The maximum daily water consumption to be used as the basis for determining the capacities of the water supply facilities will be set up by referring to the standards used by Rwanda and Rwanda's neighboring countries as follows:

i) Large and Medium Water Supply Areas (Systems 1 and 2):
By taking into account the head losses and fluctuations in the water use amount, the maximum daily water consumption of each water supply system with distribution pipes was set

as being 1.15 times the system's average daily water consumption.

$$\text{ratio of load} = \frac{\text{Maximum Daily Water Consumption}}{\text{Average Daily Water Consumption}} = \frac{115}{100} = 1.15$$

ii) Small Water Supply Areas (Systems 3 and 4): The maximum daily water consumption in each small water supply area was set as being equivalent to its average daily water consumption.

c) Water Intake Amount

i) Large Water Supply Area (System 1): By taking into account the washing water in treatment plants, each system's daily water intake amount was set as being 1.1 times its maximum daily water consumption.

ii) Medium and Small Water Supply Areas (Systems 2 and 3): Each system's daily water intake amount was set as being equal to its maximum daily water consumption.

d) Maximum Hourly Water Supply Amount
The maximum hourly water supply amount will be the basis for determining the diameters of water distribution pipes.

The maximum hourly water supply amount is the amount of water that is taken at one time from one supply system's service connections, such as house connections, standpipes, faucets, etc. This can be shown by the following equation:

$$q = K \times \frac{Q}{24}$$

Where, q: design maximum hourly water supply (m3/hr)
Q: design maximum daily water supply (m3/day)
K: coefficient (ratio of the maximum hourly water supply to the average hourly water supply)

As kiosks with standpipes are to be adopted for the Project, water will be supplied for twelve hours a day; thus, K was set as 2.0.

e) Capacity of Reservoir Tank
The capacity of a reservoir tank shall be half of the maximum daily water supply amount by taking into account the service hours of kiosks (6:00 to 18:00).

f) Design Pump Discharge
To minimize the sizes of water supply facilities, it is planned to operate the pumps 24 hours a day. The design pump discharge will be obtained by the following equation:

$$\text{Design Pump Discharge} = \frac{\text{Minimum Daily Water Supply Amount}}{24 \times 60} \quad (m3/min)$$

(4) Design Criteria and Capacity

The design criteria for the preliminary design are in accordance with MINITRAPEE's design manual (draft) and Japanese design criteria for waterworks facilities.

The design criteria for the piped water supply systems for Systems 1 and 2 are planned as follows:

Item	System 1	System 2
1. Daily Maximum Supply:	Daily Average Supply X 1.15	Same as for System 1
2. Planned Intake Amount:	Daily Maximum Supply X 1.1 (including washing water for filtration material)	Daily Maximum Supply
3. Planned Treating Amount:	Daily Maximum Supply	——
4. Pump Operating Time:	24 hr a day	24 hr a day
5. Planned Pump Discharge:	Daily Maximum Supply/24 hr	Same as for System 1
6. Distribution Reservoir Capacity:	Daily Maximum Supply/2	Same as for System 1
7. Hourly Maximum Supply:	(Daily Maximum Supply/24) X 2 (to be used to determine the distribution pipe diameter)	

(5) Choice of Water Resources for the System Design

By taking into consideration the development priority of water resources(refer Sections 4.6 and 5.3.5), the basic water resource development concept for each system can be set up as follows:

System 1:
1) First priority should be given to such springs that have a stable yield amount and good water quality.
2) For designing purposes, a spring's water yield should be its minimum yield during the dry season.
3) The shortage of spring water needed to fulfill the design water supply amount should be supplemented by treated lake water.

System 2:

1) Priority should be given to the use of spring water. However, in areas where, during the planning stage, it is uncertain if sufficient amounts and satisfactory qualities of water can be obtained, consideration should be given to the development of groundwater by drilling a well.
2) During the project implementation stage, the location of springs, the water yield, and the water qualities should be reexamined and a priority assigned to the use of the direct water intake method or the horizontal boring method for the development of springs.
3) For designing purposes, a spring's water yield should be its minimum yield during the dry season.
4) The shortage of spring water needed to fulfill the design water supply amount should be taken from wells.

System 3:

1) Groundwater use by drilling wells.
2) First priority of "Sa-Development Potentiality Class" should be given.

System 4:

1) Harvesting rainwater from roofs.

2.3 SYSTEM 1

(1) General

System 1 will be installed in those areas having populations greater than 21,000 where the installation of System 3 (handpump type) will be difficult and where the infrastructure, such as roads and electricity supply facilities, are well developed.

(2) Population served and Water Demand

System 1 will be installed in two areas: Muhazi and Sake. The outline of the planned areas is shown in the following table.

Name of Area	Served Area(km2)	Population 2000	Density 2000	Average Daily Consumption(m3/day)
1. MUHAZI	39.9	21,944	550	518.2
2. SAKE	54.1	33,865	626	774.9
TOTAL	94.0	55,809	594	1,293.1

(Detailed conformation can be referred in Table M.3.)

(3) **Water Source**

As it will be difficult to obtain groundwater, the water of lakes Muhazi and Sake will be used. Thus, the installation of purification facilities will be required for both areas. In the Sake area, however, 200 m3/day of spring water, including new development, will be used. Thus, the water supply system for the Sake area will be a combined surface water and spring water use type.

(4) **Intake Facilities**

In both the Muhazi and Sake area, water for installing System 1 will be taken from lakes. As the shorelines of the lakes are extremely contaminated by such objects as decomposed aquatic plants and algae, it will be necessary to take into consideration appropriate measures against their inflow when selecting the water intake facility type.

Following area the possible water intake facility types:

1) Intake tower type
2) Floating type
3) Intake crib type

The floating type is to be adopted for the following reasons:

- At about 100 m off the shorelines of lakes Muhazi and Sake, the water quality is good and contains no floating objects. The floating type intake facility enables taking water at offshore points.
- The intake tower type facility also enables taking water at offshore points, but it costs more to construct than the floating type intake facility.
- The intake crib type facility is insecure because floating objects may clog the filters and cause the intake capacity to decrease.

As a result of the field surveys, the intake points at both lakes shall be 100 m off the shoreline.

(5) **Decision of Purification Method**

A regards selection of purifying methods, the most suitable one shall be chosen with provision of disinfection equipment, from among the following in consideration of the quality of raw water, amount of filtrate, procurement of site, construction costs, maintenance expenses, convenience of management, level of management, etc. (see Fig. M.1).

- Method solely dependent upon chlorination
- Slow sand-filtration
- Rapid sand-filtration

1) Chlorination

In case the raw water quality remains unchanged throughout the year, disinfection of the water depends solely upon this method.

2) Slow sand-filtration

Slow sand-filter stands eminent in this method. The so-called filter-film produced or formed biologically by the accumulated inorganic and organic impurities in the filter layers, purifies the influx through the processes of screening, absorption and biochemical action; the purifying force is so effective that even very small quantities of ammonia, manganese and other odorgenerating matters can be removed.

The filtrate is of high sanitary safety and of good quality. Although no technical proficiency required, labor for scraping of the filterbeds needed. When the turbidity of raw water is low, slow sand-filtration will prove preferable, because, in such cases, coagulation effect by chemicals is not necessarily excellent and, at the same time, uneconomical, that is, more expensive. According to the quality of raw water, setting basins of common type or chemical-treatmentary sedimentation basins might be provided or no provision of sedimentation basins can be considered.

3) Rapid sand-filtration

In this method, coagulation-settling basins and rapid sand-filters play the major part of operation. In this type of basin, sands of larger size than that in slow filters are used, and filtration is carried on with much higher velocity than in the slow filters; the prerequisite to this operation is that the clay particles, bacteria and algae, etc. contained in the influx are in advance coagulated in the form of flocks easy to be caught by the filter layers.

Regarding this type of filtration, it is presumed that the flocks are caught, not by the film formed on the surface of the filter layer, but by the adhesion brought by physicochemical action on the surface of the filter media and between the flocks themselves (coagulation within layers, flock-formation).

By this method, large quantities of water can be treated in a small area without human labor, but a good adequate pretreatment is indispensable and, in addition, high rate proficiency and minutest caution required for satisfactory results. In the case of rapid filtration, coagulation by chemicals is indispensable.

Minute suspensions in the raw water must be coagulated as flocks prior to filtration process, or most of the suspensions will be passed through the sand layers without being arrested. As to the problem of which of the two basins ie. sedimentation of filter basin should perform the work of turbidity removal; there are two ways or principles.

One is the traditional course where, by coagulation attended by mixing and flock-formation, such flocks as steady and liable to settle are produced and led to settling basins. Thus the water conditioned will be led into the filter basins under desired conditions.

In other words, by extending the period of filtering operation, economical operation of filter basins is contributed; the other which is usually employed in periods of comparatively low turbidity, intends to check the growth of flocks by conducting coagulating operation only and without settling process, intends to remove turbidity in the filter basins. This latter is termed direct filtration.

The purification method to be adopted in the system will be decided based on the following criteria.

The qualities of raw water in Muhazi and Sake area are given as below.

	MUHAZI System	SAKE System
Turbidity (NTU)	4.5	12.5
Color (APHA)	40	150
Ph value	8.5	8.5
Coliform group (MPN/100 ml)	> 1000	> 1000

In view of the content of the coliform group, turbidities, and the amount of floating objects, such as decomposed aquatic plants and algae, in the waters of lakes Muhazi and Sake, it would be inappropriate to adopt the slow sand filtration method; thus, the rapid sand filtration method shall be adopted.

(6) Water Purification Facilities

It may be possible to install the following two types of water purification facilities for Project use:

Type A: High rate coagulosedimentation basin and gravity rapid sand filter

Type B: Portable-type purifier

As shown in Table M.4 and Fig.M.2 - M.5, Type B would be cheaper to construct and easier to operate and maintain than Type A. Type B, having the following merits, is to be adopted:

1) The basic design concept of the portable-type purifier for Project use is a compact version of the normal large-scale water purification plant. The portable-type purifier will have the same functions (quick mixing, slow mixing, inclined-boards settlement, rapid filtration) as the large-scale water purification plant. Therefore, the purifier will be very reliable.

   As each function of the purifier is self-adjusting, no fine operational adjustments will be required. The purifier is easy to operate; it does not require a highly qualified operator.

2) Not only is the lake water very turbid, it contains iron, manganese, and other organic matter. The contents vary seasonably. To handle this particular situation, it would be necessary to fully utilize the functions of the portable-type purifier. To treat the lake water through the use of other types of purifiers would be difficult.

3) For the Project, three portable-type purifier units will be installed in parallel. As each unit will operate independently, they can be stopped easily for maintenance purposes. Even if one unit is shut down for some reason, such as repairs, the remaining two units will be able to treat 66.6 to 70% of the planned supply amount of water.

4) Each of the three purifier units that operate in parallel will have 1/3 of the planned water purifying capacity. The purifiers will be fabricated as small-sized units. Each unit will have following equipments:

   . Raw water distribution tank
   . Chemical dosing equipment (Al, CaOCl and Lime)
   . Mixing tank (rapid and slow)
   . Sedimentation tank with baffle board
   . Rapid filtration equipment
   . Washing water tank
   . Treated water reservoir
   . Pump facilities

   Most portions of the purifier units can be manufactured and fabricated in Japan, thus minimizing the installation work at the sites.

5) As many of the assembling parts for the purifier units will be fabricated into compact units by the manufacturer and then be shipped to the installation sites, they will not be subjected to loss or theft.

6) As the purifier units are portable, it will be possible, if necessary, to relocate them in the future.

7) Each function of the portable-type purifier is utilized in the educational models of the water purification units that are normally installed at water treatment training centers in developing countries. This type of purification unit is well known by water treatment operators in those countries.

(7) Transmission Type

A pump is to be used to deliver water from the purification facilities to the distribution reservoir. A turbine pump that is suitable for high water head will be installed.

A water hammer will be caused in the pipeline by the sudden stopping of the pump or by the sudden closing or opening of the valve, and the pipeline will be subjected to a strong instantaneous dynamic hydraulic pressure. Thus, piping material shall be strong enough to withstand the hydraulic pressures. For this reason, ductile cast iron pipe (DCIP) that is strong, easy to install, and anticorrosive, shall be used.

(8) **Distribution Reservoir**

It is planned to convey the water from the distribution reservoir to the public standpipes by gravity flow. Thus, the reservoir would be located at a high elevation. By taking into account the serving times (6:00 to 18:00) of the public standpipes. The reservoir would be able to store one half of the maximum daily supply amount.

(9) **Distribution Pipe**

Polyvinyl chloride (PVC) pipe that is economical and easy to install is obtainable in Rwanda and is to be used for the distribution pipelines.

(10) **Water Distribution Method**

The service level of water distribution shall be the public standpipe type. By taking into consideration the certainty of water fee collection, kiosks with public standpipes shall be installed.

2.4 SYSTEM 2

(1) **General**

System 2 will utilize high quality spring water and pumped up groundwater without treatment. This System will be installed in highly populated areas where hand pump installation (System 3) is difficult. This is the same type of system installed in Nyankora under the Phase I Project.

(2) **Population Served and Water Demand**

System 2 installation areas and each area's water supply plan are outlined in the following Table.

Block Name	Served Area(km2)	Population 2000	Density 2000	Water Demand (m3/day)
1. KAYONZA-1	12.9	4,374	339	100.4
2. KAYONZA-2	8.2	3,508	428	80.3
3. RUTONDE	6.0	3,720	620	80.7
4. KABARONDO	15.7	5,956	379	133.3
5. BIRENGA	9.3	3,588	386	77.8
6. RUSUMO-1	15.0	7,300	487	171.2
7. RUSUMO-2	13.8	8,292	601	199.0
8. RUSUMO-3	21.3	7,278	342	170.5
Total	102.2	44,016	431	1,013.1
Average	12.8	5,500	430	127.0

The water demands of systems by each sector are given in Table M.6 and locations are given in DRAWINGS of Volume IV.

(3) Outline of System

System 2 is a piped water supply system utilizing high quality spring water and pumped up ground water without water treated as water source.

This system consists of the following components:

1) Well
2) Pump
3) Transmission Pipe
4) Distribution Reservoir (High level tank)
5) Distribution Pipe
6) Public Standpipe (Kiosk)

(4) Water Source

The water source for System 2 will be mainly good quality groundwater having a stable amount.

In the Rusumo-3 Area, a spring (30 m3/day) that is used for an existing water supply system will be utilized as the water source. A 60 m deep, 8 inch diameter tube-well is planned to supply 100 m3/day of groundwater. Each System 2 installation area's water source dependence rate is listed in the following Table.

Block Name	Groundwater (m3/d)	Spring (m3/d)	Total (m3/d)
1. KAYONZA-1	115.4	0.0	115.4
2. KAYONZA-2	92.3	0.0	92.3
3. RUTONDE	92.8	0.0	92.8
4. KABARONDO	153.3	0.0	153.3
5. BIRENGA	89.5	0.0	89.5
6. RUSUMO-1	196.8	0.0	196.8
7. RUSUMO-2	228.9	0.0	228.9
8. RUSUMO-3	166.1	30.0	196.1

(5) Transmission Pipe

Ductile cast iron pipes (DCIP) are to be used for System 2 for the same reason it is used in the System 1 installation (see 2.3.7).

(6) Distribution Reservoir

(See 2.3.8)

(7) Distribution Pipe

(See 2.3.9)

(8) Type of Distribution

(See 2.3.10)

2.5 SYSTEM 3

(1) General

System 3 is a handpump installation type. Its per capita capital cost and per household operation and maintenance cost will be less than those of Systems 1 and 2. Among the Systems that satisfy the basic development policy for the Basic Plan of the Project, System 3 is the most economical.

System 3 will be adopted in all areas where shallow wells are suitable.

(2) **Population Served and Water Demand**

System 3 installation areas are listed in Table M.8. The water supply plan for each commune in those areas is outlined in the following Table.

Commune	Service Area (km2)	Population 2000	Density 2000	Water Demand (m3/day)
RUKARA	158.4	27,428	173	507.0
MUHAZI	0	0	0	0
MUGESERA	127.4	51,802	407	886.9
SAKE	68.2	19,255	282	320.1
KAYONZA	63.1	14,423	229	232.0
RUTONDE	24.1	8,839	367	140.9
KABARONDO	33.7	10,173	302	161.5
KIGARAMA	142.9	26,231	184	470.4
RUKIRA	48.5	7,682	158	123.2
BIRENGA	78.4	17,242	220	287.6
RUSUMO	265.2	36,769	139	605.3
Total	1,009.9	219,844	218	3,734.9

(3) **Outline of System**

System 3 is a water supply system utilizing high quality ground water through manual pumps.

The systems consist of the following components.

1) Well
2) Manual pump
3) Auxiliary facilities

(4) **Hydrogeological Classification of Well Condition**

The wells for System 3 will be drilled in suitable shallow groundwater development areas. These areas are classified into the following groups based on their hydrogeological conditions (see the classification map of groundwater development potential).

Sa: Suitable for a shallow groundwater development with lower limitations of both quantity and quality
Sb: Moderately suitable for a shallow groundwater development with a low limitation of quantity but some limitation of quality
Sc: Moderately suitable for a groundwater development with a high limitation of drilling work
Sd: Marginally suitable for a shallow groundwater development with limitations of quantity

(5) Type of Manual Pump

Based upon the standard of the Handpump option (World Bank) and well conditions of the Study Area, the following types of handpumps can be selected for the Project.

Abi-ASM
Afrideb
India Mark II
Kardia
Vergnet
Volanta
Consallen
NISSAKU

MINITRAPEE recommends Bellows type handpump (NISSAKU) for the Project because Bellows type handpump is currently the most type used in the Project Area and they have following characteristics:

- This pump extract the water by means of bellows expansion motion, instead of sliding motion made by generally used piston or cylinder that are apt to cause the friction, thus, this is durable.

- By same reason, as there is no frictional power derived from the said sliding motion this can extract the water with smaller power.

- The materials of this pump compose PVC, rubber, PA, brass and stainless steel, which are light in weight and no corrosive.
  (PVC : Poly Vinyl Chloride)
  (PA : Nylon)

By assuming that the daily pumping rate of one NISSAKU's handpump is 60% of its maximum capacity times 12 hours of operation, it was estimated that:

1,400 liters/hr x 12 hr x 60% = 10,080 liters/day
= 10 m3/day

(6) Design Pumping Rate

The smaller of either the well's safe yield (potential yield) value or the pump's pumping rate (see Section 2.5.4) is to be adopted as the design pumping rate.

Well Condition	Safe yield of well	Pumping rate of manual pump	Design pumping rate
Sa,Sb,Sc	77	10	10
Sd	8	10	8

(7) **Number of Wells**

In accordance with the estimated safe yields (potential yields) from a well and design maximum daily demand at each secteur as given in Table M.10. The number of wells of System-3 required for the Project are outlined below.

Groundwater Development Potential Class

	Sa	Sb	Sc	Sc	Total
RUKARA	37	12	0	14	63
MUGESERA	13	9	0	90	112
SAKE	0	4	0	38	42
KAYONZA	11	17	0	0	28
RUTONDE	9	8	0	0	17
KABARONDO	14	6	0	0	20
KIGARAMA	39	18	0	0	57
RUKIRA	0	0	12	4	16
BIRENGA	20	13	0	0	33
RUSUMO	51	0	33	5	89
TOTAL	194	87	45	151	477

(8) **Auxiliary Facilities**

The auxiliary facilities are composed of wash area around well, drainage ditch, plants handle and so on. The structure of them are presented in Drawings of Volume IV.

2.6 SYSTEM 4

(1) **General**

System 4 is a rainwater harvesting system employing the roof catchment method. This System will be installed in sparsely populated hilly areas where the installation of System 3 (manual pump type) would be difficult.

If more than 30 m2 of roof area is available, it will be possible, except during the dry season(June through August), to obtain 80 liters/household/day of water which satisfies the basic development policy. To satisfy the policy during the dry season, it will be necessary to install large capacity reservoir tanks and provide measures for retaining the water quality. The cost of such an installation would be too high.

In view of the above background, the reservoir tank capacity was decided upon by setting the per capita water supply amount at 3 liters/person/day.

As System 4 facilities will be installed at each household (quite different than Systems 1, 2 and 3), the rainwater harvesting method will be adopted.

In System 4 installation areas, it would be possible to install piped water supply systems with the use of groundwater (the same as System 2) to satisfy the basic development policy. The unit costs per capita to install the piped water supply systems in System 4 installation areas will vary from US$175 - 1,350. The capital investment would be quite inefficient and the operation and maintenance cost would be very high. Therefore, the installation of the piped water supply systems in System 4 installation areas can not be recommend.

(2) Service Area and Population Served

System 4 installation area and water supply plan for each commune in those area are outlined in the following table.

Commune	Service Area (km2)	Population 2000	Number of family 2000
RUKARA	47.4	8,566	1,430
MUHAZI	0.0	0	0
MUGESERA	0.0	0	0
SAKE	0.0	0	0
KAYONZA	96.9	4,453	743
RUTONDE	3.1	902	151
KABARONDO	40.0	5,092	850
KIGARAMA	30.2	3,632	606
RUKIRA	41.1	3,959	663
BIRENGA	26.3	3,862	645
RUSUMO	202.0	19,564	3,263
Total	487.0	50,030	8,351

Served area and population served of sectors are presented in Table M.10.

(3) Water Balance of Standard System

The average house in the Study Area has a roof area of 30 m2. The water balance of rainwater harvesting on a roof is as shown in the following Table. To secure a minimum of 3 liters/person/day of water during the dry season, it would be necessary to install a 600 liter capacity tank at each household.

Month	Monthly precipi-tation (mm)	Average collected water (l/day)	Min. demand /family (June-Aug.) (l/day/f)	Shortage (June-Aug.) (l/day/f)	Required capacity of reservoir tank
1	84.5	74			
2	72.5	70			
3	152.3	133			
4	160.9	145			
5	79.8	70			
6	10.5	9	18	9	270
7	9.2	8	18	10	310
8	20.6	18	18		
9	49.6	45			
10	78.3	68			
11	149.8	135			
12	80.3	70			
Total	948.3				580

Note: Roof area is 30 m2 which is the average of the dwellings in Kibungo Prefecture
Harvest rate = 0.9

(4) **Extension Program of Supplying/financing**

By taking into account the costs of other water supply systems to be borne by the residents and the residents' awareness of water supply projects, the extension program of the water supply systems is planned as follows:

1) The residents would bear one half of the material costs and provide the installation labor work.

2) The Government would bear the remaining half of the material costs and provide the residents with the technical guidance necessary for system installation.

3) By considering the income levels of the residents, they would pay the following costs:

- For the first month after system installation : 1,200 FRW
- From the 2nd month through the 25th month : 200 FRW

4) The Government will select the number of households for system installation that can be financed by its available budgetary fund.

Service Area and Population

Commune		System 1	System 2	System 3	System 4	Total
RUKARA	Area	0	0	158.4	47.4	205.8
	Population	0	0	27,428	8,566	35,994
MUHAZI	Area	39.9	0	0	0	39.9
	Population	21,944	0	0	0	21,944
MUGESERA	Area	0	0	127.4	0	127.4
	Population	0	0	51,802	0	51,802
SAKE	Area	54.1	0	68.2	0	122.3
	Population	33,865	0	19,255	0	53,120
KAYONZA	Area	0	21.1	63.1	96.9	181.1
	Population	0	7,882	14,423	4,453	26,758
RUTONDE	Area	0	6.0	24.1	3.1	33.2
	Population	0	3,720	8,839	902	13,461
KABARONDO	Area	0	15.7	33.7	40.0	89.4
	Population	0	5,956	10,173	5,092	21,221
KIGARAMA	Area	0	0	142.9	30.2	173.1
	Population	0	0	26,231	3,632	29,863
RUKIRA	Area	0	0	48.5	41.1	89.6
	Population	0	0	7,682	3,959	11,641
BIRENGA	Area	0	9.3	78.4	26.3	114.0
	Population	0	3,588	17,242	3,862	24,692
RUSUMO	Area	0	50.1	265.2	202.0	517.3
	Population	0	22,870	36,769	19,564	79,203
Total	Area	94.0	102.2	1,009.9	487.0	1,693.1
	Population	55,809	44,016	219,844	50,030	369,699

Note: The figure of population is of year 2000.

3. PRELIMINARY DESIGN

3.1 DESIGN OF GENERAL FACILITIES

The general facilities mean the components of the water supply systems, which are given as below.

(1) Distribution Reservoir

In Kibungo Prefecture, existing reservoirs are made of rocks and concrete. In general, they are maintained in good condition. For the Phase III Project, the same type of reservoirs are to be adopted for economical reasons.

The effective depth of distribution reservoir should be in between H.W.L and L.W.L. If it is too shallow, spacious area is needed for the required capacity, while too deep, though the area may be saved, problems arise of security of earthquake-proof, watertightness.

In gravity system, if the effective depth is too large, it becomes difficult to maintain the dynamic water pressure of the pipe within the proper range. In general, therefore, the effective depth should desirably be 2 - 4 m.

The inflow pipe will be installed at the upper portion of the reservoir with a float valve to control the tank level. A flow meter and a stop valve will be installed in the outflow pipe.

(2) Distribution Pipe

1) Type of Pipe

As for type of distribution pipe, selection must be made according to the following requirements:

- Safety against the inner pressure
- Safety against the outer pressure
- Adequacy for pipe diameter

Pipe must have strong resistance to both inner and outer pressures. For inner pressures, maximum static pressure and hammering pressure should be considered, while for outer pressure, ground pressure and surface load (of the road), and in other cases, load conditions according to each situation must be surveyed on the occasion of pipe pressure designing.

Since there is a specified scope of pipe size according to the respective kinds, no problems arise so far as pipes of the specified-size are used, but in case those out of the scope are ordered, thorough technical check-up in view of the utilization planned must be made in every respect.

Distribution pipe is such a pipe as is laid starting from distribution reservoir for supplying potable water to the area concerned. It consists of distribution main which is the trunk pipeline and of distribution submain branching from the trunk line and connecting with the service pipe.

The type of distribution pipe range over cast iron, ductile cast iron, steel, cement-asbestos and PVC pipes. In selection of pipes, safety from inner and outer pressures, adoptability to pipeline conditions, or pipe laying techniques, non-influences upon water quality, etc. along with economy, should be considered.

Characteristics of Distribution Pipes

Materials	Merit	Demerit
Ductile cast iron pipe (Inside mortar lining) (DCIP)	(1) Intensive and corrosion resistance (2) Strong to impact (3) Mechanical joint is flexible and expansive (4) Easy to construct (5) Many kinds joints	(1) Heavy (2) Need specials protection against joint remove (3) Need outside lining in humus (4) in case large size pipe impossible to repair from inside
Steel pipe (lining pipe) (SP)	(1) Intensive (tension and bend) (2) Strong to impact (3) No need countermeasure to joint remove by welding joint (4) Light (5) Easy manufacturing	(1) Need temperature expansion joint or flexible joint (2) Weak to electric corrosion (3) Take much time welding and lining difficult to construct in spring ground (4) Flexibility is large (large size pipe)
Risid poly venyl chloride (PVC)	(1) Corrosion and electric corrosion resistance (2) Light, easy to construct (3) Possible to adhere (4) Inside roughness is not changing (5) Cheap	(1) Weak to impact at low temperature (2) Weak against heatness, ultraviolet rays and organic solvent (3) Caution to fire solvent cement (4) Need temperature expansive and flexible joint

2) **Pipe Size**

The adopted pipe size will be determined considering with the followings.

a. Maximum velocity of water flow within pipelines shall be 3.0 m/sec.
b. Dynamic hydropressure at the points of Kiosks shall be secured 5.0 m (0.5 kgf/cm2).
c. The top of buried pipes shall be kept lower than hydraulic grade line at any point.
d. The hydrostatic pressure at any point shall be less than 10.0 kgf/cm2, which is the available hydrostatic pressure of PVC pipe.

Pipe flow formulae generally used Hazen-Williams(refer to Fig.M.7). Hazen-Williams' formula which is the representative of them is as follows:

$$D = 1.6258.C^{-0.38}.Q^{0.38}.I^{-0.205}$$

V: average flow rate (m/sec) $= 0.35464.C.D^{0.63}.I^{0.54}$
Q: quantity of flow (m3/sec) $= 0.27853.C.D^{2.63}.I^{0.54}$
I: hydraulic gradient = h/l $= 10.666.C^{-1.85}.D^{-4.87}.Q^{1.85}$
l: extension or length (m)
C: value(=110) $= 3.5903.Q.D^{-2.63}.I^{-0.54}$

Based on above discussion, PVC pipe is to be used for the distribution pipeline, which is economical, easy to install and obtainable in Rwanda. The available hydrostatic pressure of PVC pipe is 10 kgf/cm2. The calculations are given in Fig. M.10.

3) **Related Structure**

<u>Sluice Valve</u>
Sluice valve of distribution pipe should desirably be provided in accordance with the following:

a. Sluice valve should be so provided that the fewest possible number of these can function to limit the area affected by water cut to as small as possible.
b. At the point of pipe branching, sluice valve shall be installed on the branch pipe as well as on the downstream side of the branching point of the main, in principle, too.
c. Besides the above, sluice valve shall be installed at intervals within 2,000 m.

Air Valve
As to provision of air valve, the following must be observed:

a. Air valve shall be installed either on a convex part of pipeline, or, in absence of a convex between the sluice valves, direct under the sluice valve located higher, provided that no provision is required, in the case of distribution submain, when there is no convex part between the sluice valves.
b. In the case of pipe buried underground, protecting shed shall be built for air valve.

Flow Meter and Pressure Gauge
Flow meter and pressure gauge shall be provided according to the following criteria:

a. At the starting point of distribution main flow meter must be provided.
b. Flow meter must be equipped with Public Stand pipe (kiosk) for operation.

Drainage Facilities
As regards installation of drainage facilities, the following shall be observed:

a. For a hollow part of the pipe route, adequate draining channel, draining facilities shall be built.
b. The standard size of drain (or blow off) pipe is 1/2 - 1/4 of those of distribution mains. In case discharge into water route is possible, size should better be enlarged.

(3) Transmission Pipeline

1) Pipe Size

The diameter of the pipeline is to be determined in relation to its length and the pumping head.

In pumping system line, the state of affairs being utterly different, combinations of the size of the conveyance pipe and the lift to the pumps can be numerous, even innumerable. If the pipe size is too small, though the laying cost becomes low, passage resistance will rise, hydraulic gradient becoming acute, and it is necessary to raise the pump-lift. Thus, not only the cost of pumping equipment construction becomes high, but the power expense for pumping (generally called power expenses) will eternally be high. On the contrary, when the pipe size is too large, pumping cost can be held low, the cost of pipe laying will increase as a natural course of things. In either case, the design is far from economical.

Following is the procedure for determining the diameter of the pipeline:

a. Calculate the hydraulic head losses of the pipeline when the design water supply amount flows through the 75 mm dia., 100 mm dia, 150 mm dia. and 200 mm dia. pipeline.

b. Estimate the cost of different diameter pipelines.

c. Estimate the pumping cost per 1 m lift head. The average value of pumping cost divided by the total lift head was 45,000 FRW/1.0 m.

d. Obtain pumping cost by multiplying the pumping cost per unit head by the total lift head.

e. Calculate the required pump power per 1 m lift head. The average value obtained by diving the pumping power by the total lift head was 0.123 kw/1.0 m.

f. Calculate the cost of electricity by assuming the pumps' service life as being 10 years and by multiplying the required pump power per 1 m lift head with the total pipeline head loss.

g. Compare the total cost for each diameter's pipeline to determine which is the most economical.

Based on the above procedure, the most economical pipe diameters were found to be as follows:

For System 1 in Muhazi and Sake:	150 mm dia.
For System 2 in all adoptable areas:	75 mm dia.

75 mm dia. is the smallest diameter of available ductile-iron pipe.

2) Pipe line Route and Pipe Burying Depth

The planned pipeline routes and pipe burying depths are shown in the drawings provided in DRAWINGS OF Volume IV.

(4) Comparative Study of Power Source for Pump

Possible power sources for System 1 and 2 pumps are the presently supplied electricity, or generator installation.

As a result of the following economic comparisons, electricity will be utilized in areas where power line extension from existing supply lines will be less than 3.4 km, and generator units will be installed where power line extension will be more than 3.4 km.

Model for Economic Comparison:

- Pumping Rate: 200 liters/min, pumping head: 100m, pump's rated power: 7.5 kw
- Pump Type: Deep well submersible motor pump, 150 mm dia.
- Electricity Rate: US$0.10/kw
- Gasoline: US$1.0/liter
- Generator Capacity: 50 kVA, 66 ps

1) A case where Electricity is used:

a) Electricity Fee:
7.5 kwh x 24 hr x 0.1 = US$18.0/day

b) Power Line Extension Work Cost (service life of 10 years):
US$74,000/km / 10 years / 365 days = US$20.3/day/km

2) A case where Generator unit is used:

a) Fuel Cost:
0.05 liter/hr/ps x 66 ps x 24 hr x US$1.0/liter
= US$79.2/day

b) Generator's Depreciation Cost (service life of 10 years):
US$29,000 / 10 years / 365 days = US$7.9/day

3) Comparison Results

For a case where electricity is used, an electricity fee of US$18.0/day and the cost of power line extension work will be required.

For a case where a generator unit is used, the required daily costs will be US$ 87.1 ($ 79.2 + $7.9).

If the cost of power line extension work is less than US$ 69.1/day ($ 87.1 - $18.0), it would be more economical to use electricity rather than a generator unit. The break even point for evaluating which power source to utilize will be as follows:

US$ 69.1/day / US$20.3/day/km = 3.4 km

As a result, a generator unit shall be installed in an area where more than 3.4 km of power line extension work is required.

Block Name	Transmission line (km)	Power source
SYSTEM-1		
1.Muhazi	0.1	Existing Electric Service
2.Sake	3.0	Existing Electric Service
SYSTEM-2		
1. KAYONZA-1	1.8	Existing Electric Service
2. KAYONZA-2	1.2	Existing Electric Service
3. RUTONDE		Generator
4. KABARONDO	2.0	Existing Electric Service
5. BIRENGA		Generator
6. RUSUMO-1		Generator
7. RUSUMO-2		Generator
8. RUSUMO-3		Generator

3.2 DESIGN OF SYSTEM 1

(1) Water Purification Facilities for MUHAZI Area

1) Outline of System

The system components of Muhazi area can be roughly classified into the following 4 facility groups.

- . Intake Facilities
- . Purification Facilities
- . Transmission Facilities
- . Distribution Facilities

The outline of MUHAZI System is shown in DRAWINGS of Volume IV.

2) Facility Size

Water Treatment Amount:
  Daily average supply x 1.15 = 518 m3/day x 1.15
  = 595.7 m3/day = 600 m3/day

Water Treatment Facility: Portable Purifier unit
  Rated capacity: 200 m3/day/unit (output)
  Number of units: 3
  Material: Steel

Examination of Washing Water Discharge:
  Filter area of the treatment units = 3 m2/unit x 3
  = 9 m2
  By assuming the cleaning time of once a day, the washing water discharge will be:
  3 m2/unit x (0.6 m/min + 0.1 m/min) x 7 min x 3 units
  = 44.1 m3
  Remaining water in the tank:
  3 m2/unit x 0.8 m x 3 units = 7.2 m3

  Washing portion of the inflow water = approx. 1.1 m3

  Total washing water discharge = 44.1 + 7.2 + 1.1
  = 52.4 m3

  54.2 m3 is less than the daily average supply x 1.15 x 0.1 = 60.00 m3

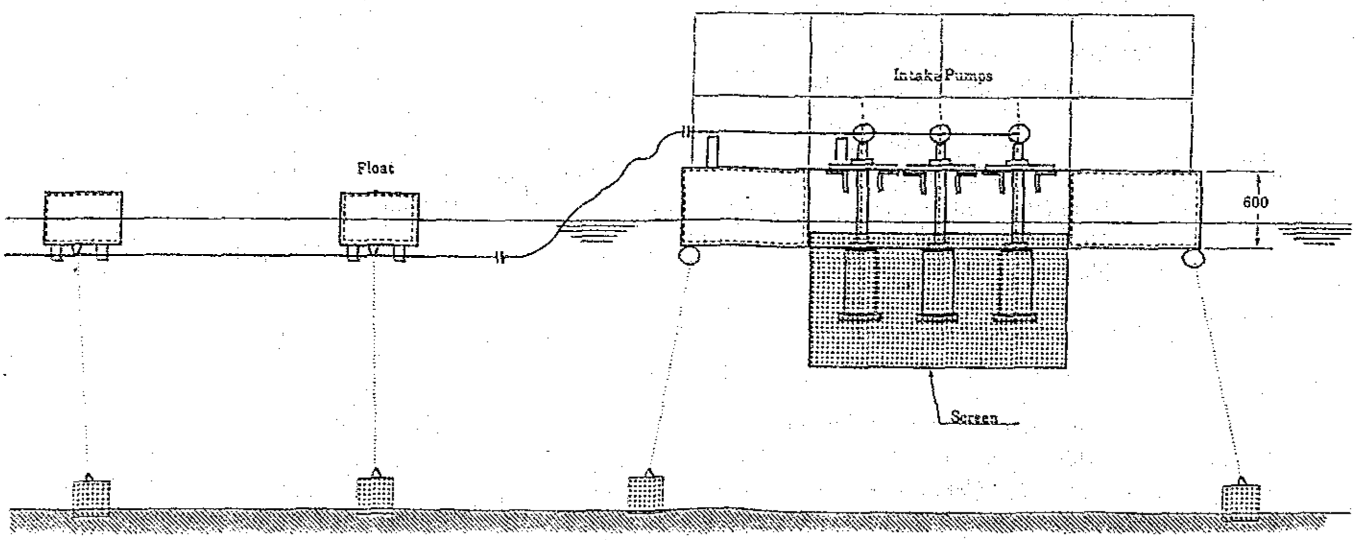
Intake amount = 518 m3 x 1.15 x 1.1 = 655.3 m3/day
  = 0.455 m3/min
  Number of pumps: 2 working units + 1 spare unit
  Pump capacity: 0.23 m3/min x 15 m x 1.5 kw

3) Water Intake Facility

The floating type intake facility shown in the following figure will be adopted for the Muhazi water supply system. The floating pump stages are to be 4.0 m x 3.0 m per each in view of the necessary inspection and maintenance space. The floating pump stages shall be anchored.

The specifications for the intake pumps will be as follows:

Design intake amount: 655 m3/day = 0.46 m3/min
Pump type: Submersible
Number of pumps: 2 working units + 1 spare unit
Capacity: 0.23 m3/min x 15 m x 1.5 kw



4) Purification Facilities

The purification facilities of the rapid sand filtration system with the portable type purifiers will be arranged as shown in Fig.M.7.

The major facility units are as follows:

a) Raw Water Distribution Weir

Delivered raw water by the intake pumps will be divided into three equal amounts by the weir.

b) Aluminum Sulfate Dosing Facility

This facility is to flocculate suspended matter that makes the raw water turbid. The facility consists of storage tanks, mixers, circulation pump, and distribution tank. The specifications for the facility are as follows:

Dosage amount:
  600 m3/day x 50 mg/liter = 30 kg/day (normal)
  600 m3/day x 70 mg/liter = 42 kg/day (maximum)
Dosage volume (by assuming a 10% solution):
  30 kg/day x 10 = 300 liters/day (normal)
  42 kg/day x 10 = 420 liters/day (maximum)
Mixing and storage tank (for 2 days of normal dosage):
  Nominal capacity: 1,000 liters
  Dimensions: 1,065mm (diameter) x 1,225mm (height)
  Number of units: 2
  Material: Polyethylene
Distribution tank:
  Approximate dimensions:
    400 mm (width)x600 mm(length)x400 mm(height)
  Number of units: 1
  Material: Stainless steel
Circulation pump:
  Capacity: 0.05 m3/min x 10 m x 0.4 kw

c) Calcium Hypochlorite Dosing Facility

The purpose of this facility is to oxidize the iron and manganese contained in raw water and, as a result, disinfect the water. The facility is composed of storage tanks, mixers, circulation pump, and distribution tank. The specification for the facility are as follows:

Dosage rate: normal 7mg/liter, maximum 10mg/liter
Dosage amount:
  600 m3/day x 7 mg/liter = 4.2 kg/day (normal)
  600 m3/day x 10 mg/liter = 6.0 kg/day (maximum)
Dosage volume (by assuming a 2% solution):
  4.2 kg/day x 50 = 210 liters/day (normal)
  6.0 kg/day x 50 = 300 liters/day (maximum)

Mixing and storage tank (for 2 days of normal dosage):
  Normal capacity: 1,000 liters
  Dimensions: 1,065mm (diameter) x 1,225mm (height)
  Number of units: 2
  material: Polyethylene

Distribution tank:
  Approximate dimensions:
    400mm (width) x 600mm (length) x 400mm (height)
  Number of units: 1
  Material: Stainless Steel
Circulation pump:
  Capacity: 0.05 m3/min x 10 m x 0.4 kw

d) **Slaked Lime Dosing Facility**

The purpose of this facility is to adjust the pH values of water by dosing it with alum earth. The facility is composed of storage tanks, mixers, circulation pump, and distribution tank. The specifications for the facility are as follows:

Dosage rate: normal 25 mg/liter, maximum 35 mg/liter
Dosage rate:
  600 m3/day x 25 mg/liter = 15 kg/day (normal)
  600 m3/day x 35 mg/liter = 21 kg/day (maximum)
Dosage volume (by assuming a 10% solution):
  15 kg/day x 10 = 150 liters/day (normal)
  21 kg/day x 10 = 210 liters/day (maximum)
Mixing and storage tank (for normal dosage of 4 days):
  Nominal capacity: 1,000 liters
  Dimensions: 1,065mm (diameter) x 1,225mm (height)
  Number of units: 2
  Material: Polyethylene
Distribution tank:
  Approximate dimensions:
    400mm (width) x 600mm (length) x 400mm (width)
  Number of units: 1
  Material: Stainless Steel
Circulation pump (slurry pump):
  Capacity: 0.05 m3/min x 10 m x 3.7 kw

e) Rapid Mixing Tank

The purpose of this tank is to mix the chemicals added to the raw water at the chemical dosage facilities. The specifications of the tank are as follows:

Tank dimensions:
500mm (width) x 500mm (length) x 1,745mm (height)

Effective depth:	1,655 mm
Tank capacity:	0.414 m3
Retention time:	2.48 min
Number of mixing units:	1
Mixer motor:	240V, 50Hz, 0.1kw

f) Slow Mixing Tank

The raw water and chemicals mixed by the rapid mixing tank will be stirred slowly in this tank and the suspended particles in the raw water will coagulate into flocks. The specifications for the slow mixing tank are as follows:

Tank dimensions:
1,800mm(width) x 1,800mm(length) x 1,745mm(depth)

Effective depth:	1,655 mm
Tank capacity:	4.94 m3
Retention time:	29.6 min
Number of mixer units:	2
Mixer motor:	240V, 50Hz, 0.2kw

g) Sedimentation Tank with Baffle Board

Flocculated suspended particles in the slow mixing tank will settle in the sedimentation tank with baffle board and separate from the water. To accelerate the flocks' settling and separation action, titled boards are installed in the tank. The upper layer of the water will flow through the collecting troughs into the settling boards tank located behind the slow mixing tank. The settled flocks, sludge, will be collected and periodically withdrawn from the tank by opening the sludge discharge valve.

The specifications for the sedimentation tank with baffle board tank are as follow:

Tank dimensions:
1,800mm(width) x 3,800mm(length) x 1,745mm(depth)

Effective depth:	1,655 mm
Tank capacity:	11.32 m3
Retention time:	67.9 min

Number of scrapers (rakes): 2 units
Scraper: 240V, 50Hz, 0.2 kw
Titled board material: PVC

h) Rapid Filtration Equipment

The filter of the rapid filtration equipment is composed of an anthracite layer on top, a manganese sand layer in the middle, and a gravel layer at the bottom.

Most of the suspended particles in the raw water can be removed in the sedimentation tank; however, very fine particles and manganese must be removed by filtrating the water through the use of the rapid filtration equipment. The filtrated water is then collected into the washing tank through the underdrain pipes. The small particles and manganese trapped by the filter will periodically be back washed and discharged from the tank.

The water in the washing water tank will be used for back washing the particles that are lied in the filter and will also wash the filter surface.

The specifications for the rapid filtration equipment are as follows:

Tank dimensions:
1,800mm(width) x 1,660mm(length) x 1,840mm(depth)
Effective filter area: 2.98 m2
Filtration velocity: 80.5 m/day
Filter: Anthracite layer thickness: 200 mm
Manganese layer thickness: 400 mm
Gravel layer thickness: 150 mm

i) Washing Water Tank

The filtrated water flows into the washing water tank and the water in the tank will be used to wash the filtration equipment. However, most of the filtrated water will flow into the treated water reservoir through the washing water tank. The specifications for the washing water tank are as follows:

Tank dimensions:
1,800mm(width) x 3,000mm(length) x 750mm(depth)
Effective depth: 600 mm
Tank capacity: 3.24 m3

j) **Treated Water Reservoir**

The water treated by the rapid filtration tank flows into the treated water reservoir through the washing water tank and is stored in it. The water will then be delivered to the distribution reservoir by high lift pumps. The specifications for the treated water reservoir are as follows:

Reservoir capacity:
120 m3 (retention time = 4.4 hours)
Reservoir dimensions:
5 m (width) x 17.2 m (length) x 1.4 m (effective depth)

5) **Transmission Facilities**

a) **High Lift Pump**

Water in the treated water reservoir will be delivered into the distribution reservoir (high level tank) by the high lift pumps. Following are the specifications for the high lift pumps:

Delivery amount:	0.4167 m3/min
Number of pumps:	2 working units + 1 spare unit
Pump capacity:	0.21 m3/min x 250 m x 18.5 kw

b) **Transmission Pipe**

Ductile cast iron pipes (DCIP) will be used for transmission pipe. As a result of the economic comparison study, the pipe to be used will have a diameter of 150 mm (see 3.1).

6) **Distribution Facilities**

The features of the distribution facilities are to be as follows:

Facility	Type	Size	Quantity
Reservoir Tank	Rock and Concrete	300 m3	1
Distribution Pipe	PVC	50-150 mm dia.	27,500 m
Public Standpipe (Kiosk)			16 units

For the detail of facilities, see 3.1.

(2) Water Purification Facility for SAKE Area

1) General

The water supply system in the Sake area can be classified into the following five facility groups:

- Spring water collecting facilities
- Lake water intake facilities
- Purification facilities
- Water conveyance facilities
- Water distribution facilities

The difference between the Sake area's water supply system and the one for the Muhazi area is that it is a combined spring water and lake water (Lake Sake) use type ... 100 m3/day of water from a spring that is already used for an existing water supply system and 100 m3/day from a spring that will be developed.

The outline of the Sake System is shown in DRAWINGS of Volume IV.

2) Facility Size

Water Treatment Amount:
(Daily average water supply) x 1.15 - spring water use amount = 774.9 m3/day x 1.15 - 200 m3/day = 690 m3/day

Treatment facility: Portable purifier units
Nominal treatment capacity: 230 m3/day(output) per unit
Number of purifiers: 3
Material: Steel

Examination of Washing Water Discharge Amount:
Filtration equipment's filter area:
3 m2 x 3 units = 9 m2
By assuming one time washing a day, the washing water discharge amount will be:
3 m2/unit x (0.6 m/min + 0.1 m/min) x 7 min x 3 units = 44.1 m3 -- [1]
Remaining water in the tank:
3 m2/unit x 0.8 m x 3 units = 7.2 m3 ------------ [2]
Washing water out of the inflow amount will be approximately 1.3 m3 ------------------------------ [3]

Thus, the total washing water discharge amount will be [1]+[2]+[3] = 44.1 m3 + 7.2 m3 + 1.3 m3 = 52.6 m3/day

This amount is less than,
the daily water supplyx1.15x0.10 = 69.00 m3/day

Intake amount:
690 x 1.15 x 1.1 = 759.0 m3/day
= 0.527 m3/min

Number of pumps	:	2 working units + 1 spare units
Pump capacity	:	0.26 m3/min x 15 m x 1.5 kw

3) Spring Collecting Facilities

The spring collecting facilities of 100 m3/day capacity are planned to be newly installed in addition to the existing spring collecting facilities of 100 m2/day Capacity which will be also used for the project.

The system of spring collecting facility is outlined as below:

Facility Name	No. of Unit	Size
(Construction)		
Collecting Chamber	2	3.0 m3
Storage Tank	1	40.0 m3
Booster Pump	1	40 m dia x 7.5 kw (Head 100 m)
(Existing)		
Collecting Chamber	1	
Storage Tank	1	50.0 m3
Booster Pump		40 m dia. x 7.5 kw (Head 100 m)

4) Water Intake Facilities

Floating type intake system, which is adopted in Muhazi area, will be adopted in Sake area.

The dimensions of floating type intake system are given as below.

Floating pump stage: 4.0 m x 3.0 m
Design discharge of intake water:
690 m3/day = 479.2 liters/min
Type of pump: Submersible pump
Number of pumps: 2 working unit + 1 reserved unit

5) Purification Facilities

a) Raw Water Distribution Weir

See 3.3 (1)

b) **Aluminum Sulphate Dosing Facility**

Dosing rate:
50 mg/liter (normal), 70 mg/liter (maximum)

Dosing amount:
690 m3/day x 50 mg/liter = 34.5 kg/day (normal)
690 m3/day x 70 mg/liter = 48.3 kg/day (maximum)

Dosage volume (by assuming a 10% solution):
34.5kg/day x 10 = 345 liters/day (normal)
48.3kg/day x 10 = 483 liters/day (maximum)

Mixing and storage tank (for 2 days of normal dosage):
Nominal capacity: 1,000 liter
Dimensions of unit:
1,065 mm (diameter) x 1,225 mm (height)
Number of units: 2
Material: Polyethylene

Distribution tank:
Dimensions of unit (approximate):
400mm (width) x 600mm (length) x 400mm (height)
Number of units: 1
Material: Stainless steel

Circulation pump:
Capacity: 0.05 m3/min x 10 m x 0.4 kw

c) **Calcium Hypochlorite Dosing Facility**

Dosing rate:
7 mg/liter (normal), 10 mg/liter (maximum)

Dosing amount:
690 m3/day x 7 mg/liter = 4.83 kg/day (normal)
690 m3/day x 10 mg/liter = 6.90 kg/day (maximum)

Dosing volume (by assuming a 2% solution):
4.83 kg/day x 50 = 243 liter/day (normal)
6.90 kg/day x 50 = 345 liter/day (maximum)

Mixing and storage tank (for 2 days of normal dosage):
Nominal capacity: 1,000 liter
Dimensions of unit:
1,065 mm (diameter) x 1,225 m (height)
Number of units: 2
Material: Polyethylene

Distribution tank:
Dimensions of unit (approximate):
400mm (width) x 600mm (length) x 400mm (height)
Number of units: 1
Material: Stainless steel

Circulation pump:
Capacity: 0.05 m3/min x 10 m x 0.4 kw

d) Slaked Lime Dosing Facility

Dosing rate:
25 mg/liter (normal), 35 mg/liter (maximum)
Dosing amount:
690 m3/day x 25 mg/liter = 17.3 kg/day (normal)
690 m3/day x 35 mg/liter = 24.2 kg/day (maximum)

Dosing volume (by assuming a 10% solution):
17.3 kg/day x 10 = 173 liter/day (normal)
24.3 kg/day x 10 = 243 liter/day (maximum)

Mixing and storage tank(for 4 days of normal dosage):
Nominal capacity: 1,000 liter
Dimensions of unit:
1,065 mm (diameter) x 1,225 mm (height)
Number of units: 2
Material: Polyethylene

Distribution tank:
Dimensions of unit (approximate):
400mm (width) x 600mm (length) x 400mm (height)
Number of units: 1
Material: Stainless steel

Circulation pump (slurry pump)
Capacity: 0.05 m3/min x 10 m x 3.7 kw

e) Rapid Mixing Tank

Tank dimensions:
500mm (width) x 50mm (length) x 1,745mm (height)
Effective depth: 1,655 mm
Tank capacity: 0.414 m3
Retention time: 2.3 min
Number of mixing units: 1
Mixing motor: 240V, 50Hz, 0.1 kw

f) Slow Mixing Tank

Tank dimensions:
1,800mm(width) x 1,800mm(length) x 1,745mm(height)
Effective depth: 1,655 mm
Tank capacity: 4.94 m3
Retention time: 27 min
Number of mixing units: 2
Mixing motor: 240V, 50Hz, 0.2 kw

g) Sedimentation Tank with Baffle Board

Tank dimensions:
1,800mm(width) x 1,800mm(length)x1,745mm(height)
Effective depth: 1,655 mm
Tank capacity: 11.32 m3
Retention time: 61.9 min
Number of scrapers (rakes): 2
Scraper: 240V, 50Hz, 0.2 kw
Material of baffle board: PVC

h) Rapid Filtration Equipment

Tank dimensions:
1,800mm(width) x 1,660m(length) x 1,840mm(height)
Effective filter area: 2.98 m2
Filtration velocity: 88.4 m/day
Filter: Anthracite layer thickness: 200 mm
Manganese layer thickness: 400 mm
Gravel layer thickness: 150 mm

i) Washing water Tank

Tank dimensions:
1,800mm(width) x 3,000mm(length) x 750mm(height)
Effective depth: 600 mm
Tank capacity: 3.24 m3

j) Treated Water Reservoir

Reservoir dimensions:
5m(width) x 17.2m(length) x 1.4m(effective depth)
Reservoir capacity: 120 m3
Retention time: 3.9 hours

6) Transmission Facilities

Transmission facilities are composed of two systems, which connect between spring collecting facilities to distribution tank (System A) and between purification facilities to distribution tank (System B).

The outline of both system is given as below.

	System A	System B
Water source	Sake Lake	Spring
Design discharge	690m3/day (0.479m3/min)	200m3/day
Type of pump	turbine pump	turbine pump
Number of pumps	2 working units + 1 reserved unit	2 working units
Pump capacity	0.31m3/min x 300m x 30kw	0.07m3/min x 100m x 5.5kw
Transmission pipe	DCIP 150mm dia.	DCIP 75mm dia.

7) Distribution Facilities

a) Distribution Reservoir (High lift tank)

The existing reservoir, which has 350 m3 of capacity and is available for this project, will be used as the distribution reservoir of the project.

b) Others

Facilities	Type of pipe	Diameter of pipe	Quantity
Distribution pipe	PVC	50 mm	17,200 m
"	"	75 mm	10,300 m
"	"	100 mm	14,000 m
"	"	150 mm	2,000 m
Public standpipe (Kiosk)			26 unit

For the detail, see 3.1.

3.3 DESIGN OF SYSTEM 2

(1) Well

1) Location

The potential areas to be developed are presented in "Classification of Groundwater Development Potential".

However, the drilling locations of wells should be determined at the most prospective points selected through the field geological survey including geophysical prospecting, at implementation stage of the Project.

2) Well Screen

The length of well screens required for the new wells is determined, based upon both the conditions of aquifers to be penetrated and the structure of wells, as follows:

The relationships among the screen length (l) and pumping rate (Q) etc. are expressed by formula below:

$l = Q / (2 \times r \times V)$

Q : Pumping rate
r : Radius of screens (3" = 75 mm)
: Unit opening area of screen (15%)
l : Screen length (m)
V : Critical inflow velocity (2.8 mm/sec = 0.168 m/min - lower limit of very fine sand)

The calculation of screen length for motor pump well is:

$l = Q/(2 \times 75\ mm \times 15\% \times 0.168)$
Q : 85 liter - 150 liter/min
$l = 7.2 - 12.6$ m

According to the above calculation, the required screen length is more than 8 m at lowest discharge charge.

3) Well Structure

The hydrogeological conditions at shallow groundwater development area are that unconfined groundwater is expected in upper subsurface portion consisting alluvium of 20 m and underlying weathered rock of 40 m in thickness. The groundwater Table is estimated at 20 m-GL and design drawdown at pumping duration is considered to be 10 m. Thus, 60 m of well depth is recommended. Through the unconfined aquifer to depth of 60 m, a diameter of 6" (150 mm) is considered to be suitable on account of size of installed pumping facilities and capacity of drilling rig.

Since the filter thickness (gravel pack) is required over 40 mm, drilling diameter should be more than 230 mm (9 1/2").

In addition, as groundwater in upper subsurface of 20 - 30 m may be contaminated by surface water, the upper portion of the wells should be sealed by complete cementation.

The well structure is presented in DRAWINGS of Volume IV.

(2) **Pump**

1) Required Facilities

Proposed pump facilities of System 2 installation area are listed as below:

Name of Block	Pumping rate, Power Load and Number of pumps			Power source
	1/min	kw	set	
KAYONZA-1	100	x 7.5	x 1	Existing electric Service
KAYONZA-2	120	x 11	x 1	"
RUTONDE	100	x 5.5	x 1	Generator 12.5 KVA
KABARONDO	85	x 7.5	x 2	Existing electric Service
BIRENGA	115	x 11	x 1	"
RUSUMO-1	85	x 7.5	x 2	Generator 37 KVA
RUSUMO-2	110	x 11	x 2	" 37 KVA
RUSUMO-3	85	x 7.5	x 2	" 37 KVA

The pump selection procedure is presented in the followings.

The location, structure and dimensions of pump facilities are shown on DRAWINGS of Volume IV.

2) Selection of Pump Facilities

a) Type of Pumping Facility

Submersible motor pump will be installed as a pumping facilities *** wells because the pump is fitted to higher lifting due to the structure.

The required head and discharge capacity are given as below:

Name of Block	Pumped Capacity (l/min)	Total Heads (m)
KAYONZA-1	80.1	180
KAYONZA-2	64.1	220
RUTONDE	64.4	125
KABARONDO	106.5	185
BIRENGA	62.1	220
RUSUMO-1	136.7	180
RUSUMO-2	159.0	250
RUSUMO-3	136.2	185

b) Capacity

Pumping Rate

Pumping rate of well pumps are determined, based upon daily safe yields (102 m3/day) of shallow well. Thus, the pumping rate can be calculated by the maximum daily demand (m3/day) within safe yields divided by design pumping duration of 24 hours.

Required pumping rate therefore, is based upon the following conditions:

. Max. Daily Demand < Safe Yield
    Pumping Rate = Max. Daily Demand/24 hr

. Max. Daily Demand > Safe Yield
    Pumping Rate = Max. Daily Demand/n/24 hr

    Where,
      n = Max. Daily Demand/Safe Yield
      (n : raise to an integral number)

Head

Required heads for pumps are calculated in accordance with the following formula:

Total head = Actual head + Pipeline head loss

The results of the head calculation with the respective pumps employed are presented in the table below:

CALCULATION OF SUBMERGIBLE PUMP TYPE

SERVICE BLOCK NAME	WATER DIMAND (m3/day)	PUMP CAPACITY (m3/min)	REFERENCE PLANE (m)	SUCTION LEVEL (m)	DISCHARGE LEVEL (m)	TRANS-MISSION LINE (m)	HEAD LOSS OF T.M. LINE (m)	HEAD LOSS OF OTHERS (m)	CALCURATED TOTAL HEAD LOSS (m)	TOTAL HEAD (m)
KAYONZA-1	115.5	0.080	1,455	1,425	1,600	506	1.31	2.00	178.31	180
KAYONZA-2	92.3	0.064	1,450	1,420	1,625	260	0.44	2.00	207.44	220
RUTONDE	92.8	0.064	1,450	1,420	1,540	796	1.38	2.00	123.38	125
KABARONDO	153.5	0.107	1,430	1,400	1,580	600	2.63	2.00	184.63	185
BIRENGA	89.5	0.062	1,420	1,390	1,605	950	1.53	2.00	218.53	220
RUSUMO-1	196.8	0.137	1,465	1,435	1,600	1,290	8.95	2.00	175.95	180
RUSUMO-2	228.9	0.159	1,550	1,520	1,755	1,365	12.53	2.00	249.53	250
RUSUMO-3	196.1	0.136	1,405	1,375	1,550	714	4.92	2.00	181.92	185

OPERATION TIME : 24hr/day

For the calculation, the low water levels at the wells during pumping are assumed as 30 m below from ground-surface.

3) **Selection of Pump**

Based on required discharge and head, pump facilities are selected using pump selection diagram (Fig. M.8).

4) **Design Pumping Rate and Duration**

The design pumping rate is 70 to 80% of maximum potential in order to plan a shorter pumping duration.

The pump types, design pumping rate and pumping duration at design rate are obtained as Table below:

Name of Block	Max Water demand (115%)	Discharge Capacity (l/min)	Head (m)	No.	Load (kw)	Max Potential (l/min)	Design Pumping Rate (l/min)	Pumping Duration at Design Rate (hr)
KAYONZA-1	115.4	80.1	180.0	1	7.5	130.0	100.0	19.2
KAYONZA-2	92.3	64.1	220.0	1	11.0	150.0	120.0	12.8
RUTONDE	92.8	64.4	125.0	1	5.5	130.0	100.0	15.5
KABARONDO	153.3	106.3	185.0	2	7.5	110.0	85.0	15.0
BIRENGA	89.5	62.2	220.0	1	11.0	145.0	115.0	13.0
RUSUMO-1	196.8	136.6	180.0	2	7.5	110.0	85.0	19.3
RUSUMO-2	228.9	159.0	250.0	2	11.0	140.0	110.0	17.3
RUSUMO-3	196.1	136.2	185.0	2	7.5	110.0	85.0	19.2
TOTAL	1165.1	808.9		12	68.5			

Other related facilities;i.e. transmission pipe, distribution reservoir, distribution pipe and public standpipe, are designed using same manner of System 1.

3.4 DESIGN OF SYSTEM 3(MANUAL PUMP WELL)

(1) Well

1) Location

The drilling locations of wells should be also determined through the field geophysical prospecting as same as the motor pump well of System-2, at the Project implementation stage.

2) Well Screen

The screen length is also calculated using the formula below mentioned in Section 2.4.

l = Q/(2 x 50 mm x 15% x 0.168)
Q : 1.4 m3/hr = 23.5 l/min
l = 3.0 m

According to the calculation, screen length of more than 3.0 m is required for manual pump wells of System 3.

3) Well Structure

The hydrogeological conditions at the recommended well sites are similar to those of motor wells of System 2.

The design drawdown is estimated between 7.0 and 9.0 m as Table below. Therefore, 50 m of well depth is suitable for manual pump installation. However, wells in "Sb" of groundwater development class is recommended. 60 m deep to intake deeper groundwater, because of bad water qualities within upper subsurface.

Well Type	Well Condition	Borehole depth	Static Water level	Dynamic Water level
I	Sa,Sb,Sc	50 m	GL-20.0 m	GL-27.5 m
II	Sd	60 m	GL-20.0 m	GL-30.0 m

A diameter of 4" (100 mm) is proposed on account of size of pumping facilities. As filter thickness (gravel pack) is required more than 30 mm, drilling diameter should be over 160 mm (6-2/5").

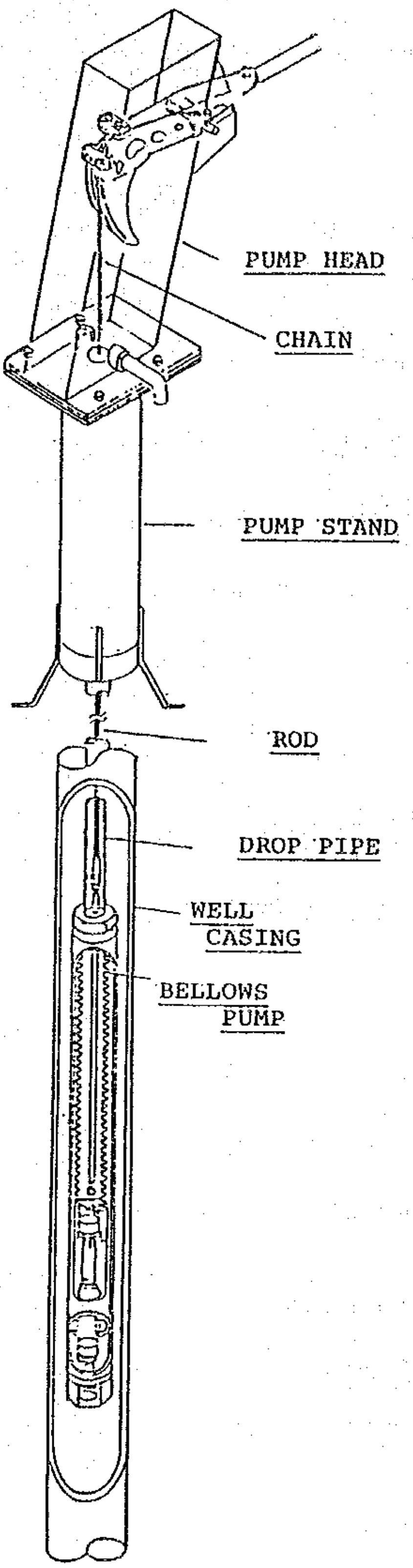
According to the same conditions of groundwater contamination in upper subsurface as System-2 motor pump wells, the upper portion of the wells should be sealed by complete cementation.

The well structure is given in DRAWINGS of Volume IV.

(2) **Manual Pump of System 3**

NISSAKU's handpump is selected for the Project.

The structure, dimensions, etc are shown in the followings.



3.5 DESIGN OF SYSTEM 4

The material of System 4(ROOF CATCHMENT FACILITIES) for one household will be given as the followings.

	Quantity	Amount(FRW)
Steel fuel tank (used)	3 unit	6,000
Collection pipe	5 m	5,000
Gutter	3 m	900
Total		11,900

At the Stage, only "Extension Program of Supplying /Financing" for System 4 is recommended.

(BIRENGA)	System-1		System-2		System-3		System-4		TOTAL	
	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION
BARE	0.0	0	0.0	0	8.8	1,237	0.0	0	8.8	1,237
BIRENGA	0.0	0	0.0	0	9.0	1,351	10.7	1,802	19.7	3,153
GAHARA	0.0	0	0.0	0	26.0	3,709	15.6	2,060	41.6	5,769
GAHULIRE	0.0	0	0.0	0	3.8	1,512	0.0	0	3.8	1,512
GASHONGORA	0.0	0	0.0	0	11.6	2,231	0.0	0	11.6	2,231
KIBAYA	0.0	0	0.0	0	7.0	3,570	0.0	0	7.0	3,570
KIBARA	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
KIBIMBA	0.0	0	0.0	0	6.9	1,522	0.0	0	6.9	1,522
KIBUNGO	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
MATONGO	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NDAMIRA	0.0	0	9.3	3,588	0.0	0	0.0	0	9.3	3,588
SAKARA	0.0	0	0.0	0	5.3	2,110	0.0	0	5.3	2,110
TOTAL	0.0	0	9.3	3,588	78.4	17,242	26.3	3,862	114.0	24,692

(RUSUMO)	System-1		System-2		System-3		System-4		TOTAL	
	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION
GATORE	0.0	0	6.4	3,285	17.5	3,285	11.6	1,641	35.5	8,211
GISENYI	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
KANKOBWA	0.0	0	0.0	0	117.6	4,847	55.7	7,109	173.3	11,956
KIGARAMA	0.0	0	0.0	0	15.8	3,361	32.2	5,041	48.0	8,402
KIGINA	0.0	0	0.0	0	22.0	5,838	5.7	730	27.7	6,568
KIREHE	0.0	0	8.6	4,015	6.7	2,149	0.0	0	15.3	6,164
MUSAZA	0.0	0	0.0	0	30.4	6,978	18.1	3,489	48.5	10,467
NYABITARE	0.0	0	0.0	0	9.9	5,177	16.2	864	26.1	6,041
NYAMUGALI	0.0	0	21.3	7,278	17.6	1,679	39.5	0	78.4	8,957
NYARUBUYE	0.0	0	13.8	8,292	27.7	3,455	23.0	690	64.5	12,437
TOTAL	0.0	0	50.1	22,870	265.2	36,769	202.0	19,564	517.3	79,203

	System-1		System-2		System-3		System-4		TOTAL	
COMMUNE	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION
BIRENGA	0.0	0	9.3	3,588	78.4	17,242	26.3	3,862	114.0	24,692
KABARONDO	0.0	0	15.7	5,956	33.7	10,173	40.0	5,092	89.4	21,221
KAYONZA	0.0	0	21.1	7,882	63.1	14,423	96.9	4,453	181.1	26,758
KIGARAMA	0.0	0	0.0	0	142.9	26,231	30.2	3,632	173.1	29,863
MUGESERA	0.0	0	0.0	0	127.4	51,802	0.0	0	127.4	51,802
MUHAZI	39.9	21,944	0.0	0	0.0	0	0.0	0	39.9	21,944
RUKARA	0.0	0	0.0	0	158.4	27,428	47.4	8,566	205.8	35,994
RUKIRA	0.0	0	0.0	0	48.5	7,682	41.1	3,959	89.6	11,641
RUSUMO	0.0	0	50.1	22,870	265.2	36,769	202.0	19,564	517.3	79,203
RUTONDE	0.0	0	6.0	3,720	24.1	8,839	3.1	902	33.2	13,461
SAKE	54.1	33,865	0.0	0	68.2	19,255	0.0	0	122.3	53,120
TOTAL	94.0	55,809	102.2	44,016	1009.9	219,844	487.0	50,030	1693.1	369,699

(continue)

(RUKARA)	System-1		System-2		System-3		System-4		TOTAL	
	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION
GAHINI	0.0	0	0.0	0	5.8	3,827	0.0	0	5.8	3,827
KAWANGIRE	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
KIYENZI	0.0	0	0.0	0	10.6	3,511	4.5	1,505	15.1	5,016
NYAKABUNGO	0.0	0	0.0	0	17.6	2,345	13.2	1,698	30.8	4,043
NYAWERA	0.0	0	0.0	0	30.0	4,024	13.1	1,724	43.1	5,748
RUKARA	0.0	0	0.0	0	28.0	6,677	3.0	921	31.0	7,598
RWIMISHINYA	0.0	0	0.0	0	12.2	3,594	6.1	2,248	18.3	5,842
RYAMANYONI	0.0	0	0.0	0	54.2	3,450	7.5	470	61.7	3,920
TOTAL	0.0	0	0.0	0	158.4	27,428	47.4	8,566	205.8	35,994

(MUHAZI)	System-1		System-2		System-3		System-4		TOTAL	
	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION
GATI	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
GISHALI	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
KABARE	7.5	4,873	0.0	0	0.0	0	0.0	0	7.5	4,873
[illegible]AZIGURWA	7.5	4,428	0.0	0	0.0	0	0.0	0	7.5	4,428
MUKARANGE	5.6	3,628	0.0	0	0.0	0	0.0	0	5.6	3,628
MUNYIGINYA	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
MURANBI	10.7	5,200	0.0	0	0.0	0	0.0	0	10.7	5,200
NKOMANGWA	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NYAGATOVU	8.6	3,815	0.0	0	0.0	0	0.0	0	8.6	3,815
NYARUBUYE	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NYARUGARI	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
RUHUNDA	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
TOTAL	39.9	21,944	0.0	0	0.0	0	0.0	0	39.9	21,944

(MUGESERA)	System-1		System-2		System-3		System-4		TOTAL	
	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION
CYIZIHIRA	0.0	0	0.0	0	8.3	4,199	0.0	0	8.3	4,199
GATARE	0.0	0	0.0	0	13.8	4,311	0.0	0	13.8	4,311
KAGASHI	0.0	0	0.0	0	18.3	5,137	0.0	0	18.3	5,137
KAREMBO	0.0	0	0.0	0	0.9	614	0.0	0	0.9	614
[illegible]ARE	0.0	0	0.0	0	7.4	4,892	0.0	0	7.4	4,892
KIBILIZI-1,2	0.0	0	0.0	0	10.4	5,169	0.0	0	10.4	5,169
KIRAMBO	0.0	0	0.0	0	9.0	3,584	0.0	0	9.0	3,584
KUKABUYE	0.0	0	0.0	0	4.3	2,936	0.0	0	4.3	2,936
MATONGO	0.0	0	0.0	0	4.4	3,726	0.0	0	4.4	3,726
NGARA	0.0	0	0.0	0	8.8	3,944	0.0	0	8.8	3,944
NYANGE	0.0	0	0.0	0	17.1	3,105	0.0	0	17.1	3,105
SANGAZA	0.0	0	0.0	0	13.8	4,190	0.0	0	13.8	4,190
SHYWA	0.0	0	0.0	0	7.0	3,931	0.0	0	7.0	3,931
ZAZA	0.0	0	0.0	0	3.9	2,064	0.0	0	3.9	2,064
TOTAL	0.0	0	0.0	0	127.4	51,802	0.0	0	127.4	51,802

(continue)

(SAKE)	System-1		System-2		System-3		System-4		TOTAL	
	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION
GITUZA	12.0	5,083	0.0	0	0.0	0	0.0	0	12.0	5,083
MABUGA-1	6.7	4,329	0.0	0	0.0	0	0.0	0	6.7	4,329
MABUGA-2	6.3	4,174	0.0	0	0.0	0	0.0	0	6.3	4,174
MBUYE	0.0	0	0.0	0	6.2	2,010	0.0	0	6.2	2,010
MURWA	0.0	0	0.0	0	31.6	5,666	0.0	0	31.6	5,666
NGOMA	6.1	2,974	0.0	0	0.0	0	0.0	0	6.1	2,974
NSHILI-1	8.0	6,038	0.0	0	0.0	0	0.0	0	8.0	6,038
NSHILI-2	2.7	1,926	0.0	0	0.0	0	0.0	0	2.7	1,926
RUBAGO	8.5	5,366	0.0	0	0.0	0	0.0	0	8.5	5,366
RUKUMBERI	0.0	0	0.0	0	16.0	6,058	0.0	0	16.0	6,058
RUYEMA-1	1.3	1,553	0.0	0	0.0	0	0.0	0	1.3	1,553
RUYEMA-2	2.5	2,422	0.0	0	0.0	0	0.0	0	2.5	2,422
SHOLI	0.0	0	0.0	0	14.4	5,521	0.0	0	14.4	5,521
TOTAL	54.1	33,865	0.0	0	68.2	19,255	0.0	0	122.3	53,120

(KAYONZA)	System-1		System-2		System-3		System-4		TOTAL	
	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION
GASOGI	0.0	0	0.0	0	11.1	2,617	3.3	1,122	14.4	3,739
KAYONZA	0.0	0	12.9	4,374	0.0	0	0.0	0	12.9	4,374
MBURABUTURO	0.0	0	0.0	0	7.7	1,932	1.9	828	9.6	2,760
MUSUMBA	0.0	0	0.0	0	8.6	1,471	10.7	1,831	19.3	3,302
NYAMIRAMA	0.0	0	5.3	1,403	13.5	3,285	0.0	0	18.8	4,688
RUTARE	0.0	0	0.0	0	12.6	3,267	0.0	0	12.6	3,267
RWINKWAVU	0.0	0	0.0	0	5.3	448	81.0	672	86.3	1,120
SHYOGO	0.0	0	2.9	2,105	4.3	1,403	0.0	0	7.2	3,508
TOTAL	0.0	0	21.1	7,882	63.1	14,423	96.9	4,453	181.1	26,758

(RUTONDE)	System-1		System-2		System-3		System-4		TOTAL	
	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION
KADUHA	0.0	0	0.0	0	4.6	1,339	3.1	902	7.7	2,241
KIGABIRO	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NKUNGU	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NSHINDA	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
NYARUSANGE	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
RUTONDE	0.0	0	0.0	0	9.8	3,326	0.0	0	9.8	3,326
RWERU	0.0	0	6.0	3,720	1.5	930	0.0	0	7.5	4,650
RWIKUBO	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
SOVU	0.0	0	0.0	0	8.2	3,244	0.0	0	8.2	3,244
TOTAL	0.0	0	6.0	3,720	24.1	8,839	3.1	902	33.2	13,461

(continue)

(KABARONDO)	System-1		System-2		System-3		System-4		TOTAL	
	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION
BISENGA	0.0	0	0.0	0	9.2	2,223	7.1	1,110	16.3	3,333
CYINZOVU	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
KABARONDO	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
MURAMA	0.0	0	0.0	0	4.6	941	14.8	1,412	19.4	2,353
NKAMBA	0.0	0	3.7	1,447	2.5	934	0.0	0	6.2	2,381
RUBIRA	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
RUKIRA	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
RUNDU	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
RURAMIRA	0.0	0	6.5	1,914	6.5	1,914	0.0	0	13.0	3,828
RUSERA	0.0	0	0.0	0	5.9	2,159	2.9	1,064	8.8	3,223
RUYONZA	0.0	0	5.5	2,595	2.3	1,115	0.0	0	7.8	3,710
SHYANDA	0.0	0	0.0	0	2.7	887	15.2	1,506	17.9	2,393
TOTAL	0.0	0	15.7	5,956	33.7	10,173	40.0	5,092	89.4	21,221

(KIGARAMA)	System-1		System-2		System-3		System-4		TOTAL	
	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION
[illegible]KWE	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
[illegible]SETSA	0.0	0	0.0	0	8.2	696	0.0	0	8.2	696
GASHANDA	0.0	0	0.0	0	10.1	2,326	0.0	0	10.1	2,326
KABARE-1	0.0	0	0.0	0	9.3	1,507	0.0	0	9.3	1,507
KABARE-2	0.0	0	0.0	0	37.8	3,370	16.6	1,683	54.4	5,053
KABERANGWE	0.0	0	0.0	0	9.0	1,714	0.0	0	9.0	1,714
KANSANA	0.0	0	0.0	0	11.8	2,395	0.0	0	11.8	2,395
REMERA	0.0	0	0.0	0	9.9	1,748	2.9	803	12.8	2,551
RUBONA	0.0	0	0.0	0	10.7	6,110	10.7	1,146	21.4	7,256
RURENGE	0.0	0	0.0	0	14.9	1,924	0.0	0	14.9	1,924
VUMWE	0.0	0	0.0	0	21.2	4,441	0.0	0	21.2	4,441
TOTAL	0.0	0	0.0	0	142.9	26,231	30.2	3,632	173.1	29,863

(RUKIRA)	System-1		System-2		System-3		System-4		TOTAL	
	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION	AREA	POPULATION
GASIRU	0.0	0	0.0	0	8.3	1,733	7.4	694	15.7	2,427
GITUKU	0.0	0	0.0	0	0.0	0	2.5	595	2.5	595
[illegible]TWE	0.0	0	0.0	0	9.3	2,056	0.0	0	9.3	2,056
[illegible]UBAGO	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
MURAMA	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
MUSHIKILI	0.0	0	0.0	0	15.1	1,786	11.3	1,191	26.4	2,977
NTARUKA	0.0	0	0.0	0	3.7	224	8.8	223	12.5	447
RUGARAMA	0.0	0	0.0	0	12.1	1,883	11.1	1,256	23.2	3,139
RURAMA	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
RURENGE	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
TOTAL	0.0	0	0.0	0	48.5	7,682	41.1	3,959	89.6	11,641

Table Design Specified Water Demand

No.	Type of Consumpion	Water Demand		Remarks
		Quantity	Unit	
1.	DOMESTIC CONSUMPION			
1.1	Public Taps			1family
1.1.1	Low Population Density	80	l/family/day	=6persons
1.1.2	High Population Density	120	l/family/day	
1.1.3	Water Demand for Livestock	10	l/family/day	
1.2	Individial House Connection			
	a) water demand rate	5 or 10	%	consumpt.
	b) water demand	240	l/family/day	per day
2.	PUBLIC FACILITIES			
2.1	Health			
2.1.1	Hospital	15	m3/day	per 100bed
	- water demand	150	l/bed/day	
2.1.2	Dispensary	1000	l/day	
2.1.3	Maternity	150	l/bed/day	max.20bed
2.1.4	Health Center	6 or 10	m3/day	maximum
2.1.5	Nutritional Center	500	l/day	
2.2	Education			
2.2.1	Primary School	10	l/student/day	
2.2.2	Secondary School			
	- boarder	70	l/student/day	
	- student,outside	10	l/student/day	
2.3	Social Institute			
2.3.1	Vocational Training Center	250	l/day	
2.3.2	Public Hall	250	l/day	
2.3.3	Youth Center	50	l/pers/day	
2.3.4	Orphanage	30	l/pers/day	
2.4	Administration			
2.4.1	Communal Bureau	500	l/day	
2.4.2	Sectoral Bureau	100	l/day	
2.4.3	Sub Prefecture	500	l/day	
2.4.4	Court	200	l/day	
2.5	Others			
2.5.1	Church	* 0.5	m3/day	studying
2.5.2	Prison	* 7.0	m3/day	studying
	- water demand	70	l/occupant/day	
2.5.3	Military Camp	100	l/occupant/day	
3.	COMMERCE/INDUSTRY			
3.1	Business Center	*	l/day	see 1.1.2
3.2	Market	1000	l/day	
3.3	Artisan/small enterprise	*	-	studying
3.4	Slaughterhouse	1.5	m3/day	
	- water demand	350	l/animal/day	maximum
3.5	Tea Factory	5	m3/ton	
3.6	Others	*	-	by case

Table M.3

PROPOSED WATER DEMAND OF SYSTEM-1

COMMUNE NAME	SECTOR NAME	AREA (km2)	POPULATION 2000	FAMILY 2000	WATER DEMAND (m3/day) FAMILY (0.13m3/f)	PUBLIC	TOTAL (m3/day)	MAX WATER DEMAND (115%)	PUMP CAPACITY (1/min)	RESORVOIR CAPACITY (m3)
MUHAZI	KABARE	7.5	4,873	813	105.7	8.6	114.3	131.4	91.2	
	KITAZIGURW	7.5	4,428	738	95.9	3.7	99.6	114.5	79.5	
	MUKABANGE	5.6	3,628	605	78.7	26.4	105.1	120.8	83.9	
	MURANBI	10.7	5,200	867	112.7	3.9	116.6	134.0	93.1	
	NYAGATOVU	8.6	3,815	636	82.7	0.1	82.8	95.2	66.1	(300)
	TOTAL	39.9	21,944	3,659	475.7	42.5	518.2	596.0	413.9	298.0
SAKE	GITUZA	12.0	5,083	848	110.2	4.1	114.3	131.4	91.2	
	MABUGA-1	6.7	4,329	722	93.9	1.8	95.7	110.1	76.4	
	MABUGA-2	6.3	4,174	696	90.5	25.6	116.1	133.5	92.7	
	NGOMA	6.1	2,974	496	64.5	3.0	67.5	77.6	53.9	
	NSHILI-1	8.0	6,038	1,007	130.9	0.4	131.3	150.9	104.8	
	NSHILI-2	2.7	1,926	321	41.7	2.8	44.5	51.2	35.6	
	RUBAGO	8.5	5,366	895	116.4	2.9	119.3	137.1	95.2	
	RUYEMA-1	1.3	1,553	259	33.7	0.0	33.7	38.8	27.0	
	RUYEMA-2	2.5	2,422	404	52.5	0.1	52.6	60.5	42.0	(450)
	TOTAL	54.1	33,865	5,648	734.3	40.6	774.9	891.1	618.8	445.5
TOTAL		94.0	55,809	9,307	1,210.0	83.1	1,293.1	1,487.1	1,032.7	743.5

	Type A	Type B
Characteristics	1. A special design is made to the flocculator to allow high up-lift flow velocity. Thus, a small flocculation area is needed. 2. Operation is unstable for variable conditions. 3. In the flocculator, time of contact with the chemical is short and some types of particles cannot be removed. 4. Deviation between jar test results and the qualities of actually treated water by Type A purifier is large. 5. Treatment results vary depending upon the qualities of the water source. 6. It requires more difficult operation and maintenance work than Type B.	1. It requires slightly larger space to install than Type A. 2. Compared to Type A, it is suitable for variable conditions. 3. In the flocculator, the time of contact with the chemical is long and stable water treatment is possible. 4. Deviation between jar test results and the qualities of actually treated water by Type B purifier is small. Thus, it is quite easy to predict water treament results. 5. Installation is easy and requires only a short period of time. 6. Expansion of the facility is quite easy. 7. By installing the same type of units, it will be possible to utilize compatible spare parts, making the operation and maintenance work of the unit easy. 8. Highly skilled operating personnel is not required.

(continue)

Table M.4 (2)

	Type A		Type B	
Equipment Costs (Yen)	Intake Facility:	14,600,000	Intake Facility	14,600,000
	Raw Water Well:	2,500,000	Raw Water Well:	2,500,000
	Coagulant Settling Facility:	34,600,000	Small-sized Purifier	94,100,000
	Filtration Facility:	23,600,000		
	Chemical Injection Pumping Facility:	47,800,000		
	Delivery Pumping Facility:	64,300,000	Delivery Pumping Facility:	64,300,000
	Distribution Pond Facility:	18,000,000	Distribution Pond Facility:	18,000,000
	Drainage Tank Facility:	10,000,000	Drainage Tank Facility:	10,000,000
	Electrical Measuring Facility:	54,600,000	Electrical Measuring Facility:	54,600,000
	SUBTOTAL	270,000,000	SUBTOTAL	242,000,000
Civil Eng. Work Costs (Yen)	Intake Work	2,000,000	Intake Work:	2,000,000
	Raw Water Well Construction	1,600,000	Raw Water Well Construction	1,600,000
	Coagulant Settling Basin Construction:	1,200,000	Purifier Foundation Construction:	2,000,000
	Filter Construction:	900,000	Chemical Injection Chamber Construction:	9,300,000
	Chemical Injection Chamber Construction:	9,300,000		
	Clear Water Reservoir Construction:	10,100,000	Clear Water Reservoir Construction:	10,100,000
	Distribution Pond Construction:	19,000,000	Distribution Pond Construction	19,000,000
	SUBTOTAL:	44,100,000	SUBTOTAL:	44,000,000
Installation Costs (Yen)	Installation Work:	17,000,000	Installation Work:	9,000,000
	Piping Work:	60,000,000	Piping Work:	60,000,000
	Painting Work	9,000,000	Painting Work:	9,000,000
	SUBTOTAL	86,000,000	SUBTOTAL	78,000,000
Project Costs (Yen)		400,000,000		364,000,000

Note: The construction costs were obtained from the model study of the water treatment facilities (treatment capacity of 1,200 m^3/day) in the Mugesera Area.

LIST OF WATER SUPPLY SCHEME FOR SYSTEM-1

Service Block Name	Treatment Plant			Transmission Pipe		Reservoir Tank		Distribution Facilities													Trans-mission Line
	Booster Pump		Plant Capacity	DCIP (m)	Aire Valve	(unit)		PVC Pipe (m)				Aire Valve	Stand Pipe	Drain Valve (pcs)			Gate Valve (pcs)				
	Pump Unit	Head	(m3)	φ 150mm	φ 150mm	100m3	300m3	φ 50mm	φ 75mm	φ 100mm	φ 150mm	(unit)	(unit)	75mm	100mm	150mm	50mm	75mm	100mm	150mm	(m)
MUHAZI	18.5kwx3	250	200x3	11.000	5		1	10.000	11.700	3.300	2.500	4	16		3	1	5	5	4	2	100
SAKE	30kwx3	300	270x3	7.000	5	1		17.200	10.300	14.000	2.000	15	26	1	2		12	1	5		3.000
	7.5kwx1	100																			
TOTAL	7		6	18.000	10	1	1	27.200	22.000	17.300	4.500	19	42	1	5	1	17	6	9	2	3.100

PROPOSED WATER DEMAND OF SYSTEM-2

SYSTEM NAME	COMMUNE NAME	SECTOR NAME	AREA (km2)	POPULATION 2000	FAMILY 2000	WATER DEMAND (m3/day) FAMILY (0.13m3/f)	PUBLIC	TOTAL (m3/day)	MAX WATER DEMAND (115%)	PUMP CAPACITY (l/min)	RESORVOIR CAPACITY (m3)
KAYONZA-1	KAYONZA	KAYONZA	12.8	4,374	729	94.8	5.6	100.4	115.4	80.1	57.7 (60)
KAYONZA-2	KAYONZA	NYAMIRAMA	5.3	1,403	234	30.4	1.9	32.3	37.2	25.8	18.6
		SHYOGO	2.9	2,105	351	45.6	2.3	47.9	55.1	38.3	27.6
		TOTAL	8.2	3,508	585	76.0	4.3	80.3	92.3	64.1	46.2 (60)
RUTONDE	RUTONDE	RWERU	6.0	3,720	620	80.6	0.1	80.7	92.8	64.4	46.4 (60)
KABARONDO	KABARONDO	NKAMBA	3.7	1,447	242	31.5	0.1	31.6	36.3	25.2	18.2
		RURAMIRA	6.5	1,914	319	41.5	3.8	45.3	52.1	36.2	26.1
		RUYONZA	5.5	2,595	433	56.3	0.1	56.4	64.8	45.0	32.4
		TOTAL	15.7	5,956	994	129.3	4.0	133.3	153.3	106.5	76.7 (80)
BIRENGA	BIRENGA	NDAMIRA	9.3	3,588	598	77.7	0.1	77.8	89.5	62.1	44.7 (60)
RUSUMO-1	RUSUMO	GATORE	6.4	3,285	548	71.2	4.9	76.1	87.5	60.8	43.8
		KIREHE	8.6	4,015	670	87.1	8.0	95.1	109.3	75.9	54.7
		TOTAL	15.0	7,300	1,218	158.3	12.9	171.2	196.8	136.7	98.4 (100)
RUSUMO-2	RUSUMO	NYARUBUYE	13.8	8,292	1,382	179.7	19.4	199.0	228.9	159.0	114.4 (120)
RUSUMO-3	RUSUMO	NYAMUGALI	21.3	7,278	1,213	157.7	12.8	170.5	196.1	136.2	98.1 (100)
TOTAL			102.2	44,016	7,336	954.1	59.1	1,013.1	1,165.1	809.1	582.6

LIST OF WATER SUPPLY SCHEME FOR SYSTEM-2

Service	Intake Facilities					Transmission		Reservoir Tank				Distribution Facilities												Power Supply Facilities			
Block	No. of	Pump Facility φ40(unit)			Head	DCIP (m)	Aire Valve	(unit) m3				PVC Pipe (m)				Aire Valve	Stand Pipe	Drain Valve (pcs)			Gate Valve (pcs)			Trans-mission	Generater (unit)		
Name	Well	5.5kw	7.5kw	11kw	(m)	φ75mm	φ75mm	60	80	100	120	φ30mm	φ50mm	φ75mm	φ100mm	(unit)	(unit)	φ30mm	φ50mm	φ75mm	φ30mm	φ50mm	φ75mm	Line(m)	5.5kw	7.5kw	11kw
KAYONZA-1	1		1		180	506	1	1				6.700	2.500	420		4	6	2			3	2	1	1.800			
KAYONZA-2	1			1	220	260	1	1				5.750	2.300			4	5	2				2	3	1.200			
RUTONDE	1	1			125	796	1	1				3.600	130			3	5				5				1		
KABARONDO	2		2		185	600	1		1			5.050	1.700	30		7	7	4			3	3	1	1.800			
BIRNGA	1			1	220	950	1	1				6.400	1.200			2	6	2			5	1					1
RUSUMO-1	2		2		180	1.290	2			1		7.400	4.250	1.450		7	8	4	2		4	2	2			2	
RUSUMO-2	2			2	250	1.365	2				1	7.750	7.200	2.700	550	6	11	3	2		6	5	2				2
RUSUMO-3	2		2		185	714	1			1		6.550	10.400	700	6.000	8	17	3	3		7	5	2			2	
TOTAL	12	1	7	4		6.481	10	4	1	2	1	49.200	29.680	5.300	6.550	41	65	20	7	0	33	20	11	4.800	1	4	3

Table M.7

PROPOSED WATER DEMAND OF SYSTEM-3 NO.1

COMMUNE NAME	SECTOR NAME	AREA (km2)	POPULATION 2000	FAMILY 2000	WATER DEMAND (m3/day) FAMILY (0.09m3/f)	PUBLIC	TOTAL (m3/day)
RUKARA	GAHINI	5.8	3,827	638	57.4	54.0	111.4
	KIYENZI	10.6	3,511	586	52.7	4.1	56.8
	NYAKABUNGO	17.6	2,345	391	35.2	2.9	38.1
	NYAWERA	30.0	4,024	671	60.4	2.2	62.6
	RUKARA	28.0	6,677	1,113	100.2	19.7	119.9
	RWIMISHINY	12.2	3,594	599	53.9	4.1	58.0
	RYAMANYONI	54.2	3,450	575	51.8	8.4	60.2
	TOTAL	158.4	27,428	4,573	411.6	95.4	507.0
MUGESERA	CYIZIHIRA	8.3	4,199	700	63.0	0.1	63.1
	GATARE	13.8	4,311	719	64.7	4.9	69.6
	KAGASHI	18.3	5,137	857	77.1	4.2	81.3
	KAREMBO	0.9	614	103	9.3	0.1	9.4
	KIBARE	7.4	4,892	816	73.4	2.4	75.8
	KIBILIZI-1	10.4	5,169	862	77.6	5.6	83.2
	KIRAMBO	9.0	3,584	598	53.8	0.1	53.9
	KUKABUYE	4.3	2,936	490	44.1	1.1	45.2
	MATONGO	4.4	3,726	621	55.9	0.1	56.0
	NGARA	8.8	3,944	658	59.2	2.8	62.0
	NYANGE	17.1	3,105	518	46.6	11.2	57.8
	SANGAZA	13.8	4,190	699	62.9	4.7	67.6
	SHYWA	7.0	3,931	656	59.0	3.4	62.4
	ZAZA	3.9	2,064	344	31.0	68.6	99.6
	TOTAL	127.4	51,802	8,641	777.6	109.3	886.9
KAYONZA	GASOGI	11.1	2,617	437	39.3	2.2	41.5
	MBURABUTUR	7.7	1,932	322	29.0	0.1	29.1
	MUSUMBA	8.6	1,471	246	22.1	2.1	24.2
	NYAMIRAMA	13.5	3,285	548	49.3	4.5	53.8
	RUTARE	12.6	3,267	545	49.1	2.5	51.6
	RWINKWAVU	5.3	448	75	6.8	2.3	9.1
	SHYOGO	4.3	1,403	234	21.1	1.6	22.7
	TOTAL	63.1	14,423	2,407	216.7	15.3	232.0
RUTONDE	KADUHA	4.6	1,339	224	20.2	0.1	20.3
	RUTONDE	9.8	3,326	555	50.0	4.7	54.7
	RWERU	1.5	930	155	14.0	0.0	14.0
	SOVU	8.2	3,244	541	48.7	3.3	52.0
	TOTAL	24.1	8,839	1,475	132.9	8.1	141.0
KABARONDO	BISENGA	9.2	2,223	371	33.4	3.1	36.5
	MURAMA	4.6	941	157	14.1	0.9	15.0
	NKAMBA	2.5	934	156	14.0	0.1	14.1
	RURAMIRA	6.5	1,914	319	28.7	3.8	32.5
	RUSERA	5.9	2,159	360	32.4	0.1	32.5
	RUYONZA	2.3	1,115	186	16.7	0.0	16.7
	SHYANDA	2.7	887	148	13.3	0.9	14.2
	TOTAL	33.7	10,173	1,697	152.6	8.9	161.5
sub-TOTAL		406.7	112,665	18,793	1,691.4	237.0	1,928.4

PROPOSED WATER DEMAND OF SYSTEM-3 NO.2

COMMUNE NAME	SECTOR NAME	AREA (km2)	POPULATION 2000	FAMILY 2000	WATER DEMAND (m3/day) FAMILY (0.09m3/f)	PUBLIC	TOTAL (m3/day)
SAKE	MBUYE	6.2	2,010	335	30.2	0.8	31.0
	MURWA	31.6	5,666	945	85.1	15.2	100.3
	RUKUMBERI	16.0	6,058	1,010	90.9	8.6	99.5
	SHOLI	14.4	5,521	921	82.9	6.4	89.3
	TOTAL	68.2	19,255	3,211	289.1	31.0	320.1
KIGARAMA	GASETSA	8.2	696	116	10.4	1.9	12.3
	GASHANDA	10.1	2,326	388	34.9	6.5	41.4
	KABARE-1	9.3	1,507	252	22.7	15.9	38.6
	KABARE-2	37.8	3,370	562	50.6	10.5	61.1
	KABERANGWE	9.0	1,714	286	25.7	3.2	28.9
	KANSANA	11.8	2,395	400	36.0	7.2	43.2
	REMERA	9.9	1,748	292	26.3	5.5	31.8
	RUBONA	10.7	6,110	1,019	91.7	16.0	107.7
	RURENGE	14.9	1,924	321	28.9	4.4	33.3
	VUMWE	21.2	4,441	741	66.7	5.4	72.1
	TOTAL	142.9	26,231	4,377	393.9	76.5	470.4
RUKIRA	GASIRU	8.3	1,733	289	26.0	1.4	27.4
	GITWE	9.3	2,056	343	30.9	3.3	34.2
	MUSHIKILI	15.1	1,786	298	26.8	1.3	28.1
	NTARUKA	3.7	224	38	3.4	0.5	3.9
	RUGARAMA	12.1	1,883	314	28.3	1.3	29.6
	TOTAL	48.5	7,682	1,282	115.4	7.8	123.2
BIRENGA	BARE	8.8	1,237	207	18.6	3.3	21.9
	BIRENGA	9.0	1,351	226	20.3	3.3	23.6
	GAHARA	26.0	3,709	619	55.7	6.9	62.6
	GAHULIRE	3.8	1,512	252	22.7	1.8	24.5
	GASHONGORA	11.6	2,231	372	33.5	1.9	35.4
	KIBAYA	7.0	3,570	595	53.6	5.2	58.8
	KIBIMBA	6.9	1,522	254	22.9	4.0	26.9
	SAKARA	5.3	2,110	352	31.7	2.2	33.9
	TOTAL	78.4	17,242	2,877	259.0	28.6	287.6
RUSUMO	GATORE	17.5	3,285	548	49.3	4.9	54.2
	KANKOBWA	117.6	4,847	808	72.7	6.8	79.5
	KIGARAMA	15.8	3,361	561	50.5	2.9	53.4
	KIGINA	22.0	5,838	973	87.6	15.3	102.9
	KIREHE	6.7	2,149	359	32.3	4.3	36.6
	MUSAZA	30.4	6,978	1,163	104.7	3.3	108.0
	NYABITARE	9.9	5,177	863	77.7	4.9	82.6
	NYAMUGALI	17.6	1,679	280	25.2	3.0	28.2
	NYARUBUYE	27.7	3,455	576	51.8	8.1	59.9
	TOTAL	265.2	36,769	6,131	551.8	53.5	605.3
sub-TOTAL		603.2	107,179	17,878	1,609.2	197.4	1,806.6
TOTAL		1,009.9	219,844	36,671	3,300.6	434.4	3,735.0

PROPOSED SHALLOW WELL FOR SYSTEM-3 (1)

COMMUNE NAME	SECTOR NAME	AREA (km2)	POPULATION 2000	CLASSIFICA DEPTH SAFTY FACT	Sa (50m) 1.00	Sb (60m) 1.25	Sc (50m) 1.25	Sd (50m) 1.25
RUKARA	GAHINI	5.8	3,827		12			
	KIYENZI	10.6	3,511		6			
	NYAKABUNGO	17.6	2,345		5			
	NYAWERA	30.0	4,024		8			
	RUKARA	28.0	6,677			12		
	RWIMISHINY	12.2	3,594		6			
	RYAMANYONI	54.2	3,450					14
	TOTAL	158.4	27,428		37	12	0	14
MUGESERA	CYIZIHIRA	8.3	4,199					8
	GATARE	13.8	4,311					9
	KAGASHI	18.3	5,137					11
	KAREMBO	0.9	614		1			
	KIBARE	7.4	4,892					10
	KIBILIZI-1	10.4	5,169			9		
	KIRAMBO	9.0	3,584					7
	KUKABUYE	4.3	2,936		5			
	MATONGO	4.4	3,726					7
	NGARA	8.8	3,944		7			
	NYANGE	17.1	3,105					8
	SANGAZA	13.8	4,190					9
	SHYWA	7.0	3,931					8
	ZAZA	3.9	2,064					13
	TOTAL	127.4	51,802		13	9	0	90
SAKE	MBUYE	6.2	2,010			4		
	MURWA	31.6	5,666					13
	RUKUMBERI	16.0	6,058					13
	SHOLI	14.4	5,521					12
	TOTAL	68.2	19,255		0	4	0	38
KAYONZA	GASOGI	11.1	2,617			5		
	MBURABUTUR	7.7	1,932			3		
	MUSUMBA	8.6	1,471		3			
	NYAMIRAMA	13.5	3,285		6			
	RUTARE	12.6	3,267			6		
	RWINKWAVU	5.3	448		2			
	SHYOGO	4.3	1,403			3		
	TOTAL	63.1	14,423		11	17	0	0
RUTONDE	KADUHA	4.6	1,339		3			
	RUTONDE	9.8	3,326		6			
	RWERU	1.5	930			2		
	SOVU	8.2	3,244			6		
	TOTAL	24.1	8,839		9	8	0	0
KABARONDO	BISENGA	9.2	2,223		4			
	MURAMA	4.6	941		2			
	NKAMBA	2.5	934		2			
	RURAMIRA	6.5	1,914			4		
	RUSERA	5.9	2,159		4			
	RUYONZA	2.3	1,115		2			
	SHYANDA	2.7	887			2		
	TOTAL	33.7	10,173		14	6	0	0
	sub-TOTAL	474.9	131,920		84	56	0	142

PROPOSED SHALLOW WELL FOR SYSTEM-3 (2)

COMMUNE NAME	SECTOR NAME	AREA (km2)	POPULATION 2000	CLASSIFICA DEPTH SAFTY FACT	Sa (50m) 1.00	Sb (60m) 1.25	Sc (50m) 1.25	Sd (50m) 1.25
KIGARAMA	GASETSA	8.2	696		3			
	GASHANDA	10.1	2,326		5			
	KABARE-1	9.3	1,507		4			
	KABARE-2	37.8	3,370		10			
	KABERANGWE	9.0	1,714			3		
	KANSANA	11.8	2,395		5			
	REMERA	9.9	1,748			4		
	RUBONA	10.7	6,110			11		
	RURENGE	14.9	1,924		4			
	VUMWE	21.2	4,441		8			
	TOTAL	142.9	26,231		39	18	0	0
RUKIRA	GASIRU	8.3	1,733					4
	GITWE	9.3	2,056				4	
	MUSHIKILI	15.1	1,785				4	
	NTARUKA	3.7	224				1	
	RUGARAMA	12.1	1,883				3	
	TOTAL	48.5	7,682		0	0	12	4
BIRENGA	BARE	8.8	1,237		3			
	BIRENGA	9.0	1,351		3			
	GAHARA	26.0	3,709			7		
	GAHULIRE	3.8	1,512		3			
	GASHONGORA	11.6	2,231		4			
	KIBAYA	7.0	3,570			6		
	KIBIMBA	6.9	1,522		3			
	SAKARA	5.3	2,110		4			
	TOTAL	78.4	17,242		20	13	0	0
RUSUMO	GATORE	17.5	3,285				6	
	KANKOBWA	117.6	4,847		30			
	KIGARAMA	15.8	3,361		6			
	KIGINA	22.0	5,838		11			
	KIREHE	6.7	2,149		4			
	MUSAZA	30.4	6,978				11	
	NYABITARE	9.9	5,177				9	
	NYAMUGALI	17.6	1,679					5
	NYARUBUYE	27.7	3,455				7	
	TOTAL	265.2	36,769		51	0	33	5
	sub-TOTAL	535.0	87,924		110	31	45	9
TOTAL		1,009.9	219,844		194	87	45	151

PROPOSED WATER DEMAND OF SYSTEM-4

COMMUNE NAME	SECTOR NAME	AREA (km2)	POPULATION 2000	FAMILY 2000	UNIT NO.
RUKARA	KIYENZI	4.5	1,505	251	251
	NYAKABUNGO	13.2	1,698	283	283
	NYAWERA	13.1	1,724	288	288
	RUKARA	3.0	921	154	154
	RWIMISHINY	6.1	2,248	375	375
	RYAMANYONI	7.5	470	79	79
	TOTAL	47.4	8,566	1,430	1,430
KAYONZA	GASOGI	3.3	1,122	187	187
	MBURABUTUR	1.9	828	138	138
	MUSUMBA	10.7	1,831	306	306
	RWINKWAVU	81.0	672	112	112
	TOTAL	96.9	4,453	743	743
RUTONDE	KADUHA	3.1	902	151	151
	TOTAL	3.1	902	151	151
KABARONDO	BISENGA	7.1	1,110	185	185
	MURAMA	14.8	1,412	236	236
	RUSERA	2.9	1,064	178	178
	SHYANDA	15.2	1,506	251	251
	TOTAL	40.0	5,092	850	850
KIGARAMA	KABARE-2	16.6	1,683	281	281
	REMERA	2.9	803	134	134
	RUBONA	10.7	1,146	191	191
	TOTAL	30.2	3,632	606	606
RUKIRA	GASIRU	7.4	694	116	116
	GITUKU	2.5	595	100	100
	MUSHIKILI	11.3	1,191	199	199
	NTARUKA	8.8	223	38	38
	RUGARAMA	11.1	1,256	210	210
	TOTAL	41.1	3,959	663	663
BIRENGA	BIRENGA	10.7	1,802	301	301
	GAHARA	15.6	2,060	344	344
	TOTAL	26.3	3,862	645	645
RUSUMO	GATORE	11.6	1,641	274	274
	KANKOBWA	55.7	7,109	1,185	1,185
	KIGARAMA	32.2	5,041	841	841
	KIGINA	5.7	730	122	122
	MUSAZA	18.1	3,489	582	582
	NYABITARE	16.2	864	144	144
	NYAMUGALI	39.5	0	0	0
	NYARUBUYE	23.0	690	115	115
	TOTAL	202.0	19,564	3,263	3,263
TOTAL		487.0	50,030	8,351	8,351

Results of Economical Study of Transmission Pipe

SYSTEM-1 MUHAZI

Discharge	Q=	596 m3/day			
		0.414 m3/min		6.898 l/s	
Transmission Pipe	L=	11500 m			

Pipe Dia	D=	75	100	150	200
Head Loss (Unit)	m/m	0.058	0.017	0.0017	0.00045
Head Loss (total)	m	667	195.5	19.55	5.175
Pipe Cost (unit)	RWF	5,077	7,400	9,481	12,476
Pipe Cost (total)	RWF	58,389,333	85,100,000	109,027,667	143,474,000
Pump Cost	RWF	30,015,000	8,797,500	879,750	232,875
Electric Fee	RWF	61,286,388	17,963,252	1,796,325	475,498
TOTAL		149,690,721	111,860,752	111,703,742	144,182,373

SYSTEM-1 SAKE

Discharge	Q=	661 m3/day			
		0.459 m3/min		7.650 l/s	
Transmission Pipe	L=	6000 m			

Pipe Dia	D=	75	100	150	200
Head Loss (Unit)	m/m	0.065	0.018	0.002	0.0005
Head Loss (total)	m	390	108	12	3
Pipe Cost (unit)	RWF	5,077	7,400	9,481	12,476
Pipe Cost (total)	RWF	30,464,000	44,400,000	56,884,000	74,856,000
Pump Cost	RWF	17,550,000	4,860,000	540,000	135,000
Electric Fee	RWF	35,834,620	9,923,433	1,102,604	275,651
TOTAL		83,848,620	59,183,433	58,526,604	75,266,651

SYSTEM-2 CASE STUDY 1

Discharge	Q=	100 m3/day		
		0.069 m3/min		1.157 l/s
Transmission Pipe	L=	100 m		

Pipe Dia	D=	75	100	150
Head Loss (Unit)	m/m	0.0018	0.00047	0.00005
Head Loss (total)	m	0.18	0.047	0.005
Pipe Cost (unit)	RWF	5,077	7,400	9,481
Pipe Cost (total)	RWF	507,733	740,000	948,067
Pump Cost	RWF	8,100	2,115	225
Electric Fee	RWF	16,539	4,319	459
TOTAL		532,372	746,434	948,751

SYSTEM-2

Discharge	Q=	100 m3/day		
		0.069 m3/min		1.157 l/s
Transmission Pipe	L=	500 m		

Pipe Dia	D=	75	100	150
Head Loss (Unit)	m/m	0.0018	0.00047	0.00005
Head Loss (total)	m	0.9	0.235	0.025
Pipe Cost (unit)	RWF	5,077	7,400	9,481
Pipe Cost (total)	RWF	2,538,667	3,700,000	4,740,333
Pump Cost		40,500	10,575	1,125
Electric Fee		82,695	21,593	2,297
TOTAL		2,661,862	3,732,168	4,743,755

SYSTEM-2

Discharge	Q=	100 m3/day		
		0.069 m3/min		1.157 l/s
Transmission Pipe	L=	1000 m		

Pipe Dia	D=	75	100	150
Head Loss (Unit)	m/m	0.0018	0.00047	0.00005
Head Loss (total)	m	1.8	0.47	0.05
Pipe Cost (unit)	RWF	5,077	7,400	9,481
Pipe Cost (total)	RWF	5,077,333	7,400,000	9,480,667
Pump Cost		81,000	21,150	2,250
Electric Fee		165,391	43,185	4,594
TOTAL		5,323,724	7,464,335	9,487,511

SYSTEM-2

Discharge	Q=	100 m3/day		
		0.069 m3/min		1.157 l/s
Transmission Pipe	L=	1500 m		

Pipe Dia	D=	75	100	150
Head Loss (Unit)	m/m	0.0018	0.00047	0.00005
Head Loss (total)	m	2.7	0.705	0.075
Pipe Cost (unit)	RWF	5,077	7,400	9,481
Pipe Cost (total)	RWF	7,616,000	11,100,000	14,221,000
Pump Cost		121,500	31,725	3,375
Electric Fee		248,086	64,778	6,891
TOTAL		7,985,586	11,196,503	14,231,266

SYSTEM-2 CASE STUDY 2

Discharge	Q=	200 m3/day		
		0.139 m3/min		2.315 l/s
Transmission Pipe	L=	100 m		

Pipe Dia	D=	75	100	150
Head Loss (Unit)	m/m	0.0068	0.0016	0.00021
Head Loss (total)	m	0.68	0.16	0.021
Pipe Cost (unit)	RWF	5,077	7,400	9,481
Pipe Cost (total)	RWF	507,733	740,000	948,067
Pump Cost		30,600	7,200	945
Electric Fee		62,481	14,701	1,930
TOTAL		600,814	761,901	950,941

SYSTEM-2

Discharge	Q=	200 m3/day		
		0.139 m3/min		2.315 l/s
Transmission Pipe	L=	500 m		

Pipe Dia	D=	75	100	150
Head Loss (Unit)	m/m	0.0068	0.0016	0.00021
Head Loss (total)	m	3.4	0.8	0.105
Pipe Cost (unit)	RWF	5,077	7,400	9,481
Pipe Cost (total)	RWF	2,538,667	3,700,000	4,740,333
Pump Cost		153,000	36,000	4,725
Electric Fee		312,404	73,507	9,648
TOTAL		3,004,071	3,809,507	4,754,706

SYSTEM-2

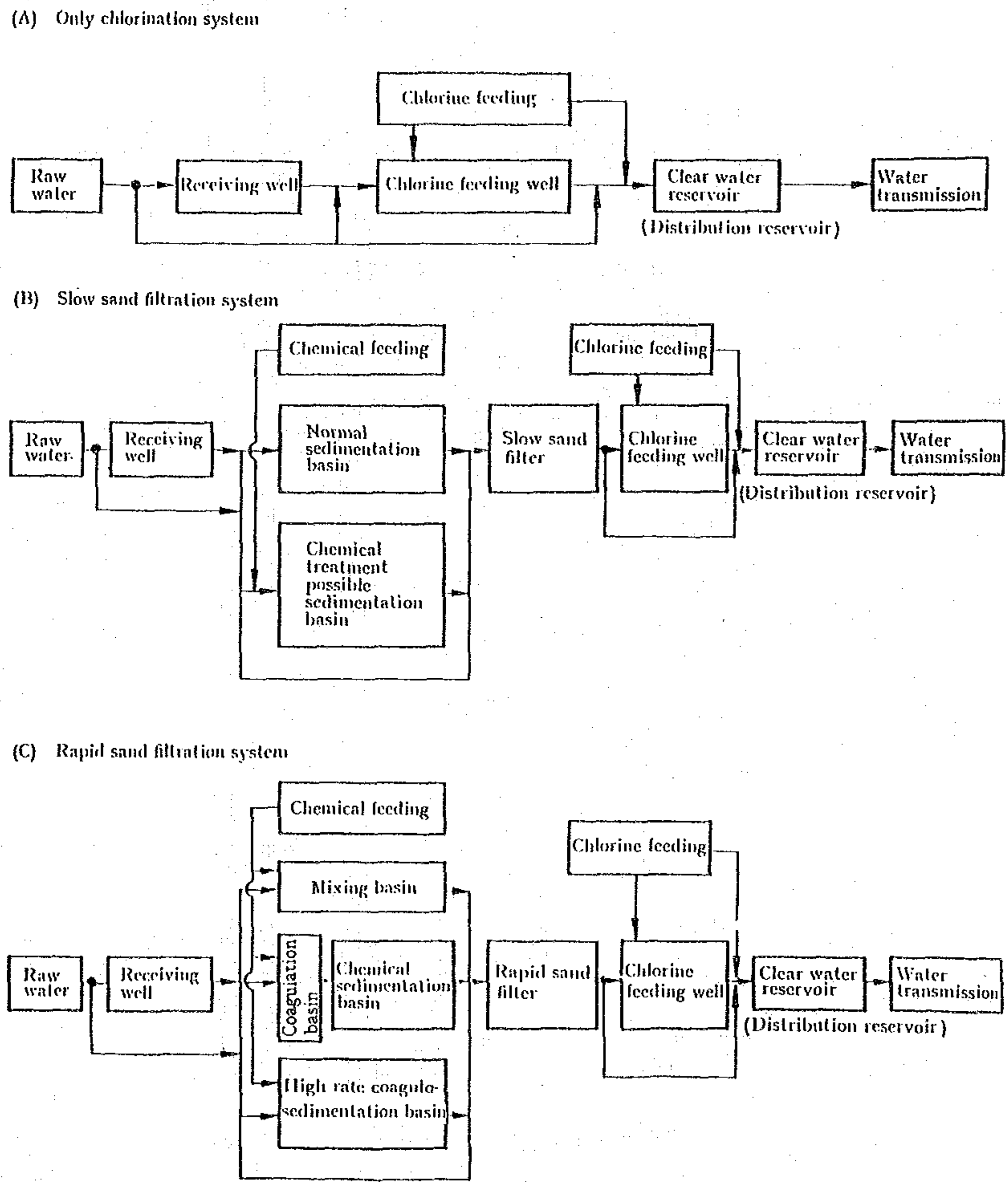
Discharge	Q=	200 m3/day		
		0.139 m3/min		2.315 l/s
Transmission Pipe	L=	1000 m		

Pipe Dia	D=	75	100	150
Head Loss (Unit)	m/m	0.0068	0.0016	0.00021
Head Loss (total)	m	6.8	1.6	0.21
Pipe Cost (unit)	RWF	5,077	7,400	9,481
Pipe Cost (total)	RWF	5,077,333	7,400,000	9,480,667
Pump Cost		306,000	72,000	9,450
Electric Fee		624,809	147,014	19,296
TOTAL		6,008,142	7,619,014	9,509,412

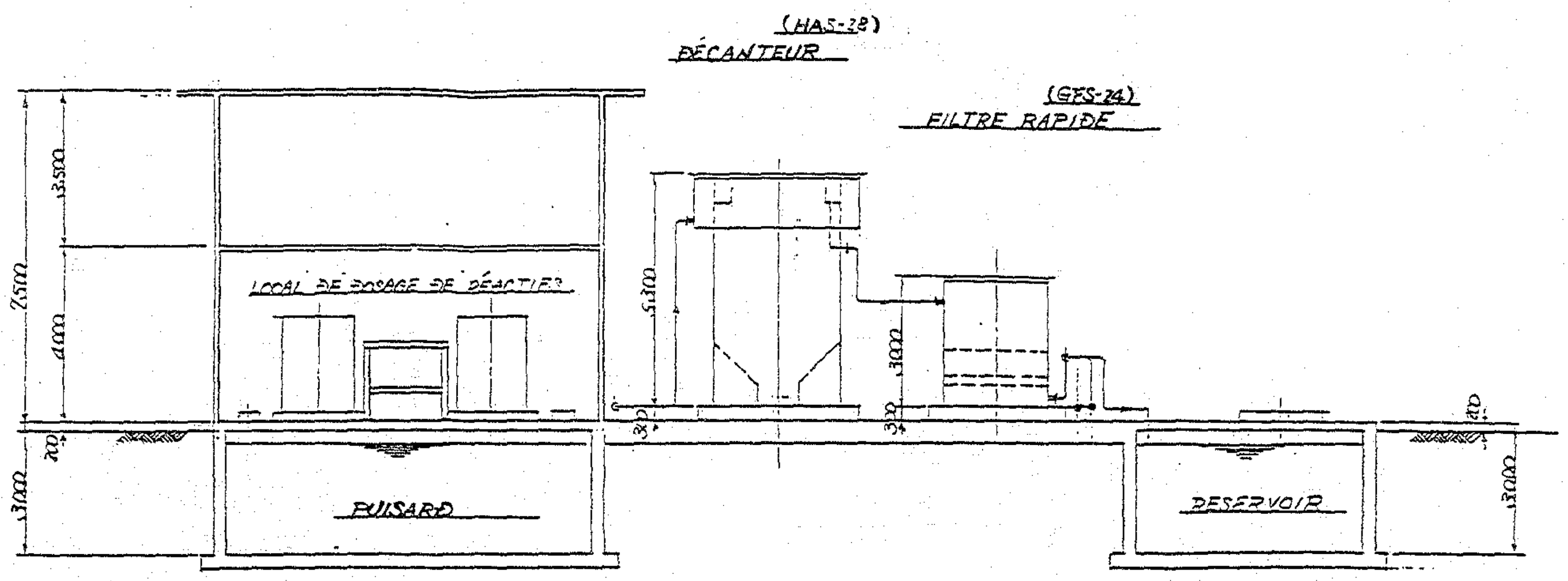
SYSTEM-2

Discharge	Q=	200 m3/day		
		0.139 m3/min		2.315
Transmission Pipe	L=	1500 m		

Pipe Dia	D=	75	100	150
Head Loss (Unit)	m/m	0.0068	0.0016	0.00021
Head Loss (total)	m	10.2	2.4	0.315
Pipe Cost (unit)	RWF	5,077	7,400	9,481
Pipe Cost (total)	RWF	7,616,000	11,100,000	14,221,000
Pump Cost		459,000	108,000	14,175
Electric Fee		937,213	220,521	28,943
TOTAL		9,012,213	11,428,521	14,264,118



Purification Systems



COUPE A A

Type A : High Rate Coagulosedimentation Basin
with Gravity Rapid Sand Filter-1