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**SUMMARY  
AND  
RECOMMENDATIONS**

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## SUMMARY AND RECOMMENDATIONS

### INTRODUCTION

- 001: The purpose of the Rural Supply Project was to supply safe and stable drinking water to the residents of Kibungo Prefecture located in the eastern part of Rwanda.
- 002: The Project's first feasibility study was made during the 1984-85 period, in which the Phase I and Phase II projects composed mainly of groundwater development were proposed. The Phase I project was completed under Japanese Grant Aid.
- 003: The Area to be covered under the Phase III Study would include the entire Kibungo Prefecture except the Akagera National Park.

### WATER RESOURCES AND WATER SUPPLY SYSTEM OPTIONS

- 004: The Government of Rwanda proposed a basic policy for providing all the people with safe and stable drinking water by the year 2000, the target year of the "Basic Sanitary Plan for All People".
- 005: Kibungo Prefecture's drinking water demand in the year 2000 was estimated as 5.2 million m<sup>3</sup>/year. This figure was 1.73 times that of the 1988 water demand (3.0 million m<sup>3</sup>/year). It was believed that 0.8 million m<sup>3</sup>/year of drinking water was supplied in 1988, therefore it would be necessary to develop 4.4 million m<sup>3</sup>/year by the year 2000.
- 006: According to the results of the water balance simulation conducted in this Study, the amount of rainwater in the Study Area reached 3.30 billion m<sup>3</sup>/year of this, 2.26 billion m<sup>3</sup> of the rainwater evaporated, 0.45 billion m<sup>3</sup> became surface runoff and 0.59 billion m<sup>3</sup> infiltrated to replenish groundwater. Therefore, sufficient amounts of water resources were available to satisfy the demand.
- 007: Surface water in the Study Area was more or less contaminated by domestic sewage. Consequently, it would be necessary to install a water treatment plant in order to utilize surface water. For this reason, it was desirable to utilize groundwater and spring water which did not require further treatment.

008: According to test drilling results, the quartzite layers and granite-diorite layers in the Study Area were extremely hard and would result in costly drilling for deep wells. Furthermore, it was difficult to find drilling sites for deep wells that could produce ample amounts of water. Thus, to make use of groundwater, shallow wells were desirable. 273 springs had been found in the Study Area and those yielding large amounts of water were already tapped and distributing to certain parts. Thus, the remaining springs were mainly considered as unsuitable for the Project water sources because of their small and unsettled yield.

009: As a result of the comprehensive study on topography, water sources, village distribution, income of the residents, and infrastructure conditions in the Study Area, the following four water supply systems were proposed as the Basic Plan:

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

The outline of each system was as illustrated in Fig.S.1.

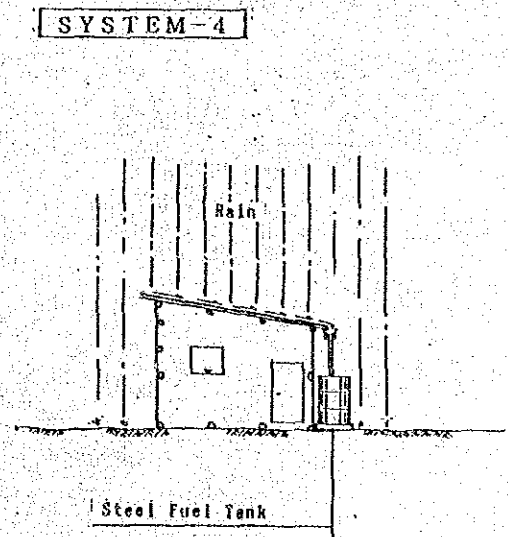
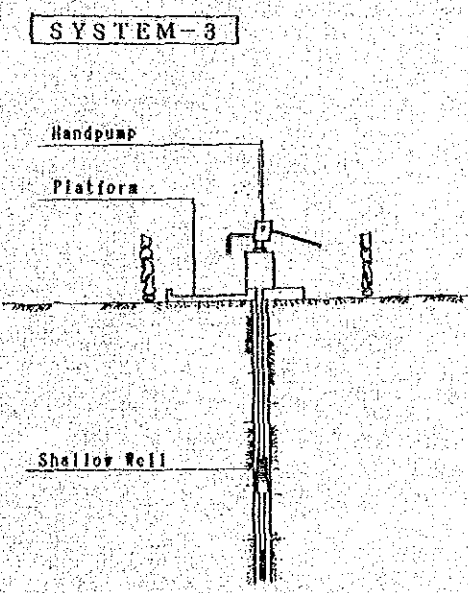
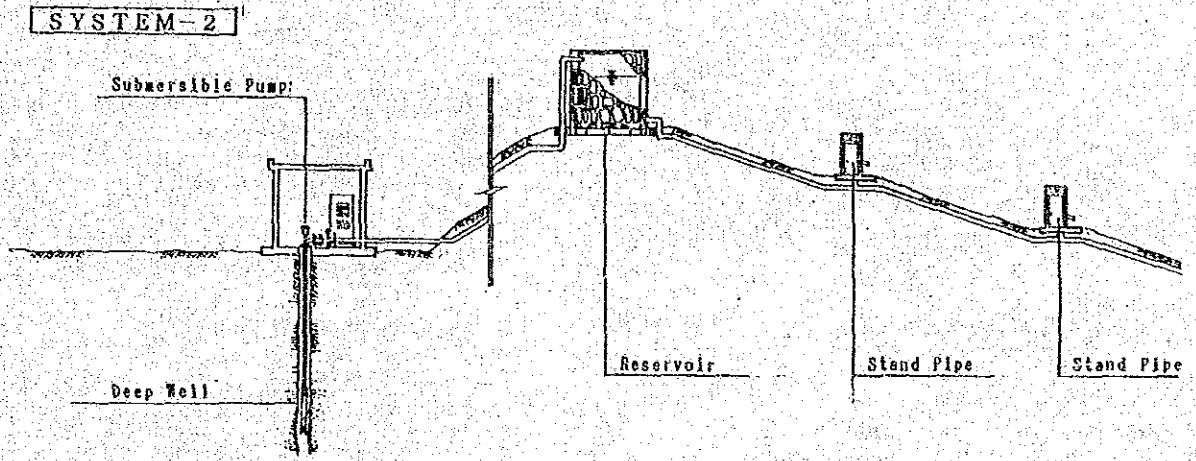
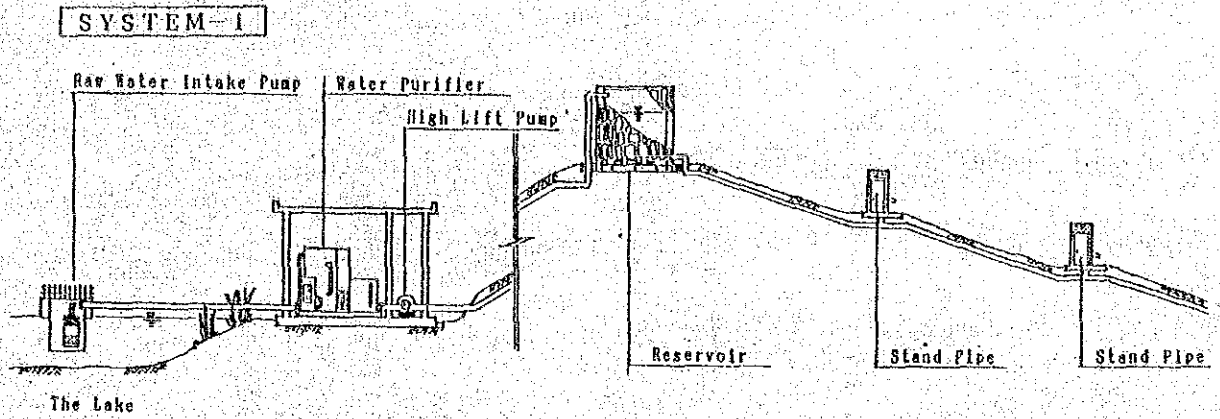
#### BASIC PLAN

010: According to the "National Development Plan", the entire "Basic Plan" would be established by the year 2000. The service level of the water supply was principally considered to be the public standpipe. The design water demand was mainly based on MINITRAPEE's design criteria.

011: The Study Area was subdivided into the following five zones of which Zone E was proposed as the Basic Plan area of the Phase III Study:

<u>Zone</u>	<u>Project</u>	<u>Area (km<sup>2</sup>)</u>	<u>Population (1988)</u>	<u>Population (2000)</u>
Zone A	Phase I	184	36,100	51,600
Zone B	Phase II	373	50,100	85,500
Zone C	Existing	178	37,200	52,600
Zone D	On-going	239	62,400	94,100
Zone E	Phase III	1,693	247,200	369,700
Total		2,667	433,000	653,500

Fig. S.1 Outline of Each System



012: As a result of the Study, it was proposed to install the following water supply facilities as the "Basic Plan".

System	Number	Area (km <sup>2</sup> )	Population (2000)
1	2 blocks	94.0	55,800 ( 8.5%)
2	8 blocks	102.2	44,000 ( 6.7%)
3	477 wells	1,009.9	219,850 (33.6%)
4	8,351 families	487.0	50,050 ( 7.7%)
Total		1,693.1	369,700 (56.5%)

<The estimated population of year 2000 in Kibungo Prefecture was 653,500 (100.0%)>

013: The total cost of the Basic Plan at current prices (August, 1991) was 5,2 billion FRW(40.8 million US\$) as shown in the following table:

(Unit: million FRW)		
1. Construction Cost	System 1	846.6
	System 2	583.2
	System 3	2,570.9
	System 4	99.4
	Sub-total	4,100.1
2. Indirect Cost	Administration	26.0
	Engineering service	410.0
	Sub-total	436.0
3. Physical Contingency	(1 + 2) x 15%	680.4
4. Total		5,216.5

014: The implementation schedule was formulated on a target of completion within nine (9) years between 1992 and 2000; the first year for mainly preparatory work and four (4) Packages; Package A of 1993 to 1994, Package B of 1995 to 1996, Package C of 1997 to 1998 and Package D of 1999 to 2000, were proposed on account of the large project scale, long project period and smooth/effective execution. High priority projects were selected in Packages A and B. The implementation schedule of the Basic Plan was given in Fig. S.2.

Implementation Schedule for the Basic Plan

	1992	1993	1994	1995	1996	1997	1998	1999	2000
	Preparation	Package A	Package A	Package B	Package B	Package C	Package C	Package D	Package D
1. LOAN EFFECTIVE									
2. PREPARATORY WORK Set Up Implementation Office									
3. CONSTRUCTION WORKS									
System 1 : MUHAZI (B) SAKE (B)		D/D	Construction MUHAZI		SAKE				
System 2 : KAYONZA-2 (A) KABARONDO (A) KAYONZA-1 (A) RUTONDE (C) BIRENGA (C) RUSUMO-1 (C) RUSUMO-2 (C) RUSUMO-3 (C)			KAYONZA-2 KABARONDO KAYONZA-1				RUTONDE BIRENGA RUSUMO-1		RUSUMO-2 RUSUMO-3
System 3 : Priority A Priority B Priority C			Priority A (75 wells)		Priority B (153 wells)		Priority C (249 wells)		
System 4 : Program Preparation Announce and PR Financing and Supply Routine Maintenance									
4. INSTITUTIONAL SUPPORT Preparatory Works Implementation [Training Center] Planning/Construction Works Intensive Training Routine Training									
5. TECHNICAL ASSISTANCE									

Fig. S.2 Implementation Schedule for the Basic Plan

## POSSIBLE PROJECTS SCHEME

015: The Possible Project Scheme was selected by taking into account the maximum investment cost (2.90 billion FRW) for drinking water supply and local conditions in the Kibungo Prefecture.

016: The individual projects were selected as being possible to implement by the year 2000. These possible individual projects had been evaluated and considered appropriate from social, economic, financial and engineering standpoints. The early implementation of these individual projects was highly desired. Following is an outline of the Possible Project Scheme:

System	Number	Area (km <sup>2</sup> )	Population (2000)
1	2 blocks	94.0	55,800 (15.1%)
2	3 blocks	36.8	13,850 ( 3.7%)
3	228 wells	528.5	102,900 (27.8%)
Total		245.6	172,550 (46.6%)

<The estimated beneficiaries of the Basic Plan in the year 2000 was 369,700 (100.0%)>

017: The project cost of the Possible Project Scheme at current prices was estimated at 2.83 billion FRW(22 million US\$) as given in the table below:

(Unit: million FRW)		
1. Construction Cost	System 1	846.6
	System 2	200.7
	System 3	1,167.7
	Sub-total	2,215.0
2. Indirect Cost	Administration	26.0
	Engineering service	221.5
	Sub-total	247.5
3. Physical Contingency	(1 + 2) x 15%	369.3
4. Total		2,831.8

018: The planned overall implementation of the Possible Project Scheme was sub-divided into four (4) Packages. This would consist of Package A (2 years), Package B (2 years), Package C (2 years) and a final Package D (2 years) to be completed by the year 2000. The implementation schedule for the Possible Project Scheme was given in Fig. S.3.



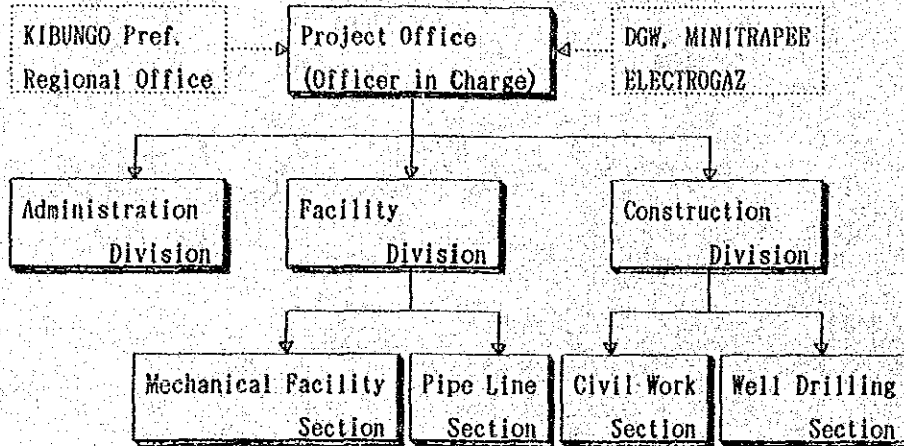
Implementation Schedule for the Possible Project Scheme

	1992	1993	1994	1995	1996	1997	1998	1999	2000
	Preparation	Package A	Package B	Package C	Package D	Package E	Package F	Package G	Package H
1. LOAN EFFECTIVE	▼			▼					
2. PREPARATORY WORK Set Up Implementation Office									
3. CONSTRUCTION WORKS									
System 1 : MUHAZI (B) SAKE (B)				D/D	Construction MUHAZI			D/D	Construction SAKE
System 2 : KAYONZA-2 (A) KABARONDO (A) KAYONZA-1 (A)		D/D	Construction KAYONZA-2 KABARONDO		D/D	Construction KAYONZA-1			
System 3 : Priority A Priority B		D/D	Construction Priority A (75 wells)		D/D	Construction Priority B (153 wells)			
Routine Maintenance									
4. INSTITUTIONAL SUPPORT Preparatory Works Implementation [Training Center] Planning/Construction Works Intensive Training Routine Training									
5. TECHNICAL ASSISTANCE									

Fig. S.3 Implementation Schedule for the Possible Project Scheme

**EXECUTING AGENCY OF THE PROJECT**

019: The executing agency for Project implementation was the Directorate General of Water (DGW) of MINITRAPEE. It was proposed to establish a Project Implementation Office (RWI/ER Office) under the jurisdiction of DGW.



**OPERATION AND MAINTENANCE**

020: It was proposed that the O/M Unit at Commune level and the System Management Organization at service block level would take full responsibility for all matters concerning O/M and water fee collection.

021: The monthly cost per household for the operation and maintenance of each system was estimated as follows:

<u>System</u>	<u>O/M Cost</u>	<u>Remarks</u>
1	185- 203 FRW(1.4- 1.6 US\$)	
2	120- 150 FRW(0.9- 1.1 US\$)	Electric power
	700-1,335 FRW(5.5-10.4 US\$)	Diesel power
3	27- 63 FRW(0.2- 0.5 US\$)	

022: Based on the estimated O/M costs and also considering the financial capabilities of the residents, it was proposed that the water fee collection system would be a combination of the fixed fee rate and the meter rate methods. The water fee rate for each water supply system was to be established as follows:

	<u>System 1</u>	<u>System 2</u>	<u>System 3</u>
-Basic Fixed Fee Rate (per household/month):	100 FRW	70 FRW	30-65 FRW
-Meter Fee Rate:	2 FRW/20 liters excess of 2 m <sup>3</sup> /month		none

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## CONCLUSIONS

### Importance of the Project

023: The coverage rate of safe and stable drinking water supply in the Kibungo Prefecture was only 24%, this figure was far less than the national average of 64%. Many residents in the Prefecture were obliged to use surface water which was not safe. The health and hygienic environment of the Prefecture was comparatively poor and the occurrence rate of waterborne diseases was comparatively high. The need for a water supply facility improvement plan was an urgent matter. Thus, the implementation of the Phase III Basic Plan in Kibungo Prefecture was considered to be one of high priority in Rwanda.

### Basic Plan

024: The project cost of the Basic Plan was 5.2 billion FRW, which exceeded the Government's budget of 4.1 billion for water supply during the period 1982 to 1986. Even if sufficient funding for the Project was raised, Governmental policy would make it difficult to invest it all during a nine (9) year period only on the Kibungo Prefecture's water supply project.

025: Therefore, in view of the country's overall water supply improvement plan, it was considered to be more realistic to select the higher priority projects that are proposed in the Basic Plan and implement them according to their priority.

### Possible Project Scheme

026: The total cost for the Possible Project Scheme at current prices was 2.83 billion FRW (22 million US\$). This amount was lower than the estimated maximum investment cost (2.90 billion FRW) for drinking water supply in the Kibungo Prefecture.

027: The monthly water fee and income of an average household were as shown in the following table:

	Water Fee Payment (US\$/month)	Water Fee per Jerry Can (FRW)	Average Income (US\$/month)	Income for Water Fee (%)
System 1	1.5	1.33	30	5.0
System 2	1.3	1.13	30	4.3
System 3	0.3	0.35	30	1.0

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The water fee portion would be within 5% of the average household's income; internationally, this amount was considered to be reasonable.

028: Once the Possible Project Scheme was implemented, the following direct and indirect effects could be expected.

- Increase of water supply rate
- Decrease of water drawing work
- Rise of people's awareness in term of water supply project
- Economic effect
- Establishment of a self-supporting system for groundwater development

## RECOMMENDATIONS

### Implementation of the Project

029: From a financial, economical and social point of view, it would be quite difficult to implement the entire Basic Plan by the year 2000. Thus, the projects would be implemented stepwise. The Possible Project Scheme was regarded as vital when considering the social, financial, and technical aspects, consequently their early implementation was highly recommended.

### Maintenance Works of the Piped System by "ELECTROGAZ"

030: The technical management and essential maintenance works of the proposed piped system; i.e. System 1 and System 2, would be directed by "ELECTROGAZ" which have a developed O/M system and water fee collecting system.

### Strengthening MINITRAPEE's Kibungo Office

031: Only one representative from MINITRAPEE's Water Supply Bureau was stationed in the Kibungo Prefectural Government Office. Thus, MINITRAPEE's Kibungo Office would be developed prior to commencing the implementation of the Phase II Project and the implementation of the Possible Project Scheme of the Basic Plan. The following items would be considered for developing the office:

- Assign one Project Manager and an appropriate number of technical personnel.
- Build a material warehouse to store the groundwater prospecting equipment, well drilling machinery and

- 
- spare parts for handpumps.
  - Build a roofed parking lot in Kibungo for the well drilling machinery, large-sized air compressors, trucks and jeeps.

#### **Environmental Preservation Measures**

032: Appropriate measures, such as introduction of the improved toilet recommended by MINITRAPEE and MINISANTE, at household level, would be taken to confront the untreated sewage problems. For the sake of water source preservation, the promotion of reforestation projects and the setting up of land conservation areas were highly recommended.

#### **Strengthening of the Education Program for Residents**

- 033: For the success of the Rural Water Supply Project, the water supply facilities' O/M costs at least would be borne by the beneficiaries even though the construction costs would not be recovered.
- 034: MINITRAPEE regards the promotion of the residents' awareness of the public health, hygiene and water supply systems as important. Although on-going education programs existed for residents, they were not conducted in rural areas due to a lack of funds and instructors. Effective education programs for residents would be examined in cooperation with rural governments and schools.

#### **Phase II Project**

035: The condition of the infrastructure, such as roads and electricity supply lines, in the Phase II Project Area were poor. The actual implementation of the Phase II Project would require more finance and a much longer construction period than originally estimated. Thus, well drilling in higher priority areas and in areas where drilling was easy (this takes in the Phase III Basic Plan Area) would be included in the actual implementation plan.







## TABLE OF CONTENTS

LOCATION MAP

GENERAL PLAN

SUMMARY

DEFINITION

ABBREVIATIONS

CONVERSION FACTORS

CHAPTER 1 INTRODUCTION .....	1- 1
1.1 BACKGROUND OF THE STUDY .....	1- 1
1.2 OBJECTIVES OF THE STUDY .....	1- 2
1.3 SCOPE OF THE STUDY .....	1- 3
1.4 UNDERTAKING OF THE STUDY .....	1- 4
1.5 COMPONENTS OF THE REPORTS .....	1- 4
1.6 STUDY TEAM AND MINITRAPEE'S COUNTERPARTS .....	1- 5
CHAPTER 2 BACKGROUND OF THE PROJECT .....	2- 1
2.1 COUNTRY BACKGROUND .....	2- 1
2.2 ECONOMIC INDICATORS .....	2- 3
2.3 HEALTH INDICATORS .....	2- 5
2.4 NATIONAL DEVELOPMENT PLAN .....	2- 6
2.5 SECTOR ORGANIZATION .....	2- 7
2.6 PRESENT SITUATION AND DEVELOPMENT PLAN OF THE WATER SUPPLY SECTOR .....	2-10
2.7 FINANCIAL IMPLICATIONS OF THE SECTOR .....	2-12
2.8 FOREIGN AIDS .....	2-13
CHAPTER 3 THE STUDY AREA .....	3- 1
3.1 GENERAL .....	3- 1
3.2 PHYSICAL ENVIRONMENT .....	3- 1
3.3 POPULATION .....	3- 9
3.4 ECONOMIC AND SOCIAL CONDITIONS .....	3-12
3.5 EXISTING WATER SUPPLY SYSTEM AND POPULATION SERVED .....	3-15
CHAPTER 4 WATER RESOURCES EVALUATION .....	4- 1
4.1 OUTLINE OF THE WATER RESOURCES CONDITIONS ...	4- 1
4.2 HYDROGEOLOGY .....	4- 2
4.3 WATER BALANCE SIMULATION .....	4-14
4.4 GROUNDWATER DEVELOPMENT POTENTIALITY .....	4-19
4.5 WATER QUALITY .....	4-20
4.6 DEVELOPMENT POTENTIALITY OF WATER RESOURCES .....	4-22

<b>CHAPTER 5 OVERVIEW OF THE WATER SUPPLY DEVELOPMENT PLAN .....</b>	<b>5- 1</b>
5.1 PRESENT ENVIRONMENT FOR THE BASIC PLAN .....	5- 1
5.2 BASIC DEVELOPMENT POLICY .....	5- 6
5.3 FORMULATION OF THE BASIC PLAN .....	5- 7
<b>CHAPTER 6 THE BASIC PLAN .....</b>	<b>6- 1</b>
6.1 CONDITION OF BASIC PLANNING .....	6- 1
6.2 PROPOSED WATER SUPPLY SYSTEM .....	6- 7
<b>CHAPTER 7 IDENTIFICATION OF POSSIBLE PROJECT SCHEME .....</b>	<b>7- 1</b>
7.1 GENERAL .....	7- 1
7.2 FINANCIAL LIMITATION FOR PROJECT IMPLEMENTATION .....	7- 1
7.3 IDENTIFICATION OF POSSIBLE PROJECT .....	7- 4
<b>CHAPTER 8 IMPLEMENTATION PROGRAM AND COST ESTIMATE .....</b>	<b>8- 1</b>
8.1 EXECUTING AGENCY .....	8- 1
8.2 FINANCING .....	8- 2
8.3 IMPLEMENTATION SCHEDULE FOR THE BASIC PLAN ..	8- 2
8.4 PROJECT COST OF THE BASIC PLAN .....	8- 4
8.5 IMPLEMENTATION PLAN OF THE POSSIBLE PROJECT SCHEME .....	8- 8
8.6 COST OF THE POSSIBLE PROJECTS .....	8-12
8.7 PROJECT OPERATION AND MAINTENANCE COST .....	8-14
8.8 OPERATION AND MAINTENANCE .....	8-16
<b>CHAPTER 9 PROJECT EVALUATION .....</b>	<b>9- 1</b>
9.1 IMPORTANCE OF THE PROJECT .....	9- 1
9.2 FINANCIAL AND ECONOMIC EVALUATION .....	9- 1
9.3 ENVIRONMENTAL EXAMINATION .....	9- 6
9.4 BENEFITS FROM RURAL WATER SUPPLY PROJECTS ...	9- 8
<b>CHAPTER 10 CONCLUSIONS AND RECOMMENDATIONS .....</b>	<b>10- 1</b>
10.1 CONCLUSIONS .....	10- 1
10.2 RECOMMENDATIONS .....	10- 4

## LIST OF TABLES

Table 2.1	Comparison of Amounts Planned and Actually Spent during the 3rd Five-year Development Plan Period .....	2-12
Table 2.2	Annual Budgeetary Funds of MINITRAPEE and DGW .....	2-12
Table 3.1	Drainage Basins in the Study Area .....	3- 6
Table 3.2	Population in the Study Area .....	3-10
Table 3.3	Existing Rural Water Supply Systems (Piped Systems) .....	3-17
Table 3.4	Water Supply Project at Planning/ Construction Stages .....	3-19
Table 3.5	Type of Piped Water Supply Systems .....	3-20
Table 3.6	High Priority Area to Improve .....	3-21
Table 3.7	Evaluation of Existing Water Supply System .....	3-22
Table 3.8	Classification of Existing Systems .....	3-23
Table 3.9	Fee Collecting System .....	3-24
Table 4.1	Coefficient of Aquifer .....	4- 8
Table 4.2	Characteristics of Aquifer .....	4-11
Table 4.3	Hydrogeological Parameter .....	4-14
Table 4.4	Results of Water Balance Simulation .....	4-17
Table 4.5	Characteristics of Water Quality in the Study Area .....	4-21
Table 5.1	Population and Area of Each Zone .....	5- 8
Table 5.2	Merit/Demerit Table of Water Supply System Options .....	5-11
Table 5.3	Development Priority of Water Resources .....	5-13
Table 5.4	Selected Water Supply System .....	5-20
Table 6.1	Service Area and Population .....	6- 4
Table 6.2	Design Criteria .....	6- 6
Table 6.3	Water Demand (System 3) .....	6- 7
Table 6.4	Outline of Proposed Facilities (System 1) .....	6-12
Table 6.5	Water Demand (System 2) .....	6-13
Table 6.6	Outline of System-2 .....	6-16
Table 6.7	Water Demand (System 3) .....	6-17
Table 6.8	Outline of System 3 .....	6-20
Table 6.9	Service Area and Population (System 4) .....	6-21
Table 6.10	Water Balance for System 4 .....	6-22
Table 6.11	Outline of System 4 .....	6-23

Table 7.1	Invested Founds for Water Supply Sector .....	7- 1
Table 7.2	Estimate of Investment Amount for the Rural Water Supply Field during the Project Period .....	7- 2
Table 7.3	Rural Water Supply Rate and Population to be Provided with Rural Water Supply in Each Prefectures .....	7- 3
Table 7.4(1)	Evaluation Points for Priority Project Selection (Systems 1 and 2 Areas) .....	7- 7
Table 7.2(2)	Evaluation Points for Priority Project Selection (System 3 Areas) .....	7- 8
Table 7.3	Selection of Priority Block for System 1 and 2 .....	7- 9
Table 7.4(1)	Selection of Priority Block for System 3 (1/2) .....	7-10
Table 7.4(2)	Selection of Priority Block for System 3 (2/2) .....	7-11
Table 8.1	Project Cost of the Basic Plan .....	8- 5
Table 8.2	Construction Cost of Each Package .....	8- 5
Table 8.3	Disbursement Schedule of the Basic Plan .....	8- 6
Table 8.4	Overall Implementation Program for the Basic Plan .....	8-10
Table 8.5	Project Cost of the Possible Project Scheme ...	8-12
Table 8.6	Construction Cost of Each Package .....	8-12
Table 8.7	Disbursement Schedule of the Possible Project Scheme .....	8-13
Table 8.8	Operation and Maintenance Costs .....	8-15
Table 8.9	Balance between Water Fee and O/M Cost .....	8-20
Table 9.1	Sources of Founds for Public Investments .....	9- 2
Table 9.2	Water Fee Payment .....	9- 3
Table 9.3	Cash Flow of Possible Projects .....	9- 4
Table 9.4	Construction Cost and Operation and Maintenance Cost .....	9- 5
Table 9.5	Reduction in Diarrheal Morbidity Rates Due to Improvements in Water Supply and Sanitation .....	9- 9

## LIST OF FIGURES

Fig. 3.1	Mean Monthly Climatological Data .....	3- 6
Fig. 3.2	River System and River Basin .....	3- 8
Fig. 3.3	Population Density of Each Secteur .....	3-11
Fig. 3.4	Existing Rural Water Supply Systems (Piped System) .....	3-18
Fig. 4.1	Location of Test Boring Points .....	4- 6
Fig. 4.2	Estimated Hydrological Cycle in the Area .....	4-18
Fig. 5.1	Classification of Rural Center for Development .....	5- 5
Fig. 5.2	Approach to Phase III Planning .....	5- 7
Fig. 5.3	Zone Classification .....	5- 9
Fig. 5.4	Diagram of Water Supply Systems .....	5-12
Fig. 5.5	Water Supply Systems Selection Flow .....	5-18
Fig. 5.6	Proposed Water Supply Plan .....	5-21
Fig. 6.1	Flow Diagram of Muhazi Area .....	6- 8
Fig. 6.2	Typical Section of Water Well .....	6-20
Fig. 8.1	Project Implementation Office .....	8- 1
Fig. 8.2	Implemented Schedule for The Basic Plan .....	8- 3
Fig. 8.3	Implementation Schedule of the Possible Project Scheme .....	8-11
Fig. 8.4	Proposed Operation and Maintenance System .....	8-17

## DEFINITION

1. the Study : the Study on Rural Water Supply Project
2. the Study Area : the area of the Kibungo Prefecture selected for Rural Water Supply Project of Phase III Study
3. the Basic Plan : the Basic Rural Water Supply Plan of Phase III Study
4. the Basic Plan Area : the area of the Study Area selected for the Basic Plan
5. the Area : the Basic Plan Area to be used in the case of avoidance of repetition
6. the Individual Project: the individual Project of the Basic Plan which is covered by one water supply system
7. the Possible Project : Scheme : the Scheme for implementation of high priority individual projects selected from the Basic Plan
8. the Possible Project : /Possible Individual Project : the individual Project of the Basic Plan selected for high priority Rural Water Supply Project
9. the Service Block : the area which will receive the benefits from the individual Project
10. the Block : the Service Block

## ABBREVIATIONS

AIDR	: Association of International Rural Development (Belgium)
APHA	: American Public Health Association
B/D	: Basic Design
CIF	: Cost, Insurance and Freight
COFORWA	: Corporation for Rwanda Water
DAC	: Development Assisting Countries
D/D	: Detailed Design
DGW	: Directorate General of Water (MINITRAPEE)
EIU	: Economic Intelligence Unit
ELECTROGAZ	: A Public Organization to Produce Electric, Gaz and Water Supplies
FAO	: Food and Agricultural Organization of UN
FOB	: Free on Board
F/S	: Feasibility Study
IBRD	: International Bank for Reconstruction and Development
IDA	: International Development Association
JICA	: Japan International Cooperation Agency
GDP	: Gross Domestic Product
GNP	: Gross National Product
GO	: Government Organization
GOJ	: Government of Japan
GOR	: Government of the Rwanda
GRDP	: Gross Regional Domestic Product
MINAGRI	: Ministry of Agriculture, Livestock and Forests
MINIMART	: Ministry of Industry, Mines, Artisanry and Crafts
MININTER	: Ministry of the Interior and Communal Development
MINIPLAN	: Ministry of Planning
MINISANTE	: Ministry of Public Health
MINISAPASO	: Ministry of Public Health and Social Affairs
MINITRAPEE	: Ministry of Public Works, Energy and Water
MIS	: Management Information System
O/M	: Operation and Maintenance
PD	: Planning Department, DGW
RWIO/ER	: Project Implementation office of Rural Water Supply Project in Eastern Region
RWSD	: Rural Water Supply Department, DGW
RWSP/ER	: Rural Water Supply Project in Eastern Region
SVN	: Dutch Volunteer Organization
TA	: Technical Assistance
UN	: United Nations
UNDP	: United Nations Development Program
UNICEF	: United Nations Children's Fund
WHO	: World Health Organization

### CONVERSION FACTORS

<u>Unit</u>	<u>Comparison</u>	<u>English Equivalent</u>
Unit of Length :		
Millimeters (mm)	0.001 m	0.0394 inch
Centimeter (cm)	0.01 m	0.3937 inch
Meter (m)	3.2800 feet	
Kilometer (km)	1,000 m	0.6213 mile
Unit of Area :		
Square centimeter (cm <sup>2</sup> )	0.0001 m <sup>2</sup>	0.155 square inch
Square meter (m <sup>2</sup> )		10.764 square feet
Hectare (ha)	10,000 m <sup>2</sup>	2.471 acres
Square kilometer (km <sup>2</sup> )	1,000,000 m <sup>2</sup>	0.3861 square mile
Unit of Volume :		
Cubic centimeter (cm <sup>3</sup> )		0.061 cubic inch
Liter (lit)	1,000 cm <sup>3</sup> (0.21997 gallons)	0.264 US gallons
Cubic meter (m <sup>3</sup> )	1,000 lit	35.3145 cubic feet
Unit of Weight :		
Gram (g)		0.0353 ounce
Kilogram (kg)	1,000 g	2.2046 pounds
Metric ton (ton or mt)	1,000 kg	2,204.6 pounds



### UNIT OF MEASUREMENT

mm	:	millimeter(s)
cm	:	centimeter(s)
m	:	meter(s)
km	:	kilometer(s)
cm <sup>2</sup>	:	square centimeter(s)
m <sup>2</sup>	:	square meter(s)
km <sup>2</sup>	:	square kilometer(s)
lit	:	liter(s)
m <sup>3</sup>	:	cubic meter(s)
lit/sec	:	liter per second
m/sec	:	meter(s) per second
PPM or ppm	:	part(s) per million
g	:	gram(s)
kg	:	kilogram(s)
ton	:	ton(s)
m <sup>3</sup> /sec second	:	1,000 lit/sec = 35.3145 cubic feet per = 15,850 US gallons per minute
m <sup>3</sup> /sec/day	:	8.64 mm depth over 10 km <sup>2</sup>
sec	:	second(s)
min	:	minute(s)
hr	:	hour(s)
Max.	:	maximum
Min.	:	minimum
p.a.	:	per year
%	:	percent(s)
No. or no.	:	number
°C	:	degree centigrade
°F	:	degree fahrenheit
KW	:	kilowatt(s)
KWh	:	kilowatt(s) hour = 1,000 WH
-GL	:	below ground level
GW	:	groundwater
GWT	:	groundwater table
EL	:	elevation above MSL
MSL	:	mean sea level
HWL	:	high water level
LWL	:	low water level

EC	:	electric conductivity
Et	:	evapotranspiration
pH	:	potential of hydrogen
CO2	:	carbonic acid
NH4	:	ammonia
N	:	nitrogen
SS	:	suspended solids
Cl	:	chlorine
NO2	:	nitrogen dioxide
NO3	:	nitrogen trioxide
S04	:	sulfur oxide
P04	:	phosphorus oxide
Ca	:	calcium
Mg	:	magnesium
Mn	:	manganese
Fe	:	iron
O/M	:	operation and maintenance
EIRR	:	economic internal rate of return
FIRR	:	financial internal rate of return
B/C	:	benefit cost ratio
NTV	:	net present value
FY	:	fiscal year (1st of January to 31st December)
FRW	:	Rwanda Fran(s) = US\$0.0078 (as of Aug. 1991)
US\$	:	dollar(s) = 128 FRW (as of Aug. 1991) = 135 JY
JY	:	Japanese Yen

CHAPTER 1

INTRODUCTION



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## 1. INTRODUCTION

### 1.1 BACKGROUND OF THE STUDY

Water is indispensable for the life of all living creatures, including man. Also, the provision of a safe, stable and accessible water supply is of paramount importance to health.

The Government of Rwanda therefore declared 1981 as the "Year of Rural Water" under "The International Drinking Water Supply and Sanitation Decade Plan" established by the United Nations. This National policy aimed at the complete supply of drinking water for the entire population by the target year 2000.

Despite increased improvement/expansion efforts of the water supply system, access to drinking water was still at an inadequate level throughout Rwanda. Unprotected drinking water sources were common, especially in rural areas. The majority of people in Rwanda depended heavily on traditional sources such as springs, streams and lakes for potable water. Water-related diseases such as diarrhea were major causes of infant mortality in Rwanda. Consequently, the provision of clean and safe drinking water was essential for the improvement of living conditions.

The Kibungo Prefecture located in the eastern part of Rwanda and was the target area of the Study. This area was considered to be particularly inferior to other prefectures of Rwanda in terms of a safe water supply system.

The activities of providing a suitable water supply system therefore, were considered to be an important component for the rural development program. Hence, the activities in the Kibungo Prefecture would be strongly supported by the Government of the Republic of Rwanda (hereinafter referred to as "the Government of Rwanda", GOR) to redress the low level of safe water supply.

Due to the above-mentioned situation, in 1982 the Government of Rwanda requested the Government of Japan to study the Rural Water Supply Project. In response to this request, the Government of Japan entrusted the study to the Japan International Cooperation Agency (hereinafter referred to as "JICA"). In 1984 JICA conducted the study and formulated a rural water supply scheme in the eastern region (Phases I & II) for the target year 1990.

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Phase I Project, including the drilling of 72 wells, had been executed under Japanese Grant Aid during the period 1986 to 1989. Phase II Project would be implemented by the Government of Rwanda.

As a consequence, the Study (Phase III), which included a supplementary study of Phase II, aimed to establish an integrated water supply program for the whole area of Kibungo Prefecture, as requested in 1988 by the GOR from the Government of Japan.

In response to this request, the Government of Japan decided to conduct a study called the Rural Water Supply Project in the Eastern Region of Rwanda - Phase III -, (hereinafter referred to as "the Study"), in accordance with the relevant laws and regulations in force in Japan. JICA, the official agency responsible for the implementation of technical cooperation programs by the Government of Japan, would undertake the Study in close cooperation with the authorities of the Government of Rwanda.

The Ministry of Public Works, Energy and Water - MINITRAPEE- (hereinafter referred to as "the Ministry"), would act as counterpart agency for the Japanese Study Team and also as a governmental organization concerned with the smooth implementation of the Study.

In December 1988, JICA dispatched a mission to the Republic of Rwanda for the preliminary survey as well as for discussions on the Scope of Works for the Study. The Scope of Work was agreed between the Government of Rwanda and the JICA mission on December 17, 1988.

## 1.2 OBJECTIVES OF THE STUDY

According to the Scope of Work, the objectives of the Study were as follows:

- (1) To formulate a Basic Plan for Rural Water Supply and prepare a water supply scheme (Phase III) in the eastern region of Rwanda
- (2) To perform a technology transfer with the Rwanda Government counterpart during the course of the Study.

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### 1.3 SCOPE OF THE STUDY

The Study Area (2,667 km<sup>2</sup>) is part of the Kibungo Prefecture, excluding the area of Akagera National Park (1,467 km<sup>2</sup>) and two cities (Kibungo city and Rwamagana city) as they were served by existing water supply systems.

The Kibungo Prefecture (area: 4,134 km<sup>2</sup>, population: 433,000 in 1988) was located in the eastern part of Rwanda. The mean annual rainfall was estimated to be 960 mm and the mean height above MSL (mean sea level) ranged from 1,300 m to 1,500 m. This Prefecture was one of the less developed areas in Rwanda and there existed a continuous problem of water shortages as well as the spreading of diseases due to contamination of water.

The Study covered the following items:

#### (1) Data collection and review

- socio-economic background
- development plans
- physical conditions
- water supply and demand
- previous study results on water resources
- water supply facilities

#### (2) Field Survey

- field reconnaissance
- geological survey (electric prospective survey)
- water quality analysis
- hydrological observation
- test well drilling and investigations

#### (3) Analysis and evaluation of water resources potential

- geological and hydrogeological analysis
- hydrological and water balance analysis
- quantitative analysis on groundwater potential
- quantitative analysis on surface water potential
- water demand projection and allocation

#### (4) Formulation of a basic plan and water supply scheme

- zoning of water supply districts
- appropriate water supply system
- project design
- construction plan