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No.122



# THE ABTHERCAIRE STUDY ON THE NATIONAL WATER MASTER PLAN IN THE REPUBLIC OF KENYA

## FINAL REPORT

## EXECUTIVE SUMMARY

November 1992



NIPPON KOEI CO., LTD.
KOKUSAI KOGYO CO., LTD.

JAPAN INTERNATIONAL COOPERATION AGENCY

THE MINISTRY OF WATER RESOURCES
THE REPUBLIC OF KENYA

# THE AFTERCARE STUDY ON THE NATIONAL WATER MASTER PLAN IN THE REPUBLIC OF KENYA

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## LIST OF REPORTS

1. EXECUTIVE SUMMARY
2. MAIN REPORT
3. SUPPORTING REPORTP
4. DATA BOOK


**Exchange Rate Applied**

**US$1.00 = Kshs 61.1 = ¥124.7**

**(as of 10 February 1998)**

# PREFACE

In response to a request from the Government of the Republic of Kenya, the Government of Japan decided to conduct a Aftercare Study on the National Water Master Plan in the Republic of Kenya and entrusted to study to the Japan International Cooperation Agency (JICA).

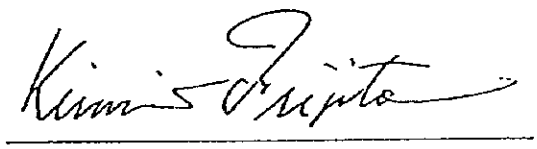
JICA selected and dispatched a study team headed by Mr. Hirofumi Sadamura of Nippon Koei Co., Ltd. and consist of Kokusai Kogyo Co., Ltd. to Kenya, two times between November 1997 and October 1998. In addition, JICA set up an advisory committee headed by Masayuki Watanabe, Development Specialist, Institute of International Cooperation of JICA between November 1997 and October 1998, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of Kenya, and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Kenya for their close cooperation extended to the study.

November, 1998



Kimio Fujita
President
Japan International Cooperation Agency

November, 1998

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

# LETTER OF TRANSMITTAL

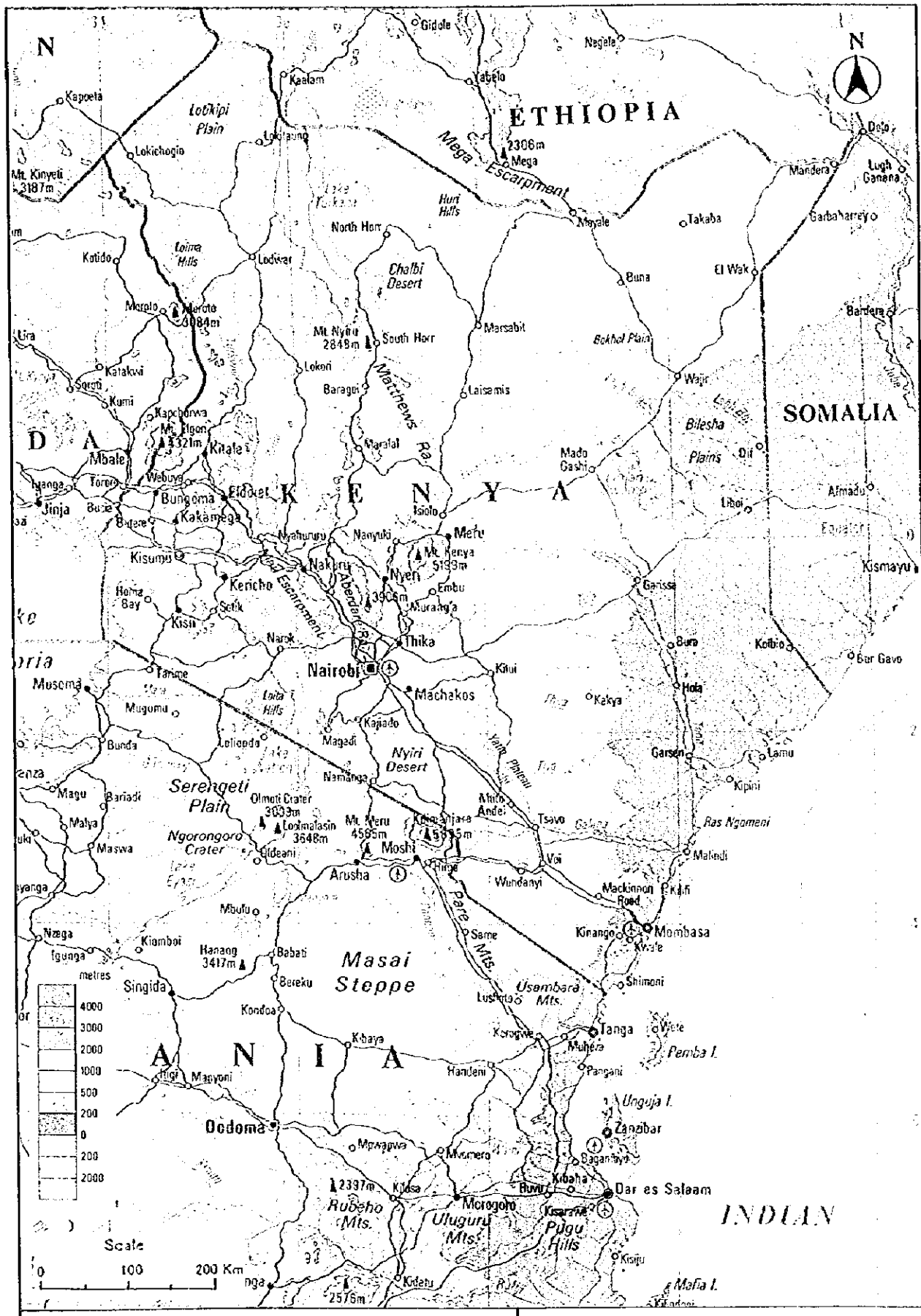
It is with great pleasure that we submit to you the Final Report of the Aftercare Study on the National Water Master Plan in the Republic of Kenya completed by our Study Team with cooperative efforts of the Ministry of Water Resources of the Government of Kenya and other parties concerned. The report has been prepared for the Government of Kenya for consideration in implementing the future water supply and sewerage development projects in Kenya.

The report consists of four volumes of Executive Summary, Main Report, Supporting Report and Data Book. The Executive Summary presents the outline of the study results and the Main Report give the summary of all the study results, especially implementation program of the future water supply and sewerage development projects and priority projects. The Supporting Report describes the sectoral study results of socioeconomy, water supply development plan, sewerage development plan, water resources development plan, law and public administration and project evaluation to support the Main Report. The Data Book compiles useful reference data relevant to the Study.

Taking this opportunity, all the members of the Study Team would like to express their heartfelt gratitude to the personnel from JICA, JICA Advisory Committee, Ministry of Foreign Affaires, Ministry of Construction, Ministry of Welfare, Embassy of Kenya and JICA Kenya Office and Kenyan officials from Steering Committee comprised of relevant government agencies and Technical Sub-committee of Ministry of Water Resources who extended the kind assistance and cooperation for the entire study period to the Study Team. The Study Team hopes that the results of this study contribute to the future implementation of water supply and sewerage projects in Kenya and to socioeconomic development of Kenya.

Yours faithfully,

Hirofumi Sadamura
Team Leader
The Aftercare Study on the National Water Master Plan




| THE AFTERCARE STUDY ON THE NATIONAL WATER MASTER PLAN | LOCATION MAP |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

# THE AFTERCARE STUDY ON THE NATIONAL WATER MASTER PLAN

## EXECUTIVE SUMMARY

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## ABBREVIATIONS

| | |
|---|---|
| AG | Attorney General |
| AFW | Accounted for Water |
| ASAL | Arid, Semi-Arid Lands |
| CBS | Central Bureau of Statistics |
| CSRP | Civil Service Reform Programme |
| CSS | Computer Service Section of MWR |
| DAO | District Agricultural Officer |
| DC | District Commissioner |
| DCO | District Commissioner's Office |
| DDC | District Development Committee |
| DDP | District Development Plan |
| DO | District Officer |
| DRSRS | Department of Resource Surveys & Remote Sensing |
| DTO | District Treasury Office |
| DWB | District Water Board |
| DWE | District Water Engineer |
| DWO | District Water Office |
| EAMD | East Africa Meteorological Department |
| FAO | Food and Agriculture Organization of the United Nations |
| GDP | Gross Domestic Product |
| GIS | Geological Information System |
| GOJ | Government of Japan |
| GOK | Government of Kenya |
| GRDP | Gross Regional Domestic Product |
| GTZ | German Agency for Technical Cooperation |
| HRD | Human Resource Development |
| IBRD | International Bank for Reconstruction and Development |
| ICDC | Industrial and Commercial Development Corporation |
| IDA | International Development Association |
| ILUS | Integrated Land Use Survey |
| IPC | Investment Promotion Center |
| IRS | Integrated Rural Survey |
| JICA | Japan International Cooperation Agency |
| KBS | Kenya Bureau of Standard |
| KIRDI | Kenya Industrial Research & Development Institute |
| KIU | Kenya Industrial Estates Limited |
| KMD | Kenya Meteorological Department |
| KPLC | Kenya Power and Lighting Co. |
| KPTC | Kenya Posts and Telecommunication Corporation |
| KS | Kenya Standard |
| KSS | Kenya Soil Survey |
| KTDA | Kenya Tea Development Authority |
| KVDA | Kerio Valley Development Authority |
| KWAHO | Kenya Water and Health Organization |
| Kshs | Kenya Shillings |
| K£ | Kenya Pounds (20 Kenya Shillings) |
| LA | Local Authority |
| LBDA | Lake Basin Development Authority |
| LU | Livestock Unit |
| MCSS | Ministry of Culture and Social Services |
| MLRRWD | Ministry of Land Reclamation, Regional and Water Development (presently MOWR) |
| MOA | Ministry of Agriculture |
| MOE | Ministry of Energy |
| MOED | Ministry of Education |
| MOENR | Ministry of Environment and Natural Resources |
| MOF | Ministry of Finance |
| MOH | Ministry of Health |
| MOHANH | Ministry of Home Affairs and National Heritage |
| MOI | Ministry of Industry |
| MOL | Ministry of Labour |
| MOLA | Ministry of Local Authorities |
| MOLD | Ministry of Livestock Development |
| MOLG | Ministry of Local Government (presently MOLA) |
| MOLH | Ministry of Lands and Housing |
| MOMDE | Ministry of Manpower Development and Employment |
| MOP | Ministry of Planning |
| MOPND | Ministry of Planning and National Development |
| MOPW | Ministry of Public Works |

| | |
|---|---|
| MORD | Ministry of Region Development |
| MORST | Ministry of Research, Science and Technology |
| MOSM | Ministry of Supplies and Marketing |
| MOTC | Ministry of Transport and Communication |
| MOTW | Ministry of Tourism and Wildlife |
| MOWR | Ministry of Water Resources |
| MPND | Ministry of Planning and National Development |
| MWR | Ministry of Water Resources |
| NCC | Nairobi City Commission |
| NCPB | National Cereals and Produce Board |
| NEAP | National Environmental Plan |
| NES | National Environment Secretariat |
| NGO | Non-Governmental Organisation |
| NIB | National Irrigation Board |
| NMWP-I | National Master Water Plan (Stage I) |
| NWCPC | National Water Conservation and Pipeline Corporation |
| NWMP | National Water Master Plan |
| NWP | National Water Policy |
| O&M | Operation and Maintenance |
| OECD | Organization for Economic Cooperation and Development |
| OECF | Overseas Economic Cooperation Fund |
| OP | Office of the President |
| PC | Provincial Commissioner |
| PIP | Public Investment Programme |
| PIU | Project Implementation Unit |
| PPCSCA | Presidential Permanent Commission on Soil Conservation and Afforestation |
| PSC | Public Service Commission |
| PSP | Private Sector Participation |
| RTPC | Rural Trade and Production Center |
| RWSDP | Rural Water Supply Development Project |
| SDD | Social Dimensions of Development |
| SOK | Survey of Kenya |
| SWAP | Surface Water Extraction Permit |
| SWPD | Special Water Programmes Division (MWR) |
| TARDA | Tana and Athi Rivers Development Authority |
| UC | Urban Centre |
| UDD | Urban Development Department (MOLA) |
| UFW | Unaccounted for Water |
| UNDP | United Nations Development Programme |
| UNEP | United Nation Environment Programme |
| UNESCO | United Nations Educational, Scientific, and Cultural Organization |
| UNICEF | United Nations International Children's Emergency Fund |
| UNIDO | United Nations Industrial Development Organization |
| UNPEP | United Nation Population Fund Programme |
| USAID | United States Agency for International Development |
| UWASAM | Urban Water and Sanitation Management |
| WAB | Water Apportionment Board |
| WDD | Water Development Department (MWR) |
| WHO | World Health Organization |
| WID | Women in Development |
| WRA | Water Resources Authority |

# ABBREVIATION OF MEASURES

## Length

| | | |
|---|---|---|
| mm | = | millimeter |
| cm | = | centimeter |
| m | = | meter |
| km | = | kilometer |

## Area

| | | |
|---|---|---|
| ha | = | hectare |
| $m^2$ | = | square meter |
| $km^2$ | = | square kilometer |

## Volume

| | | |
|---|---|---|
| 1, lit | = | liter |
| $m^3$ | = | cubic meter |
| $m^3/s$, cms | = | cubic meter per second |
| MCM | = | million cubic meter |
| $m^3/d$, cmd | = | cubic meter per day |

## Weight

| | | |
|---|---|---|
| mg | = | milligram |
| g | = | gram |
| kg | = | kilogram |
| t | = | ton |
| MT | = | metric ton |

## Time

| | | |
|---|---|---|
| sec | = | second |
| hr | = | hour |
| d | = | day |
| yr | = | year |

## Money

| | | |
|---|---|---|
| Kshs. | = | Kenya shilling |
| KL | = | Kenya pound |
| US$ | = | U.S. dollar |
| US¢ | = | U.S. cent |

## Energy

| | | |
|---|---|---|
| Kcal | = | Kilocalorie |
| KW | = | kilowatt |
| MW | = | megawatt |
| KWh | = | kilowatt-hour |
| GWh | = | gigawatt-hour |

## Others

| | | |
|---|---|---|
| % | = | percent |
| o | = | degree |
| ' | = | minute |
| " | = | second |
| °C | = | degree Celsius |
| cap. | = | capital |
| LU | = | livestock unit |
| md | = | man-day |
| mil. | = | million |
| no. | = | number |
| pers. | = | person |
| mmho | = | micromho |
| ppm | = | parts per million |
| ppb | = | parts per billion |
| lpcd | = | litter per capita per day |

# CHAPTER 1 INTRODUCTION

## 1.1 Background of the Aftercare Study

The National Water Master Plan was formulated in 1992 by JICA. In line with this plan, several projects have been implemented by international financing agencies and NGO's. However, implementation of most of the projects proposed in the plan have been delayed due mainly to financial constrains and institutional weakness of the Government of the Republic of Kenya (GOK). GOK has been making every effort to work out a national water policy to ensure sustainable development of the nation and enhance social welfare of the public since 1996. In consideration of this fact, the Government of Japan (GOJ) dispatched a project formation mission to Kenya in April 1996. The mission confirmed the need for the Aftercare Study on National Water Master Plan (the Study) and GOJ decided to extend technical cooperation. The scope of work was concluded between JICA and GOK on May 20, 1997 and the Study was started on November 9, 1997.

## 1.2 Objectives and Objective Areas of the Aftercare Study

The objectives of the Study are as follows:

1) to review the development plans for water supply and sewerage sectors in the National Water Master Plan prepared in 1992 and establish new implementation programmes, and also to make recommendations on strengthening of law, organisation and institution for project implementation, and improvement of management, operation and maintenance of the project.

   The present Aftercare Study will propose national water supply development plan and sewerage development plan for the target year 2010, and also formulate their implementation programme and finally select priority projects in both sectors. On the other hand, existing water supply and sewerage schemes are facing many problems and constraints in their management, operation and maintenance and thus they are not sustainable. To ensure the sustainable water supply development and sewerage development, it is essential to strengthen organisation and institution of the sectors and improve operation and maintenance system of the schemes. In addition to the development plans, therefore, the institutional strengthening plan and the operation and maintenance improvement plan will be proposed.

2) to transfer the technology of water supply and sewerage development planning through the Study.

The objective areas of the Study are as follows:

1) 141 urban centres for urban water supply planning
2) 50 districts for rural water supply planning
3) 40 urban centres for sewerage planning

## 1.3 Scope of the Aftercare Study

The Study covers the whole of Kenya. The target year for the planning is set at 2010. The Study was done in one year, in two phases. In Phase I, a basic study of data collection, field reconnaissance, field survey and preliminary study was carried out in Kenya from November 1997 to March 1998 to grasp the present conditions of water supply and sewerage schemes. In Phase II, review of the National Water Master Plan and formulation of the new implementation plan was carried out in Japan from May 1998 to July 1998 based on the results of the Phase I work. The final report was completed in November 1998.

## 1.4 Related Studies in the Past

A lot of studies related to the water supply and sanitation sectors have been carried out in the past. The most nation wide or extensive studies are the previous National Water Master Plan (NWMP) and Water Resources Assessment and Planning (WRAP).

The study of NWMP was carried out by the Japan International Cooperation Agency (JICA) in collaboration with the Kenyan Government from January 1990 to July 1992. The study aimed at formulating a framework for planning and implementation of water resources development in conformity to the nation's social and economic development objectives.

WRAP aimed at developing capabilities and methodologies for: (i) systematic and regular water resources assessment at regional or catchment level, (ii) rational development and effective management of water resources, and (iii) facilitating rural water supply in selected districts; by providing basic water resources data. WRAP was initiated in 1981 and is continuing in phases under assistance of the Government of Netherlands. To date, WRAP has completed studies for 14 districts in 4 phases, out of 63 districts.

## 1.5 Survey on Socio-Economy, Water Supply and Sewerage Sectors

The present study covers the whole of Kenya, however, nation wide data on socio-economic and physical conditions of the existing water supply and sewerage schemes are limited. In order to fully understand existing conditions and reflect them in the formulation of water supply and sanitation plans, the following field works were sub-contracted to a local consultant.

1) Survey on Socio-economy (39 urban centres and 14 districts)
2) Survey on Water Sources (158 urban centres and 14 districts)
3) Survey on the Existing Urban and Rural Water Supply Systems (158 urban centres and 14 districts)
4) Survey on the Existing Sewerage Systems (30 urban centres)
5) Water Quality Analysis for the Existing Sewerage Systems (30 urban centres)

The details of the above works are given in the Specifications attached in the DATA BOOK. The work was started from the end of December 1997 and completed in March 1998.

# CHAPTER 2 PRESENT PHYSICAL AND SOCIO-ECONOMIC CONDITIONS IN THE STUDY AREA

## 2.1 Physical Conditions

The Republic of Kenya has a territorial area of 582,646 $km^2$, consisting of water area of 11,230 $km^2$ and land area of 571,416 $km^2$. Of the land area, more than 85% is classified as arid and semi-arid lands (ASAL). The remaining land of approximately 81,000 $km^2$ sustains more than 75% of the nation's population and substantial portions of GDP.

## 2.2 Climate

Climate in Kenya is primarily controlled by the Inter Tropical Convergence Zone and a wide range of topographic relief. Air temperature varies from 40°C in the low altitude arid area to below freezing on Mt. Kenya. The average annual rainfall over the country is approximately 630 mm, ranging from less than 200 mm in the northern ASAL area to 1,800 mm in the western region.

## 2.3 Surface Water Resources

The country is divided into five drainage systems: Lake Victoria (8.0% of total land area), Rift Valley (22.5%), Athi River and Coast (11.5%), Tana River (21.7%) and Ewaso N'giro and North (36.3%). The potential volume of the surface water resources is estimated at about $19.7 \times 10^9$ $m^3$/year. It is the highest in the Lake Victoria basin ($282.6 \times 10^3$ $m^3$/year/$km^2$) and the lowest in the Athi River and Coast basin ($21.3 \times 10^3$ $m^3$/year/$km^2$). On the other hand, the present surface water abstraction volume is estimated at $1.1 \times 10^9$ $m^3$/year that corresponds to only 5.4% of the potential resources volume. The quality of the surface water is assessed to be adequate for drinking water use. It is therefore concluded that there is a great development potential in the surface water resources quantitatively and qualitatively.

## 2.4 Groundwater Resources

Characterised by geological conditions, the country can be divided into five hydrogeological areas, out of which Volcanic Rock and Quaternary Sediment areas are evaluated to be blessed with rich groundwater resources. The safe abstraction volume of the groundwater is estimated as large as $610.5 \times 10^6$ $m^3$/year, consisting of $184.5 \times 10^6$ $m^3$/year by boreholes and $426.0 \times 10^6$ $m^3$/year by shallow wells. It is generally large in Bomet and Kipsigis districts of Rift Valley province and Muranga district of Central Province (over 900 $m^3$/year/$km^2$) and low in Tana River and Kwale districts of Coastal Province and Sambru district of Rift Valley Province (less than 100 $m^3$/year/$km^2$). The

groundwater that contains saline, fluoride and iron seems often to meet the requirement of the Kenyan Standard. The present groundwater abstraction volume is estimated at 57.2 × $10^6$ $m^3$/year. The groundwater possesses a large development potential and to be a priority water resources for drinking water in ASAL areas.

## 2.5 Administrative Division

The administrative divisions have changed year after year in harmony with increasing population. The numbers of provinces, districts, divisions, locations and urban centres adopted in the Study are 8, 50, 256, 1,099, and 215, respectively, as of January 1996 because their latest administrative maps are available. Local governments in the country total 165, classified into city councils (1), municipal councils (44), county councils (60) and town councils (60). The number of districts increased to 64 as of January 1998, but no district map is available.

## 2.6 Socioeconomic Situation

(1) Kenya's population increased significantly at an annual growth rate of 2.8% during an 8-year period from 1991 to 1997, reaches 29.7 million in 1998. The highest population density has been observed in Nairobi province, 3,010 persons/$km^2$ in 1997, while all the other provinces stayed at less than 500 persons/$km^2$. The lowest is found in North Eastern province at only 6 persons/$km^2$. A population size of the urban centres varies widely, ranging from the smallest population of 186 in Kambu Town Centre (Makueni District) to the largest population of 1,324,570 in Nairobi in 1989.

(2) The economy of Kenya has been and is still largely dependent on agriculture and tourism, which accounted for an average of 29% and 15% of GDP, respectively. These two key sectors have largely contributed to earning foreign exchange. The tourism and agriculture sectors achieved the highest annual growth rate of 28.6% and 19.9%, respectively, while the national average was at 17.7% per annum. The economy continues to grow and GDP per capita achieved Kshs 15,500 in 1996.

(3) Public expenditure can be divided into recurrent expenditure and development (investment) expenditure. Nationally, the recurrent expenditure accounted for approximately 78% of the total expenditure, while the development expenditure was a mere 22%, on average for the five years fiscal period. These figures do vary quite largely according to each ministry. Focusing on the development expenditure, the share of appropriation-in-aid to total expenditure averaged approximately 54%, which is considered quite high. This situation simply substantiates the fairly poor financial basis of the country and capabilities of the government in financing and implementing all the necessary development projects with internal funds.

(4) The monthly household income averaged at Kshs 9,696. The mean monthly income of urban households (Kshs 17,673) is more than three times that of the rural households (Kshs 5,130). Nationally, the share of mean monthly household income obtained from non-agricultural activities is 66.4%, while the agricultural income accounts for 33.6%.

# CHAPTER 3 WATER SUPPLY AND SANITATION SECTOR BACKGROUND

## 3.1 Present Situation of Water Supply and Sanitation Sector

### *National Target and National Water Policy*

(1) The Government, in the 8th National Development Plan (1997-2001), clarified its intention to push development towards increased agricultural and industrial activity in the coming decades to improve the living standards of Kenyans and create employment opportunities for the rapidly increasing labour force. The plan, recognising needs for an adequate and reliable supply of clean water as essential input to all sectors of economy, suggests urgent rehabilitation and augmentation of many existing schemes which are currently inoperable due to managerial, technical and financial problems.

(2) The Government has prepared the National Water Policy in 1998, addressing four important aspects: i) Water Resources Management, ii) Water Supply and Sewerage Development, iii) Institutional Framework, iv) Financing of the Water Sector. As stated in the Policy, the basic sector objective of the National Water Development is to facilitate the provision of water in sufficient quantity and quality and within a reasonable distance so as to meet the needs of human beings, agriculture, livestock, and industry. To achieve the objective the department in-charge of water within the Ministry of Water Resources (MWR) applies the strategy of supporting and coordinating all water projects and programmes in urban and rural Kenya.

### *Accessibility to Safe Water and Sanitation*

(3) The access to safe water ratio is estimated at 44.9% of the population on a national average according to the Welfare Monitoring Survey II 1994. Accessibility in urban areas is quite high of 93.3% where the main source of water is piped water (90.2%). On the other hand, accessibility is very low for rural areas (32.5%) where the main source of water is from rivers (30.5%). Nairobi Province has the highest ratio of 96.2% in the county. The lowest ratio of 16.9% is found in North Eastern Province where a large part of the land belongs to ASAL area.

(4) It is estimated that 80.4% of the population on a national average have access to sanitation (Welfare Monitoring Survey II 1994). Focusing on the urban-rural difference, the access ratio is 97.6% in urban area and 75.9% in rural area. The most used toilet is pit latrine both in the urban area (50.7%) and rural area (73.2%). In the rural areas, indeed 24.1% of the households had no access to sanitation. The highest in the country is found in Nairobi Province with a ratio of 98.2% where pit latrine is the most used type of toilet (39.6%). The lowest accessibility is found in North Eastern Province (32%) where 74.6% of households have no access to any sanitation facilities.

### *Mode of Present Water Supply and Sanitation Services*

(5) According to the National Development Plan 1997 - 2001, the number of water supply schemes operated as of 1994 is broken down as follows:

| Operator/Supplier | No. of Water Supply Schemes in 1994 |
|---|---|
| Ministry of Water Resource | 579 |
| National Water Conservation and Pipeline Corporation | 188 |
| Community Water Supplies | 339 |
| Self-helps Schemes | 243 |
| Local Authorities | 164 |
| Non Governmental Organisation | 266 |
| Total | 1,779 |

931 water supply schemes are operated by MWR, NWCPC and Local Authorities (LA) which are responsible for operating, maintaining and managing the water supply schemes in urban centres and rural areas. Other authorities of communities, various institutes and NGO operate and maintain their own water supply systems.

(6) Local Authorities, under the responsibility of Ministry of Local Authorities (MOLA) provide sewerage for the safe disposal of sewage and industrial effluent into public sewers in municipalities and urban areas. There are 38 sewage treatment facilities located in 30 urban centres. Sewerage development is under the responsibility of the MOLA, although the MWR also has some regulatory and advisory functions. MOLA's current strategy for sewerage development in Kenya is to complete on-going projects in large urban centres and focus on the development of basic infrastructure (including sewage) in smaller urban centres throughout the country in order to curb rural-urban migration.

### *On-going and Planned/Designed Projects*

(7) According to the MWR water supply projects and schemes status report in 1996, the number of on-going and planned/designed projects is broken down as follows:

| Classification | Water Undertaker | Status 1 | Status 2 | Total |
|---|---|---|---|---|
| Urban Water Supply | MWR | 22 | 16 | 38 |
| | NWCPC | 12 | 5 | 17 |
| | Others | - | - | - |
| Rural Water Supply | MWR | 239 | 191 | 430 |
| | NWCPC | 251 | 182 | 433 |
| | Others | 54 | 64 | 118 |
| Total | | 578 | 458 | 1,036 |

Note: Status 1 – on-going projects
Status 2 – projects planned or designed

(8) The status of development programmes identified in the Public Investment Plan (1997-2000) and 43 District Development Plans indicate many sewerage projects that were identified in the previous 7th National Development period. Only the projects funded by donors have been completed.

| Plan | Status 1 | Status 2 | Status 3 | Grand-total |
|---|---|---|---|---|
| PIP | 12 | 3 | 6 | 21 |
| DDP | 15 | 3 | 4 | 22 |
| Total | 27 | 6 | 10 | 43 |

Note: Status 1 – projects under investigation, planning or design (require funding to proceed)
Status 2 – projects under implementation (funding has been obtained for construction)
Status 3 – projects completed, under operation & maintenance
PIP = project investment plan, DDP = district development plan

*Water Carrying Burden to Women*

(9) The women in Kenya are traditionally responsible for collecting water for domestic use. The time taken to carry water is significantly different between dry areas and wet areas. In the North Eastern province of ASAL, 33% of the households spend more than two hours per day fetching water during dry season. Even in the wet season, this ratio comes to 19%. This water carrying is very harmful to women's health.

*Assistance by Donors to the Sector*

(10) Since the establishment of MWR in 1974, many bilateral and multilateral donors have extended support to various projects and programmes of the water and sanitation sector, implemented by GOK. Donor financing still remains significant, ranging from 54.1% to 88.8% during the period from 1992/93 to 1996/97.

(11) Most donors have a clear strategy for technical and financial assistance. To attain sustainable development of water and sanitation projects, they tend to support decentralisation of management and operation to the local communities and the private sectors in the form of commercialisation and privatisation of water and sanitation schemes. They are paying far more attention to institutional and operational aspects of the schemes rather than investment on physical facilities.

(12) In sharp contrast to the many sponsored water supply development projects in Kenya there has been only limited activity by donors in sewerage development. More recently donors have recognised that improving water supply conditions also creates a corresponding need to provide for adequate wastewater disposal. Most donors now included sanitation and wastewater disposal as an integral part of their water sector development strategy.

## 3.2 Related Sectors and Plans

(1) Public Health and Hygiene Condition

The major cause of morbidity still remains fever/malaria, which on average affects 51.7% of the total population. The incidence of vomit/diarrhea as an another water-related disease is ranked third affecting 9.4% of the total population, and approximately 17.7% of the population in the Coastal province.

(2) Women in Development

Participation of women at all levels of project implementation has a significant impact, particularly on achieving the sustainability of the project in the rural areas. The report "Participation of Women in Water Supply and Sanitation" points out particular potential contribution of and benefits to women and community in water supply and sanitation projects.

(3) Poverty Alleviation Programmes

The "Social Dimensions of Development" (SDD) is a priority policy for poverty alleviation of the Government. In the programme, it is importantly addressed that, at the local level, the SDD programme should highly strengthen the coordination and partnerships among the key stakeholders in the delivery of the SDD programme.

***Public Investment Programme***

(4) Arid and Semi-Arid Land Development Plan

The ASAL comprises over 80% of Kenya's total land surface. The Government established the "Development Policy for the Arid and Semi-Arid Lands" in 1992. The goal of this policy is to improve the standard of living of the ASAL population by integrating ASAL into the mainstream of the national economy and social development in an environmentally sustainable manner. This matches the national goal to create employment, generate income and attain food security. Water supply is one of ASAL's nine key priority areas for intervention by this policy.

(5) National Environmental Action Programme (NEAP)

NEAP formally adopted by the Government in June 1994, sets the framework to deal with the crucial urban and coastal environmental problems that needed to be urgently addressed. NEAP focuses particularly on environmental management to be reflected by an operational programme of effective policy, legislative, and institutional action.

(6) National Tourism Development Master Plan (NTDMP)

NTDMP was prepared in 1996 under technical assistance of JICA. NTDMP includes the five-year action programme to better develop a basic infrastructure for tourism development. The infrastructure projects related to water supply and sanitation were prepared for communities where most major tourism points are located. The master plan assumes that water supply and sewerage for urban areas could be absorbed by the public service.

(7) The District Development Plan 1997-2001 (DDP)

A DDP was prepared by each district. Of the total of 60 DDPs, only 39 DDPs were collected during the Study; the others were unfortunately not available. In the 39 DDPs, there are a total of 1,026 priority projects listed by MWR and MOLA. Of these, a total of 648 are water-related projects including water supply projects (602), sewerage projects (39), and water supply and sewerage projects (7).

## 3.3 Water Supply and Sanitation Sector Administration

(1) The organisations chiefly involved in the water supply sector are:

1) Ministry of Water Resources (MWR), through its Water Development Department and its provincial and district water offices, and the regulatory agencies such as the Water Apportionment Board, the Catchment Boards, and the District Water Boards,
2) National Water Conservation and Pipeline Corporation (NWCPC),
3) Municipal Councils when acting as water undertakers,
4) Ministry of Local Authorities (MOLA) when supervising the activities of LA water undertakers,
5) District Development Committees,
6) NGOs and community groups, and
7) Ministry of Culture and Social Services (MCSS) as mobiliser of community groups.

(2) The organisations chiefly involved with the provision of sewerage and sanitation services are:

1) Local authorities, responsible for administrating the City of Nairobi, 44 municipalities, 60 county councils, and 59 town councils throughout Kenya,
2) MOLA, which is responsible for all activities of local authorities,
3) MWR which has certain technical responsibilities in the subsector,
4) Ministry of Health (MOH), and
5) NWCPC, on certain development projects only.

## 3.4 Legislation Related to Water Supply and Sanitation Sector

### *National Water Policy*

(1) Institutionally, the National Water Policy is for ministries in a sector to divest direct service provision (to autonomous departments within local authorities, for example) and retain regulatory and enabling functions, support private sector participation and community management of services, and strengthen local institutions. MWR should define roles for, and coordinate all actors in the sector. Legislation should support this policy as far as possible.

### *Related Law Registration and Regulations*

(2) The Government has enacted many laws concerning water supply and sewage disposal and has proposed some environmental legislation. The most important of these in the context of this Study are: the Water Act (Cap 372), the National Water Conservation and Pipeline Corporation Order (Legal Notice No. 270), the Mombasa Pipeline Board Act (1957), the Irrigation Act, the Tana and Athi Rivers Development Authorities Act, the Kerio Valley Development Authorities Act, the Lake Basin Development Authorities Act, the Agriculture Act, the Local Government Act (Cap 265), the Public Health Act (Cap 242), and the Environmental Management and Coordination Bill 1996.

## 3.5 Financial Management of Water Supply and Sanitation Sector

### *Overall Public Expenditure*

(1) A review of MWR and MOLA financial data indicates that development expenditure largely exceeds the recurrent expenditure. For MWR, development expenditure averaged 68.2% of total expenditure in the years of 1992/93 to 1996/97, while for MOLA the average was 88.4%. These figures are quite high compared to the national level (21.5%). Also, appropriation-in-aid for MWR and MOLA accounts for more than half of the development expenditure.

(Unit: K£ million)

| Item | 1992/93 | | 1993/94 | | 1994/95 | | 1995/96 | | 1996/97 | | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Amount | % | Amount | % | Amount | % | Amount | % | Amount | % | |
| A. Ministry of Water Resources (MWR) | 122.060 | 100.0 | 141.735 | 100.0 | 257.123 | 100.0 | 261.928 | 100.0 | 266.349 | 100.0 | - |
| Recurrent Expenditure by MWR | 38.015 | 31.1 | 51.063 | 36.0 | 74.767 | 29.1 | 83.572 | 31.9 | 82.135 | 30.8 | 31.8 |
| Development Expenditure by MWR | 84.042 | 68.9 | 90.672 | 64.0 | 182.356 | 70.9 | 178.356 | 68.1 | 184.214 | 69.2 | 68.2 |
| Appropriation-in-Aid | (31.198) | (53.6) | (27.613) | (43.3) | (92.893) | (62.0) | (77.694) | (53.3) | (99.704) | (58.4) | (54.1) |
| B. Ministry of Local Authorities (MOLA) | 93.706 | 100.0 | 109.339 | 100.0 | 156.089 | 100.0 | 101.408 | 100.0 | 199.359 | 100.0 | - |
| Recurrent Expenditure by MOLA | 9.002 | 9.6 | 11.020 | 10.1 | 16.659 | 10.7 | 14.010 | 13.8 | 27.221 | 13.7 | 11.6 |
| Development Expenditure by MOLA | 84.704 | 90.4 | 98.319 | 89.9 | 139.430 | 89.3 | 87.398 | 86.2 | 172.138 | 86.3 | 88.4 |
| Appropriation-in-Aid | (57.414) | (83.0) | (76.479) | (88.8) | (87.273) | (75.2) | (42.072) | (54.1) | (124.700) | (78.7) | (76.0) |

Source: Development Estimates and Estimates of Recurrent Expenditure, 1992/93-1997/98
Economic Survey 1997 Central Bureau of Statistics

### *Development Expenditure on Water Supply and Sanitation Sector*

(2) In the water supply sector, MWR has greatly subsidised NWCPC, which takes up an average 60% of MWR's development expenditure, although NWCPC was established as a state corporation and has its own revenue income. Excluding the development expenditure spent for NWCPC, the next highest share was spent on rural water supply at an average 17.3%. In MOLA, an average 70.9% of development expenditure is allocated for water supply and sewerage sector.

(Unit: K£ million)

| Item | 1992/93 | | 1993/94 | | 1994/95 | | 1995/96 | | 1996/97 | | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Amount | % | Amount | % | Amount | % | Amount | % | Amount | % | |
| Ministry of Water Resources (MWR) | 58.240 | 100.0 | 63.695 | 100.0 | 149.857 | 100.0 | 145.875 | 100.0 | 170.754 | 100.0 | - |
| Water Development | 2.885 | 5.0 | 1.272 | 2.0 | 28.607 | 19.1 | 21.999 | 15.1 | 32.454 | 19.0 | 12.0 |
| Training of Water Development Staff | 0.155 | 0.3 | 0.095 | 0.1 | 1.120 | 0.7 | 2.737 | 1.9 | 0.594 | 0.3 | 0.7 |
| Rural Water Supply | 15.446 | 26.5 | 12.074 | 19.0 | 24.768 | 16.5 | 17.293 | 11.9 | 21.237 | 12.4 | 17.3 |
| Self Help Water Supply | 0.078 | 0.1 | 0.040 | 0.1 | 0.164 | 0.1 | 0.056 | 0.0 | 0.031 | 0.0 | 0.1 |
| Urban Water Supply and Sewerage | 4.990 | 8.6 | 3.892 | 6.1 | 4.855 | 3.2 | 3.050 | 2.1 | 5.033 | 2.9 | 4.6 |
| Special Water Programmes | 6.070 | 10.4 | 3.616 | 5.7 | 5.550 | 3.7 | 3.307 | 2.3 | 4.844 | 2.8 | 5.0 |
| Water Conservation and Pipeline Corporation | 28.616 | 49.1 | 42.709 | 67.0 | 84.763 | 56.6 | 97.393 | 66.8 | 106.561 | 62.4 | 60.4 |
| Ministry of Local Authorities (MOLA) | 93.706 | 100.0 | 109.339 | 100.0 | 156.089 | 100.0 | 101.408 | 100.0 | 199.359 | 100.0 | - |
| Local Authorities Water Supply Schemes | 61.818 | 89.3 | 79.367 | 92.2 | 65.952 | 56.9 | 41.841 | 53.8 | 93.465 | 62.2 | 70.9 |

Source: Development Estimates and Estimates of Recurrent Expenditure, 1992/93-1997/98
Economic Survey 1997 Central Bureau of Statistics

(3) At MOLA, the expenditure for the sanitation sector accounts for only 29.1% on average of the total development expenditure, since a large part of the expenditure is spent for water supply sector. Appropriation-in-aid funded approximately 76% on average of the development expenditure.

(Unit: K£ million)

| Item | 1992/93 | | 1993/94 | | 1994/95 | | 1995/96 | | 1996/97 | | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Amount | % | Amount | % | Amount | % | Amount | % | Amount | % | |
| Ministry of Local Authorities (MOLA) | 93.706 | 100.0 | 109.339 | 100.0 | 156.089 | 100.0 | 101.408 | 100.0 | 199.539 | 100.0 | - |
| Recurrent Expenditure by MOLA | 9.002 | 9.6 | 11.020 | 10.1 | 16.659 | 10.7 | 14.010 | 13.8 | 27.221 | 13.7 | 11.6 |
| Development Expenditure by MOLA | 84.704 | 90.4 | 98.319 | 89.9 | 139.430 | 89.3 | 87.398 | 86.2 | 172.138 | 86.3 | 88.4 |
| Development Expenditure for Water Supply and Sewerage Sector by MOLA | 69.197 | 100.0 | 86.092 | 100.0 | 116.025 | 100.0 | 77.753 | 100.0 | 158.427 | 100.0 | - |
| Appropriation-in-Aid | (57.414) | (83.0) | (76.479) | (88.8) | (87.273) | (75.2) | (32.072) | (54.1) | (124.700) | (78.7) | (76.0) |
| Local Authorities Sewerage Schemes | 7.379 | 10.7 | 6.725 | 7.8 | 50.043 | 43.1 | 35.912 | 46.2 | 59.962 | 37.8 | 29.1 |

Source: Development Estimates and Estimates of Recurrent Expenditure, 1992/93-1997/98
Economic Survey 1997 Central Bureau of Statistics

### *Public Investment Programme (PIP)*

(4) The Public Investment Programme (PIP) 1997/1998 – 1999/2000 sets forth, among others, strategies, policies and programmes. Regarding the public water supply and sewerage sector, both MWR and MOLA are responsible ministries in the country. In the PIP, 18 water-related core projects are listed out of 27 core projects of MWR, and 8 water-related core projects are listed out of 24 core projects of MOLA. Investment costs for the water-related core projects are Kshs 365 million for MWR and Kshs 665 million for MOLA. Furthermore, investment costs of all water-related PIP projects are Kshs 1,915 million for MWR (201 projects) and Kshs 769 million for MOLA (30 projects).

## 3.6 Tariff Billing and Collection

(1) The water tariff rate of MWR and NWCPC set in August 1997 as follows:

| Water Consumption | 0 ~ 10 m³ | 11 ~ 20 m³ | 21 ~ 40 m³ | 41 ~ 60 m³ | more than 60 m³ |
|---|---|---|---|---|---|
| Rate | 12 | 18 (15) | 23 | 35 | 45 |

Note: Figure in parenthesis indicates government/commercial use.

Flat rate tariff, that is where no meter is installed or operational, is Kshs 160 per month.

(2) While, the local authorities running water supply schemes set their own water tariff. The percentage to the water tariff of MWR and NWCPC are as follows:

| Nairobi | Kisumu | Nakuru | Kitale | Nyeri | Kericho | Eldoret |
|---|---|---|---|---|---|---|
| 77 ~ 120% | 73 ~ 167% | 48 ~ 368% | 22 ~ 117% | 62 ~ 175% | 58 ~ 183% | 73 ~ 193% |

(3) The sewerage tariff is charged on metered water consumers and is based on the amount of water used. Rate is set at 50 - 100% of the water tariff rate. However, the sewerage tariff rates are not cost based and, therefore, do not cover whole costs of construction of facilities and operation and maintenance.

(4) In MWR, the District Water Office (DWO) reads the installed water meters at month end, prepares water bills based on the readings taken, and then distributes them to consumers at the beginning of the following month. Consumers should pay the water charges within the same month to the District Treasury Office (DTO). Revenue is then transferred to MOF as are all other public charges in the country, and fully refunded to MWR. MWR then allocates, after adjustment, the revenue to each DWO, to be used exclusively for the operation and maintenance of the water supply systems.

(5) The sewerage charge is normally a surcharged to the water supply charge although this is not easy to implement where the water undertaker is under different management. In some towns significant amounts of money have not been transferred from the water undertakers (MWR and NWCPC) to the LA.

(6) Current major problems relating to meter reading, billing, and collecting revenue are:

1) Large number of consumers being provided with water at a flat rate,
2) Existence of illegal connections,
3) Lack of serviceable meters,
4) Lack of, or inadequate maintenance of meters,
5) Inefficient meter reading and billing, and bill distribution, and
6) Many consumers unwilling to pay because of their dissatisfaction with water supplies.

### 3.7 Donors Coordination Meeting

Donor support continues to be important to the sector and to GOK. To improve coordination and, thereby, maximise the effectiveness of donor assistance, it was decided in 1996 to streamline the arrangements by adopting a Programme Approach. The following coordination framework was adopted:

1) General Coordination Group, to be facilitated by the World Bank and UNDP,
2) Programme Coordination Groups, under the leadership of the relevant GOK ministry, and
3) Working Groups, to be formed temporarily under the direction of Programme Coordination Groups.

### 3.8 Operation and Maintenance Staff Training Facilities

(1) The Kenya Water Institute (KEWI) is the main training establishment for the entire water supply and sanitation sector. As such, it is responsible for training employees of MWR, local authorities and other organisations in the sector. The Institute offers diploma and certificate courses in water technology as well as numerous shorter courses. It has seven teaching departments in: water engineering; water resources; planning, Marketing and coordinating; mathematics, science and computer use; operation and maintenance; mechanical and electrical engineering; and management and general studies.

(2) The present organisational scale of KEWI is as below.

| | | |
|---|---|---|
| 1) | Administrative Staff | 90 persons |
| 2) | Teaching Staff | 60 persons |
| 3) | Number of Trainees | 250 persons/year |
| 4) | Number of Trainees by Course | 20 - 50 persons/year |

(3) KEWI has recently received donor support from German and France. The German Technical Cooperation Agency (GTZ) is helping KEWI in the following areas.

1) Achieving a greater degree of autonomy
2) Extending the curriculum,
3) Improving staff training,
4) Providing additional training equipment, and

(4) The French-funded Kenya/France Development Co-operation Task Force on Human Resources Development (HKD) in the Water Sector, has prepared, and is presumably executing, a two-year Action Plan. The Action Plan includes:

1) Setting up a central human resources development unit,
2) Setting up training management information system,
3) Developing existing ministerial human resources development unit, and
4) Preparing and implementing prioritised training plan

## 3.9 Summary of Sector Development Problems and Constraints

The problems and constraints in the water supply and sewerage sectors for their development are summarised as follows:

(1) Financial Aspects

1) Short fall in allocations to public expenditure,
2) Greatest portion of sector investment depends on appropriation-in-aid, and
3) Great amount of subsidy to NWCPC.

(2) Institution

1) Weak regulation of the sector (water pollution, water abstraction, water quality, tariffs) and the institutions in it,
2) Too broad role of MWR as country's largest water undertaker as well as policy maker,
3) Fragmented management and apparent lack of recognition for the sewerage and sanitation subsector,
4) Lack of logic and clarity in the roles and limits of responsibility between the main actors in the water supply and sewage sector,
5) Separation of the management of water supply from sewerage schemes, and
6) Weak performance of most Local Authorities in the sustainable management of water and sewerage services.

(3) Legislation

1) Poor implementation of acts and regulation, and
2) Significant shortcomings of the Water Act (defunct legislation).

(4) Personnel Administration

1) Reported very low remuneration of the public sector in comparison with the private sector,
2) Recruitment, placement, and transfer of senior and middle level staff by the Public Service Commission (PSC) without the approval of the managers involved,
3) Numerous staff shortages in key senior and middle level positions throughout the sector, particularly in unpopular field postings, and
4) Lack of qualified tradesmen and trained operators at scheme level, particularly in the sewerage subsector.

(5) Tariff Structure and Collection

1) Inadequate customer service in the areas of: customer registration and records; meter installation, repair, and reading; billing and revenue collection: connection, disconnection and reconnection,
2) Tariffs too low, inappropriate tariff structures in some cases, and inadequate recovery from the commercial and industrial sector,
3) Excessive waste of water due to an absence of leakage control,
4) Many public agencies failing to settle their bills for water supply and sewerage services, and
5) In non-commercialised municipalities, revenues accruing from water are being used to defray other unrelated costs.

(6) Operations and Maintenance

1) Lack of funds,
2) Lack of qualified staff, and
3) Lack of facilities, equipment and tools.

## CHAPTER 4 PRESENT WATER SUPPLY CONDITIONS

### 4.1 Available Data

Out of 1,779 water supply schemes existing in the country, 579 and 188 schemes are under jurisdiction of MWR and MWCPC respectively. Unfortunately there is only inventory and detailed information on some of those schemes. MWR and NWCPC published "Water Supply Projects and Schemes Status Report, July 1996" (MWR Status Report) and "NWCPC Activities and Present Status, June 1997" (NWCPC Status Report) respectively, and MWR prepared in 1998 a long list of projects to be proposed for urgent rehabilitation.

### 4.2 Existing Water Supply Schemes

(1) There are many types of water supply schemes developed in the country. The typical types are i) urban water supply schemes that cover mainly urban centres and their peripheral areas, ii) community based water supply schemes that serve rural communities, and iii) regional water supply schemes that supply to several urban and rural areas simultaneously. MWR defines "Urban Water Supply" as schemes that have major demand zones in urban centres and "Rural Water Supply" schemes which serve mainly rural population.

(2) In the 1986 Design Manual, the large scale water supply is defined as water supply that serves for more than 50,000 populations, but no definition is given to the medium and small scale water supply. In the present Study, it is tentatively defined that the large scale

water supply serves for more than 5,000 populations and the small scale water supply for less than that.

(3) The population served by the urban water supply schemes is estimated approximately 5.0 million. The total design capacity of 141 urban centres subject to the Aftercare Study is 629,800 $m^3$/day, equivalent to 126 lpcd on an average.

(4) On the other hand, it is not possible to reveal exactly the natures and status of the rural water supply situation. According to an inventory of large scale rural water supply projects existing in the respective districts, there are 295 LSRWS in the country. The existing schemes serve approximately 4.2 million people and have a design capacity of about 448,600 $m^3$/day in total, equivalent to 107 lpcd on an average.

(5) The present water supply quantity is estimated by the method for 141 urban centres and 50 districts of the objective areas for the Study as shown below:

| Service Area | Supply System | Quantity (1,000 $m^3$/day) |
|---|---|---|
| Urban areas | Urban Water Supply | 709 |
| Rural areas | Large Scale Rural Water Supply | 449 |
| | Small Scale Rural Water Supply | 301 |
| | Sub-total | 750 |
| National | Urban and Rural Water Supply | 1,459 |

Source: The Aftercare Study Team

The above figures do not include for the livestock water supply. On the basis of the above estimated water supply quantity, the water consumption per capita is estimated at 143 lpcd for urban centres and 78 lpcd for rural areas.

## 4.3 Physical Conditions of Existing Water Supply Facilities

(1) The surface water source facilities are grouped into run-of-river intake, a large dam, pumping facilities, and small dam/pan. The run-of-river intake is predominant and uses the unregulated surface water of the river. Large urban water supply system like in Nairobi and Eldoret depend on large dams for their raw water source. Pumping facilities are widely used for lifting the water up from lakes and rivers. According to "Inventory of Dams and Pans in the Country, July 1997, MWR", there are 1,359 small dams and 825 water pans.

(2) The groundwater source facilities are divided into boreholes and dug wells. A total of 8,448 boreholes have been registered with water right and approximately 57 million $m^3$ are abstracted annually for various purposes, of which more than 50% is supposed to be used for the domestic and livestock water supplies. No countrywide statistic is available as to the number of dug wells, but they sustain 11.8% of the total households in Kenya. It is supposed that the majority of dug wells are not equipped with pumping facilities.

(3) At the treatment works in local authorities' water supply schemes aiming at commercialisation under GTZ's assistance, alum dosing process is controlled by applying a Jar-test twice a day. But, most of the treatment works have few laboratory apparatus or Jar-tester, so that alum dosing is made without any consideration to suitable dosing rate. Filters are usually washed by air scouring and backwash water every 24 hours. However, because of poor sedimentation efficiency resulting from improper chemical dosing, filters are washed twice a day. When turgidity of raw water is low in dry season, the operator can decide not to do chemical dosing. Due to lack of enough budgets to purchase chemicals, rural small scale treatment works hardly ever perform chemical dosing so that quality of produced water is poor.

(4) Storage capacity of the existing reservoirs is quite small. Out of 343 water supply facilities of MWR and NWCPC surveyed, only 37 facilities are provided with required 24 hour storage capacity. The remaining 306 facilities have storage capacity less than 50% of the required volume. This results in reduction of water supply hours to the consumers or otherwise inhibits operating hours of the water works. It is, therefore, required to expand the storage capacity of most of existing water supply facilities to solve rationing.

(5) Steel pipe is used for important high pressure transmission pipelines. No master meter is installed on transmission pipelines. Master meters are required for flow control on transmission and distribution main pipelines after treatment works or pump stations.

(6) Accessibility to meters is good but there are few meter chambers except schemes operated by LAs. Meters are difficult to read accurately due to silt. While MWR and NWCPC established a metering system for the system operation, there are many urban centres without house meters due to insufficient budget to purchase them. In the local authorities' schemes under assistance of GTZ, all house connections are installed with water meters which are well maintained.

### 4.4 Operation and Maintenance Practice

(1) Out of 302 schemes of MWR and NWCPC inventoried, 171 (57% of the total) are not operated intermittently and 90% run less than 12 hours a day. This can be attributed to i) deterioration and defects in facilities, ii) improper attendance of operation and maintenance staff, iii) saving of inputs such as chemicals and electric power supply, iv) decrease in the river discharge and borehole/dug well production in the dry season.

(2) The present flow control and metering systems under MWR and NWCPC are very poor, causing low recovery of water charge and complaints by water consumers. Many bulk meters are malfunctioning at present due mainly to poor maintenance and/or timeworn. Proper recording of water quantities of distribution and real consumption is critical to grasp unaccounted-for-water (UFW) conditions of the system. The Water Supply Sector Survey revealed that more than 20% of the urban consumers and 40% of the rural consumers are unmetered.

(3) Water quality control is rarely practised. In addition, no periodical water quality analysis is done for any scheme. When turgidity of raw water is low in the dry season, no chemical is dosed according to operator's decision. Major urban water supply schemes have their own laboratory and test water quality on turgidity, conductivity, pH and residual chlorine and Jar-test to manage appropriate chemical dosing levels and the treatment process. But, test apparatus are generally few in numbers and are defective.

## 4.5 Typical Organisation and Staffing for Operation and Maintenance

(1) In general, staffing for operation and maintenance is not adequately provided. This is one of the reasons why many of the water supply systems are run intermittently. The operation and maintenance staff in water supply schemes work a three shift system. The number of experienced staff is very limited and normally only one operator, in most cases, is assigned for system operation and supported by unskilled labour. Effective operation can hardly be achieved.

(2) Periodical training of staff is not carried out for operation and maintenance of treatment works other than short term training for assignment of new staff. Most of district water engineers don't supervise treatment process or get involved in operation and maintenance for treatment works and pump stations.

## 4.6 Operation and Maintenance Expenditure

It is well known that almost all the water supply schemes are facing a lack of fund for their operation and maintenance. Usually, MWR allocates 65% of the revenues collected by the District Water Offices (DWO) to them as operation and maintenance fund of the facilities and then DWOs provide chemicals to each water treatment works. It is almost impossible to collect detailed data as to operation and maintenance cost of each water supply schemes at field level.

## 4.7 Summary of Problems and Constraints of Existing Water Supply Schemes

Through the review and analysis of the Water Supply Sector Survey, available data and information from the government authorities concerned and field reconnaissance, the following problems and constraints of the existing water supply schemes are identified:

1) No inventory of existing water supply schemes operated by government organisations, communities and NGOs and unknown features of the schemes for most cases,
2) Inevitable intermittent operation of existing facilities due to deterioration and damages of the facilities,
3) No repair of damaged facilities such as pump, dosing equipment, etc. and water supply with no chrorination in a lot of rural water schemes,
4) Insufficient operation and maintenance of water supply facilities due to inadequate staff,

5) Law quality water supply due to lack of water treatment process and water quality monitoring, resulting in low collection rate of water charge, and
6) High rate of unaccounted-for-water (probably more than 40%) resulting from waste of water due to flat rate tariff.

# CHAPTER 5 PRESENT SANITATION CONDITIONS

## 5.1 Existing Sanitation Systems and Population Served

(1) The data assembled by the Aftercare Study provides approximate estimates of the number of people served by sanitation type. Existing sewerage systems serve an estimated 1.8 million people in 1998 or 28% of the total urban population. This leaves an estimated 4.7 million urban dwellers without the benefits or convenience of waterborne sanitation connected to a public sewer system.

(2) There are 10 large urban centres with a population greater than 100,000 and all of these have developed conventional waterborne sewerage to some extent. There are 205 urban centres with a population less than 100,000 and only 20 of these have sewerage systems.

| Population Range | No. of Urban Centres with Sewerage | No. of Urban Centres without Sewerage | Total |
|---|---|---|---|
| 300,000 ≧ P | 2 | 0 | 2 |
| 300,000 > P > 100,000 | 8 | 0 | 8 |
| 100,000 > P > 20,000 | 16 | 8 | 24 |
| P ≦ 20,000 | 4 | 177 | 181 |
| Total | 30 | 185 | 215 |

Source: The Aftercare Study Team

(3) Further analysis of the survey results indicates that the percentage of the population connected to sewerage schemes in the 30 urban centres ranges widely from a low 5% to a high 70%. There is no apparent relationship between urban population size and level of service coverage.

(4) According to the results of the household survey, about 50% of the people who receive piped water supply use pit latrine for excreta disposal. Also, almost 47% of the urban population use unimproved pit latrines which are considered unacceptable for hygienic reasons.

(5) Approximately 23% of the total urban population use water borne toilet facilities connected to a septic tank or cesspit. Most septic tanks discharge effluent into a soak-away pit or drainage tiles located on the building plot. Septic tanks generally are not properly maintained which leads to clogging of the soak-away pits.

(6) In general, where public sewerage systems exist, industries usually discharge their effluents into the sewers. Enforcement of the National Trade Effluent Standards is the

responsibility of the MWR. It is severely crippled by a lack of resources to inspect industries, monitor, collect and analyse data. The continued uncontrolled disposal of industrial wastewater has already degraded the water environment around large urban centres, and could seriously jeopardise the quality of drinking water supplies in the near future, making it difficult to treat and provide safe potable water.

## 5.2 Physical Conditions of Sewerage Systems

*Sewer Reticulation*

(1) Sewers for domestic and industrial wastewater are separate from sewers for storm water drainage. Unfortunately the Local Authorities surveyed in the Study provided very little information on the physical condition of sewer reticulation making it impossible to comment on actual sewer rehabilitation needs. Sewer management authorities lack the basic sewer inspection programmes that are needed to collect the data.

(2) The average per capita length of sewers installed in urban centres is 1.4 m. This value is low and indicates poor service coverage. This conclusion is supported by the relatively high number of persons per sewer connection (house lateral), over 30 in 7 urban centres.

(3) Newly constructed sewers (last ten years) are generally in good working order despite a general lack of preventative maintenance such as regular cleaning and inspection. Trunk sewers are usually oversized to provide spare capacity for future flows. Unfortunately in many cases projected wastewater flows have not materialised because of water rationing or the unwillingness of consumers to connect to sewers. As a result, flows are too low to provide self-cleansing velocities. Low flows lead to operating problems such as accumulation of sedimentation.

(4) The vast majority of sewers where constructed in the 50s, 60s and 70s have never been inspected. Local experience indicates that many are in poor structural condition. In several urban centres the trunk sewers installed in central areas over twenty years ago are only 150 mm in diameter. Development has exceeded the available hydraulic capacity of older sewers resulting in frequent blockages, overflows and surface flooding.

*Wastewater Treatment Facilities*

(5) Waste stabilisation ponds are used in 25 out of 38 facilities. These generally provide problem free operation with the exception that most of the older ponds are filling with sludge and vegetation, which generally reduces retention times and thus treatment efficiency. The remaining treatment works use conventional processes such as biological attached growth filters, oxidation ditches, or aerated lagoons, etc.

(6) In general, most of the recently constructed sewage works are operating far below their intended design capacity. The low flow rates can be attributed to: low rate of sewer connections, and inadequate water supply systems resulting in low per capita water consumption.

(7) The older treatment works (1980's) are generally hydraulically and organically overloaded, a condition attributed to: (i) Population growth beyond design capacity, (ii) Reduction in designed treatment capacity due to sludge accumulation or mechanical failure of the process, (iii) Ageing sewer reticulation resulting in more infiltration of ground and surface water.

***Treatment Performance***

(8) A limited sampling programme of wastewater treatment plants throughout Kenya (20 existing plants) was carried out during the Study. Only two treatment works met the required National Effluent Standard of 20 mg/ℓ $BOD_5$. All treatment works met the National Effluent Standard of 5,000 faecal coliform counts per 100 mℓ and only two treatment works exceed the limit of 1,000 faecal per 100 mℓ proposed in the Study.

(9) On average, the influent BOD is strong at most treatment works indicating that individual water consumption is low. The samples obtained at the treatment works had an average BOD of 480 mg/ℓ, which agrees well with results of other studies in Kenya. The estimated BOD per capita obtained from the results of this study varied tremendously from 13 to 134 grams/capita/day and no conclusions can be drawn from these results.

(10) COD values range from medium to strong indicating that there is potentially a large component of untreated industrial liquid waste being discharged into public sewers. Effluent COD's in all cases exceed effluent standards of 10 mg/ℓ.

***Treated Water Disposal***

(11) In Kenya all treatment plant effluent is discharged into an inland stream or lake except for Mombasa where uncontrolled and untreated sewage is discharged into the ocean. Two urban centres (Homabay and Kisumu) discharge high BOD and nutrient rich waste directly into lake Victoria, and two urban centres (Nakuru and Naivasha) discharge treated effluent into the sensitive ecosystems of lakes Nakuru, and Naivasha.

(12) Samples taken in the receiving stream at 20 treatment facilities provide insight into water quality issues. In 10 cases, the BOD of the receiving watercourse upstream of the treatment plant is higher than the effluent standard of 20 mg/ℓ indicating a significant contribution from other sources of pollution upstream. At 10 treatment works, the BOD downstream of the treatment plant is lower than the BOD upstream. This result appears to indicate that the effluent is diluting the natural watercourse.

***Sludge Treatment and Disposal***

(13) Desludging of ponds is rarely done and as observed during the surveys most ponds are in desperate need of relief. Where ponds are desludged, the sludge is normally dumped on the ground within the site and left to dry before being trucked off to a land disposal site.

(14) Conventional treatment works generate much larger volumes of sludge than ponds. All of the conventional works surveyed had facilities for digesting and subsequently drying the sludge. Treated sludge is usually disposed of at the municipal dump or sold to farmers for agricultural use where cultural acceptable.

(15) Septic sludge of privately owned septic tanks and soak-away pits is removed by local authorities or private firms operating on call. Most local authorities own at least one sludge truck but generally these are unreliable and often unavailable. Numerous single truck owners operate on an irregular and unpredictable basis.

(16) There is little control over the disposal of septic sludge. Treatment works do not have any special provisions for accepting septic wastes. Private firms tend to discharge sludge into nearby drainage ditches or open field. The indiscriminent disposal of septic sludge is a serious health hazard and a threat to the environment.

## 5.3 Operation and Maintenance Practice

(1) Operation and maintenance practices vary widely from one urban centre to the next depending on the level of funding available, management, and staffing. In several urban centres, sewerage systems are working below capacity due to water rationing, blocking of sewers.

(2) Sewers are not inspected or cleaned on a regular and there appears to be no effort to prevent conditions that will eventually lead to more serious and costly maintenance problems. With the exception of newer facilities (last ten years), most sewage treatment facilities have either fallen into serious disrepair or are non-operational and beyond repair.

(3) Maintenance requirements for waste stabilisation ponds are very simple however they are neglected at most facilities. Although the treatment process is not immediately affected the pond environment will suffer leading to odours, flies and mosquitoes.

(4) There is a lack of process control and monitoring at most conventional treatment works. These treatment plants require constant monitoring and process adjustments in order to provide intended performance.

## 5.4 Typical Organisation and Staffing for Operation and Maintenance

(1) Generally speaking, operations and maintenance is usually organised in one sewerage department under the direction of the Town or Municipal Engineer. A superintendent reporting to the engineer usually oversees actual day to day operation of the treatment works and sewer system. The functional organisation under the operating superintendent usually consists of four separate divisions:

1) treatment works,
2) sewers,

3) pumping stations, and
4) laboratory, inspection and by-law enforcement.

The laboratory and inspection functions are only found in large urban centres such as Nakuru, Eldoret and Nairobi.

(2) Staffing levels generally appear to be adequate where treatment is provided by waste stabilisation ponds, but inadequate at large conventional treatment works and in larger collection systems where pump stations are operated. The lack of skilled trades such as mechanics and electricians is especially apparent. There is also a lack of trained operators resulting in no process control at most conventional treatment works which typically require constant monitoring and adjustment to process parameters to provide effective and efficient treatment.

## 5.5 Operation and Maintenance Expenditure

(1) In most local authorities there is a serious lack of revenue to support the on-going operation and maintenance of sewerage infrastructure. Lack of revenue is particularly acute where the LA is not the water undertaker and has therefore no control on billing and collection of revenue from sewer surcharges. According to data collected in the Study, only two schemes (Achi and Nyeri) have given a reasonable contribution to asset management having spent a significant amount on operation and maintenance (O&M). Few schemes, if any, are yet financially viable in being able to recover the costs of O&M, depreciation and a contribution to reserves.

(2) The sewer surcharge is normally set as a percentage of the water tariff (usually 50%) regardless of the actual cost of providing the services. At present, progressively less revenue is collected to pay for sewerage, as more people become dissatisfied with the water supply services in some municipalities. The viability of providing sewerage operations is completely dependent on the good management of the water supply system and the extent to which water can be metered for revenue and delivered to satisfied consumers who will pay their water bills.

## 5.6 Summary of Problems and Constraints of Existing Sewerage Schemes

The population is growing at an alarming rate, exerting pressure on existing water and sewerage infrastructure. Most existing sewerage facilities have fallen into serious disrepair. The need for rehabilitation and increased sewerage system services is urgent to reduce health risks and environmental contamination. The major problems and constraints of the existing sewerage schemes are as follows:

1) Insufficient operating revenue to support operation and maintenance resulting in the principal cause for the serious state of disrepair in most sewerage systems,
2) No national standard for the planning and design of sewerage resulting in a wide variety of plans and designs and selection of inappropriate technology,

3) Insufficient water supply for proper sewer operations resulting in blocking and in some cases complete failure,
4) Lack of qualified personnel, and inadequate training for staff,
5) Inadequate, facilities, equipment, and tools,
6) Inadequate preventive maintenance resulting in costly maintenance,
7) Ineffective control of industrial wastewater discharges affecting the treatment systems and possibly interfere with its performance, and
8) Poor operation of sewerage works.

## CHAPTER 6 WATER SUPPLY DEVELOPMENT STRATEGY

### 6.1 Development Target and Strategy

(1) All schemes under the present Study in principle shall have a planning horizon year 2010. Target areas for the current study are 141 urban centres with population of more than 5,000 in 2010 for urban water supply development and the remaining urban centres and rural areas for rural water supply development.

(2) Water supply development strategy in the Study is set as below based on the National Development Plan 1997-2001 and also the National Water Policy mentioned in Chapter 3.

1) Provision of water in sufficient quantity and quality and within a reasonable distance so as to meet the needs of human beings, agriculture, livestock, and industry, and
2) Urgent rehabilitation and augmentation of many existing schemes which are currently inoperable due to managerial, technical and financial problems.

(3) The previous NWMP adopted a target of providing safe and potable water within a reasonable distance to all the population by the year 2010 in line with the 1989 - 1993 Five Year National Development Plan. In the present Study, however, more moderate targets are set up taking into account the present situation of water supply development in Kenya as follows:

1) The current 90% service coverage in urban centre will increase to 95% in the year 2010. In the rural area, the present 35% service coverage will increase to 70% in the year 2010. The overall service coverage in the country will attain 80% from the present 50%.
2) All water supply schemes shall have a certain level of accounted-for-water ratio (AFW), preferably over 70%. This target ratio shall be achieved by each scheme by the year 2010.

(4) To ensure sustainable development of the schemes, the following fundamental concepts are worked out for the planning.

1) Maximum utilisation of the existing facilities by rehabilitation,
2) Minimum use of mechanical and electrical equipment,

3) Planning of gravity supply, pumping being limited to areas where topography requires it,
4) Metering system to be established by installing service meters at all connections, and
5) Safe and potable water production by chemical treatment.

## 6.2 Population Projection

(1) The Annual average growth rate of the total population will decrease rapidly from 3.0% (1990 to 1995) to 1.6% during the period from 2005 to 2010, with an average rate of 2.3% over the period from 1990 to 2010. The total population will reach 37.4 million by the year 2010. The urban population will have an average annual growth rate of 5.3% for the period from 1990 to 2010 and reach 11.5 million by the year 2010, while the rural population will reach 25.9 million with an average growth rate of 1.4%.

(2) The population for 215 urban centres identified in the National Population Census 1989 was projected up to the year 2010. A total population of urban centres less than 5,000 will slightly decrease from 232 thousand in 1995 to 197 thousand in 2010 with a lower average annual growth rate of 1.7%. For the urban centres more than 20,000, the total population will grow significantly at 6.0% on an annual average and increase from 4,395 thousand to 10,607 thousand in 2010. The population of urban centres with a population between 5,000 and 20,000 will slightly increase from 625 thousand in 1995 to 692 thousand in 2010.

## 6.3 Water Demand Projection

(1) The 1995 population served by type of schemes is based mainly on 1996 MWR Status Report and Welfare Monitoring Survey II. Population served in 2010 are estimated from the population forecast. On the assumption that the present service coverage is improved to the target ratio, 80% on average in 2010, the total population served is estimated to increase to 30.6 million in 2010. Urban water supply schemes will serve 11.1 million people, while 8.8 million and 10.7 million people will be serviced by large and small scale rural water supply schemes, respectively. Development of the water supply schemes will double the number of the present served population, 14.6 million.

(2) Residential water demand is forecast reflecting income categories and service type of the customers. Non-residential water demand consists of those for livestocks, health, schools, commerce and industry. Water demand for livestocks, health and schools are estimated on the basis of the latest data available. Regarding commerce and industry, statistical data on the number of workers, businessmen, farmers and composition ratio of water consumption are utilised to estimate industrial and commercial water demand.

(3) Water demand estimated in the above procedures are ideal ones based on the 1986 Design Manual. Estimated water demand is summarised in the table below;

(Unit: $10^3$ m$^3$/day)

| Category | 1995 | | 2010 | |
|---|---|---|---|---|
| | Current Study | NWMP | Current Study | NWMP |
| Residential | | | | |
| Urban | 616.2 | 747.8 | 1,574.0 | 1,642.8 |
| Rural - large scale | 208.8 | | 401.9 | |
| - small scale | 110.1 | 468.2 | 421.6 | 932.6 |
| Sub-total | 935.1 | 1,216.0 | 2,377.5 | 2,575.4 |
| Non-residential | | | | |
| Health facilities | 16.0 | | 25.4 | |
| Schools | 135.3 | | 176.3 | |
| Industry & commerce | 201.1 | | 499.0 | |
| Sub-total | 352.4 | 593.9 | 701.3 | 986.3 |
| Total | 1,287.5 | 1,809.9 | 3,078.8 | 3,561.7 |
| Unit Consumption Rate(l/c/d) | 88.8 | | 101.6 | |
| Livestock Water Demand | 517.5 | 376.6 | 583.2 | 621.4 |
| Grand Total | 1,805.0 | 2186.6 | 3,662.0 | 4,183.2 |

Note: 1992 figures of NWMP are obtained from interpolation of the 1990 and 2000 figures.

(4) Water demand estimates, 1.8 million m$^3$/day in 1995 will increase to 3.7 million m$^3$/day in 2010 mainly due to the rapid population growth expected in the coming 10 - 15 years. Livestock, health, schools, industry and commerce water demand for 2010 estimated in the current study are similar to those in NWMP, although slight differences are seen in livestock and industrial water demand.

## 6.4 Future Development Requirement

***Water Balance between Forecast Water Demand and Water Supply***

(1) The water supply capability of all existing water supply facilities is estimated at 1.3 million m$^3$/day under the present conditions, whereas the overall safe water demand is forecast to amount to as large as 3.7 million m$^3$/day in the year 2010. It is evident that there is serious need for development of new water supply projects, though the magnitude of development needed varies largely from one area to the another.

(2) The water supply schemes in Kenya are grouped into urban water supply schemes (UWS), large scale rural water supply schemes (LSRWS) and small scale rural water supply schemes (SSRWS). In order to facilitate the planning of future water supply projects, the water balance calculation was worked out along with the following for successive steps:

1) Step 1 : Under the existing condition
2) Step 2 : Step 1 + completion of the on-going projects
3) Step 3 : Step 2 + completion of the planned/designed project
4) Step 4 : Step 3 + completion of the proposed rehabilitation works of existing facilities

In this study, however, water supply for livestock is separately dealt with. The water balance for livestock supply is made using present supply capacity assumed at 80% of the livestock water demand. The results of water balance calculation are given in **Tables - 6.1 to 6.3.**

(3) The table below presents summary of the water balance calculation results for the water demand in 2010.

| Objective Water Supply System | Number of Urban Areas/ Districts Subject to Water Deficit | | | | Amount of Water Deficit ($10^3$ m$^3$/day) | | | |
|---|---|---|---|---|---|---|---|---|
| | Step 1 | Step 2 | Step 3 | Step 4 | Step 1 | Step 2 | Step 3 | Step 4 |
| UWS | 133 | 121 | 111 | 109 | 1,315 | 1,255 | 1,154 | 1,113 |
| LSRWS | 36 | 15 | 11 | 9 | 233 | 66 | 42 | 36 |
| SSRWS | 46 | 42 | 34 | 34 | 355 | 325 | 292 | 292 |
| Total | | | | | 1,904 | 1,646 | 1,488 | 1,441 |
| Livestock | 50 | - | - | - | 169 | - | - | - |

Source: The Aftercare Study Team

***Water Resources Development Plan for UWS, LSRWS and SSRWS***

(4) Surface water from rivers is the predominant source of raw water for the large urban centres, and accordingly is given 1st order of development. In as much as the unregulated runoff of the river is available, a run-off-river intake method is considered to be best suited. When the unregulated runoff of the river is insufficient to meet the water deficit, a large scale dam with seasonal flow regulating capacity or inter-basin transfer scheme will be considered. Depending on the magnitude of the water deficit, groundwater, sources particularly boreholes will be proposed in place of the surface waters it available in the vicinity of the urban area concerned and more economical than the surface water.

(5) In the large urban centres, Nairobi and Mombasa, organisations concerned have been implementing the water supply improvement projects with assistance of international funding agency and/or donor countries and have sufficient development plans. Those two urban centres are therefore discarded from the further study. Consequently, remaining 139 urban centres are subject to further study.

(6) For large scale rural water supply, the same development concepts as the urban water supply schemes are basically adaptable. However, the groundwater development will be given 1st order of development when the urban area concerned is located in ASAL area.

(2) For small scale rural water supply, groundwater development will be considered the predominant source. It is evident that there are no perennial surface water resources available in the ASAL area. In general for small community water supply, construction of boreholes or dug wells are more advantageous than the surface water in view of initial investment and operation and maintenance cost.

(8) The summary of the water resources development plan is as follows:

| Type of Water Supply System | Forecast Water Deficit in 2010 ($10^3$ m$^3$/day) | Proposed Water Resources Development ($10^3$ m$^3$/day) | | | | |
|---|---|---|---|---|---|---|
| | | Surface Water | Groundwater | Surface & Groundwater | | Total |
| | | | | Surface | Ground | |
| UWS | 1,113 | 1,049 | 42 | 16 | 4 | 1,113 |
| LSRWS | 36 | 35 | 1 | 0 | 0 | 36 |
| SSRWS | 292 | 7 | 109 | 128 | 49 | 292 |
| Total | 1,441 | 1,091 | 152 | 144 | 53 | 1,441 |

Source: The Aftercare Study Team

## 6.5 Water Supply System Development Method

(1) Evaluated production capacity of the existing treatment works, water demand forecast and the succeeding water resource assessment indicate that the available treatment capacity is far less than the estimated water requirements in 2010, merely 50% of the total requirements. The following measures to meet water demand should be taken.

1) Structure measures

i) Rehabilitation works of existing water supply projects
ii) Completion of on-going projects
iii) Implementation of planned/designed projects
iv) Implementation of newly proposed projects

2) Non-structural measures

i) Leakage control programme
ii) Functional metering system
iii) Institutional and legislative improvement

(2) The proposed scope for rehabilitation includes i) installation of master and district meters and ii) repair/installation of chemical dosing equipment, iii) construction of storage facilities, iv) leakage control activities, and v) establishment of metering system, and vi) public campaign on needs of safe water, metering system, hygienic water use, etc.

Out of the proposed scope for the rehabilitation above, work items iv), v) and vi) shall be attained in the course of routine operation and maintenance. Urgent rehabilitation should be initiated for schemes where system operation is in a crucial situation if the fund can be sufficiently supplied. If the fund is insufficient, rehabilitation for the schemes of which accounted-or-water is less than 50% should be made.

(3) There are many projects under way in the country. The water balance study revealed that this project will play a predominant role in the long term water supply plan for both urban and rural. To incorporate these projects in the current study, key design factors worked out by the Government and agencies concerned are adopted without any amendment. In

case some contradictions are found in the design values, minor adjustment is inevitably made.

(4) Based on evaluation of the existing treatment works, the needs for system expansion will be also assessed to establish an adequate supply for a planning horizon year of 2010. The present study will emphasise the following fundamental aspects of water supply system development.

1) Continuous supply with a minimum pressure of 10m,
2) Disinfection which is a minimum requirement for all schemes to meet MWR water quality guidelines,
3) Measures for increasing cost recovery through a number of initiatives including reduction of unaccounted-for water and the universal application of metering, and
4) Gravity supplies to reduce recurrent costs and pumping being limited to areas where it is essential.

(5) In case of the SSRWS, water will be supplied to main water points with only a few pipe works to supply for residential and non-residential consumers excluding livestock. To the contrary, LSRWS may have pipe reticulation consisting of trunk, secondary and tertiary mains for distribution and transmission. Individual connections are a major type of service connections. At the peripheral supply areas, schemes may have water points to serve the surrounding rural population. Planning concept for expansion and rehabilitation of the LSRWS is similar to those for the UWS.

(6) The following planning concepts, accordingly, are for constructing new SSRWS.

1) Supply basically from water points with minor piping works.
2) Disinfection which is a minimum requirement for all schemes to meet MWR water quality guidelines.
3) Community based organisation and management in line with the decentralisation policy set up by the Government.

(7) Apart from domestic water supply, water supply points for livestocks will be designed at strategic locations of the study area. The following concepts are worked out in identifying needs for and planning the livestock water points.

1) Supply by earth pans or small dam,
2) ASAL areas shall have a priority in selecting potential areas,
3) Storage capacity of the pans is tentatively assumed to be 50,000 $m^3$, and
4) Earth pans shall be accessible both for livestocks and human-beings.

## 6.6 Improvement Plan of Operation and Maintenance System for Water Supply

(1) Metering is a basic tool for effective management of water supply schemes. Without metering, water production and consumption cannot be measured. Accordingly, tariff will have no base for billing. Flat rate tariff is not an optional solution.

1) Mobilise meter readers from existing staff through Kenya Water Institute (KEWI) courses for the training of trainers, and local training programmes,
2) Mobilise accountants for requisite bookkeeping and accounting at District level,
3) Mobilise technicians from existing staff for meter calibration and repair through KEWI courses for the training of trainers, and local training programmes,
4) Assist DWOs to set-up or refurbish meter repair shops with the necessary equipment, and
5) Conduct public awareness campaigns for the introduction of the metering system, directly and through the media.

(2) Many waterworks are suffering from a large quantity of water losses particularly at their transmission, distribution and service pipelines. In these waterworks, leakage and wastage control are considered effective not only to reduce water losses but to save precious water resources. To materialise this programme, the MWR shall take the following actions:

1) Establish a short course at KEWI for active leakage control (detection and repair),
2) Mobilise technicians from existing staff through KEWI courses for the training of trainers, and through local training programmes,
3) Assist DWOs to acquire and install bulk meters at the outlet of each treatment works and storage reservoir, and subsidiary meters to isolate sub-areas of each system,
4) Assist DWOs to set up or refurbish the necessary detection and repair facilities and equipment, and
5) Assist DWOs to prepare the necessary work programmes to cover detection and repair in the distribution network where the majority of leakage occur.

(3) The training needs of the above programmes should be reviewed against the latest Action Plan for KEWI to see if they can be accommodated within the planned implementation schedule. If not, the KEWI's resources should be further strengthened in both range of courses and capacity to accommodate larger numbers of trainees.

(4) Besides the above programmes, the following actions are also needed.

1) Customer registration to ensure billing and revenue collection and also to reduce unaccounted for water,
2) Chemical water treatment to protect public health, especially when water rationing,
3) Technical assistance at districts by experts externally sourced to achieve the above programmes, and
4) Water tankers at provincial offices to alleviate water shortage hardship during dry season.

# CHAPTER 7 SEWERAGE DEVELOPMENT STRATEGY

## 7.1 Development Target and Strategy

(1) The planning horizon for the Study is the year 2010. The Study covers 40 urban centres: 30 that already have sewerage systems and 10 more where there is an urgent need because on-site sanitation conditions are inadequate.

(2) As preceding chapters have indicated, urban centres in Kenya have well developed water supply systems serving a high percentage of the population (more than 90%). In comparison, sewerage remains poorly developed serving only 28% of the population living in urban centres while almost 50% rely on pit latrines. This results in disposal of a large amount of untreated wastewater. The environmental and health implications of inadequate sanitation have been further aggravated by a poorly maintained and failing sewerage infrastructure.

(3) Based on a review of existing conditions and discussions with MWR and MOLA the following development strategy is proposed:

1) Existing failing infrastructure should, where economically feasible, be rehabilitated before investing in new works.
2) Residences with water connections should have conventional sewer connections if they are located in already sewered areas.
3) Residences with water connections in presently unsewered areas should have connections to conventional sewers, or small bore sewers or septic tanks by the year 2010.
4) Residences which today have a water connection but which cannot be served by a conventional or small bore sewer connection should improve their sanitation by upgrading their existing cesspits or septic tanks by 2010.
5) Residences that do not have a water connection today but will be supplied with one by 2010 should be served by pour flush toilets with sludge soak-aways if they do not install flushing toilets.
6) Those who are unable to afford the sanitation system that must accompany a water connection will have to rely on standpipes for their water supply. Such residents will principally use either ventilated improved pit latrines or pour-flush toilets for sanitation.

(4) The implementation and monitoring of on-site sanitation in urban centres must be formalised to make them more effective. Formalising on-site sanitation will require:

1) Setting standards for construction of pit latrines, septic tanks and soak away pits
2) Regulating construction through the issuing of permits and follow-up inspections
3) Providing facilities for disposal of septage
4) Regulating municipal and private sludge collection services through licensing and manifest system to ensure proper disposal

(5) Target service ratio is set on the basis of population size as shown in the following table taking into account service ratios of urban centres having sewerage systems.

| Population in Urban Centre | % of Population Connected to Sewer |
|---|---|
| P ≧ 300,000 | 50% |
| 100,000 < P < 300,000 | 40% |
| 20,000 < P < 100,000 | 25% |
| P ≦ 20,000 | 15% |

The development targets proposed for each urban centre is presented in **Table - 7.1**. The overall service ratio comes to 38%. In some cases where urban centres already have a higher service ratio the strategy will be to continue sewerage development to keep pace population growth in effect maintaining existing percentage service ratio.

## 7.2 Forecast Wastewater Quantities

(1) The usual method of calculating wastewater flows is on the basis of population and water consumption for various land use zoning. Since land use data is unavailable, wastewater flows adopted for planning are estimated by establishing average contributions from domestic users and adding a percentage for commercial, institutional, and industrial wastewater flows.

(2) Data from previous master planning studies for six urban centres indicates that on average the total sewage flow is composed of domestic sewage (60%), commercial/institutional sewage (20%) and industrial wastewater (20%). The average domestic wastewater flow is approximately 93 lpcd. Therefore, using the above percentages the total base sewage flow including residential, commercial, institutional and industrial is 155 lpcd.

(3) The total base sewage flow is multiplied by a factor of 1.2 to account for the significant contribution of water from extraneous sources such as groundwater infiltration and surface water inflow that occurs even during dry weather periods. The total dry weather flow assumed for planning purposes is 186 lpcd.

(4) By the year 2010 if the development target for the 40 urban centers is achieved, approximately 4.4 million people and a large number of industries will produce an estimated 750,000 $m^3$/day of wastewater requiring a total incremental treatment capacity of 510,000 $m^3$/day.

## 7.3 Planning Criteria

*Sewage Collection*

(1) Most urban centres have implemented separate sewer systems and it is advisable to continue this practice where sewers are an economically viable option.

(2) Where possible, sewerage systems should be designed to flow by gravity to reduce the need for pumping, and the problems associated with mechanical and electrical maintenance.

*Sewage Treatment Facilities*

(3) Where land is readily available, stabilisation ponds are generally the most suitable method of treatment providing three major advantages:

1) Removal of excreted pathogens at a much lower cost than any other form of treatment,
2) Good removal efficiencies for BOD, and
3) Minimum operation and maintenance requirements and production of very little sludge.

(4) In urban centres, where land availability is small and a more energy intensive treatment method must be considered, it is generally more cost-effective to provide aerated lagoons where receiving streams do not require tertiary treatment.

(5) For the purpose of preparing a national sewerage development plan it is assumed that waste stabilisation ponds will be constructed in all urban centres where sewerage treatment works are required. The final selection of treatment method will depend on site-specific conditions and should be evaluated in future feasibility studies based on a detailed assessment of technical and economic criteria.

(6) Treatment works should be rehabilitated or replaced in urban centres where they are overloaded or where effluent greatly exceeds standards.

*Sludge Disposal*

(7) Currently most sewage treatment facilities have no provision for the discharge of sludge wastes removed from septic tanks and cesspits. These are often discharged into facultative ponds, or mixed with raw sewage at the head of the treatment process in many cases contributing to organic overload, treatment upsets, and build-up of sediments. All sewage treatment facilities in the future should be provided with separate anaerobic ponds to receive and pre-treat septic wastes.

(8) For disposal of sludge removed from anaerobic and facultative ponds the current practice of using sludge drying beds is simple, low cost, and effective. The only condition is that the sludge must be properly digested, stored, and dried for over 12 months to ensure that the material is stabilised and pathogen-free.

*Strength of Influent*

(9) The BOD strength of influent raw sewage to the treatment works is an important design criteria. BOD will depend on domestic per capita contributions, the load contributed by industry, and the amount of "clean" groundwater and surface water that enters the sewer.

A value commonly used in design around Kenya is 550 mg/ℓ. This value is within the average range of BOD's that were measured at various treatment works, so that it is used for planning purpose in the Study.

*Effluent Criteria*

(10) Effluent standards for planning purpose are adopted as follows:

1) $BOD_5$ not to exceed 20 mg/ℓ when filtered to remove algae
2) Faecal coliforms not to exceed 1,000 MPN per 100 mℓ

## 7.4 Improvement Plan of Operation and Maintenance System for Sewerage

(1) In the previous Chapters 3 and 5, a lot of problems and constraints in the sewerage sector are pointed out. Some of them are related to operation and maintenance aspects of the sewerage systems. The sewerage schemes are presently suffering from a lack of sustainability of the schemes as well as water supply schemes. The strengthening of operation and maintenance system is very important to recover the sustainability of the schemes in problem.

(2) Since operating revenue for sewerage is based on water consumption, it is recommended that improvements for water supply systems such as metering, billing and collection should be implemented to increase operating revenue of sewerage schemes. Other institutional changes, discussed in Chapter 11 will also have a significant impact on improving revenue for sewerage.

(3) It is recommended that the following actions should be undertaken to upgrade staff levels and skills within each operating authority under the supervision of MOLA:

1) a detailed review of organisational structures, staff establishment, and qualifications needed,
2) a detailed audit of personnel already in post, their qualifications and experience against their job descriptions,
3) identification of: vacancies, training needs for existing staff, non-performing surplus staff, and
4) development of a program of: recruitment, training, or transfers to other more suitable positions.

The training needs for various operating authorities must be reviewed against the latest Action Plan for KEWI to see if they can be accommodated within the planned implementation schedule. If not, KEWI's resources should be further strengthened in both scope and capacity to accommodate larger numbers of trainees from the sewerage sector.

(4) Proper facilities, equipment, and tools are essential to operation and maintenance of collection and treatment works. Without them, even the best-trained and motivated staff

will be ineffective. It is recommended that the following actions be undertaken within each operating authority under the supervision of MOLA:

1) Prepare an inventory of existing tools and equipment to identify what is required,
2) Rank items required in order of priority, and
3) Obtain funding to construct required facilities and purchase required tools and equipment.

(5) Preventive maintenance is effective for the purpose of extending equipment life, reduces maintenance costs, and increases reliability. The preventive maintenance should be carried out as routine maintenance with periodical inspection so as to avoid occurrence of problems. In the short-term, it is recommended that the following actions should be undertaken.

1) Prepare a detailed sewer inventory identifying pipe size, material and locations,
2) Prepare a maintenance schedule for all equipment and regular inspection,
3) Establish a work order system to track all maintenance, and
4) Prepare standard operating procedures.

In the long term, it is recommended that preventive maintenance programmes be developed within each operating authority.

(6) Industrial effluent laws are in place but enforcement is very weak because there is a lack of money, manpower, and equipment to implement a comprehensive programme at the local level. It is recommended to implement a pre-treatment programme at the local authority level where the sewerage operator is responsible for inspecting and monitoring industries connected to its sewer system to ensure compliance with local sewer by-laws. The pre-treatment programme proposed includes the following elements:

1) Development of an inventory of industrial discharges to the public sewer system,
2) Adoption of an industrial pre-treatment by-law,
3) Purchase of monitoring and laboratory equipment,
4) Sampling and analysis of industrial effluents to ensure compliance, and
5) Establishment of administrative procedures to obtain compliance with regulations.

## CHAPTER 8 URBAN WATER SUPPLY DEVELOPMENT PLAN

### 8.1 Rehabilitation Works of Existing Facilities

(1) Rehabilitation works are proposed for all existing urban water supply systems. Through the information obtained from reconnaissance survey, it is identified that the rehabilitation requirements are quite diversified and the rehabilitation works cover the following:

1) Repair/replacement of damaged equipment and pipe works,
2) Installation of chemical dosing equipment,

3) Installation or repair/replacement of master meters,
4) Construction of additional service reservoirs to achieve continuous water supply, and
5) Other miscellaneous works to restore the system into original function.

## 8.2 Preliminary Design Criteria

(1) For UWS, the surface water resources will be the predominant source of raw water supply, though the groundwater resources will also be required to be developed in ASAL and other minor urban centres. The water source facilities are planned by the following three types depending on the water demand and site conditions.

1) Large dam and inter-basin transfer system
2) Run-of-river intake
3) Borehole with powered pump

(2) The treatment of surface water is assumed to be made by the process of conventional coagulation, flocculation, rapid sand filtration and disinfection. The capacity of storage reservoir/tank is assumed to correspond to one day average water demand for small scale schemes and 12 hours for medium and large scale schemes. Distribution is assumed to be made by gravity flow.

## 8.3 Preliminary Construction Cost Estimate

(1) Unit cost of materials and equipment is estimated at the price prevailing in February 1998. The exchange rate applied is US$1.00 = Kshs 61.1 = Japanese Yen 124.7 (as of 10 February 1998).

(2) The construction cost consists of (a) direct construction cost, (b) land acquisition and compensation, (c) engineering services for design and supervision, (c) administration cost of the executing agency and (d) contingency. The cost estimate was made for rehabilitation works of existing facilities, on-going and planned/designed projects and newly proposed projects. The construction costs of on-going and planned/designed projects were obtained for the MWR Status Report and the NWCPC Status Report.

(3) The costs of urban water supply projects estimated are summarised by type as follows:

| Type of Projects | Nos. of Projects | Amount (1,000 US$) |
|---|---|---|
| Rehabilitation Works | 120 | 44,400 |
| On-going Projects | 21 | 7,400 |
| Planned/designed Projects | 21 | 27,400 |
| Newly Proposed Projects | 108 | 1,243,000 |
| Total | 270 | 1,322,400 |

## 8.4 Annual Operation and Maintenance Cost

(1) The annual operation and maintenance cost is estimated for the on-going and planned/designed and newly proposed projects and also leakage reduction programme. The cost except leakage reduction programme comprise expense for annual maintenance and repair costs, operation costs (e.g., salary, power, fuels, chemicals) and miscellaneous costs.

(2) It is difficult to estimate the O&M cost for this programme because the actual situation varies greatly from one urban centre to another. Therefore, referring to the actual annual expenditure of typical Japanese municipal water supply and taking into account the difference in price levels between Kenya and Japan, it was roughly estimated at Kshs 3/$m^3$ of water produced.

(3) The annual operation and maintenance cost of water supply facilities amounts to US$31.3 million and the annual cost of leakage reduction programme implementation is estimated at US$23.6 million.

## 8.5 Construction Period

The construction period of the project is assumed as follows. The contractors will be procured through competitive bidding. In addition to the construction period, the required time for feasibility study, detailed design, and financial arrangement is assumed to be two years and also pre-construction procedure is assumed to be one year.

| Type of Project | Construction Period (Year) |
|---|---|
| Rehabilitation Works | 1 |
| On-going Project | |
| - Present progress less than 30% | 2 |
| - Present progress 30% or more | 1 |
| Planned/Designed and Newly Proposed Projects | 1 |
| - Project with borehole | 1 |
| - Project with run-of-river intake | 2 |
| - Project with a large dam | 4 |
| - Project with inter-basin transfer | 4 |

# CHAPTER 9 RURAL WATER SUPPLY DEVELOPMENT PLAN

## 9.1 Rehabilitation Works of Existing Facilities

As with urban water supply schemes, it is proposed to rehabilitate the existing rural water supply. The rural water supply schemes are categorised as large scale water supply (LSRWS) and small scale water supply (SSRWS). For the LSRWS, the rehabilitation works will be the same as that of the urban water supply project, which is explained in Section 8.1. For the SSRWS, it is not possible to systematically identify the present

operation and maintenance status. It is, therefore, assumed that no public investment would be required for rehabilitation.

## 9.2 On-going, Planned/Designed Projects

As the same as the urban water supply projects, The on-going water supply projects and planned/designed projects by Kenyan Government are indispensable to meet rural water demand till the target year 2010, but it is not necessarily required to complete all of them according to the water balance study. Therefore, the selected on-going and planned/designed projects required to meet the projected water demand are incorporated into the Study.

## 9.3 Newly Proposed Projects

(1) In principle the same design criteria as stated in subsection 8.3.1 will be adopted for the rural water supply projects. It is, however, necessary to recognise the following particulars:

1) Application of protected dug well and or boreholes as major water sources,
2) Hand pumps installation at dug well for required production less than 10 $m^3$/day,
3) Provision of balancing tanks with a capacity of one day water demand, and
4) Roof catchment as a supply source in the sparsely populated rural areas.

(2) To rationally estimate the required investment with any accuracy, it is considered necessary to develop a number of water supply scheme models.

| Design Pop. & Production Cap. | Type of Schemes | Water Source + Treatment Process | Distribution Method |
|---|---|---|---|
| 200 pop. 4 $m^3$/day | Small Scale (SS - 1) | Dug well (hand pump) | Point supply |
| | | Borehole (hand pump) | |
| 500 pop. 10 $m^3$/day | Small Scale (SS - 2) | Dug well (hand pump) | Point supply |
| | | Borehole (hand pump) | |
| 5,000 pop. 600 $m^3$/day | Large Scale (LS - 1) | Borehole with chlorination | Point and piped supply |
| | | Surface water with full treatment | |
| 20,000 pop. 2,500 $m^3$/day | Large Scale (LS - 2) | Borehole with chlorination | Same as above |
| | | Surface water with full treatment | |

Source: The Aftercare Study Team

## 9.4 Livestock Water Supply Facilities

Livestock water supply will depend on water pans and/or small dams. A storage capacity is assumed to be 50,000 $m^3$ per unit, according to NWMP. It is supposed the rainwater and/or seasonal flow is available during the rainy period so that water storage is required for the rest of the year. A total of 597 small dams/water pans are required to meet the long term livestock water demand.

## 9.5 Preliminary Construction Cost Estimate

(1) The construction cost estimate for rural water supply projects is made under the same general conditions as the urban water supply projects. For cost estimate of the rehabilitation works of LSRWS, the same manner as the urban water supply project is adopted, while the construction cost of the newly proposed projects is estimated based on the unit costs of respective scheme type models mentioned in Section 9.3.

(2) The cost estimate was made for rehabilitation of existing facilities, on-going and planned/designed projects and newly proposed projects. The construction costs of on-going and planned/designed projects were obtained for the MWR Status Report and the NWCPC Status Report. The costs estimated are summarised as follows:

| Type of Project | No. of Projects | Amount (1,000 US$) |
|---|---|---|
| Rehabilitation of Existing Projects | 295 | 95,100 |
| On-going Projects | 552 | 67,700 |
| Planned/Designed Projects | 217 | 8,800 |
| Newly Proposed Projects | 51,183 | 185,400 |
| Total | 52,247 | 357,000 |

Source: The Aftercare Study Team

(3) The construction cost of livestock water supply projects was estimated based on MWR's data. The average construction cost of small dam/water pan is US$0.61/m$^3$ of active storage capacity, resulting in initial construction cost US$30,500/small dam/water pan (50,000 m$^3$ × US$0.61). The total construction cost is estimated at US$18.2 million for the entire works of 597 projects.

## 9.6 Annual Operation and Maintenance Cost

(1) The annual operation and maintenance costs of the rural water supply projects are estimated basically by the same method as used for the urban water supply projects. The proposed small dams/pans for livestock water supply will be located in a relatively remote area and of earthfill structure. They are almost free from operation and maintenance; and therefore, one percent of the initial cost is allowed as annual operation and maintenance cost.

(2) The total annual operation and maintenance cost of rural water supply facilities is estimated at US$25.6 million. The annual cost of leakage reduction programme implementation for large scale rural water supply is estimated at US$8.0 million. While, the annual operation and maintenance cost of livestock water supply facilities is US$0.2 million.

## 9.7 Construction Period

(1) Each SSRWS is actually very minor in scope of work. The construction can be completed within a one year period, without regard to the fact that there is a great number of such SSRWS in the district concerned. Normally it is common practice that the rural water supply project will be implemented on the basis of district unit. Accordingly, it is assumed that the rural water supply plan will be implemented on a basis of a district unit. On the other hand a LSRWS will normally require the same construction period as that of a UWS.

| Type of Project | Construction Period (Year) | |
|---|---|---|
| | LSRWS | SSRWS |
| Rehabilitation Works | 1 | - |
| On-going Project | | |
| - Present progress less than 30% | 2 | 2 |
| - Present progress more than 30% | 1 | 1 |
| Planned/Designed and Newly Proposed Projects | | |
| - Project with borehole | 1 | 3 |
| - Project with run-of-river intake | 2 | |
| - Project with large pond | 2 | (for entire district without regard to type of project) |

Source: The Aftercare Study Team

(2) Concerning livestock water supply, MWR for many cases has been mobilising its own resources for construction small dams/water pans. Major work is earth moving/excavation, and it does not require complicated concrete and/or mechanical installation. As such a three-month period for construction of each structure is assured.

# CHAPTER 10 SEWERAGE DEVELOPMENT PLAN

## 10.1 Rehabilitation Works of Existing Facilities

### *Sewer Reticulation*

(1) Rehabilitation of sewers is necessary in all urban centres. The needs vary for each urban centre and it is impossible at this stage to establish exactly what is required without underground inspection and conditions assessment. Therefore, the sewer rehabilitation projects in each urban centre were developed by assuming that all trunk sewers need to be cleaned, and that 25% of all small diameter sewers (150 mm) should be replaced with a minimum 225 mm pipe.

(2) The rehabilitation of existing sewers should be the first priority in urban centres where the service coverage is below the proposed target ratio and existing treatment plants have capacity for increased sewage flows. Trunk sewers that do not have the required hydraulic capacity should be replaced or augmented before extensions are made in upstream drainage areas.

*Sewage Treatment*

(3) The decision to maintain existing treatment facilities in operation should be based on an economic evaluation of the site-specific technical options. This type of detailed evaluation should be carried out when a master plan for the urban centre is developed. For the purpose of establishing programme costs it is assumed that it will generally be cost effective to rehabilitate and keep existing facilities in operation.

(4) Three facilities are in extremely poor condition: Nairobi (Kariobangi conventional), Mombasa (Kizingo primary sedimentation) and Kakamega (Kiambi waste stabilisation ponds). It is assumed that it would be technically and economically advantageous to abandon these works and divert flows to a new facility with more capacity.

## 10.2 Extension of Sewer Reticulation and Expansion of Treatment Works

*Sewer Reticulation*

(1) The feasibility of extending sewer reticulation within each urban centre will depend on water supply conditions and existing sewage treatment works capacity. The general conditions that are known to exist in each urban centre are summarised in the following table along with the proposed sequence of works.

| Water Supply Condition | Treatment Works Condition | Proposed Measures | Urban Centres Subject |
|---|---|---|---|
| Water supply conditions are probably adequate to support conventional sewerage. | Treatment works is operating at or above design capacity. | Increase treatment capacity before extending sewer network. | Eldoret, Kakamega, Kapsabet, Kisumu, Machakos, Meru, Nairobi, Nanyuki, Nyahururu, Thika |
| | Treatment works has short-term capacity. | Extend sewer reticulation coverage up to treatment works capacity | Athi River, Karatina, Kiambu, Kisii, Muranga, Webuye |
| Water supply conditions are probably not adequate to support conventional sewerage. | Treatment works has short-term capacity. | Improve water supply conditions before extending sewer network. | Bungoma, Isiolo, Kitale, Mombasa, Naivasha, Nakuru, Nyeri |
| | Treatment works is operating at or above design capacity. | Increase treatment capacity before extending sewer network. Extend sewer network only if water supply conditions improve. | Busia, Embu, Homa Bay, Kericho, Limuru, Ngong, Voi |

*Treatment Works*

(2) The need for expansion of sewage treatment works in urban centres with existing facilities is summarised in the following table:

| Capacity Condition | Proposed Measures | Urban Centres Subjects |
|---|---|---|
| Short term (1998-2005)<br>More treatment capacity is required because existing facilities are overloaded | Rehabilitate and/or expand existing treatment works | Kisumu (Nyalenda), Kapsabet, Limuru, Kakamega, Nairobi (Dundora), Nanyuki, Nyahururu |
| | Provide new treatment works | Busia, Eldoret, Embu, Kericho, Homa Bay, Machakos, Meru, Ngong, Thika, Voi |
| Long-term (2005-2010)<br>Provide more treatment capacity to meet target for 2010 | Rehabilitate and/or expand existing treatment works | Bungoma, Isiolo, Kakamega, Karatina, Kisii, Muranga |
| | Provide new treatment works | Kitake, Kisumu, Mombasa, Nakuru, Naivasha, Nyeri |

## 10.3 Preliminary Design Criteria

(1) The size, and length of pipe required to serve the target population is determined by multiplying the incremental population requiring sewer connections in 2010 by the average per capita length of 1.14 m. The total length is then divided into pipe sizes according to the typical percentages found from the results of the survey done for this Study.

(2) Waste stabilisation ponds will be used in all cases. Pond systems were sized on the basis of formula and design criteria given in the UK Overseas Development Administration publication entitled "Waste Stabilisation Ponds: A Design Manual for Eastern Africa". The stabilisation ponds consist of a configuration of anaerobic ponds, facultative ponds, and maturation ponds required to achieve effluent standards. Considering future rehabilitation and expansion, more than two series of pond are planned.

(3) Capacity at existing treatment works is increased by adding more ponds. Capacity at existing conventional works is also increased by adding stabilisation ponds downstream of existing treatment processes. The type of expansion works may be classified into the following 3 groups;

1) Provision of one or more additional series of ponds
2) Provision of additional maturation ponds
3) Provision of stabilisation pond to other treatment types

## 10.4 Preliminary Construction Cost Estimate

(1) The general conditions set forth for estimating the costs of urban water supply are also applicable for urban sewerage projects. The total construction cost is made up of: (a) direct construction cost, (b) land acquisition and compensation, (c) engineering services, (d) administration cost, and (e) contingency. Land acquisition and compensation costs are estimated by assessing how much land is required to accommodate the selected sewage treatment works.

(2) Sewer construction costs are estimated by multiplying pipe length of each diameter by the unit construction cost per meter. Unit cost includes pre-cast concrete pipe, excavation, and manholes at 50 m intervals. The construction cost of new treatment facilities is

estimated by assuming a linear relationship between the construction costs and the design wastewater flow for each type of waste stabilisation facility. The unit costs for replacing sewer pipes are assumed to be 1.5 times the cost of new construction.

(3) The estimated costs are summarised as follows:

| Type of Projects | Nos. of Projects | Amount (1,000 US$) |
|---|---|---|
| Rehabilitation Works | 52 (34) | 52,100 |
| Expansion Works | 18 | 89,600 |
| On-going and planned/designed projects (Mombasa, Eldoret) | 2 | 31 |
| New facilities | 64 (40) | 341,400 |
| Total | 136 (74) | 483,131 |

Source: The Aftercare Study Team
Note: Figures in parenthesis indicate number of sewer reticulation projects.

## 10.5 Annual Operation and Maintenance Cost

The cost of operation and maintenance (O&M) consists of (i) equipment maintenance and repair cost, and (ii) staff salary cost. Maintenance and repair cost for equipment is estimated as a percentage of the capital cost. The numbers of staff are estimated by referring to a World Bank technical report (1983: Notes on the Design and Operation of Waste Stabilisation Ponds in Warm Climates of Developing Countries Washington D.C.). The total annual operation and maintenance cost of sewerage facilities is estimated at US$22,885,000.

## 10.6 Construction Period

The construction period of sewerage project is assumed as follows:

| Required Actions | Construction Period (Year) |
|---|---|
| Feasibility Study | 1 |
| Detailed Design and Financial Arrangement | 1 |
| Pre-construction Stage | 1 |
| Actual Construction | |
| - Rehabilitation | 1 |
| - New schemes, Large scale | 3 |
| Small-medium scale | 2 |

Source: The Aftercare Study Team

Urban centres such as Nairobi and Mombasa are classified as large-scale centres and sewerage expansion works will need to be implemented in more than one phase.