REPUBLIC OF KENYA

NAKURU SEWAGE WORKS REHABILITATION AND EXPANSION PROJECT (FEASIBILITY STUDY)

FINAL REPORT

VOLUME (I) EXECUTIVE SUMMARY

MARCH 1994

JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF LOCAL GOVERNMENT

NIPPON KOEI CO., LTD.
NIHON SUIDO CONSULTANTS CO., LTD.

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PREFACE

In response to a request from the Government of the Republic of Kenya, the Government of Japan decided to conduct a feasibility study on the Nakuru Sewage Works Rehabilitation and Expansion Project and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Kenya a study team headed by Mr. Kazushige Endo, Nippon Koei Co., Ltd., and composed of members from Nippon Koei Co., Ltd. and Nihon Suido Consultants Co., Ltd., two times between June 1993 and January 1994.

The team held discussions with officials concerned of the Government of Kenya, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Kenya for their close cooperation extended to the team.

March, 1994

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

JAPAN INTERNATIONAL COOPERATION AGENCY
THE STUDY ON THE NAKURU SEWAGE WORKS REHABILITATION AND EXPANSION PROJECT

March, 1994

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo

Dear Sir,

LETTER OF TRANSMITTAL

We are pleased to submit herewith the Final Report of "the Study on the Nakuru Sewage Works Rehabilitation and Expansion Project".

The project is one of urgent programmes to protect and conserve the precious ecology of Lake Nakuru and particularly envisages to rehabilitate and expand existing sewage works in Nakuru Municipality, which have been identified to be major pollution source.

The Study has revealed the sources and volume of pollution loads flowing into Lake Nakuru from its catchment area and formulated a water pollution control plan on the basis of "Wastewater Standard for Discharge into Lake Nakuru", which was set forth by the Government of Kenya in June 1993. The proposed plan includes not only the rehabilitation and expansion of sewage works but also non-structural measures such as institutional support, enforcement and implementation of "Trade Effluent By-laws", control of development activities in the lake catchment area, etc.

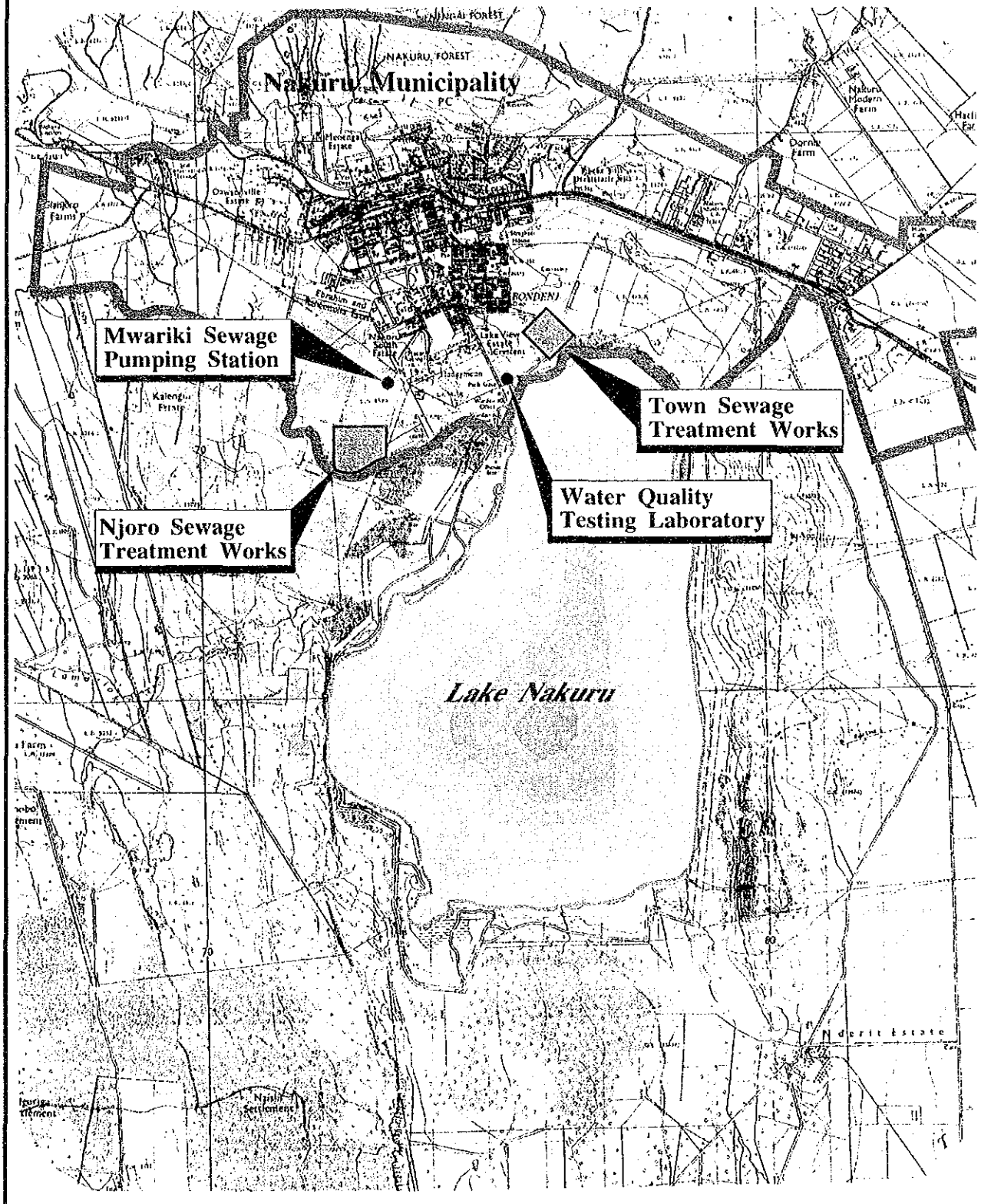
The preliminary design of the Project was also accomplished and presented in the report. It is proposed to construct a new sewage treatment works with a daily treatment capacity of 3,200 m^3. Upon completion of this treatment works, sewage treatment capacity reach 16,200 m^3/day in total, which is completely capable of treating the whole sewage deriving from existing sewered area in Nakuru Municipality.

It is concluded that the Project greatly contributes to conservation of the ecology of Lake Nakuru, as the Project results in reducing a great deal of pollutant load.

All members of the Study Team wish to express grateful acknowledgment to the personnel from your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction, and Embassy of Japan in Kenya as well as the officials and individuals from Kenya for the kind assistance extended to the Study Team. The Study Team sincerely hopes that the proposed plan be realized and implemented earlier as possible for a peaceful coexistence of human activities and precious ecology of Lake Nakuru.

Yours sincerely,

Kazushige Endo
Team Leader



THE REPUBLIC OF KENYA	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILITATION AND EXPANSION PROJECT	TITLE
MINISTRUY OF LOCAL GOVERNMENT	JAPAN INTERNATIONAL COOPRATION AGENCY	**Location Map**

EXECUTIVE SUMMARY

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ABBREVIATION AND LOCAL TERMS

1. Abbreviation of Measures

1.1 Length

mm	=	millimeter
cm	=	centimeter
m	=	meter
km	=	kilometer
"	=	inch

1.2 Area

m^2, sq.m	=	square meter
ha	=	hectare
km^2, sq.km	=	square kilometer

1.3 Volume

cc	=	cubic centimeter
lit, l, L	=	liter
lcd	=	liter per capita per day
m^3, cu.m	=	cubic meter

1.4 Weight

mg	=	milligram
g	=	gram
kg	=	kilogram
t	=	ton

1.5 Time

s, sec	=	second
min	=	minute
h, hr	=	hour
d	=	day
yr	=	year

1.6 Money

KShs.	=	Kenya Shilling (unit of Kenya currency)
US$, $	=	US Dollar
¥	=	Japanese Yen

1.7 Electric Measures

A	=	ampere
V	=	volt
KV	=	kilovolt
KW	=	kilowatt
KWh	=	kilowatt hour
KVA	=	kilovolt ampere
Hz	=	hertz

1.8 Other Measures

mS	=	milli Siemens
mmho	=	micromho = conductance
ppb	=	parts per billion
ppm	=	parts per million
MPN	=	most probable number
‰	=	per mil
%	=	percent
PS	=	0.736 kW
°	=	degree
'	=	minute
"	=	second
℃	=	degree centigrade
BOD	=	biochemical oxygen demand
COD	=	chemical oxygen demand
T-N	=	total nitrogen
I -	=	inorganic
O -	=	organic
T-P	=	total - phosphorus
DO	=	dissolved oxygen
pH	=	exponent of hydrogen ion concentration
TDS	=	total dissolved solids
SS	=	suspended solids
VS	=	volatile solids

1.9 Derived Measures Based on the Same Symbols

cm/sec	=	centimeter per second
m/s, m/sec	=	meter per second
cm^3/min	=	cubic centimeter per minute
m^3/sec, cu.m/sec	=	cubic meter per second
m^3/s, cu.m/s	=	cubic meter per second

m^3/min, cu.m/min	=	cubic meter per minute
m^3/h, cu.m/h	=	cubic meter per hour
m^3/day, cu.m/day	=	cubic meter per day
m^3/d, cu.m/d	=	cubic meter per day
lpcd	=	liter per capita per day
m^3/m^2/day	=	cubic meter per square meter per day
m^3/sec/km^2	=	cubic meter per second per square kilometer
kg/day	=	kilogram per day
ton/m^2	=	ton per square meter
kg/day/km^2	=	kilogram per day per square kilometer
mg/kg	=	milligram per kilogram
mS/cm	=	milli Siemens per centimeter
mg/L	=	milligram per litre
g/cm^3	=	gram per cubic centimeter

2. Other Abbreviations

BS	=	British Standards
JIS	=	Japanese Industrial Standards
ASTM	=	American Society of Testing and Material
GDP	=	gross domestic product
GNP	=	gross national products
GRDP	=	gross regional domestic product
El.	=	elevation
NOL	=	normal operation level
FOB	=	free on board
CIF	=	cost, insurance and freight
STW	=	sewage treatment works
Q'ty	=	quantity
Srl	=	serial
GL	=	Ground level
SD	=	Sewerage District
EIA	=	Environmental Impact Assessment

3. Abbreviation of Organization

GOJ	=	Government of Japan
GOK	=	Government of Kenya
JICA	=	Japan International Cooperation Agency
KWS	=	Kenya Wildlife Service
MOENR	=	Ministry of Environment and Natural Resources
MOF	=	Ministry of Finance
MOALD・	=	Ministry of Agriculture and Livestock Development
MOLG	=	Ministry of Local Government
MOLRRWD	=	Ministry of Land Reclamation, Regional and Water Development
MOC & I	=	Ministry of Commerce and Industry
MOL & S	=	Ministry of Land Settlement
MOTC	=	Ministry of Transport and Communication
MOTW	=	Ministry of Tourism and Wildlife
MOLMD	=	Ministry of Labour and Manpower Development
MOH	=	Ministry of Health
NES	=	National Environmental Secretariat
NWCPC	=	National Water Conservation and Pipeline Corporation
ODA	=	Overseas Development Administration, Britain
OECF	=	Overseas Economic Cooperation Fund, Japan
OP	=	Office of President
SOK	=	Survey of Kenya
WWF	=	World Wide Fund for Nature
NMC	=	Nakuru Municipal Council
PHD	=	Public Health Department, NMC
WSD	=	Water and Sewerage Department, Nakuru Municipal Council
Ramsar Convention	=	Convention on Wetlands of International Importance especially as Waterfowl Habitat
UNICED	=	United Nations Conference on Environment and Development
UNEP	=	United Nations Environment Programme
IMCE	=	The Inter Ministerial Committee on Environment
NCST	=	National Council for Science and Technology
KSTC	=	Kenya Science Teachers College
NEAP	=	National Environment Action Plan

IWG	=	Inter-ministerial Working Group
DDC	=	District Development Committee
UDD	=	Urban Development Department, MOLG
NGO	=	Non-governmental Organization
KEWI	=	Kenya Water Institute, MOLRRWD
TECU	=	Trade Effluent Control Unit, WSD
WAB	=	Water Apportionment Board
WRD	=	Water Resources Division, MOLRRWD
AALAE	=	African Association for Literacy and Adult Education
ANEN	=	African NGO's Environmental Network
APEMAM	=	African Pesticide and Environment Management Foundation
AWF	=	African Wildlife Foundation
CARE	=	Care International
CHEK	=	Council for Human Ecology Kenya
ELCI	=	Environmental Liaison Center International
ICRAF	=	International Council for Research in Agroforestry
WCK	=	Wildlife Clubs of Kenya
IOCN	=	The International Union for Conservation of Nature
ACTS	=	African Centre for Technology Studies

1. INTRODUCTION

1.1 Background to the Study

The Government of Republic of Kenya has launched the Nakuru Sewage Works Rehabilitation and Expansion Project aiming at properly treating sewage generated from the Nakuru Municipality in order to preserve the precious natural environment of Lake Nakuru. The lake was registered by Ramsar Convention in 1989. The feasibility study was initiated with a primary focus on rehabilitation and expansion of existing sewage treatment works.

1.2 Organization for the Study

The Study was accomplished successfully in a joint effort of the Kenyan and Japanese teams. The Kenyan side has organized a Counterpart Team under the Ministry of Local Government, while the Japanese side also organized a Technical Advisory Committee and Study Team. The Study extended a 10-month period from June 1993 to March 1994, including field survey and investigation during the period from June to September 1993.

2. THE STUDY AREA

2.1 Nakuru Municipality

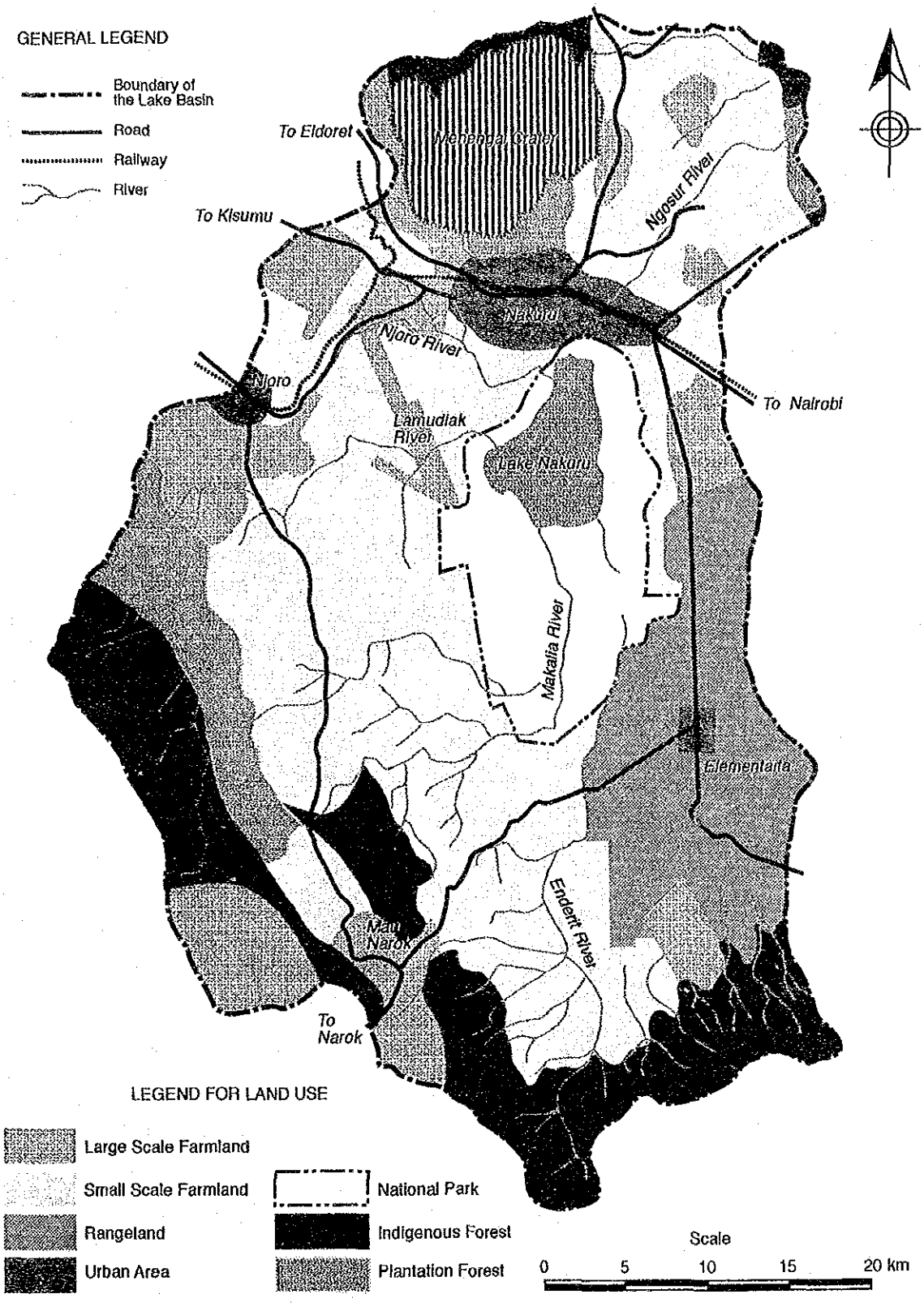
Nakuru Municipality is located at approximately 160 km northwest of Nairobi, the capital of Republic of Kenya. The municipal area of 69.2 km^2 extends over the southern slope of Menengai Crater and bounds with Lake Nakuru National Park on the south. The altitude of the municipal area varies widely from around El. 1,750 m at the southern boundary to about El. 2,100 m in the northern boundary. A map of the Lake Nakuru catchment basin is shown in Fig. 2-1.

Although the population census was conducted in 1989, it is not available for the current study. NMC has also no population data of the recent years. According to the previous study, the estimated population is 240,000 in 1987 and is forecast to grow to 361,000 in 1993. The average growth rate is as high as 7.0 per cent per annum, mainly owing to rural-urban immigration.

2.2 Lake Nakuru and National Park

The Lake Nakuru National Park is one of the most famous parks in Kenya. The birds and wildlife form unique spectacular display that attracts thousands of domestic and foreign tourists into the park every year. The national park area is about 188 km^2, including the lake itself.

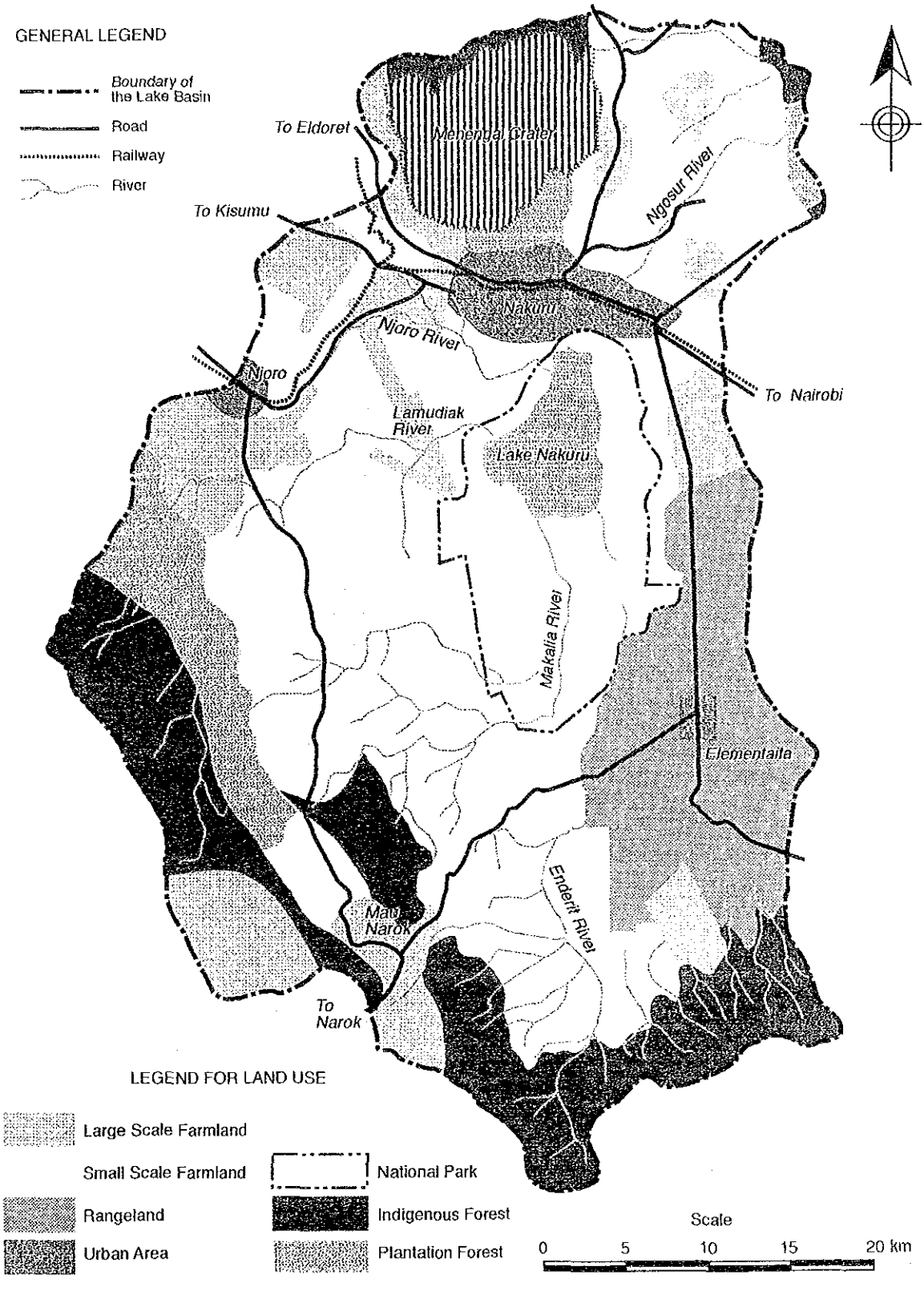
Fig. 2 - 1



Data Source : WWF

THE REPUBLIC OF KENYA	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILITATION AND EXPANSION PROJECT	TITLE
MINISTRY OF LOCAL GOVERNMENT	JAPAN INTERNATIONAL COOPERATION AGENCY	MAP OF LAKE NAKURU BASIN

Fig. 2 - 1



Data Source : WWF

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MINISTRY OF LOCAL GOVERNMENT	JAPAN INTERNATIONAL COOPERATION AGENCY	MAP OF LAKE NAKURU BASIN

The surface area of the lake is 43 km^2 at El. 1,758.5 m, although it varies largely depending on the level. Lake Nakuru is one of four broad shallow soda lakes in Kenya and its bottom elevation is at around El. 1,756 m.

Fig. 2-2 shows the lake level fluctuation in the past six decades. The level have changed largely during the recorded period. In the years 1933, 1939, 1947, 1961, and 1987, the lake dried up completely. It is believed that in the dried up periods the floor of the lake had been subjected to wind erosion resulting in clouds of alkaline dust being blown over the surrounding area.

46.7 % and 23.1 % of in the National Park area is covered with bush land and grasses respectively. The foreshore only contributes 11.7 % while woodlands make up 18.7 %. This vegetation distribution pattern is likely to influence the abundance and special distribution of the mammals to be found within the park.

Lesser Flamingo is identified as the most predominant bird in Lake Nakuru followed by White Pelican. But its number change greatly from time to time, since flamingoes move from one lake to another. The departure of flamingoes is believed to be related to food availability in these lakes and for breeding purpose. Only Lake Natron, which is located in Tanzania, is identified in the Rift Valley as a breeding environment. The number of flamingoes and the lake level fluctuation are as shown in Fig. 2-2.

2.3 Physical Development Plan of Nakuru Municipality

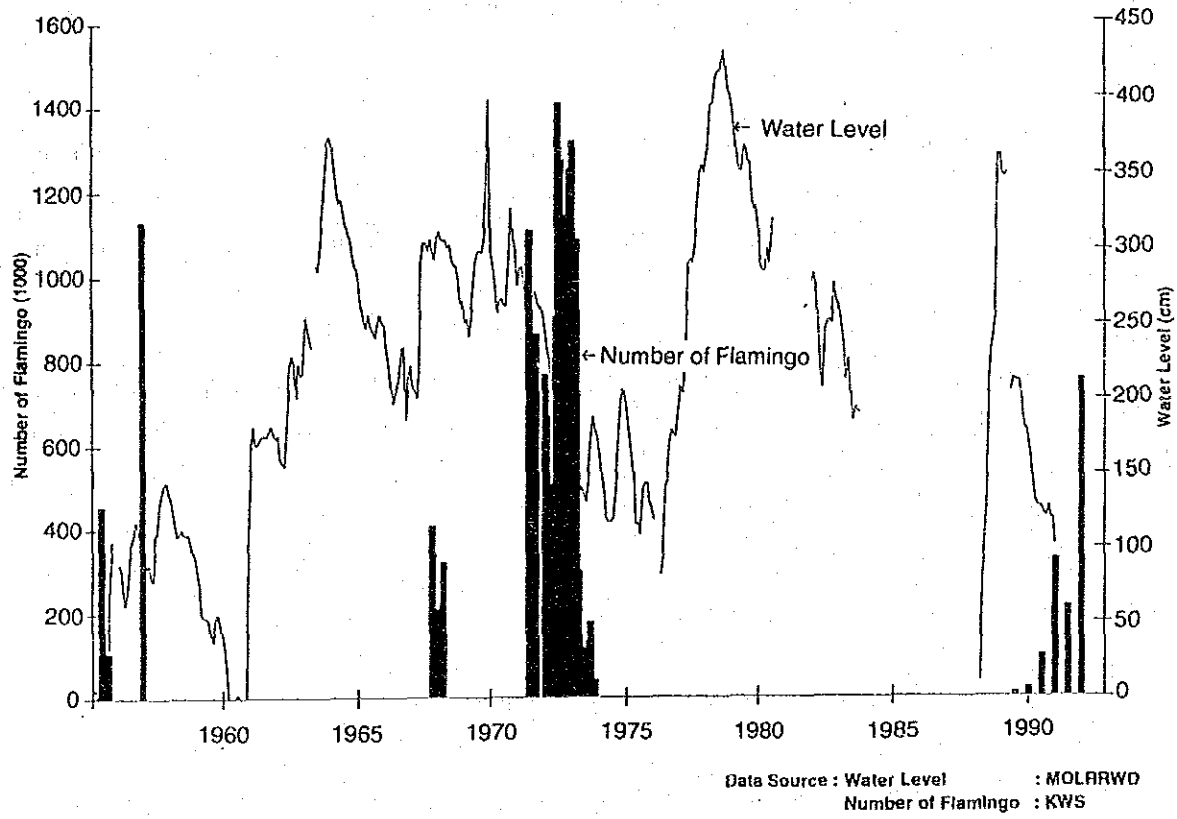
A physical development plan of the Nakuru Municipality has been mapped by the municipal council. According to the map, the municipal area is planned to be expanded to 72.6 km^2. It is foreseeable that the proposed physical development plan would result in augmenting pollutant load generation unless otherwise adequate precautions are taken up. It is recommended that every development activities be coordinated and controlled systematically by the IWG for conservation of Lake Nakuru.

3. EXISTING SANITARY SERVICES

3.1 Public Sanitary Service System

The NMC has established a systematic billing system for pipe water supply, sewerage and garbage collection. The municipal area is divided into Town and Lanet areas in view of the public services. The Town area is further sub-divided into a number of sections, while the Lanet area is mainly for the military services. The WSD is responsible for pipe water supply

Fig. 2 - 2



Data Source : Water Level : MOLRRWD
Number of Flamingo : KWS

THE REPUBLIC OF KENYA MINISTRY OF LOCAL GOVERNMENT	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILITATION AND EXPANSION PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE RECORDS OF WATER LEVEL AND NUMBER OF FLAMINGOES IN LAKE NAKURU

and sewerage services, while the PHD assumes responsibility for garbage and septage collection and disposal as well as public health care.

3.2 Pipe Water Supply Situation

3.2.1 Public Water Supply

It is not exaggeration to say that a whole of inhabitants depends on public water supply for domestic use. There are 14,904 registrants for public water supply as of April 1993. The Town area is fed by two water works and three groundwater fields, which have supplied about 22,080 m^3/day on the average during the recent five years. It is however recommended to deploy such measures as installation of additional water meters, leakage detection programme, etc. to save the un-accounted for water, which is supposed to be in a range of 40 to 50%. The Lanet area is dependent on the MOLRRWD's water supply facilities, which have supplied 1,300 m^3/day on the average.

3.2.2 Private Water Supply

There are 8 private deep wells, all of which are used as making up/emergency source in case of failure of public water supply in industrial sector. These wells supply 640 m^3/day on the average.

3.3 Existing Wastewater Treatment Situation

3.3.1 Public Sewerage System

The existing sewer network extends over the central part of the municipal area and covers an area of 1,285 ha only. There are 9,530 registrants for sewerage service. The sewered area is divided into three sewerage districts as shown in Fig. 3-1. The Njoro SD encircles 633 ha with 5,155 registrants, Town SD 419 ha with 3,164 registrants and Central SD 233 ha with 1,251 registrants.

The volume of sewage was 8,998 m^3/day on the average during the last 5 years and BOD concentration is around 800 mg/L at present. The sewage generation analysis concluded that out of the total water supply, 55% comes into the sewage treatment works.

There are two sewage treatment works at present in the municipality. One is Njoro STW with a waste stabilization pond process, and the other is Town STW with a conventional type comprising the primary and secondary clarifiers and trickling filter. Their daily treatment capacities are 3,600 m^3 and 3,400 m^3 respectively. Both the sewage treatment works have been under severe over-loading conditions and deteriorated due to lack

maintenance, resulting in producing degenerated effluent quality. It is concluded that both sewage treatment works be improved and expanded immediately.

The Nakuru Sewerage Project is in progress by NWCPC and has a daily treatment capacity of 6,000 m^3 with a waste stabilization pond.

3.3.2 On-site Wastewater Treatment

Septic tanks, cesspools and pit latrines are the dominant on-site wastewater treatment manner in unsewered area. Septage collected from these facilities are currently directly dumped into sewers, being one of the over-loading causes on sewage treatment works. The amount collected was 14.4 m^3/day in 1992.

3.3.3 Industrial Wastewater Treatment

Some of individual industries are provided with simple wastewater treatment facilities. They are not properly functioning, resulting in discharge of settled solids, oil/fat, and extreme temperatures and pH into public sewers. The industrial wastewater is the major source of the pollutant loads and hampers the treatment process. The heavy metals and toxic materials contained are likely to accumulate in the waste stabilization pond so that they must be controlled at source.

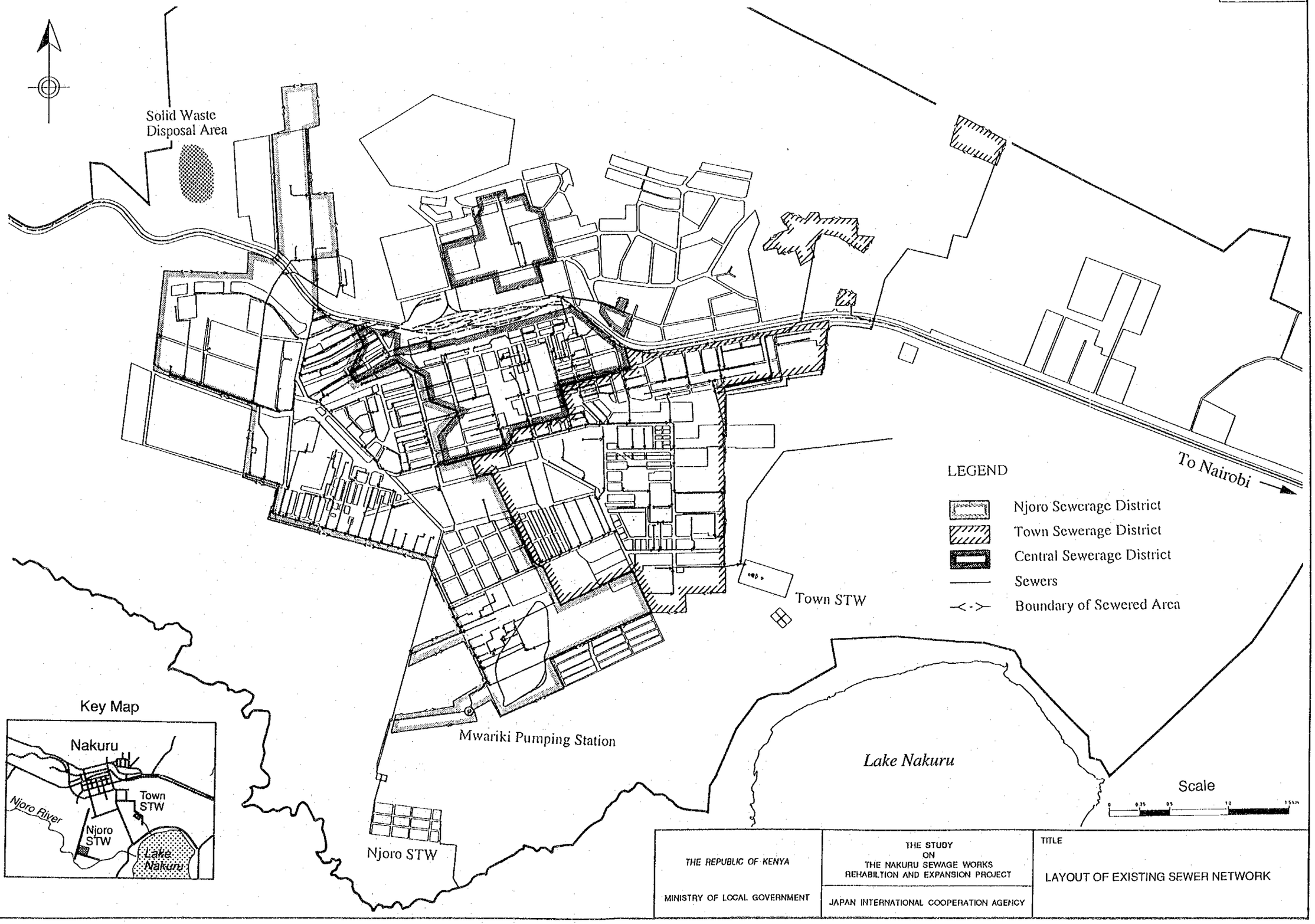
3.4 Stormwater Drainage

Presently the stormwater drainage network covers only 374 ha extending over the central part of the municipal area. Its main drain runs down not only stormwater but also sediment, garbage, oil, etc. It is also recognized to be one of pollutant load sources.

3.5 Domestic and Industrial Refuses

Both domestic and industrial refuses are being dumped at the same disposal area located in the western part of the municipal area. The industrial solid wastes disposal is handled by industries themselves. According to the PHD of NMC, the quantities of the domestic and industrial wastes were amounted to 23,040 ton/year and 4,956 ton/year respectively in 1992.

Fig 3 - 1



THE REPUBLIC OF KENYA MINISTRY OF LOCAL GOVERNMENT	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILTION AND EXPANSION PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE LAYOUT OF EXISTING SEWER NETWORK

4. WATER POLLUTION CONTROL PLAN

4.1 Source of Pollution Load

Pollution sources are classified into point and non-point sources, depending on how pollution is emitted or discharged into the receiving body. Further pollution can be grouped into man-made and others. The pollutants inflow into Lake Nakuru are mainly through rivers, channels and springs, and types of influent and pollution are as summarized in Table 4-1.

Table 4-1 Type of Influents and Pollution

Source of Pollution	Man-made Pollution	Others
The Njoro River (including effluent from sewage treatment works)	Yes	Yes
The Makalia River	No	Yes
The Nderit River	No	Yes
Town Stormwater Drainage Channel	Yes	No
Spring water	No	Yes

(Data source: Study Team)

The above pollution process is schematically presented in Fig. 4-1. The present study focused on the process when pollutants discharge into rivers, channels, sewerage facilities and lake in a discernible manner.

4.2 Forecast of Sewage Augmentation

It is evident that volume of sewage increases subsequent to increase in water supply. In the present case, it is assumed that the additional water supply of 13,300 m^3/day will be distributed evenly into the sewered and unsewered area in proportion to the number of registrants for public water supply. It is forecast that a dry weather flow from the sewered area will be augmented to 16,137 m^3/day. It is recognized that there will be a deficit in sewage treatment capacity even after completion of the on-going Nakuru Sewerage Project. Accordingly it is recommended that the Town STW be expanded with construction of a new sewage treatment works having a daily treatment capacity of 3,200 m^3.

4.3 Effluent Quality Standards

The GOK established the "Wastewater Standard for Discharge into Lake Nakuru" (the Wastewater Standards) in June 1993, which are summarized in Table 4-2.

Fig. 4 - 1

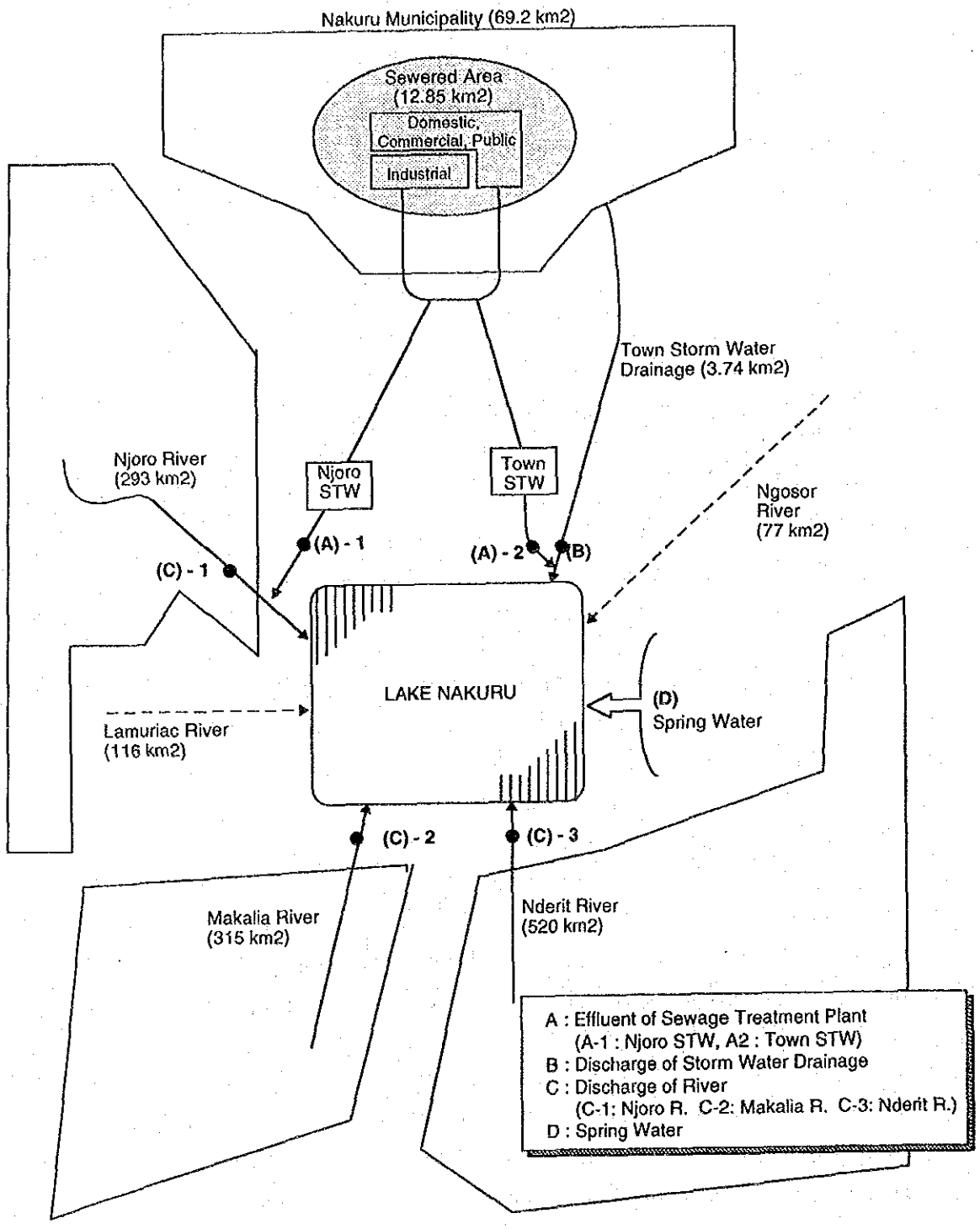


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Table 4-2 Wastewater Standards for Discharge into Lake Nakuru

Parameter	Limit
pH	7.0 - 9.0
BOD_5 at 20 °C (filtered), mg O_2/L	10
COD_{Cr} (filtered), mg O_2/L	30
Temperature, °C	25±2
Total suspended Solids, mg/L	15
Oil/Grease	Trace
Nitrogen as nitrates, mg/L	5.0
Free Ammonia (NH_3), mg/L	1.0
Total Dissolved Solids, mg/L	1,500
Chloride mg Cl/L	1,000
Total phosphorous, mg/L	5.0
Sulphides, mg/L	0.5
Sulphates, mg/L	500
Pesticides, mg/L	0.05
Phenols, mg/L	2.0
Hexavalent Chromium (Cr^{6+}), mg/L	0.05
Total Chromium, mg/L	0.1
Copper, mg/L	0.05
Zinc, mg/L	0.5
Other metals in combination (except iron), mg/L	1.0

(Data Source : MOLG)

In addition, NMC has drafted up "Municipal Council of Nakuru (Trade Effluent) By-laws" (the Trade Effluent By-laws) as shown in Table 4-3.

Both the Wastewater Standards and Trade Effluent By-laws are reviewed and appraised technically in the light of quality of sewage and the similar standards in other countries and from the viewpoint of sewage treatment process. The following is conclusion and recommendations:

(1) The Wastewater Standards are stringent. It is recommendable to make minor revision for such parameters as CODcr, nitrogen, heavy metals, toxic material and carcinogenic compound.

(2) It is recommended that the Wastewater Standards be applied on a basis of step by step and Trade Effluent By-Laws be enforced as soon as possible.

Details for the above conclusions and recommendations are reported in Supporting Report F in Volume III.

Table 4-3 Trade Effluent Standards for Discharge into Public Sewers

(Unit: mg/L)

Item	Concentration
Total Suspended Solids	600
Total Non-volatile Dissolved Solids	3,000
BOD_5 at 20°C	500
COD	1,000
Phenols (total at connection point)	10
Detergents	15
Soaping oils and fats	10
Hydro carbons	20
Silver (Ag)	0.02
Arsenic (As)	0.02
Barium (Ba)	0.5
Cadmium (Cd)	0.01
Chloride (Cl)	1,000
Cyanide (CN^-)	0.02
Cyanide (CN) total	1
Cobalt (Co)	0.05
Hexavalent Chromium (Cr^{6+})	0.05
Total Chromium	3
Copper (Cu)	0.5
Mercury (Hg)	0.01
Ammonical Nitrogen	20
Nickel (Ni)	0.5
Free Ammonia	10
Total Kjeldahi Nitrogen	Nil
Nitrite	0.5
Lead (Pb)	2
Total Phosphate	30
Selenium (Se)	0.5
Tin (Sn)	0.5
Sulphite (SO_3)	2
Sulphate (SO_4)	1,000
Zinc (Zn)	0.5
Total Nonferrous Metals	0.5
Total Soluble Nonferrous Metals	30
Pesticides	Nil
pH	6.5 - 8.0
Temperature	Not exceeding 35°C
In addition, effluent should not contain any toxic matter or any matter that will cause blockage and damage to sewers. Inflammable material and tar should not be present in the final effluent entering the sewer.	

(Data Source : NMC)

4.4 Pollution Control Plan

The proposed pollution control plan comprises structural and non-structural measures, and is envisioned to be implemented in a stage-wise way. It strongly favours the structural measures to be realized in advance of the non-structural measures, exerting an immediate effect on reduction of pollutant loads.

4.4.1 Structural Measures

The proposed structural measures involves the following:

(1) Sewage treatment works

It is concluded that the existing sewage treatment works be rehabilitated and expanded with the following measures:

- To remodel the existing waste stabilization pond at Njoro STW to increase treatment capability.

- To install additional treatment facilities such as rock filter and grass plots at the new 6,000 m^3/day line at Njoro STW to upgrade the quality of effluent.

- To add the facultative and maturation ponds, rock filters and grass plots to the existing 3,400 m^3/day line at Town STW to upgrade the quality of effluent.

- To construct the new 3,200 m^3/day line, consisting of waste stabilization ponds, rock filters and grass plots at Town STW.

The above plans are judged to be the most feasible based on technical and economical comparative study on alternative treatment processes. Upon realization of the above plans, the BOD concentration is expected to be around 15 mg/L in influent into Lake Nakuru.

(2) Sludge treatment and disposal

The quantity of raw sludge produced at sewage treatment works is estimated at 7,300 m^3/year for the entire Njoro STW and 2,410 m^3/year for the 3,200 m3/day line at Town STW. The sludge drying bed is concluded to be technically and economically feasible for sludge treatment.

It is to be noted that there are several industries emitting the heavy metals and toxic materials without proper treatment into public sewer. It is likely that such materials settle in anaerobic ponds. It is therefore proposed to dump the dried sludge to a new dumping site, which should be designated by the GOK in a remote area from Lake Nakuru prior to commencement of construction works. The quality of dried sludge is recommended to be carefully monitored to confirm whether or not the dried sludge can safely be dosable for agricultural purposes. The present and proposed sludge management are schematically shown in Fig. 4-2.

(3) Septage treatment and disposal

It is proposed to treat the septage collected from cesspools/septic tanks at the sludge drying beds to be constructed at both the Njoro and Town STWs so as not to overburden on sewage treatment works. The dried sludge should be processed in the same manner as above (2). However septage would be allowed to be hauled to and damped at the disposal area depending on its quality.

(4) Stormwater retention pond

It is proposed to construct a stormwater retention pond in Town STW in order to restrain the discharge of oil, inorganic matters, solid waste, sediment, etc. into Lake Nakuru, when heavy storm rainfall occurred over the Nakuru Municipal area.

(5) Disposal of industrial solid waste

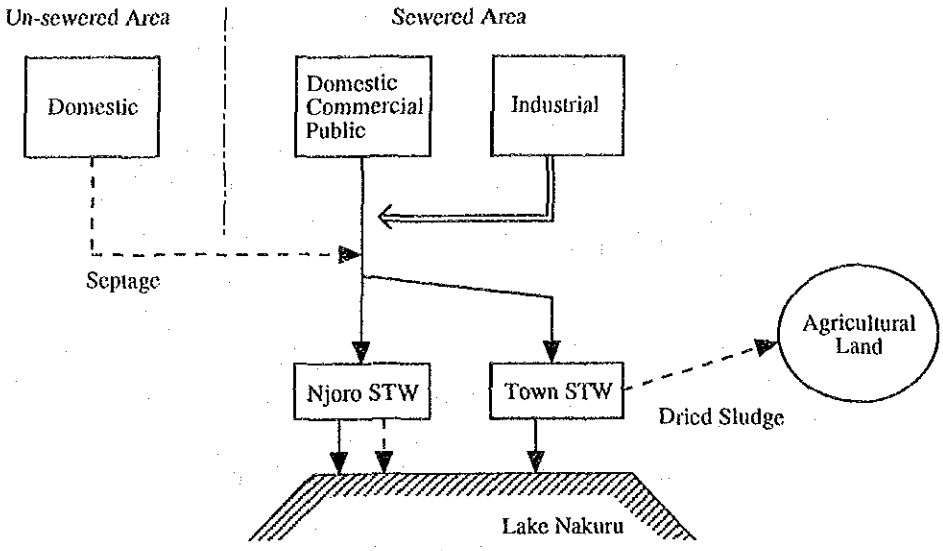
The industrial solid waste is being dumped without any precautions against environment and natural resources. It is proposed to adopt such measures as a specific dumping site lined with concrete and reduction of volume by compression.

4.4.2 Non-structural Measures

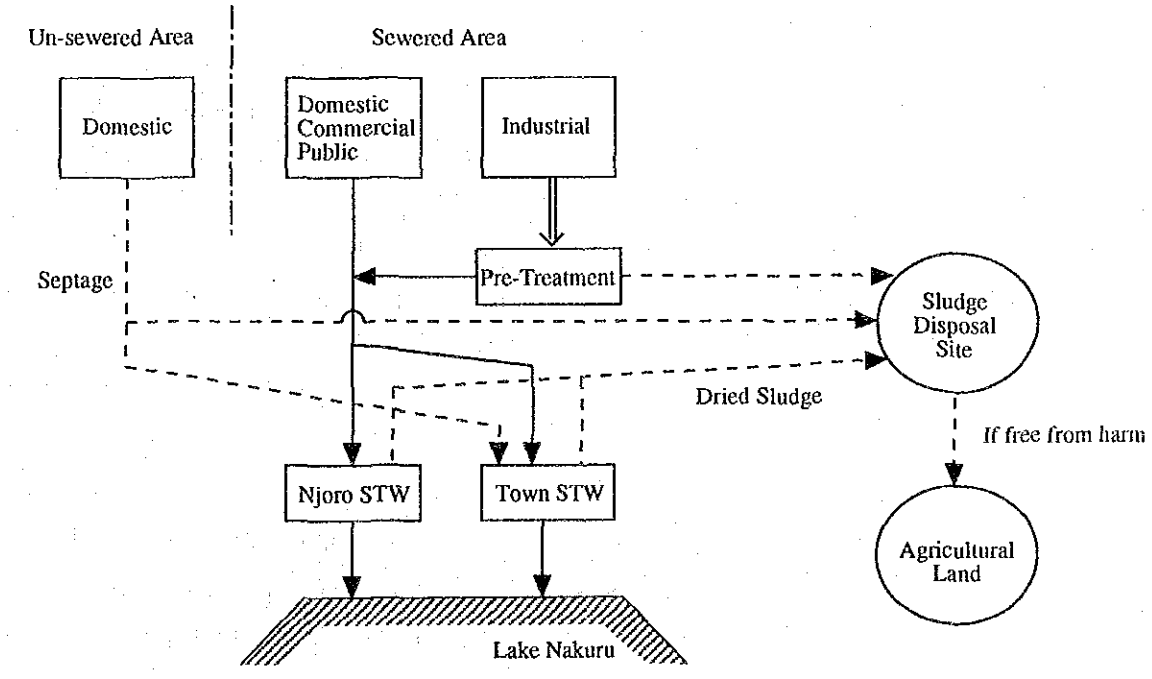
The proposed non-structural measures comprise a short term plan and a medium-long term plan.

Fig. 4 - 2

Present Condition



Proposed System



THE REPUBLIC OF KENYA MINISTRY OF LOCAL GOVERNMENT	THE STUDY ON *THE NAKURU SEWAGE WORKS* REHABILITATION AND EXPANSION PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE WASTEWATER AND SLUDGE FLOW IN SEWAGE ROUTE

(1) Short-term plan

(a) Water-related legislation

Upon review of all the existing and drafted legislation the following recommendations are made:

(i) To approve and enact the Trade Effluent By-laws by MOLG with additional provision for handling and storage of hazardous and toxic substances.

(ii) To enact amendment to the Water Act (Cap 372) to provide for protection of the water resources from pollution.

(iii) To enact amendment to the Local Government Act (Cap 265) in line with the provisions of the By-laws, especially provision of stiffer penalty against polluting water resources.

(iv) To gazette the National Environmental Bill for enactment

It should be noted that, without implementation and enforcement of the Trade Effluent By-laws, it is difficult to achieve the Wastewater Standards as a whole and eliminate the heavy metals and toxic materials.

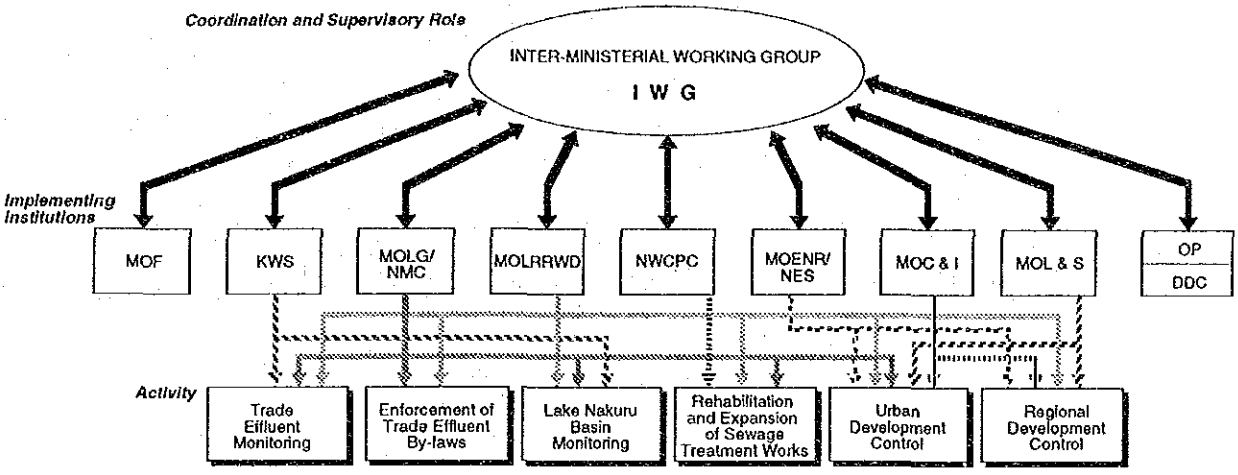
(b) Overall institutional support

The GOK has organized the IWG for coordination and supervision of the various institutions that are geared towards environmental protection and management of Lake Nakuru. Fig. 4-3 illustrates the proposed institutional support system. It is apparent that the IWG plays an important role and its activities should be encouraged more than present to accomplish the successful environmental protection and management.

(c) Monitoring activities

It is a matter of vital importance to monitor pollution loads flowing into Lake Nakuru, the lake water quality and quantity and quality of industrial effluents. Especially monitoring of industrial effluents plays significant role in the proper enforcement of the Trade Effluent By-Laws. For the respective category, sampling frequency and water quality testing items are proposed as shown in Tables 4-4 through 4-6. For the above purpose, it is proposed to establish a Water Quality Testing Laboratory, organization of which is elaborated as shown in Fig. 4-4.

Fig. 4 - 3



Legend

Coordination and Supervisory Relationship

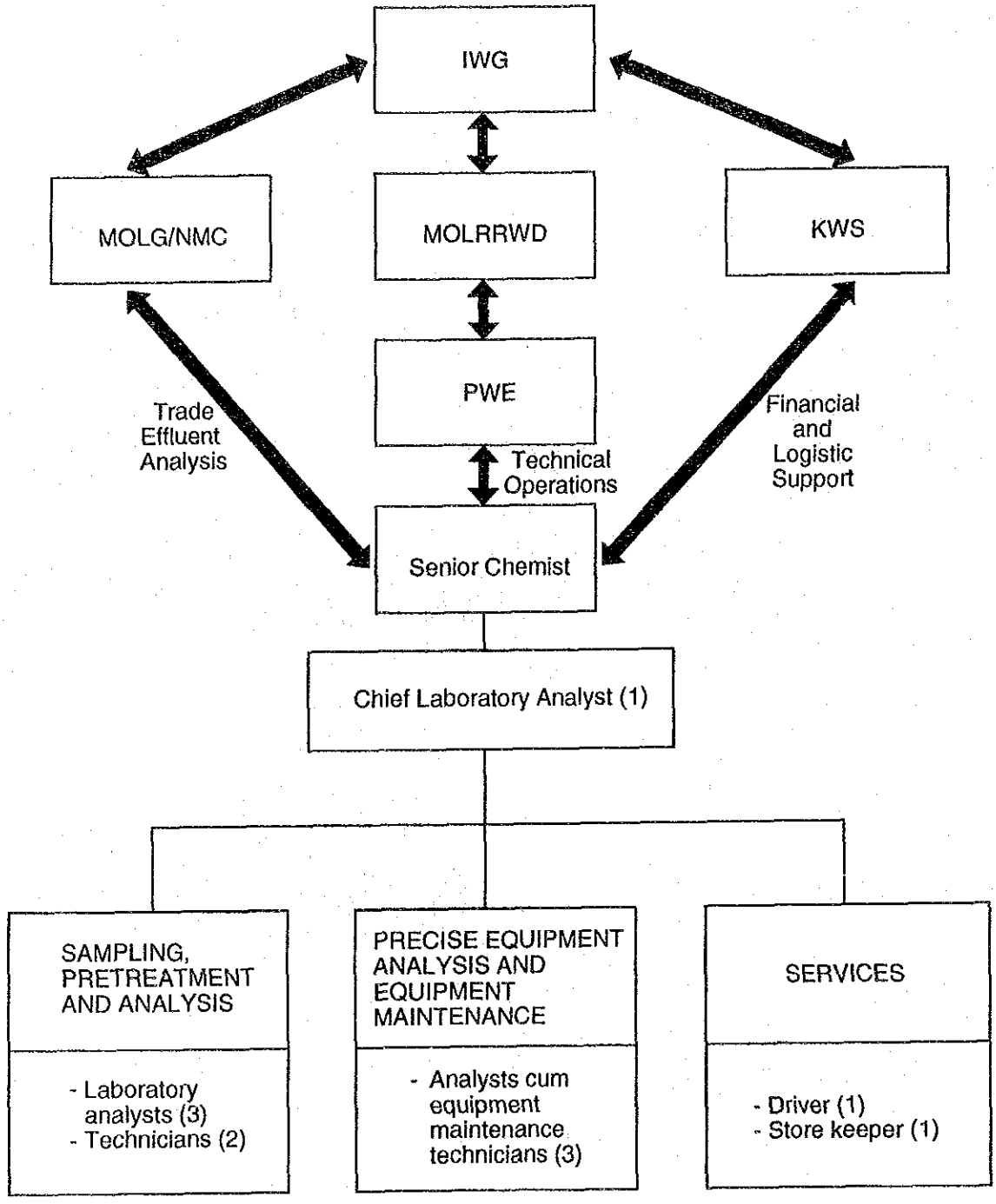
Activity Implementation Relationship

Abbreviation

MOF	- Ministry of Finance
KWS	- Kenya Wildlife Services
MOLG	- Ministry of Local Government
NMC	- Nakuru Municipal Council
MOLRRWD	- Ministry of Land Reclamation, Regional & Water Development
MOENR	- Ministryof Environment and Water Resources
MOC & I	- Ministry of Commence and Industry
OP	- Office of President
NWCPC	- National Water Conservation and Pipeline Corporation
MOL&S	- Ministry of Lands and Settlement
DDC	- District Development Committee
NES	- National Environment Secretariat

THE REPUBLIC OF KENYA	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILITATION AND EXPANSION PROJECT	TITLE PROPOSED INSTITUTIONAL ORGANIZATION FOR ENVIRONMENTAL CONSERVATION AND PROTECTION OF LAKE NAKURU CATCHMENT BASIN
MINISTRY OF LOCAL GOVERNMENT	JAPAN INTERNATIONAL COOPERATION AGENCY	

Fig. 4 - 4



Note: Numbers in parentheses indicate the number of staff proposed

THE REPUBLIC OF KENYA MINISTRY OF LOCAL GOVERNMENT	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILITATION AND EXPANSION PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE ORGANIZATION OF THE PROPOSED WATER QUALITY LABORATORY

(2) Medium and long term plan

(a) Urban and regional development control

As a strategy for reduction of the increasing pollutant load, it is necessary to systematically control urban and regional development activities within the Lake Nakuru basin. The control plan will envisage restricting the size and type of industries, relocation of industries producing heavy metals and causing excessive hydraulic loading on the lake, and excessive use of fertilizers and agro-chemicals.

(b) Master plan for Lake Nakuru basin development

It is proposed to formulate a master plan for development and conservation the natural resources of the Lake Nakuru basin. The objectives of the master plan will basically include (1) assessment of development potential of the natural resources, (2) development of policy guidelines for future development on an environmentally sustainable basis, and (3) development of strategies for Lake Nakuru from degradation.

(c) Master plan for sewerage development

It is recommended that a masterplan on longterm sewerage system development be established as earlier as possible for every urban centers within the catchment area of Lake Nakuru. In formulating the masterplan, particular attention should be drawn to natural environmental, topographic and socio-economic conditions peculiar to the lake catchment area. Especially, in view of reducing hydraulic and pollutant loads, it is suggested to study a feasibility of trans-basin diversion of treated wastewater.

4.5 Forecast of Pollutant Loads into Lake Nakuru with the Project

With implementation of the proposed pollution control plan, pollution loads into Lake Nakuru will be reduced greatly. Especially a great deal of reduction is anticipated to be derived from the sewage treatment works. The reduction of BOD and nutrient is estimated.

(1) BOD load reduction

BOD pollutant loads into Lake Nakuru are estimated for the following five cases:

Case-1 : Present conditions
Case-2 : After additional water supply of 13,300 m^3/day
Case-3 : After Nakuru Sewerage Project
Case-4 : After proposed rehabilitation and expansion of sewage treatment works
Case-5 : After implementation and enforcement of Trade Effluent By-laws

The results of the estimate are as presented in Table 4-4.

Table 4-4 Pollutant (BOD) Loads into Lake Nakuru

(Unit: ton/year)

Route of Pollutant Load	Case-1	Case-2	Case-3	Case-4	Case-5
1. Sewage Treatment Works	626	2,964	1,450	89	59
2. Stormwater drainage	161	161	161	113	113
3. Rivers and Springs					
- Njoro River	356	356	356	356	356
- Makalia River	122	122	122	122	122
- Nderit River	152	152	152	152	152
- Springs	54	54	54	54	54
Total	1,471	3,809	2,295	886	856

(Data source: Study Team)

There are no reduction in BOD pollutant loads other than the sewage treatment works and stormwater drainage, since no structural measures are proposed for other sources under the present study. It is apparent that the Project results in reducing a great deal of BOD pollutant load, especially the rehabilitation and expansion of sewage treatment works. Fig 4-5 illustrates schematically the process of BOD pollutant reduction for sewage treatment works.

(2) Nutrient load

Table 4-5 presents the nutrient load into Lake Nakuru. The Case 1 is derived from the results of the water quality investigation, while the Case 5 is based on typical values (8 mg/L for T-N and 6 mg/L for T-P), which could be achieved when industrial wastes are properly controlled and sewage are properly treated.

Table 4-5 Pollution Load (Nutrient) into Lake Nakuru

(Unit: ton/year)

	T-N		T-P	
	Case (1)	Case (5)	Case (1)	Case (5)
Sewage Treatment Works	491	47	151	35
Stormwater Drainage	12	12	13	13
River & other	44	44	3	3
Total	547	103	167	51

(Data source: Study Team)

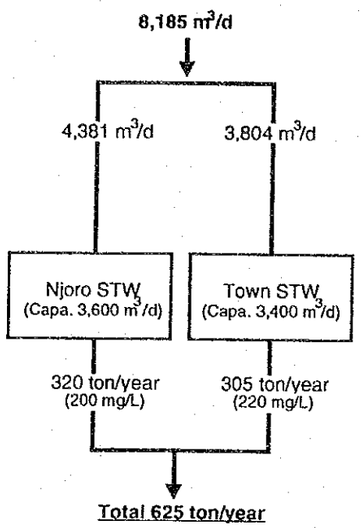
It is assumed that the stormwater retention pond is of no effect on reduction of nutrients. Fig. 4-6 depicts the nutrient pollutant loads under the Cases 1 and 5.

(3) Effect of evaporation

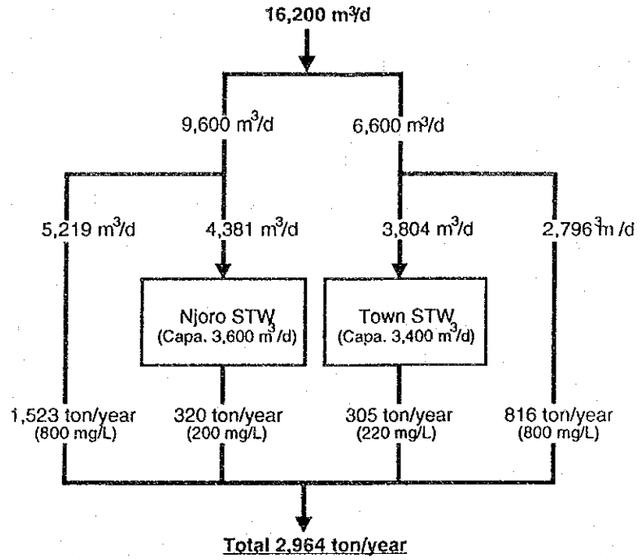
As the sewage treatment process depends on waste stabilization pond, rock filter and grass plot, there is a great deal of evaporation and evapo-transpiration. The volume of effluent is therefore smaller than influent. The sewage inflows into Njoro and Town STWs are 9,60 m^3/day and 6,600 m^3/day respectively, whereas treated sewage volumes are estimated at 9,054 m^3/day and 6,250 m^3/day respectively.

Fig 4 - 5

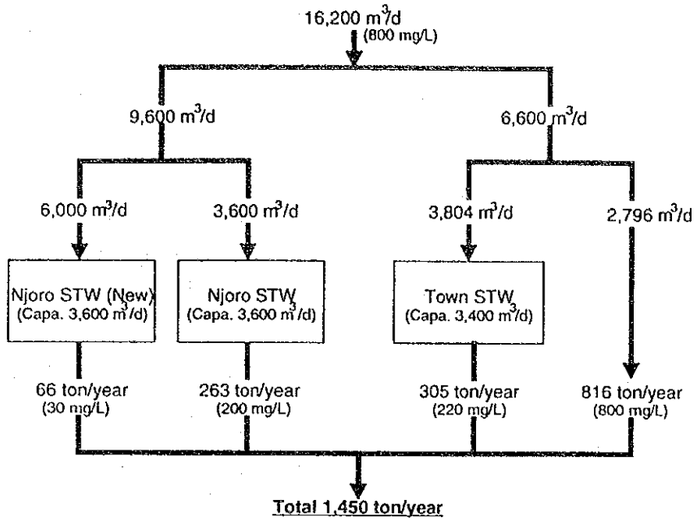
PRESENT CONDITION



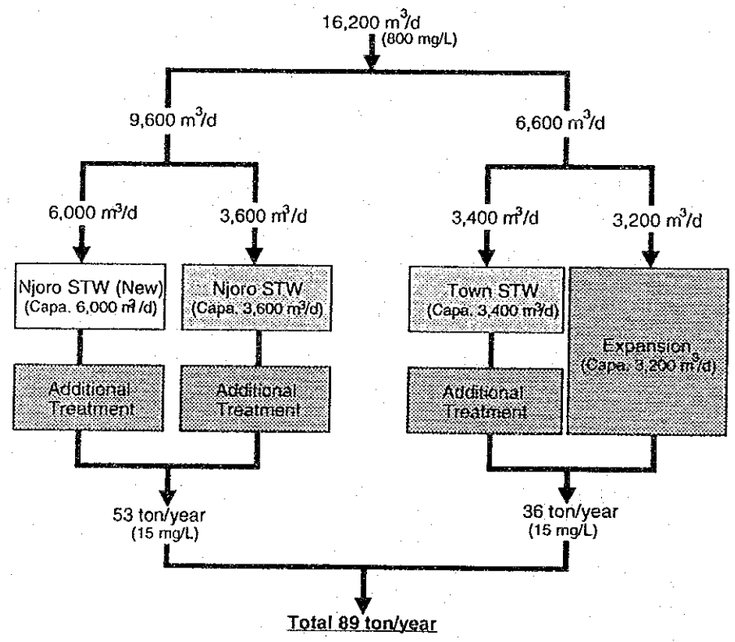
AFTER ADDITIONAL WATER SUPPLY



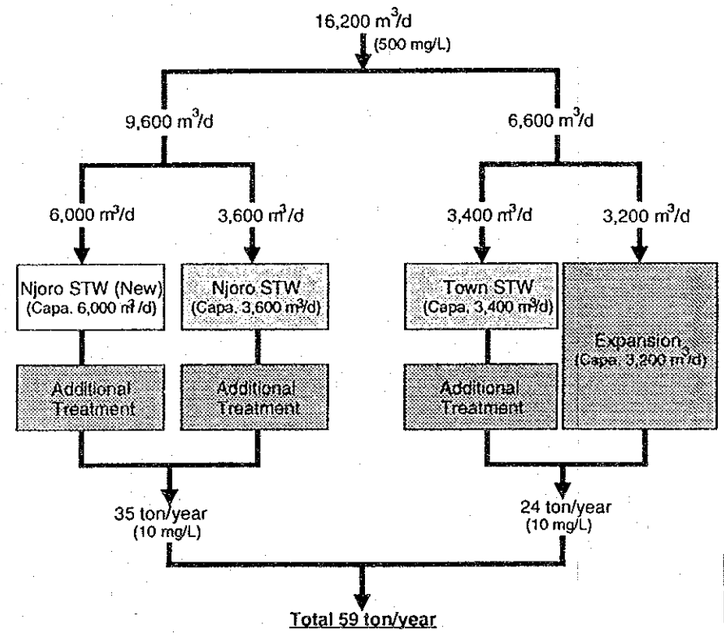
AFTER NAKURU SEWERAGE PROJECT



AFTER PROPOSED REHABILITATION & EXPANSION



AFTER IMPLEMENTATION AND ENFORCEMENT OF TRADE EFFLUENT BY-LAWS



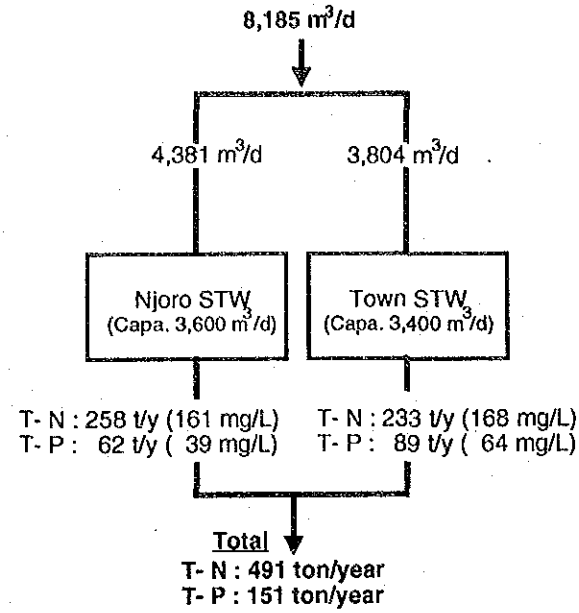
Rehabilitation
Expansion & Additional Treatment

Note: Volume of sewage is expressed in unit of m^3/d and that of pollutant load in unit of ton/year.

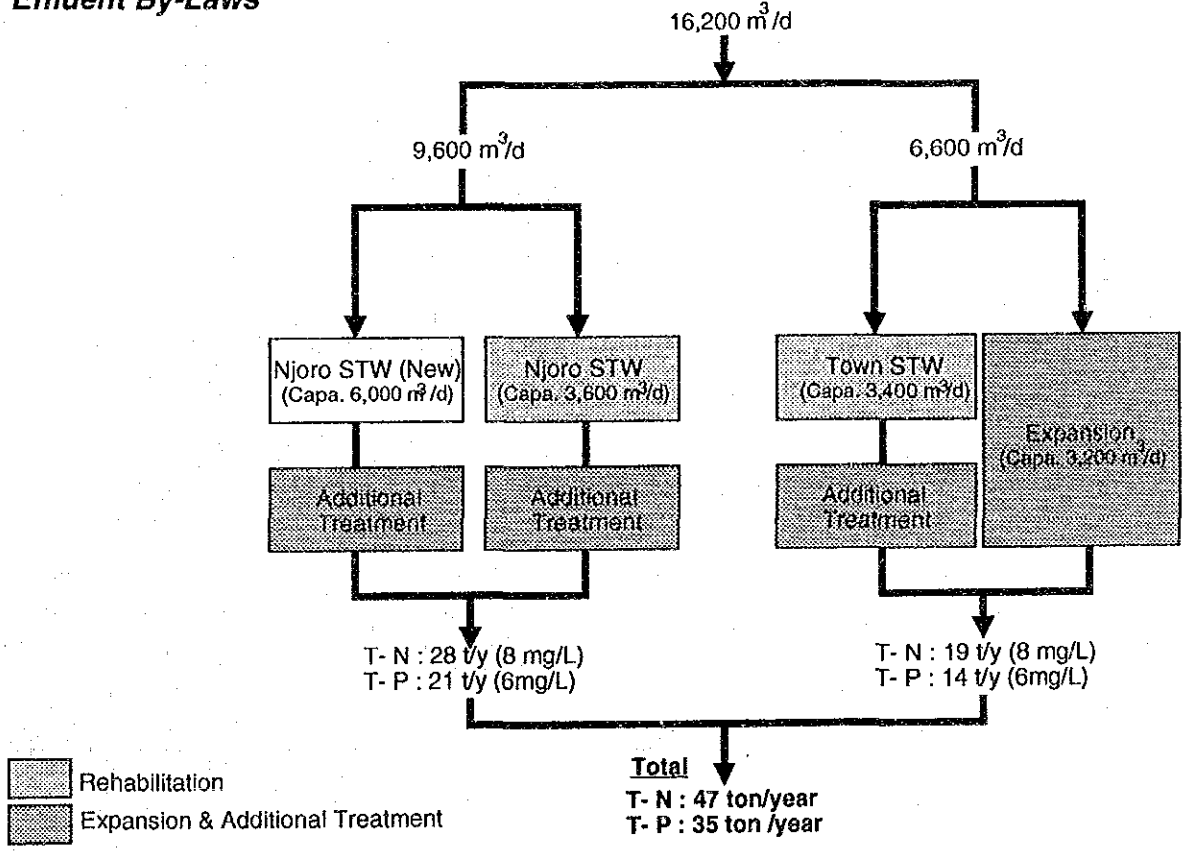
THE REPUBLIC OF KENYA MINISTRY OF LOCAL GOVERNMENT	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILTION AND EXPANSION PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE BOD POLLUTANT LOAD FORECAST THROUGH SEWAGE TREATMENT WORKS

Fig. 4 - 6

Present Condition



After Implementation and Enforcement of Trade Effluent By-Laws



THE REPUBLIC OF KENYA	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILITATION AND EXPANSION PROJECT	TITLE
MINISTRY OF LOCAL GOVERNMENT	JAPAN INTERNATIONAL COOPERATION AGENCY	NUTRIENT POLLUTANT LOAD FORECAST THROGH SEWAGE TREATMENT WORKS

5. PRELIMINARY DESIGN

5.1 Mwariki Pumping Station

The new pumping station with an floor area of 30 m^2 is sited opposite the existing one. Out of existing three submersible pumps, two have been out of order and thus three pumps are to be replaced with the new ones. The pump is of cutter type, 7.5 kW, 240 V, 1.5 m^3/min.

5.2 Sewage Treatment Works

The preliminary design of the sewage treatment works has been based on the design conditions and criteria set forth herein.

(1) Design discharge

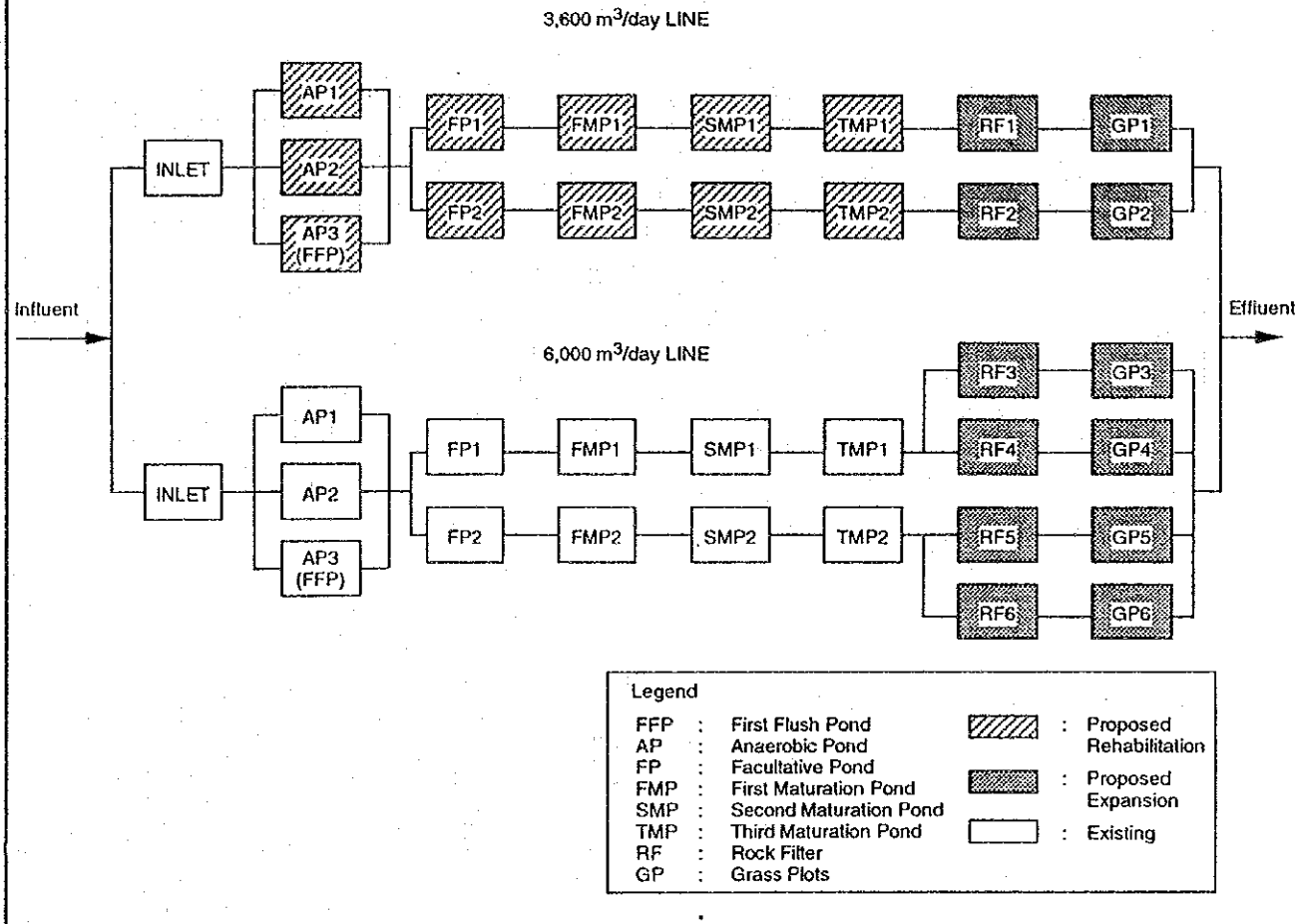
	Sewage Treatment Works	Sewage Inflow (m^3/day)			Storm water mixture (m^3/day)
		Average daily	Maximum daily	Hourly peak	
(a)	Njoro STW				
	3,600 m^3/day line	3,600	4,800	7,200	-
	6,000 m^3/day line	6,000	8,000	12,000	-
	Total	9,600	12,800	19,200	1,900
(b)	Tow STW				
	3,400 m^3/day line	3,400	4,500	6,800	-
	3,200 m^3/day line	3,200	4,300	6,400	-
	Total	6,600	8,800	13,200	1,400

The average daily discharge is applicable to the design of the sewage treatment works and the hourly peak discharge for inlet works and pond connection pipes.

(2) Water quality of influent and effluent

Item	Influent	Effluent (Target value)
BOD_5	800 mg/L	15 mg/L
Suspended solid	700 mg/L	15 mg/L
Fecal coliform	10^8/100 mL	10^3/100 mL
Air temperature at coldest month	16°C	16°C

Fig. 5 - 1

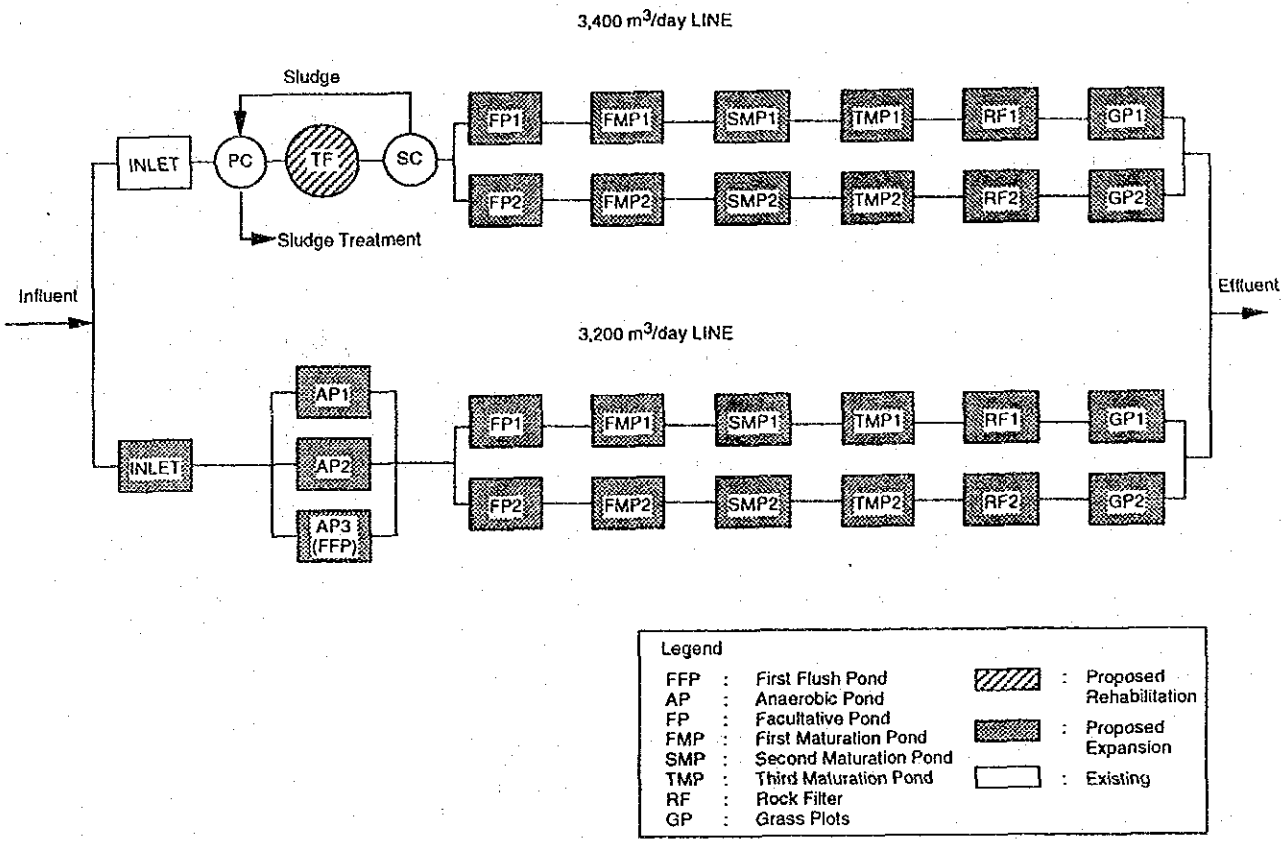


Legend

FFP	: First Flush Pond		:	Proposed Rehabilitation
AP	: Anaerobic Pond			
FP	: Facultative Pond			
FMP	: First Maturation Pond		:	Proposed Expansion
SMP	: Second Maturation Pond			
TMP	: Third Maturation Pond		:	Existing
RF	: Rock Filter			
GP	: Grass Plots			

THE REPUBLIC OF KENYA	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILITATION AND EXPANSION PROJECT	TITLE
MINISTRY OF LOCAL GOVERNMENT	JAPAN INTERNATIONAL COOPERATION AGENCY	SEWAGE TREATMENT PROCESS OF NJORO STW

Fig. 5 - 2



Legend

FFP	: First Flush Pond		:	Proposed Rehabilitation
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GP	: Grass Plots			

THE REPUBLIC OF KENYA	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILITATION AND EXPANSION PROJECT	TITLE
MINISTRY OF LOCAL GOVERNMENT	JAPAN INTERNATIONAL COOPERATION AGENCY	SEWAGE TREATMENT PROCESS OF TOWN STW

(3) Design calculation for waste stabilization ponds

It is basically dependent on the "Design Manual for East Africa, Overseas Development Administration (UK), Lagoon Technology International, 1992" (hereinafter referred to as the "ODA Manual").

(4) Design loads on rock filters and grass plots

The design loads have been set forth conservatively referring to (1) the ODA Manual, (2) the State of Illinois, USA, Rock Filter Design Standards and (3) Waste Water Engineering, Mc Graw-Hill International Edition.

Description	Unit	Loading Rate			
		ODA Manual	Illinois State Standards	Wastewater Engineering	Adopted
Rock filters	m3/rock m3/day	1.0	0.8	-	0.5
Grass plots	m3/ha/day	2,000-5,000	-	208-1,560	1,000

The sewage treatment process of the Njoro and Town STW are as illustrated in Fig. 5-1 and 5-2 respectively. Every lines are divided into two sub-lines, each having equal treatment capacity and consisting of WSP, rock filters and grass plots, excepting the 3,400 m^3/day line at Town STW. General layouts of Njoro and Town STWs are shown in DWGs. 1 and 3 respectively. All the sewage treatment process has been designed with a gravity flow as shown in DWGs. 2 and 4.

As one of the rehabilitation works, it is also proposed to install additional ventilation at the existing trickling filter at Town STW aiming at increasing its efficiency and function. Although the proposed rehabilitation and expansion works associate with various structural components, major components are as outlined below:

(1) Inlet pipe/inlet works
(2) Pond connection pipes between the successive ponds including pond outlet and inlet as well as flow splitting chamber
(3) Waste stabilization ponds, rock filters and grass plots
(4) Outlet works
(5) Rock filter drain pit
(6) Building works for staff accommodation and control office at Town STW
(7) Mechanical and electrical works

Salient features of the major components are summarized in Table 5-1 for Njoro STW and Table 5-2 for Town STW.

5.3 Sludge Treatment and Disposal

The sludge treatment and disposal have been planned under the following conditions and criteria:

Water content		
Raw sludge	:	90%
Dry sludge	:	50%
Density of dried solid	:	1,500 kg/m^3
Density of water	:	1,000 kg/m^3

The sludge drying bed is sited within a compound of the respective sewage treatment works. It is estimated that the production of raw sludge is at 20 m^3/day for the entire lines of the Njoro STW and 6.6 m^3/day for the 3,200 m^3/day line of the Town STW. The salient features of the sludge drying bed are shown in Tables 5-1 and 5-2.

5.4 Stormwater Retention Pond

The following design parameters have been adopted according to the previous study :

(1) Design storm

Storm duration	:	46 minutes
Rainfall intensity	:	42 mm/hour with a return period of 5 years

(2) Runoff estimate

Method	:	Rational
Catchment area	:	374 ha
Runoff coefficient	:	0.10 - 0.40, depending on land use
Volume of runoff	:	14,200 m^3

(3) Sediment deposit : 150 m^3/year

With construction of the additional and new sewage treatment facilities at the Town STW, it is required to relocate the existing stormwater drainage. The drainage is designed with the same dimensions as the existing one. The stormwater retention pond is capable of absorbing a whole volume of the estimated stormwater and is connected directly with the stormwater drainage. Its principal features are as shown in Table 5-2. It is provided with an oil trap at its inlet and outlet structures to make the pond empty.

Table 5-1 Principal Features of Njoro Sewage Treatment Works (1/2)

1. 3,600 m^3/day Line

(1) Inlet Connection Pipe

Design discharge (Hourly Maximum)	:	0.100 m^3/sec
Inlet water level	:	El. 1,786.1 m
Pipe diameter	:	D300 mm & D450 mm
Pipe length	:	315 m
Flow splitting chamber	:	1 no.

(2) Waste Stabilization Ponds, Rock Filters and Grass Plots

	Anaerobic Ponds	Facultative Ponds	First Maturation Ponds	Second Maturation Ponds	Third Maturation Ponds	Rock Filters	Grass Plots
Number of Ponds	3	2	2	2	2	2	2
Design Capacity (Average Daily)	1,800 m^3/d	1,800 m^3/d	1,800 m^3/d	1,800 m^3/d	1,800 m^3/d	1,800 m^3/d	1,800 m^3/d
BOD_5 Concentration							
Influent	800 mg/L	384 mg/L	115 mg/L	-	-	30 mg/L	-
Effluent	384 mg/L	34 mg/L	-	-	30 mg/L	-	15 mg/L
Normal Operation Level	El.1,784.5m	El.1,784.0 m	El.1,779.0 m	El.1,778.5 m	El.1,778.0 m	El.1,777.5 m	-
			El.1,778.0 m	El.1,777.5 m	El.1,777.0 m	El.1,776.5 m	-
Ponds Dimension							
Bottom area	24m x 57m	139m x 251m	88m x 158m	18m x 158m	18m x 158m	17.4m x 97.4m	110m x 165m
Surface area at NOL	42m x 75m	151m x 263m	97m x 167m	27m x 167m	27m x 167m	27m x 107m	-
Effective depth	3.0 m	2.0 m	1.5 m	1.5 m	1.5 m	1.6 m	-
Effective volume	6,777 m^3	74,602 m^3	22,577 m^3	5,514m^3	5,514 m^3	3,667 m^3	-
Min. freeboard	0.5 m	0.5 m	0.5 m	0.5 m	0.5 m	0.5 m	-
Side slope	1.0 : 3.0	1.0 : 3.0	1.0 : 3.0	1.0 : 3.0	1.0 : 3.0	1.0 : 3.0	-
Retention Period	3.7 days	41.4 days	12.5 days	3.0 days	3.0 days		

(3) Pond Connection Pipes

AP - FP	D300 - 450 mm,	length 490 m, including one flow splitting chamber
FP - FMP	D300 mm,	length 375 m
FMP - SMP	D300 mm,	length 10 m
SMP - TMP	D300 mm,	length 10 m
TMP - RF	D300 mm,	length 160 m

(4) Outlet Works

Design discharge (Hourly Maximum)	:	0.100 ~ 0.222 m^3/sec
Dimension	:	W675 mm x W675 mm
Length	:	495 m
Outfall	:	W675 mm x H4.3 m

Table 5-1 Principal Features of Njoro Sewage Treatment Works (2/2)

2. 6,000 m^3/day Line

(1) Rock Filters and Grass Plots

	Rock Filters	Grass Plots
Number of Ponds	4	4
Design Discharge (Average Daily)	1,500 m^3/day	1,500 m^3/day
BOD_5 Concentration		
Influent	30 mg/L	-
Effluent	-	15 mg/L
Normal Operation Level	El.1,771.1 m	-
Ponds Dimension		
Bottom area	17.4m x 97.4m	92m x 165 m
Surface area at NOL	27m x 89m	-
Effective depth	1.6 m	-
Effective volume	3,027 m^3	-
Min. freeboard	0.5 m	-
Side slope	1.0 : 3.0	-

(2) Pond Connection Pipes

TMP - RF D375 mm, length 835 m

3. Rock Filter Drain Pit

(1) Pit

Number of pit	:	1
Pit dimension		
Bottom area	:	37m x 95m
Effective depth	:	1.2 m
Effective volume	:	4,804 m^3
Side slope	:	1.0 : 3.0
Normal Operation Level	:	El. 1,768.7 m

(2) Pond connection pipes between RF and Pit

Number of lines	:	4
Pipe		
Diameter	:	D300 mm, D450 mm, D600 mm
Total length	:	791 m

4. Staff House

Type	:	Type D, 30 m^2 in floor area
Number	:	4

5. Sludge Drying Bed

Number of Pond	:	1
Objective Treatment Line	:	3,600 m^3/day and 6,000 m^3/day line
Ponds Dimension		
Bottom area	:	74.8m x 151.8m
Surface area	:	82.0m x 159.0m
Effective depth	:	1.2 m
Effective volume	:	14,635 m^3
Side slope	:	1.0 : 3.0

Table 5-2 Primcipal Features of Town Sewage Treatment Works (1/3)

1. 3,400 m^3/day Line

(1) Inlet Connection Pipe (SC-FP)

Design discharge (Hourly Maximum)	:	0.094 m^3/sec
Inlet water level	:	El. 1,779.5 m
Pipe diameter	:	D450 mm
Pipe length	:	460 m
Flow splitting chamber	:	1 no.

(2) Waste Stabilization Ponds, Rock Filters and Grass Plots

	Facultative Ponds	First Maturation Ponds	Second Maturation Ponds	Third Maturation Ponds	Rock Filters	Grass Plots
Number of Ponds	2	2	2	2	2	2
Design Capacity (Average Daily)	1,700 m^3/day	1,700 m^3/day	1,700 m^3/day	1,700 m^3/day	1,700 m^3/day	1,700 m^3/day
BOD_5 Concentration						
Influent	280 mg/L	84 mg/L	-	-	30 mg/L	-
Effluent	32 mg/L	-	-	30 mg/L	-	15 mg/L
Normal Operation Level	El.1,770.5 m El.1,769.0 m	El.1,786.0 m	El.1,767.5 m	El.1,767.0 m	El.1,766.0 m	-
Ponds Dimension						
Bottom area	78m x 305m	58m x 164m	16m x 164m	16m x 164m	17.4m x 91.4m	170m x 100m
Surface area at NOL	90m x 317m	67m x 173m	25m x 173m	25m x 173m	27m x 101m	-
Effective depth	2.0 m	1.5 m	1.5 m	1.5 m	1.6 m	-
Effective volume	52,320 m^3	15,827 m^3	5,181 m^3	5,181 m^3	3.454 m^3	-
Min. freeboard	0.5 m	0.5 m	0.5 m	0.5 m	0.5 m	-
Side slope	1.0 : 3.0	1.0 : 3.0	1.0 : 3.0	1.0 : 3.0	1.0 : 3.0	-
Retention Period	30.7 days	9.3 days	3.0 days Total	3.0 days 46.0 days	-	-

(3) Pond Connection Pipes

FP - FMP	D300 mm,	length 310 m
FMP - SMP	D300 mm,	length 10 m
SMP - TMP	D300 mm,	length 10 m
TMP - RF	D300 mm,	length 95 m

(4) Rock Filter Drain Pit

(a) Pit

Number of pit	:	1
Pit dimension		
Bottom area	:	8.6m x 112.6m
Effective depth	:	1.2 m
Effective volume	:	1,701 m^3
Side slope	:	1.0 : 3.0
Normal Operation Level	:	El. 1,763.8 m

(b) Pond connection pipe between RF and Pit

Number of lines	:	6
Pipe		
Diameter	:	D300 mm, D450 mm, D600 mm
Total length	:	120 m

Table 5-2 Principal Features of Town Sewage Treatment Works (2/3)

2. 3,200 m^3/day Line

(1) Inlet Works

Design Discharge	:	0.089 m^3/sec
Inlet water level	:	El.1,779.75 m
Coarse screen	:	W 0.6 m x H 1.2 m
Fine screen	:	W 0.6 m x H 1.35 m
Constant velocity grit removal channel	:	W 0.8 m x H 0.5 m x L 9 m
Parshall flume	:	Throat width 150 mm
Inlet pipe	:	D 300 mm, D 450 mm
Pipe length	:	460 m

(2) Waste Stabilization Ponds

	Anaerobic Ponds	Facultative Ponds	First Maturation Ponds	Second Maturation Ponds	Third Maturation Ponds	Rock Filters	Grass Plots
Number of Ponds	3	2	2	2	2	2	2
Design Capacity (Average Daily)	1,600 m^3/day	1,600 m^3/day	1,600 m^3/day	1,600 m^3/day	1,600 m^3/day	1,600 m^3/day	1,600 m^3/day
BOD_5 Concentration							
Influent	800 mg/L	384 mg/L	115 mg/L	-	-	30 mg/L	-
Effluent	384 mg/L	33 mg/L	-	-	30 mg/L	-	15 mg/L
Normal Operation Level	El.1,775.0m	El.1,774.0 m El.1,772.5 m	El.1,770.5 m	El.1,768.5 m	El.1,769.5 m	El.1,767.5 m	-
Ponds Dimension							
Bottom area	23m x 52m	100m x 311m	76 x 163m	15m x 163m	15m x 163m	17.4m x 85.4m	160m x 100m
Surface area at NOL	41m x 70m	112m x 323m	85m x 172m	24m x 172 m	24m x 172 m	27m x 95m	-
Effective depth	3.0 m	2.0 m	1.5 m	1.5 m	1.5 m	1.6 m	-
Effective volume	6,099 m^3	62,276 m^3	20,256 m^3	4,899 m^3	4,899 m^3	3,240 m^3	-
Min. freeboard	0.5 m	0.5 m	0.5 m	0.5 m	0.5 m	0.5 m	
Side slope	1.0 : 3.0	1.0 : 3.0	1.0 : 3.0	1.0 : 3.0	1.0 : 3.0	1.0 : 3.0	-
Retention Period	3.8 days	42.0 days	12.6 days	3.0 days	3.0 days	-	-

(3) Pond Connection Pipes

AP - FP	D300 - 450 mm,	length 470 m, incl. one flow splitting chamber
FP - FMP	D300 mm,	length 370 m
FMP - SMP	D300 mm,	length 10 m
SMP - TMP	D300 mm,	length 10 m
TMP - RF	D300 mm,	length 50 m

(a) Pit

Number of pit	:	1
Pit dimension		
Bottom area	:	8.6m x 106.6m
Effective depth	:	1.2 m
Effective volume	:	1,613 m^3
Side slope	:	1.0 : 3.0
Normal Operation Level	:	El. 1,765.3 m

(b) Pond connection pipe between RF and Pit

Number of lines	:	6
Pipe		
Diameter	:	D300 mm, D450 mm, D600 m
Total length	:	120 m

Table 5-2 Principal Features of Town Sewage Treatment Works (3/3)

3. Sludge Drying Bed

(1) Sludge Drying Bed

Number of Pond	:	1
Objective Treatment Line	:	3,200 m^3/day line
Ponds Dimension		
Bottom area	:	40.8m x 84.8m
Surface area at NOL	:	48.0m x 92.0m
Effective depth	:	1.2 m
Effective volume	:	4,726 m^3
Side slope	:	1.0 : 3.0

4. Stormwater Retention Pond

(1) Stormwater Drainage

Shape	:	Trapezoidal
Dimension		
Bottom width	:	1.10 m
Height	:	2.00 m
Side slope	:	1.0 : 0.475
Length	:	1,110 m

(2) Stormwater Retention Pond

Number of Pond	:	1
Normal Operation Level	:	El.1,777.0 m
Ponds Dimension		
Bottom area	:	68m x 126m
Surface area at NOL	:	77m x 135m
Effective depth	:	1.5 m
Effective volume	:	14,222 m^3
Min. freeboard	:	0.5 m

5. Staff House

Type	:	Type D, 30 m^2 in floor area
Number	:	10

5.5 Water Quality Testing Laboratory

The water quality testing laboratory is one of the non-structural measures and is very important especially for successful implementation of the Trade Effluent By-laws. The proposed water quality sampling and testing items are as given in Tables 5-3 through 5-6.

The laboratory is selected to be located within the Lake Nakuru National Park in the vicinity of Training Center. The building is divided into a number of rooms including the testing rooms such as biological laboratory, central laboratory, analyzing laboratory, balance room and research room. It has a floor area of 350 m^2 as shown in DWG. 5.

The selected laboratory equipment and apparatus are shown in Table 5-7.

5.6 Basic Guidelines for Operation and Maintenance

The guidelines are summarized in Table 5-8. The operation and maintenance works are basically classified into a daily routine and a periodical work. The periodical maintenance works could be divided into two categories depending on the natures and volume of the work. Heavy and infrequent maintenance work would be entrusted to appropriate contractor, while the light and frequent work can be achieved directly by the staff of WSD with provision of appropriate equipment.

Table 5-3 Monitoring Plan for Lake Nakuru and Industrial Effluents - Rivers, Drainage Channels and Springs

	Parameters	Njoro River		Town Stormwater Drainage Channel	Makalia River	Makalia River Mouth	Nderit River	Nderit River Mouth	Lamudiak River	Ngosorr River	Baharin Spring	Spring near Special Camp Site	Spring near Lion Hill	Annual Sub Total	Annual Total
		Before STW Discharge	River Mouth												
1	Flowrate	12	12	12	12	12	12	12	12	12	12	12	12	144	144
2	Temperature	12	12	12	12	12	12	12	12	12	12	12	12	144	144
3	pH	12	12	12	12	12	12	12	12	12	12	12	12	144	144
4	Conductivity	12	12	12	12	12	12	12	12	12	12	12	12	144	144
5	DO	12	12	12	12	12	12	12	12	12	12	12	12	144	144
6	ORP	12	12	12	12	12	12	12	12	12	12	12	12	144	144
7	BOD	12	12	12	12	12	12	12	12	12	12	12	12	144	144
8	COD	12	12	12	12	12	12	12	12	12	12	12	12	144	144
9	SS	12	12	12	12	12	12	12	12	12	12	12	12	144	144
10	T-N	12	12	12	12	12	12	12	12	12	12	12	12	144	144
11	NH4-N	12	12	12	12	12	12	12	12	12	12	12	12	144	144
12	NO3-N	12	12	12	12	12	12	12	12	12	12	12	12	144	144
13	T-P	12	12	12	12	12	12	12	12	12	12	12	12	144	144
14	PO4-P	12	12	12	12	12	12	12	12	12	12	12	12	144	144
15	Sechi Depth													0	0
16	Chlorophyll a													0	0
17	Plankton count													0	0
	HEAVY METALS														
18	Chromium (Cr)	6	6	6	6	6	6	6	6	6	6	6	6	72	72
19	Hexavalent Chromium (Cr6+	6	6	6	6	6	6	6	6	6	6	6	6	72	72
20	Lead (Pb)	6	6	6	6	6	6	6	6	6	6	6	6	72	72
21	Copper (Cu)	6	6	6	6	6	6	6	6	6	6	6	6	72	72
22	Cadmium (Cd)	6	6	6	6	6	6	6	6	6	6	6	6	72	72
23	Zinc (Zn)	6	6	6	6	6	6	6	6	6	6	6	6	72	72
24	Nickel (Ni)	6	6	6	6	6	6	6	6	6	6	6	6	72	72
25	Iron (Fe)	6	6	6	6	6	6	6	6	6	6	6	6	72	72
26	Total Manganese (Mn)	6	6	6	6	6	6	6	6	6	6	6	6	72	72
27	Cyanide (CN-)	6	6	6	6	6	6	6	6	6	6	6	6	72	72
28	Total Mercury (Hg)	6	6	6	6	6	6	6	6	6	6	6	6	72	72
29	Arsenic (As)	6	6	6	6	6	6	6	6	6	6	6	6	72	72
	OTHERS														
30	Oil	6	6	6	6	6	6	6	6	6	6	6	6	72	72
31	Anionic Surfactant (MBAS)	6	6	6	6	6	6	6	6	6	6	6	6	72	72

Table 5-4 Monitoring Plan for Lake Nakuru and Industrial Effluents - Industrial and Sewage Treatment Works Effluents

No.	Parameters	Organic 1 Waste Containing Effluents	Heavy 2 Metal Containing Effluents	Njoro STW Influent / Effluent	Town STW Influent / Effluent									Annual Sub-total	Annual Total
1	Flowrate	30	15	12	12									69	213
2	Temperature	30	15	12	12									69	213
3	pH	30	15	12	12									69	213
4	Conductivity	30	15	12	12									69	213
5	DO	30	15	12	12									69	213
6	ORP	30	15	12	12									69	213
7	BOD	30	15	12	12									69	213
8	COD	30	15	12	12									69	213
9	SS	30	15	12	12									69	213
10	T-N	30	15	12	12									69	213
11	NH4-N	30	15	12	12									69	213
12	NO3-N	30	15	12	12									69	213
13	T-P	30	15	12	12									69	213
14	PO4-P	30	15	12	12									69	213
15	Secchi Depth													0	0
16	Chlorophyll a													0	0
17	Plankton count													0	0
	HEAVY METALS														
18	Chromium (Cr)		8	12	12									32	104
19	Hexavalent Chromium (Cr6+)		8	12	12									32	104
20	Lead (Pb)		4	12	12									28	100
21	Copper (Cu)		6	12	12									30	102
22	Cadmium (Cd)		4	12	12									28	100
23	Zinc (Zn)		4	12	12									28	100
24	Nickel (Ni)		4	12	12									28	100
25	Iron (Fe)			12	12										
26	Total Manganese (Mn)			12	12										
27	Cyanide (CN-)		8	12	12									32	104
28	Total Mercury (Hg)		4	12	12									28	100
29	Arsenic (As)			12	12									24	96
	OTHERS														
30	Oil	10		12	12									34	106
31	Anionic Surfactant (MBAS)	10		12	12									34	106

Note: 1 - a total of 15 high organic strength factores are envisaged.
2 - a total of 7-8 heavy metal containing effluents are envisaged.
Frequency of sampling is twice per year.

Table 5-5 Monitoring Plan for Lake Nakuru and Industrial Effluents - Lake Water Quality

No.	Parameters	LE1	LE2	LE3	LS1	LS2	LS3	Sediment						Annual Sub-total	Annual Total
1	Flowrate	-	-	-	-	-	-	-						0	213
2	Temperature	6	6	6	12	12	12	6						60	273
3	pH	6	6	6	12	12	12	6						60	273
4	Conductivity	6	6	6	12	12	12	6						60	273
5	DO	6	6	6	12	12	12	-						54	267
6	ORP	6	6	6	12	12	12	-						54	267
7	BOD	-	-	-	-	-	-	-						0	213
8	COD	6	6	6	6	6	6	6						42	255
9	SS	6	6	6	6	6	6	6						42	255
10	T-N	6	6	6	6	6	6	6						42	255
11	NH4-N	6	6	6	6	6	6	6						42	255
12	NO3-N	6	6	6	6	6	6	6						42	255
13	T-P	6	6	6	6	6	6	6						42	255
14	PO4-P	6	6	6	6	6	6	6						42	255
15	Sechi Depth	6	6	6	6	6	6	-						36	36
16	Chlorophyll a	6	6	6	6	6	6	-						36	36
17	Plankton count	6	6	6	6	6	6	-						36	36
	HEAVY METALS														
18	Chromium (Cr)	6	6	6	6	6	6	6						42	146
19	Hexavalent Chromium (Cr6+	6	6	6	6	6	6	6						42	146
20	Lead (Pb)	6	6	6	6	6	6	6						42	142
21	Copper (Cu)	6	6	6	6	6	6	6						42	144
22	Cadmium (Cd)	6	6	6	6	6	6	6						42	142
23	Zinc (Zn)	6	6	6	6	6	6	6						42	142
24	Nickel (Ni)	6	6	6	6	6	6	6						42	142
25	Iron (Fe)	6	6	6	6	6	6	6						42	42
26	Total Manganese (Mn)	6	6	6	6	6	6	6						42	42
27	Cyanide (CN-)	6	6	6	6	6	6	6						42	146
28	Total Mercury (Hg)	6	6	6	6	6	6	6						42	142
29	Arsenic (As)	6	6	6	6	6	6	6						42	138
	OTHERS														
30	Oil	6	6	6	6	6	6	6						42	148
31	Anionic Surfactant (MBAS)	6	6	6	6	6	6	6						42	148

Table 5-6 Monitoring Plan for Lake Nakuru and Industrial Effluents - Rivers, Drainage Channels During Storm Drainage

	Parameters	Njoro River		Town Stormwater Drainage Channel	Makalia River	Makalia River Mouth	Nderit River	Nderit River Mouth	Lamudiak River	Ngosorr River	Baharin Spring	Spring near Special Camp Site	Spring near Lion Hill	Annual Sub-total	Annual Total
		Before STW Discharge	River Mouth												
1	Flowrate		2	5		2		2						11	224
2	Temperature		2	5		2		2						11	284
3	pH		2	5		2		2						11	284
4	Conductivity		2	5		2		2						11	284
5	DO		2	5		2		2						11	278
6	ORP		2	5		2		2						11	278
7	BOD		2	5		2		2						11	224
8	COD		2	5		2		2						11	266
9	SS		2	5		2		2						11	266
10	T-N		2	5		2		2						11	266
11	NH4-N		2	5		2		2						11	266
12	NO3-N		2	5		2		2						11	266
13	T-P		2	5		2		2						11	266
14	PO4-P		2	5		2		2						11	266
15	Sechi Depth													0	36
16	Chlorophyll a													0	36
17	Plankton count													0	36
	HEAVY METALS														
18	Chromium (Cr)		2	5		2		2						11	157
19	Hexavalent Chromium (Cr6+)		2	5		2		2						11	157
20	Lead (Pb)		2	5		2		2						11	153
21	Copper (Cu)		2	5		2		2						11	155
22	Cadmium (Cd)		2	5		2		2						11	153
23	Zinc (Zn)		2	5		2		2						11	153
24	Nickel (Ni)		2	5		2		2						11	153
25	Iron (Fe)		2	5		2		2						11	53
26	Total Manganese (Mn)		2	5		2		2						11	53
27	Cyanide (CN-)		2	5		2		2						11	157
28	Total Mercury (Hg)		2	5		2		2						11	153
29	Arsenic (As)		2	5		2		2						11	149
	OTHERS														
30	Oil		2	5		2		2						11	159
31	Anionic Surfactant (MBAS)		2	5		2		2						11	159

Table 5-7 Major Laboratory Equipment and Other Accessories

No.	Name	Number of Units	Specification
1	Incubator (20°C)	1	80 cm x 70 cm x 120 cm, 220 - 240 V, 0.7 - 1.2 kW, for about 100 BOD bottles
2	COD (Cr) Digestion Unit	1	for 12 samples
3	Drying oven (102°C)	1	about 10 ~ 15 Litres
4	Kjeldahl Nitrogen Digestion Unit	1	for 12 number of samples
5	Spectrophotometer	1	double beam with 1, 2 and 5 cm cells
6	Water Bath	1	for 20 petri dishes
7	Vacuum Pump Unit	2	manually operated with water (non-oil)
8	Water Distillation Unit	1	for about 20 Litres/day
9	Atomic Absorption Spectrophotometer	1	for Cr, Pb, Cu, Cd, Zn, Ni, Fe, Mn, Hg, As, K and Na
10	Balance	1	1 ~ 500 g/0.001 g accuracy, digital
11	pH meter	1	for laboratory use
12	Composite sampler	2	for use at sewage treatment works
13	Rubber Boat	1	for 5 persons (600 kg)
14	Velocity Meter	2	0.1 ~ 2m/s
15	Microscope	1	for plankton identification and plankton count
16	Centrifuge	1	chlorophyll a analysis maximum five samples
17	Refrigerator (1)	1	for sample preservation
18	Refrigerator (2)	1	for reagent reservation
19	Lake Level Gauge	3	with either stainless steel or ceramic scales, graduated to 0.05 cm
20	Binoculars	1	for 2 ~ 3 km able to read 0.05 cm

(Data source: Study Team)

Table 5-8 Basic Guidelines for Operation and Maintenance

Description	Daily Routine	Periodical Work
(1) Sewerage System		
(1.1) Sewer network	- Removal of blockage - Cleansing of sewer - Leakage detection and protection	- Cleansing of sewer by block by block, preferably every 5 years by WSD
(1.2) Mwariki pumping station	- Monitoring of sewage inflow and pump operation - Removal of grit and sediment - Lubrication of mechanical equipment	- Maintenance and repair of mechanical and electrical works, by contractor
(1.3) Sewage treatment works	- Removal of grit, scum, rubbish and other foreign materials at inlet and waste stabilization ponds - Monitoring of quantity and quality of influent and effluent - Lubrication of mechanical equipment - Grass cutting at WSPs and GPs	- Desludging at APs, every 6 months by WSD - Desludging and repair of associated works, when required, by contractor - Sludge removal, washing and drying of rock fragments at RFs, preferably every 3 months, by the WSD - Grade adjustment and refilling of watercourses by WSD as required, to avoid a short-cut flow - Sludge removal from rock filter drain pit as required.
(2) Stormwater Retention Pond	- Removal of rubbish, oil and other materials - Operation of outlet to make pond empty	- Removal of sediment deposit, preferably once in two years, by WSD

In addition to the above basic guidelines, it is recommended to operate the trickling filter of the 3,400 m^3/line through day and night so that more higher efficiency can be achieved and function of the filter can be maintained. It is necessary to change the operation mode of the recirculation pump accordingly.

Table 5-9 Proposed Operation Mode of Trickling Filter

Time	Operation Mode
AM 6:00 - PM 9:00	Full operation
PM 9:00 - AM 6:00	Intermittent operation, at least 10 min. every three hours

5.7 Required Operation and Maintenance Equipment

The existing operation and maintenance equipment are far from satisfaction. They must be strengthen in order to ensure a sustained operation and function of the completed Project. The required equipment has been selected as listed up in Table 5-10. .

Table 5-10 List of Operation and Maintenance Equipment

Item No.	Items	Unit	Quantity
A.	**Workshop Equipment**		
(1)	Tool box with assorted tools	lot	1
(2)	Electric angle grinder, 8 inch	set	1
(3)	Drill bits, 2 to 12 mm dia. with stand	set	1
(4)	Portable electric blower, 50 cm dia..	set	1
(5)	Gear puller	set	1
(6)	Tap and dies. M2 to M12 fine thread	set	1
(7)	Gas welding set	set	1
(8)	Electric welder, 100A	set	1
(9)	Electric tool box with assorted tolls	lot	1
(10)	Drilling machine	set	1
(11)	Air compressor	set	1
(12)	Vice	set	1
(13)	Chain block	set	1
(14)	Hydraulic jack	set	1
(15)	Shelf with rock	set	1
(16)	Gate crane, movable type	set	1
B.	**Operation and Maintenance Equipment**		
(1)	Mud pump, Dia. 100 mm, 1.2 m3/min., H=10 m	set	3
(2)	Generator for the above, 8 KVA	set	2
(3)	Truck with 1 ton crane	unit	1
(4)	High pressure sewer cleaner, 4 ton vehicle	unit	1
(5)	High pressure sewer cleaner, vacuum car, 4 ton	unit	1
(6)	High pressure sewer cleaner, water tanker, 4 ton	unit	1
(7)	Plug for water stop, 225, 300, 375 mm, 2 each	nos.	6
(8)	Pick up truck, 1 ton	unit	2
(9)	Tractor shovel with back-hoe attachment, 0.4 m3	unit	1
(10)	Dump truck, 6 ton	unit	2
(11)	Gas mask	set	6
C.	**Testing Apparatus for Existing Njoro Laboratory**		
(1)	Low temperature incubator	no.	1
(2)	Drying oven	no.	1
(3)	Aspirator	no.	1
(4)	Air pump	no.	1
(5)	Portable pH meter	no.	1
(6)	Portable D0 meter	no.	1
(7)	Portable conductivity meter	no.	1
(8)	Portable ORP meter	no.	1
(9)	Balance	no.	1
(10)	Analytical balance	no.	1
(11)	Automatic sampler	no.	1
(12)	Sampling bottles	set	1
(13)	Glassware & other accessories	lot	1

(Data source : Study Team)

5.8 Re-use of Treated Wastewater

The water is the precious resources in arid zones like the Study Area and it is possible to use the sewage after proper treatment to the quality required by the purpose under consideration. In view of the natures of the project facilities, quality of treated sewage and geographic condition of the project area, it is prospective to apply treated wastewater for agriculture and aquaculture. The irrigated agriculture makes possible to increase cropping intensity but would induce farmers to use more fertilizer and agrochemical than the present to increase crop yield. Eventually residual of fertilizer and agrochemical is pollutant load into Lake Nakuru. Aquaculture may be possible in the 3rd maturation pond but fish cultivated could not be suitable for human consumption. Under this Study, it is not positively suggested to re-use treated wastewater for such purposes. It is necessary to carry out more study for appropriate use of treated wastewater.

5.9 Land Requirement

For the construction of the new and additional treatment facilities, it is unavoidable to acquire the additional lands. According to the preliminary design, the land requirement was measured as summarized below:

Table 5-11 Estimated Land Requirement

Sewage Treatment Works	Total Area	Present Compound Area	Additional Requirement
Njoro	102.1 ha	92.8 ha	9.3 ha
Town	55.3 ha	13.3 ha	42.0 ha

6. CONSTRUCTION PLAN AND COST ESTIMATE

6.1 Mode of Construction

The construction works of the Project will be executed by a contractor selected through a competitive bidding.

6.2 Construction Plan

The construction works will be classified into 6 categories: (1) preparatory works, (2) Mwariki Pumping Station, (3) Town STW, (4) Njoro STW, (5) water quality testing laboratory and (6) supply of operation and maintenance equipment. The construction quantity is summarized in Table 6-1 for the major construction items.

Table 6-1 Estimated Major Construction Quantities

Work Items	Town STW	Njoro STW	Total
Land clearing	66,000 m^2	33,000 m^2	99,000 m^2
Excavation	209,000 m^3	157,000 m^3	352,000 m^3
Embankment	205,000 m^3	147,000 m^3	334,000 m^3
Rock fragments at RFs	16,000 m^3	25,000 m^3	41,000 m^3
Sodding at GPs	80,000 m^2	120,000 m^2	200,000 m^2
Dredging	6,100 m^3	34,800 m^3	40,900 m^3

(Data source: Study Team)

6.3 Construction Time Schedule

The construction time schedule was worked out in harmony with the proposed construction plan and in due consideration of climatological conditions prevailing over the site. It is shown in Fig. 6-1. The construction works will be completed wholly within a period of 16 months. It is conditional that the works shall be executed without suspension of operation of the existing sewage treatment works and thus require a systematic construction sequence.

6.4 Construction Cost

The construction cost is estimated based on the prices of construction materials and equipment, labour wages, etc. prevailing as of November 1993. The estimated construction cost is shown in Table 6-2, and the annual disbursement schedule in Table 6-3.

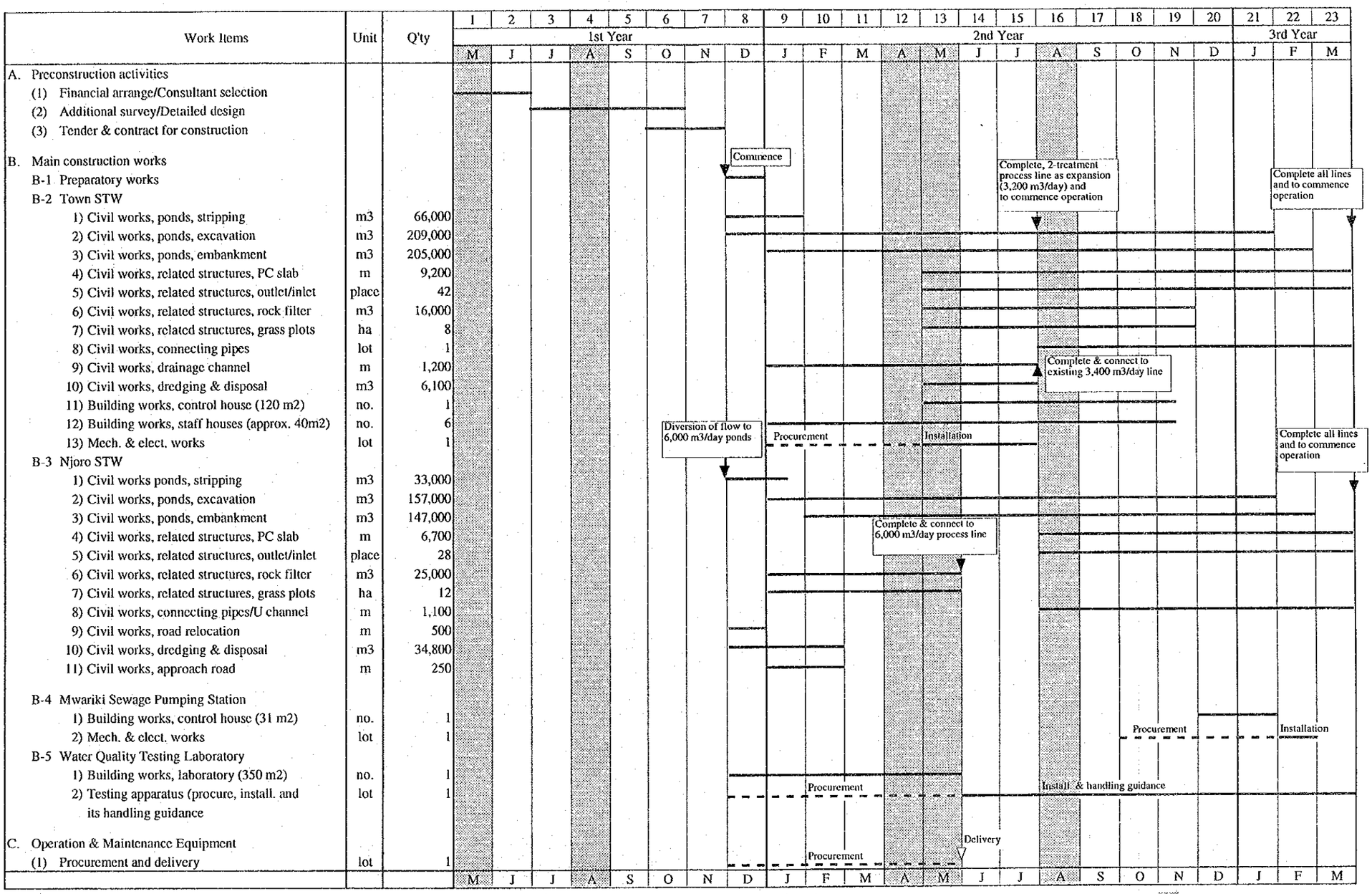
Table 6-2 Estimated Construction Cost

(Unit: US$10^3)

	Cost Items	Foreign Component	Local Component	Total
1.	Direct cost	8,188	8,196	16,384
	(a) Preliminary and general items	45	652	697
	(b) Mwariki pumping station	116	35	151
	(c) Town STW	3,898	2,723	6,621
	(d) Njoro STW	3,099	1,996	5,095
	(e) Water quality testing laboratory	464	276	740
	(f) O&M equipment	566	10	577
	(g) VAT	-	2,503	2,503
2.	Land acquisition and compensation cost	0	16	16
3.	Administration expenses	0	820	820
4.	Engineering services expenses	1,571	748	2,319
5.	Physical contingency	976	978	1,954
6.	Price contingency	467	870	1,337
	Total	11,201	11,629	22,830

(Data source: Study Team)

Work Items	Unit	Q'ty
A. Preconstruction activities		
(1) Financial arrange/Consultant selection		
(2) Additional survey/Detailed design		
(3) Tender & contract for construction		
B. Main construction works		
B-1 Preparatory works		
B-2 Town STW		
1) Civil works, ponds, stripping	m3	66,000
2) Civil works, ponds, excavation	m3	209,000
3) Civil works, ponds, embankment	m3	205,000
4) Civil works, related structures, PC slab	m	9,200
5) Civil works, related structures, outlet/inlet	place	42
6) Civil works, related structures, rock filter	m3	16,000
7) Civil works, related structures, grass plots	ha	8
8) Civil works, connecting pipes	lot	1
9) Civil works, drainage channel	m	1,200
10) Civil works, dredging & disposal	m3	6,100
11) Building works, control house (120 m2)	no.	1
12) Building works, staff houses (approx. 40m2)	no.	6
13) Mech. & elect. works	lot	1
B-3 Njoro STW		
1) Civil works ponds, stripping	m3	33,000
2) Civil works, ponds, excavation	m3	157,000
3) Civil works, ponds, embankment	m3	147,000
4) Civil works, related structures, PC slab	m	6,700
5) Civil works, related structures, outlet/inlet	place	28
6) Civil works, related structures, rock filter	m3	25,000
7) Civil works, related structures, grass plots	ha	12
8) Civil works, connecting pipes/U channel	m	1,100
9) Civil works, road relocation	m	500
10) Civil works, dredging & disposal	m3	34,800
11) Civil works, approach road	m	250
B-4 Mwariki Sewage Pumping Station		
1) Building works, control house (31 m2)	no.	1
2) Mech. & elect. works	lot	1
B-5 Water Quality Testing Laboratory		
1) Building works, laboratory (350 m2)	no.	1
2) Testing apparatus (procure, install. and its handling guidance	lot	1
C. Operation & Maintenance Equipment		
(1) Procurement and delivery	lot	1



Legends: Expected heavy rainy period

THE REPUBLIC OF KENYA MINISTRY OF LOCAL GOVERNMENT	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILTION AND EXPANSION PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE CONSTRUCTION TIME SCHEDULE

Table 6-3 Annual Disbursement Schedule

(Unit: US$10^3)

Year	Foreign Currency	Local Currency	Total Equivalent
First	2,550	2,522	5,072
Second	7,502	7,789	15,291
Third	1,149	1,317	2,467
Total	11,201	11,629	22,830

(Data source: Study Team)

6.5 Annual Operation and Maintenance Cost

The annual operation and maintenance cost is estimated as shown in Table 6-4.

Table 6-4 Annual Operation and Maintenance Cost

	Items	Amount	
		(KShs million)	(Equivalent US$10^3)
(1)	Sewers	3.53	57
(2)	Mwariki pumping station	0.10	2
(3)	Town STW	1.92	31
(4)	Njoro STW	0.85	14
	Total	6.40	103

The above cost does not include such costs as loan charges, computer services and sewer extension, which are being budgeted annually by the Sewerage Sector of the WSD.

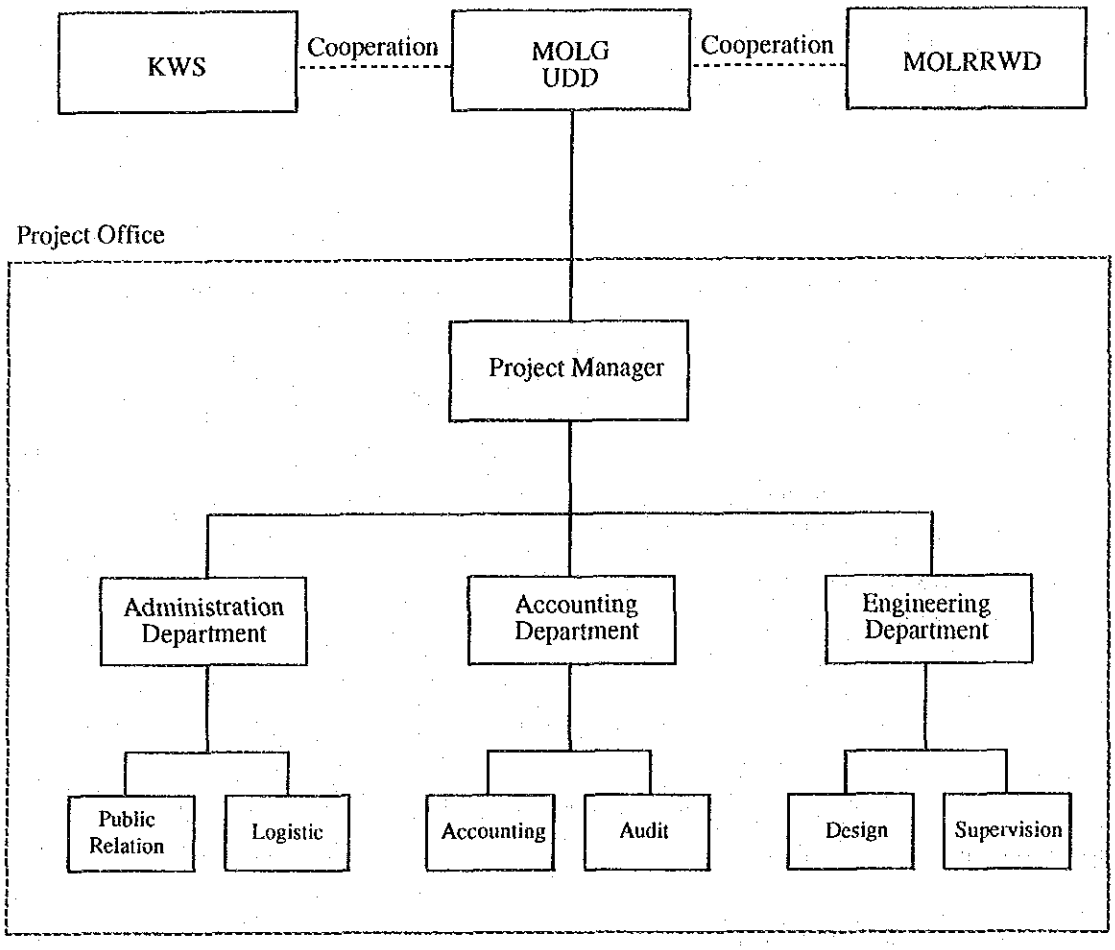
7. ORGANIZATION AND MANAGEMENT

7.1 Organization for Project Implementation

The Urban Development Department of the MOLG will be assigned as an executing agency of the Project. For the purpose of the construction of the Project, it is proposed to construct a project office, organization of which is as shown in Fig. 7-1. The basic function of the Project Office will be the following:

(1) to arrange all the legal procedures for the implementation of the Project;
(2) to carry out the survey and investigation necessary for design and quality control of the works;
(3) to make tender for the procurement of the contractor;

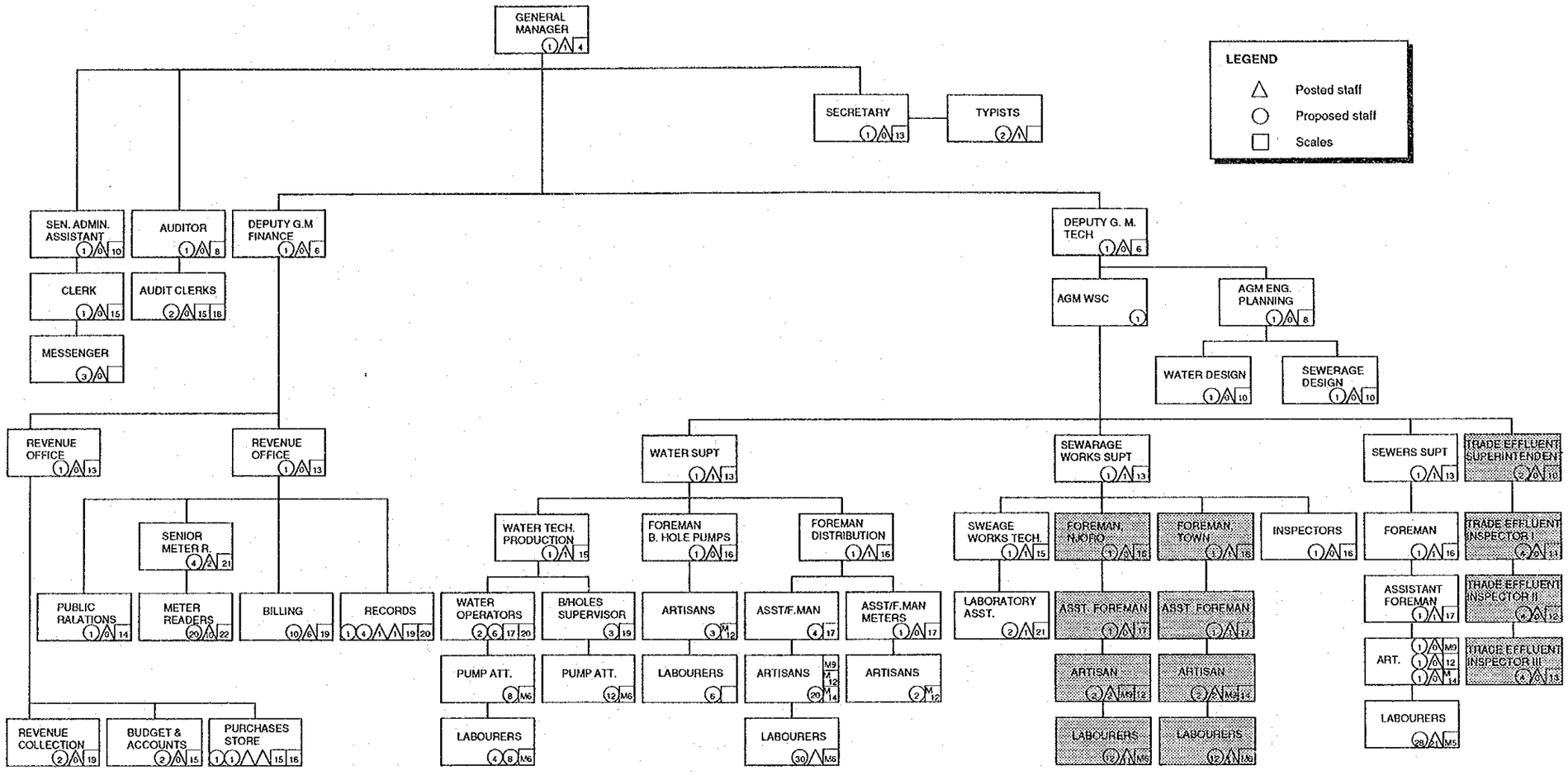
Fig. 7 - 1



MOLG : Ministry of Local Government
UDD : Urban Development Department
KWS : Kenya Wildlife Service
MOLRRWD : Ministry of Land Reclamation Regional and Water Development

THE REPUBLIC OF KENYA	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILITATION AND EXPANSION PROJECT	TITLE ORGANIZATION CHART OF PROJECT OFFICE
MINISTRY OF LOCAL GOVERNMENT	JAPAN INTERNATIONAL COOPERATION AGENCY	

Fig. 7 - 2



Data souce : Nakuru Municipality

Proposed addition/improvement

THE REPUBLIC OF KENYA MINISTRY OF LOCAL GOVERNMENT	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILTION AND EXPANSION PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE PROPOSED IMPROVEMENT OF WSD ORGANIZATION

(4) to execute the construction supervisory works;

(5) to undertake accounting and auditing of the contract works.

7.2 Organization for Operation and Maintenance of the Project

The WSD will have direct and overall responsibility for the operation and maintenance of the project facilities. In order to attain this objective, it is proposed to strengthen the WSD, especially the Sewerage Service Sector in terms of manpower and maintenance equipment. For successful implementation of the Trade Effluent by-Laws it is proposed to organize a Trade Effluent Control Unit (TECU) within the WSD. The proposed organization is as shown in Fig. 7-2.

7.3 Financial Management

At moment the financial management of the WSD is under control of the Treasurers Department. The Sewerage Sector has been facing financial constraints: actual funds disbursement are far from desirous, being ranged from KShs. 2.93 million in 1988/89 to KShs. 5.93 million in 1993/94. Of the 1993/94 budget, only KShs. 1.4 million or 23.6% is due to operation and maintenance of the existing facilities and KShs. 1.3 million and 0.8 million are allocated for loan charges and computer services respectively. It is strongly recommendable that NMC allocates a sufficient fund for a sustained operation and maintenance of the sewerage system, which virtually and greatly contributes to conservation and protection of precious environment of Lake Nakuru and its surroundings.

7.4 Office Accommodation

The WSD is not provided with a sufficient office space to accommodate its key staff. In order to attain autonomy of WSD and perform efficient and rational management and administration, NMC is expected to take up necessary action.

8. ENVIRONMENTAL IMPACT ASSESSMENT

8.1 Introduction

The environmental study mainly concerns with the sewage treatment works and Lake Nakuru National Park including Lake Nakuru. It is commonly and widely known that Lake Nakuru has a very delicate and precious ecology and its features and characteristics have not wholly clarified yet to date scientifically, qualitatively and qualitatively, although the KWS has been laying a great efforts on preservation and conservation under international assistance. It is therefore inevitable to assess the environmental impact of the project only

Table 8-1 Summary of Environmental Impact Assessment

	Check Items	Impact	Problems	Action & Counter Measure
Project Site (Construction Period)	1. Erosion & Slope protection	1-b	The construction works includes a great deal of earthworks.	At the construction stage, proper embankment and slope protection works are required.
	2. Muddy Water	1-b	Muddy water will cause impact to downstream.	Sedimentation pond and drainage ditch should be prepared.
	3. Noise, vibration, dust	1-a	There are no resident houses near the construction sites.	
	4. Traffic situation	1-a	The traffic volume will not be increased. The construction work need not many material to be conveyed from outside.	
	5. Excess soil disposal	1-a	Earthwork balance has been considered that these will be little excess soil. Excess soil will not be generated so much.	
	6. Sludge Disposal	2	The construction work includes de-sludging from existing WSP. These sludge may cause impact on downstream water body, if not treated properly.	Dry space will be prepared in the sites. The accumulated sludge is discharged into the space, and the dried sludge will be taken to disposal site.
	7. Land acquisition	1-b	The area of Lake Nakuru National Park should be used for the STWs construction sites.	Appropriate measure should be taken up by the Government.
	8. Flora	2	The project sites are covered with open grass land. The stripping of grass will be taken place over the entire area.	Regreening should be done on excavated area.
	9. Fauna	1-b	Relocation of the fence should be done. It may cause impact on Fauna in the National Park.	The works should be done under the supervision of KWS
	10. Safety & Working Environment	1-b		Wastewater and garbage from working persons should be treated properly. Safety and working environment precaution should be managed.
Project Site (Operation Period)	1. Offensive Odour	2	Offensive odour will be generated from anaerobic ponds. But it will not be serious because of wind direction and location of STW.	Tree belt around the anaerobic pond is recommendable.
	2. Sludge Disposal	2	Sludge should be taken out from anaerobic pond. The sludge may become to be pollution source.	Sludge treatment system including new disposal sites should be established as soon as possible (Refer to 4.4.1).
	3. Noise	1-a	Proposed facilities have no major mechanical equipment.	
	4. Effect on Landscape	1-a	STWs sites look like natural ponds and natural open grass land.	Regreening will be done, and tree belt will be planted around anaerobic ponds.
Downstream of Site (Operation Period)	1. Water Pollution	1-a	Main purpose of the project is to reduce the water pollutant load.	The situation shall be improved (Refer to 4.5).
	2. Fauna & Flora	Not Clear	Impact of water pollution on ecological condition will be mitigated.	Long term monitoring program and detail ecological study is required.

Note: Level of impact : 1-a : No impact by Project
1-b : No impact after counter measure
2 : Minor impace