(5) Disposal of industrial solid waste

Currently the industrial solid waste is dumped together with domestic refuse at the municipal dumping site. However some of them are toxic and hazardous. In order to prevent possible pollution of groundwater by leakage from the dumping site, it is proposed to take such alternative measures as (1) separate site for industrial solid waste disposal, (2) reducing the volume by means of compression, dewatering or incineration by factories themselves, and (3) encasing with concrete.

4.4.2 Non-structural Measures

The non-structural measures could be divided into a short term plan and a medium-long term plan. Detailed proposal is presented in Supporting Report K in Volume IV. Upon successful accomplishment of the non-structural measures, the Wastewater Standards could be attainable.

(1) Short term plan

(a) Water-related legislations

There are many Acts, Rules, Regulations and By-laws with regard to water supply, sewerage, public health and environmental conservation. It is noteworthy to report that the GOK has drafted up "National Environmental Bill" and Trade Effluent By-laws.

All the existing and drafted legislation has been studied and reviewed in view of conservation and protection of environment of Lake Nakuru as reported in detail in Supporting Report K. As the results 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

(b) Overall institutional support

There is a multiplicity of the government ministries and agencies in implementation of the legislations. Most of the problems encountered arise from a low level of implementation and enforcement of law due to lack of coordination of the ministries and agencies concerned. The GOK has organized the IWG for coordination and supervision of the various institutions that are geared towards environmental protection and management. Fig. 4-5 illustrates the proposed institutional organization for environmental conservation and protection of Lake Nakuru.

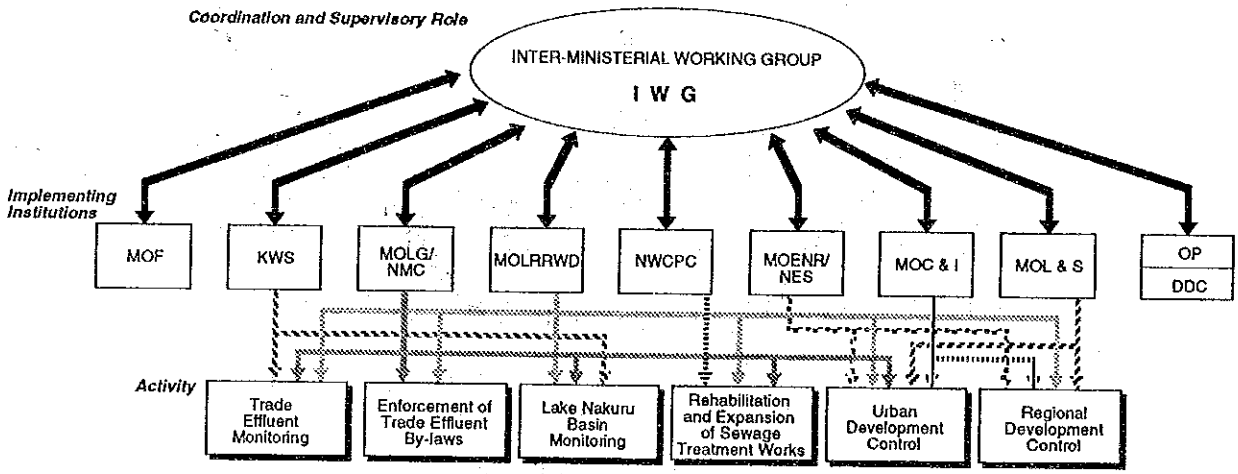
(c) Monitoring activities

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 from the Nakuru Municipality. Especially monitoring of industrial effluents is necessary for the proper enforcement of the Trade Effluent By-Laws, which is the most important and integral element of the proposed pollution control plan.

The monitoring plan is elaborated in detail as presented in Supporting Report K. It is classified into four categories; (1) rivers, channels and springs, (2) industrial effluents and sewage treatment works effluents, (3) lake water quality, and (4) stormwater drainage. For the respective category, sampling frequency and water quality testing items are proposed.

For the above purpose, it is proposed to establish a Water Quality Testing Laboratory, organization of which is elaborated as shown in Fig. 4-6. The Laboratory will be operated and maintained through coordination and cooperation among MOLG/NMC, MOLRRWD and KWS and staffed by 11, of which 9 should be of qualified.

Fig. 4 - 5



Legend

Coordination and Supervisory Relationship

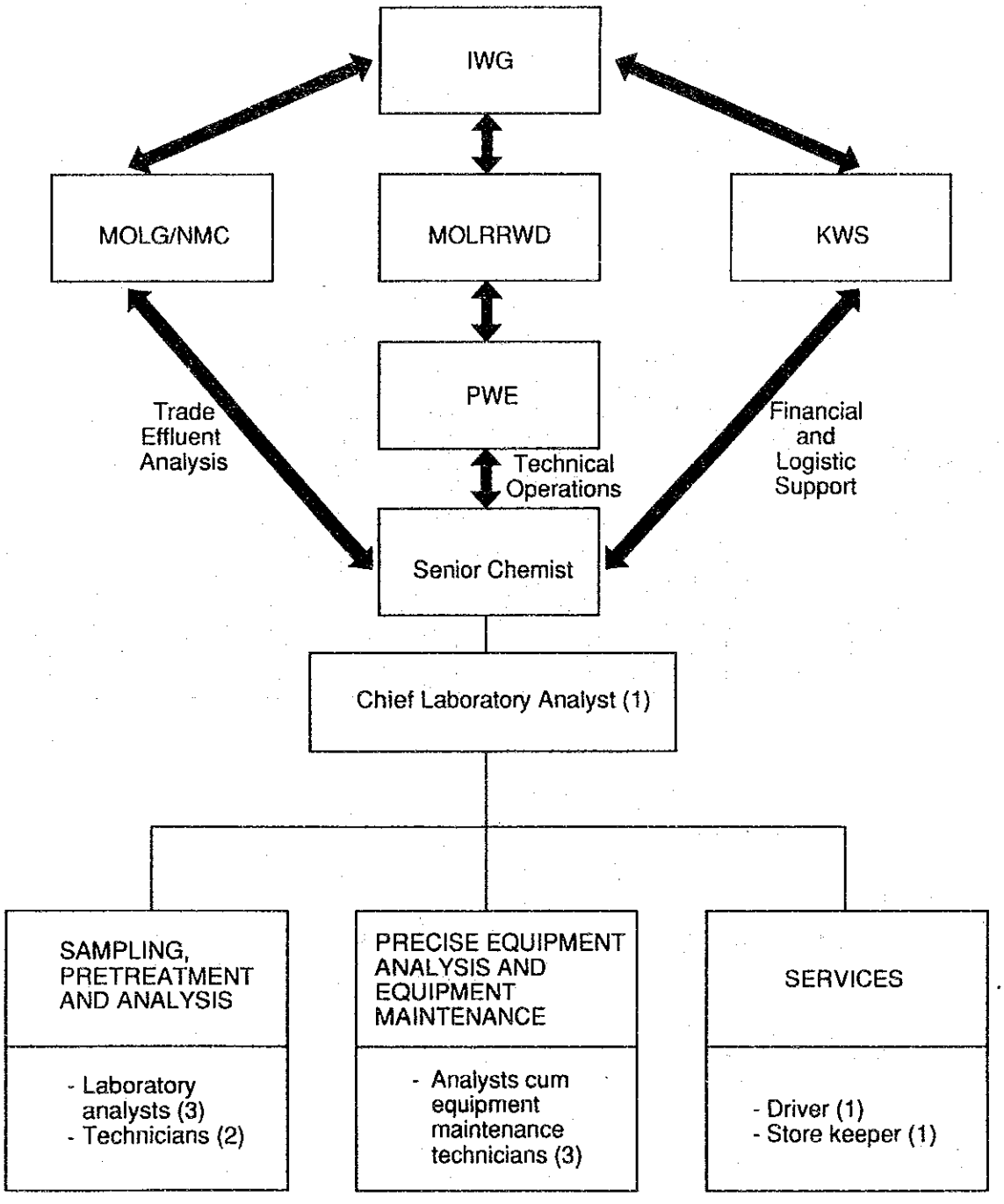
Activity Implementation Relationship

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 - 6



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) Monitoring activities

The monitoring activities proposed as one of the short term plan is required to be continued.

(b) Urban and regional development control

As a strategy for reduction of the increasing pollutant load, it is proposed that urban and regional development activities within the Lake Nakuru basin be controlled. The control plan will envisage:

(i) Restricting the size and type of industries

(ii) Relocation of industries producing heavy metals and toxic materials and causing excessive hydraulic loading on the lake

(iii) Control of residential area development

(iv) Excessive use of fertilizers and agro-chemicals

As noted in the short term plan, all the development activities will be controlled and supervised by the IWG.

(c) 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 include, but not limited to (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.

(d) Master plan for sewerage development

Comprehensive sewerage development plan has not yet been established by GOK for the Nakuru Municipality and other urban areas in the catchment area of Lake Nakuru. It is therefore strongly recommended that a long term master

plan on sewerage system development be formulated for every urban areas as soon as possible. The plan shall be elaborated not only on the basis of ordinary methodology and process of the sewerage system development planning, but also in due consideration of unique geographic, environmental and socio-economic condition in the catchment area of Lake Nakuru. Especially it is absolutely necessary to draw attention on resolving the increase of sewage and pollutant loads into the lake owing to implementation of expansion of sewerage systems. In this context it is deemed essential to place emphasis on justification of technical feasibility of inter-basin diversion scheme of treated sewage, which will also associate with re-demarcation of sewerage districts in the Nakuru Municipality.

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 reduction is anticipated to be derived from the sewage treatment works. The reduction of BOD and nutrient is estimated as described below:

(1) BOD load reduction

BOD pollutant loads into Lake Nakuru 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
Case-5	After implementation and enforcement of Trade Effluent By-Laws

The calculation condition of the respective cases is shown in Table 4-10.

Table 4-10 Pollutant Load Forecast Criteria

	Case (1)	Case(2)	Case(3)	Case(4)	Case(5)
Quantity of Sewage Generation (m^3/d)	8,185	16,200	16,200	16,200	16,200
BOD Concentration of Raw Sewage (mg/L)	800	800	800	800	500
Effluent BOD Concentration (mg/L)					
Njoro 3,600	200	200	200	15	10
Njoro 6,000	-	-	30	15	10
Town 3,400	220	220	220	15	10
Town 3,200	-	-	-	15	10
Total Capacity of STWs (m3/d)	7,000	7,000	13,000	16,200	16,200
Pollutant Load from Stormwater	Same as present	Same as present	Same as present	30 % reduction	30 % reduction

The estimate for both the Cases 1 and 2 is reported in Section 4.1 of this Chapter. The process of the estimate for Cases 3, 4 and 5 is as illustrated in Fig. 4-7 and the results of the estimate are as presented in Table 4-11.

Table 4-11 Pollutant (BOD) Loads into Lake Nakuru

(Unit: ton/year)

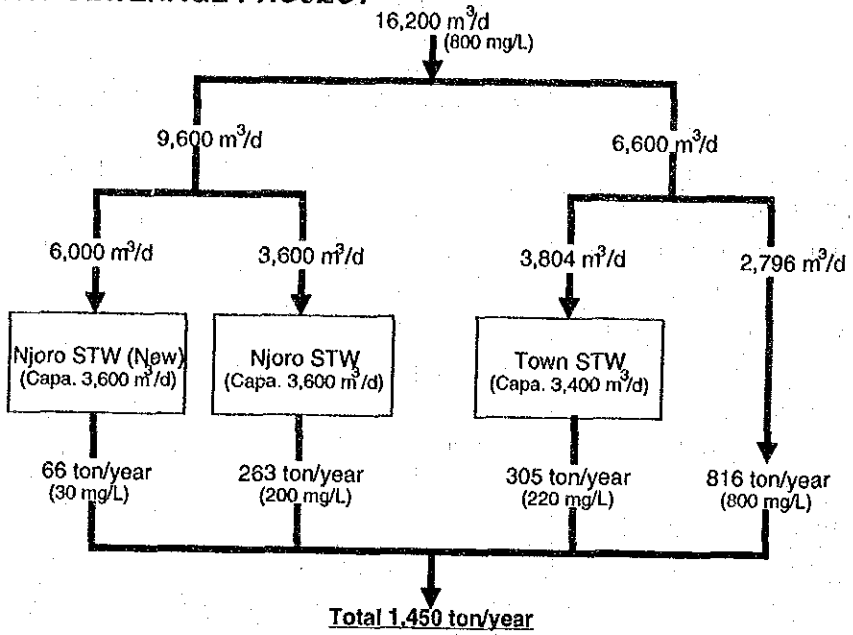
Route of Pollutant Load	Case-1	Case-2	Case-3	Case-4	Case-5
1. Sewage Treatment Works	626	2,964	1,450	89	59
2. Stormwater drainage	161	161	161	113	113
3. Rivers and Springs					
- Njoro River	356	356	356	356	356
- Makalia River	122	122	122	122	122
- Nderit River	152	152	152	152	152
- Springs	54	54	54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

(Data source: Study Team)

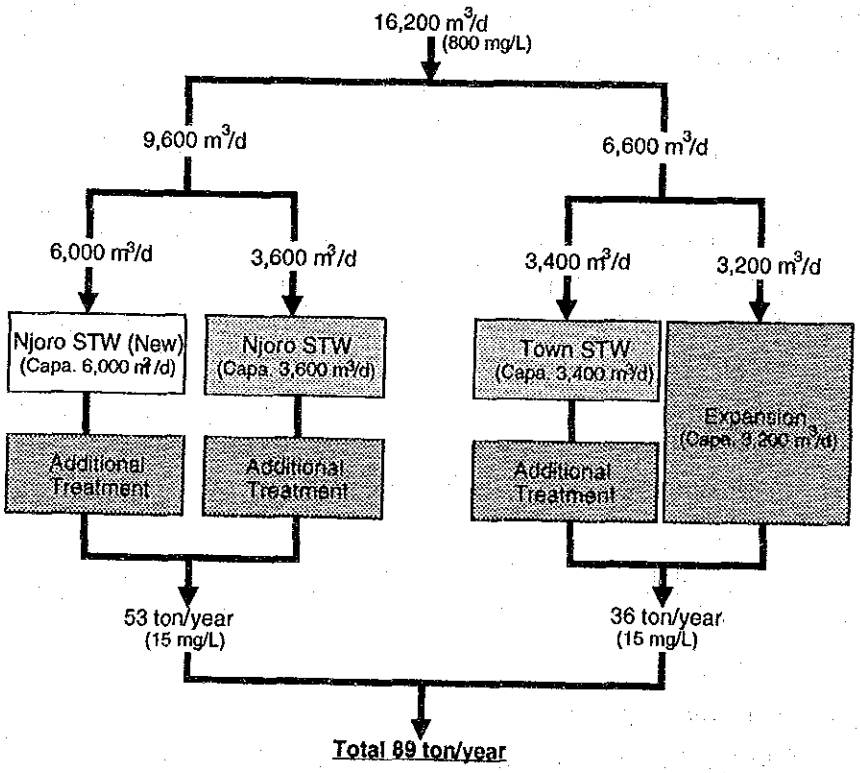
It is clear that pollutant (BOD) load into Lake Nakuru decreases greatly, 1,514 ton/year by Nakuru Sewerage Project and 1,409 ton /year by the rehabilitation and expansion of sewage treatment works, and 2,953 ton/year in total corresponding to 78% of the forecast value after the additional water supply. When compared to the present condition, pollutant load decreases to 58% so that a great contribution is expected for conservation of environment of Lake Nakuru.

Fig. 4 - 7 (1/2)

AFTER NAKURU SEWERAGE PROJECT



AFTER PROPOSED REHABILI TATION & EXPANSION

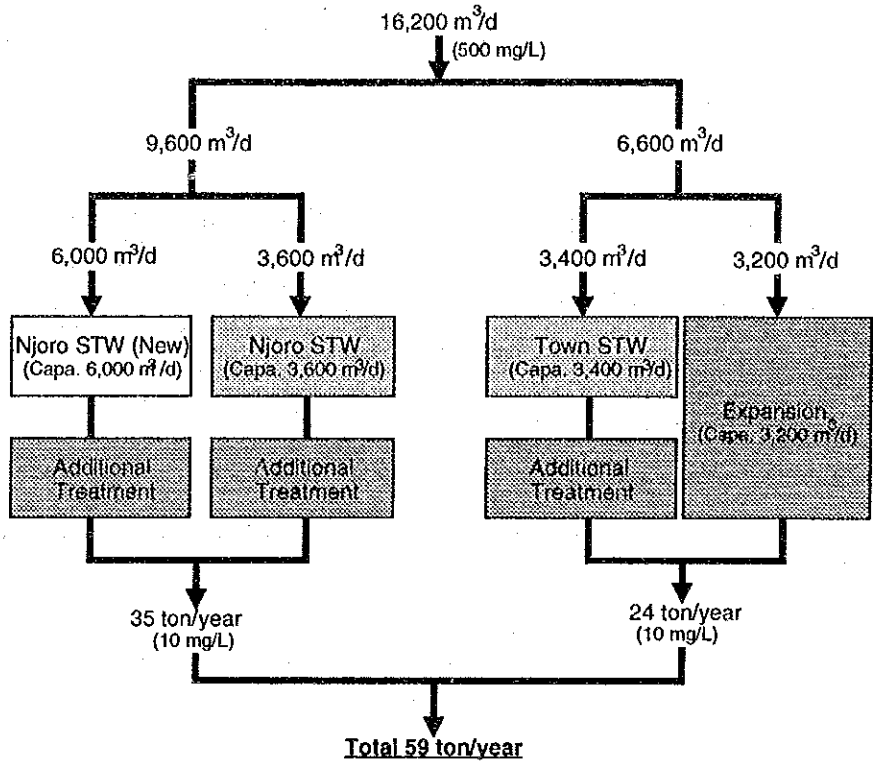


Note: Volume of sewage is expressed in unit of m3/d and that of pollutant load in unit of ton/year.

Rehabilitation
Expansion & Additional Treatment

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

AFTER IMPLEMENTATION AND ENFORCEMENT OF TRADE EFFLUENT BY-LAWS



Note: Volume of sewage is expressed in unit of m3/d and that of pollutant load in unit of ton/year.

Rehabilitation
Expansion & Additional Treatment

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

(2) Nutrient Load Forecast

T-N and T-P concentrations are forecast only for Cases 1 and 5 based on typical values that could be achieved when industrial wastes are properly controlled and sewage are properly treated. Such value is 8 mg/L for T-N and 6 mg/L for T-P. The T-N and T-P loads for Case-1 are derived from the results of the water quality investigation.

Table 4-12 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
Stomwater 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.

(3) Effect of evaporation

As the sewage treatment process mainly depends on waste stabilization ponds, rock filters and grass plots, it is expected that a certain amount of water will be lossed in form of evaporation and evapo-transpiration through such treatment facilities. The effect of evaporation and evapo-transpiration would be as summarized below:

(a) Reduced effluent from sewage treatment works
(b) Increase in concentration of sewage stored in ponds
(c) Increase in retention time of sewage in ponds

An attempt was made to estimate volume of evaporation loss based on monthly rainfall and evaporation records during the period from 1990 and 1992. The total area of the ponds, rock filter and grass plots is 48.2 ha at Njoro STW and 30.9 ha at Town STW. It is estimated that about 5% of influent will be lossed as shown in Table 4.13.

Table 4-13 Evaporation Loss from Ponds

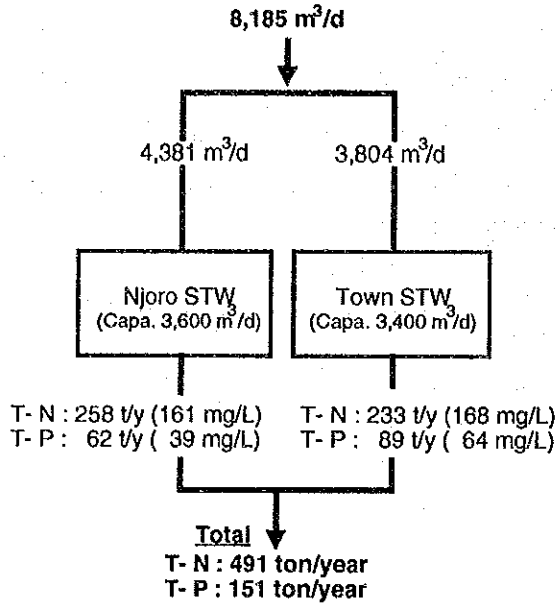
Sewage Treatment Works	Inflow	Evaporation Loss	Outflow
Njoro	9,600	546	9,054
Town	6,600	350	6,250

(Data source: Study Team)

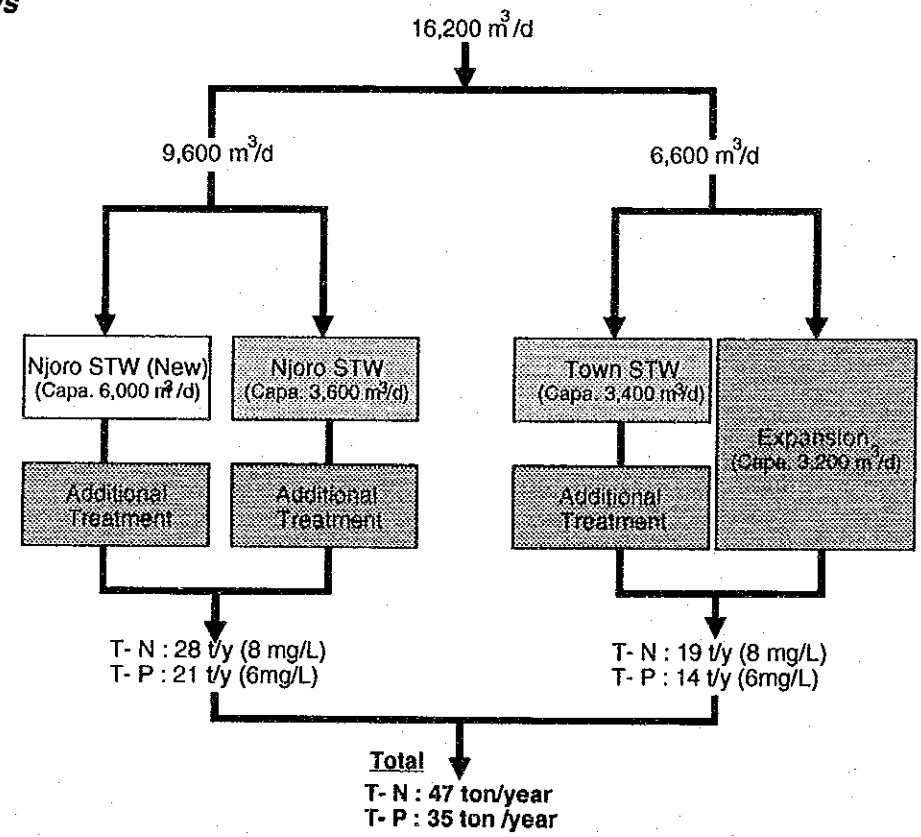
It is supposed that effect of (b) may be offset by that of (c).

Fig. 4 - 8

Present Condition



After Implementation and Enforcement of Trade Effluent By-Laws



Note: Volume of sewage is expressed in unit of m3/d and that of pollutant load in unit of ton/year.

Rehabilitation

Expansion & Additional Treatment

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 THROUGH SEWAGE TREATMENT WORKS

5. PRELIMINARY DESIGN

5.1 Outlines of Structural Components

The Project includes the following construction works:

(1) Structural measures

(a) Sewage treatment works

- Rehabilitation and expansion of sewage treatment works
- Construction of control/workshop at Town STW
- Construction of a generator house and replacement pumping facilities at Mwariki pumping station
- Staff houses at both Njoro and Town STWs.

(b) Sludge drying bed

(c) Stormwater retention pond

(2) Non-structural measures

(a) Water quality testing laboratory

The preliminary design of the above works are reported in the succeeding sections. The preliminary design drawings are complied in Volume V, Drawings.

5.2 Preliminary Design of Sewage Treatment Works

5.2.1 Planning Conditions and Design Criteria

The conditions and abilities of the existing sewage treatment works were surveyed and evaluated thoroughly, and rehabilitation and expansion plan of sewage treatment works has been worked out as an integral component of the water pollution control plan. The planning condition and design criteria have been established as mentioned herein in order to proceed with the preliminary design of various components of the sewage treatment works:

(1) Sewered area

1,285 ha, same as the present.

(2) Planned sewage volume

16,200 m^3/day in terms of dry weather flow, to be generated upon commissioning of Greater Nakuru Water Supply Project Eastern Division, Stage 1.

(3) Design discharge of structures

	Sewage Treatment Works	Sewage (m^3/day)			Rain water (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 inlet and pond connection pipes.

(4) 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 conform	10^8/100 mL	10^3/100 mL
Air temperature at coldest month	16°C	16°C

As noted in Chapter 4 of this report, the standard value of BOD_5, 10 mg/L could ultimately be achieved by means of a combination of rehabilitation and expansion of sewage treatment works and implementation/enforcement of the Trade Effluent By-laws. The sewage treatment works is accordingly designed so as to accomplish a target value of 15 mg/L.

(5) Sewage treatment process

(a) Njoro STW

3,600 m^3/day line	:	Waste stabilization ponds with additional treatment facilities composing of rock filters and grass plots
6,000 m^3/day line	:	Same as the above

(b) Town STW

3,400 m^3/day line	:	Existing conventional system associated with additional treatment facilities such as waste stabilization ponds, rock filter and grass plots
3,200 m^3/day line	:	Same as the Njoro STW

A comparative study has been deployed in order to select the sewage treatment process best suited to the sites as reported in detail in Supporting Report H in Volume IV. Both the Kenyan and Japanese teams have mutually concluded that the existing sewage treatment works should be supported by the additional treatment facilities as an initial step to satisfy the targeted water quality and it is the most technically and economically feasible to apply a combined treatment process of waste stabilization ponds and additional treatment facilities for the new 3,200 m^3/day line at Town STW. It is also noted that the sewage treatment process should be dependent on a gravity flow system in order to minimize annual operation and maintenance cost.

(6) 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"). Details of calculation process are given in Supporting Report I in Volume IV.

(7) 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	Illinoi 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

5.2.2 Mwariki Pumping Station

The new pumping station with an floor area of 30 m^2 is sited opposite the existing one. DWG. B-1 gives the preliminary design of building works.

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.

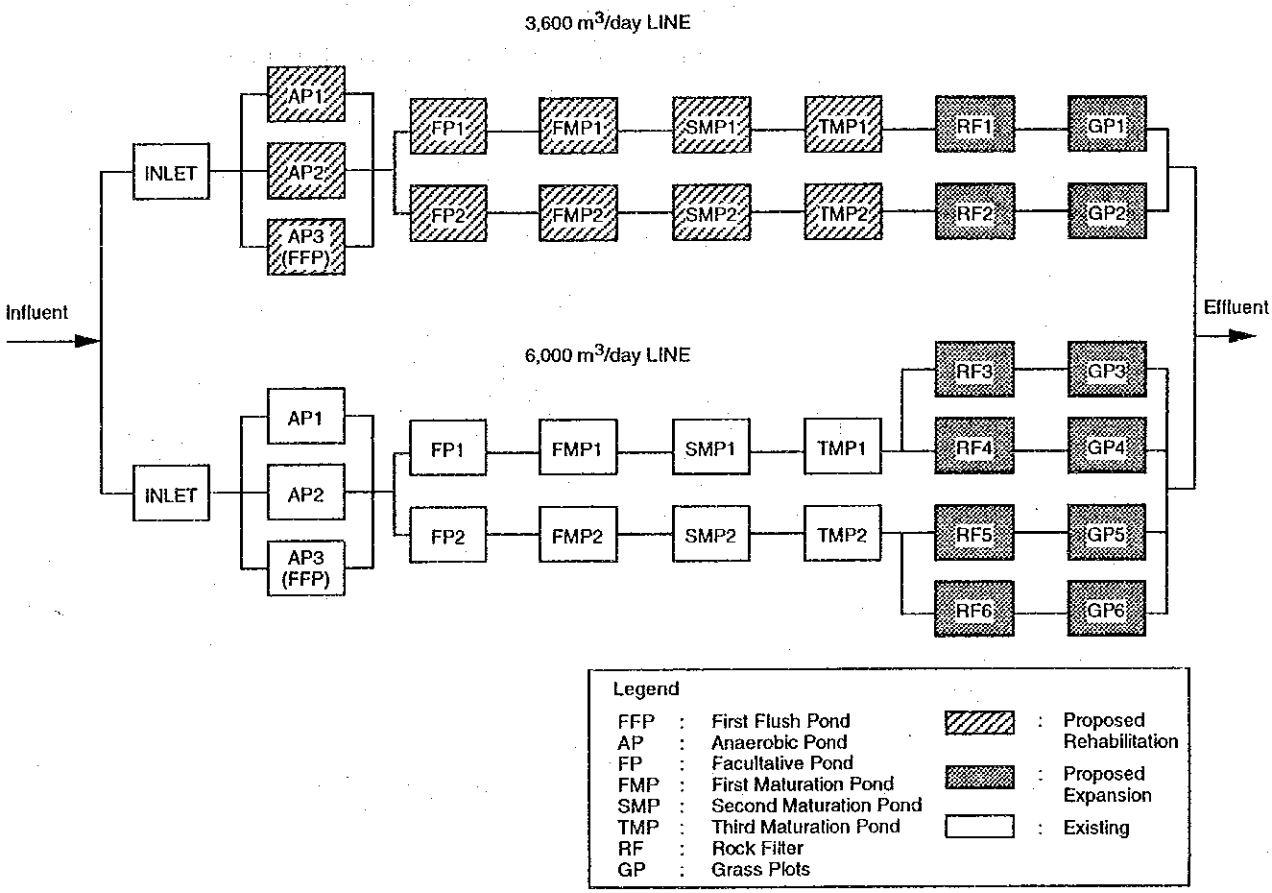
The electrical works include the installation of mercury switch for stirres and integrated control cabinet for operation of pumps and stirres. A single line diagram is given in DWG. M-1.

5.2.3 Njoro Sewage Treatment Works

The sewage treatment process is illustrated in Fig. 5-1. Both the 3,600 m^3/day and 6,000 m^3/day lines are divided into two lines, each having equal treatment capacity and consisting of WSP, rock filters and grass plots. General layout and hydraulic profile are shown in DWGs. N-1 and N-2 respectively. Of the 6,000 m^3/day line, the waste stabilization ponds have been programmed to be completed by the middle of 1994 under the Nakuru Sewerage Project.

The project will include or comprise the construction of the following major structural components:

Fig. 5 - 1



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(1) 3,600 m^3/day line

(a) Remodeling the existing waste stabilization ponds to increase sewage treatment capability
(b) Inlet pipe between the existing flow splitting chamber and the anaerobic ponds
(c) Pond connection pipes between the successive ponds including pond outlet and inlet
(d) Waste stabilization ponds, rock filters and grass plots
(e) Outlet works including an outfall on the left bank of Njoro river

(2) 6,000 m^3/day line

(a) Pond connection pipe between the third maturation ponds and rock filters
(b) Rock filters and grass plots

(3) Rock filter drain pit

(4) Building works for staff house

The preliminary designs of the respective work are summarized below:

(1) Sewage treatment works

Salient features of the sewage treatment works are shown in Table 5-1.

(a) Inlet pipe

The location and profile of the inlet pipe of the 3,600 m^3/day line is given in DWGs. N-3 and 4 respectively. It is 300 - 450 mm in a diameter and 315 m in total length and connected to the AP1 to AP3 through the flow splitting chambers.

(b) Waste stabilization ponds (WSP)

The dimensions of the respective pond depend on the results of the sewage treatment process design calculation, which is given in Supporting Report I in Volume IV.

Table 5-1 Principal Features of Njoro Sewage Treatment Works

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 Discharge (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.1,784.0m	El.1,779.0m	El.1,778.5m	El.1,778.0m	El.1,777.5m	-
			El.1,778.0m	El.1,777.5m	El.1,777.0m	El.1,776.5m	-
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

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	:	D300mm, D450mm, D600mm
Total length	:	791 m

4. Staff House

Type	:	Type D, 30m^2
Number		4

5. Sludge Drying Bed

Number of Pond	:	1
Design Discharge (Average Daily)	:	9,600 m^3/day
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

Out of the three new APs one acts as a stand-by AP to facilities desludging and first flush pond to receive stormwater.

The total retention period is calculated at 63.6 days for the 3,600 m^3/day line and BOD_5 concentration is estimated at 30 mg/L at the outlet of the TMP. The 6,000 m^3/day line will also attain the same BOD concentration, since it has been designed in accordance with the same process design criteria.

The WSPs can be constructed by excavation and embankment and their bottom are designed to be sufficiently compacted in order to prevent seepage. The preliminary designs of the WSPs and GPs are shown in DWG. N-4.

(c) Rock filters and grass plots (RFs and GPs)

The preliminary designs of the RFs and GPs are shown in DWG. C-3. The RFs are provided with open ditch with overflow weir at its downstream end in order to evenly distribute the water into the GPs. The GPs are also furnished with treated sewage channel at its downstream end. It is proposed to be planted with "Kikuyu" grass, which is one of the fodder crops for livestocks. The treated sewage is drained out into the outlet works.

(d) Pond connection pipes

The pond connection pipe links one pond with another. Its alignment is shown in DWG. N-4. At the preceding pond, an outlet with horizontal flow type is to be sited and an inlet with chuteway type is to be located at the following pond. The diameter of the pipe ranges from 300 to 450 mm and total length is estimated at 1,045 m for the 3,600 m^3/day line and 835 m for the 6,000 m^3/day line.

(e) Outlet works

The effluent from all the GPs is collected by an outlet work and will be discharged into Njoro river. The outlet works comprise a conduit and an outfall on the left bank of the Njoro river, and its profile is given in DWG. N-10. The conduit is in general open channel excepting road-crossing and has 495 m in total length.

(2) Rock filter drain pit

In order to facilitate removal of sludge accumulated in the RFs, a rock filter drain pit will be provided adjacent to the RFs. It is designed to apply hydraulic flushing system to drain the water and sludge from the RFs to the drain pit. Thus the drain pit is located at lower elevation than the RFs and has an effective storage capacity of 4,80 m3, corresponding to 25% volume of all the RFs as the RFs will be emptied alternately.

(3) Building works

Four type D houses, each with a floor area of 35 m^2, are to be constructed adjacent to the staff house compound as shown in DWG. N-1. Each house consists of a bed room, a living room, a shower room and a lavatory as shown in DWG. B-3.

5.2.4 Town Sewage Treatment Works

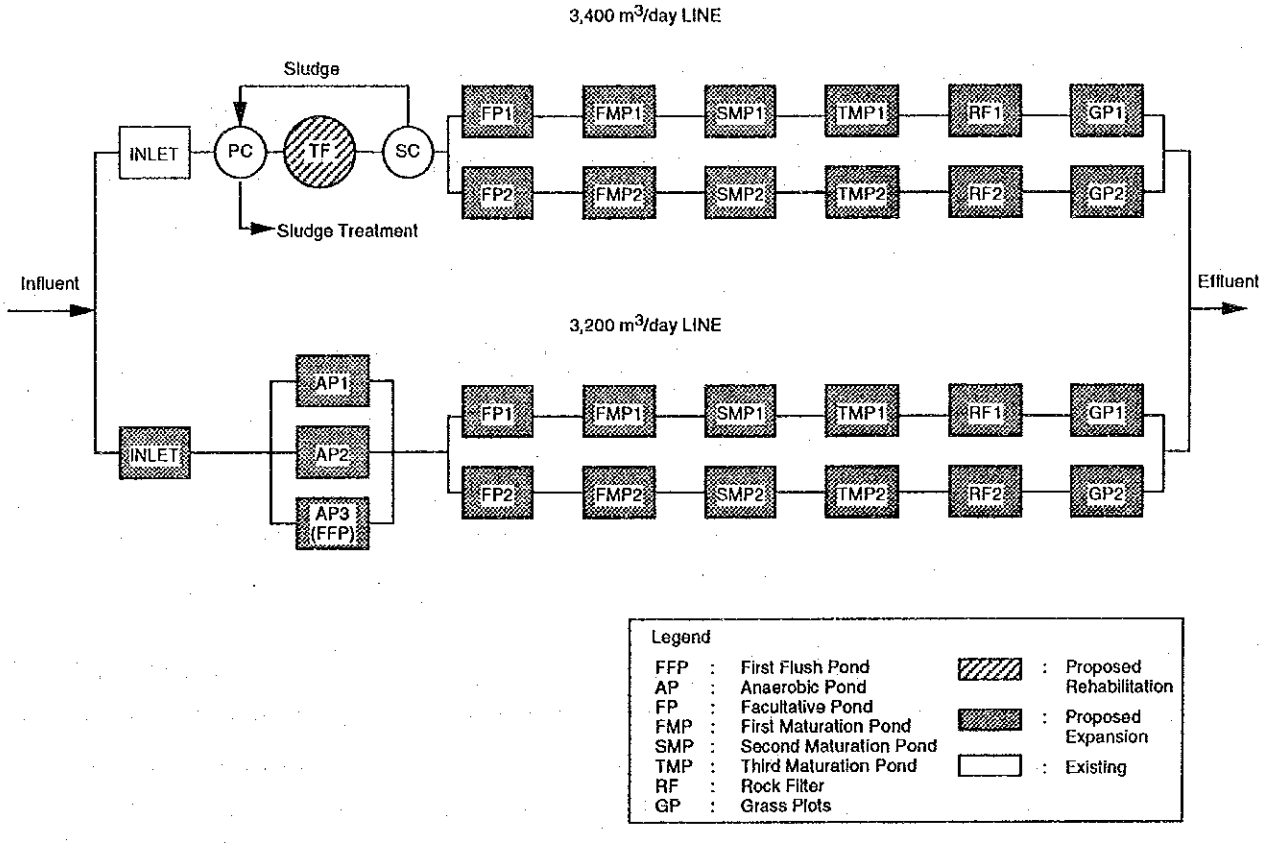
There are two slightly different sewage treatment works in the Town STW and their proposed stream of treatment process is shown in Fig. 5-2. General layout and hydraulic profile of the respective treatment works are shown in DWGs. T-1 and T-2 respectively.

The project involves the construction of the following major structural component as far as the sewage treatment works are concerned.

(1) 3,400 m^3/day line

- Ventilation at trickling filter
- Inlet pipe between the existing secondary clarifier and the FPs
- Pond connection pipes between the successive ponds including pond outlet and inlet
- Waste stabilization ponds, rock filters, and grass plots
- Rock filter drain pit

Fig. 5 - 2



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

(2) 3,200 m^3/day line

- Inlet works between the existing inlet and the new APs
- Pond connections between the successive ponds including pond outlet and inlet
- Waste stabilization ponds, rock filters and grass plots
- Rock filter drain pit

(3) Building works for control office and staff house

(4) Mechanical and electrical works

The preliminary design of the respective work is summarized below:

(1) Sewage treatment works

Salient features of the sewage treatment works are presented in Table 5-2.

(a) Inlet pipe and inlet works

The inlet pipe necessary for the 3,400 m^3/day line is 300-450 mm in diameter and 460 m in total length. Its alignment is indicated in DWG. T-6.

The inlet works for the new 3,200 m^3/day line consists of an inlet channel with a width of 0.50 - 0.60 m, two constant velocity with grit removal chamber with a width of 0.80 m, parshall flume with a throat width of 0.15 m and inlet pipe with a diameter of 300 - 450 mm and 460 m in total length. The girt chamber has been designed to ensure a retention period of 30 seconds against grit retained by a 65-mesh sieve. The preliminary designs of inlet works and inlet pipe are shown in DWGs. T-3 and T-4 respectively.

(b) Trickling filter

Through the evaluation of the existing trickling filter, it is identified that there is a need for installation of additional ventilation in order to ensure the proper performance. Three additional ventilations are proposed to be installed as shown in DWG. T-12.

Table 5-2 Project Features of Town Sewage Treatment Works

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 Discharge (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.1,770.5m El.1,769.0m	El.1,786.0m	El.1,767.5m	El.1,767.0m	El.1,766.0m	-
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	3.0 days	-	-
			Total	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	:	D300mm, D450mm, D600m
Total length	:	120 m

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
Flow splitting chamber	:	1 no.

(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 Discharge (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.1,774.0m El.1,772.5m	El.1,770.5m	El.1,778.5m	El.1,769.5m	El.1,767.5m	-
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 172m	24m x 172m	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

(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	:	1,613 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	:	D300mm, D450mm, D600m
Total length	:	120 m

3. Sludge Drying Bed

(1) Sludge Drying Bed

Number of Pond	:	1
Design Discharge (Average Daily)	:	3,200 m^3/day
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
Min. freeboard	:	0 m
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
Side slope	:	1.0 : 3.0

5. Staff House

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

(c) Waste stabilization ponds (WSP)

The WSPs of both the 3,400 m^3/day and 3,200 m^3/day lines are separated into two equal capacity lines. Their process design is also given in Supporting Report I.

There are three APs in the 3,200 m^3/day line, one of which acts as a stand-by and first flushing pond to absorb the rainwater. The preliminary designs of the WSP are shown in DWG. T-6.

(d) Rock filters and grass plots (RFs and GP)

Both the RFs and GPs are designed on the basis of the same design loading rates as adopted to those at the Njoro STW. The treated sewage water is however to be drained into the stormwater drainage which runs almost center of the Town STW. The preliminary designs of the RFs and GPs are shown in DWGs. T-6 and C-3 respectively.

(e) Pond connection pipe

The pond connection pipe has the same structural components as those of the Njoro STW. The alignment of the pipe is as given in DWG. T-6. There are two different diameters of the pipes, 300 m and 450 mm depending on discharge, and the total length of the pipes are estimated at 1,295 m for the 3,400 m^3/day line and 1,400 m for the 3,200 m^3/day line.

(2) Rock filer drain pit

The rock filter drain pit will be constructed for each sewage treatment line. The same design principle as that in Njoro STW is applied. The effective storage capacity is 1,701 m^3 for 3,400 m^3/day line and 1,613 m^3 for 3,200 m^3/day line.

(3) Building work

It is proposed to construct a new control office and 10 Type D staff houses at the locations shown in DWG. T-1.

The office is 120 m^2 in floor area and comprises an office space, a workshop, a spare part storage, a kitchen and a lavatory. Its preliminary design is given in DWG. B-4.

There is no accommodation facilities at the Town STW and thus the sewage treatment works is not attended by operation staff during night time, hampering proper operation and maintenance. It is therefore recommended to construct the staff houses at the site.

(4) Mechanical and electrical works

The mechanical works mainly cover the replacement of timeworn equipment in the 3,400 m^3/day line, while the electrical works are mainly to install control cabinet at various locations and relocation of existing distribution line. Table 5-3 summarizes the major mechanical and electrical works.

Table 5-3 Major Mechanical and Electrical Works

	Work Items	Unit	Quantity
(1)	Mechanical works		
	Drain pumps, 50 mm dia., H = 12 m, with mercury level switch	set	3
	Inlet gate, cast iron	set	2
	Coarse screen, SUS, at inlet	set	1
	Fine screen, SUS, at inlet	set	1
(2)	Electrical works		
	Main distribution board	set	1
	Distribution panel at grit chamber	set	1
	Control cabinet at deep well pumps	set	1
	Control cabinet at recirculation pumps	set	1
	Control cabinet at sludge dry bed pumps	set	1

(Data source : Study Team)

5.3 Preliminary Design of Sludge Treatment Facilities

5.3.1 Planning Conditions and Design Criteria

(1) Characteristics of sludge

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

(2) Sludge treatment

In the waste stabilization pond process, most of sludge is produced in anaerobic ponds, which are required to be desludged periodically in order to sustain function of anaerobic ponds. It is proposed to treat the sludge by the sludge drying bed, taking advantage of climatological condition and in view of saving operation cost.

(3) Sludge disposal

The dried sludge will be disposed to the dumping sites, which will be designated by the NMC prior to implementation of the Project as recommended in the preceding sub-section 4.4.1 of this report..

Sludge generated at the 3,400 m^3/day line at Town STW will continuously be treated by a digester and sludge drying bed.

5.3.2 Sludge Drying Bed

The sludge drying bed is sited within a compound of the respective sewage treatment works as shown in DWGs. N-4 and T-6. It is estimated that the production of raw sewage 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 principal features of the sludge drying bed is given in Table 5-1 for Njoro STW and Table 5-2 for Town STW. The dried sludge will be reduced one fifth of the raw sludge in terms of volume so that the designed sludge dry bed capacity almost corresponds to the sludge generation volume for 10 years. It is proposed to treat the septage collected from cesspools/septic tanks at the sludge by beds.

5.4 Preliminary Design of Stormwater Retention Pond

5.4.1. Planning Conditions and Design Criteria

The stormwater drainage runs along the eastern boundary of the Town STW and washes out during storm garbage, debris, oil and other materials accumulated in the town area, resulting in anaethenic conditions. According to the estimate, pollution load through the drainage is estimated at about 161 ton/year in term of BOD, constituting about 11% of total BOD load into Lake Nakuru. It is therefore recommended to construct a stormwater retention pond to remove the above-said matters.

The design parameters have been derived from the Preliminary Design Report on Sewage Treatment Works (Town Site), June 1988, which was prepared for NMC and MOLRRWD.

(1) Design storm

Return period	:	5 years
Storm duration	:	46 minutes
Rainfall intensity	:	42 mm/hour

(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

Sediment yield	:	0.04 mm/km^2/year
Sediment volume	:	150 m^3/year

The sediment deposit is estimated based on the sediment yield given by "Study on Construction of Dam in Malewa River System for Greater Nakuru Water Supply Project" prepared for MOLRRWD.

5.4.2 Stormwater Retention Pond

With construction of the additional and new sewage treatment facilities at the Town STW, it is required to relocate the existing stormwater drainage as shown in DWG. T-1. The drainage is designed with the same dimensions and cross-sectional shape as the existing one so as not cause the adverse effect due to relocation.

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 and preliminary in DWG. T-2. It is provided with an oil trap at its inlet and outlet structures to make the pond empty. The stored water will be discharged into either the stormwater drain and the facultative ponds.

5.5 Preliminary Design of Water Quality Testing Laboratory

5.5.1 Planned Water Sampling and Testing

As noted in Chapter 4 of this report, it is proposed to build a water quality testing laboratory in Nakuru as one of the monitoring activities. Tables 5-4 through 5-7 presents the water quality monitoring plan.

5.5.2 Water Quality Testing Laboratory

The site for the laboratory is selected within the Lake Nakuru National Park in the vicinity of Training Center. Its preliminary design is made as shown in DWG. B-5.

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 and is designed in frame structure, being reinforced concrete structure. Roof and wall are steel and concrete block structures respectively.

The selected laboratory equipment and apparatus are shown in Table 5-8.

Table 5-4 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 5-5 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	Sechi 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 5-6 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 5-7 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 5-8 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)

5.6 Basic Guidelines for Operation and Maintenance

5.6.1 Sewerage System

The existing operation and maintenance practice has been reviewed and, in the light of the natures, features and treatment process of the sewerage facilities, basic guidelines for operation and maintenance are drafted up as presented herein. It should however be noted that the WSD is keenly required to place much effort on a sustained operation of the sewerage system in order to satisfy the objective of the Project as a whole.

The guidelines are summarized in Table 5-9. 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 5-9 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. In due consideration of diurnal variation of quality and quantity of influent, the trickling filter operation mode is suggested as follows:

Table 5-10 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

It is necessary to change the operation mode of the recirculation pump accordingly.

5.6.2 Sludge Drying Bed

The volume of raw sludge generation is estimated at 7,300 m^3/year for the entire Njoro STW and 2,410 m^3/year for the 3,200 m^3/day line in Town STW. The water contents of the raw sludge and dried sludge are estimated 90% and 50% respectively. Accordingly the dried sludge volume is 1,460 m^3/year for the Njoro STW and 475 m^3/year for the 3,400 m^3/day line in Town STW.

The raw sludge should be spread over the sludge drying bed as thin as possible to accelerate drying raw sludge, preferably within 30 cm in thickness.

5.6.3 Stormwater Retention Pond

As the same as the sewerage system, there are the daily routine and periodical work for the stormwater retention pond. Table 5-9 also summarises the basic guidelines.

5.6.4 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. In due consideration of the natures and features of the project facilities and in the light of the basic guidelines for operation and maintenance, the required equipment has been selected as listed up in Table 5-11. These equipment shall be kept and maintained under the WSD.

In addition, it is also proposed to supplement some minor workshop equipment in order to facilitate the daily operation and maintenance work. The proposed equipment is also shown in Table 5-11.

Table 5-11 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 DO 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)

5.7 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. The Project is basically designed with the waste stabilization pond treatment process and it is expected that its effluent would meet the water quality standards required for such productive activities as irrigated agriculture and aquaculture.

Especially it may be predictable that the development of irrigated agriculture would increase the dosage volume of fertilizers and agro-chemicals to increase crop yield and it is supposed that drainage water from the irrigated lands may contain a certain amount of their residuals and fish cultivated in WSP will not be suitable for consumption by human beings. Such phenomena contravenes the primary purpose of the Project and accordingly under this Study it is not positively suggested to re-use treated sewage. It is necessary to carry out more investigation and study in future.

5.8 Land Requirement

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

Table 5-12 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

As is clear from DWGs. N-1 and T-1, it is unavoidable to locate the new facilities beyond the existing sewage treatment works boundaries. The GOK will be required to proceed with legal process for land acquisition.

6. CONSTRUCTION PLAN AND COST ESTIMATE

6.1 Implementation Schedule

The Project will be realized through the process of financial arrangement, detailed design including additional survey, competitive bidding for procurement of contractor and construction works. It will be brought into operation at the 23rd month at the earliest although it is largely subject to the period required for financial arrangement. Since the Project is of urgent nature, it is strongly recommend that the GOK takes immediate action necessary for financial arrangement.

6.2 Mode of Construction

The construction works of the project will be executed by a contractor selected through a competitive bidding. It will be supervised by the Project Office, which is proposed to be organized specifically for the purpose of the Project as described in Chapter 7 of this report.

6.3 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. Based on the preliminary design, bill of quantities is prepared for the respective category as presented in Supporting Report J in Volume IV. Among the above six categories, construction works at both Njoro and Town STWs are substantial and their major construction quantities are estimated as follows:

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)

For the above major construction items, it is planned to adopt the following construction plans:

(1) Land clearing

The land clearing and stripping are planned to be made to a depth of 15 cm below the original ground surface and will be executed by bulldozers of 21 ton-class.

(2) Excavation

The excavation work will be executed by 21 ton-class bulldozers and carried out after land clearing and stripping. The excavated material will be loaded on 11 ton-class dump trucks by 1.8 m^3-class crawler loader and transported to the designated embankment places. When embankment site is within a distance of 60 m from the excavation site, it is rational and efficient to perform the embankment directly by the bulldozers used for the excavation.

(3) Embankment

The embankment will be constructed by using the excavated materials and will be carried out in parallel with the excavation works without temporary stock piling as much as possible. The dumped material will be spread over the embankment area and, in compliance with result of soil test, vibratory roller will basically be employed for compaction of soil. In order to ensure more than 95% in dry density, moisture control is essential so that 8 ton-class water tanker will be required to be mobilized. The embankment works will be suspended when daily rainfall exceeds 5 mm/day.

(4) Dredging work

Dredging work is required only for existing west stabilization ponds. Due to nature of work, it is planned to be carried out only during the dry season. Pump dredge by 1.5 m^3/min-class will be employed and dredged materials will be transported to a temporary drying beds by 11 ton-class dump trucks in order to reduce the water content to appropriate level. Dried material will then again hauled to the dumping site, which should be selected and designated by the NMC prior to commencement of the construction work.

6.4 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. It is proposed to proceed with the construction works of the six categories in parallel with each other to complete all the works within a given period.

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 sewage sewage treatment and thus require a systematic construction sequence. The following is a milestone during the construction sequence.

(1) Njoro STW

The Njoro STW includes the construction of additional treatment facilities such as rock filters and grass plot and remodeling of existing waste stabilization ponds. It is premised that the 6,000 m^3/day line is already in operation. The milestones are identified as follows:

(a) To divert all the inflowing sewage into the new 6,000 m^3/day line at beginning to allow construction of the additional treatment facilities and dredging of the ponds at the 3,600 m^3/day line.

(b) To complete the construction of the additional treatment facilities at the 6,000 m^3/day line.

(c) To complete the dredging work of the existing 3,600 m^3/day line within the initial 3-month period to complete its remodeling works.

(d) To re-divert the sewage amounting to 3,600 m^3/day into the remodeled ponds.

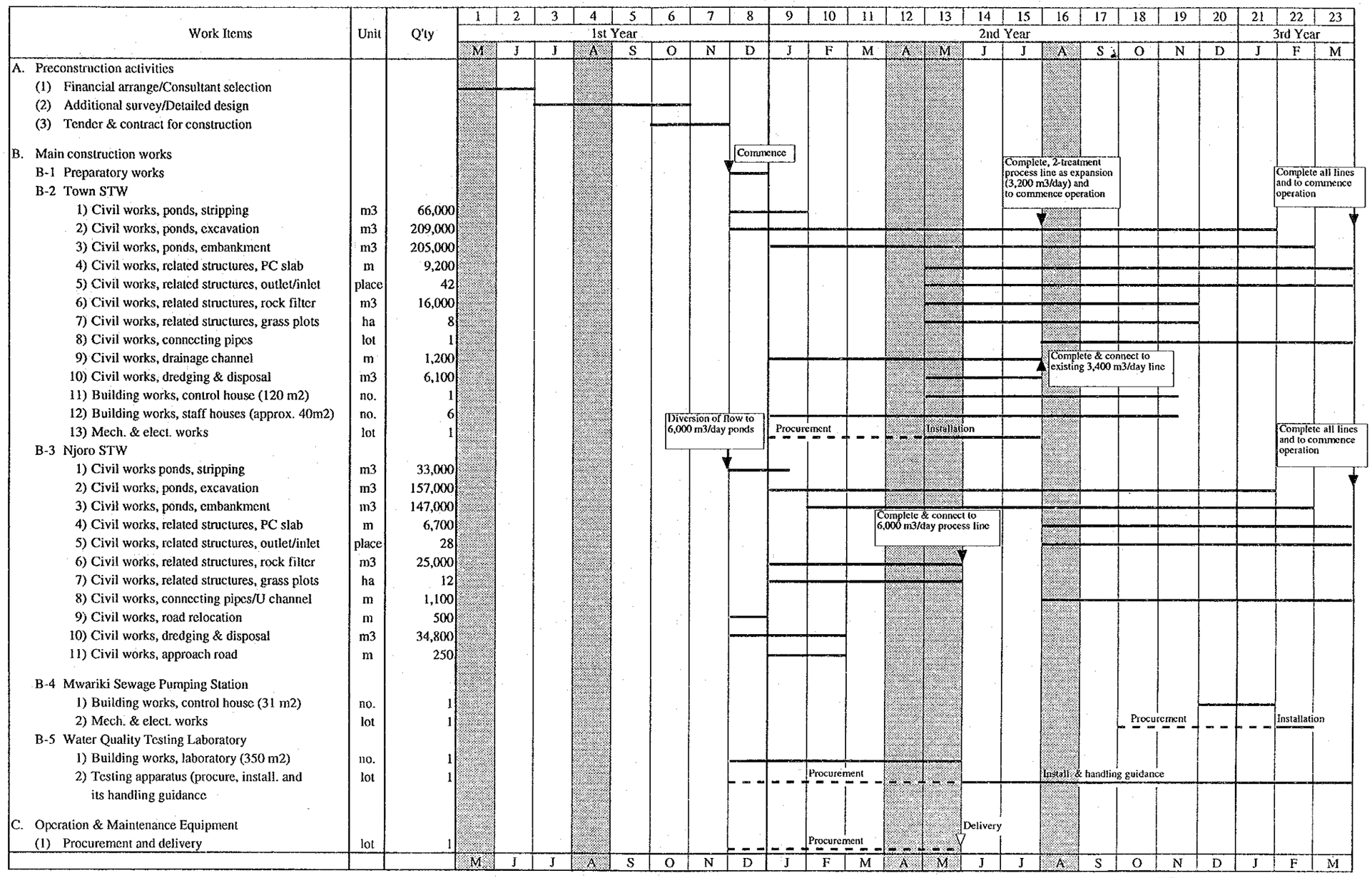
(2) Town STW

The Town STW includes the constructions of the new treatment works with a capacity of 3,200 m^3/day and additional treatment facilities to be connected to the 3,400 m^3/day line. The following milestones are anticipated:

Fig 6-1

Construction Time Schedule for Nakuru Sewage Expansion & Rehabilitation Project

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

(a) To complete the construction of the 3,200 m^3/day line at the first to allow the construction of the additional treatment facilities for the existing 3,400 m^3/day line.

(b) To divert the entire inflowing sewage into the 3,200 m^3/day line and to complete the construction of the additional treatment facilities required for the 3,400 m^3/day line.

(c) To put into the 3,400 m^3/day line into operation.

6.5 Cost Estimate

6.5.1 Construction Cost

The construction cost is estimated in accordance with the JICA guidelines and based on the prices of construction materials and equipment, labour wages, etc. prevailing as of November 1993. Details of the cost estimate method is reported in Supporting Report J in Volume IV.

The construction cost is divided into five major categories and cost is estimated for each category as summarized below:

(1) Direct construction cost

This is further divided into two sub-categories as follows:

(a) Preparatory works

The preliminary items cover the costs necessary for bonds, insurances, contractor's camp, and offices, temporary access road, etc.

The general items cover the Project Offices, transportation facilities, temporary bridges, maintenance of existing roads and bridges and other incidentals.

The preliminary and general items are estimated on the basis of lump sum.

(b) Direct construction cost

It is estimated based on the quantities of the respective work items and the corresponding unit rate. The unit rate is estimated based on labour cost, costs of construction materials and equipment, and contractor's overhead and profit.

The unit prices of construction materials and labour wages are based on the results of the survey, which was carried out in September 1994 in Nairobi and Nakuru.

The value added tax will be imposed by the GOK. It is taken at 18% of the sum of the direct cost in accordance with the present regulation.

(2) Land acquisition and compensation cost

No land acquisition cost is allowed since the proposed sites are all designated as public lands. The compensation cost is however estimated for crops being cultivated at the proposed sites.

(3) Administration expenses

The executing agency incurs a certain amount of expense in the project execution. It is assumed to be 5% of the direct construction cost.

(4) Engineering services

The engineering services will be required for detailed design, pre-construction activities and construction supervision. It is also assumed to be 12% of the direct construction cost.

(5) Contingency

The contingency comprises physical contingency and price contingency. The former is assumed to be 10% of the direct construction cost. The later is assumed to be 2.3% per annum for foreign currency portion and 4.2% per annum for local currency portion, making reference to such statistics as International Financial Statistics (Oct. 1993), Consumer Price Index in Kenya, etc.

The estimated construction cost is shown in Table 6-2. It is divided into foreign and local currency components. Rates of exchange were taken at US$1.00 = Kshs. 62.40 = Yen 109.75. The annual disbursement schedule is as shown 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	11	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	466	871	1,337
	Total	11,201	11,629	22,830

(Data source: Study Team)

Table 6-3 Annual Disbursement Schedule

(Unit: US$10^3)

Year	Foreign Currency	Local Currency	Total Equivalent
1994	2,550	2,523	5,073
1995	7,502	7,789	15,291
1996	1,149	1,317	2,466
Total	11,201	11,629	22,830

(Data source: Study Team)

6.5.2 Operation and Maintenance Cost

The annual operation and maintenance costs comprising the salaries of operation and maintenance staff, materials, costs for repair and maintenance of equipment, and the running costs for the project facilities 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. The UDD will keep a close coordination and liaison with the WSD through out the period of the project implementation. Both the KWS and MOLRRWD would be required to extend various assistance and cooperation.

For the purpose of the construction of the project, it is proposed to construct a project office in the vincity of the Town STW. The Project Office will be headed by a Project Manager and composed of Administration, Accounting and Engineering Departments as shown in Fig. 7-1.

The basic function of the Project Office will be, but not limited to 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;
(4) to execute the construction supervisory works;
(5) to undertake accounting and auditing of the contract works.

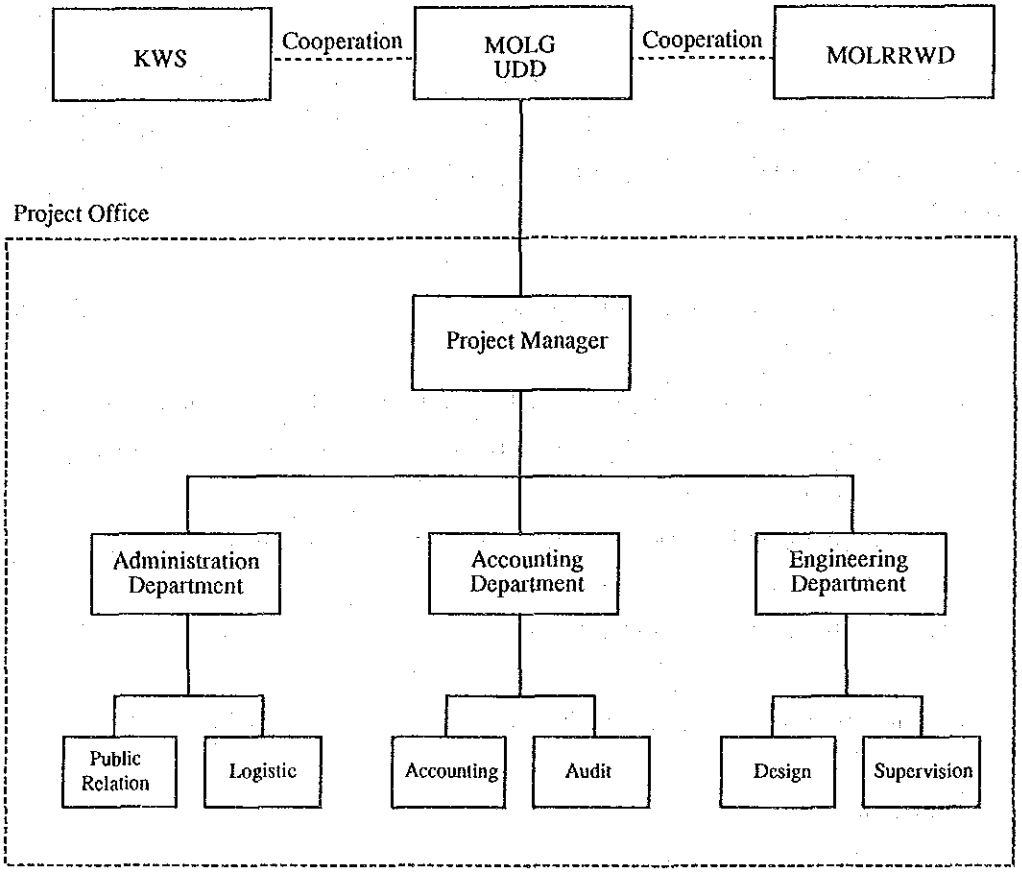
7.2 Organization for Operation and Maintenance of the Project

7.2.1 Roles of WSD

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.

The WSD is responsible for management and administration of water supply and sewerage affairs within the Nakuru Municipality and is one of seven departments of NMC. It was established in 1992 vide the Council Minutes.

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

Main roles of WSD are as follows:

(1) To supply safe and reliable portable water
(2) To plan, design, operate and maintain efficiently water distribution and sewerage systems
(3) To operate sewage treatment works so as to conform with the acceptable effluent standards
(4) To operate a self financing enterprise that will allow sufficient financial reserve for development and proper preventive maintenance of water supply and sewerage services
(5) To implement an efficient billing and revenue collection system and to maintain a sound accounting system

7.2.2 Proposed Organization and Staffing

For successful implementation of the Trade Effluent by-Laws it is proposed to organize a Trade Effluent Control Unit (TECU) within the WSD. It is also proposed that the Sewage Works Section be divided into Njoro and Town Sewage Works Sub-sections for responsible operation and maintenance. The proposed organization is as shown in Fig. 7-2 and the proposed staffing in Table 7-1. The total number of the staff is 76, comprising 3 in Sewage Work Section, 14 at Njoro STW, 12 at Town STW, 34 in Sewers section, and 13 in TECU.

7.2.3 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 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.

7.2.4 Office Accommodation

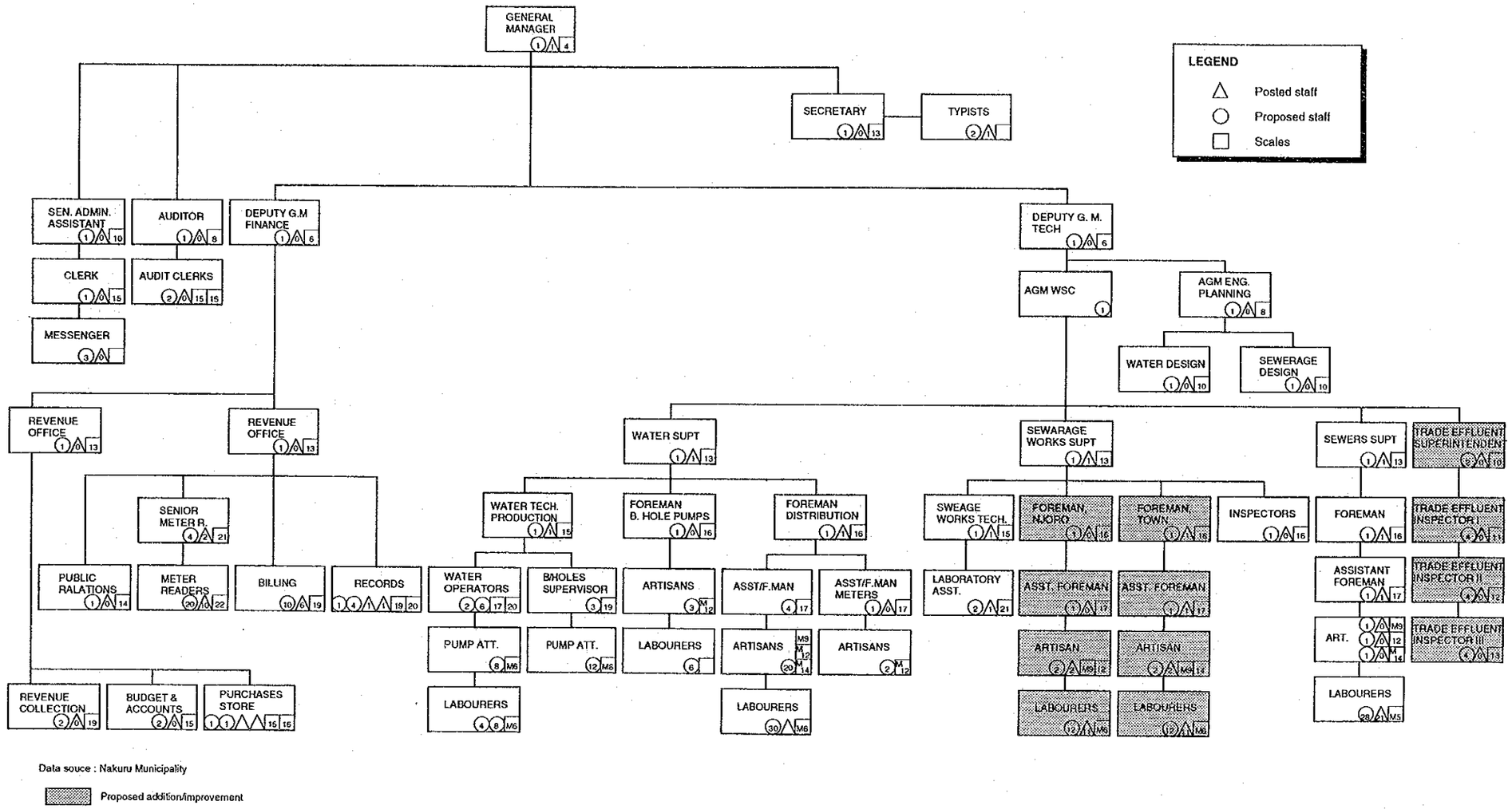
The WSD is not provided with a sufficient office space to accommodate its key staff. In order to attain autonomy of WSD and perform efficient and rational management and administration, NMC is expected to take up necessary action.

Table 7-1 Proposed Staffing for Sewerage Sector

	Positions	Proposed	Posted	Proposed for 1993/94	Vacant
(a)	Assistant General Manager, Water and Sewerage Quality Control	1	0	0	1
(b)	Sewage Works Section				
	b.1 Sewage Works Superintendent	1	1	0	0
	b.2 Sewage Works Technician	1	1	0	0
	b.3 Inspectors	1	0	1	0
(c)	Njoro Sewage Works Sub-section				
	c.1 Foreman	1	0	0	1
	c.2 Assistant Foreman	1	0	0	1
	c.3 Artisan	2	(2)	0	0
	c.4 Labourers	10	(10)	0	0
(d)	Town Sewage Works Sub-section				
	d.1 Foreman	1	1	0	0
	d.2 Assistant Foreman	1	0	0	1
	d.3 Artisan	2	(2)	0	0
	d.4 Labourers	8	(8)	0	0
(e)	Sewers Section				
	e.1 Sewer Superintendent	1	1	0	0
	e.2 Sewer Foreman	1	1	0	0
	c.3 Asst. Sewer Foreman	1	1	0	0
	e.4 Artisans	3	0	3	0
	e.5 Labourers	28	21	4	3
(f)	TECU				
	f.1 Trade Effluent Superintendent	2	0	0	2
	f.2 Trade Effluent Inspector I	4	0	0	4
	f.3 Trade Effluent Inspector II	4	0	0	4
	f.4 Trade Effluent Inspector III	4	0	0	4

(Data source: WSD and Study Team)

Fig 7 - 2



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

8. ENVIRONMENTAL IMPACT ASSESSMENT

8.1 Introduction

8.1.1 General Description

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, although the KWS has been laying a great efforts on preservation and conservation under international assistances. It is therefore inevitable to assess the environmental impact of the project only qualitatively based on the data and information made available so far.

The field investigation was carried out during the period from June to September 1993 and its major effort was concentrated on collection of data and information and formulation of environmental impact assessment form (EIA form) through a number of discussions among the MOLG, NES and Study Team. The EIA is accordingly made in accordance with established criteria and its details are reported in Supporting Report L in Volume III.

8.1.2 Objective Area and Conditions for EIA

There are two areas to be objective of the environmental impact assessment. One is the sites of both Njoro and Town STWs, where the actual construction works take place for installation of sewage treatment facilities, and the other is Lake Nakuru, being beneficiary of the Project.

The environmental impact assessment was conducted for two conditions: one is the construction period and the other is the operation period.

8.2 Environmental Impact Assessment

The summary of environmental impact assessment are shown in Table 8-1.

The contemplated Project contributes not only to alleviate pollution loads into Lake Nakuru but also make it possible to commence the additional water supply of 13,300 m^3/day to the Nakuru Municipality. It is foreseeable that adverse environmental impacts resulting

from the installation of a waste stabilization pond system will be kept minimal, and the positive impacts, such as alleviation of water pollution, will greatly outweigh any potential negative impacts such as odour nuisance or sludge generation.

Table 8-1 Summary of Environmental Impact Assessment (1/2)

	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 pollution	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. Excess soil will not be generated so much.	
	6. Sludge Disposal	2	The construction work includes de-sludgging 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.

Note: Level of impact : 1-a No impact by the Project
1-b No impact after countermeasure
2 Minor impact

Table 8-1 Summary of Environmental Impact Assessment (2/2)

	Check Items	Impact	Problems	Action & Counter Measure
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 Proposed Works (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 the Project
1-b No impact after countermeasure
2 Minor impact

Some items are forecast to be subject to minor impact. The mitigation method is studied and proposed for the respective item as described in Section 8.3.

8.3 Environmental Impact Mitigation Methods

(1) Drainage Pit & Sedimentation Pond

Muddy water flow may cause the impact on the downstream water body. As the mitigation measure of muddy water treatment, drainage pit and sedimentation ponds should be constructed at the construction sites during the construction period. Even the short retention period in the sedimentation pond shall improve the quality of muddy water.

(2) Sludge Disposal System

Existing garbage disposal site is located at the points about 8 km from Lake Nakuru. Pollution released from the garbage site may discharge into Lake Nakuru through the groundwater aquifer. The suitable garbage disposal site should be selected by NMC.

The sludge accumulated in the existing waste stabilization ponds, and the sludge generated from anaerobic pond during operation period should be treated properly. Suitable sludge disposal site and sludge convey system are required. The sludge disposal site is preferred to be identified away from Lake Nakuru in the view point of Lake Nakuru conservation.

(3) Regreening on Excavation Area

The major construction work of this project is earth works such as stripping, excavation and embankment. Open grass land which cover the construction sites will be destroyed. As counter measure for slope erosion, "vegetation restoration" and deterioration of landscape, regreening on the embankment and excavated area are required.

(4) Tree Belt Planting

At present offensive odour is not considered to be problem. Nobody complain such issue at present, although actually offensive odour is generated from existing anaerobic ponds. Tree planting around the anaerobic pond is recommendable not only for offensive odour mitigation, but for landscape improvement.

(5) Cooperation with KWS

The construction schedule and method should be discussed with KWS prior to commencement of the construction works in order to minimize the impact of the construction work on fauna and flora in the park. The meeting and discussion should be continued with KWS throughout the construction period in order to assess the impact and to feed back such impact for construction work.

(6) Working Environmental

Infrastructure for working persons at the construction site should be established properly, especially wastewater and garbage treatment facilities. Wastewater and garbage generated from working persons may cause the impact on downstream waterbody.

9. FINANCIAL AND ECONOMIC EVALUATION

9.1 Financial Evaluation

9.1.1 Conditions and Assumptions for Financial Estimation

The total amount of the project construction costs was estimated at KShs. 1,427 million. This capital for investment is assumed to be procured as follows on consideration of the credit system for sewage development in Kenya.

Case 1: Procurement of a loan through Local Government Loans Authority (LGLA). A repayment period is 30 years without grace period. This case is further divided into two cases under the terms of interest.

Case 1-A: Under the lowest interest rate of 7% per annum; and
Case 1-B: Under the highest interest rate of 13% per annum.

Case 2: Procurement of a grant through the central government under the condition of foreign assistance.

The operation and maintenance (O&M) costs was estimated at KShs. 6.4 million per annum after the completion of the construction works. These costs were assumed to escalate annually at 4.2% for local currency portion and 2.3% for foreign currency potion. Incidentally, the physical life of the facility is assumed at 30 years.

The revenue through sewage treatment services is assumed to be the same composition as projected in "Estimates for 1993/94-Report of Finance, Staff and General Purposes Committee (Budget) Meeting". The income in the fiscal year 1992/93 is estimated at KShs. 12.9 million. The rate of charges for water supply and sewage treatment services is revised as proposed in Table 9-1. The designed volume is 8,185 m^3/day under the present condition. Since this volume is calculated to 2,988 m^3/year at dry weather flow, the analytical unit price is estimated at KShs. 4.31/m^3. With the project implementation, this volume is estimated about 16,200 m^3/day. The total annual income is calculated as a product of the annual sewage volume and the unit price which is arranged through price escalation.

Table 9-1 Rate of Charges for Water Supply and Sewage Treatment Services

Item		Approved 1989/90	Approved 1990/91	Approved 1991/92	Approved 1992/93	Proposed 1993/94
1. Water Deposits						
(a) Institutions		-	-	-	-	1000.00
(b) Industries		-	-	-	-	3000.00
(c) Commercial users		660.00	800.00	800.00	800.00	2000.00
(d) Domestic users per family		500.00	600.00	600.00	600.00	1000.00
2. Meter Rents per Month	[Classification 1993/94]					
(a) 1/2" and including 1"	1/2"	9.20	9.70	10.00	10.00	45.00
(b) over 1" and Including 2"	1" and 1.5"	16.00	16.00	18.00	18.00	55.00
(c) over 2" and Including 3"	2" and 2.5"	27.00	27.00	29.00	29.00	80.00
(d) over 3" and Including 4"	3"	40.00	40.00	45.00	45.00	150.00
(e) over 4"	4"	50.00	50.00	55.00	55.00	300.00
(f) -	over 4"	-	-	-	-	400.00
3. Reconnection Fee						
(a) 1/2"		70.00	70.00	70.00	70.00	100.00
(b) over 1" and Including 2"		160.00	160.00	165.00	165.00	250.00
(c) over 2" to 4"		310.00	310.00	315.00	315.00	450.00
4. Turning Off/On Fee per Visit		25.00	25.00	50.00	50.00	75.00
5. Special Reading Fee per Visit		60.00	60.00	65.00	65.00	80.00
6. Damage to Meter - Cost Plus 25%		+20%	+20%	+20%	+50%	+60%
7. Penalty on Tampering with Council Water Supply		500.00	500.00	700.00	1,500.00	2,500.00
8. Meter Testing at Consumers Request Where It Is Not Found to Register Incorrectly 5% Either Way - Minimum Charge		-	-	-	60.00	60.00
9. Water Application Forms (each)		-	-	-	100.00	180.00
10. Penalty on Tempering with Meter Seals		-	-	-	-	600.00
11. Sewer Unblocking Vehicle (Cannon Jet)		-	-	-	-	2000.00
12. Water Charges - Premises Connected to Sewer						
(a) Minimum charge 3000 litres		19.70	19.70	19.70	19.70	36.00
(b) Each 1000 litres consumed in excess of 3000 litres		2.00	2.50	2.50	3.50	7.50
13. Water Charges - Premises Not Connected to Sewer						
(a) Minimum charge 3000 litres		19.70	19.70	19.70	19.70	36.00
(b) Each 1000 litres consumed in excess of 3000 litres		2.00	2.50	2.50	3.50	6.50
14. Water Charges - Outside Municipality / Peri-Urban Supply						
(a) Minimum charge 3000 litres		105.00	105.00	105.00	105.00	200.00
(b) Each 1000 litres consumed in excess of 3000 litres		3.35	4.25	4.25	4.25	7.50
Turning off/on fee per visit		25.00	25.00	100.00	100.00	200.00
Reconnection fee	- 1/2"	70.00	70.00	120.00	120.00	300.00
	- 1"	160.00	160.00	200.00	200.00	400.00
	- Over 1"	310.00	310.00	350.00	350.00	550.00
(c) Sale of water per drum		-	-	-	-	40.00
(d) Water application form for areas outside Municipality		-	-	-	-	250.00
(e) Emptying of septic into sewer line		-	-	-	-	100.00

(Source : Municipal Council of Nakuru)

9.1.2 Financial Evaluation

(1) Financial Soundness of Undertaker

Financial internal rate of return (FIRR) for gross capital was 1.8%, as shown in Table 9-2. This rate is far smaller than the interest rates of 7% to 13%, which LGLA applies to local authorities for capital investment. Thus, from the financial point of view, this Project might be not viable as far as the WSD procures the investment capital through LGLA. In order to make the Project feasible, it would be necessary to introduce special funds and/or grants for relieve the burden of repayment and interest of loan.

Financial stream of revenue and expenditure is shown in Tables 9-3 to 9-4. In Case 1-A, the negative cash balance will continue to the 23rd year, as shown in Table 9-3. By the end of the physical facility life, the accumulated deficit will become KShs. 1,006.2 million. Accordingly, to manage the sewage service soundly, the WSD must employ the following two countermeasures: (1) to receive subsidies from the municipal finance and/or the central government finance; and (2) to increase sewage unit price to around 40% more than the present level. Applying the second measure, the accumulated balance would change into the black within the facility life. In Case 1-B in the same manner, the sewage unit price must be increased to about 90% more than the present prices.

In Case 2, the both balances of capital and revenue can keep sound financial condition until the end of the facility life. In this case, the accumulated profits could be inserted into municipal finance.

(2) Household Budget of Domestic User

An average family size of middle income class in Nakuru Municipality is 5.6, according to the questionnaire survey in 1993. This average family might consume domestic water of about 15.12 m^3/month. In this case, the family must pay KShs. 171.90/month for water and sewage service charge including meter rent, applying the water rate of 1993/94 in Table 9-1.

In the same manner, if a family belongs to low income class, the average family size is 4.3. If consumes 5.16 m^3 monthly in total, this family must pay KShs. 52.20 for water and sewage service charge excluding meter rent.

Table 9-2 Financial Cost and Revenue Stream

(Unit: KShs. million)

Year	Cost			Revenue	Balance
	Initial Construction Works	O&M Works	Total		
1	316.4	4.8	321.2	18.2	-303.0
2	957.3	5.0	962.3	19.0	-943.3
3	153.6	5.2	158.9	19.8	-139.1
4		7.5	7.5	40.7	33.2
5		7.8	7.8	42.4	34.6
6		8.2	8.2	44.2	36.0
7		8.5	8.5	46.0	37.5
8		8.8	8.8	48.0	39.1
9		9.2	9.2	50.0	40.8
10		9.6	9.6	52.1	42.5
11		9.9	9.9	54.3	44.3
12		10.3	10.3	56.5	46.2
13		10.8	10.8	58.9	48.2
14		11.2	11.2	61.4	50.2
15		11.6	11.6	64.0	52.3
16		12.1	12.1	66.7	54.5
17		12.6	12.6	69.5	56.9
18		13.1	13.1	72.4	59.3
19		13.7	13.7	75.4	61.8
20		14.2	14.2	78.6	64.4
21		14.8	14.8	81.9	67.1
22		15.4	15.4	85.3	69.9
23		16.0	16.0	88.9	72.9
24		16.7	16.7	92.6	76.0
25		17.3	17.3	96.5	79.2
26		18.1	18.1	100.6	82.5
27		18.8	18.8	104.8	86.0
28		19.6	19.6	109.2	89.7
29		20.4	20.4	113.8	93.5
30		21.2	21.2	118.6	97.4
31		22.1	22.1	123.6	101.5
32		23.0	23.0	128.8	105.8
33		23.9	23.9	134.2	110.3

FIRR: 1.8%

Table 9-3 Financial Stream of Income and Expenditure: Case 1-A

(Unit: Shs. million)

Year	Capital Balance					Revenue Balance								Cash Balance *1	Accumulated Cash Balance
	Income	Expenditure			Balance	Income			Expenditure				Balance		
	LGLA Loan	Construc-tion Cost	Repayment of Loan	Total		Sewage Charge	Other Income	Total	Operation & Maintenance	Depreciation *2	Interest of Loan	Total			
1	316.4	316.4	0.0	316.4	0.0	18.1	0.1	18.2	6.2	0.0	22.1	28.3	-10.1	-10.1	-10.1
2	957.3	957.3	10.5	967.9	-10.5	18.9	0.1	19.0	6.4	0.0	88.4	94.8	-75.8	-86.4	-96.4
3	153.6	153.6	42.5	196.1	-42.5	19.7	0.1	19.8	6.7	0.0	96.2	102.9	-83.1	-125.5	-222.0
4			47.6	47.6	-47.6	40.5	0.2	40.7	7.6	47.6	92.9	148.0	-107.3	-107.3	-329.3
5			47.6	47.6	-47.6	42.2	0.2	42.4	7.9	47.6	89.5	145.0	-102.6	-102.6	-431.9
6			47.6	47.6	-47.6	44.0	0.2	44.2	8.2	47.6	86.2	142.0	-97.8	-97.8	-529.7
7			47.6	47.6	-47.6	45.8	0.2	46.0	8.5	47.6	82.9	139.0	-92.9	-92.9	-622.6
8			47.6	47.6	-47.6	47.7	0.2	48.0	8.9	47.6	79.6	136.0	-88.0	-88.0	-710.6
9			47.6	47.6	-47.6	49.7	0.3	50.0	9.2	47.6	76.2	133.0	-83.0	-83.0	-793.7
10			47.6	47.6	-47.6	51.8	0.3	52.1	9.6	47.6	72.9	130.1	-78.0	-78.0	-871.7
11			47.6	47.6	-47.6	54.0	0.3	54.3	10.0	47.6	69.6	127.1	-72.8	-72.8	-944.5
12			47.6	47.6	-47.6	56.3	0.3	56.5	10.4	47.6	66.2	124.2	-67.6	-67.6	-1,012.1
13			47.6	47.6	-47.6	58.6	0.3	58.9	10.8	47.6	62.9	121.3	-62.4	-62.4	-1,074.5
14			47.6	47.6	-47.6	61.1	0.3	61.4	11.2	47.6	59.6	118.4	-57.0	-57.0	-1,131.5
15			47.6	47.6	-47.6	63.7	0.3	64.0	11.7	47.6	56.2	115.5	-51.5	-51.5	-1,183.0
16			47.6	47.6	-47.6	66.3	0.3	66.7	12.2	47.6	52.9	112.7	-46.0	-46.0	-1,229.0
17			47.6	47.6	-47.6	69.1	0.4	69.5	12.7	47.6	49.6	109.8	-40.3	-40.3	-1,269.3
18			47.6	47.6	-47.6	72.0	0.4	72.4	13.2	47.6	46.2	107.0	-34.6	-34.6	-1,304.0
19			47.6	47.6	-47.6	75.0	0.4	75.4	13.7	47.6	42.9	104.2	-28.8	-28.8	-1,332.7
20			47.6	47.6	-47.6	78.2	0.4	78.6	14.3	47.6	39.6	101.4	-22.8	-22.8	-1,355.6
21			47.6	47.6	-47.6	81.5	0.4	81.9	14.8	47.6	36.3	98.7	-16.8	-16.8	-1,372.4
22			47.6	47.6	-47.6	84.9	0.4	85.3	15.4	47.6	32.9	96.0	-10.6	-10.6	-1,383.0
23			47.6	47.6	-47.6	88.5	0.5	88.9	16.1	47.6	29.6	93.2	-4.3	-4.3	-1,387.3
24			47.6	47.6	-47.6	92.2	0.5	92.6	16.7	47.6	26.3	90.6	2.1	2.1	-1,385.2
25			47.6	47.6	-47.6	96.0	0.5	96.5	17.4	47.6	22.9	87.9	8.6	8.6	-1,376.6
26			47.6	47.6	-47.6	100.1	0.5	100.6	18.1	47.6	19.6	85.3	15.3	15.3	-1,361.3
27			47.6	47.6	-47.6	104.3	0.5	104.8	18.9	47.6	16.3	82.7	22.1	22.1	-1,339.2
28			47.6	47.6	-47.6	108.7	0.6	109.2	19.6	47.6	12.9	80.2	29.1	29.1	-1,310.2
29			47.6	47.6	-47.6	113.2	0.6	113.8	20.4	47.6	9.6	77.6	36.2	36.2	-1,274.0
30			47.6	47.6	-47.6	118.0	0.6	118.6	21.3	47.6	6.3	75.1	43.5	43.5	-1,230.5
31			47.6	47.6	-47.6	122.9	0.6	123.6	22.1	47.6	3.0	72.7	50.9	50.9	-1,179.6
32			37.0	37.0	-37.0	128.1	0.7	128.8	23.0	47.6	0.4	71.0	57.8	68.3	-1,111.3
33			5.1	5.1	-5.1	133.5	0.7	134.2	24.0	47.6	0.0	71.6	62.6	105.1	-1,006.2

Remark : *1 (Capital Balance)+(Revenue Balance)+(Depreciation)

*2 Loan charges of K£64,053 is assumed to be inclueded in the O&M cost till the 26th year.

Table 9-4 Financial Stream of Income and Expenditure: Case 1-B

(Unit: Shs. million)

Year	Capital Balance					Revenue Balance								Cash Balance *1	Accumulated Cash Balance
	Income	Expenditure			Balance	Income			Expenditure				Balance		
	LGLA Loan	Construc-tion Cost	Repayment of Loan	Total		Sewage Charge	Other Income	Total	Maintenance & Operation	Deprecia-tion *2	Interest of Loan	Total			
1	316.4	316.4	0.0	316.4	0.0	18.1	0.1	18.2	6.2	0.0	41.1	47.3	-29.1	-29.1	-29.1
2	957.3	957.3	10.5	967.9	-10.5	18.9	0.1	19.0	6.4	0.0	164.2	170.6	-151.6	-162.2	-191.2
3	153.6	153.6	42.5	196.1	-42.5	19.7	0.1	19.8	6.7	0.0	178.7	185.3	-165.5	-208.0	-399.2
4			47.6	47.6	-47.6	40.5	0.2	40.7	7.6	47.6	172.5	227.6	-186.9	-186.9	-586.1
5			47.6	47.6	-47.6	42.2	0.2	42.4	7.9	47.6	166.3	221.7	-179.3	-179.3	-765.5
6			47.6	47.6	-47.6	44.0	0.2	44.2	8.2	47.6	160.1	215.9	-171.7	-171.7	-937.2
7			47.6	47.6	-47.6	45.8	0.2	46.0	8.5	47.6	153.9	210.0	-164.0	-164.0	-1,101.2
8			47.6	47.6	-47.6	47.7	0.2	48.0	8.9	47.6	147.7	204.2	-156.2	-156.2	-1,257.4
9			47.6	47.6	-47.6	49.7	0.3	50.0	9.2	47.6	141.6	198.3	-148.4	-148.4	-1,405.7
10			47.6	47.6	-47.6	51.8	0.3	52.1	9.6	47.6	135.4	192.5	-140.5	-140.5	-1,546.2
11			47.6	47.6	-47.6	54.0	0.3	54.3	10.0	47.6	129.2	186.7	-132.5	-132.5	-1,678.6
12			47.6	47.6	-47.6	56.3	0.3	56.5	10.4	47.6	123.0	181.0	-124.4	-124.4	-1,803.1
13			47.6	47.6	-47.6	58.6	0.3	58.9	10.8	47.6	116.8	175.2	-116.3	-116.3	-1,919.3
14			47.6	47.6	-47.6	61.1	0.3	61.4	11.2	47.6	110.6	169.4	-108.0	-108.0	-2,027.4
15			47.6	47.6	-47.6	63.7	0.3	64.0	11.7	47.6	104.4	163.7	-99.7	-99.7	-2,127.1
16			47.6	47.6	-47.6	66.3	0.3	66.7	12.2	47.6	98.3	158.0	-91.3	-91.3	-2,218.4
17			47.6	47.6	-47.6	69.1	0.4	69.5	12.7	47.6	92.1	152.3	-82.8	-82.8	-2,301.3
18			47.6	47.6	-47.6	72.0	0.4	72.4	13.2	47.6	85.9	146.6	-74.3	-74.3	-2,375.5
19			47.6	47.6	-47.6	75.0	0.4	75.4	13.7	47.6	79.7	141.0	-65.6	-65.6	-2,441.1
20			47.6	47.6	-47.6	78.2	0.4	78.6	14.3	47.6	73.5	135.4	-56.8	-56.8	-2,497.9
21			47.6	47.6	-47.6	81.5	0.4	81.9	14.8	47.6	67.3	129.8	-47.9	-47.9	-2,545.7
22			47.6	47.6	-47.6	84.9	0.4	85.3	15.4	47.6	61.1	124.2	-38.8	-38.8	-2,584.6
23			47.6	47.6	-47.6	88.5	0.5	88.9	16.1	47.6	55.0	118.6	-29.7	-29.7	-2,614.3
24			47.6	47.6	-47.6	92.2	0.5	92.6	16.7	47.6	48.8	113.1	-20.4	-20.4	-2,634.7
25			47.6	47.6	-47.6	96.0	0.5	96.5	17.4	47.6	42.6	107.6	-11.0	-11.0	-2,645.8
26			47.6	47.6	-47.6	100.1	0.5	100.6	18.1	47.6	36.4	102.1	-1.5	-1.5	-2,647.3
27			47.6	47.6	-47.6	104.3	0.5	104.8	18.9	47.6	30.2	96.7	8.2	8.2	-2,639.1
28			47.6	47.6	-47.6	108.7	0.6	109.2	19.6	47.6	24.0	91.2	18.0	18.0	-2,621.1
29			47.6	47.6	-47.6	113.2	0.6	113.8	20.4	47.6	17.9	85.9	27.9	27.9	-2,593.2
30			47.6	47.6	-47.6	118.0	0.6	118.6	21.3	47.6	11.7	80.5	38.1	38.1	-2,555.1
31			47.6	47.6	-47.6	122.9	0.6	123.6	22.1	47.6	5.5	75.2	48.4	48.4	-2,506.7
32			37.0	37.0	-37.0	128.1	0.7	128.8	23.0	47.6	0.7	71.3	57.5	68.0	-2,438.7
33			5.1	5.1	-5.1	133.5	0.7	134.2	24.0	47.6	0.0	71.6	62.6	105.1	-2,333.6

Remark : *1 (Capital Balance)+(Revenue Balance)+(Depreciation)

*2 Loan charges of K£64,053 is assumed to be inclueded in the O&M cost till the 26th year.

Table 9-5 Financial Stream of Income and Expenditure: Case 2

(Unit: Shs. million)

Year	Capital Balance					Revenue Balance								Cash Balance *1	Accumulated Cash Balance
	Income	Expenditure			Balance	Income			Expenditure				Balance		
	Foreign Grant	Construc-tion Cost	Repayment of Loan	Total		Sewage Charge	Other Income	Total	Maintenance & Operation	Deprecia-tion*2	Interest of Loan	Total			
1	316.4	316.4	0.0	316.4	0.0	18.1	0.1	18.2	6.2	0.0	0.0	6.2	12.1	12.1	12.1
2	957.3	957.3	0.0	957.3	0.0	18.9	0.1	19.0	6.4	0.0	0.0	6.4	12.6	12.6	24.7
3	153.6	153.6	0.0	153.6	0.0	19.7	0.1	19.8	6.7	0.0	0.0	6.7	13.1	13.1	37.8
4			0.0	0.0	0.0	40.5	0.2	40.7	7.6	0.0	0.0	7.6	33.1	33.1	70.9
5			0.0	0.0	0.0	42.2	0.2	42.4	7.9	0.0	0.0	7.9	34.5	34.5	105.5
6			0.0	0.0	0.0	44.0	0.2	44.2	8.2	0.0	0.0	8.2	36.0	36.0	141.5
7			0.0	0.0	0.0	45.8	0.2	46.0	8.5	0.0	0.0	8.5	37.5	37.5	179.0
8			0.0	0.0	0.0	47.7	0.2	48.0	8.9	0.0	0.0	8.9	39.1	39.1	218.1
9			0.0	0.0	0.0	49.7	0.3	50.0	9.2	0.0	0.0	9.2	40.8	40.8	258.8
10			0.0	0.0	0.0	51.8	0.3	52.1	9.6	0.0	0.0	9.6	42.5	42.5	301.3
11			0.0	0.0	0.0	54.0	0.3	54.3	10.0	0.0	0.0	10.0	44.3	44.3	345.6
12			0.0	0.0	0.0	56.3	0.3	56.5	10.4	0.0	0.0	10.4	46.2	46.2	391.8
13			0.0	0.0	0.0	58.6	0.3	58.9	10.8	0.0	0.0	10.8	48.1	48.1	439.9
14			0.0	0.0	0.0	61.1	0.3	61.4	11.2	0.0	0.0	11.2	50.2	50.2	490.1
15			0.0	0.0	0.0	63.7	0.3	64.0	11.7	0.0	0.0	11.7	52.3	52.3	542.4
16			0.0	0.0	0.0	66.3	0.3	66.7	12.2	0.0	0.0	12.2	54.5	54.5	596.9
17			0.0	0.0	0.0	69.1	0.4	69.5	12.7	0.0	0.0	12.7	56.8	56.8	653.7
18			0.0	0.0	0.0	72.0	0.4	72.4	13.2	0.0	0.0	13.2	59.2	59.2	712.9
19			0.0	0.0	0.0	75.0	0.4	75.4	13.7	0.0	0.0	13.7	61.7	61.7	774.6
20			0.0	0.0	0.0	78.2	0.4	78.6	14.3	0.0	0.0	14.3	64.3	64.3	838.9
21			0.0	0.0	0.0	81.5	0.4	81.9	14.8	0.0	0.0	14.8	67.0	67.0	906.0
22			0.0	0.0	0.0	84.9	0.4	85.3	15.4	0.0	0.0	15.4	69.9	69.9	975.8
23			0.0	0.0	0.0	88.5	0.5	88.9	16.1	0.0	0.0	16.1	72.8	72.8	1,048.7
24			0.0	0.0	0.0	92.2	0.5	92.6	16.7	0.0	0.0	16.7	75.9	75.9	1,124.6
25			0.0	0.0	0.0	96.0	0.5	96.5	17.4	0.0	0.0	17.4	79.1	79.1	1,203.7
26			0.0	0.0	0.0	100.1	0.5	100.6	18.1	0.0	0.0	18.1	82.5	82.5	1,286.2
27			0.0	0.0	0.0	104.3	0.5	104.8	18.9	0.0	0.0	18.9	86.0	86.0	1,372.2
28			0.0	0.0	0.0	108.7	0.6	109.2	19.6	0.0	0.0	19.6	89.6	89.6	1,461.7
29			0.0	0.0	0.0	113.2	0.6	113.8	20.4	0.0	0.0	20.4	93.4	93.4	1,555.1
30			0.0	0.0	0.0	118.0	0.6	118.6	21.3	0.0	0.0	21.3	97.3	97.3	1,652.4
31			0.0	0.0	0.0	122.9	0.6	123.6	22.1	0.0	0.0	22.1	101.4	101.4	1,753.9
32			0.0	0.0	0.0	128.1	0.7	128.8	23.0	0.0	0.0	23.0	105.7	105.7	1,859.6
33			0.0	0.0	0.0	133.5	0.7	134.2	24.0	0.0	0.0	24.0	110.2	110.2	1,969.8

Remark : *1 (Capital Balance)+(Revenue Balance)+(Depreciation)

*2 Depreciation is not added up because an entry of the assets granted should not be made in an account book as reduction entry.

An average household income in Nakuru is estimated at KShs. 6,690 in middle income class and at KShs. 5,020 in low income class in 1993, according to the survey. The above water and sewage service charges accounts for 2.6% for middle income family and 1.0% for low income family, respectively.

Central Bureau of Statistics (CBS) conducted "Urban Household Budget Survey" in 1983 in major municipalities and towns. In Nakuru, the survey results say that the water charge accounted for 1.5% of the income. Supposing that this percentage is a standard of water charge, the above percentages of middle income families exceed this standard level. These families would try to curtail water for saving money or to demand a reduction of water price to the WSD. On the other hand, the some water charges of low income families do not exceed this level. However, since KShs. 45/month of meter rent could be a heavy burden, the present communal distribution system has to be maintained for low income people even in the future.

These charges mentioned above were based on the current water rates as of the fiscal year 1993/94. As discussed in the previous section, the water rate must be raised to approximately 40% more than the current one in Case 1-A and to 90% in Case 1-B, if the deficit of management is covered by a raising of the water rates only. In these cases, middle income people could not afford to receive water through the present system. For low income people, they will not be able to get water even through the communal system. Thus, if the WSD implement the proposed project by means of loan, they should bring about better understanding among all the parties concerned as well as people in the municipality.

9.2 Economic Evaluation

9.2.1 Conditions and Assumptions for Economic Estimation

In economic evaluation, the costs and benefits must be estimated in economic terms. The economic values are converted from financial values through conversion procedure. A conversion factor is assumed at 0.90 for local currency portion. After going through the conversion procedure, the respective economic costs are obtained as presented in Table 9-6. They are summarized as follows:

Cost Item	1st year	2nd year	3rd year	Total
Foreign Portion (KShs. million)	155	449	68	672
Local Portion (KShs. million)	101	294	49	444
Total Equivalent (KShs. million)	256	743	117	1,116

(Remark: Exchange rate of ¥1.75 to KSh.1.00 was applied.)

The O&M cost is annually required during the economic life of the Project after the completion of the construction. The O&M cost is estimated at KShs. 5.9 million in economic terms, as shown in the same table.

This sewage works aim not only to conserve sanitary condition of the municipal area but also to maintain very delicate ecology of Lake Nakuru. Because, Nakuru Municipality is deemed as the major source of pollution load for Lake Nakuru. At the same time, Lake Nakuru is one of the most important tourist spots in Kenya. Accordingly, it is important from the economic point of view for Kenya to keep the natural environment of Lake Nakuru.

Fig. 9-1 illustrates structure of benefit which accrues from the sewage works, taking the above project background into consideration. The direct benefit of the Project is made up of two major components, 1) benefit on people in the municipality and 2) benefit for Lake Nakuru. Besides these direct benefits, the Project brings about indirect benefits as indicated in the figure. These are (1) to improve amenity in the municipality, (2) to induce another regional development activity through the Project implementation and (3) to stimulate the regional economy through capital investment of the Project.

Among these direct benefits, the following two benefits could be selected as tangible benefits: (1) benefit on direct beneficiaries, i.e., residents and establishments such as factories, stores and other facilities covered by sewage treatment services and (2) benefit on conservation of tourism resources, i.e., nature of Lake Nakuru.

Table 9-6 Financial Cost and Economic Cost

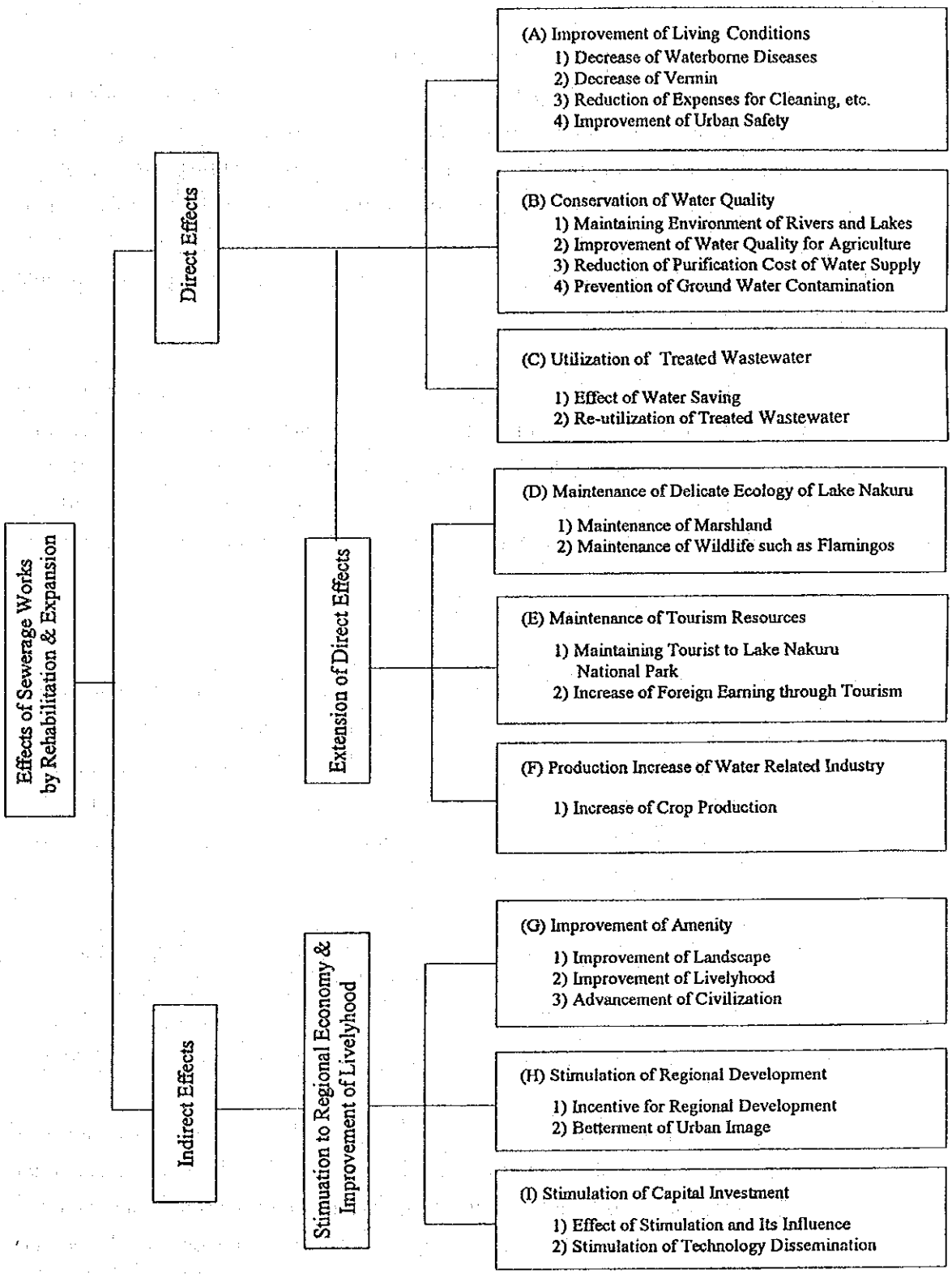
(Unit: million)

Item	Total			1st year		2nd year		3rd year	
	Total Equivalent (KShs.)*1	Foreign Portion (KShs.)*1	Local Portion (KShs.)	Foreign Portion (KShs.)*1	Local Portion (KShs.)	Foreign Portion (KShs.)*1	Local Portion (KShs.)	Foreign Portion (KShs.)*1	Local Portion (KShs.)
I. Financial Cost									
1. Initial Construction Works									
1) Direct Cost	1,024	513	511	102	102	359	358	51	51
a. Construction Works	867	513	355	102	71	359	249	51	35
b. Value Added Tax	156	0	156	0	31	0	109	0	16
2) Land Acquisition	1	0	1	0	1	0	0	0	0
3) Government Administration	51	0	51	0	15	0	26	0	10
4) Engineering Services	145	98	47	39	19	49	24	10	4
5) Physical Contingency	123	61	62	14	14	41	41	6	7
6) Price Contingency	84	29	54	4	6	21	39	5	9
Total	1,427	701	726	159	157	470	488	72	81
2. Operation and Maintenance Works*2	6.4	1.1	5.3	-	-	-	-	-	-
II. Economic Cost									
1. Initial Construction Works									
1) Direct Cost	832	513	319	102	64	359	224	51	32
a. Construction Works	832	513	319	102	64	359	224	51	32
b. Value Added Tax	0	0	0	0	0	0	0	0	0
2) Land Acquisition	1	0	1	0	1	0	0	0	0
3) Government Administration	46	0	46	0	14	0	23	0	9
4) Engineering Services	120	98	22	39	9	49	11	10	2
5) Physical Contingency	117	61	56	14	13	41	37	6	6
6) Price Contingency	0	0	0	0	0	0	0	0	0
Total	1,116	672	444	156	100	449	295	68	49
2. Operation and Maintenance Works	5.9	1.1	4.8	-	-	-	-	-	-

Remark: *1 Exchange Rate: KShs.1.00=¥1.75, US$1.00=KShs.62.40=¥109.50

*2 After the completion of the construction works

Fig. 9 - 1



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

(1) Benefit of Residents and Establishments

Quantification of this benefit is based on willingness-to-pay of the beneficiaries in the target areas. The willingness-to-pay for sewage services is considered to reflect their desire regarding environmental living conditions. It also is a convincing factor to convert their desire to monetary terms. In 1993, the average willingness-to-pay was estimated at KShs. 36.42 per household in financial terms. In the future, this value is assumed to increase in proportion to the household income which links with the growth of GDP per capita. Incidentally, the relation between willingness-to-pay and household income is illustrated in Table 9-7.

Benefit of major urban establishments was estimated as a product of sewage volume from them and unit value of sewage which was calculated in the resident's benefit. Then, the total benefit of both residents and establishments was KShs. 21.7 million in economic terms in 4th year, as shown in Table 9-8. It was broken down as follows: KShs. 9.3 million for residents in Nakuru and KShs. 12.3 million for establishments.

(2) Conservation Benefit of Tourism Resources

This benefit is estimated as the national revenue through tourism, that is, the expenditure of tourists. The total amount of tourist's expenditure in Lake Nakuru National Park was estimated by applying the results of the questionnaire survey to tourists and statistical data presented by KWS. The tourists were divided into two categories, Kenyan and Foreigner. The total amount of tourist's expenditure was estimated on the basis of the following assumptions.

Tourist	Annual Number of Tourists	Length of Stay in Nakuru	Expenditure
Foreign Tourist	40,000	2 days	KShs. 3,900/day
Kenyan Tourist	20,000	4 days	KShs. 2,300/day

The total expenditure of the tourists was summed up as follows: KShs. 434.6 million in 1997, KShs. 461.2 million in 2000 and KShs. 530.3 million in 2010 in economic terms. This total amount is benefit through tourism and does not accrue from the effect of sewage system. However, if the sewage system does not exist and does not function to keep better environment for tourism resources in Lake Nakuru, this national revenue through tourism would decrease in the future because of water pollution of the lake. In this study, thus, the tourism benefit is assumed to be a half of the total revenue mentioned above.

Table 9-7 Relation Between Household Income and Willingness-to-Pay

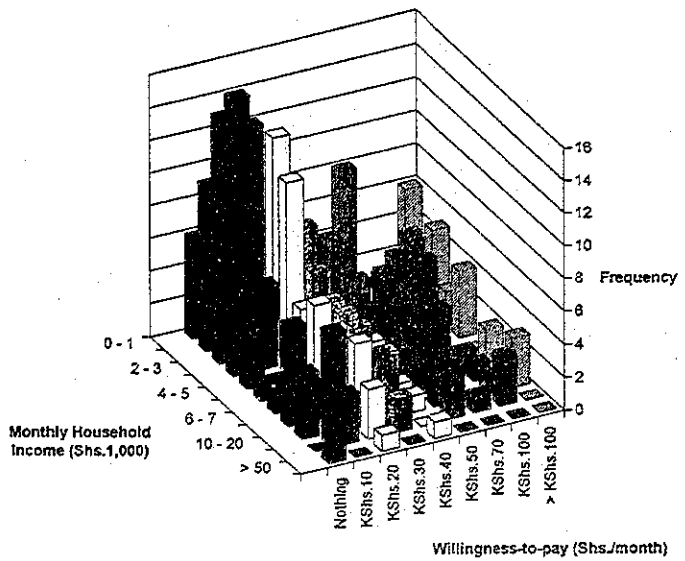
Willionness-to-Pay (KShs./month)	Household Income (KShs./Month)												
	Less Than 1,000	1,001 - 2,000	2,001 - 3,000	3,001 - 4,000	4,001 - 5,000	5,001 - 6,000	6,001 - 7,000	7,001 - 10,000	10,001 - 20,000	20,001 - 50,000	More Than 50,000	No Answer	Total
1. Nothing	6	10	12	5	2	1	2	6	2	0	2	11	59
2. KShs.10	13	15	14	5	0	4	2	2	6	3	0	13	77
3. KShs.20	7	7	13	11	4	5	1	4	5	3	1	6	67
4. KShs.30	3	5	7	5	4	4	4	1	4	2	0	8	47
5. KShs.40	0	1	2	2	2	2	1	1	1	0	1	6	19
6. KShs.50	4	9	3	2	5	3	3	8	4	3	0	13	57
7. KShs.70	1	0	1	1	2	1	0	1	0	1	0	4	12
8. KShs.100	1	3	5	2	2	0	1	1	1	3	0	6	25
9. Others	6	3	5	2	4	0	2	0	3	0	0	1	26
10. No Answer	4	3	1	0	1	0	0	0	3	1	0	8	21
Total	45	56	63	35	26	20	16	24	29	16	4	76	410

Lenear Regression Analysis

(1) Efficient sample number: 317
(2) Mean of Willingness-to-Pay (y): Shs.36.42
(3) Mean of Household Income ($\bar{x}$) : Shs.6,429
(4) Correlation Coefficient [$y = a + b (x - \bar{x})$]

	Estimate	95% Confidence Interval		
a:	36.423	30.549	-	42.296
b:	0.000064	-0.000051	-	0.000064

(5) Regression Equation: $y = 36.01 + 0.000064x$
where, y: Willingness-to-pay (Shs./month); and
x: Monthly Household Income (Shs.)



9.2.2 Economic Evaluation

The proposed Project was examined in economic efficiency through Economic internal rate of return (EIRR). Table 9-8 shows the stream of economic costs and benefits and the results of the examination. The project resulted in 18.6%, exceeding the opportunity cost of capital of 10%. Thus, the proposed Project is viable from economic point of view.

Yet, the quantification of tourism benefit seems to be controversial. As mentioned before, the tourism benefit is assumed to be a half of the national revenue. In this paragraph, then, the sensitivity of this benefit would be tested in the case that the benefit for the Project was reduced to a quarter of the national revenue. In this case, EIRR was 10.8%. In this condition, it is still higher than 10%. Then, the project is concluded as feasible even under this condition.

In the current study, all cost items have been quantified after careful study. However, there always remains the question as to the degree of reliability of input. Thus, the another test is made for the variation in 10% up of the total cost. EIRR still holds a higher rate of 17.2%. It is identified to be economically viable.

Table 9-8 Economic Cost and Benefit Stream of Proposed Project

(Unit: KShs. million)

Year	Cost			Benefit			Balance
	Initial Construction Works	O&M Works	Total	Residents & Estab-lishments	Tourism	Total	
1	255.7		255.7			0.0	-255.7
2	743.7		743.7			0.0	-743.7
3	116.7		116.7			0.0	-116.7
4		5.9	5.9	21.7	217.3	239.0	233.1
5		5.9	5.9	22.4	221.6	244.1	238.2
6		5.9	5.9	23.2	226.1	249.3	243.4
7		5.9	5.9	24.1	230.6	254.7	248.8
8		5.9	5.9	24.7	233.8	258.4	252.6
9		5.9	5.9	25.3	237.0	262.3	256.4
10		5.9	5.9	25.9	240.2	266.2	260.3
11		5.9	5.9	26.6	243.5	270.1	264.2
12		5.9	5.9	27.3	246.9	274.1	268.3
13		5.9	5.9	28.0	250.4	278.4	272.6
14		5.9	5.9	28.8	254.0	282.8	276.9
15		5.9	5.9	29.6	257.7	287.2	281.4
16		5.9	5.9	30.4	261.4	291.8	285.9
17		5.9	5.9	31.2	265.1	296.4	290.5
18		5.9	5.9	31.2	265.1	296.4	290.5
19		5.9	5.9	31.2	265.1	296.4	290.5
20		5.9	5.9	31.2	265.1	296.4	290.5
21		5.9	5.9	31.2	265.1	296.4	290.5
22		5.9	5.9	31.2	265.1	296.4	290.5
23		5.9	5.9	31.2	265.1	296.4	290.5
24		5.9	5.9	31.2	265.1	296.4	290.5
25		5.9	5.9	31.2	265.1	296.4	290.5
26		5.9	5.9	31.2	265.1	296.4	290.5
27		5.9	5.9	31.2	265.1	296.4	290.5
28		5.9	5.9	31.2	265.1	296.4	290.5
29		5.9	5.9	31.2	265.1	296.4	290.5
30		5.9	5.9	31.2	265.1	296.4	290.5
31		5.9	5.9	31.2	265.1	296.4	290.5
32		5.9	5.9	31.2	265.1	296.4	290.5
33		5.9	5.9	31.2	265.1	296.4	290.5

EIRR 18.6%

JICA