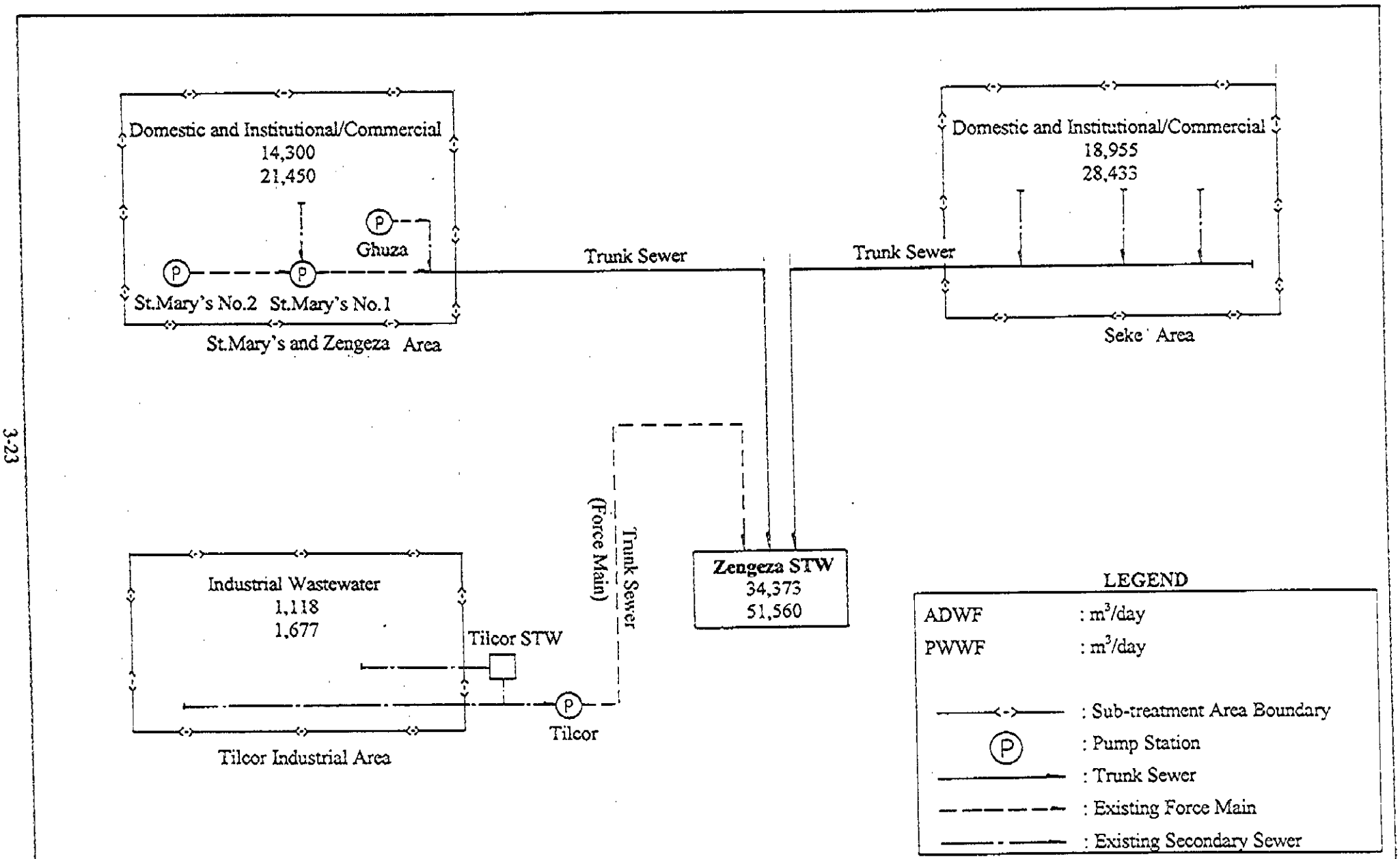


Figure 3.2.2 Flow Diagram of Sewage Volume by Trunk Sewer

Table 3.2.5 Present Conditions of Existing Trunk Sewres

(St. Mary's and Zengeza)

Sewer/Pump No.	Downstream Sewer No.	Area (km^2)	Accumulated Area (km^2)	Unit Sewage Quantity ($m^3/sec/km^2$)	Sewage Quantity (m^3/sec)	Sewer Length (m)	Sewer Flow Capacity: Diameter (mm)	Gradient (1/1,000)	Velocity (m/sec)	Flow (m^3/sec)	Evaluation
P-1	1-1	1.52	1.52	0.0252	0.038	N/A	N/A	N/A	N/A	N/A	
P-2	1-1	0.33	0.33		0.008	N/A	N/A	N/A	N/A	N/A	
1-1	1-2	0.00	1.85		0.047	1,240 *1	300	Force Main	1.50 *2	0.106	Affordable
1-2	1-3	3.32	5.17		0.130	1,790	450	4.4 *3	1.19	0.189	Affordable
							525	4.4 *3	1.32	0.285	Affordable
1-3	1-4	2.05	7.22		0.182	1,230 *1	525	4.2 *3	1.29	0.279	Affordable
							675	4.2 *3	1.52	0.545	Affordable
1-4	1-5	1.09	8.31		0.209	340 *1	675	3.2 *3	1.33	0.476	Affordable
1-5	STW	1.56	9.87		0.249	920 *1	675	5.1 *3	1.68	0.600	Affordable

(Seke)

Sewer No.	Downstream Sewer No.	Area (km^2)	Accumulated Area (km^2)	Unit Sewage Quantity ($m^3/sec/km^2$)	Sewage Quantity (m^3/sec)	Sewer Length (m)	Sewer Flow Capacity: Diameter (mm)	Gradient (1/1,000)	Velocity (m/sec)	Flow (m^3/sec)	Evaluation
2-1	2-2	1.38	1.38	0.0254	0.035	800 *1	300	10.0 *3	1.37	0.097	Affordable
						720	375	4.0 - 5.0 *3	1.00 - 1.12	0.111 - 0.124	Affordable
2-2	2-3	1.86	3.24		0.082	1,240	375	4.4 - 5.7 *3	1.05 - 1.20	0.116 - 0.132	Affordable
2-3	2-4	5.17	8.41		0.214	1,300	525	2.9 - 3.3 *3	1.07 - 1.14	0.232 - 0.247	Affordable
						2,420	600	2.2 *3	1.02	0.288	Affordable
2-4	STW	4.54	12.95		0.329	1,420	675	2.1 *3	1.08	0.385	Affordable

(Tilcor)

Sewer No.	Downstream Sewer No.	Area (km^2)	Accumulated Area (km^2)	Unit Sewage Quantity ($m^3/sec/km^2$)	Sewage Quantity (m^3/sec)	Sewer Length (m)	Sewer Flow Capacity: Diameter (mm)	Gradient (1/1,000)	Velocity (m/sec)	Flow (m^3/sec)	Evaluation
3-1	STW	Tilcor Industrial Area			0.019	1,040 *1	300	Force Main	1.2 *2	0.085	Affordable

Note : *1 ; Measured Length
*2; Assumption
*3; Assumption based on the Ground Gradient
N/A : Not Applicable

P-1 : St.Mary's No.1 Pump Station
P-2 : St.Mary's No.2 Pump Station
3-1 : Tilcor Pump Station

c) Evaluation of pump capacity

The pump capacities of St. Mary's No. 1, No. 2 and Tilcor were evaluated based on the specifications of their pump equipment as shown in Table 3.2.2.

- St. Mary's No. 1 PS

  Sewage inflow volume: Q = 1.52 x 0.0252 = 0.038 m^3/sec = 2.28 m^3/min

  Existing pump capacity:q = 0.0883 m^3/sec x 3(1 standby) units

  = 10.60 m^3/min

- St. Mary's No. 2 PS

  Sewage inflow volume: Q = 0.33 x 0.0252 = 0.008 m^3/sec = 0.48 m^3/min

  Existing pump capacity:q = 0.032 m^3/sec x 2(1 standby) units = 1.92 m^3/min

- Tilcor PS

  Sewage inflow volume: Q = 0.019 m^3/sec = 1.14 m^3/min

  Existing pump capacity:q = 177 m^3/hr x 3(1 standby & 1 inoperative) units

  = 2.95 m^3/min

According to the above-mentioned study, the pump capacities at the three (3) pump stations still have allowance to or cater for the expected inflow. However, the overflow of raw sewage from the pump pits at these pump stations has occurred frequently. The reason for this can probably be attributed to the decease of the pump efficiency over the past 20 years and to inadequate maintenance.

3) Present problems of sewer reticulation

As a result of the evaluation of existing sewers, the sewer reticulations are affordable in sewer flow and rated pump discharge capacities. In actuality however, the following problems were identified by the Municipality Report of the "Second Urban Development Project, Reference No. 3070, Project Proposals for the Sewage Augmentation Scheme, February 1996", these problem areas were also confirmed through the field survey.

- Foreign matter discharged into the sewers, causing blockages: The foreign matter included rags; large quantities of paper; mealie cobs; and sand or silt, which may have been used for cleaning pans and pots
- Excessive flows from manholes: with peak flows exceeding the sewer and pump

capacities causing overflows from manholes

- Damaged sewers as a result of adjacent work and vandalism; vehicle-damaged manholes, etc.
- Poor sewer gradients coupled with low flows, resulting in low velocities, the settlement of solids and ultimately to blockages
- Decrepit pump equipment and insufficient capacity, causing overflows.
- No preventative maintenance system for the above problems due to the lack of finance and manpower

Table 3.2.2 show the problem spots identified by the above-mentioned municipality report (refer to Figure 3.2.4, Section 3.2, Chapter 2, Supporting Report).

(3) Sewage treatment works

1) Outline of existing facilities

a. The existing Zengeza STW (Present and On-going)

The treatment processes employed at the existing Zengeza STW include anaerobic ponds for the primary treatment and trickling filters for the secondary treatment , there is no final sedimentation tanks as shown below.

Influent → Screen & grit chamber →Anaerobic pond → Trickling filter → Farm land

The existing Zengeza STW receives the combined sewage consisting of industrial wastewater and domestic sewage. Industrial wastewater is discharged to the inlet works of the STW from the Tilcor pump station via sewer. Because of the strict regulation of effluent discharge into the water courses stipulated by the Water Regulations, 1977, the effluent is conveyed to the farm land for further treatment and reuse/disposal. The layout plan of the whole treatment works is shown in Figure 3.2.3.

The details of each facility are explained below.

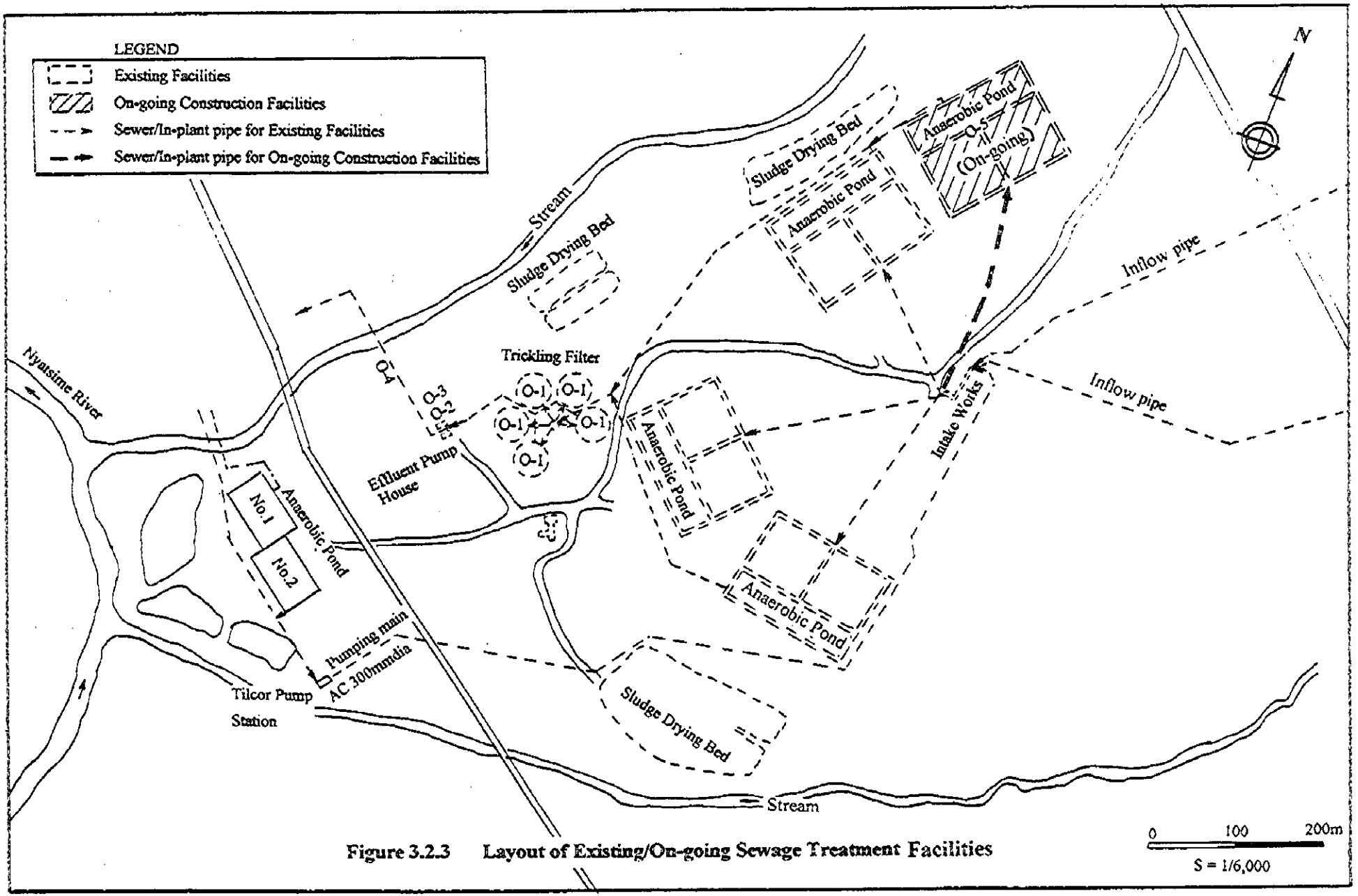


Figure 3.2.3 Layout of Existing/On-going Sewage Treatment Facilities

a) Screen & grit chamber

The inlet works consist of two channels running in parallel. Two screens (coarse and fine screens) are provided for each channel. The structure of Parshall flume is provided at the end of each channel, at which flow meter ganging sewage inflow is installed. After the channels the combined sewage flows into two grit chambers where grit is intermittently removed by airlift.

b) Anaerobic pond

Sewage flows to the anaerobic pond units by gravity through pipes from the distribution box installed after the grit chamber. Each unit is composed of three ponds. Anaerobic ponds usually suits for sewage whose influent concentration is high. Then sewage is treated by chemical reaction of anaerobic bacteria.

c) Trickling filter

After anaerobic ponds treated sewage flows by gravity to the distribution tower, and then distributed to each trickling filter. Trickling filters employing aerobic bacteria guarantees a stable treatment even under the conditions of load fluctuation or strong load though treatment efficiency decreases to some extent. The advantage of trickling filters is its easy maintenance associated with low energy cost for operation. Treated sewage from trickling filters finally flows into the pump pit for sending it to the farm land.

d) Sludge treatment

Sludge accumulated in the anaerobic ponds is dried in sludge drying bed and reused periodically on farm lands. There are currently three sludge drying beds according to the locations of anaerobic ponds.

Some improvement/augmentation projects to the existing STW were planned/implemented in the last few years. The project consists, primarily, of Phase I, a provision of the facilities for transmitting treated effluent to farm land, and Phase II, mitigation of the overload conditions of the treatment facilities. Phase I was completed in 1995 while Phase II was suspended excepting for the on-going fourth anaerobic pond unit. Existing five trickling filters are operated providing repairs to the rotating distributor.

The existing and on-going treatment facilities are shown in Figure 3.2.3 and Table 3.2.6, while the detailed data on the facilities in terms of dimension is presented in Table 3.2.7.

Table 3.2.6 Existing/On-going Sewage Treatment Works

Existing(before 1995)	Completed/On-going construction
Treatment capacity 21,750 m^3/day	21,750m^3/day (AP + 6,850)(*2)
	Phase I (Completed)
Inlet works (Screen & grit chamber) 3 Anaerobic ponds 5 Biological filters (Trickling filters) Effluent pump station, effluent pumps and effluent force main.(*1) 3 Sludge drying beds	0 - 1 Supply and installation of filter arms 0 - 2 Construction of effluent pump station 0 - 3 Supply, installation and commissioning of effluent and recycle pump 0 - 4 Construction of effluent force main and effluent sludge pond
	Phase II(Partial scope : on-going)
	0 - 5 Construction of anaerobic pond unit (6,850m3/d)

(*1) : The old effluent pumping facilities are not in operation.

(*2) : Incremental capacity of 6,850 m3/day due to the additional unit of AP.

b. Facilities for the effluent pumping and final disposal (Present/On-going)

Treated effluent is discharged from the Zengeza STW to the Imbgwa farm through a force main of 7 km in length. The sewage flow diagram from the STW to the Imbgwa farm is shown in Figure 3.2.4 and summarized as follows.

Effluent pump → Effluent force main → Pond facilities → Channels →

Pump for irrigation → Farm land

Table 3.2.7 List of Existing Sewage Treatment Works Facilities

Facility			Existing			On-going project	
			Size		Tank surface area, volume	Size	Tank surface area, volume
Inlet Pipe	Inlet Pipe	Zengeza	Diameter	675 mm			
		Seke	Diameter	675 mm			
		Tilcor	Diameter	300 mm			
Screen and grit chamber	Screen	Coarse screen (43 mm)	Width	1.2 m			
			Depth	1.2 m			
			Number	2.0 m			
		Fine screen (27 mm)	Width	0.9 m			
			Depth	1.2 m			
			Number	2.0 m			
	Grit chamber	Vertical flow grit chamber	Width	1.8 m			
			Length	6.0 m			
			Dept	7.7 m			
			Number	2			
	Flow meter		Type	Parshall flume			
			Width	440 mm			
			Numoer	2			
Anaerobic pond	per 1 unit	No.1, No.2 pond	Type	Trapezoid	A=4,560x2=9120 m^2	NUmber 1 unit	A=13,290 m^2
			Width	67.5 m	V=13,300x2=26,600 m^3	(No.1 to No.3 pond)	V=36,300 m^3
			Length	67.5 m			
			Water Depth	4.0 m			
			Free boad	0.45 m			
		No.3 pond	Type	Trapezoid	A=4,170 m^2		
			Width	30.0 m	V=9,700 m^3		
			Length	139.0 m			
			Water Depth	3.5 m			
			Free boad	0.43 m			
	Total		1 Unit (No.1 to No.3 pond, in series)		A=9,120+4,170=13,290 m^2/series		
					V=26,600+9,700=36,300 m^3/series		
			Total 3 units		Total A=13,290x3=39,870 m^2		
					Total V=36,600x3=108,900 m^3		
Trickling filter	Distribution tower		Diameter				
			Height				
			Number	1			
	Trickling filter		Diameter	38.7 m	A=1,175x5=5,875 m^2		
			Depth	3.7 m (3.6 to 3.8 m)	V=4,350x5=21,750 m^3		
			Media	Rock			
			Media size	30 - 60 mm			
			Number	5			
	Recirculation pump					Capacity 625 m^3/hr	Recirculation rate
						Motor 200 kw	15,000 m^3/day
						Number 2 (1 standby)	Recirculation ratio 0.74
Sludge drying bed			No.1 90m x 25m x 2beds		A=4,500 m^2		
			No.2 40m x 200m x 1bed		A=8,000 m^2		
			No.3 95m x 190m x 1bed		A=18,050 m^2		
					Total A=30,550 m^2		

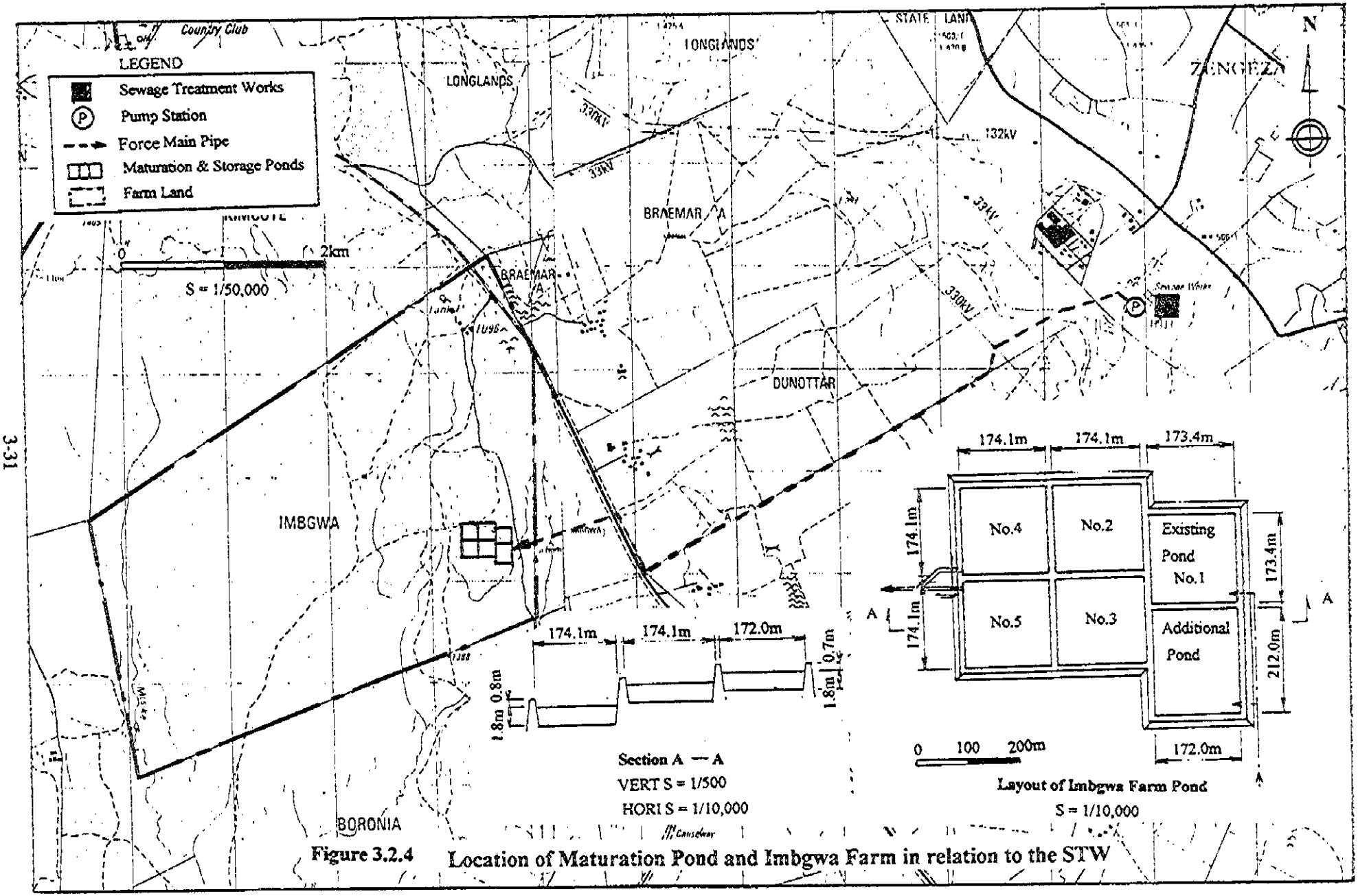


Figure 3.2.4 Location of Maturation Pond and Imbgwa Farm in relation to the STW

Since treated effluent from the trickling filters does not meet the effluent regulations for irrigation reuse (max. BOD 70mg/l), effluent is stored and polished in the ponds during a detention time. The details of the ponds in terms of the number and size are shown in Table 3.2.8.

The on-going work of Phase I resulted in completion of a new effluent pump, a effluent force main and an additional pond. The new effluent pump having a capacity of 35,000m^3/day was designed to transport the whole volume of treated effluent to the farm through a force main since its completion in 1995. Effluent transported is stored and polished in ponds and then distributed to irrigation land of 376 ha.

c. Pre-treatment facilities for the Tilcor industrial area

The Tilcor industrial area is located adjacent to the Zengeza STW. The pre-treatment facilities of industrial wastewater from the factories consist of anaerobic ponds. The layout of these facilities is shown in Figure 3.2.5. Industrial wastewater constitutes mostly of organic substances and accounts for 5 % of the sewage inflow to the STW.

The anaerobic ponds were mainly designed to treat the starchy and highly contaminated wastewater discharged from the Chibuku Breweries Limited, by reducing BOD from 6,000mg/l to 1,000mg/l. Then wastewater flows into the pump pit of the Tilcor pump station. Wastewater discharged from other small factories is collected to flow into the pump pit. Pre-treated wastewater collected in the Tilcor area is then conveyed from the pump station to the STW.

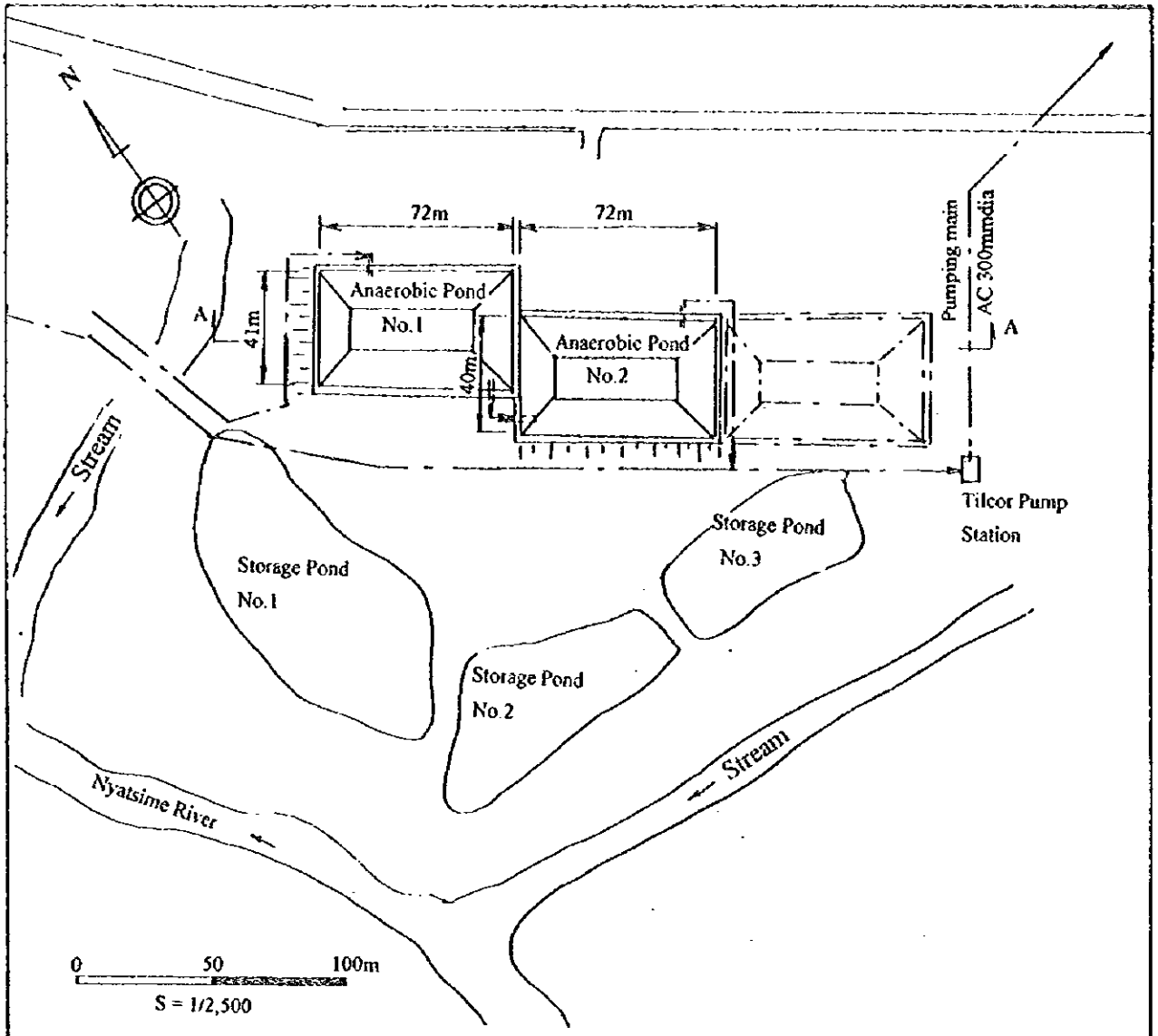
The details of the pre-treatment facilities are shown in Table 3.2.9.

2) Current conditions of existing facilities

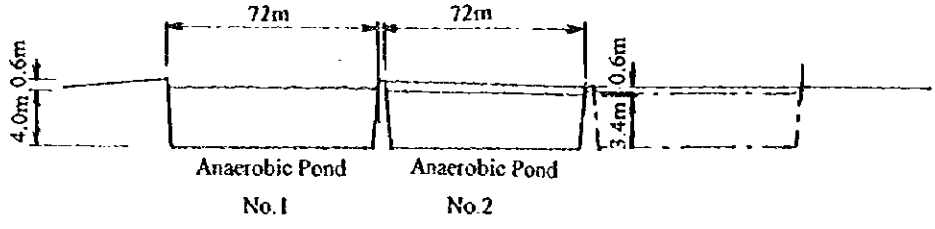
The problem areas on each facility were identified in terms of hydraulic, structural, and operation and maintenance. Details of them are discussed in Section 3.2, Chapter 2, Supporting report.

Table 3.2.8 List of Existing Facilities for the Effluent Pumping and Final Disposal

Facilities	Constructed before Phase I Project	Constructed by Phase I Project (completed)
Pump station	a) Irrigation pump 18,000m³/d (not working) b) Building Number 1	a) Irrigation pump Type Horizontal spindle centrifugal pump Capacity 850 m³/hr/pump (20,400 m³/day/ pump) Number 3 (including 1 standby) Motor 150 kW b) Building Number 1
Force main	Asbestos cement 525mm dia about 7 km	a) Force main on the pump station Asbestos cement 675mm dia Class 24 4,264 m b) Force main on the pond Asbestos cement 600mm dia Class 18 3,016 m c) Total 7,280 m
Pond	No. 1 173.4m x 173.4m x 1.8m (depth) V = 50,000 m³ No. 2 174.1m x 174.1m x 1.8m (depth) V = 50,400 m³ No. 3 174.1m x 174.1m x 1.8m (depth) V = 50,400 m³ No. 4 174.1m x 174.1m x 1.8m (depth) V = 48,400 m³ No. 5 174.1m x 174.1m x 1.8m (depth) V = 48,400 m³ Total V = 247,600 m³	Additonal Pond 172m x 212m x 1.8m (depth) V = 61,300m³
Facilities in the irrigation land	a) Open channel Trapezoidal concrete channel b) Pump station for each farm 4 No. c) Irrigation methods Sprinkler method d) Irrigation land Pasture land for cattle e) Storage pond Pond for storage of excess treated water at the end of channel	



Layout of the Pre-treatment Facilities for Tilcor Industrial Area



Section A — A

VERT S = 1/500
HORI S = 1/2,500

Figure 3.2.5 Layout of the Pre-treatment Facilities for Tilcor Industrial Area

Table 3.2.9 List of Pre-treatment Facilities for Tilcor Industrial Area

Facilities	Details
Influent pipe	a) Chibuku Brewer Line 300^{mm} dia b) Another Line 300^{mm} dia
Anaerobic pond	No. 1 pond, 72m x 41m x 4.0m (effective depth) A = 2,952 m^2, V = 5,730 m^3 No. 2 pond, 72m x 40m x 3.65m (effective depth) A = 2,880 m^2, V = 5,329 m^3 No. 3 pond, It is not built. The land area for No.3 pond is prepared.
Storage pond	No. 1 pond (not in use) No. 2 pond (not in use) No. 3 pond (currently functions as an equalizing pond)
Pump station	a) Pump Type Horizontal centrifugal pump Capacity 177m^3/hr/pump Number 2 units Motor 37kW b) Screen manual bar screen 0.5m (width) c) Pump pit 7.3m x 2.3m x 1.7m (depth) d) Building 28 m^2 (7.3m x 3.8m)
Pumping main	Asbestos cement pipe 300^{mm} dia

a. The existing Zengeza STW

Major problems on the facilities are summarized below.

a) Flow meters

The flow meters are installed next to the Parshall flume in order to measure water level of the incoming sewage flow. They are currently out of order and the flow rate can not be measured.

b) Accumulation of sludge in anaerobic ponds

Accumulated sludge has not properly been removed from anaerobic ponds. This implies deterioration of treatment efficiency due to reduction of detention time. The observation of the ponds comes to the tentative conclusion that the

current condition nearly reaches to the saturation point in terms of treatment efficiency. It was confirmed until now that sludge was only removed from one pond of a unit.

c) Sludge accumulation in trickling filters

The occurrence of ponding is observed in all five of the trickling filters as a result of sludge accumulation. The size of filter media employed is fairly small from 30 to 60mm. Accordingly when the filter is overloaded, sludge accumulated in the filters tends to clog the filter, which causes the occurrence of ponding. The major cause of this problem is described to influent flow rates higher than the treatment capacity.

d) Administration building

The location of the administration building is not recommendable with the following two reasons: firstly it is inconvenient for the entire management of all plants because of the building's location on the edge of the STW. Secondly the hygienic condition is pretty bad in respect of strong odour and many flies because the building is located adjacent to the anaerobic ponds and trickling filters.

e) Reuse of sludge

A considerable volume of sludge still remains piled up in sludge drying bed. Sludge might be washed away to the near-by river during the rainy season, which causes contamination of water quality. Further investigations are required to establish whether there is a market for the sludge on the surrounding farms. If demand for the sludge can not be identified, the sludge is deemed environmentally unacceptable because of the pollution threat to groundwater and the Nyatsime River. The wastewater sludge containing high percentage of silt and sand is almost decomposed, which implies that the quality of sludge is poor for reuse.

f) Dumping of refuse

Refuse is widely scattered at the site of the STW. Local residents dump refuse on the site illegally at night. This problem might be attributed to lack of a fence or insufficient night lighting.

b. Facilities for the effluent pumping and final disposal

The secondary treatment process, by means of the trickling filters, is employed for reuse of effluent for irrigation. A new effluent pump station and force main was built at the Zengeza STW and an additional maturation pond was constructed in the Imbgwa farm. It has become possible to send all of the treated influent to irrigation land, but in the future, when the inflow rate increases, this will no longer be possible.

c. Pre-treatment facilities for the Tilcor industrial area

a) Tilcor pump station

Three (3) pumps were installed inside the existing Tilcor pump station built in the mid of 1970's. One broken pump was already removed and the remaining pumps in full use becomes aged, which entails a water leaking problem.

b) Sludge accumulation in the Tilcor anaerobic ponds

Sludge accumulation in the two anaerobic ponds is tremendous, which causes deterioration of treatment efficiency. The broken jet nozzle for scum breaking further aggravates treatment efficiency.

c) Storage pond

The existing three storage ponds were designed to treat industrial wastewater from the factories other than Chibuku Breweries. Two ponds are not in use at present. The remaining pond marked as No.3 shown in Figure 3.2.5 currently functions as an equalizing pond for the Tilcor pump station. It is littered with refuse and sludge.

3) Capacity of existing facilities

a. The existing Zengeza STW

The current sewage flow rate is approximately 36,000m^3/day while the concentration of BOD and SS is 600mg/l and 650mg/l respectively. The treatment capacity of the STW is evaluated based on the number and storage

capacity of both anaerobic ponds and trickling filters with the following conditions:

- 3 units of anaerobic ponds with a storage volume of 108,900m^3, and
- 5 trickling filters with a filter volume of 21,750m^3 and a surface area of 5,875m^2.

a) Treatment capacity of the anaerobic ponds

Based on the Zimbabwe version of the "Sanitation Manual Design Procedures 5" published in 1990, a detention time to treat sewage in anaerobic pond is assumed to be 5 days. Using this detention time, the treatment capacity per day is calculated to be:

$$108{,}900m^3/5 \text{ days} = 21{,}780m^3/day$$

b) Treatment capacity of the trickling filters

The treatment capacity of the existing trickling filters can be estimated on the basis of solids loading rate. According to the said Sanitation Manual, the solids loading rate (0.2 $kg/m^3/day$) is established as the design criteria. The following conditions are assumed in order to estimate the solids loading rate applied to the existing trickling filters.

- The maturation ponds on the Imbgwa farm provides a more BOD polishing effect.

- Therefore it might be possible to load the existing trickling filters more than the design criteria despite of some loss in treatment efficiency.

- Accordingly, the solids loading rate is assumed to be that with a 20% margin than the design criteria, resulting in 0.24 (= 0.2 x 1.2) $kg/m^3/day$.

The assumed rate (0.24 $kg/m^3/day$) is compared to those given in "Wastewater Engineering: Treatment, Disposal and Reuse, Third Edition" Metcalf and Eddy INC, Page 615.

- Low rates : 0.08 - 0.40 $kg/m^3/day$
- Intermediate rates : 0.24 - 0.48 $kg/m^3/day$

The assumed rate is deemed to be the average of the bound of low rates and the lowest of intermediate range. The treatment capacity of the existing trickling filters is eventually estimated with the following equation.

$$21{,}750m^3 \times 0.24kg/m^3/day \,/\, (240\ mg/l \times 1{,}000) = 21{,}750\ m^3/day$$

Where $21{,}750m^3$ is the filter volume of 5 trickling filters.
240mg/l is the BOD value at the entry of the trickling filters assuming that the BOD concentration (600 mg/l) of the sewage inflow would be reduced to 240 mg/l in the anaerobic ponds.

Based on the treatment capacity (21,750 m^3/day) estimated, the hydraulic loading rate using the recirculation ratio (1.0) is estimated to be as follows.

$$21{,}750m^3/day \times (1 + 1.0) / 5{,}875\ m^2 = 7.4m^3/m^2/day$$

where 5,875 m^2 is the surface area of the existing trickling filters.

The estimated rate (7.4 m^3/m^2/day) is compared to those given in Wastewater Engineering: Treatment, Disposal and Reuse, Third Edition, page 615".

- Low rates : 1.17 - 3.52 $m^3/m^2/day$
- Intermediate rates : 3.52 - 9.39 $m^3/m^2/day$

The estimated rate corresponds to the middle value of intermediate rates. According to the said reference, the estimated rate implies that a 60% BOD removal ratio can be expected in the existing trickling filters.

Based on a 60% BOD removal ratio estimated, the water quality at the outlet of the trickling filters is estimated to be as follows.

240mg/l x (1 - 0.6) = 96mg/l

c) Treatment capacity of the STW

Both treatment capacities of the anaerobic ponds and the trickling filters are estimated to be 21,780 m^3/day and 21,750 m^3/day respectively. Thus the smaller of the two, 21,750m^3/day is taken as the treatment capacity of the STW.

b. Facilities for effluent pumping and final disposal

The storage capacity of the existing maturation ponds on the Imbgwa farm is summarized as follows.

	Maturation ponds	Storage Capacity
1)	5 ponds previously constructed	247,600m^3 (48,400m^3/pond - 50,400m^3/pond)
2)	A new pond	61,300m^3
	Total	308,900 m^3

The primal purpose of the maturation ponds is storage, but some treatment effect can be expected during a detention period. If the effluent is treated at the STW so as to meet the effluent quality (BOD 70mg/l) stipulated by the "Effluent Regulations for Irrigation Reuse", there is no need of a detention time for polishing at the maturation ponds. The effluent quality treated at the STW is estimated to be 96 mg/l, which is obviously higher than the design quality (BOD 70 mg/l).

The following two sets of effluent quality are used in order to estimate both detention time and pond volume to be required.

- Estimated effluent quality (96 mg/l) based on the treatment capacity of 21,750m^3/day.

- Average quality of effluent (141mg/l) based on the current sewage inflow of 36,000m^3/day.

Based on the two sets of effluent quality, the BOD removal rates at maturation ponds are estimated with the following results.

- (1 - 70mg/l / 96mg/l) x 100 = 30% in case the effluent quality is 96 mg/l.
- (1 - 70mg/l / 141mg/l) x 100 = 50% in case the effluent quality is 141mg/l.

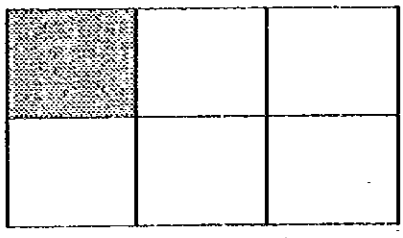
Based on the BOD removal ratio estimated, both detention time and pond volume to be required are estimated and summarized below.

	1st case	2nd case
1) Effluent quality	96 mg/l	141 mg/l
2) BOD removal rate	30%	50 %
3) Detention time	3 days	5 days
4) Pond volume	65,250 m^3	180,000 m^3

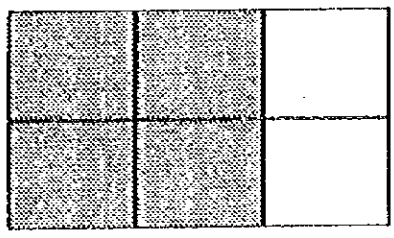
Note: Both estimation of 3) and 4) are based on the "Wastewater Engineering: Treatment, Disposal and Reuse, Third Edition, page 644 - 648".

How to use the existing ponds can be assessed by the results of both detention time and pond volume estimated.

1st case



2nd case



Note: The shaded area indicates the area to be used as maturation ponds.

Out of 6 ponds, the number of ponds to be used as maturation ponds is estimated to be one for the 1st case and 4 for the 2nd case. This implies that if improvement of effluent quality can be achieved from 141mg/l down to 96mg/l, 5 ponds would be

used as storage ponds.

c. Pre-treatment facilities for the Tilcor industrial area

The treatment capacity of the Tilcor anaerobic ponds is estimated as follows.

1) Volume of ponds :	No. 1 pond	No. 2 pond	Total
	5,700 m^3	5, 300 m^3	11,000 m^3

2) Daily water consumption of Chibuku Breweries Ltd. :	Monthly consumption	Operation days per month	Daily consumption
	14,000m^3	20 days	700m^3/day

3) Detention days : 15.7 days

Retention time (d)	BOD_5 reduction(%) Influent BOD		
	<= 400mg/l	500-600mg/l	>=800mg/l
1	30	40	50
2.5	40	50	60
5	50	60	70

Note : Adapted from "Sanitation manual design procedures, No.5 in Zimbabwe"

The above table shows the BOD removal rates in respect of influent BOD and retention time. The maximum ratio is identified to be 70% in the cases of influent BOD more than 800mg/l and retention time of 5 days. The BOD concentration of industrial wastewater from Chibuku Breweries Ltd. is about 6,000mg/l. The detention time is 15.7days. Due to the long detention time and high concentration, the BOD removal rates in the range from 80 to 85% are assumed to estimate the effluent quality at the Tilcor anaerobic ponds with the following equation.

6,000 mg/l x (1 - 0.80 to 0.85) = 900 mg/l to 1,200 mg/l

Accordingly the target quality (1,000 mg/l) can be achieved.

3.2.2 Institutional, Legislative and Financial Arrangements

(1) Institutional Set-up

1) Central government agencies for implementation of water pollution control project

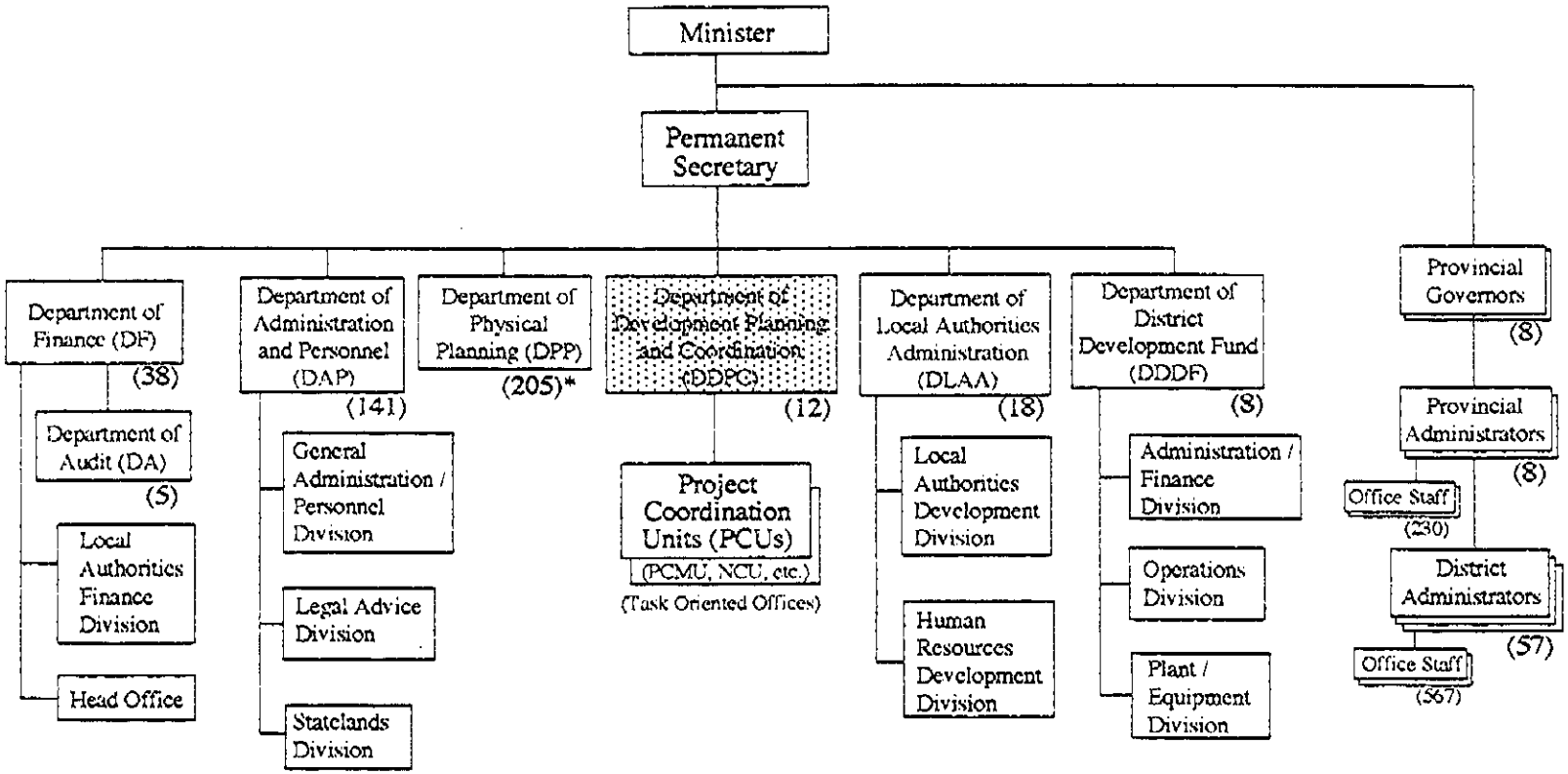
At central government level, the planning and financing the water pollution control projects are administered by the following three government agencies :

a) Ministry of Local Government, Rural and Urban Development (MLGRUD) ;
b) Ministry of Finance (MF); and
c) National Economic Planning Commission (NEPC).

The Ministry of Local Government, Rural and Urban Development (MLGRUD) is responsible for supervising all local authorities decentralized which take direct charge of environmental protection and management including the water pollution control (see Figure 3.2.6). The MLGRUD consists of seven (7) departments. Among the seven, the Department of Development Planning and Coordination (DDPC) is deeply involved in the project implementation.

The DDPC is the primary project promoting institution which liaises and coordinates with other government agencies and institutions for smooth implementation of projects/programmes and responsible for overall coordination of regional (rural and urban) development assistance activities.

At present, the permanent staff of DDPC totals to 12 in total. Due to the national large budget deficits of recent years, the central government is not in a financial situation to augment its proper staff/officers and this might spur on the decentralization of the present administration system to the local authorities. The roles of central government agencies in water pollution are therefore mainly to provide technical guidance for the smooth implementation and coordination of its development programmes and projects.



Notes: Total No. of Head Office Staff (Permanent) : 222, as of December 1996, excluding DPP Personnel.
Figures in parentheses ( ) indicate the total number of permanent staff of the Departments and Divisions involving in implementation of the water pollution control project.
PCMU = Programme Coordination and Monitoring Unit NCU = National Coordination Unit (for National Action Plan)
* This figure is not included in the Head Office Total Number, because it comprises its own provincial/ district staff.

Source : MLGRUD

Figure 3.2.6 Organizational Chart of the Ministry of Local Government, Rural and Urban Development (MLGRUD)

In case of a foreign-assisted project which concerns socio-economic development in a number of local government areas, a project coordination unit consisting of several staffs is usually created under the DDPC for coordination purpose. Most of staffs in such task-oriented units are hired on the contract basis for the project period and their personnel expenses are covered by each project budget.

Besides, in conjunction with the Ministry of Finance (MF) and National Economic Planning Commission (NEPC), the MLGRUD determines the nature of local finance. The MLGRUD-DDPC is also the executing agency to promote the Public Sector Investment Programme (PSIP) which is designated to be the main instrument for implementing the provision of economic and social infrastructure in the country. The project financial sources for planning, construction and operation of a sewage treatment system usually come from the PSIP funds.

Figure 3.2.7 indicates the procedure flow for implementation of the water pollution control projects. In the event that the local authority has recourse to the funds from international agencies, most of activities for project implementation will necessarily be carried out through inter-agency co-ordination as shown in Figure 3.2.7.

2) Chitungwiza Municipal Council

By the "Regional, Town and Country Planning Act, 1976", local authorities are empowered to prepare and amend the development plans. In addition, with establishment of "Urban Councils" in 1995 by the Urban Councils Act, the basis for strengthening administrative system of the urban local authorities was prepared. Then, Chitungwiza Municipality, as a local authority, is political or administrative entity established by law for the purpose of acquiring, constructing, improving, maintaining, and operating projects for the public's use.

The Municipal Council is also responsible for the collection, treatment and disposal of sewage and industrial effluents within their boundaries. Chitungwiza Municipality has a sewerage system called "Zengeza Sewage Treatment Works" (refer to Figure 3.1.2).

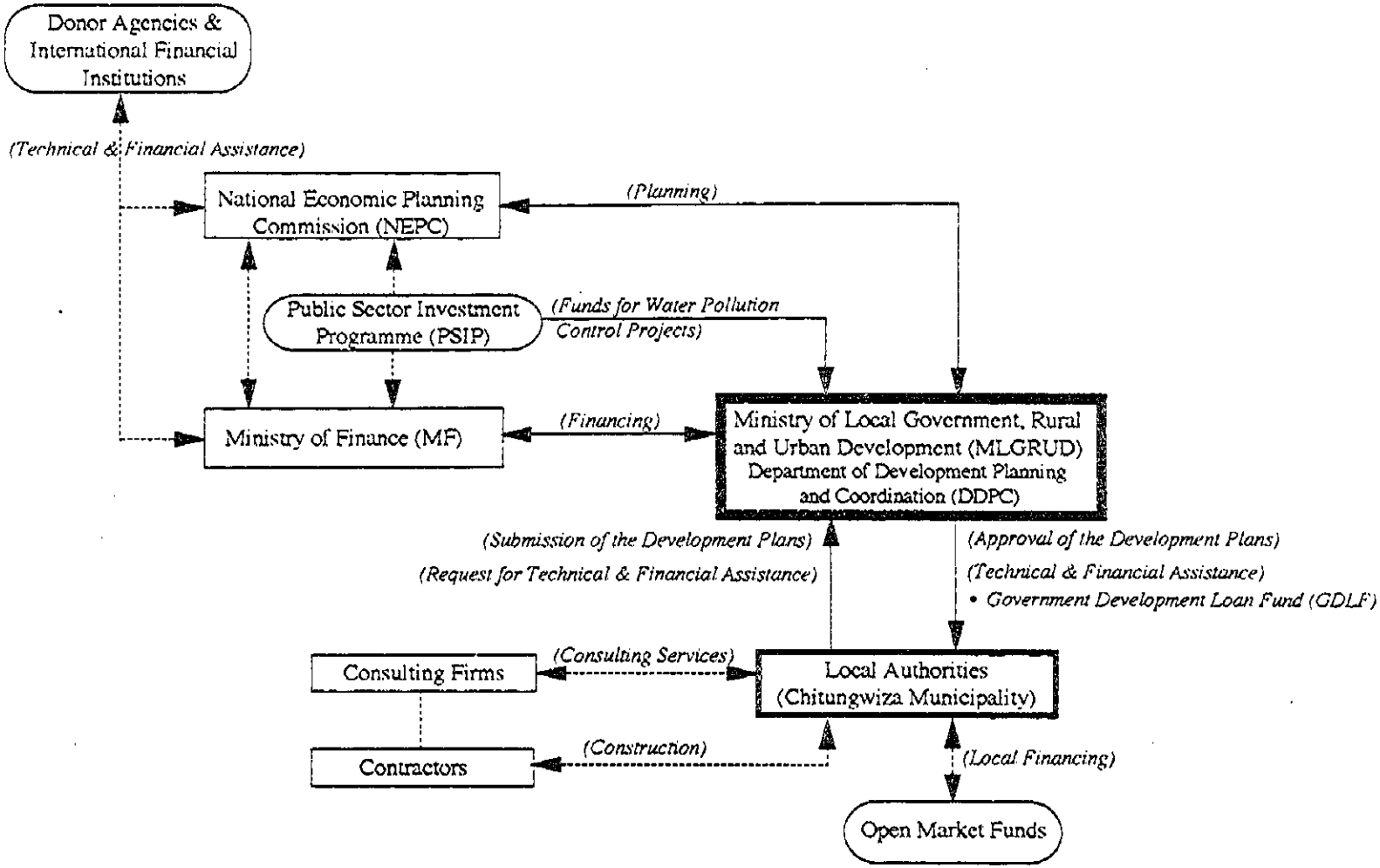


Figure 3.2.7 Procedure Flow for Implementation of the Water Pollution Control Projects

The top decision-making organ of the Chitungwiza Municipality is the "Municipal Council" which is composed of a Mayor and 24 Councilors elected by municipal people in every four years. Municipal Council is presided by Mayor who is also elected in every four years by the people. Under this Council, there are six (6) "Council Committees", in which all municipal matters/issues are substantially supervised and decided to submit for final approval of the Council or not. The above Municipal Committees are convened once a month.

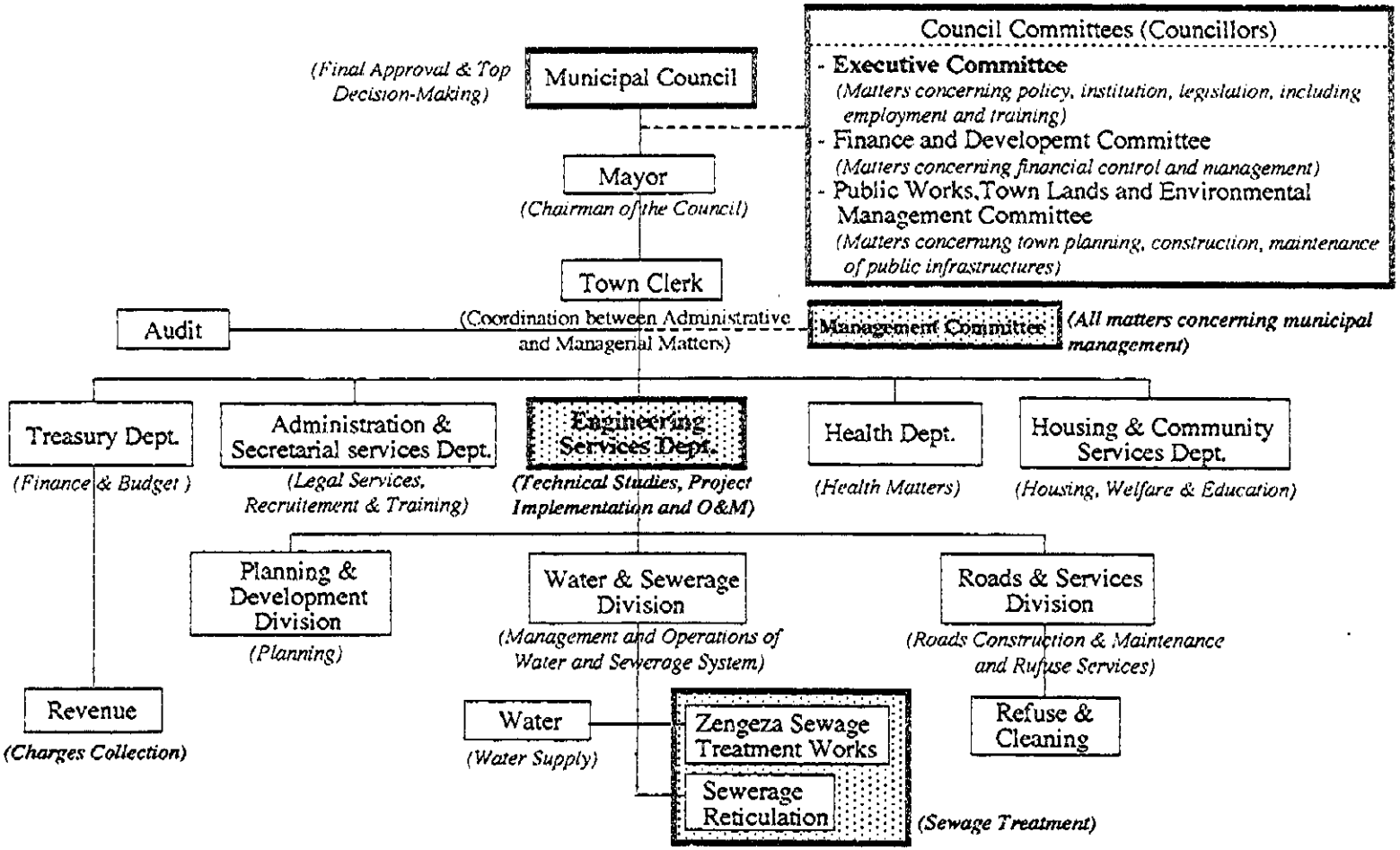
The Committees at administrative level are the following :

a) Executive Committee [Mayor takes the chair and its members consist of 4 chairmen of the Committees from b) to e)]
b) Finance and Development Committee
c) Public Works, Town Lands and Environmental Management Committee
d) Health, Housing and Community Services Committee
e) Education Committee
f) Audit Committee

In addition to the above, there exists a "Management Committee" composed of a Town Clerk and 5 Directors of the Municipal Departments : Engineering Services, Treasury, Health, Housing & Community Services and Administration & Secretarial Services (refer to Figure 3.1.2). In this Committee at managerial level, all municipal matters/issues are discussed and agenda to be submitted to each Council Committee are prepared for further deliberations.

For implementation of the sanitation/sewerage projects, the Management Committee and first three Council Committees are deeply concerned to decide on most of matters relating to the projects planning and management, and their operations as well. Relations/functions of each Committee and organization are summarized in Figure 3.2.8.

One of agenda discussed lately in this Committee as a major problem regarding to sanitation/sewerage was "replacement of sewer pipes" caused by an old sewer reticulation system. The Municipality since applies for Z$15 million from



Notes: Functions of each organizations are described in parentheses ( ).

Source : Chitungwiza Municipal Council

Figure 3.2.8 Structure for Implementation of Sanitation/ Sewerage Projects and Major Functions of Each Organization Concerned

MLGRUD under the PSIP to replace the system and its works are expected to start without delay to avert the flow of raw sewage onto the streets.

The engineering planning for sewerage projects is formulated by the Planning & Development Division under the "Engineering Services Department". This Department undertakes technical studies, overall management for project implementation and O&M of the completed infrastructures & facilities. The refuse collection and cleaning of the Municipality is carried out by the staff of Roads & Services Division under the Engineering Services Department (refer to Figure 3.1.1).

In case of large-scale projects implementation, it is usual way to hire and/or contract with several experienced consultants registered in the Association of Consulting Engineers. At present, there are 32 member-consultants registered in this Association. Among them, several are the consultants specialized in sewerage sector development.

In the same way as water charge system, sewerage charges are also fixed by the Municipal Council after the written approval of the Minister of Local Government, Rural and Urban Development. Charges are reviewed once a year and go up with effect from July (starting month of the fiscal year). Sewerage charges are billed and collected together with the refuse and basic water charges by the Treasury Department staff. Staffs in charge of charges collection in the Revenue Section (total staff : 84) are based in four (4) Area Offices of the Municipality : St. Mary's, Zengeza, Seke South and Seke North.

The sewerage collection is carried out in the following procedure : meter reading -- preparation of bills -- door to door distribution of bills -- users coming to pay to each area office concerned. In case of non-payment, the water pipe is disconnected and penalty is charged for reconnection. The sewerage collection rate in the Municipality is reported to be around 90%.

In conclusion, the shortcomings of the Chitungwiza Municipality in institutional aspects can be summarized as follows :

a) Management structure of the Municipality is still weak in spite of recent legal/institutional arrangements to accelerate the decentralization.

b) The number of staff in charge of planning, implementing and managing sanitation/sewerage projects are very limited.

c) Capabilities of the staff in planning, implementing and managing sanitation/ sewerage projects are not sufficiently developed due to lack of training.

d) Information management system is not yet well established for the reason of poor coordination among the central ministries/agencies and between central and local authorities.

It should be noted that the above issues are mostly due to financial constraints, lack of manpower and poor training programme of the Municipality.

3) Zengeza Sewage Treatment Works

Due to rapid urban growth of the Municipality, the capacity of the existing Zengeza Sewage Treatment Works in Chitungwiza Municipality became too small for the anticipated workloads and needs to be expanded. Major institutional & organizational issues in the existing sewerage system resides in lack of qualified & experienced personnel and poor training.

With regard to the operations and maintenance of the existing sewerage system, their costs are barely covered by the revenues within the "sewerage account" of the Municipal Council.

The present staff complement of the municipal sewerage system is given in Table 3.2.10. As of July 1996, the total number of staff was 65 and 45 posts were vacant, in spite of appropriation of their hiring expenditures in the budget. And now (as of December 1996), the total staff working for the sewerage system has increased to 81 by filling up a part of vacant posts. Furthermore, with a view to ensuring more efficient operations and management of the municipal sewerage system, the Engineering Services Department plans to reinforce its organizational set-up by recruiting the following staffs.

Table 3.2.10 Staff Complements for the Zengeza Sewage Treatment Works and Sewerage Reticulation

Occupation Title	Grade	No. of Personnel		
		Budgeted	Actual	Vacant
(Zengeza Sewage Treatment Works)				
- Works Superintendent	12	1	1	0
- Assistant Works Superintendent	10	1	0	1
- Works Attendant	9	2	1	1
- Trade Waste Inspector	9	1	0	1
- Charge Hand	6	2	2	0
- Pump/ Plant Operator	5	27	27	0
- Pond Operator	4	30	24	6
- General Hand	1 to 4	10	0	10
- Clerk	6	1	1	0
Sub-Total	-	75	56	19
(Sewerage Reticulation)				
- Sewerage Foreman	9	1	0	1
- Plumber Class I	8	1	0	1
- Plumber Class II	7	2	2	0
- Assistant Sewerage Foreman	7	2	2	0
- Charge Hand	6	3	3	0
- Senior Drainlayer	5	2	2	0
- Drainlayer Assistant	4	6	6	0
- Sewer Rodman	4	18	10	8
Sub-Total	-	35	25	10
Grand Total	-	110	81	29

Notes : Data as of 15 December 1996.
Vacant posts are expected to be filled up before the end of March 1997 and most of positions are already advertised for recruitment.
Source : Chitungwiza Municipal Council

Recruitment Plan of the Chitungwiza Municipal Sewerage System

Sewage Treatment Works		Sewer Reticulation	
- Assistant Superintendent	1	- Foreman	1
- Works Attendant	1	- Plumber Class I	1
- Trade Waste Inspecter	1	- Unskilled Laborers	8
- Unskilled Laborers	16		
Sub-totol	19	Sub-total	10
Grand Total			29

Note: Information as of December 1996

Source: Engineering Services Department and Zengeza Sewage Treatment Works of the Chitungwiza Municipality

The placement of the above staffs are expected to be completed not later than the end of March 1997.

In the municipal sewage system, water quality monitoring is carried out twice a month at several points : a) inlet of the screen/ grit chamber, b) outlets of each anaerobic pond, c) outlets of each biological/ trickling filter and d) inlet and outlet of the anaerobic pond in the Tilcor Industrial Area. Sampled waters are analyzed in the private analytical laboratories, because the Municipality has not any facilities for chemical analyses nor qualified staff.

Although Tilcor Industrial Area deeply depends upon the municipal sewerage system for its wastewater treatment and Imbwa Farm, on the other hand, constitutes an integral part of the system as destination of the treated wastewater, any agreement does not exist between the Municipality and them. Their relations need to be institutionally clarified based on the long-term water pollution control planning.

With regard to human resources development for the municipal water & sewerage systems, a "Water and Wastewater Operators Course" is provided to their staffs in the Institute of Water and Sanitation Development (IWSD). This course is for 2 years from 1996 to 1997 and actually two (2) middle and senior engineers are participating in this training programme to improve their operational skills. On the other hand, some management staffs of the Municipality have the opportunity to attend the "Management Training and Development Programmes (July - December

1996)", organized and provided by the Zimbabwe Institute of Public Administration and Management (ZIPAM).

The Municipality thus strives to consolidate its institutional and administrative structure. Sanitation/sewerage system in the Municipality will be only improved, when its Council succeeding in financial and capability building.

(2) Laws and Regulations

As one of the local authorities, Chitungwiza Municipality is required to comply with the requirements of national policies, laws and regulations when executing their legal powers and responsibilities. The following are the primary national laws and regulations currently in force, relating to environmental management and water pollution control at central government and local urban authority levels.

- Water Act, 1976
- Public Health (Effluent) Regulations, 1972
- Water (Effluent and Wastewater Standards) Regulations, 1977
- Public Health Act (relative to sanitation, housing and water supplies)
- Regional, Town and Country Planning act, 1976
- Urban Councils Act, 1995

As a result of decentralization of the national administration system, every urban local authorities are now empowered to promulgate their own by-laws, regulations and/or standards relating to water pollution control, as far as they are in conformity with the general requirements of existing national laws or regulations.

1) Trade effluent control

With regard to water pollution control, some urban local authorities like the City of Harare have the "Trade Effluent Control" regulations and established trade effluents standards for discharge into public sewers. For the reason that Chitungwiza was once an urban precinct of the Greater Harare, the Municipality declares application of the same Trade Effluent Control regulations as those prepared by the City of Harare to control trade effluents from the industries. However, the inherited statutory instrument is not reviewed yet considering its locality and no enforcement of the regulations. The situations are the same for the other regulations and

standards; i.e. Model Building By-laws regulating septic tank installation, Waste Management By-laws and water quality standards at STWs.

As to the trade effluents from Tilcor Industrial Area, an agreement among the authorities concerned was drawn up more than ten years ago, to charge factories according to the volume of sewage pumped and determine the following effluent standards or limitations.

- 5 days BOD not to exceed 1,000 mg/l
- Ph not to be less than 6.8 nor greater than 9.0
- Settleable solids shall not exceed 10 cm^3/l
- No mineral oil shall be discharged

But, the above agreement was not brought into effect. Presently, the sewerage rates are charged according to the number of water closets in each establishment and not yet based on the volume and strength of "permanganate value" in the effluents like in the City of Harare.

For the Zengeza Sewage Treatment Woks, Tilcor Industrial Area is a major source of water pollution. To enforce properly the regulations/standards to the factories like Cone Textiles, Chibuku Breweries, etc., which discharge large volumes of effluent adversely affecting the quality of the water, the Municipality proceeds to undertake institutional and legal arrangements. The establishment of such regulations/standards is to be accompanied by sanctions which may be imposed on the source in the event of non-compliance.

The Municipality also makes inquiries about specific parameters to limit the pollutant concentration that factories and households may discharge into the sewerage network. For such legal arrangements, consultants specialized in legislation are expected to be hired and work together with the technical staff of the Engineering Services Department to enable work out the realistic regulations and standards.

2) Use of effluent for irrigation

The effluents from sewage treatment works are not allowed to discharge directly to a water course. Then, the effluents are commonly used to irrigate the land specifically set aside for this purpose. In the municipal sewerage system, a part of Imbwa farm is reserved for effluent irrigation. This farm covers over 1,500 ha and approximately 370 ha of the land is currently irrigated for pasture culture. The farm itself belongs to the Ministry of Lands and Water Resources and the Zengeza Sewage Treatment Works uses gratuitously a part of it.

In any cases, final effluents from the maturation ponds should be to an acceptable standard, at least complying with the Public Health (Effluent) Regulations which is much less strict. In reality, no periodic water quality monitoring is done at the discharging point to farming land.

In conclusion, the effectiveness of measures for control of water pollution depends on the enactment of comprehensive and realistic laws and regulations, coupled with their prudent administration and management and the commitment of adequate financial and other resources. Actual ineffective control of sewer use results in clogging, improper or illegal connections to the sanitary system, and uncontrolled industrial waste discharges.

As observed above, Chitungwiza Municipality is far lagged behind in legal arrangement. The Municipality should turn to establishing or strengthening its legal structure as a means of more effectively controlling water quality. A principal provision of such statute is the promulgation of water quality standards.

Table 3.2.11 summarizes the major issues for implementation of the sewage projects in Chitungwiza Municipality, in the aspects of institutions/organization, legal arrangements, operations & maintenance and management & finance. Their diagnoses might be instrumental in grasping the municipal managerial capabilities.

(3) Financial Arrangement

1) Public Sector Investment Program (PSIP)

Table 3.2.11 Major Issues for Implementation of the Sewerage Improvement Project in Chitungwiza Municipality

Issues / Problems	Status or Extent		
	Large (Much or High)	Medium (Common)	Small (Less or Low)
1. Institutions/ Organization			
1) Position of the sewage project in national water pollution control policy (Clearness)	○		
2) Intention for self-reliance (Large/ Small)	○		
3) Institutional capability to implement a new sewerage project (Large/ Small)		○	
4) Number of technical staff for implementatin of a new project (Much/ Less)			○
5) Charge collection structure & system (Established conditions)		○	
6) Organizational self-development (Degree of problem)		○	
2. Legal Arrangements			
1) Enactment of regulations & standards (Degree of arrangements)			○
2) Enforcement & penalities (Degree of application)			○
3. Operations & Maintenance			
1) Number of qualified technical staff for required work volumes (Much/ Less)			○
2) Technical level for operations and management (Suitability)		○	
3) Proper maintenance of the facilities (Degree of performance)		○	
4. Management & Finance			
1) Self-paying system (Degree of problem)		○	
2) Transition status to the self-paying system (Degree of transition)		○	
3) Superannuation of the facilities/ equipment (Degree of problem)	○		
4) Allocation of budget (Degree in lack of fund)	○		
5) Procurement of O&M funds (Degree of problem)		○	

Source : JICA Study Team

PSIP of Sanitation/ Sewerage

The MLGRUD is responsible for development finance of various projects executed by local governments in the following schemes, namely, i) District Development Fund (DDF) for rural infrastructure, mainly roads, ii) Water Supply and Sanitation Programme for rural districts, and iii) Urban Sector and Regional Development Project. The first and second schemes are basically financed by the government grant, while the third is financed by domestic and external loans.

The purpose of sanitation is different between Water Supply and Sanitation Program, and Urban Sector and Regional Development Project. Projects implemented under the former scheme are mostly identified to be groundwater development without reticulation and treatment works in rural districts, so that sanitation program principally aims to supply clean and drinkable water to rural people. On the other hand, urban areas face environmental deterioration caused by the population pressure on water cources and lands. In this respect, sanitation is closely related to water pollution control in the latter scheme in which projects aiming to upgrade the existing sewerage systems for major urban councils are involved.

The field of sanitation and sewerage is included in Urban Sector and Regional Development Project, hereinafter called USRDP. Projects of PSIP are classified into the government-assisted and foreign-assisted projects. The former is financed by the government loan called GDL and loan which the council borrows. The latter is co-financed by foreign donors, GDL and loan which the council borrows. Both GDL and foreign loans are disbursed from MLGRUD, while loans the council borrows is outside USRDP, which is mobilized from domestic financial market.

The Sewerage Augmentation Scheme implemented in Chitungwiza is included in the government-assisted projects, financed by GDL only. Most of sewerage augmentation works implemented in major urban councils take the form of co-financing projects assisted by the World Bank. The on-going Firle V and Lower Mukuvisi Outfall Sewer (City of Harare) co-financed by European Investment Bank and loan the Council borrowed is the only sewerage project financed by external source other than the World Bank. The World Bank-assisted Programe called Urban II ecompases most of sewerage augmentation works implemented nation-wide.

Loan disbursement for sewerage projects by source of fund and type of project during the last 6 years is shown in Table 3.2.12.

Table 3.2.12. Loan Disbusement for Sewerage Projects

Type of Project	Period	Source of Fund (Sewerage)				USRDP
		USRDP		Loan funded	Total	as a
		GDL	Donors	by council		whoel
Government-assisted	90/91 - 95/96 (6 years)	142.3	-	-	142.3	649.8
Foreign-assisted	91/92 - 95/96					
Urban II	(5 years)	56.5	56.5	-	113.0	347.9
Others	92/93 - 95/96					
	(4 years)	-	35.0	253.4	288.4	35.0
Total		198.8	91.5	253.4	543.7	1,032.7

Source: PCMU (Urban II), Local authority Administration of MLGRUD, City Treasurer (City of Harare).

Remarks : GDL disbused to the government-assisted sewerage projects is an estimated figure.

About Z$ 540 million has been disbursed for sewerage projects during the last 6 years, out of which the large scale of projects (Firle V and Lower Mukuvisi) in City of Harare shares a substantial portion of loans (Z$288 million). About 88% or Z$253 million for implementation of these projects was funded from the so-called Consolidated Loans Fund consisting of private loans and the City's internal fund. Urban II Programe disbursed Z$113 million for sewerage projects which is about one-third of Urban II loans as a whole. Depending on the scale of sewerage augmentation work, an average investment per project was in the range from Z$1 to Z$2 million. GDL disbursed during the last 6 years amounts to Z$ 142 million in total. Sewerage components of PSIP for 1996/97 is shown in Table 3.2.13.

Table 3.2.13 Sewerage Component of PSIP for 1996/97

Type of Project	Source of Fund (Sewerage)				USRDP
	USRDP		Loan to be	Total	as a
	GDL	Donors	funded by council		whole
Government-assisted	19.5	-	-	19.5	25.7
Foreign-assisted					
Urban II	39.1	53.8	15.0	107.9	353.0
Others	-	88.0	100.0	188.0	88.0
Total	58.6	141.8	115.0	315.4	466.7

Source: PSIP of USRDP, Local Authority Administration of MLGRUD

About Z$315 million is planned to be disbursed for sewerage projects in 1996/97, out of which Z$188 million is to be invested for the on-going Firle V and Lower Mukuvisi. The Harare City will borrow Z$100 million from the money market. GDL shared by the government-assisted projects turns out to be Z$19.5 million, of which most of them was already disbursed for the remaining portion of Sewerage Augmentation Work in Chitungwiza. Urban II projects for 1996/97 are mostly on-going projects. Due to time constraint that the Program comes to an end by June 1998, PSIP of Urban II appears to facilitate implementation of all on-going projects. Loan disbursement shared by sewerage component is expected to be Z$108 million, which is more or less equivalent to the previous loan disbursed during the last 5 years. About a third of total urban II loan is scheduled to be disbursed for sewerage component. Implementation of urban II projects tended to be delayed due to the lack of the government's counterfund, thereby some of Donors' fund remained unutilized. The prompt implimentation of on-going projects is to be highly expected.

2) Economic and financial base of Chitungwiza

Chitungwiza is currently the third largest urban center followed by Bulawayo and City of Harare. Basic statistic showing the present conditions of Chitungwiza would be the fundamental indicators to comprehend financial strength of the said urban center. Table 3.2.14 shows a comparison of economic and financial profile between the Harare City and Chitungwiza, which is used for assessment of relative strength of Chitungwiza in terms of economic and financial parameters.

Relative strength implies rates of socioeconomic and financial bases of Chitungwiza compared to those of Harare City. Population is often used as the basic parameter indicating economic strength of a country or an urban center. A hundred (100) is given to the relative strength of population (33%) as the base index number. Index numbers of other parameters are calculated on the basis of the relative strength of population and somehow shows real strength of economic and financial bases Chitungwiza possessses.

(a) Relative strength of population

The relative strength of population turns out to be 33%, indicating that Chitungwiza is endowed with 33% of economic strength of the Harare City in terms of population.

Table 3.2.14 Relative Strength of Chitungwiza

Parameters	Harare (1)	Chitungwiza (2)	Relative Strength (2)/(1)%	Index of Strength
Socio-economic data				
a) 1) Population	1,210,326	400,000	33.0	100
2) Nos. of home stands	136,535	31,134	22.8	69
3) Nos. of industrial employees	85,845	2,500	2.9	9
b) Nos. of water connection				
— Home stands	120,885	31,134	25.8	78
— Commercial/industrial stands	4,476	413	9.2	28
Sub-total	125,361	31,547	25.2	76
Finance data				
1) Rate income in 1994/95 (Z$ million)	308	39	12.7	38
2) Water revenue in 1994/95 (Z$ million)	241	31	12.9	39
3) Sewerage revenue in 1994/95 (Z$ million)	60	5	8.3	25
4) Fixed assets in 1994/95 (Z$ million)	1,292	88	6.8	21
5) Own capitals in 1994/95 (Z$ million)	603	-8		
6) Capital investment during 3 years from 1991/92 to 1994/95 (Z$ million)	1,406	28	2.0	6

Sources: Department of work, City Treasurer (Harare)
Town Treasurer (Chitungwiza)

(b) Tax and revenue base

Councils levy local tax and water charge on registered residents. The number of home stands and water connections are the fundamental figures of tax and revenue bases respectively. Both index numbers of home stands and home stand water connections are lower than 100, which implies that tax and revenue base of Chitungwiza is relatively lower than those of the Harare City.

(c) Commercial and industrial base

The relative strengths of industrial employees and commercial/industrial water connections are 2.9 and 9.2 respectively. This implies that Chitungwiza has the

far-smaller collection base on tax and revenue from commercial/industrial stands relative to those of the capital city.

(d) Financial strength

Relative strength of financial parameters are around or less than 10. Financial parameters are largely classified into income and stocks. Income is represented by rate income, water and sewerage revenue, while stocks by fixed assets and own capitals. Rate income comprises of various local taxes and surcharges levied from tax base. The low index number (12.7) of this parameter is clearly correlated to the relative strength of tax or commercial/industrial base. Relative strengths of stocks are further lower than those of income flow. Unlike the capital city, capital stocks of the Chitungwiza municipality has not been amply accumulated, which is clearly indicated by fixed assets or own capitals. The scale of capital investment mostly financed by GDL and external loans is closely correlated to the borrowing power of councils themselves, which might be represented by the council's own capitals. In this regard, capital finance of Chitungwiza has to be owned to cost recovery that debt services should be repaid from revenue generation.

(e) Conclusion

Population often misguides real strength of area assessed. This is proved by the condition that Chitungwiza does not have comparable bases on tax or revenue, and commercial/industrial activities relative to population strength. Financial strength is much weaker due to insufficient capital stocks the Council possesses. This implies that capital finance should adhere to the principle of cost recovery as long as capital projects are financed by loans.

3) Financial arrangement for sewage work

Unlike water works depending on the bulk water supplied from the City of Harare, sewage work is the Force Account entirely managed by the Council. The Force Account needs a consistent management system encompassing planning, construction, operation and maintenance, and financial arrangement. Cost recovery is obviously emphasized to conduct dairy operation of financial arrangement. This section presents the fundamental issues relating to financial arrangement for sewage work.

Revenue collection

Because of flat tariff system, sewerage charge is combined with the other fixed charges including tax and those charges consolidated are currently levied on customers in the form of cash notes. The failure or delay to pay for those charges recorded in cash note brings serious penalty to customers in the form of removal from rent house or water disconnection. The fear of such penalties tends to force customers to pay regularly, resulting in collection rate of nearly 100% from home stands. Some public and industrial stands whose payment suspends for a few months are marked as blacklist by the Council. But no effective penalty measure has been enforced to such black customers, industrials stands particularly.

Application of cost recovery to sewerage tariff

The Council currently levies sewerage charge on customers based on flat tariff system. Flat tariffs are charged on water closets and urinals provided inside customers' stands. During the budget cycle the Council proposes new tariffs to be applied in the following fiscal year. It seems that new tariffs proposed have nothing to do with cost recovery, thereby only to inflate previous tariffs by price escalation rate. But cost recovery is actually taken into account to propose new tariffs. Incremental rate of tariffs is simply determined so as to cover estimated expenditures in the following fiscal year. To what extent the existing tariffs should be increased is exemplified based on the proposed expenditures budgeted for 1996/97. Table 3.2.15 shows revenue and expenditures budgeted for both fiscal years of 1995/96 and 1996/97.

Table 3.2.15 Sewerage/Revenue and Expenditures Budgeted

Revenue/Expenditures	Units	1995/96 Tariff (Z$/month)	1995/96 Revenue (Z$,000/year)	1996/97 Tariff (Z$/month)	1996/97 Revenue (Z$,000/Year)
Water closet					
Residential	31,134	23.70	8,854	29,63	11,070
Commercial/Public	750	70,56	635	88,20	794
Industrial	313	117,60	442	147,00	552
Sub-total			9,931		12,416
Urinals					
Commercial/Public	638	46,37	355	57,96	444

Revenue/Expenditures	Units	1995/96 Tariff (Z$/month)	Revenue (Z$,000/year)	1996/97 Tariff (Z$/month)	Revenue (Z$,000/Year)
Industrial	137	69,55	114	86,94	143
Sub-total			469		587
Other charges			11,056		13,822
Total		1995/96		1996/97	
Expenditures	(Z$,000)	11,801		13,714	

Source: Revenue, Expenditure and Capital Budget 1996/97

Sewerage expenditures are estimated to the Z$ 13,714 thousands for 1996/97. The revenue (Z$11,056 thousands) for 1995/96 should be increased by 25% to come up with the proposed revenue (Z$13,822 thousands) for 1996/97. This incremental rate (25%) is applied to all the existing tariffs so as to generate the proposed revenue.

The process to determine the proposed tariffs is actually not complex but simple. In due course of tariff determination, the Council considers only the following point that proposed tariff for residential users would be socially acceptable or not in terms of capacity-to pay-of local residents. Application of proposed tariffs is entirely subject to approval of the central government (MLGRUD). It usually takes time to approve new tariffs. Thus, new tariffs are to be usually effect in 5 months after the first month (July) of new fiscal year, resulting in revenue generation lower than expected.

Capital investment and finance

The existing facilities of Zengeza Sewage Treatment Works were completed in 1987 under the ownership of the Harare City, and then was transferred to Chitungwiza in 1991. After the transfer of ownership, Chitungwiza faced the following problems with respect to the Zengeza STW.

- Discharge of incompletely treated trade effluent into the near-by Nyatisme river.
- Obsolution of pumphouse.
- Insufficinet treatment capacity (21,750m^3/day) against actual inflow of raw sewerage (36,000m^3/day).

To settle these problems, Chitungwiza launched the Sewerage Augmentation Work consisting of phase I and II. The facilities constructed at each stage are as follows.

Phase I

- New pump house with three units of pumping plants,
- Expansion of maturation ponds in Imbgwa Farm, and
- Rehabilitation of the esting 5 trickling filters.

Phase II

- Construction of the fourth unit of anaerobic pond.

The two direct benefits were brought forward by the Sewerage Augmentation Works. One is that expansion of maturation pond prevented effluent from inflowing into the Nyatisme river. The other is uprating of treatment capacity due to the 4th unit of anaerobic pond.

Both stages of phase I and II were financed by loans mostly and the Council's reserves partially. Loans consist of GDL and the Council's internal funds called Capital Development Fund. The details of capital investment and finance are shown in Table 3.2.16.

Table 3.2.16 Capital Investment and Finance **Unit: thousand Z$**

	1992/93	1993/94	1994/95	1995/96
Fixed assets				
Building/equipment	969	907	1,063	1,010
Water/sewage works	17,910	17,910	35,132	44,790
Total	18,879	18,817	36,195	45,800
Liabilities				
GDL	14,112	14,145	28,218	43,214
CDF	2,515	2,234	3,071	5,049
Reserves	2,252	2,438	3,178	3,426
Special funds	0	0	1,728	(5,889)
Total	18,879	18,817	36,195	45,800
Investment		—	17,378	9,605
Finance				
GDL		33	14,073	14,996
CDF		—	837	1,978
Reserves		189	740	248
S.F		0	1,728	(7,617)
Total		219	17,378	9,605

Source: Auditor's Report

The amount of Z$26,983 thousands was invested for Phase I and II during the last two fiscal years. The sources of capital finance consist of GDL (Z$29,0069 thousands), CDF (Z$2,815 thousands) and the Council's reserves (Z$988 thousands). At the end of the last fiscal year (June, 1996), the loan conditions of Sewerage Augmentation Work and previous liabilities are summarized in Table 3.2.17. The loan conditions of GDL for phase 1 and II are as follows:

- Interest rate (9.75%)
- Grace period (2 years)
- Repayment period (25 years).

Table 3.2.17 Loan Conditions of Existing Liabilities

Conditions	Previous loan	Phase 1 and II
1) Loan outstanding (Z$,000)		
GDL	14,145	29,069
CDF	2,234	2,815
2) Interest rate (%)		
GDL	9.75	9.75
CDF	10.50	10.50
3) Grace period (yrs)		
GDL (2yrs)	none	Z$14,073,000 (1994-95) Z$14,996,000 (1995-96)
CDF	none	none
4) Repayment period (yrs)		
GDL	9 (-2005)	25 yrs
CDF	9 (-2005)	9 (-2005)

Source: Auditor's Report
Remarks: The composition of loan outstanding of previous loan for water and sewage works is estimated to be 20 and 80% respectively.

Analysis of actual revenue and expenditures

Table 3.2.18 shows actual revenue and expenditures from 1992/93 to 1995/96. The contrast of planned (budget) and actual performance is also given for the year of 1995/96.

Table 3.2.18 Sewerage Revenue and Expenditures Unit: thousand Z$

Sewerage Account	1992/93	1993/94	1994/95	1995/96 Actual	1995/96 Budget
Revenue	2,821	3,845	5,062	8,549	11,056
Sewerage charges	2,724	3,777	4,841	8,533	10,587
Maintenance charges	97	68	221	16	656
Expenditures	2,238 (100)	2,656 (100)	4,724 (100)	10,016 (100)	10,525 (100)
Salaries	868 (39)	1,264 (48)	1,740 (37)	2,405 (24)	2,656 (25)
General expenses	825 (37)	958 (36)	2,439 (52)	2,583 (26)	3,229 (31)
Repair/maintenance	545 (24)	434 (16)	536 (11)	59 (1)	1,370 (13)
Dept. services	—	—	9 (0)	4,969 (49)	3,270 (31)
Balance	583	1,189	338	-1,416	535

Remarks: Parentheses indicate the proportion of each expenditure item.

Sewerage charge consist of income generated by levying various flat tariffs on customers, while maintenance charge are the supporting income coming from sewer connection fees and charges on clearing of toilet blockage. Expenditures are broadly classified into the four items, salaries, general expenses, repair/ maintenance and debt services.

Sewerage account somehow maintained the principle of self-financing until the year of 1994/95. Even when the phase 1 work actually started in 1994/95, resulting in the sharp increase of general expenses mainly caused by administration cost associated with the implementation of phase 1, the Account gained the marginal revenue surplus.

An attention should be paid to actual performance of the Account in 1995/96, when the Account plunged into deficit finance of Z$1.4 million. The reasons for such deficit could be observed for both sides of revenue and expenditures. On the revenue side, actual revenue collection rate of sewerage charges resulted in about 80% of revenue budgeted. The lower collection rate than planned is attributed to the Councils side (i.e black-list of customers pending payment for charges or the Council's poor task of revenue collection) and institutional matter caused by delay in the government's approval of the proposed tariffs. The latter is more dominant than the former in terms of the lower rate of revenue collection. The proposed tariff was actually effect from December in 1995, which means that the Council was forced to

use the previous tariffs for 5 months from July to November 1995. The loss rate caused by this reason is estimated to be about 16%. Perhaps revenue collection performance to be achieved lower than planned would not be improved because of the institutional issue explained.

Under such a circumstance, the Council's control on expenditures is more meaningful than revenue management in order to avoid deficit finance. The Council estimates expenditures item by item during the budget cycle. The year of 1995/96 is particularly earmarked for rush repayment of debt services due to implementation of Phase I and II. At the time of budget, debt services were estimated to be Z$3.27 million, but actually increased to Z$5.0 million. Most of Z$5.0 million is originated in repayment of CDF borrowed from other surplus accounts. Repayment schedule of CDF tends to be unsuitable as the borrowed money is sometimes required to pay back to lending account more than scheduled. Rush repayment of CDF resulted in squeeze down of expenditures for repair and maintenance. This is the unfavorable result due to the raising amount of debt services. Towards the coming period when the Council will be continuously obliged to pay for debt services of Phase 1 and II, it can be concluded that the control on expenditures would be the crucial action to avoid the deficit finance.

CHAPTER 4

FRAME VALUES AND LAND USE

CHAPTER 4 FRAME VALUES AND LAND USE

4.1 General

The frame values for the year 2000 were studied with reference to planning/design of sewerage facilities. The concerned items are population, industry and commercial activities. The study results of the Water Pollution Control Master Plan are the basis for the purpose. However, the design population in 2000 was modified referring to two scenarios. The land use plan also refers to the Master Plan.

4.2 Population

The most recent population census was conducted in 1992 for the urban areas. The census figures could be used in principle as the projection base for the planning years. However, some studies conducted as of now present modified figures to meet actual situations. Available data in 1992 for the Minicipality are as follows:

Information Source	1992 Population	Remarks
1992 Census	274,912	
Harare Combination M/P	354,541	Modification of the census data was made conducting survey

The population employed in Harare Combination M/P was employed to meet the current population status. The annual average growth rate in the census results between 1982 and 1992 was approximately 4.8%. However, the actual increase of the municipal population become considerable, as noted in the second urban development project (analysed growth rate is 9% per annum).

Population projection was made for the four alternatives as studied in the Water Pollution Control M/P. Among them, two scenarios were selected as a range of future population; (1) application of the factors used in "Master Plan for Water Distribution, Harare City, Volume 3, 1995" and (2) application of the population growth rates used in "Harare Combination M/P, Report of Study, 1992". The following are the calculation results for Chitungwiza Municipality.

Present (1992)	Year 1995	Year 2000	Year 2015
354,500	405,000	Case 1: 537,800	Case 1: 962,500
		Case 2: 439,500	Case 2: 573,100

Note: Case 1; Application of the factors (by density category) used in "Master Plan for Water Distribution, Harare City"

Case 2; Application of population growth rates used in "Harare Combination M/P, 1992"

Referring to the two scenarios, design population in the year 2000 was established to be 489,000 as a intermediate figure. The present population in 1995, as a reference figure, was simply projected assuming a linear relationship between the year 1992 and 2000. The projected population, 405,000, meets the reported about 400,000. Distribution of the municipal population to the concerned wards is studied in Section 7.

4.3 Industry

The number of employees was estimated on the assumption that the number will increase in proportion to the increase rate of industrial area in future land use plan. The land occupation ratio of the factories in the industrial area in 2000 was assumed to be 80%. Furthermore, it was assumed that directly related factories' land area for the calculation of employees would proportionately increase between the present (57.5 %) and the year 2015 (100 %).

The number of employees per hectare at present was determined at 43.48 persons, which was assumed to be constant through the future. Table 4.3.1 presents a total number of employees.

Table 4.3.1 Present and Future Number of Employees

Item	Present	Year 2000	Year 2015
Industrial Area (km^2)	1.35	1.35	9.41
Factory Land Area (ha) (80% of I.A)	108.0	108.0	752.8
Factory Area (ha) and percent related to calcu. of No. of Employees	57.5 (53,2%)	70.1 (64,9%)	752.8 (100%)
No. of Employees / ha	43.48	43.48	43.48
No. of Employees	2,500	3,100	32,800

The number of employees for the major six industrial types identified through present analysis was estimated through the future assuming that present composition of industrial types is adaptable. Table 4.3.2 shows the calculation results.

Table 4.3.2 Present and Future Number of Employees by Industrial Type

Industrial Type	Composition (%)	Present	Year 2000	Year 2015
Processed Foodstuffs	42.0	1,048	1,301	13,776
Plastic Products	1.3	33	40	427
Ceramics, Stone & Clay Products	1.5	38	47	492
Metal Products	4.7	118	146	1,541
Transportation Equipment	43.9	1,098	1,361	14,399
Other Products	6.6	165	205	2,165
Total	100.0	2,500	3,100	32,800

4.4 Land Use at Present and in the Future

At the present time, about 55 % (22.82 km^2) of the municipal area (42 km^2) is used for residential purposes, comprising high and medium density areas without any low density areas. About 85 % of the residential area is occupied by high density areas (19.47 km^2). Open spaces account for about 40 % of the land area. Figure 4.4.1 presents the current land use of the municipality.

Of the open spaces at present, land development for the target year 2000 is planned with an area of 1.75 km^2 in St. Mary's, northwestern periphery of the municipality. The development entails the following:

- High density housing : 2,346 stands for 150 m^2/ H.H
  721 stands for 200 m^2/ H.H
  56 stands for 300 m^2/ H.H
- School : Primary 5 units
  Secondary 1 unit
- Commercial establishments and church

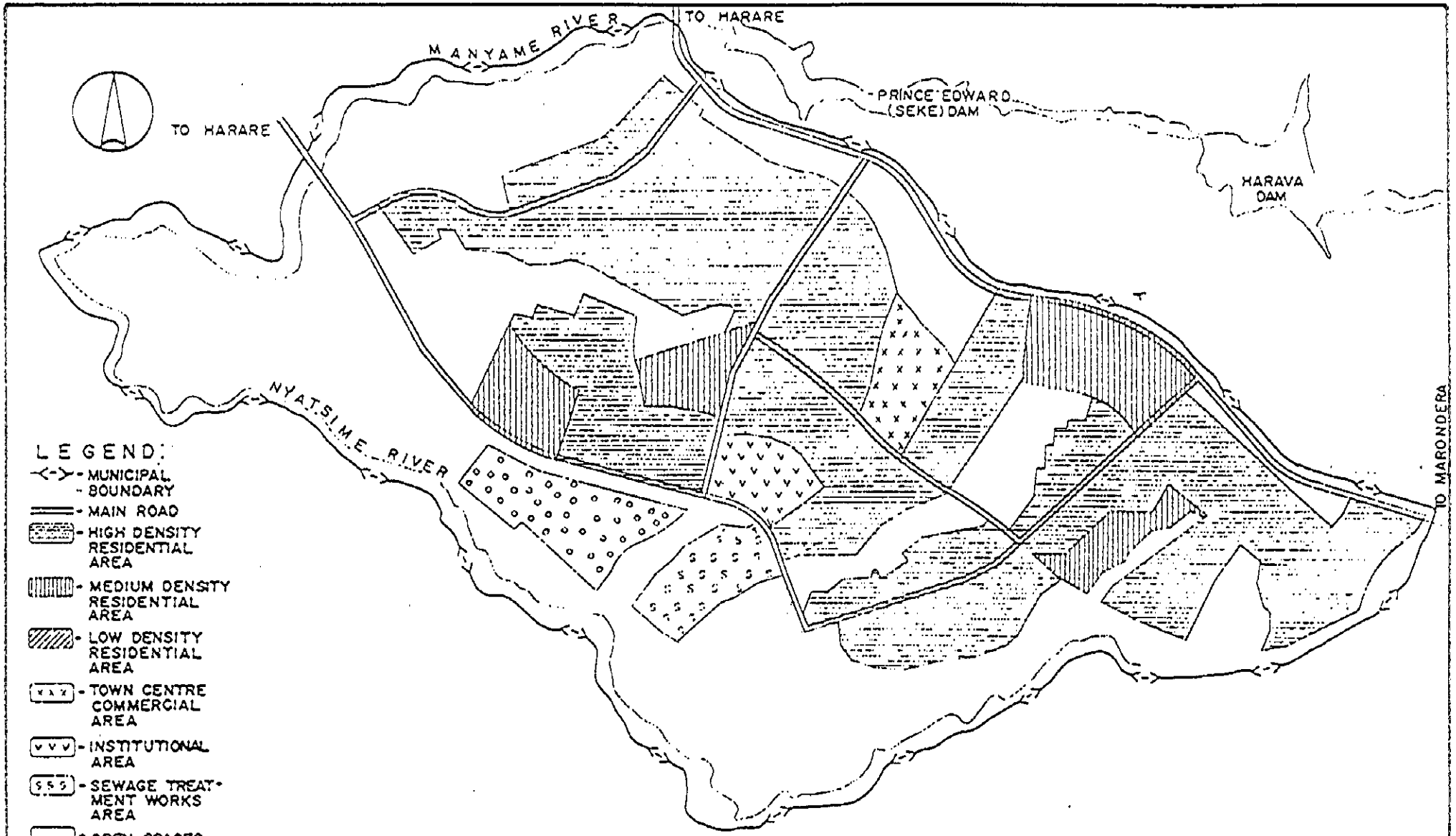


Figure 4.4.1 Present Land Use in Chitungwiza Municipality

Figure 4.4.2 shows the land use plan of the municipality for the year 2000 and Figure 4.4.3 for St. Mary's area development.

The future expansion of the municipality through the year 2015 is projected, as shown in Figure 4.4.4, on the left bank of the Nyatsime River. The proposed 2000 onward housing development (3,000 stands) and irrigation farm land south of the Nyatsime River on the Braemar, Dunottar and Cawdor Farms are shown in Figure 4.4.5. In early the procurement of the land, treated effluent and sludge may be disposed of together with the storage pond on Imbgwa Farm. Table. 4.4.1 presents land use of the municipality through the future.

Table 4.4.1 Present and Future Land Use

Land Use Type		Present	Year 2000	Year 2015
Residential Area	Low Density	0.00	0.00	2.14
	Medium Density	3.35	3.35	8.26
	High Density	19.47	21.22	26.67
	Sub-Total	22.82	24.57	37.07
Industrial Area		1.35	1.35	9.41
Commercial Area		0.85	0.85	0.85
Institutional Area		0.74	0.74	0.74
Sewage Treatment Works Area		0.93	0.93	0.93
Open Spaces		15.31	13.56	5.50
Total		42.00	42.00	54.50

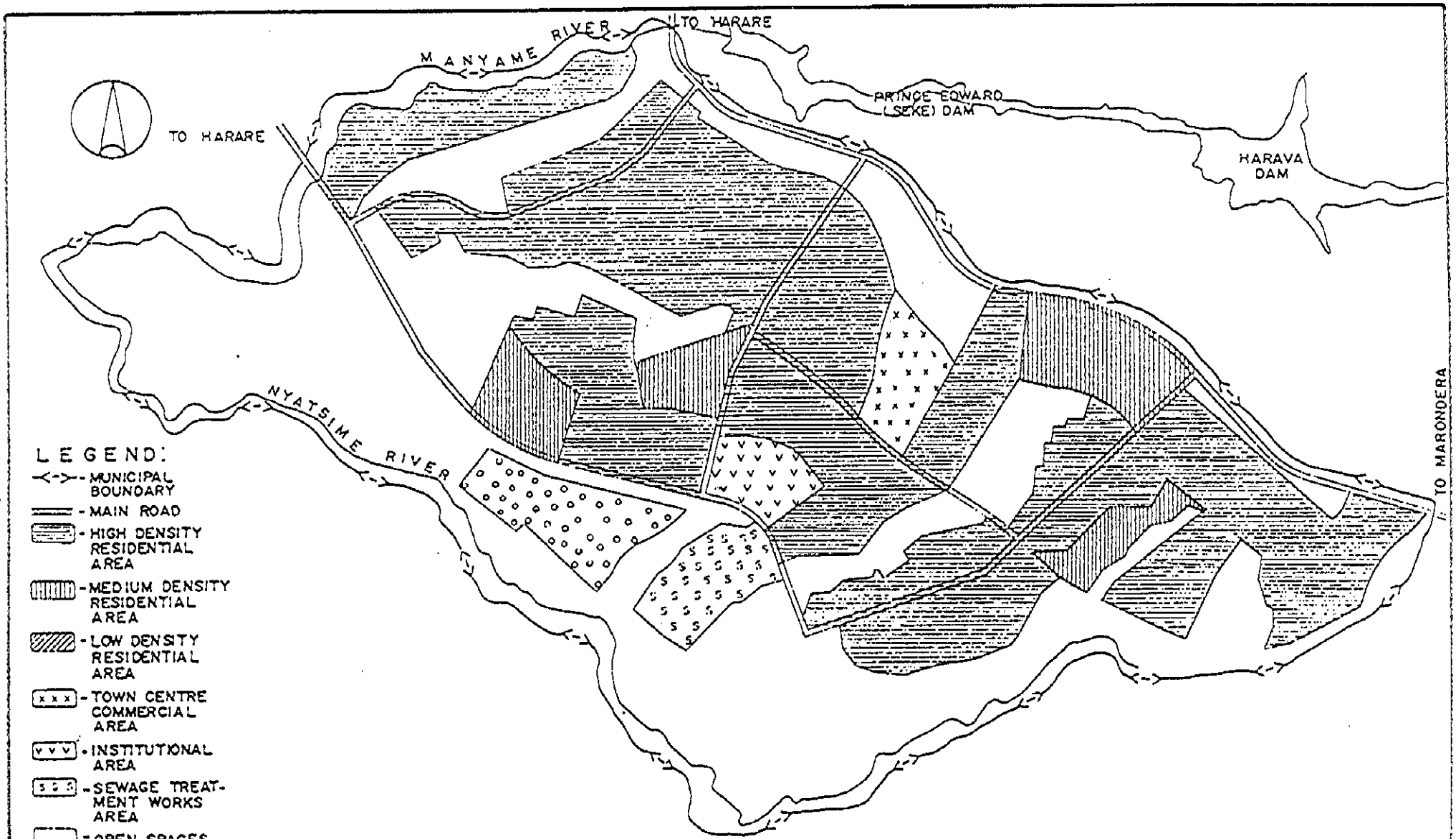


Figure 4.4.2 Land Use Plan in Chitungwiza Municipality (Year 2000)

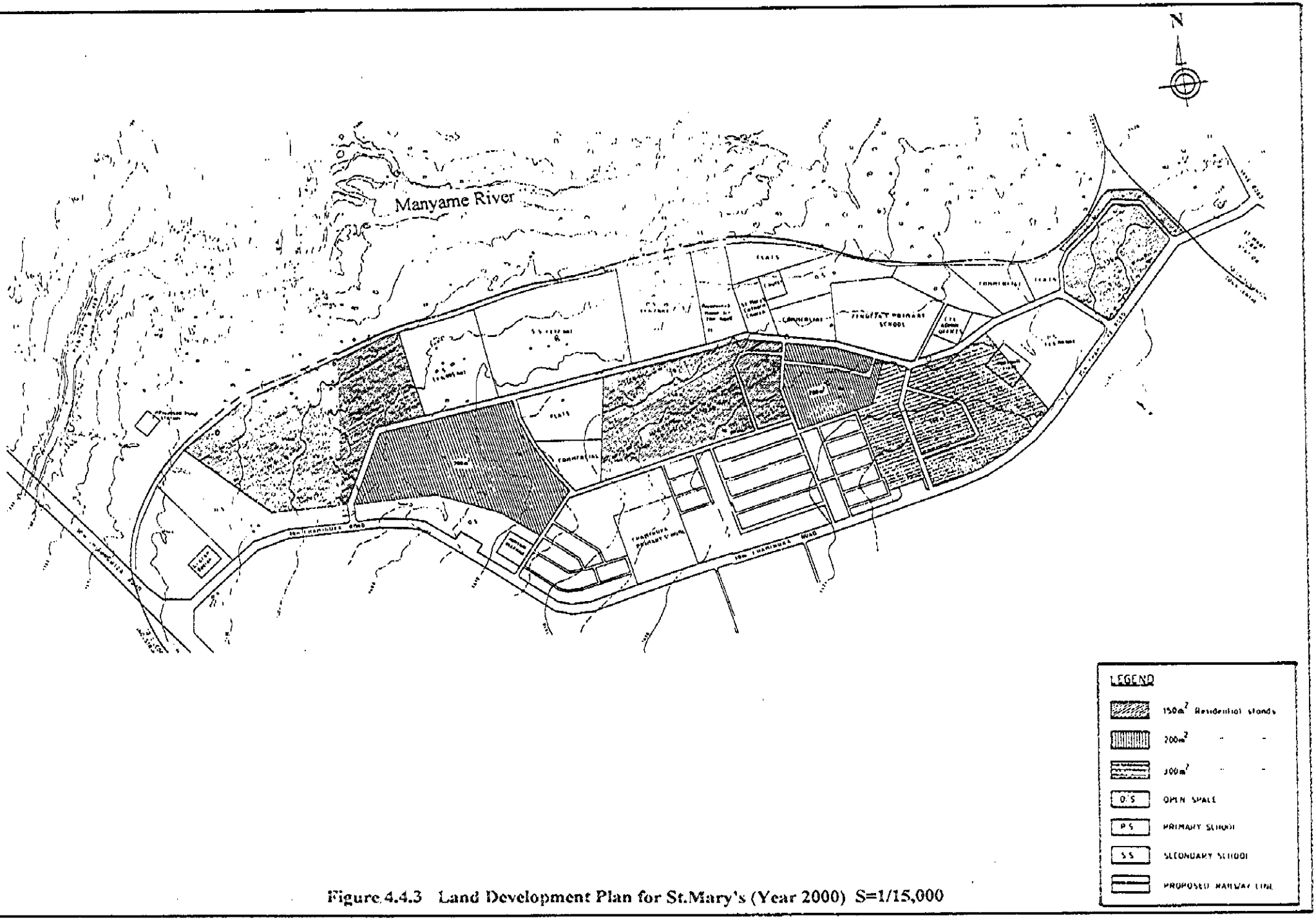


Figure 4.4.3 Land Development Plan for St.Mary's (Year 2000) S=1/15,000

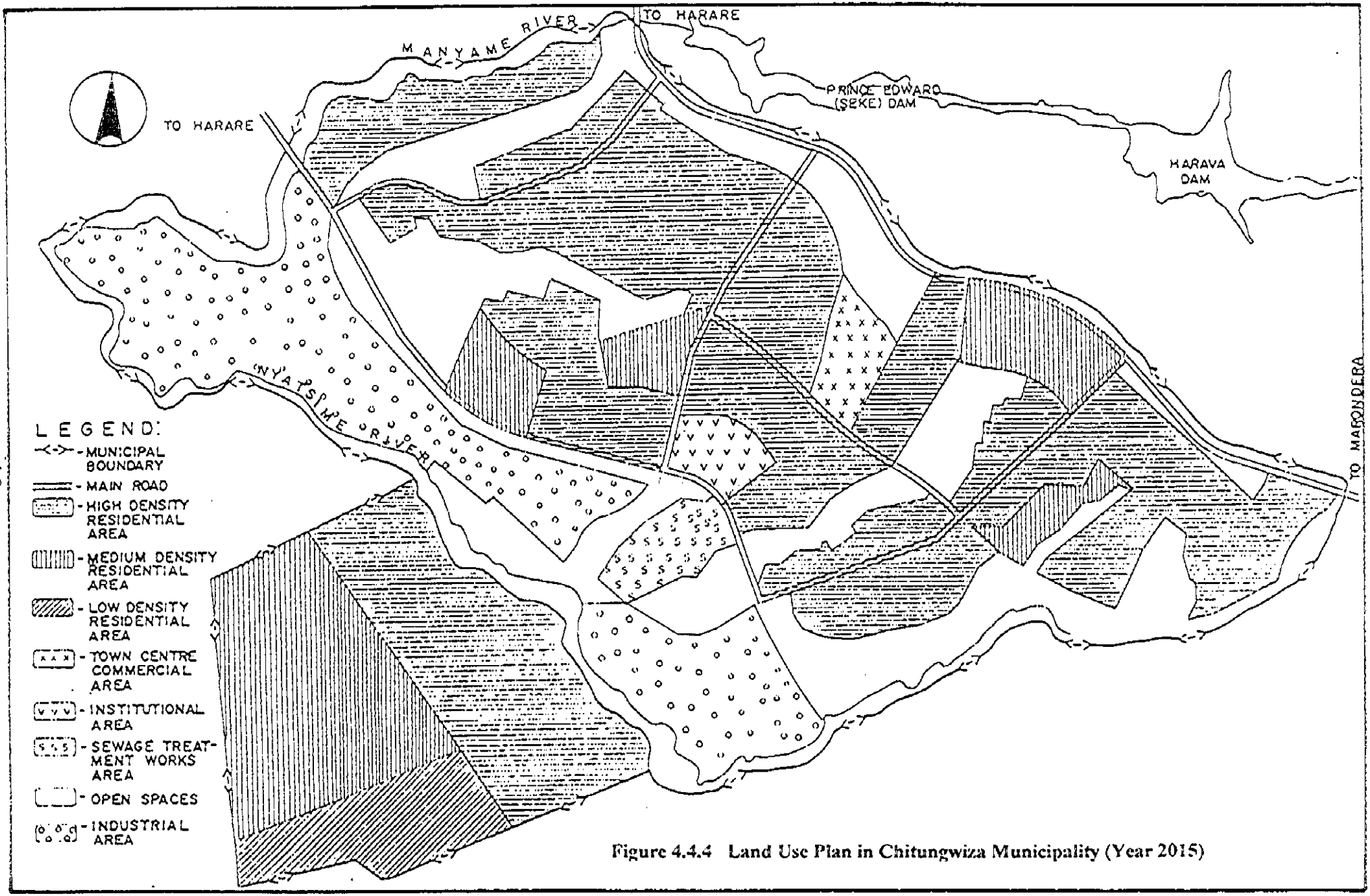


Figure 4.4.4 Land Use Plan in Chitungwiza Municipality (Year 2015)

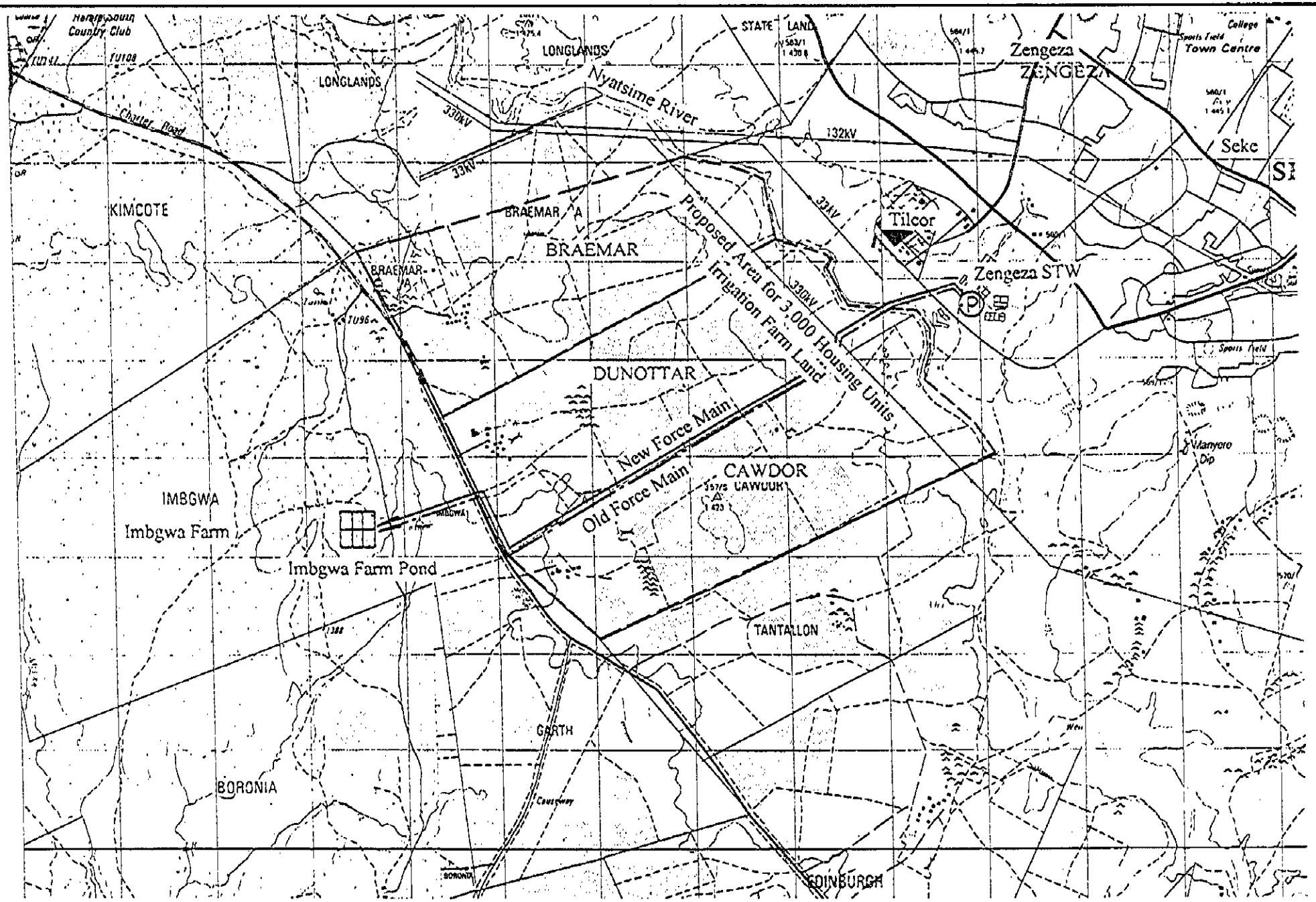


Figure 4.4.5 Proposed Area for the Development of Housing and Irrigation Purpose S=1/50,000

CHAPTER 5

QUANTITY AND QUALITY OF SEWAGE

CHAPTER 5 QUANTITY AND QUALITY OF SEWAGE

5.1 General

The design sewage volume and quality are summarised based on the study in the Master Plan. Pollution sources cover population, commercial/institutional activities and industry. Water quality indices include BOD, SS, T-N and T-P for design of sewerage facilities.

Frame values and unit quantity and quality by pollution source are discussed to come up with a design sewage volume and quality referring to the average dry weather flow (ADWF) and the peak wet weather flow (PWWF).

5.2 Domestic and Commercial/Institutional Sewage

(1) Unit quantity and quality of domestic sewage and those of commercial/institutional wastewater

The unit domestic sewage quantity on the ADWF was established by different residential density in the Master Plan as shown in Table 5.2.1.

Table 5.2.1 Unit Domestic Sewage Quantity

unit: lpcd

Category	Present	Year 2000	Year 2015
High density	60	63	70
Medium density	210	210	210
Low Density	315	315	315

The average quantity in the overall service area in 2000 was calculated at 68 lpcd using the above unit quantity and population distribution of different densities (Scenario 1 in the Master Plan). The figure is affected by majority of the population resided in high density area. The wastewater discharged by commercial/institutional establishments was assumed to be 5 % of the domestic sewage through the future based on the investigation results of the bulk water reading in the municipality.

The unit generated pollution loads of domestic sewage were assumed referring to previous sewerage studies, the Sanitation Manual and data at the Donnybrook STW (where majority of the people reside in high density area). Unit Suspended Solid (SS) was assumed in use of the relationship with BOD. Data of last one year (fiscal year 1995) on BOD and SS in Harare City were referred to as shown in Table 5.2.2.

Table 5.2.2 Relationship Between BOD and SS in Harare

Unit: mg/l

STW	BOD	SS
Crowborough	619	650
Firle (No 1 & 2)	483	509
Firle (No 3)	461	583
Firle (No 4)	474	589
Hatcliff	705	791
Average	548	624

The average ratio between BOD and SS, 1.15 (SS/BOD) was employed. The unit generated pollution loads for BOD, SS, TN and TP are as shown in Table 5.2.3.

Table 5.2.3 Unit Generated Pollution Loads

Unit: gpcd

Water quality index	High - density	Medium - density	Low - density
BOD	44	47	50
SS	51	54	58
TN	11	12	13
TP	1.2	1.3	1.4

Regarding the quality of commercial/institutional wastewater, the concentrations were assumed to be same as that of domestic sewage.

(2) Sewage volume and quality (pollution loads)

Sewage volume including institutional/commercial wastewater was estimated under the above mentioned conditions as follows:

- Domestic sewage quantity (population in 2000 x average unit quantity)
  489,000 x 0.068 m^3/p.d = 33,252 m^3/d
- Institutional/commercial W.W (5% of domestic sewage quantity)
  33,252 m^3/d x 0.05 = 1,662 m^3/d

The total of the sewage quantity arrived at about 34,900 m^3/d.

Pollution loads caused by the population in 2000 were calculated using average unit loads (BOD 44.1 gpcd; SS 52.1 gpcd; TN 11 gpcd and TP 1.2 gpcd) and population of the municipality as follows:

- BOD 489,000 x 0.0441^{kgpcd} = 21,565 kg/d
- SS 489,000 x 0.0511^{kgpcd} = 24,988 kg/d
- TN 489,000 x 0.011^{kgpcd} = 5,379 kg/d
- TP 489,000 x 0.0012^{kgpcd} = 587 kg/d

5.3 Industrial Wastewater

(1) Unit quantity and quality of industrial wastewater

The unit quantity and quality of industrial wastewater for the selected six types were studied in the Master Plan, which are summarised in Table 5.3.1

Table 5.3.1 Unit Quantity and Quality of Industrial Wastewater

Type of Industry	W.W. Quantity m^3/d/person	W.W. Quality (g/d/person)			
		BOD	SS	TN	TP
Processed Foodstuffs	0.677	966	301	25.06	9.61
Plastic Products	0.083	23	1,954	0.27	0.08
Ceramic, Stone & Clay	0.833	91	682	13.89	2.26
Metal Products	0.218	61	93	6.92	0.66
Transportation Equip.	0.137	70	81	3.54	4.90
Other Products	0.315	230	397	56.04	6.51

(2) Industrial wastewater quantity and quality

Industrial wastewater quantity and pollution loads discharged from factories for the year 2000 were calculated using the projected number of employees and the unit quantity and quality figures by identified industrial type as shown in Table 5.3.2.

The number of employees in 2000 was assumed to increase by about 25%. Wastewater quantity and pollution loads will increase in proportion to the increase rate except for BOD load (only 5 % increase).

Table 5.3.2 Industrial Wastewater Quantity and Quality (the year 2000)

Type of Industry	No. of Employees	W.W. Quantity (m^3/d)	Pollution Load (kg/d)			
			BOD	SS	TN	TP
Processed Foodstuffs	1,301	881	1,256	392	33	13
Plastic Products	40	3	1	78	0	0
Ceramics, Stone & Clay	47	39	4	32	1	0
Metal Products	146	32	9	14	1	0
Transportation Equip.	1,361	186	95	111	5	7
Other Products	205	65	47	81	11	1
Total	3,100	1,206	1,412	708	51	21

5.4 Design Sewage Volume and Concentrations of Pollution Loads

(1) Design sewage inflow volume into the STW

The ADWF for the sewerage planning purpose was summarised in consideration of 15% groundwater inflow against discharged sewage as shown in Table 5.4.1.

Table 5.4.1 Design Sewage Inflow Volume

Type	Discharged sewage/W.W. (m^3/d)	Inflow sewage flow into the STW (m^3/d)
Domestic	33,252	38,240
Insti/comm.	1,662	1,912
Sub-total	34,914	40,152
Industrial	1,206	1,387
Total	36,120	41,539

With regard to the discharged sewage volume in the year 2000 (36,120 m^3/day), a trial calculation of the sewage volume was made using projected water demand. The water demand for the year 2000 arrived at about 40,000 m^3/day in assumption that the water demand (28,900 m^3/day) in 1992 increased in proportion to the population increase from 354,500 to 489,000. Assuming sewage discharge rate of 90%, the sewage volume is about 36,000 m^3/day.

The total inflow of sewage into the STW in 2000 was calculated at about 41,500m^3/d. The design sewage volume for the expansion of the existing STW was established at 20,000m^3/d for the treatment of only domestic sewage, while existing treatment capacity has 21,750 m^3/d (combined domestic and industrial sewage).

(2) Concentrations of pollution loads (BOD, SS, TN and TP)

The concentrations of domestic sewage, industrial wastewater and combined sewage of domestic and industrial wastewater were calculated as follows:

1) Domestic Sewage

Table 5.4.2 Concentrations of Domestic Sewage

Indices	Pollution loads (kg/d)	Inflow quantity (m^3/d)	Concentration (mg/l)
BOD	21,565	38,240	564
SS	24,988		653
TN	5,379		141
TP	587		15

2) Institutional/Commercial wastewater

The concentrations of institutional/commercial wastewater were assumed to be same as domestic sewage. The total pollution loads in this category are as shown in Table 5.4.3.

Table 5.4.3 Pollution Load of Institutional/Commercial Wastewater

Indices	Concentration (mg/l)	Inflow quantity (m^3/d)	Pollution load (kg/d)
BOD	564	1,912	1,078
SS	653		1,249
TN	141		270
TP	15		28.7

3) Industrial Wastewater

The concentrations of inflow industrial wastewater into the STW are as shown in Table 5.4.4.

Table 5.4.4 Concentrations of Industrial Wastewater

Indices	Pollution loads (kg/d)	Inflow quantity (m^3/d)	Concentration (mg/l)
BOD	1,412		1,018
SS	708	1,387	510
TN	51		37
TP	21		15

4) Combined Concentrations of Domestic, Institutional/commercial and industrial wastewater

The overall average concentrations of inflow sewage (41,500 m^3/d) into the STW are estimated by water quality index as shown in Table 5.4.5.

Table 5.4.5 Concentrations of Combined Sewage

Source type	Pollution loads (kg/d)				Concentration (mg/l)			
	BOD	SS	TN	TP	BOD	SS	TN	TP
Domestic	21,565	24,988	5,379	587				
Inst./Commercial	1,078	1,249	270	28.7	580	649	137	15
Industry	1,412	708	51	21				
Total	24,055	26,945	5,700	636.7				

(3) Concentrations of pollution loads both for expansion and rehabilitation of existing sewage treatment facilities

1) Expansion facilities (domestic sewage only)

Design sewage volume : 20,000 m^3/d

BOD : 564 mg/l

SS : 653 mg/l

TN : 141 mg/l

TP : 15 mg/l

2) Rehabilitation of existing facilities

Design sewage volume : 21,750 m^3/d

Concentrations of pollution loads are calculated as shown in Table 5.4.6.

Table 5.4.6 Concentrations of Pollution Loads for Rehabilitation of Existing Sewage Treatment Facilities

Source type	Sewage quantity (m^3/d)	Pollution load (kg/d)				Concentration (mg/l)			
		BOD	SS	TN	TP	BOD	SS	TN	TP
Domestic & Inst./Comm.	20,363	(564 mg/l) 11,485	(653 mg/l) 13,297	(141 mg/l) 2,871	(15 mg/l) 305	592	644	134	15
Industry	1,387	1,412	708	51	21				
Total	21,750	12,897	14,005	2,922	326				

CHAPTER 6

PLANNING AND DESIGN APPROACH FOR THE URGENT PROJECT

CHAPTER 6 PLANNING AND DESIGN APPROACH FOR THE URGENT PROJECT

6.1 Technical Considerations

6.1.1 Conformity of the Urgent Project with the Long-term Sewerage Development Plan

The sewerage system of the municipality for the year 2015 was planned n consideration of the land use plan in the final target year. The existing sewage collection system, consisting of three sub-areas : Zengeza, Seke and the Tilcor industrial area, will be unchanged by the fact that the sewerage service cover the entire municipal area at present and the expansion and improvement of the existing facilities are to be required through the future.

The existing sewage works, with an area of about 100 ha, will be fully used for the expansion of the treatment facilities to meet the expected increase of sewage volume n the future. Although the existing treatment process (TF) will be used within its capacity through the future, the staged construction of the treatment facilities using BNR method was proposed as a means to replenish the area's water sources while meting the effluent quality standards.

The urgent sewerage project for the year 2000 was intended to construct additional sewers to serve for the planned housing development in St. Mary's, parallel to the existing trunk sewers, and the expansion of the sewage treatment facilities with an additional 20,000 m^3/day utilizing the BNR method. The rehabilitation of the existing sewage treatment facilities, sewers and pump stations was also proposed in order to restore their design capacity/functions.

The urgent project was planned to mitigate the overloaded condition of the sewage treatment facilities and to augment the sewage collection system - especially in the St. Mary's area. The new sewage treatment facilities were also planed to be constructed at the existing sewage treatment site in consideration of the effective use of the land in the context of the staged expansion of the facilities. In this regard, the urgent project was arranged in conformity with the long-term development.

6.1.2 Interrelationship between the Urgent Project and the Planed/designed/On-going Projects

As of December 1996, the fourth anaerobic pond unit is under construction, comprising two primary and one secondary pond per unit with all the requisite interconnecting pipeworks boxes and recirculation pipework and nozzles. Upon the completion of this work, the existing biological filter process, with a design capacity of 21,750 m^3/day, can be operated to achieve the planned effluent quality level. There is no concrete plan regarding the augmentation/improvement of the existing sewers.

The construction of an additional unit of anaerobic pond will contribute to the performance of the existing sewage treatment works to meet the design effluent quality for irrigation use, while an urgent project will be arranged for sanitation improvement in the problem areas, water pollution control in the area's water bodies, the reuse of effluent for water source replenishment and for treatment of sludge for agriculture use.

There is no overlap in the functions of the sewerage facilities between the on-going and the planned urgent projects. These facilities will rather be arranged to supplement each other, with provisions not to discharge raw sewage into the river even in the event of a breakdown/accident of the BNR process, the use of effluent treated by the BNR process for breaking scum in the anaerobic pond, etc.

6.1.3 Combined/Separate Treatment of Industrial Wastewater and Domestic Sewage

Currently, industrial wastewater is received by public sewers in a pre-treated condition from each factory to meet the domestic sewage quality level. However, the complete treatment of health-related substances by the respective factories is a prerequisite for the urgent project to operate successfully. These arrangement on the part of the local authorities are concerned not only with the sewage treatment at the STW, but also with the reuse of treated sludge as a fertilizer.

The combined sewage will be treated by using the existing trickling filter process, however, the BNR process shall be used to treat only domestic sewage to ensure stable influent quality, together with the condition of the design volume of 20,000 m^3/day.

6.1.4 Rehabilitation/Modification of the Existing Facilities for the Full Use

The existing system covers the entire area of the municipality. However, the augmentation/rehabilitation of the existing sewers shall be planned to meet the future increase in population and land development, though the trains of the sewage collection system could be adopted through the future. The preventative maintenance of the sewers shall be planned not only for the technical requirements but also for the annual budgetary arrangements.

The rehabilitation/replacement of the mechanical and electrical facilities at the existing pump station is also a requisite to recover the pump stations' design functions. The improvement of the pond system at the Tilcor Sewage Treatment Works shall be planned taking into account the particulars of the STW since the commencement of its operation and the fact that the site is owned by the municipality.

In reference to the new construction of the treatment facilities using the BNR process, the existing facilities shall be fully utilized in emergencies so as not to discharge raw sewage into the river. The in-plant piping network shall be designed with this in mind. The rehabilitation/replacement of the pump facilities at the old pump station of the STW shall also be planed to accommodate and send (to Imbgwe farm) the untreated sewage of the BNR process in case of a breakdown.

6.1.5 Reuse of Treated Effluent and Sludge

Two kinds of sewage treatment process are to be employed to meet the different purpose of effluent reuse. The trickling filter process used by the existing STW is to be continued for irrigation use, while the BNR process will be adopted for discharging effluent into the Nyatsime River that meets the quality standards. The use of the effluent to replenish the water resources f the study basin is requisite for meeting the water demands of the expected population of 2015, which is projected to be double that of the present population. The present intake from the impoundments plays a critical role in conserving the existing aquatic environment.

The reuse of the sludge generated by the STW is not commonly practiced in Zimbabwe. However, the promotion of the use of the sludge of the STW shall be planned since the amount of sludge increases annually.

A sanitary landfill will be necessary for sludge generated from the anaerobic pond and the sludge digestion tank (partially). The digested sludge shall be reused in cooperation with the agriculture sector. The sludge will also be used in the control of activated sludge in the BNR process.

6.1.6 Sewage Collection Method and Reticulation

The separated sewage collection method currently used shall be continued. The combined treatment of domestic and commercial sewage as well as industrial wastewater will also be accepted, while enforcing a proper pre-treatment of the industrial wastewater. The existing sewer reticulation will be used for expansion and improvement work in the municipal area. The capacity of the existing sewers allows for the sewage volume in the year 2000, with provisions for rehabilitation in the problem sections. Therefore, only a parallel sewer line to the existing trunk sewer from the St. Mary's area to cope with new housing development is to be continued.

6.1.7 Sewage and Sludge Treatment Methods

The sewage treatment method of the new STW, with a design capacity of 20,000 m^3/day shall be selected to meet the effluent quality required with an emphasis on nutrient removal to prevent eutrophication in the lakes The BNR method may be employed as Harare City uses it for the same purpose. The disinfection of the effluent before its discharging into the river shall not be considered since various kinds of bacteria contained in the raw sewage could be removed in the course of the treatment process and this could have an adverse impact on the aquatic environment.

The generated sludge shall be treated through the use of thickening, anaerobic digestion and drying for reuse as a fertilizer. The storage area for the treated sludge shall be designed so as to not flow out during heavy rains in order to prevent water pollution problems.

6.1.8 Construction Plan

The construction plan for the new treatment facilities and the rehabilitation/modification of the existing facilities will be developed both for the sewage and sludge treatment. The soil conditions and groundwater table are major concerns for the design of the foundation of the

facilities. The local construction experience in regards to sewerage facilities were also taken into account.

The grade of facilities and equipment will be determined based o the experience in Harare City as well as the ease and simplicity of operation of the facilities. The use of local materials and labor-intensive arrangements both for the construction and operation and maintenance of the facilities are fully considered.

6.1.9 Countermeasures against Emergency Cases

Special emphasis is to be placed o the emergency countermeasures related to water pollution control. In other words, the measures will focus on the prevention of discharge of raw sewage into the river even emergencies. In the case of a breakdown of the BNR process, the sewage shall be diverted to farmland along with the discharge from the trickling filter process. Relevant in-plant pipe system will accordingly be arranged.

6.2 Institutional Reinforcement

In this report, the term "institution" denotes the organizational forms responsible for management of the various functions and programmes. Generally, an "institution" concerns each of the political levels from national government agencies to local authorities, even including the private entities. No one institution can function alone and each level is inseparably interrelated. Then, this chapter discusses both the overall (national) institutional framework and the basic strategies to reinforce the municipal institution, especially focusing on its Department in charge of the project implementation.

6.2.1 Overall Institutional Framework

In order to assure successful development and implementation of water pollution control programmes and projects, a definitely deliberate and strategic approach is highly required, mobilizing all development resources on the long-term perspectives.

The national government agencies should concern itself with major policy and planning issues and with establishing the criteria to be applied by the lower governmental levels in resolving major issues. Besides, effective coordination is essential and can best be provided

at the national level in order to avoid adversely affecting economic, industrial and social development.

At each political and administrative level, it is "must" to delineate clearly the authority and responsibility of the organizational structure. Whatever the organizational structure, the responsible agency must be provided with sufficient staff, funds, and other resources to enable carrying out its assigned missions. It is vital that it be given full political and other government support on a continuing and long-term basis.

The basic strategies for strengthening the overall institutional structure are the following:

a) alignment of public administration and/or remodeling of overall structure for environmental management,
b) Provision of sufficient staff, funds, and other resources to enable carrying out their respective assigned missions,
c) Clear delineation of the responsibilities, authorities, levels of activities and resources for each of political levels involved to ensure the inter-agency coordination,
d) Organization of seminars, training workshops and/or in-house training for those tasked with and interested in water pollution control, and
e) Encouragement of public participation in water pollution control in order to improve general environmental management performance.

6.2.2 Strategies for Municipal Institutional Consolidation

(1) Organizational Structure for Project Implementation

As described in Section 3.2.2 (2), Chitungwiza Municipality is a political and corporate entity established by law for the purpose of planning, constructing, improving, maintaining, and operating projects for the public's use, including wastewater collection and treatment facilities. The sewage disposal in Chitungwiza Municipality is essentially a function of the Municipal Council at local authority level, while the central government agencies generally provide varying degrees of regulation, supervision and assistance.

In the Chitungwiza Municipality, the planning and project implementation for expansion of the Zengeza Sewage Treatment Works and its operations and management are vested in the Engineering Services Department (ESD). The important functions to be performed

by the Municipality for project implementation (especially by the ESD as a primary executing organization) should include, but not necessary be limited to, the following:

a) operate and maintain, on a continuous basis, the wastewater collection ad disposal systems in such manner as to protect the interests and promote the well-being of the area served and its people,
b) control the entrance of pollutants which can damage the collection system, interfere with the treatment processes, or pass unchanged through the entire treatment to receiving waters,
c) establish appropriate cost recovery policies and price incentives and, in accordance with these, apply a user charge system for domestic, industrial and other wastes discharged to the municipal sewers,
d) monitor, inspect and conduct laboratory testing to assure compliance with all applicable rules and regulations governing discharge limitations,
e) develop and maintain a data base suitable for establishing and modifying sewer service user fees and for determining compliance with applicable rules and regulations,
f) conduct or sponsor research and development projects directed to solutions of known local problems,
g) coordinate wastewater collection and treatment activities with those of other agencies which may be involved,
h) provide technical assistance and disseminate general information, relating to liquid waste disposal, to other agencies, industries, and the public levels,
i) coordinate the application of financial policies, project selection and resource allocation criteria with the central government agencies and other local authorities concerned, and
J) materialize the people's participation in water pollution control process throughout all the stages of project implementation: regulation, planning, construction, O&M and monitoring, through establishing the information networks among the municipal authority, private & industrial sector and the public.

In any case, the organizational structure needs to be sensitive to major and significant changes and flexible enough to make adjustments when the need arises. In addition, to keep the system's efficiency, frequent retraining and upgrading of skills are indispensable.

(2) Operations and Management of the Municipal Sewerage System

Collection and treatment works, no matter how well designed and constructed, will not achieve the projected goals, unless they are properly operated and maintained. Lack of systematic management and poor maintenance will eventually result in a very inefficient or inoperative STW. It must be recognized however that good operation and maintenance is expensive and the success in water pollution control efforts depends upon the effective, efficient and continuous long-term operation and maintenance of the facilities.

Steps have to be taken in advance of the STW start-up, to help assure efficient operation. The design contract should include a provision for preparation of an operating manual to fit the specific works. A basic cadre of personnel should be identified or employed well in advance of the STW start-up, so that the group may be given additional training, if necessary. This cadre should also work closely with the designers ad contractors during the construction phase in order to become thoroughly familiar with the physical works.

As for the water quality monitoring, regular sampling and analyses of process flows and receiving waters are essential to the day-to-day management. Sampling schedules and analytical procedure should be well established and samples must be properly collected and analyzed. Accurate records of all aspects of the STW operation and maintenance, including the sampling and analytical schedules, are needed to :

- assess the STW efficiency and long-term performance,
- recognize the need to upgrade one or more of the STW's components, and
- provide data for designing expanded or new treatment facilities.

Since the adoption of the economic structural adjustment programme, the Municipality has also studied the possibility to commercialize their activities and services, including water supply, sewerage and solid waste management, but possible disadvantages of such privatization are mainly concerned with potential loss of control on the part of the local authority. The Municipal Council then came to the conclusion that it is not practically possible to privatize completely the water and sewage treatment services nor even partially for the reason that these two services directly affect and deeply concern the health of the people. However, for the solid waste management, a partial privatization is now considered.

6.2.3 Staffing and Training

A staffing structure must be based on the specific functions assigned to an institution and needs to be established on an individual case-by-case basis. The shortage of adequately trained personnel is a major obstacle to developing and implementing programmes and projects.

For the both technical and administrative positions, it is required to assign highly-skilled professional staffs. An adequate supporting staff is also essential to ensure smooth project implementation and O&M. In water pollution control, the staffing structure is more complex, because multi-disciplinary team approaches utilizing several disciplines are more often being required, i.e.: engineering. biological sciences, chemistry, physical sciences, mathematics, operational research, systems analysis, financial analysis, economics, computer technology and its applications, social sciences, and others.

Since the capability of the Chitungwiza Municipality to undertake sewerage project is still limited in every aspects, most of activities for project implementation will necessarily be carried out the through interagency coordination. To ensure the smooth implementation of the priority project, the training programme should be duly carried out for the both administrative and technical personnel, particularly for the staff undertaking the operations & maintenance of the sewage treatment works and water quality monitoring.

For the officers in charge of the project management, the training programme will include, but not be limited to :

- Financial and budget management for implementation of the sewerage project,
- Environmental health management,
- Environmental impact assessment appreciation,
- General strategies for water pollution control :
  - legal and institutional framework for water pollution control and environmental management,
  - preventive measures for water pollution including direct regulation and economic incentives,
  - measures to be taken for pollution control enforcement (ex. procedure to set and enforce the regulatory standards and sanctions/ penalties),

- General guidance on the sewerage project to be implemented prior to its construction (i.e. responsibilities, authorities, levels of activities of the local authority),
- Charge structure and sewerage tariff system,
- Charge collection system,
- Accounting and budgeting systems and their standardization,
- Need to consider the recurrent costs in planning and budgeting,
- Manpower development to assure the smooth operations and maintenance of the sewage treatment works; and
- Others.

To the staff directly engaging in the operations and maintenance of the sewage treatment works, the training programmes should be designed to strengthen the planning and management capacity of middle and senior level professionals working in the sanitation/sewerage sector and also provide adequately trained personnel for the operation of the relevant treatment works. The emphasis is to be on the inter-disciplinary nature of the sanitation/sewerage sector with the aim of familiarizing participants with the interaction between health, engineering, planning and social science in the development of sanitation/sewerage services.

The training courses to be provided for the middle and senior level technical staff should be designed and offered with the following specific principles and/or objectives:

- to build capacity of the personnel in charge of project implementation and engineering of the sanitation/ sewerage projects,
- to upgrade skills in operations and maintenance of the sewage treatment facilities,
- to provide a basic understanding of the impact of inadequate sanitation/sewerage on health and development,
- to examine available technologies and the factors affecting the choice of technology,
- to give participants a full understanding of planning and management and the opportunities for maximizing the sustainability of programmes through increased beneficiary responsibility,
- to gain practical experience in monitoring and evaluation of sanitation/sewerage projects,
- to improve communication skills and consider the use of participatory methods for improved planning, management and implementation of projects,

- to identify and address practical problems facing the water pollution control and adequate sanitation in the region, and
- to examine community management strategies in sanitation/sewerage projects.

The approach to determining the training needs will vary according to the educational background and occupational skills of each staff concerned, regulatory requirements and local circumstances. The manpower development programmes mentioned above are suitable for general guidance purposes, but decisions on final programmes and courses should be made on an individual case-by-case basis.

In addition, the training courses should be both theoretical and practical. Since participants are not allowed to leave for long time their positions, the training courses are needed to be designed in a way that they will be supplied with course modules and a series of assignments to be submitted whilst on duty at their home station. One to two days every month will be reserved for consultation to resolve questions, and review course materials and assignments if there is an expressed need.

Furthermore, to realize the expected satisfactory results of the project, the municipal authority should provide training seminars and workshops to disseminate all water pollution related information to the interested people. It is essential to awake or make realize the people about the importance of water pollution control in order to secure their sanitary living environment.

Consideration should also be given to contracting with outside groups, such as local consulting or special services firms, to carry out specialized tasks of short duration and of a non-repetitive nature, especially at the initial stage. This may eliminate the need for acquiring costly specialized personnel on the staff for which there is no long-term use.

Finally, in the case that the project is to be implemented with the external source, it is advised to initiate communications with that source as early as possible, so as to gain not only technical assistance from the agency staffs, but also financial support in the form of grants or loans through a series of stages in the project cycle.

6.3 Legal Arrangements

The effectiveness of measures for control of water pollution depends on the enactment of comprehensive and realistic laws and statutes, coupled with their prudent administration and management and the commitment of adequate financial and other resources.

6.3.1 Legislative Framework and Issues

The Water Act fails to address the problems of consistency in the application of standards for controlling water pollution. To tackle the legislative and administrative problems on water pollution control, the Water Act and relevant water regulations should be reviewed and updated to define the responsibilities of the national government, local authorities and business enterprises, and to clearly formulate the basic principles that should govern the promotion of environmental measures, so as to be able to implement water pollution measures in a comprehensive and unified manner.

It is also pointed out that the Water (Effluent and Waste Water) Regulations, 1977 can not effectively control the pollution from sewage plants and water woks, particularly since no safe drinking water standards have been enacted so as to impose minimum standards for drinking water.

In addition, the environmental water quality standards are no yet established in Zimbabwe. In order to deal with imminent and potential problems before they occur or become serious, and also to prepare the water pollution control plan, it is essential to formulate, as quickly as possible, the "Environmental Water Quality Standards".

Effective legislation should satisfy the following requirements :

1) be based on sound, up-to-date economic and scientific principles,
2) provide a framework for setting but not establishing the standards, and
3) provide for establishing meaningful penalties for non-conformance to standards.

6.3.2 Formulation of Effective Water Pollution Control Legislation

In view of the social, economic, cultural and other differences between local authorities, it is not possible to present a set of legal provisions which will be applicable in all local authorities. Each situation must be considered by itself and the legislation formulated to fit the specific conditions which exist. However, the approaches to legal arrangements taken by the various authorities are allowed to not be uniform.

Local conditions must be carefully analyzed to determine the issues which should be considered when enacting or modifying the regulations/ standards, and the manner in which they are to be applied for filling the municipality's specific needs. But, in any cases, the standards to be formulated at municipal level should conform to the general requirements of existing national laws or regulations.

The trade effluents in the municipal area are to be controlled in accordance with the "Trade Effluent Control" regulations. In view of their contents and actual applications, it is necessary to review and upgrade them to the status of "by-laws", in order to achieve a given percent reduction and enable charge all pollutants a uniform price, based on the quantity and quality of their discharge. For this respect, it is important to carry out the inventory survey to identify all industrial water pollution sources or polluters in the municipal area.

For determining the parameters and their maximum permissible concentrations, it is necessary to carry out more detailed investigations and these would be periodically reviewed/revised in accordance with the changes of local factors like industrial development, urbanization and so on in the Municipality. All the water quality standards in question should be integrated into the proposed by-laws on trade effluent control.

With regard to the surveillance and monitoring for water pollution control, the following provisions are to be stipulated/prescribed in the relevant laws, regulations and standards :

- Monitoring of pollutant loads, water quality, and trade effluents, and their respective frequencies at the designated points,
- Obligation of the factories and business establishments to prepare reports on effluent and their periodical submission to the local authority concerned,
- Implementation of their on-the-spot inspections (without previous notice),

- Issuance of orders for improvements and powers for prosecution of defaulters,
- Enforcement of penalties including imprisonment: penal regulations should be severe enough to deter polluting activities,
- Necessity to prepare detailed water management plans at local authority level, and
- Others.

To expedite the legal and procedural arrangements for the effective water pollution control in the Municipality area, it is advised to set up a "Task Force" which takes charge of reviewing/ updating the existing regulations & standards, and/or formulating new legislations. As there is no organization nor staff specialized in legal matters, a consultant will be hired to be a member of this Task Force to carry out the above works. The said Task Force will be placed under the direct control of the Management Committee.

The major assignments of the Task Force would include but not be limited to:

a) formulate local environmental (water quality) standards and requirements, (within the framework of national regulations) as well as rules and regulations for their enforcement,
b) establish the standards for discharge of industrial wastes, which can be injurious to the publicly-owned facilities, and require either pretreatment or totally discharged treatment,
c) prepare procedures for handling storm water flows and system overflows and minimizing deleterious effects on receiving waters and lands,
d) give legal advices on the rules and procedures for employing, hiring and raining water pollution control personnel, and
e) examine from the legal viewpoint the municipal accounting and budgeting systems and recommend the appropriate charging system.

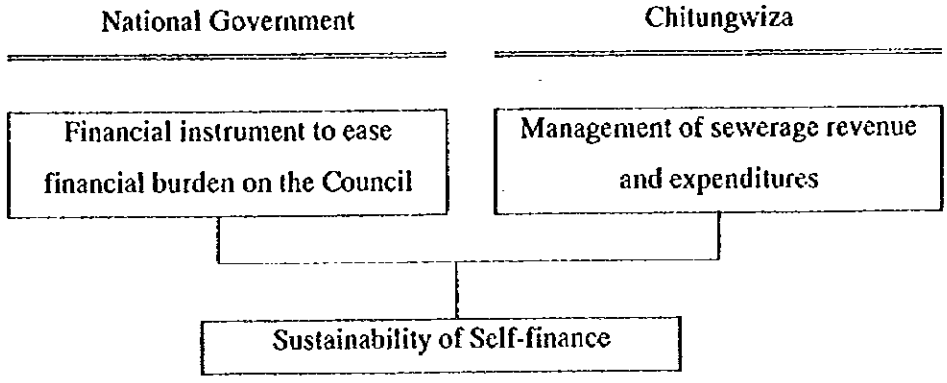
In the end, the most appropriate system, from an economic perspective, seems to establish water quality standards for receiving waters coupled with a charge system related to the volume and strength of effluents which adversely affect the quality of the water. This approach creates a market-like situation in which enterprises and other polluters have an incentive to take the costs of their pollution into account and find, individually, the most cost-effective means of reducing pollution.

6.4 Financial Management

Most of infrastructural projects is under the responsibility of local governments. Local authorities act as executing bodies in respect of projects' implementation while financially they borrow capital funds from the national government or financial market, and finance expenditures on operation and maintenance. The principle of cost recovery is strictly applied to each account under which revenue generated should be sufficient enough to cover operating expenditures and debt services.

Except for the urban council of Harare whose financial base is relatively large enough to mobilize capitals of Z$ 188 million from external funds and domestic financial market for the implementation of the on-going Firle V and Lower Mukuvisi outfall sewer, financial base of most urban councils is not firmly established, thereby only to implement the small or medium scale of sewerage project. PSIP of Urban II Programme reveals that Bulawayo, the second largest city would receive Z$45 million for sewerage components, while other urban councils are scheduled to borrow loans of sewerage components in the range from Z$1 to 3 millions. The project cost of sewerage augmentation works executed by urban council of Chitungwiza is about Z$30 million, which would be the appropriate scale of investment in view of the Council's borrowing power.

The cost of the Urgent Project is expected to be 5 to 6 times as high as that of sewerage augmentation works (Phase I and II) financed by the government loan called GDL. The ultimate objective of financial management is sustainability of the Council's self-finance provided that the Urgent Project requiring a huge amount of capitals will be implemented. The approach to financial management to attain the said objective is simply illustrated as follows.



Financial management has two approaches basically. One is the role of the national government to ease financial burden on the Council. The other is the effective management of sewerage revenue and expenditures, to be executed by Town Treasurer of Chitungwiza. Various financial countermeasures should be taken into account to put two approaches into practice. The execution of financial countermeasures implies the change or modification of the existing system. It would take time for the concerned institutions to implement them, which are to be executed as the priority actions.

6.4.1 Role of National Government

Projects for sanitation and water pollution control are clearly defined as the necessary input to enhance the quality of life environment in urban areas, which is particularly true of the Metropolitan area where a growing population pressure on water courses and land leads to the deterioration of water quality. The failure to implement the Urgent Project would worsen water quality of the existing impoundments in the Upper Manyame catchment area. In other words, the implementation of the Urgent Project is certainly to contribute to prevent water quality of down streams from deteriorating. In this respect, to sustain the better water quality should be considered on the region-wide basis.

Water resource development is currently under the responsibility of Ministry of Lands and Water Resources. Dam development contributing to a wide coverage of water supply on the region basis is not under the responsibility of a local authority locating in dam development, but clearly under jurisdiction of the national government. In this regard, to extend the responsibility of national government to water pollution control projects to some extent would be justifiable for a capital-consuming project, which is over the borrowing power of local authority while clearly contributes to sanitation improvement on the region-wide basis. The point is to what extent the government should extend the financial assistance to the project. The argument is not the sort of allocation of project cost into national and local government. Because the ownership of the project facilities is retained by the Council, financial arrangement for direct construction cost is logically under jurisdiction of the Council. Eventually the government is required to extend its supporting arm to the following fields.

(1) Donor Funds

1) Share of external funds

The on-going projects of Urban II Programme are mostly categorized as civil works, so that the Loan Agreement splits project costs to be financed by IBRD and GDL into 30% and 70% respectively. However GDL component has not been sufficiently allocated, resulting in partial utilization of IBRD loan. This implies that the overall progress of Urban II projects is actually slow and renders the authority (MLGRUD) a more serious concern that all projects scheduled would physically complete until June 1998 when Urban II is scheduled to terminate.

The lesson from Urban II is worthy of determining share of donor funds for the Urgent Project requiring a huge amount of capitals. The project costs consist of items given below.

- Direct construction cost
- Administration cost
- Engineering service
- Physical contingency
- Price contingency

In view of insufficient allocation of GDL, it is desirable for external fund to finance all direct contruction cost. In general, when Loan Agreement is made, the important agenda are the reason for necessity of a project implementation, and work progress of a project as scheduled. Because of the fixed amount of donor fund, the delay of a project implementation sometimes comes to an end with the undesirable result, incompletion of project. To avoid the worst situation, the authority (MLGRUD) should negotiate donor with the extent of external fund as large as possible.

2) Concessionary Loan

IBRD loan is currently lent to the Zimbabwe government at 7%. In order to ease financial burden on the Council, the authority is requested to seek for external fund with concessionary loan conditions. Such a preferential condition can been seen in bilateral donors. The general loan conditions of IBRD and major donors are summarized in Table 6.4.1.

Table 6.4.1 Loan Conditions of Donors

Loan Conditions	IBRD	EIB *	Germany KFW	Japan OECF
Lending rate (%)	7.0	5.5	2.0	3.5
Grace period (yrs)	3	0	3	3
Repayment period (yrs)	25	15	20	20

Note: * Loan conditions of EIB indicates those for Firle V

(2) Responsibility of national government

1) Foreign exchange premium

The prevailing on-lending rate from MLGRUD to local governments under Urban II Programme is fixed at 15% per annum. The difference of 8% between lending and on-lending rates consists mostly of foreign exchange premium. The cost of foreign exchange premium is correctly borne by local governments. The current premium rate (8%) is probably reasonable in view of long repayment period (25 years) during which local currency (Z$) would depreciate more than 8% against major donor currencies. But, high cost of premium actually pushes up the portion of debt service and causes aggravation of local governments' borrowing power.

If external fund with preferential loan conditions is to be secured for the Urgent Project, the on-leanding rate would be lower than 15% provided that the current premium rate 8% would remain unchanged. It is desirable that foreign exchange premium should be borne by the national government. The point is how such premium relating to projects under the jurisdiction of MLGRUD can be budgeted. In this respect, the MLGRUD is requested to budget the portion of premium for the Urgent Project during the budget cycle.

2) Technical Assistance

The cost of engineering service is currently borne by the borrower, local authority. Technical assistance for engineering service is the most likely field the MLGRUD can financially assists in local authority. Employment of a consultant and evaluation of tender documents are conducted by local governments as usual. MLGRUD is only requested to budget cost of engineering service as PSIP of the MLGRUD's version.

6.4.2 Role of Chitungwiza

The Urgent Project will be certainly the large scale project the Council has never experienced so far. To sustain self-financing condition needs not only the government financial assistance but also the Council's self-effort to increase revenue and control on expenditures. This section discusses the conceivable approaches of how sewerage revenue and expenditures are to be increased and controlled.

(1) Introduction of effluent charge

1) Introduction of effluent charge

Effluent charge is currently put into practice in the City of Harare. Effluent tariff is uniquely determined and charged per m^3 of industrial wastewater. Practice of effluent charge actually needs two work stages. The first is inspection and laboratory test of industrial wastewater by industrial stand. The second is the calculation of effluent charge based on the strength of oxygen absorbed (permanganate value) of industrial wastewater. The tasks and divisions in charge for effluent charge practiced in Harare City are summarized as follows.

Stage	Division	Tasks
First	Chemical Laboratory Section of Water & Sewerage Branch under Dept. of Works.	- Inspection of industrial establishments with respect of water consumption, wastewater quality, and operation conditions. - Laboratory test of trade effluent substances including PV. - Preparation of notice of letters for offenders violating the standard criteria of PV.
Second	Revenue section of City Treasurer	- Calculation of effluent charge based on PV tested - Preparation of slips on which effluent charge is recorded.

The average strength of PV of domestic raw sewerage (80mg per litter) is currently adopted as the standard criteria. Effluent charge is imposed on industrial customers violating the standard criteria.

The formula of effluent charge calculation is given as follows.

Below standard strength

Industrial wastewater x standard rate (Z$1.50/$m^3$)

Where industrial wastewater =

(water consumption x discharge rate - 20.5m^3/fitment x Nos. of fitments).

Above standard strength

Industrial wastewater x variable rate (Z$/$m^3$)

Where variable rate =

(actual strength - standard strength) / 50mg x Z$ 0.4 + standard rate (Z$1.50/$m^3$)

Provided that the above formula is applied to Chitungwiza, sewerage revenue accrued from effluent charge can be estimated on the basis of the following assumptions.

a) Average strength of PV of domestic raw sewerage
   Average strength is calculated to be 101 mg per litter based on water quality sampling test from March 95 to February 1996.
b) Average strength of PV of Tilcor industrial wastewater Average strength is about 112mg per litter based on the same sampling data.
c) Tilcor industrial wastewater quantity

Type of industry	Unit wastewater quantity (m^3/person/day)	Nos. of employees	Wastewater quality (m^3/day)
Processed food stuffs	0.677	1,048	709
Plastic products	0.083	33	3
Ceramics, Stone, Clay	0.833	38	32
Metal products	0.218	118	26
Transport equipment	0.137	1,098	150
Others	0.315	165	52
Total	-	2,500	972

The average strength (112mg per litter) of Tilcor wastewater measured at the outlet of the existing Tilcor anaerobic ponds was actually higher than (101mg per litter) of

domestic sewerage. Based on the formula and assumptions, annual effluent charge can be estimated in the following way.

Annual effluent charge = Industrial wastewater per year x variable rate

where: Annual industrial wastewater = 972m^3/day x 305 days = 354,780m^3

Variable rate = (112 - 101)/50 x Z$0.4 + Z$1.50/m^3 = Z$1.59/$m^3$

As a result, annual effluent charge is estimated to be Z$564,100. This amount corresponds to 5.4%. of total sewerage charges (Z$10,400 thousands) budgeted for the year of 1995/96.

2) Water revenue as cost recovery source of the Urgent Project

Water revenue is basically regarded as the most sustainable income source among main accounts. Revenue surplus is usually transferred to the deficit accounts. Increase of water demand would definitely push up sewerage operating expenditures. Sewerage augmentation ought to be necessary as the associated cost of incremental water demand. In this sense, the use of water revenue surplus as cost recovery source of the Project can be logically justified.

The water revenue and expenditures budgeted for the year of 1995/96 show the potential revenue surplus per m^3 at current price. Water revenue surplus is estimated to be the Z$0.68 per m^3 based on water revenue per m^3 (Z$2.91) and unit cost per m^3 (Z$2.23). The Urban II project called Water Reticulation Strengthening is scheduled to be implemented in 1996/97 onwards. The project cost is about Z$ 7.5 million. The full debt service of this project is scheduled to start repaid after 2000 onwards. Using the capital recovery factor of 0.1, the debt service is estimated to be Z$0.75 million per annum. This incremental cost of debt service would push up unit cost per m^3 from Z$2.23 at current level to Z$2.29. As a result, water account has still the sufficient margin of revenue surplus, which is estimated to be Z$0.62 in terms of Z$ per m^3. The revenue surplus of Z$0.62 per m^3 will be certainly the valuable cost recovery source for the Urgent Project.

(2) Management of expenditures

Perhaps management of debt service would be the crucial factor to keep expenditures at the level planned at the time of budgeting. The year of 1995/96 indicates how irregular expense of debt service had unfavorable affects on financial performance of sewerage

account. Because of repayment rush of CDF to leading accounts, debt service jumped to Z$5.0 million high than the planned level (Z$3.3 million). This had an unfavorable effect on the reduction of expenses for repair and maintenance.

After the implementation of the Project, the consistent control on debt service expenses will be required in order to sustain all expenditures at the planned level. For this purpose, the Project would be preferably financed by the government loans. This is mainly because repayment of the government loans are to be regularly scheduled.