8.2 Expansion of the Zengeza STW

8.2.1 Evaluation of the Treatment Results of the Existing BNR Facilities in Harare City

(1) Results of the BNR data for Crowborough and Firle STWs

According to the data of Harare City (the most recent annual average), (Section 4.2, Part I, Supporting Report), the BNR treatment status for both Firle and Crowborough STWs are shown below.

Item	Firle 3		Firle 4		Crowborough 3	
	Raw (mg/l)	Treated (mg/l)	Raw (mg/l)	Treated (mg/l)	Raw (mg/l)	Treated (mg/l)
BOD	461	23.6	496	17.3	619	21.7
COD	997	107.6	975	94.7	1,355	92.5
T-N	62.4	13.7	62.2	13.0	55.0	9.3
T-P	-	-	-	-	-	-
P-P	8.9	2.8	8.1	2.2	6.7	1.4

According to the investigation conducted by the Study Team (one test per STW), (Section 3.5, Part-I, Main Report):,

Item	Firle		Crowborough	
	Raw (mg/l)	Treated (mg/l)	Raw (mg/l)	Treated (mg/l)
BOD	1,300	8.0	610	9.0
COD	1,136.5	6.8	1,490	107.0
T-N	50.0	1.4	53.0	1.0
T-P	4.8	1.5	5.0	0.008
P-P	1.1	0.8	4.3	NIL

Based on the above data, the treatment capacity of the existing BNR facilities is considered as described below.

(2) Evaluation of the removal efficiency of existing BNR facilities

According to the latest annual data produced by both STWs, the BOD is of about 20 mg/l. In the data produced by the Study Team, which conducted one test per STW (data by 24-hours compositing sampling with 3 times per day), the BOD is of about 10 mg/l for

each STW. With suitable load and operation, the facilities can treat sewage to a BOD of 10 mg/l or less, but their annual results are estimated to be about 20 mg/l. It is common knowledge that COD-Cr is generally 5 times the BOD value, and the data for Harare City showed that for about 100 mg/l of COD, there was BOD of about 20 mg/l, which conforms to the norm. However, the Study Team's data shows relatively large values of 7.1 times and 11.9 times. One likely cause is that inorganic matter, which is hard to decompose with microbes, from industrial wastewater was included. In this case, COD value is hardly reduced, therefore, it seems difficult to reduce the COD value to 60 mg/l.

For nitrogen removal, Firle's treated sewage does not meet the required 10 mg/l of the Effluent Regulation, but Crowborough's does. Although the Study Team's data shows that it was of extremely high quality, the data still does not seem to be reliable because it was the result of only one testing. Considering all the evaluations mentioned above, if BNR treatment process is conducted properly, the treated wastewater will be able to comply with the Effluent Regulation.

For phosphorus removal, no effluent regulation limit is provided. Harare City's facilities aim to reduce the phosphate value to the target of 1.0 mg/l, but both the Firle and Crowborough STWs do not meet the target. The Study Team's data show that they meet the target.

8.2.3 Treatment Flow and Facilities Design

8.2.3.1 Capacity Calculation

(1) Design conditions and Design Criteria

Average dry weather flow	: 20,000 m^3/day
Peak factor	: 1.5 (Peak dry weather flow)
Peak dry weather flow	: 30,000 m^3/day (= 20,000 x 1.5)
Peak factor	: 3.0 (Peak wet weather flow)
Peak wet weather flow	: 60,000 m^3/day (= 20,000 x 3.0)

Design flow for capacity calculation

Distribution chamber, Screen & grit chamber : Peak wet weather flow = 60,000 m^3/day

In-plant pipe : Peak dry weather flow = 30,000 m^3/day

Primary and final sedimentation tank, BNR reactor:

Average dry weather flow = 20,000 m^3/day

Design Water Quality

Influent BOD	: 600 mg/l
Influent COD	: 1,200 mg/l
Influent SS	: 650 mg/l
T-N	: 140 mg/l
T-P	: 15 mg/l
Influent Temperature	: 14 °C
Final Effluent COD	: 60 mg/l
Final Effluent SS	: 25 mg/l
Final Effluent T-N	: 10 mg/l
Final Effluent Phosphate-P	: 1.0 mg/l

The design criteria to be employed are basically Zimbabwe's design standards (provided in the Sanitation Manual, Design Procedures 5, hereinafter called the Z Manual). When they do not follow the Z Manual, they will be decided by referring to either the South African manual, Operators' Handbook, Sewage Purification, issued by the Institute of Water Pollution Control (Southern African Branch), hereinafter called the SA manual, or the Japanese Sewage Facilities Design Criteria, hereinafter called the Japan Criteria.

(2) Capacity Calculation for Each Facility

1) Distribution Chamber (DC)

With a distribution chamber, 40,152 m^3/day of the average dry weather flow (ADWF) of the trunk sewer from the Seke and Zengeza lines will be split in two 19,789 m^3/day (20,000 m^3/day) of this will be led to the new STW and 20,363 m^3/day of the rest, the old STW. Then, 1,387 m^3/day of sewage flow from the Tilcor's force main will immediately join it to make its total flow rate 21,750 m^3/day. Consequently, with this distribution chamber, only domestic sewage will flow into the new STW.

2) Screen and Grit chamber (S & G)

In page 62 of the Z Manual, a screen is described as follows:

The objective of screening is to remove large objects such as rags, plastic bags, maize cobs, etc, which would otherwise block downstream pipes or damage equipment such as pumps, aerators and stirrers. Screens are usually hand-raked at "small" works. "Small" has been defined as anything from 4 to 40 Ml/d depending on the author. In Zimbabwe, hand-raked screens would almost certainly be used on works smaller than 10 Ml/d, and some large works, e.g. Firle(72Ml/d) and Crowborough(54 Ml/d) in Harare, still have hand-raked screens.

Screen gaps may be

Coarse ≥ 40 mm, Medium 15-30 mm, or Fine < 15 mm

Very often only medium screens are provided, or else coarse followed by fine.

The velocity between the bars should be > 0.3 m/s at minimum daily flow to avoid grit settling out upstream of the screens, and < 0.8 m/s at maximum daily flow if possible to keep down the headloss through the screen."

In compliance with this criteria, a combination method of a hand-raked coarse bar screen and a hand-raked fine bar screen will be employed as they are in existing facilities. Assuming two channels, the flow rate per channel is calculated as follows:

60,000 m^3/day ÷ 2 = 30,000 m^3/day (= 0.347 m^3/sec)

For the hand-raked coarse bar screen, assuming a water depth of 0.675 m, a channel width of 1.2 m, a screen gap of 40 mm and a bar thickness of 7 mm, the flow rate at the bar screen is calculated as follows:

0.675 x 1.20 x 40 / (40+7) = 0.689 m^2

0.347 m^3/s ÷ 0.689 m^2 = 0.50 m/sec

For the hand-raked fine bar screen, assuming a water depth of 0.675 m, a channel width of 0.9 m, a screen gap of 14 mm and a bar thickness of 7 mm, the flow rate at the bar screen is calculated as follows:

0.675 x 0.90 x 14 / (14+7) = 0.405 m^2

0.347 m^3/s ÷ 0.405 m^2 = 0.86 m/sec

In page 64 of the Z Manual, a grit chamber is described as follows:

Grit comprises heavy inorganic materials such as sand, glass, eggshells, etc., and some heavy organic matter such as vegetable seeds and coffee grounds. These heavy materials would tend to settle out in undesirable places if allowed to pass on to primary and secondary treatment and must therefore be removed by exploiting their greater Specific Gravity (SG).

The average SG of grit particles is about 2.5 compared with an average of about 1.2 for organic matter in sewage, and hence grit settles at about 30 mm/sec compared with 3 mm/sec for organic matter. Grit can thus be removed from sewage by differential settlement in grit channels designed to give a constant flow velocity, regardless of depth." (Z manual, p.64)

The grit chambers of existing facilities are of the vertical flow type. This type has also been used in a process before BNR in the Crowborough STW. Because operation and maintenance are easier if all chambers are of the same type, vertical flow type grit chambers will be employed.

The flow rate will be measured with a Parshall flume.

Capacity : 30,000 m^3/day

Number : 2 sets

3) Primary Sedimentation Tank (PST)

In order to reduce the load on the biological treatment facilities by removing settleable organic matter from sewage, PSTs will be built. The settled sludge will be stabilized through the anaerobic digestion process and be re-used for the land application. Dortmund tank type of PST will be employed, for the following reasons:

- the neighboring Harare city uses many PSTs of this type,
- it does not require any machine to function, simplifying its operation and maintenance, and
- the sludge drawn off has a sludge water content of 96%, so no sludge thickener is needed, and hence the sludge can be directly fed into the anaerobic digestion tank.

For the ADWF, assuming an overflow rate of 1.2 $m^3/m^2/hr$ (=28.8 $m^3/m^2/day$), the following surface area will be required:

20.000 m^3/day ÷ 28.8 m^3/m^2/day = 694 m^2

Assuming that two trains with three tanks each, the surface area per tank is calculated as follows:

694 / (2 x 3) = 116 m^2/tank

Assuming that the tanks are round in shape, the diameter will be as follows:

$(116 / 0.785)^{0.5}$ = 12.2 m dia

The BOD removal efficiency of the primary sedimentation tank is expected to be 30 to 50%, according to the Z Manual. Because the removal rates of Firle and Crowborough are about 50%, the BOD removal rate here is estimated to be 50%. SS removal efficiency is stated as 40 to 80% in the Z Manual, so it is estimated at the average of the two, or 60%.

The influent BOD is 600 mg/l, the PST effluent BOD is:

600 mg/l x (100-50) / 100 = 300 mg/l.

The influent SS is 650 mg/l, the PST effluent SS is:

650 mg/l x (100 - 60) / 100 = 260 mg/l.

The PST sludge solids are calculated as follows:

20,000 m^3/day x 650 mg/l x 60/100 x 1/1000 = 7,800 kg/day

Assuming that the water content is 96% as stated in the Z Manual, the sludge volume will be as follows:

7,800 kg/day x 100 / (100-96) x 1/1000 = 195 m^3/day

4) BNR Reactor

The Biological Nutrients Removal process, a kind of activated sludge process, will be employed to remove nutrients such as nitrogen and phosphorus, in addition to organic matter. The quality of the BNR influent is as follows:

BNR influent BOD	: 300 mg/l.
BNR influent COD	: 600 mg/l. (assuming 2.0 times BOD)
BNR influent SS	: 260 mg/l.

The final effluent water quality should be as follows so as to comply with the Effluent Regulation Limit.

A final effluent BOD of 12 mg/l. (assuming COD/5.0)
A final effluent COD of 60 mg/l. (requirement of the Effluent Regulation Limit)
A final effluent SS of 25 mg/l. (requirement of the Effluent Regulation Limit)

Consequently, the target removal efficiency will be calculated as follows:

BOD removal efficiency : (300 - 12) / 300 x 100 = 96%.
COD removal efficiency : (600 - 60) / 600 x 100 = 90%.
SS removal efficiency : (260 - 25) / 260 x 100 = 90%.

Many BNR processes have been developed, but here the Bardenpho process will be employed because it has been used in Harare city.

In "Wastewater Engineering: Treatment, Disposal, and Reuse, Third Edition", Metcalf & Eddy,INC, p.734, typical design information for combined removal of nitrogen and phosphorus, by biological process, for the Bardenpho process is provided as follows:

Food-to-microorganism ratio(F/M) : 0.1 - 0.2
Solids retention time (θ_C) : 10 - 40 days
MLSS : 2,000 - 4,000 mg/l
Hydraulic retention time (θ)
- Anaerobic zone : 1 - 2 hours
- Anoxic zone -1 : 2 - 4 hours
- Aerobic zone -1 : 4 - 12 hours
- Anoxic zone -2 : 2 - 4 hours
- Aerobic zone -2 : 0.5 - 1 hour

Return activated sludge : 50 - 100% of influent
Internal recycle : 400% of influent

Typical design information for combined removal of nitrogen and phosphorus, by biological process, for the Firle and Crowborough facilities is as follows.

Solids Retention Time (SRT), θ_C	: 15 - 25 days
MLSS	: 4,000 - 5,000 mg/l
Hydraulic retention time, θ	: 1.24 days (Firle Unit 3)
	: 1. 0 day (Firle Unit 4, Crowborough Unit 3

Hydraulic retention time (HRT), which also indicates the volume of the BNR reactor, is calculated by using the values of both SRT and MLSS. For this calculation, SRT (solids retention time) of 15 to 20 days, MLSS of 4000 to 5000 mg/l, the SRT and MLSS values of Harare's facilities, will be used.

$\theta = (\theta_C \times (a \times S_{CS} + b \times S_{SS})) / (1 + c \times \theta_C) \times X_A$

Where

a : Sludge conversion ratio for S - BOD (mgMLSS / mgBOD) 0.4 - 0.6 = 0.5

b : Sludge conversion ratio for SS (mgMLSS/mgSS) 0.9 - 1.0 = 0.95

c : Coefficient indicating reduction by endogenous respiration of activated sludge microorganisms (1/day) 0.03 -0.05 = 0.04

S_{CS} : Influent S-BOD (mg/l) 300 x 2 / 3 = 200 (mg/l)

S_{SS} : Influent SS (mg/l) = 260 (mg/l)

X_A : MLSS in reactor (mg/l) = 4000-5000 (mg/l)

θ_C : Sludge Retention Time (days) = 15-25 days

When $X_A = 4{,}000$, $\theta_C = 25$,

$\theta = (25 \times (0.5 \times 200 + 0.95 \times 260)) / (1 + 0.04 \times 25) \times 4{,}000 = 1.08$ days

When $X_A = 5{,}000$, $\theta_C = 25$,

$\theta = (25 \times (0.5 \times 200 + 0.95 \times 260)) / (1 + 0.04 \times 25) \times 5{,}000 = 0.87$ days

When $X_A = 4{,}000$, $\theta_C = 15$,

$\theta = (15 \times (0.5 \times 200 + 0.95 \times 260)) / (1 + 0.04 \times 15) \times 4{,}000 = 0.81$ days

When $X_A = 5{,}000$, $\theta_C = 15$,

$\theta = (15 \times (0.5 \times 200 + 0.95 \times 260)) / (1 + 0.04 \times 15) \times 5{,}000 = 0.65$ days

The longest HRT among the results above is 1.08 days (=26 hours). Therefore, the reactor volume is calculated as follows:

20,000 m^3/day x 1.08 days = 21,600 m^3.

Distributing the 26 hours over the retention times for each zone, based on the Bardenpho design information, results in the following retention times:

Hydraulic retention time, θ

Anaerobic zone	: 2 hours (7.7%)
Anoxic zone -1	: 5 hours (19.2%)
Aerobic zone -1	: 14 hours (53.8%)
Anoxic zone -2	: 4 hours (15.4%)
Aerobic zone -2	: 1 hour (3.8%)
Total	: 26 hours (100.0%)

The volume of waste activated sludge(WAS) is calculated as follows.

$Q_W = (a \times S_{CS} + b \times S_{SS} - c \times \theta \times X_A) \times Q / X_W$

Where

X_W : WAS average SS (mg/l) = 5,000 - 10,000 mg/l

Q : Influent flow rate (m^3/day) = 20,000 m^3/day

a : = 0.5

b : = 0.95

c : = 0.04

S_{CS} : = 200 mg/l

S_{SS} : = 260 mg/l

X_A : = 4000 - 5000 mg/l

θ : Hydraulic Retention Time

0.87 days (X_A = 5,000) or 1.08 days (X_A = 4,000)

When X_W =5,000, θ = 1.08 and X_A = 4,000,

Q_W = (0.5 x 200 + 0.95 x 260 - 0.04 x 1.08 x 4,000) x 20,000/5,000

= 696 m^3/day

When X_W =10,000, θ = 1.08 and X_A = 4,000,

Q_W = (0.5 x 200 + 0.95 x 260 - 0.04 x 1.08 x 4,000) x 20,000/10,000

= 348 m^3/day

When X_W =5,000, θ = 0.87 and X_A = 5,000,

Q_W = (0.5 x 200 + 0.95 x 260 - 0.04 x 0.87 x 5,000) x 20,000/5,000

= 692 m^3/day

When X_W =10,000, θ = 0.87 and X_A = 5,000,

Q_W = (0.5 x 200 + 0.95 x 260 - 0.04 x 0.87 x 5,000) x 20,000/10,000

= 346 m^3/day

Consequently, the WAS pump is expected to be able to pump up 696 m^3/day.

Waste activated sludge will be in stable condition because it will have completed a sludge retention time of 15 to 25 days. On p.96 of the Z Manual, it is stated that "WAS from plants with sludge age longer than about 20 days is stable enough for direct disposal". Therefore, the waste activated sludge will be dried in the sludge drying bed after a sludge thickening process.

Assuming two reactors, the required volume per reactor is calculated as follows:

20,000 m^3/day ÷ 2 x 1.08 days = 10,800 m^3/day/reactor

Water depth will be 4.5m.

5) Final Sedimentation Tank (FST)

A FST is employed to separate mixed liquid into sludge and supernatant liquor. The sludge will be returned back to the BNR reactor as return sludge or drawn off as waste activated sludge. The overflow rate of the Firle and Crowborough works are as follows.

Firle (Unit 3)	: 7.8 m^3/m^2/day
Firle (Unit 4)	: 9.6 m^3/m^2/day
Crowborough (Unit 3)	: 10.0 m^3/m^2/day

The Japan Criteria specifies 8 to 12 m^3/m^2/day, so it is reasonable to assume an overflow rate of 8 m^3/m^2/day for our design. Two trains with two tanks each will be

employed. Assuming an overflow rate of 8 $m^3/m^2/day$, the required surface area is calculated as follows:

20,000 m^3/day ÷ 8 m^3/m^2/day = 2,500 m^2

The required surface area per tank is calculated as follows:

2,500 m^2 ÷ 4 = 625 m^2/pond

Assuming a circular tank, the diameter is:

$(625 / 0.785)^{0.5}$ = 28.2 → 28 m

6) Outlet Work

Width	: 1.0 - 3.0 m
Length	: 5 m
Number	: 1 set

7) Sludge Thickener (ST)

As the Z Manual describes: "WAS(Waste Activated Sludge) always needs thickening unless it is to be irrigated directly", a sludge thickening process is necessary to reduce sludge feeding into sludge drying beds. A Dortmund tank, which is used for the primary sedimentation tank, will be employed because it is simple in construction, reliable and used in the Firle facilities. Two trains with one tank each will be employed. The sludge to be thickened is the waste activated sludge from the BNR reactor. This process will reduce the sludge concentration of the waste activated sludge from about 5,000 to 10,000 mg/l (water content of 99.5 to 99%) to 98%.

Because no design criteria are provided in the Z Manual, the values of the Japan Criteria, 60 to 90 kg/m^2/day, are taken into consideration. Waste activated sludge is hard to thicken, so the lowest end of the criteria, solids loading of 60 kg/ m^2/day, is employed. Assuming the sludge thickener will be operated for eight hours during the day, the required surface area is calculated as follows:

4,160 kg/day / 60 kg/ m^2/day x (24/8) = 208 m^2

Assuming two tanks, the required surface area per tank is calculated as follows:

208 m^2 / 2 tanks = 104 m^2/tank

Assuming the sludge thickener is round in shape, the diameter will be as follows:

$(104 / 0.785)^{0.5} = 11.6$ m

ST feed sludge volume will be calculated as follows:

Assuming X_W = 5,000 mg/l, θ = 1.08 and X_A = 4,000 mg/l,

$Q_W = (0.5 \times 200 + 0.95 \times 260 - 0.04 \times 1.08 \times 4{,}000) \times 20{,}000 / 5{,}000$

$= 696$ m^3/day

Assuming the ST draw-off sludge volume consists of the thickened sludge with a water content of 98%, it will be calculated as follows:

$Q=(0.5 \times 200 + 0.95 \times 260 - 0.04 \times 1.08 \times 4{,}000) \times 20{,}000 \times 100 / (100 - 98.0) / 1000 = 174$ m^3/day

The supernatant volume will be as follows:

$696 - 174 = 522$ m^3/day

8) Anaerobic Digestion Tank (ADT, No heating)

As stated on p.96 of the Z Manual: "in Zimbabwe all primary sludge is stabilized by anaerobic digestion", the raw sludge generated in the primary sedimentation tank will be processed by anaerobic digestion (no-heating). Assuming a digestion period of 60 days, the tank volume is calculated as follows:

$(195 + 86.7) / 2 \times 60 = 8{,}451$ m^3

Assuming two tanks, the volume per tank is as follows:

$8{,}451 \div 2 = 4{,}226$ m^3/tank

To provide the tank volume calculated above, the tanks required will be of tank diameter of 20 m, side depth of 10 m and hopper depth of 10 m. Because the ADT feed sludge volume is equal to the PST sludge volume, it is 195 m^3/day.

It is assumed that two thirds of the feed sludge solids are organic matter, and the remaining one third is inorganic matter. Assuming that 50% of the organic matter will decompose and disappear, the digested sludge solids will be calculated as follows:

7,800 kg/day x (1-2/3 x 0.50) = 5,200 kg/day

Assuming the digested sludge is of water content of 94% (Z manual p.96 "Digested sludge is likely to have a solids content of 4 to 8%"), the digested sludge volume is calculated as follows:

5,200 kg/day x 100 / (100 - 94) x 1 / 1000 = 86.7 m^3/day

The supernatant volume is calculated as follows:

195 - 86.7 = 108.3 m^3/day

9) Sludge Drying Bed (SDB)

A SDB is used to dry the digested sludge and the waste activated sludge and is expected to reduce their water content to about 60% in a week. The digested sludge volume is 86.7 m^3/day. The required area of the drying bed is calculated as follows:

Assuming a drying period of 7 days and a feed sludge thickness of 0.2 m,

86. 7 m^3/day x 7 days ÷ 0.2 = 3,035 m^2

Assuming two beds, 30 m wide, the length is calculated as follows:

3,035 m^2 ÷ (2 beds x 30 m) = 50.6 → 60m

The dried digested sludge volume is calculated as follows:

86.7 x (100 - 94) / (100 - 60) = 13.0 m^3/day

The waste activated sludge is 174 m^3/day. The requiring area of the drying bed will be calculated as follows:

Assuming a drying period of 7 days and a feed sludge thickness of 0.2 m,

174 m^3/day x 7 ÷ 0.2 = 6,090 m^2

Assuming four beds, 30 m wide, the length is calculated as follows:

6,090 m^2 ÷ (4 beds x 30 m) = 50.8 → 60m

The dried waste activated sludge volume is calculated as follows:

174 x (100 - 98) / (100 - 60) = 8.7 m^3/day

The supernatant volume is calculated as follows:

$(86.7 - 13.0) + (174 - 8.7) = 73.7 + 165.3 = 239\ m^3/day$

10) Sludge Storage Yard (SSY)

The yard to be of sufficient size to stock about two months' generation of dried digested sludge and dried waste activated sludge. The total dried sludge storage volume is calculated as follows:

$(13.0 + 8.7) \times 60\ days = 1{,}302\ m^3$

Assuming the yard is 12 m wide with a pile up height of 2 m, the length of the yard is calculated as follows:

$1{,}302 / (2.0 \times 12.0) = 54.3 \rightarrow 60m$

11) Sludge disposal pit

In the event of landfill disposal of the sludge in a sludge disposal pit, the required volume is as presented below.

Assuming that half of the sludge produced from the new sewage treatment works will be applied to farm land and half will be disposed of in a landfill, the volume required for the sludge disposal pit is:

$21.7\ m^3/day \times 0.50 \times 365 \times 10\ years = 39{,}600\ m^3$

Therefore, the dimensions of the required sludge disposal pit are:

length 100 m, width 100 m and piled height 4 m.

The sludge disposal area is located in the land owned by the municipality, south of the site for the new STW, across the stream.

The sludge disposal land is equipped with earth bank all around to prevent the sludge and leachate from flowing into public water bodies and causing a pollution problem. To prevent the leachate from infiltrating into the ground, the soil of the pit surface, about 15 cm deep, is improved in texture with soil cement.

12) Laboratory

The laboratory is necessary for the following three reasons:

- To comply with the legal requirements and to test if the treated sewage is sufficiently purified to comply with the Effluent Regulation for Discharge into River.
- To measure the water quality and microorganisms, which facilitate proper operation and maintenance of the sewage and sludge treatment, and to reflect these value in operation. Especially for the new BNR reactor, which is a kind of activated sludge process, the type of activated sludge microbes and their reproduction status are tested to facilitate proper operation of the reactor. Further, to test if the treated water from old trickling filter meets the target treated water quality.
- To test wastewater from the industries.

The laboratory to be constructed will have about 70 m^2 of floor space, based on the Japan Sewage Works Agency's B type. In addition to a main test table, the laboratory will include separate rooms for balances, samples and chemicals as the minimum facilities required.

8.2.3.2 Hydraulic Calculation

Typical headlosses across various treatment units are as follows.

Bar screen	: 0.2 - 0.3 m
Grit chamber	: 0.5 - 0.9 m
Primary sedimentation tank	: 0.5 - 0.9 m
BNR reactor	: 0.2 - 0.6 m
Final sedimentation tank	: 0.5 - 0.9 m

Under topographical conditions and specific design conditions, maximum water surface of treatment units, invert level of treatment units are as follows.

Influent pipe

Invert level : EL = 1,407.622 m

Maximum water surface : EL = 1,407.622 m + 0.675 = 1,408.297 m

Screen

headloss = 0.2 m

Maximum water surface : EL = 1,408.297m - 1,408.097 m

Invert level : EL = 1,407.622m - 1,407.422 m

Grit chamber

headloss = 0.3 m (Screen - Grit chamber)

Maximum water surface : EL = 1,408.097m - 0.3m = 1,407.800 m

Invert level : EL = 1,400.600 m

Primary Sedimentation Tank

headloss = 1.5 m (Grit chamber - Primary Sedimentation Tank)

Maximum water surface : EL = 1,407.800m - 1.5m = 1,406.300 m

Invert level : EL = 1,394,800 m

BNR Reactor

headloss = 1.0 m (Primary Sedimentation Tank - BNR Reactor)

Maximum water surface : EL = 1,406.300m - 1.0m = 1,405.300 m

Invert level : EL = 1,400.800 m

Final Sedimentation Tank

headloss = 1.0 m (BNR Reactor - Final Sedimentation Tank)

Maximum water surface : EL = 1,405.300 m - 1.0 m = 1,404.300 m

Invert level : EL = 1,398.800 m

Outlet work

Maximum water surface : EL = 1,396.650 m

Invert level : EL = 1,396.000 m

Nyatsime River

Water surface : EL = 1,394.000 m

8.2.3.3 In-plant Pipe Capacity Calculation

Design flow for capacity calculation

In-plant pipe : Peak dry weather flow = 30,000 m^3/day

Pipe diameter, Number of In-plant pipe are as follows.

Grit chamber - Splitter box (No.1)

20,000 x 1.5= 30,000 m^3/day = 0.347 m^3/sec, 650 mmdia (26 inches) x 1

Splitter box (No.1) - Splitter box (No.2, 3)

30,000 / 2 = 15,000 m^3/day = 0.174 m^3/sec. 500 mmdia (20 inches) x 2

Splitter box (No.2, 3) - Primary Sedimentation Tank (PST)

15,000 / 3 = 5,000 m^3/day = 0.058 m^3/sec, 300 mmdia (12 inches) x 2 x 3

Primary Sedimentation Tank (PST) - Confluence box

15,000 / 3 = 5,000 m^3/day = 0.058 m^3/sec, 300 mmdia (12 inches) x 2 x 3

Confluence box - BNR Reactor

30,000 / 2 = 15,000 m^3/day = 0.174 m^3/sec, 500 mmdia (20 inches) x 2

BNR Reactor - Splitter box

30,000 / 2 = 15,000 m^3/day = 0.174 m^3/sec, 500 mmdia (20 inches) x 2

Splitter box - Final Sedimentation Tank (FST)

15,000 / 2 = 7,500 m^3/day = 0.087 m^3/sec, 350 mmdia (14 inches) x 2 x 2

Final Sedimentation Tank (FST) - Confluence box

15,000 / 2 = 7,500 m^3/day = 0.087 m3/sec, 350 mmdia (14 inches) x 2 x 2

Confluence box - Outlet Work (to river)

20,000 x 1.5 = 30,000 m^3/day = 0.347 m^3/sec, 650 mmdia (26 inches) x 1

SECTION 9 CONSTRUCTION PLAN, AND OPERATION AND MAINTENANCE

9.1 Construction Plan

Table 9.1.1 Daily Rainfall Data from July 1991 to June 1996

Harare Belvedere Rain Gauge Station
July 1991 - June 1996, 5 years

1. July 1991-June 1992

Date	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1												
2								4.4				
3									4.4			
4					0.4							
5						7.2	2.3					
6												
7												
8						10.0						
9					0.5	29.0			13.0			
10						7.7						
11						1.0				0.4		
12					3.4							
13				0.3	12.7				1.4			4.9
14				6.8	0.9				12.3			
15				1.1	23.9							
16				8.6	2.0				5.0			
17				1.1								
18					1.5		6.0					
19							16.0					
20					1.6	6.0			4.7			
21					21.3		0.8		21.1			
22						17.4	3.8					
23						6.7	1.5		33.2			
24				1.1	0.1	11.5	19.0	0.3	5.7	Tr		
25				18.7	0.6	45.8				Tr		
26				0.8		12.8		18.6	1.7			
27						0.3		2.0	7.7	Tr		
28						24.8			0.3	17.6	4.3	
29										71.3		
30			3.0				12.8					
31												
Total	0.0	0.0	3.0	38.5	68.9	180.2	62.2	25.3	110.5	89.3	4.3	4.9

2. July 1992-June 1993

Date	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1							3.0	4.7				
2							45.2	26.9	6.7			
3							2.2			0.2		
4				1.1			4.8		2.4			
5						0.9	6.3	3.2				
6					0.5		6.0	0.4				
7						1.5	14.7	33.1				
8						20.6	5.2	0.3	0.4	1.7		
9						1.8	1.8					
10					12.7	0.8	6.5	0.6				
11					0.9	37.0	4.1	0.2	1.3			
12						13.3	1.1	41.5	3.2	3.8		
13				Tr		3.0				0.9		
14						0.8		10.9		29.2		
15					2.3	21.0		11.3				
16								3.1				
17					0.5			4.2				
18				Tr				1.4				
19				Tr		14.9		6.0				
20						4.5	5.0	1.5				
21						5.2		117.4				
22						1.0		9.7				
23						4.4	19.7	2.3	6.7			
24						24.7	0.2	26.1	13.3			
25				Tr	7.7		6.0	14.4	1.5			
26				Tr		6.5	0.5		36.2	11.3		
27							6.6					
28						27.9						
29						8.0	1.9			17.3		
30						0.2				0.8		
31						3.3	18.1		39.1			
Total	0.0	0.0	0.0	1.1	24.6	201.3	158.9	319.2	110.8	65.2	0.0	0.0

3. July 1993-June 1994

Date	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1							3.6		6.5			
2									18.4			
3	0.4					11.8	13.6		0.9			
4					0.3		36.8					
5					1.7	1.5		26.9				
6					1.9			20.7				
7					2.7			13.7				
8				4.5								
9					15.6	4.7		4.0				
10				14.6		25.5		29.3				
11					4.0	0.2			17.7			
12					15.6	12.0			3.2			
13					3.5			2.9				
14					0.4							
15					0.8		22.7					
16							25.9					
17							2.2					
18						3.5						
19						8.4	7.6					
20						1.1	7.3	39.8				
21						46.1	15.6	9.0		0.3		
22												
23					10.9	8.1	7.4					
24				0.1	0.8		2.8			1.3		
25					22.9		19.9					
26						0.3	46.3					
27						14.3	2.7					
28			6.2	0.3	1.4	13.5	1.2	9.5				
29		1.7			35.5		11.1					
30					5.5	0.9						
31		2.1				6.7						
Total	0.4	3.8	6.2	19.5	123.5	158.6	226.7	155.8	46.7	1.6	0.0	0.0

4. July 1994-June 1995

Date	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1												
2						1.3						
3						2.4						Tr
4						0.9						
5												
6									2.2	Tr		
7					0.1			9.2			Tr	
8										Tr		
9								23.8		10.9		
10						12.8	2.2					
11						0.8		13.4				
12												
13				7.5			8.6				Tr	
14				8.9			25.0				Tr	
15				26.0			5.1				Tr	
16				14.3			22.1	23.6				
17				0.7			7.5					
18				0.1		1.1	30.8					
19					Tr	0.3	43.2	5.6				
20					Tr	9.4	2.0					
21		4.8										
22		Tr		0.5								
23						13.5						
24					6.3	34.6						
25					13.6	2.4					Tr	
26					Tr	20.8					Tr	
27						2.7			0.2			
28						7.5		5.7				
29			Tr		Tr	21.2						
30				14.4	3.8	0.6				Tr		
31				33.6								
Total	0.0	4.8	0.0	106.0	23.8	132.3	146.5	81.3	2.4	10.9	0.0	0.0

5. July 1995-June 1996

Date	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1						39.5			6.5			
2								77.1	5.4			
3												
4						26.9			Tr			
5									2.5	23.2		
6		0.6				18.1			59.6	2.0		
7						6.7			0.3		3.7	
8								2.5				
9								42.0	1.4			
10						0.7	10.1	21.6				
11						19.2	22.4	4.2	4.0			
12						1.6	0.1	0.4				
13						4.5	12.1	Tr	37.7			
14								3.4			24.3	
15						8.4	10.6	14.0	0.3		0.1	
16						10.1	57.0		3.4			
17						3.4	7.5				Tr	
18						24.0	1.2	10.3				
19						0.6					1.0	
20							14.4	2.3			18.7	Tr
21				1.5	1.0		52.6				28.2	Tr
22							3.4	28.5				
23				2.2	2.6	0.1	0.2	2.4				Tr
24				3.2		5.5	2.4	9.5				
25					5.5	27.5	4.0	0.1			56.0	
26				6.3		5.0	1.4	0.5	Tr		13.7	Tr
27				16.5	2.7		9.3	6.5			9.8	
28				8.7	7.4		29.6					
29				6.1	17.4	3.6	18.0	8.2	21.6			
30				0.5			1.0		17.8			
31							5.7		0.3			
Total	0.0	0.6	0.0	45.0	36.6	205.4	263.0	233.5	160.8	25.2	155.5	0.0

Table 9.1.2 Registered Contractor of CIFOZ

The Construction Industry Federation of Zimbabwe
(1915-1995 80 Years)

1 Division/Categories and Anual Suspensions

Divisions	Category	Value of Contract
General Contractors(Building and Civil Engineering	A	Unlimited
	B	Up to 15,000,000
	C	Up to 10,000,000
	D	Up to 3,000,000
	E	Up to 1,500,000
	F	Up to 1,000,000
Electrical Subcontractors or Subcontractors	A	Unlimited
	B	Up to 6,000,000
	C	Up to 2,000,000
	D	Up to 1,000,000
	E	Up to 500,000
Prefered Subcontractor " F "		Up to 1,000,000
Prefered Subcontractor " E "		Up to 500,000

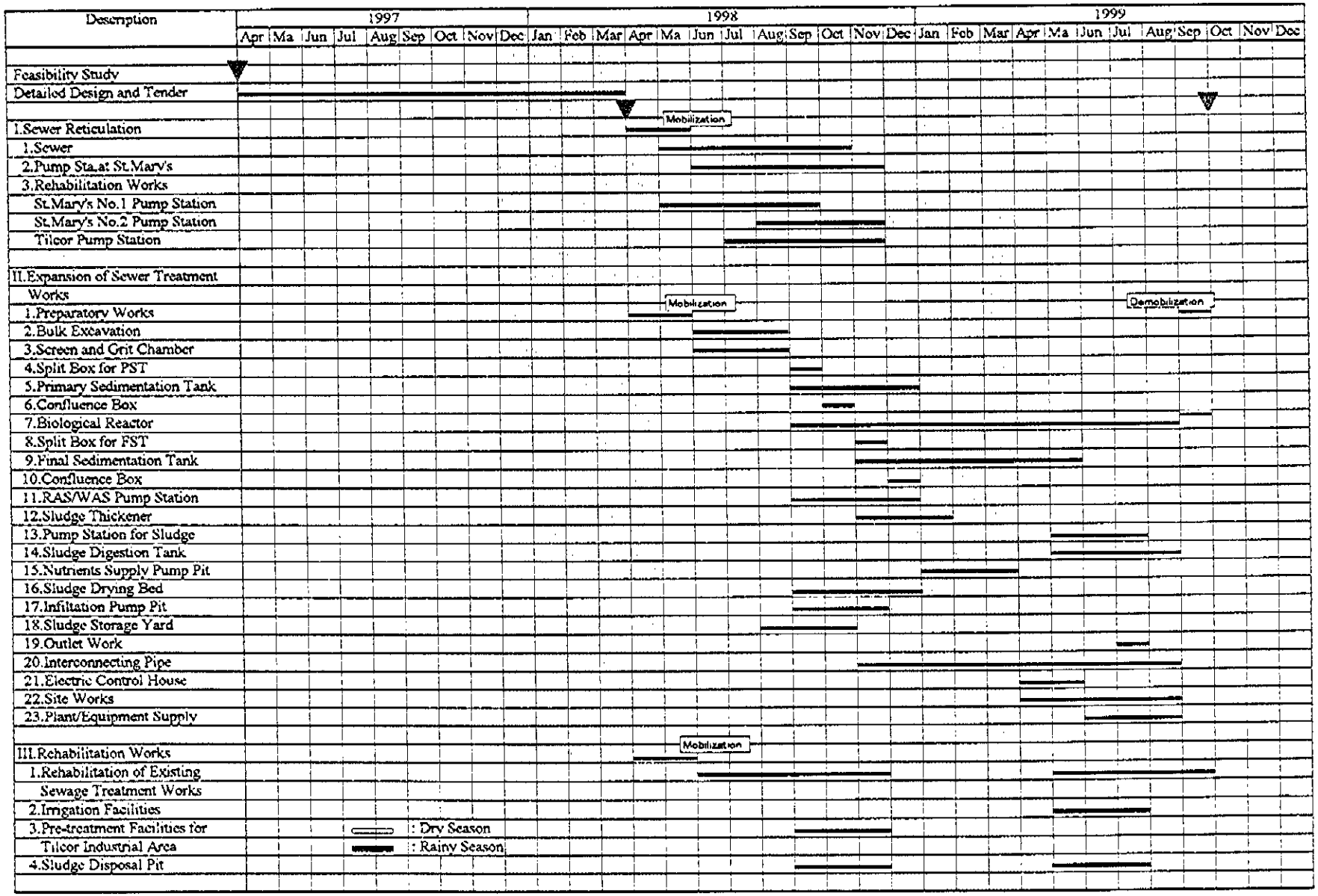
2 Number of Resistered Contractors

(1) General Contractors - Building	Category A	Building	39
	Category B	Building	16
	Category C	Building	33
	Category D	Building	37
	Category E	Building	9
	Category F	Building	15
(2) General Contractors - Civil	Category A	Civil	32
	Category B	Civil	13
	Category C	Civil	17
	Category D	Civil	17
	Category E	Civil	1
	Category F	Civil	4
(3) Electric Subcontractors or Subcontractor	Category A	Electrical	24
	Category B	Electrical	14
	Category C	Electrical	27
	Category D	Electrical	22
	Category E	Electrical	22
	Category F	Electrical	8
(4) Subcontractors			
Class 1 Acoustic Engineering,Heating, Ventilation,Air conditioning and refrigeration Engineers	Category A	Class 1	9
	Category B	Class 1	4
	Category C	Class 1	1
	Category D	Class 1	2
	Category E	Class 1	1
	Category F	Class 1	1
Class 2 Art Metal Work,Aluminium and Steel Windows Specialist	Category A	Class 2	8
	Category B	Class 2	1

		Category D	Class 2	2
		Category E	Class 2	2
		Category F	Class 2	1
Class 3	Bricklaying	Category D	Class 3	2
		Category E,Pref	Class 3	1
Class 4	Ceiling Specialist	Category A	Class 4	4
		Category B	Class 4	1
		Category D	Class 4	2
Class 5	Demolishers	Category A	Class 5	2
		Category B	Class 5	1
		Category D	Class 5	3
		Category E	Class 5	1
Class 6	Excavation and Earthmoving, Roadworks,Tennis Courts	Category A	Class 6	1
		Category C	Class 6	5
		Category D	Class 6	2
		Category E,Pref	Class 6	1
Class 7	Fencing,Precast Walling and Structures	Category A	Class 7	5
		Category B	Class 7	2
		Category C	Class 7	2
		Category D	Class 7	2
		Category E,Pref	Class 7	2
Class 8	Fire Protection and Sprinkler Engineers	Category A	Class 8	5
		Category B	Class 8	1
		Category C	Class 8	1
Class 9	Grazing	Category A	Class 9	1
		Category B	Class 9	1
		Category C	Class 9	1
		Category D	Class 9	2
		Category E,Pref	Class 9	1
Class 10	Joinery and Shop Fitting	Category A	Class 10	6
		Category B	Class 10	1
		Category C	Class 10	1
		Category D	Class 10	1
		Category E	Class 10	1
		Category E,Pref	Class 10	1
Class 11	Painting and Decorating, Signwriting	Category A	Class 11	6
		Category B	Class 11	1
		Category C	Class 11	1
		Category D	Class 11	1
		Category E	Class 11	1
		Category E,Pref	Class 11	1
Class 12	Patent Flooring and Floor Layers, Roof Water-Proofing and Tanking	Category A	Class 12	5
		Category B	Class 12	1
		Category C	Class 12	1
		Category D	Class 12	4
		Category E	Class 12	1
Class 13	Plastering	Category C	Class 13	2
		Category D	Class 13	2

		Category E	Class 13	1
Class 14	Plumbing,Drain Laying and Sheet Metal Workers	Category A	Class 14	8
		Category B	Class 14	5
		Category C	Class 14	6
		Category D	Class 14	4
		Category E	Class 14	3
		Category E,Pref	Class 14	4
Class 15	Roof Slating,Tiling and sheeting	Category A	Class 15	4
		Category B	Class 15	3
		Category D	Class 15	1
Class 16	Scaffolding,Formwork Specialist	Category A	Class 16	1
		Category B	Class 16	1
		Category C	Class 16	2
		Category E	Class 16	1
Class 17	Structural engineers,Steel Reinforcing Engineers	Category A	Class 17	12
		Category B	Class 17	2
		Category C	Class 17	7
		Category D	Class 17	7
		Category E	Class 17	3
		Category F	Class 17	1
		Category F,Pref	Class 17	1
Class 18	Wall Tiling,Mosaics Marble Workers,Terrazzo Specialists, Reconstructed Stone work	Category A	Class 18	3
		Category B	Class 18	1
		Category C	Class 18	2
Class 19	Erectro-Mechanical Engineers	Category A	Class 19	4
		Category C	Class 19	1
Class 23	Landscaping	Category D	Class 23	1

Figure 9.1.1 Detailed Construction Schedule for Rehabilitation/Expansion of Zengeza Sewage Works



9.1.1 Soil Investigation Results and The Study for Construction

(1) Purpose and Methods of the Investigation

Purpose : To plan a new sewage treatment works
Site : Zengeza STW
Date : November, 1996
Method : Grading analysis, short shoe penetrometer test, auger boring

(2) Overview of the Investigation Results

The STW site is at the edge of a gently undulating table land. Topographically, the land is slightly sloped down from north to south, and there is a smooth slope to the Nyatsime river. As a whole soil is residual, a thin layer of decomposed granite that has accumulated. The thickness of this residual soil layer was not precisely measured in this investigation, but the decomposed granite layer was 4-5 m in the north high ground, and 1-2 m along the Nyatsime river. This hard layer slopes down to the river and is believed to be connected to the river bed. The ground water level was not clear. Considering that there was no ground water recharge source nearby, it is difficult to state the existence of permanent ground water, especially in the dry season.

(3) Ground Water Conditions

According to the investigation, observation of ground water were reported at points No. B2 (-4.8 m) and C3 (-0.6 m). While, ground water was not observed at any other points, it may be concluded that the ground water at these two points were due to special conditions. There is a deep pit near the B2 point that has been used for disposal of the screenings from the existing STW. There is a lot of water in the pit, and it is likely that the water has infiltrated B2 from the pit. As for C3, judging from other information such as boring data, it may be assumed that the water was simply an isolated pool. Accordingly, there was no ground water level for the site as a whole. (refer to Figure 9.1.2)

There is a little possibility of ground water level to be formed with the rain fall in the wet season. Judging from the site's topography, water was not likely to accumulate on this site. There are gentle undulations in the land, a surface water was appropriately discharged to the surrounding rivers.

Excavation will take place in the dry season, water will not be a problem. Furthermore, even in the wet season, the site's topography was such that the surface gradient releases water to the river immediately, water need not be a consideration in the physical design. However, as one point to consider, the sludge digestion tanks were comparatively near the

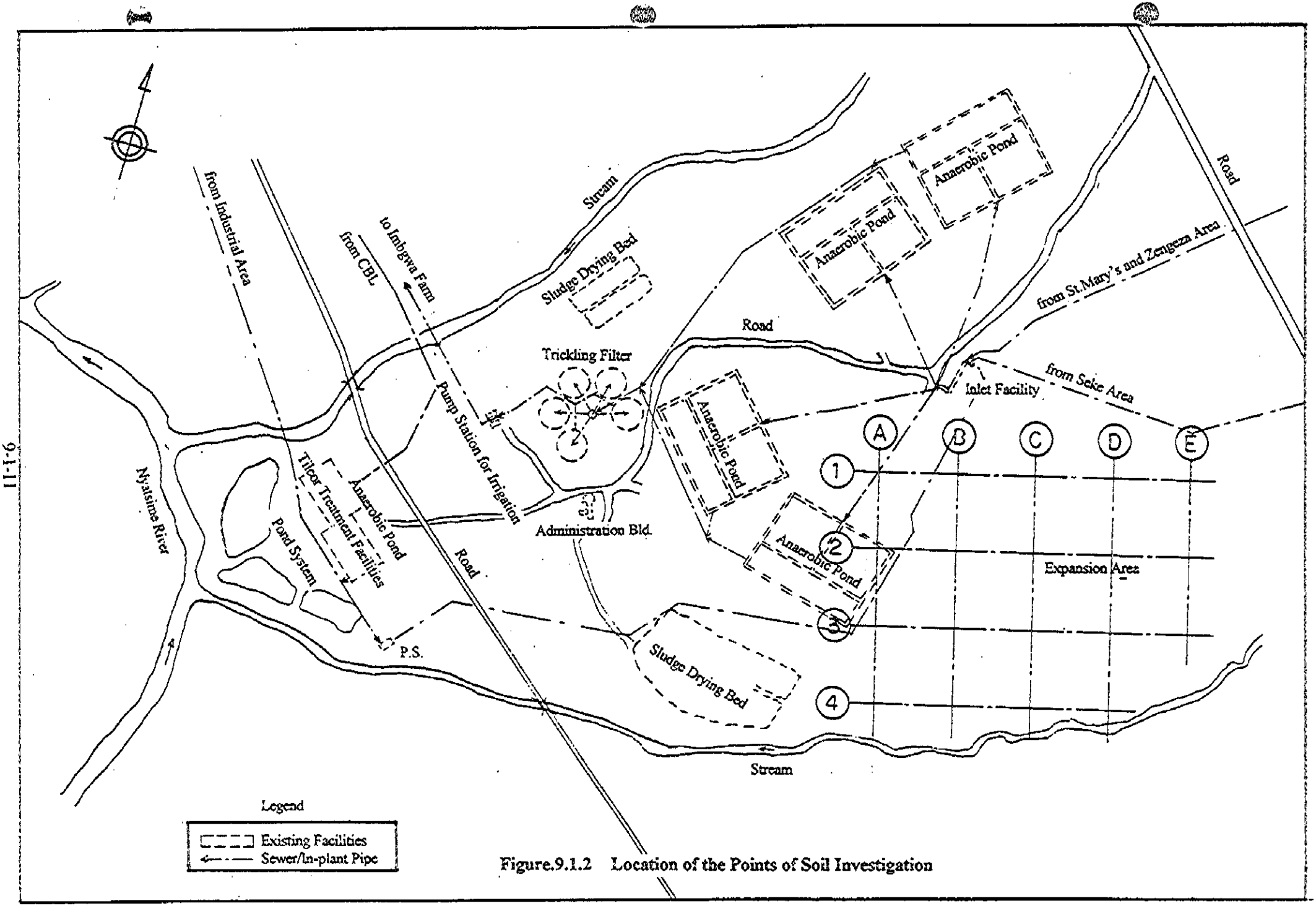


Figure.9.1.2 Location of the Points of Soil Investigation

river and will likely be affected by the water level of the river level. Therefore, it may be necessary to consider the effects of buoyancy in the tanks' O & M, particularly when emptying the tanks.

(4) Conditions for Earth Work

To construct a sewage treatment facilities, it is necessary to excavate a large area and remove a large amounts of soil. For this site, the soil is firm, so excavation will be especially problematic.

The ground surface contains a fair number of undulations, and the shapes and required depths of the planned facilities are highly varied. In order to provide an overview of the soil as a whole at this stage in planning, the soil data for the site are assumed to be as follows:

Surface - 2 m : ordinary soil (easily excavated by manual labor or machine)
2 m - 4 m : decomposed granite (it is decomposed but hard -- not easily excavated)
4 m - : rock (excavation method; blasting followed by machine excavation)

The earth works volume is calculated based on the above classification. The layer of rock is to be excavated after it has been broken up by blasting. The structure will be constructed on the excavated surface after the surface has been trimmed.

(5) Conditions for Structural Foundation

The types of structures to be constructed are of roughly three types.

- Buildings such as a laboratory
- Sewage treatment facilities (BNR reactors, primary sedimentation tank, etc.)
- Sludge treatment facilities (sludge digestion tank, sludge thickener, etc.)

The buildings are all one-storied building, for a weight of about 1 ton/m^2. The water depth of the STW is 4 - 5 m, for a weight of 5 - 6 ton/m^2. The sludge digestion tank, which are sludge treatment structures, have a water depth of 10 -20 m, so there will be a 10 - 20 ton/m^2 load on the ground. According to the soil data, the bearing average capacity is 300 kpa (= 30 ton/m^2), so the bearing capacity is sufficient.

(6) Recommendation for Further Investigation

With this investigation, an overview of the site's soil was obtained. However, because the

foundations for some of facilities are very deep, it is necessary to conduct further boring at the points being considered for construction and collect the relevant data. Especially, where the short-shoe penetrometer test reveals N-values greater than 50, the soil of those layers should be investigated and appropriate excavation methods considered. Further, it is necessary to investigate the location and grades of the layer in order to calculate the earth works volume. The profile illustrating the soil and rock layers should be prepared so that the relation between the land and the planned structures may be further considered.

9.2 Operation and Maintenance of Sewerage Facilities

9.2.2 Sewage Treatment Works

IN SERVICE TRAINING PART II

WATER AND SEWAGE TREATMENT WORKS

OPERATION AND MAINTENANCE OF UNITS (SEWAGE WORKS)

LECTURE II

Arranged By: G. Mkudu BSc. MIWPC

THE MODIFIED ACTIVATED SLUDGE PLANT (BARDENPHO)

INTRODUCTION

Southern Africa is rapidly approaching the point of maximum economic exploitation of conventional water resources. In addition, the region is faced with deteriorating water quality which may become a limiting factor in water resources development.

The accelerated deterioration of water quality is a result of, amongst other things, the discharge of increasing quantities of treated effluents to rivers and streams.

Effective removal of pollutants from waste waters, particularly the nutrients carbon, nitrogen and phosphorus is therefore of the utmost importance. In addition, high quality effluents may serve as an economic source to augment dwindling water resources.

1. REQUIRED STANDARDS FOR FINAL EFFLUENTS

It is the purpose of the modified activated sludge plant (MAS plant) to produce an effluent that will comply with the standards prescribed in the Water (Effluent and Waste Water Standards) Regulations, 1977 (Government Notice 687/77). The standards which have been laid down are as follows:

Constituent		Water Pollution Control Regulation Standards
Ammonia (free and saline)	not exceeding	0.5 mg/l
Chlorides	not exceeding	100 mg/l
Detergents (Manoxol - OT)	not exceeding	1.0 mg/l
Nitrogen (Total as N)	not exceeding	10 mg/l
Phosphorus (Total as P)	not exceeding	1.0 mg/l
COD	not exceeding	60 mg/l
Oxygen Absorbed	not exceeding	10 mg/l
Suspended Solids	not exceeding	25 mg/l
Dissolved Solids	not exceeding	500 mg/l
pH value	not exceeding	6.0 - 9.0
Iron (as Fe)	not exceeding	0.3 mg/l
Dissolved Oxygen	not exceeding	60% saturation

2. SIMILARITIES BETWEEN THE CONVENTIONAL ACTIVATED SLUDGE PROCESS AND THE MODIFIED ACTIVATED SLUDGE PROCESS (BARDENPHO)

(1) Both processes depend on groups of micro-organisms, primarily bacteria suspended in the activated sludge, for purifying the sewage.

(2) The organisms are maintained in an aerobic environment by introducing air into a mixture of the activated sludge and the waste water and the sludge is kept in suspension.

(3) Activated sludge is separated from the treated waste water by settling in final clarifiers.

(4) Settled activated sludge is reused to inoculate more waste water with micro-organisms, i.e. It is returned to the aeration basin and excess sludge is wasted away from the system.

(5) The methods of aeration area basically the same i.e. by diffusing air into the mixture using diffusers from a compressed air supply or by using various types of mechanical aerators.

3. DIFFERENCES BETWEEN THE CONVENTIONAL ACTIVATED SLUDGE PROCESS AND THE MODIFIED ACTIVATED SLUGE PROCESS (BARDENPHO)

(1) In the conventional process, the sludge is aerated for periods less than 24 hours whereas in the MAS plants, extended aeration for periods more than 24 hours is necessary.

(2) In the MAS plant, sludge ages (SRT's) ranging between 15 to 25 days should be maintained. In the conventional process, sludge ages are usually less than 10 days.

(3) The fermentation and anoxic basins have been added to the MAS plant as part of the nutrient removal system. Such basins are not necessary in the conventional process.

(4) The conventional process was designed to produce a sufficiently nitrified effluent similar to the one produced by trickling filters before the effluent was discharged to rivers or streams. There was little or no removal of the nutrients nitrogen and phosphorus.

The MAS plant is designed to remove these nutrients.

(5) In the conventional process, mixed liquor suspended solids (MLSS) are kept approximately between 2,000 and 4,000 mg/l, whereas in the MAS plant they are kept between 4,000 and 6,000 mg/l.

(6) The MAS plant requires more strict control of the dissolved oxygen concentration in the aeration basin, the mixed liquor suspended solids (MLSS) and the sludge retention time (SRT) than the conventional plant if nutrient removal is to be achieved.

(7) Because of the long sludge retention times (SRT), thickened sludge from the MAS plant is more stable than that from the conventional plant which usually requires further treatment. Sludge from the MAS plant is fairly well stabilized and can be disposed of on land without causing any problems.

4. HISTORICAL DEVELOPMENT OF THE MODIFIED ACTIVATED SLUDGE PLANT (BARDENPHO)

The basic process for the simultaneous biological removal of phosphorus and nitrogen was proposed by Barnard in 1976 and is called the Bardenpho process.

For the phosphate removal aspect, the fundamental principle embodied in this process is that an anaerobic state needs to be created at some point in the process in such a way that the bacteria are put under stress conditions and phosphate is released, a consequence of which is that biological uptake of phosphate in excess of normal metabolic requirements is enhanced when the sludge is aerated subsequently.

For the nitrate removal aspect, the principle is that when raw sewage is mixed with nitrified sludge, in the absence of free oxygen, the organic compounds in the raw sewage will be forced to use oxygen combined with nitrate for their oxidation and nitrogen gas will be released into the atmosphere.

5. COMMISSIONING OF A NEW MAS PLANT

The most effective way of commissioning a new MAS plant is to build up mixed liquor suspended solids (MLSS) as quickly as possible by introducing raw unsettled sewage and not to waste any sludge until MLSS is approximately 4,000 mg/l. Initially, the raw sewage will be fed at a rate of about 40% of the design load until the effluent from the final clarifiers clears up. For example, a plant designed to treat 18 megalitres a day (18,000 m^3) would at start up treat 7.2 megalitres a day.

All the equipment would be fully used, not only for good aeration but also to allow the mechanical units to operate at full capacity to make sure that they are operating satisfactorily.

Initially, much effort should not be directed at nutrient removal but towards sorting out mechanical teething problems and building up MLSS. Nutrient removal tests should only be done when MLSS has been built up to approximately 4,000 mg/l and clear effluent is being discharged from the final clarifiers.

6. CONTROL OF THE DISSOLVED OXYGEN CONCENTRATION

The control of the dissolved oxygen concentration in the basin (DO) is one of the most important factors in the operation of the MAS plant. The monitoring of dissolved oxygen in the aeration basin can be done by using DO probes inserted at various points of the basin. Portable DO metres can also be used.

The most critical points for the control of dissolved oxygen in the basin are:-

(1) The point before the recycled mixed liquor enters the first anoxic basin. This is a critical point of control since excessive amounts of DO passed to the first anoxic basin will prevent good denitrification. The DO concentration at this point should be approximately not more than 0.5 mg/l.

(2) The DO concentration in the reaeration basin should be kept approximately between 1 and 3 mg/l. This residual DO in the reaeration basin will help to keep sludge in the final clarifiers aerobic and prevent phosphate release into the final effluent.

(3) The DO concentration in the main aeration basin should be controlled at not more than 1 mg/l and this should taper towards the anoxic zones to approximately 0.5 mg/l and below.

7. THE CONTROL OF AMMONIA

The most important factors controlling the conversion of ammonia to nitrates are:-

(1) The dissolved oxygen concentration in the system.

(2) The sludge retention time (SRT).

(3) The amount of organic compounds in the feed (nitrogenous compounds)

(4) The temperature of the system.

7.1 The Dissolved Oxygen Concentration

To get the ammonia nitrogen concentration below 0.5 mg/l in the final effluent, sufficient DO should be present in the aeration basin for the oxidation of ammonia to nitrates. If ammonia in the final effluent is higher than the required standards, the DO concentration in the system may be increased by:-

(1) Increasing the weir level to facilitate more oxygen intake into the system.

(2) Switching on more or all of the aerators if some of these were switched off or were operating on part time using timers.

(3) If the weir setting has been increased and all aerators are on and the ammonia in the final effluent is still high, reduce the total flow to the plant if settled sewage is being used as feed. Substitute raw unsettled sewage with settled sewage to reduce the strength of feed required.

7.2 Effect of SRT on Ammonia

The nitrification of ammonia to nitrate in the MAS plant does not present a major problem at the SRT used for this plant (i.e. 15 to 25 days). If this range of SRT is maintained, sufficient nitrifying bacteria will be present. It is therefore important to avoid overwasting of sludge as these organisms will be washed out of the system.

7.3 Effect of the Amount of Organic Matter in the Feed (Strength of Feed) on Ammonia

The amount of dissolved oxygen that has to be added to the sludge in the aeration basin depends on the strength of the feed. A strong feed will contain more ammonia to be oxidized to nitrate. If maximum aeration of the sludge has been reached and the ammonia into final

effluent is high, it is necessary to reduce the amount of ammonia entering the plant by reducing the strength of the feed.

7.4 Effect of Temperature on Ammonia

Since chemical and biochemical reactions are faster at higher temperatures, the hydrolysis of organic compounds to ammonia and the subsequent nitrification of ammonia to nitrates will favour higher temperatures if sufficient dissolved oxygen is available.

8. THE CONTROL OF PHOSPHORUS

The removal of phosphorus by the MAS plant depends on the following factors:-

(1) The dissolved oxygen concentration in the basin.

(2) The strength of the feed.

(3) The anaerobic condition of the fermentation basin.

(4) The retention time in the fermentation basin.

8.1 The Dissolved Oxygen Concentration in the Basin (Effect on Phosphate Uptake)

The requirement for good phosphate uptake is that after fermentation and phosphate release in the fermentation basin, sufficient oxygen must be available in the aeration basin to bring about phosphate uptake.

However if the sludge in the basin is overaerated, very poor or no phosphate uptake will take place. This is because good phosphate uptake must be accompanied by good denitrification. If denitrification does not take place, phosphorus uptake will not be achieved.

8.2 Effect of Feed Strength on Phosphate Uptake

For good anaerobic conditions to be created in the fermentation basin, the feed must be sufficiently strong to bring about maximum phosphate release in this basin. Maximum phosphate release in the fermentation basin will facilitate good phosphate uptake when the sludge is aerated in the aeration basin.

8.3 Effect of Anaerobic Conditions in Fermentation Basin on Phosphate Uptake

Anaerobic conditions should be maintained as much as possible in this basin for the reasons

mentioned above.

8.4 Effect of Retention Time in the Fermentation Basin of Phosphate Uptake

The retention time in the fermentation basins of most MAS plants is designed at 1.5 to 2 hours. At this retention time, all traces of dissolved oxygen, nitrites and nitrates will be used up and the sludge is kept sufficiently anaerobic at this retention time. Sufficient phosphate release will be achieved and the organisms in the sludge will be well starved of oxygen before they enter the first anoxic zone for denitrification of recycled mixed liquor.

9. CONTROL OF SLUDGE RETETNION TIME (SRT)

For the successful operation of the MAS plant, it is essential to control the sludge retention time (SRT) within the range of 15 to 25 days if nutrient removal is to be achieved. There are two methods which can be used to waste sludge from the basins:-

(1) Volumetric wastage directly from the basin via the reaeration basin and thickener.

(2) Wasting underflow sludge from the final clarifiers.

9.1 Volumetric Wasting

The sludge retention time in the MAS plant can be fixed by wasting a fixed volume of sludge continuously from the basin. For example, if the volume of the basin was 2,000 m^3 and 100 m^3 a day of the sludge is continuously drawn out of the basin, the SRT would be:-

$$\frac{2{,}000\ m^3}{100\ m^3} = 20 \text{ days}$$

9.2 Wasting from Clarifier Underflow

Sludge can also be wasted from underflows discharged from the final clarifiers. Using this method, a constant volume of sludge must be wasted from the thickened sludge returning to the basin (return sludge).

However it is necessary to determine the thickness of the underflow sludge in terms of suspended solids since this varies from day to day. The suspended solids in the basin are also determined.

Since the sludge in the basin has been thickened in the clarifier by a factor of $\frac{MLSS}{RSSS}$, the SRT using this method of wasting can be calculated as follows:-

$$\frac{\text{MLSS}}{\text{RSSS}} \times \frac{\text{Volume of Basin}}{\text{Volume Wasted}}$$

Where MLSS is the mixed liquor suspended solids.

RSSS is the return sludge suspended solids.

The volume of the basin is the total volume of the basin minus the fermentation basin.

The volume wasted can be calculated from the volume pumped from the return sludge stream to waste. It is necessary in this case to know the pumping capacity of the waste sludge pumps in order to calculate this volume.

Example

If the volume of the basin is 18,000m^3, the MLSS is 4,000 mg/l, the RSSS is 8,000 mg/l and the volume wasted from the return sludge stream to waste is 450 m^3, then the sludge retention time (SRT) will be:-

$$\frac{4{,}000}{8{,}000} \times \frac{18{,}000}{450} = 20 \text{ days}$$

10. CONTROL OF MIXED LIQUOR SUSPENDED SOLIDS (MLSS)

Most of nutrient removal MAS plants are operated at a MLSS of 4,000 to 6,000 mg/l. At sludge retention times of 15 to 25 days, this range of MLSS can be easily maintained. It is however necessary to measure MLSS regularly and adjust it to suite the required SRT. The SRT can also be adjusted to suite the required MLSS.

10.1 Sludge Settleability Tests

Two test can be used in conjunction with each other to determine the settleability of sludge in the final clarifiers.

(1) The 30 min settleable solids test

In this test, a sample of the mixed liquor is collected from the reaeration basin and poured into a 1 litre (1,000 cm^3) measuring cylinder. The sludge is stirred gently with a glass rod and left to settle for 30 minutes under quiescent conditions. After 30 minutes the volume of settled sludge is read, for example 800 cm^3.

The settleability of sludge in this cylinder can be interpreted as follows:-

1) Sludge settled above 960 cm^3 after 30 minutes with a very clear supernatant liquid

If the sludge settles above 960 cm^3 per litre after 30 minutes it might be due to one of the following reasons:-

a. To much sludge has accumulated in the basin. In order to confirm that this is the case, it is necessary to determine the mixed liquor suspended solids If these are above 4,800 mg/l, wasting should be increased in order to reduce them.

b. The sludge in the basin has been overaerated:-

This condition is usually coupled with the problem of weak feed being fed into the plant and bulking of clarifiers especially in the morning. To confirm this condition, it is necessary to determine the MLSS. If this is below 4,800, the settleability of the sludge may be improved by switching off some of the aerators especially at night or to strengthen the feed into the plant by adding fractions of raw sewage to the settled sewage feed or adding small doses of raw sludge especially in the evening. When this is done it is necessary to frequently check the MLSS to avoid a build up of solids in the system due to excess of solids being added to the plant.

c. There is a deficiency of nutrients in the feed. This condition usually results in overaeration and it is necessary to strengthen the feed as discussed above.

d. Sludge settles between 450 and 850 cm^3 per litre with a fairly clear supernatant liquid

Most sludges from MAS plants will settle in this range and it is only necessary to measure the MLSS regularly since good settleability is taking place in the clarifiers within this range.

e. Sludge settling below 450 cm^3 per litre should be viewed with suspicion because it might not mean good settleability but loss of suspended solids from the system. MLSS should be measured to find out if this is the case. If it is less than 4,000 mg/l, it would be necessary to reduced wasting. Solids settling below 450 cm^3 per litre may also have a very cloudy supernatant which may also be taken as a sign of overwasting of sludge.

(2) The sludge volume index (SVI) test

This test is done in conjunction with the 30 min. settleable solids test. For example if the measured 30 min. settleable solids are 700 cm^3 per litre and the MLSS for the sludge is 4,500 mg/l (4.5 g/l), then the sludge volume index is $\frac{700}{4.5}$ = 156 mls/g.

Most activated sludges from MAS plants have indices ranging between 120 and 200 mls/g. A sludge volume index below 100 mls/g should be viewed with suspicion since this might indicate a loss of solids from the system or underaeration.

An index above 200 might indicate overaeration of the sludge, or weak feed with insufficient nutrients being fed into the plant.

11. OPERATIONAL PROBLEMS ENCOUNTERED IN MAS PLANTS

(1) Bulking of Clarifiers

Causes

1) Weak sewage being fed into the plant

2) Overaeration of sludge in the basin

3) Low dissolved oxygen in the basin

4) High mixed liquor suspended solids or long sludge retention time

Remedies

1) If bulking is being caused by a weak feed, the sludge will settle above 960 cm^3 in the 30 min. settleable solids test even if MLSS is as low as 4,000 mg/l. Settleability of this sludge may be improved by using raw unsettled sewage as feed if settled sewage is being used or adding a dose of raw sludge to the feed especially in the evenings. Switching off of some of the aerators may also help this situation.

2) Overaeration of sludge in the basin may be dealt with by switching off some of the aerators but taking care not to cause underaeration.

3) Low dissolved oxygen in the basin can also cause bulking of clarifiers. The effluent in this situation usually comes out cloudy. Particles of floc are usually seen breaking

off from the blanket and being carried over into the effluent when the blanket is quite low. In bulking associated with weak feeds or overaeration, the whole blanket comes to the surface and spills into the effluent launder.

4) Bulking of clarifiers associated with high MLSS or long SRT's can happen only if these parameters are not controlled. If MLSS is controlled between 4,000 and 5,000 mg/l and SRT's are controlled between 15 and 25 days, this type of bulking should not occur.

   If these parameters are well controlled, it is reasonable to suspect weak feeds, overaeration or underaeration if bulking has occurred.

(2) Excessive scum in main basin and clarifiers

Scum can be a problem in the operation of MAS plants. It can accumulate in the fermentation basin, anoxic zones, aeration basin and final clarifiers. It is usually more serious when raw unsettled sewage is being used as feed to the plant. In this country, it usually starts to be a problem in June to October, just before the rainy season. It is assumed that low temperatures in winter help in clumping the scum together and high temperatures in the dry season help to bake the scum so that it floats on top of the sludge. This can impede good oxygenation in the plant.

Remedies

To overcome this problem or partially cure it, it is necessary to:-

1) Reduce mixed liquor suspended solids as much as possible without disturbing the nutrient removal capacity of the plant.

2) If raw unsettled sewage is being used as feed to the plant, substitute this with settled sewage or add a fraction of settled sewage to the unsettled raw feed.

3) Hosing of anoxic zones can also help the situation.

4) Scoop out as much as possible of the scum from the return sludge sumps before it is recycled back into the basin. Scum can also damage or wear out submersible pumps.

(3) High ammonia in final effluent

Causes

1) Underaeration in basin

2) Low MLSS

3) Strength of feed

Remedies

1) High ammonia in the final effluent is usually associated with underaeration in the main aeration basin. If this is the case aeration should be increased by switching on more or all the aerators. If all aerators are switched on and ammonia is still high in the final effluent, it is necessary to reduce the strength of the feed by using settled sewage instead of raw unsettled sewage. It may also be necessary to cut down on the volume of sewage being fed into the plant per day.

2) High ammonia in the final effluent may also be caused by having too low MLSS in the basin. This situation is caused by overwasting of sludge from the basin and indicates a loss of nitrifying bacteria which are necessary in converting the ammonia to nitrate.

3) The micro-organisms in the basin can only breakdown a certain amount of organic matter being fed into the plant. The stronger the feed, the more ammonia will have to be oxidized to nitrate. It is therefore necessary not to overload the plant in order to get a good reduction of ammonia.

(4) High phosphate in the final effluent

Causes

1) Underaeration

2) Overaeration

3) Poor anaerobic condition in the fermentation basin

4) Weak feed

5) Level of blankets in the final clarifiers

6) Poor reaeration of sludge in reaeration basin

Remedies

1) Since good phosphate uptake must be accompanied by good denitrification in the primary anoxic basin, it follows that if nitrification is poor due to underaeration, it would mean that very poor or not phosphate uptake will take place after fermentation.

2) Overaeration can impede good phosphate uptake if too much dissolved oxygen is entering the primary anoxic basin from the recycled sludge because the micro-organisms from the fermentation basin will utilize free dissolved oxygen in the primary anoxic zone before they can use oxygen combined with nitrate to achieve denitrification. If denitrification has not taken place for this reason, little or no phosphate uptake can take place.

3) Poor anaerobic conditions in the fermentation basin can be caused by too weak feeds of raw sewage entering the plant or nitrate being fed back into this basin from the final clarifiers. It is therefore necessary to ensure that the feed entering the plant is sufficiently strong to create anaerobic conditions in this basin. This will automatically reduce overaeration in the main basin and nitrate feed back into the basin.

4) Weak feeds cause poor anaerobic conditions and poor phosphate release in the fermentation basin a discussed in (3).

5) If the level of blankets in the final clarifier is kept too high, the phosphate released in the blanket can enter the final effluent.

6) If insufficient oxygen is added to the sludge in the reaeration basin, the phosphate released in the second anoxic basin (if this is incorporated in the plant) will not be sufficiently taken up and there will be insufficient residual oxygen to prevent phosphate release in the final clarifiers.

(5) High nitrate in final effluent

Causes

1) Overaeration

2) Weak feeds

Remedies

1) Reduce aeration in the aeration basin by switching off some of the aerators or putting them on part time by using automatic timers.

2) Increase strength of feed by using unsettled sewage or adding doses of raw sludge.

12. MECHANICAL PROBLEMS ENCOUNTERED IN THE OPERATION OF THE MAS PLANT

(1) Aerators

Aerators should be repaired immediately after a breakdown since the operation of this plant depends so much on aeration. It is necessary also to remove rags from aerators on a regular basis.

(2) Stirrers

Stirrers are important in keeping sludge well mixed and in suspension in the fermentation and anoxic zones. A breakdown of stirrers will cause sludge to settle in these zones. This might affect the nutrient removal capacity of the plant. At least one stirrer should be working in these zones.

(3) Waste sludge pumps

The operation of the plant can come to a standstill if sludge cannot be wasted from the system. Usually standby pumps are provided but it is important to have these pumps regularly checked and serviced to avoid a complete breakdown.

(4) Return sludge pumps

These pumps are also of vital importance in the running of the plant because activated sludge should be returned to the main basin to treat the raw sewage. Standby pumps are

usually provided but all pumps should be regularly checked and maintained to avoid a complete breakdown.

(5) Clarifiers

Clarifiers are an integral part of the system and should be well maintained. If there is a breakdown of one clarifier, it may be necessary to cut down the total flow being fed into the plant to avoid overloading the other clarifiers. It is also necessary to ensure that there is an equal distribution of sludge to the clarifiers to ensure a uniform effluent from all the clarifiers. If one clarifier bulks more frequently and the others do not, it is necessary to measure the depth of effluent in the effluent launders to see which of the clarifiers is receiving more sludge from the basin and adjustments can be made.

13. DAILY CHECKS AND RECORDS

The following should be checked and recorded on a daily basis and record sheets should be kept for future reference:-

(1) Setting of raw sewage feed volume entering the plant as required.

(2) Check and record weir setting as required.

(3) Check setting on clarifier underflows and ensure it is equal for all clarifiers.

(4) Check and record the volume of sludge being wasted from the plant to ensure a specific SRT.

(5) Check and record the volume of effluent being discharged to river or to farms from the plant.

(6) Check and record dissolved oxygen readings at various points of the basin.

14. LABORATORY CHECKS

(1) Check and record MLSS at least three times a week.

(2) Check and record the SRT from the volume of sludge being wasted from the plant.

(3) Check the strength of the raw sewage feed into the plant. Ammonia, phosphate, COD and total kjeldahl nitrogen can be done on the feed.

(4) Check 30 minute settleable solids and record.

(5) Calculate and record the SVI.

(6) Determine and record ammonia, nitrate, phosphate and suspended solids in the final effluent.

(7) Carry out tests on ammonia, nitrates and phosphates from various points of the basin to find out how the plant is performing.

15. CHECKS ON MECHANICAL UNITS

(1) Check oil levels on aerator and stirrer gearboxes.

(2) Check amp readings and record on all aerators and stirrers and pumps.

(3) Check if motors are not overheating on stirrers and aerators.

(4) Check for any unusual sounds and noises on motors.

(5) Grease regularly bearings, gearboxes and motors.

(6) Check oil seal light on pumps to find out if oil level is low.

(7) Check and record performance of clarifier bridges.

(8) Check and report all electrical faults to be repaired.

SECTION 10 COST ESTIMATES

10.1 Construction Cost

Table 10.1.1 Labor Cost

Description	Unit	Labor Cost(Z$)
Foreman	M.D.	300
Skilled labor	M.D.	120
Common labor	M.D.	70
Operator,heavy	M.D.	150
Operator,light	M.D.	100
Electrician/Mechanic	M.D.	200
Concrete worker	M.D.	90
Reinforcement worker	M.D.	90
Carpenter	M.D.	110
Formworker	M.D.	100
Welder	M.D.	110
Masonry	M.D.	140
Pavement worker	M.D.	100
Plumber	M.D.	110
Driver,lorry	M.D.	100
Driver,light	M.D.	80
Driver,van	M.D.	70
Plaster	M.D.	110

Table 10.1.2 Material Cost

Description	Unit	Cost(Z$)
Gasoline(super)	lit	4.55
Gasoline(blend)	lit	3.84
Light oil,diesel	lit	3.09
Lubricant	lit	20.00
Grease	kg	50.00
Prime	lit	4.05
Asphalt mixture	ton	601.00
Cement	ton	830.00
Sand	m3	110.00
Aggregate	m3	185.00
Crusher-run	m3	170.00
Chipping	m3	190.00
Rubble stone	m3	170.00
Reinforcing bar	ton	6700.00
Ready mixes concrete		
MPA25	m3	725.00
MPA15	m3	665.00
ANFO	kg	3.50
Dynamite	kg	11.64
Detonator	pc	13.90
Timber	m3	4500.00
Plywood	m3	4630.00
Nail	kg	11.70
Wire	kg	12.00
Turf	m2	3.00
Gabion mesh	m2	92.75
Equal angle	ton	5600.00
Unequal angle	ton	5000.00
Channel stell	ton	5000.00
Universal column	ton	7200.00
Universal beam	ton	7200.00
Flat steel	ton	6000.00
Rail	ton	5200.00
Barbed wire	kg	11.20
Tying wire	kg	12.00
AC pipe,sewer		
650mm	m	653.10
600mm	m	536.78
525mm	m	436.50
500mm	m	436.50
350mm	m	214.45
300mm	m	143.27
150mm	m	44.44
AC pipe,pressure		
400mm	m	344.48
300mm	m	320.08
200mm	m	133.65
150mm	m	85.79
150mm	m	57.64
CI pipe		
350mm	m	650.00
200mm	m	400.00
150mm	m	300.00
100mm	m	250.00
Concrete slab,300x300	pc	3.46

Description	Unit	Cost(Z$)
Horrow block	pc	5.65
Concrete kerb,910mm	pc	29.74
Concrete pole,7.5m	pc	950.00
Manhole		
900mm, 300H	pc	219.51
900mm, 600H	pc	439.07
1050mm, 300H	pc	300.98
1050mm, 600H	pc	601.32
Manhole cover,900mm	pc	297.16
Step iron	pc	36.45
Fencing material		
Post,75mm	pc	178.85
Angle post	pc	65.73
Stay	pc	80.99
Birbed wire	m	0.73
Fence	m	31.83
High stria wire	m	0.53
Tying wire	m	0.57
Steel pipe		
25mm	m	50.00
32mm	m	67.00
40mm	m	80.00
50mm	m	92.00
65mm	m	150.00
80mm	m	190.00
100mm	m	270.00
150mm	m	477.00

Table 10.1.3 Equipment Cost

Description	Unit	Hiring Cost(Z$)	
		F.C.	L.C.
Bulldozer,30ton class,D8	Hr	765	25
Bulldozer,21ton,D7	Hr	645	25
Bulldozer,15ton,D6	Hr	535	25
Wheel loader,2m3	Hr	405	25
Backhoe,0.6m3	Hr	575	25
Dump truck,10ton	Hr	363	17
Vibration roller,10ton	Hr	363	17
Vibration roller,4ton	Hr	253	17
Vibration roller,1ton	Hr	84	0
Tamper	Day	190	0
Rammer	Day	70	0
Crane,20ton	Day	4560	150
Crane,15ton	Day	4340	150
Crane,5ton	Hr	526.5	37.5
Breaker,1300kg *	Hr	206	0
Crawler drill,180kg *	Hr	127	0
Air compressor,17m3 *	Day	1272	0
Leg drill *	Day	90	0
Air compressor,5m3 *	Day	520	0
Air conpressor,3m3 *	Day	348	0
Pickhammer *	Day	16	0

Remarks :
F.C. is depreciation cost, repair cost and fuel cost.
L.C. is labor cost for operator and driver.
Above cost is a hiring equipment cost obtained from contractors and hiring company.
Equipment of * marking is estimated by the depreciation basis.

Table 10.1.4 Construction Cost for Sewer Reticulation

Item No.	Description	Foreign Currency (Z$)	Local Currency (Z$)	Total (Z$)	Total (US$)
1	Sewer				
1.1	Preliminary and General	757,997.40	1,274,781.22	2,032,778.62	193,597.96
1.2	Earthworks	2,945,550.04	454,612.04	3,400,162.08	323,824.96
1.3	Pipe Laying	1,584,885.10	7,347,405.10	8,932,290.20	850,694.30
1.4	Manhole and chamber	522,880.88	696,524.34	1,219,405.22	116,133.83
	Total (1)	5,811,313.42	9,773,322.70	15,584,636.12	1,484,251.06
2	Pump Station at St.Mary's (New)				
2.1	Preliminary and General	414,459.12	175,043.50	589,502.62	56,143.11
2.2	Bulk Excavation	19,574.10	1,310.40	20,884.50	1,989.00
2.3	Screen and Grit Chammber	14,314.76	80,475.36	94,790.12	9,027.63
2.4	Pumphouse	283,080.37	536,252.33	819,332.70	78,031.69
2.5	Pumping Equipment and Electrical Works	2,443,875.00	456,215.55	2,900,090.55	276,199.10
2.6	Site Work	2,216.55	92,703.03	94,919.58	9,039.96
	Total (2)	3,177,519.90	1,342,000.17	4,519,520.07	430,430.48
3	Rehabilitation of Pump Equipment				
3.1	St.Mary's No.1 Pump Station				
3.1.1	Preliminary and General	258,783.73	124,167.63	382,951.36	36,471.56
3.1.2	Expansion of Flowmeter Box	1,387.39	5,713.97	7,101.36	676.32
3.1.3	Sewer Flow Detouring Work	368,550.00	228,900.00	597,450.00	56,900.00
3.1.4	Pump Equipment and Electrical Work	1,355,287.50	593,170.20	1,948,457.70	185,567.40
	Total (3.1)	1,984,008.62	951,951.80	2,935,960.42	279,615.28
3.2	St.Mary's No.2 Pump Station				
3.2.1	Preliminary and General	84,895.86	65,290.82	150,186.68	14,303.49
3.2.2	Expansion of Flowmeter Box	1,387.39	5,713.97	7,101.36	676.32
3.2.3	Sewer Flow Detouring Work	285,600.00	108,150.00	393,750.00	37,500.00
3.2.4	Pump Equipment and Electrical Work	278,985.00	321,408.15	600,393.15	57,180.30
	Total (3.2)	650,868.25	500,562.94	1,151,431.19	109,660.11
3.3	Tilcor Pump Station				
3.3.1	Preliminary and General	224,251.86	119,988.84	344,240.70	32,784.83
3.3.2	Expansion of Flowmeter Box	1,387.39	5,713.97	7,101.36	676.32
3.3.3	Sewer Flow Detouring Work	336,000.00	205,800.00	541,800.00	51,600.00
3.3.4	Pump Equipment and Electrical Work	1,157,625.00	588,411.60	1,746,036.60	166,289.20
	Total (3.3)	1,719,264.25	919,914.41	2,639,178.66	251,350.35
	Total (3)	4,354,141.12	2,372,429.15	6,726,570.27	640,625.74
	Total (1,2 and 3)	13,342,974.44	13,487,752.02	26,830,726.46	2,555,307.28

Table 10.1.5 Construction Cost for Expansion of Sewage Treatment Works

Item No.	Description	Foreign Currency (Z$)	Local Currency (Z$)	Total (Z$)	Total (US$)
1	Preliminary and General	10,787,268.29	7,295,849.18	18,083,117.47	1,722,201.66
2	Bulk Excavation	6,146,138.25	352,903.95	6,499,042.20	618,956.40
3	Screen and Grit Chamber	1,988,768.04	1,162,645.05	3,151,413.09	300,134.58
4	Split Box for Primary Sedimentation Tank (3nos)	7,684.90	46,034.68	53,719.58	5,116.15
5	Primary Sedimentation Tank (6nos)	1,998,893.75	2,644,931.39	4,643,825.14	442,269.06
6	Confluence Box for Primary Sedimentation Tank (2nos)	6,098.61	29,640.40	35,739.01	3,403.72
7	Biological Reactor (2nos)	29,621,762.94	17,910,886.56	47,532,649.50	4,526,919.00
8	Split Box for Final Sedimentation Tank (2nos)	6,098.61	29,640.40	35,739.01	3,403.72
9	Final Sedimentation Tank (4nos)	6,031,930.35	5,989,151.94	12,021,082.29	1,144,864.98
10	Confluence Box for Final Sedimentation Tank (2nos)	6,098.61	29,640.40	35,739.01	3,403.72
11	RAS/WAS Pump Station (2nos)	1,696,109.21	1,832,529.83	3,528,639.04	336,060.86
12	Sludge Thickener (2nos)	720,817.94	1,014,071.92	1,734,889.86	165,227.61
13	Pump Station for Sludge (1 no.)	289,095.00	322,464.01	611,559.01	58,243.72
14	Sludge Digestion Tank (2nos)	2,152,704.50	4,752,738.02	6,905,442.52	657,661.19
15	Nutrients Supply Pump Pit (1no.)	336,241.43	311,132.77	647,374.20	61,654.69
16	Sludge Drying Bed (6nos)	602,785.53	2,879,262.31	3,482,047.84	331,623.60
17	Infiltration Pump Pit	480,268.99	598,581.35	1,078,850.34	102,747.65
18	Sludge Storage Yard	35,577.36	1,066,875.60	1,102,452.96	104,995.52
19	Outlet Works	30,552.59	50,005.10	80,557.69	7,672.16
20	Interconnecting Pipe	784,809.36	1,312,601.98	2,097,411.34	199,753.46
21	Electric Control House	1,674.96	159,069.75	160,744.71	15,309.02
22	Site Works	44,331.00	6,144,187.14	6,188,518.14	589,382.68
23	Plant/Equipment	18,926,680.00	0.00	18,926,680.00	1,802,540.95
	Total	82,702,390.22	55,934,843.73	138,637,233.95	13,203,546.09

Table 10.1.6 Construction Cost for Rehabilitation Works

Item No.	Description	Foreign Currency (Z$)	Local Currency (Z$)	Total (Z$)	Total (US$)
1	Existing Sewage Treatment Works				
	(1) Preliminary and General	337,086.57	768,822.12	1,105,908.69	105,324.64
	(2) Removal of unsuitable material in existing trickling filter	89,474.80	4,815,211.40	4,904,686.20	467,112.97
	(3) Removal of sludge from existing anaerobic pond	997,424.00	46,784.00	1,044,208.00	99,448.38
	(4) Replacement of flow recorder	252,000.00	28,000.00	280,000.00	26,666.67
	(5) Sludge disposal pit adjacent to existing anaerobic pond	908,345.00	235,485.40	1,143,830.40	108,936.23
	Total 1	2,584,330.37	5,894,302.92	8,478,633.29	807,488.88
2	Irrigation Facilities				
	(1) Preliminary and General	100,434.75	21,888.75	122,323.50	11,649.86
	(2) Replacement of No.2 pump	669,565.00	145,925.00	815,490.00	77,665.71
	Total 2	769,999.75	167,813.75	937,813.50	89,315.57
3	Pre-treatment Facilities for Tilcor Industrial Area				
	(1) Preliminary and General	48,739.29	39,855.87	88,595.16	8,437.63
	(2) Rehabilitation works	324,928.60	265,705.80	590,634.40	56,250.90
	Total 3	373,667.89	305,561.67	679,229.56	64,688.53
4	Sludge Disposal Pit				
	(1) Preliminary and General	687,075.00	306,588.39	993,663.39	94,634.61
	(2) For New Sewage Treatment Work	1,740,250.00	742,081.20	2,482,331.20	236,412.50
	(3) For Existing Sewage Treatment Work	2,840,250.00	1,301,841.40	4,142,091.40	394,484.90
	Total 4	5,267,575.00	2,350,510.99	7,618,085.99	725,532.00
	Total (1,2,3 and 4)	8,995,573.01	8,718,189.33	17,713,762.34	1,687,024.98

Table 10.1.7 Detailed Construction Cost for Sewer Reticulation

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
1	Sewer								
1.1	Preliminary and General (15%)	L.S.			757,997.40		1,274,781.22		2,032,778.62
1.2	Earthworks								
	Site clearance,5m wide	m	6,880	26.70	183,696.00	3.45	23,736.00	30.15	207,432.00
	Topsoil,removal,stockpile	m	6,880	22.04	151,635.20	0.86	5,916.80	22.90	157,552.00
	replacement along trench line								
	Trench excavation in soft material								
	including backfilling and bedding								
	AC pipe,sewer 525mm dia.								
	Not exceed 2.0m	m	1,135	145.98	165,687.30	18.16	20,611.60	164.14	186,298.90
	3.0m	m	1,930	214.05	413,116.50	27.01	52,129.30	241.06	465,245.80
	4.0m	m	1,030	282.12	290,583.60	35.86	36,935.80	317.98	327,519.40
	5.0m	m	185	350.19	64,785.15	44.71	8,271.35	394.90	73,056.50
	AC pipe,pressure 300mm dia.								
	Not exceed 2.0m	m	2,600	145.98	379,548.00	18.16	47,216.00	164.14	426,764.00
	Extra over excavation								
	Intermediate	m3	5,400	190.01	1,026,054.00	40.33	217,782.00	230.34	1,243,836.00
	Hard rock	m3	500	260.36	130,180.00	40.73	20,365.00	301.09	150,545.00
	Others(5%)				140,264.29		21,648.19		161,912.48
	Subtotal (1.2)				2,945,550.04		454,612.04		3,400,162.08
1.3	Pipe Laying								
	Pipe laying including delivery,								
	joint,test								
	AC pipe,sewer,525mm dia.								
	Not exceed 2.0m	m	1,135	115.01	130,536.35	593.11	673,179.85	708.12	803,716.20
	3.0m	m	1,930	120.76	233,066.80	594.39	1,147,172.70	715.15	1,380,239.50
	4.0m	m	1,030	126.51	130,305.30	595.68	613,550.40	722.19	743,855.70
	5.0m	m	185	132.26	24,468.10	596.96	110,437.60	729.22	134,905.70
	AC pipe,pressure,300mm dia.								
	Class 18								
	Not exceed 2.0m	m	2,600	105.41	274,066.00	434.37	1,129,362.00	539.78	1,403,428.00

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	Others(5%)				792,442.55		3,673,702.55		4,466,145.10
	Subtotal (1.3)				1,584,885.10		7,347,405.10		8,932,290.20
1.4	Manhole and Chamber								
	Excavation,backfill and disposal								
	Not exceed 2.0m	no.	9	145.98	1,313.82	18.16	163.44	164.14	1,477.26
	3.0m	no.	26	214.05	5,565.30	27.01	702.26	241.06	6,267.56
	4.0m	no.	13	282.12	3,667.56	35.86	466.18	317.98	4,133.74
	5.0m	no.	3	350.19	1,050.57	44.71	134.13	394.90	1,184.70
	Extra over excavation								
	Intermediate	m3	210	190.01	39,902.10	40.33	8,469.30	230.34	48,371.40
	Hard rock	m3	20	260.36	5,207.20	40.73	814.60	301.09	6,021.80
	Blinding concrete,75mm	no.	51	0.00	0.00	75.92	3,871.92	75.92	3,871.92
	Precast concrete manhole,supply, and installation,1050mm/900mm								
	Not exceed 2.0m	no.	9	2762.53	24,862.77	4059.18	36,532.62	6821.71	61,395.39
	3.0m	no.	26	3967.15	103,145.90	6331.05	164,607.30	10298.20	267,753.20
	4.0m	no.	13	4569.46	59,402.98	7928.51	103,070.63	12497.97	162,473.61
	5.0m	no.	3	5774.08	17,322.24	9809.93	29,429.79	15584.01	46,752.03
	Others(5%)				261,440.44		348,262.17		609,702.61
	Subtotal (1.4)				522,880.88		696,524.34		1,219,405.22
	Total (1)				5,811,313.42		9,773,322.70		15,584,636.12
2	Pump Station at St.Mary's (New)								
2.1	Preliminary and General(15%)	L.S.			414,459.12		175,043.50		589,502.62
2.2	Bulk Excavation								
	Site clearance	m2	600	5.34	3,204.00	0.69	414.00	6.03	3,618.00
	Topsoil stripping,stockpile,replace	m2	600	20.02	12,012.00	0.96	576.00	20.98	12,588.00
	Land levelling	m2	600	5.71	3,426.00	0.43	258.00	6.14	3,684.00
	Others(5%)				932.10		62.40		994.50
	Subtotal (2.2)				19,574.10		1,310.40		20,884.50
2.3	Screen and Grit Chammber								

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	Excavation,common	m3	50	79.76	3,988.00	3.79	189.50	83.55	4,177.50
	Excavation,intermediate	m3	10	253.58	2,535.80	43.55	435.50	297.13	2,971.30
	Excavation,hard rock	m3	0	334.58	0.00	44.53	0.00	379.11	0.00
	Backfill	m3	30	108.43	3,252.90	10.94	328.20	119.37	3,581.10
	Gravel bedding	m2	10	0.00	0.00	29.88	298.80	29.88	298.80
	Blinding concrete	m2	10	0.00	0.00	75.92	759.20	75.92	759.20
	Unreinforced concrete	m3	0	0.00	0.00	1012.31	0.00	1012.31	0.00
	Reinforced concrete	m3	15	152.33	2,284.95	1030.87	15,463.05	1183.20	17,748.00
	Reinforcement	kg	1,500	0.45	675.00	11.31	16,965.00	11.76	17,640.00
	Shuttering	m2	70	0.00	0.00	140.00	9,800.00	140.00	9,800.00
	Screen,700mmW,1850mmH	no.	2	0.00	0.00	1100.00	2,200.00	1100.00	2,200.00
	Stoplog,700mmW,1850mmH	no.	2	0.00	0.00	4800.00	9,600.00	4800.00	9,600.00
	AC pipe,sewer 525mm dia.including trench,laying,backfill	m	5	179.29	896.45	600.79	3,003.95	780.08	3,900.40
	Handrail	m	10	0.00	0.00	1300.00	13,000.00	1300.00	13,000.00
	Grating cover,700mmx2000mm	no.	2	0.00	0.00	2300.00	4,600.00	2300.00	4,600.00
	Others(5%)				681.66		3,832.16		4,513.82
	Subtotal (2.3)				14,314.76		80,475.36		94,790.12
2.4	Pumphouse								
	Excavation,common	m3	380	79.76	30,308.80	3.79	1,440.20	83.55	31,749.00
	Excavation,intermediate	m3	230	253.58	58,323.40	43.55	10,016.50	297.13	68,339.90
	Excavation,hard rock	m3	150	334.58	50,187.00	44.53	6,679.50	379.11	56,866.50
	Backfill	m3	400	108.43	43,372.00	10.94	4,376.00	119.37	47,748.00
	Gravel bedding	m2	110	0.00	0.00	29.88	3,286.80	29.88	3,286.80
	Blinding concrete	m2	110	0.00	0.00	75.92	8,351.20	75.92	8,351.20
	Unreinforced concrete	m3	0	0.00	0.00	1012.31	0.00	1012.31	0.00
	Reinforced concrete	m3	105	152.33	15,994.65	1030.87	108,241.35	1183.20	124,236.00
	Reinforcement	kg	11,620	0.45	5,229.00	11.31	131,422.20	11.76	136,651.20
	Shuttering	m2	550	0.00	0.00	140.00	77,000.00	140.00	77,000.00
	Waterstop	m	50	156.00	7,800.00	31.20	1,560.00	187.20	9,360.00
	Joint filler	m2	20	218.40	4,368.00	43.68	873.60	262.08	5,241.60
	Roofing	m2	24	0.00	0.00	1000.00	24,000.00	1000.00	24,000.00
	Bilding work,window,door,interior works,lighting,etc.	L.S.			10,017.50		95,729.15		105,746.65
	Ladder,5m high	no.	1	0.00	0.00	3000.00	3,000.00	3000.00	3,000.00

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	Manhole cover,steel,600mm dia.	no.	2	0.00	0.00	470.00	940.00	470.00	940.00
	Handrail	m	10	0.00	0.00	1300.00	13,000.00	1300.00	13,000.00
	Crane beam,I-shape,200mm with channel support	m	10	0.00	0.00	1200.00	12,000.00	1200.00	12,000.00
	Gear chain and block hoist,5ton	L.S.			44,000.00		8,800.00		52,800.00
	Others(5%)				13,480.02		25,535.83		39,015.84
	Subtotal (2.4)				283,080.37		536,252.33		819,332.69
2.5	Pumping Equipment and Electrical Works								
	Pump,motor,panel,wiring,50kWx 3nos.	L.S.			1,540,000.00		0.00		1,540,000.00
	Valve,pipe,flange,flowmeter	L.S.			0.00		305,791.00		305,791.00
	Electrical work	L.S.			787,500.00		0.00		787,500.00
	Installation work	L.S.			0.00		128,700.00		128,700.00
	Others(5%)				116,375.00		21,724.55		138,099.55
	Subtotal (2.5)				2,443,875.00		456,215.55		2,900,090.55
2.6	Site Work								
	Turfing with topsoil	m2	320	0.00	0.00	35.06	11,219.20	35.06	11,219.20
	Gravel metalling,including subbase	m2	200	0.00	0.00	39.00	7,800.00	39.00	7,800.00
	Fencing	m	100	0.00	0.00	166.39	16,639.00	166.39	16,639.00
	Gate,road	no.	1	0.00	0.00	1869.47	1,869.47	1869.47	1,869.47
	Gate,pedestrian	no.	1	0.00	0.00	748.93	748.93	748.93	748.93
	Stormwater channel	m	100	21.11	2,111.00	0.92	92.00	22.03	2,203.00
	Staff house	m2	16	0.00	0.00	3120.00	49,920.00	3120.00	49,920.00
	Lighting facilities	L.S.			0.00		0.00		0.00
	Others(5%)				105.55		4,414.43		4,519.98
	Subtotal (2.6)				2,216.55		92,703.03		94,919.58
	Total (2)				3,177,519.90		1,342,000.17		4,519,520.06
3	Rehabilitation of Pump Equipment								
3.1	St.Mary's No.1 Pump Station								
3.1.1	Preliminary and General(15%)	L.S.			258,783.73		124,167.63		382,951.36

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
3.1.2	Expansion of Flowmeter Box								
	Excavation,common	m3	10	79.76	797.60	3.79	37.90	83.55	835.50
	Backfill	m3	4	108.43	433.72	10.94	43.76	119.37	477.48
	Gravel bedding	m2	2	0.00	0.00	29.88	59.76	29.88	59.76
	Blinding concrete	m2	2	0.00	0.00	75.92	151.84	75.92	151.84
	Reinforcement concrete	m3	2	0.00	0.00	1093.31	2,186.62	1093.31	2,186.62
	Reinforcement	kg	200	0.45	90.00	11.31	2,262.00	11.76	2,352.00
	Shuttering	m2	5	0.00	0.00	140.00	700.00	140.00	700.00
	Others(5%)				66.07		272.09		338.16
	Subtotal (3.1.2)				1,387.39		5,713.97		7,101.36
3.1.3	Sewer Flow Detouring Work								
	Temporary pond 30m x 30m x 1m, excavation and restoring	L.S.			140,000.00		7,000.00		147,000.00
	Temporary pump operation including pipe,valve	L.S.			211,000.00		211,000.00		422,000.00
	Others(5%)				17,550.00		10,900.00		28,450.00
	Subtotal (3.1.3)				368,550.00		228,900.00		597,450.00
3.1.4	Pump Equipment and Electrical Work								
	Removal and disposal of old pumps, pipes,valves,etc.	L.S.			0.00		119,610.00		119,610.00
	Pump,motor,panel,wiring,25kWx 3nos.	L.S.			897,000.00		0.00		897,000.00
	Valve,pipe,flange,flowmeter	L.S.			0.00		299,064.00		299,064.00
	Electrical work	L.S.			393,750.00		0.00		393,750.00
	Installation work	L.S.			0.00		146,250.00		146,250.00
	Others(5%)				64,537.50		28,246.20		92,783.70
	Subtotal (3.1.4)				1,355,287.50		593,170.20		1,948,457.70
	Total (3.1)				1,984,008.62		951,951.80		2,935,960.42
3.2	St.Mary's No.2 Pump Station								
3.2.1	Preliminary and General(15%)	L.S.			84,895.86		65,290.82		150,186.68

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
3.2.2	Expansion of Flowmeter Box								
	Excavation,common	m3	10	79.76	797.60	3.79	37.90	83.55	835.50
	Backfill	m3	4	108.43	433.72	10.94	43.76	119.37	477.48
	Gravel bedding	m2	2	0.00	0.00	29.88	59.76	29.88	59.76
	Blinding concrete	m2	2	0.00	0.00	75.92	151.84	75.92	151.84
	Reinforcement concrete	m3	2	0.00	0.00	1093.31	2,186.62	1093.31	2,186.62
	Reinforcement	kg	200	0.45	90.00	11.31	2,262.00	11.76	2,352.00
	Shuttering	m2	5	0.00	0.00	140.00	700.00	140.00	700.00
	Others(5%)				66.07		272.09		338.16
	Subtotal (3.2.2)				1,387.39		5,713.97		7,101.36
3.2.3	Sewer Flow Detouring Work								
	Temporary pond 40m x 40m x 1m, excavation and restoring	L.S.			250,000.00		13,000.00		263,000.00
	Temporary pump operation including pipe,valve	L.S.			22,000.00		90,000.00		112,000.00
	Others(5%)				13,600.00		5,150.00		18,750.00
	Subtotal (3.2.3)				285,600.00		108,150.00		393,750.00
3.2.4	Pump Equipment and Electrical Work								
	Removal and disposal of old pumps, pipes,valves,etc.	L.S.			0.00		40,120.00		40,120.00
	Pump,motor,panel,wiring,5kWx 2nos.	L.S.			213,200.00		0.00		213,200.00
	Valve,pipe,flange,flowmeter	L.S.			0.00		187,983.00		187,983.00
	Electrical work	L.S.			52,500.00		0.00		52,500.00
	Installation work	L.S.			0.00		78,000.00		78,000.00
	Others(5%)				13,285.00		15,305.15		28,590.15
	Subtotal (3.2.4)				278,985.00		321,408.15		600,393.15
	Total (3.2)				650,868.25		500,562.94		1,151,431.19
3.3	Tilcor Pump Station								
3.3.1	Preliminary and General(15%)	L.S.			224,251.86		119,988.84		344,240.70
3.3.2	Expansion of Flowmeter Box								

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	Excavation,common	m3	10	79.76	797.60	3.79	37.90	83.55	835.50
	Backfill	m3	4	108.43	433.72	10.94	43.76	119.37	477.48
	Gravel bedding	m2	2	0.00	0.00	29.88	59.76	29.88	59.76
	Blinding concrete	m2	2	0.00	0.00	75.92	151.84	75.92	151.84
	Reinforcement concrete	m3	2	0.00	0.00	1093.31	2,186.62	1093.31	2,186.62
	Reinforcement	kg	200	0.45	90.00	11.31	2,262.00	11.76	2,352.00
	Shuttering	m2	5	0.00	0.00	140.00	700.00	140.00	700.00
	Others(5%)				66.07		272.09		338.16
	Subtotal (3.3.2)				1,387.39		5,713.97		7,101.36
3.3.3	Sewer Flow Detouring Work								
	Temporary pond 30m x 30m x 1m, excavation and restoring	L.S.			140,000.00		7,000.00		147,000.00
	Temporary pump operation including pipe,valve	L.S.			180,000.00		189,000.00		369,000.00
	Others(5%)				16,000.00		9,800.00		25,800.00
	Subtotal (3.3.3)				336,000.00		205,800.00		541,800.00
3.3.4	Pump Equipment and Electrical Work								
	Removal and disposal of old pumps, pipes,valves,etc.	L.S.			0.00		113,700.00		113,700.00
	Pump,motor,panel,wiring,18kWx 3nos.	L.S.			819,000.00		0.00		819,000.00
	Valve,pipe,flange,flowmeter	L.S.			0.00		317,992.00		317,992.00
	Electrical work	L.S.			283,500.00		0.00		283,500.00
	Installation work	L.S.			0.00		128,700.00		128,700.00
	Others(5%)				55,125.00		28,019.60		83,144.60
	Subtotal (3.3.4)				1,157,625.00		588,411.60		1,746,036.60
	Total (3.3)				1,719,264.25		919,914.41		2,639,178.66
	Total (3)				4,354,141.12		2,372,429.15		6,726,570.27
	Total (1,2 and 3)				13,342,974.44		13,487,752.02		26,830,726.45

Table 10.1.8 Detailed Construction Cost for Expansion of Sewage Treatment Works

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
1	Preliminary and General(15%)	L.S.			10,787,268.29		7,295,849.18		18,083,117.47
2	Bulk Excavation								
	Site clearance	m2	78,000	5.34	416,520.00	0.69	53,820.00	6.03	470,340.00
	Excavation of topsoil,incl.stockpile	m2	78,000	20.72	1,616,160.00	0.96	74,880.00	21.68	1,691,040.00
	Excavation,common	m3	20,700	73.34	1,518,138.00	3.44	71,208.00	76.78	1,589,346.00
	Excavation,intermediate	m3	18,600	95.13	1,769,418.00	4.38	81,468.00	99.51	1,850,886.00
	Excavation,hard rock	m3	2,100	133.49	280,329.00	18.88	39,648.00	152.37	319,977.00
	Embankment,place and compact	m3	7,500	33.72	252,900.00	2.01	15,075.00	35.73	267,975.00
	Others(5%)				292,673.25		16,804.95		309,478.20
	Subtotal (2)				6,146,138.25		352,903.95		6,499,042.20
3	Screen and Grit Chamber								
	Excavation,common	m3	560	79.76	44,665.60	3.79	2,122.40	83.55	46,788.00
	Excavation, intermediate	m3	730	253.58	185,113.40	43.55	31,791.50	297.13	216,904.90
	Excavtion,hard rock	m3	440	334.58	147,215.20	44.53	19,593.20	379.11	166,808.40
	Backfill	m3	1,350	108.43	146,380.50	10.94	14,769.00	119.37	161,149.50
	Gravel bedding	m2	210	0.00	0.00	29.88	6,274.80	29.88	6,274.80
	Blinding concrete	m2	210	0.00	0.00	75.92	15,943.20	75.92	15,943.20
	Unreinforced concrete	m3	0	0.00	0.00	1012.31	0.00	1012.31	0.00
	Reinforced concrete	m3	150	152.33	22,849.50	1030.87	154,630.50	1183.20	177,480.00
	Reinforcement	kg	16,200	0.45	7,290.00	11.31	183,222.00	11.76	190,512.00
	Shuttering	m2	780	0.00	0.00	140.00	109,200.00	140.00	109,200.00
	Mortar finishing,10mm	m2	460	0.00	0.00	22.00	10,120.00	22.00	10,120.00
	Coarse screen,1200W,1200H	no.	2	0.00	0.00	1300.00	2,600.00	1300.00	2,600.00
	Fine screen,900W,1240H	no.	2	0.00	0.00	1000.00	2,000.00	1000.00	2,000.00
	Stoplog,aluminium,1200W,1200H	no.	2	0.00	0.00	5300.00	10,600.00	5300.00	10,600.00
	Stoplog,aluminium,900W,1000H	no.	4	0.00	0.00	1100.00	4,400.00	1100.00	4,400.00
	Grating,1200mm x 3000mm	no.	1	0.00	0.00	5900.00	5,900.00	5900.00	5,900.00
	Grating,1200mm x 2400mm	no.	1	0.00	0.00	4800.00	4,800.00	4800.00	4,800.00
	Handrail	m	20	0.00	0.00	1300.00	26,000.00	1300.00	26,000.00
	Lighting facility,for site	no.	3	0.00	0.00	3000.00	9,000.00	3000.00	9,000.00
	Roofing,incl.pillar,roof beam,tile	m2	44	0.00	0.00	1000.00	44,000.00	1000.00	44,000.00
	Air compressor,22kW	no.	3	230000.00	690,000.00	23000.00	69,000.00	253000.00	759,000.00

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	Electrical works	L.S.			345,000.00		34,500.00		379,500.00
	Air compressor house	m2	16	0.00	0.00	2340.00	37,440.00	2340.00	37,440.00
	Staff house	m2	9	0.00	0.00	3120.00	28,080.00	3120.00	28,080.00
	Flow recorder	no.	2	126000.00	252,000.00	14000.00	28,000.00	140000.00	280,000.00
	Parshall flume	no.	2	0.00	0.00	20000.00	40,000.00	20000.00	40,000.00
	Grating,2500mm x 1000mm	no.	2	0.00	0.00	4100.00	8,200.00	4100.00	8,200.00
	Grating,800mm x 800mm	no.	2	0.00	0.00	1100.00	2,200.00	1100.00	2,200.00
	Gas pipe for air lift pipe,150mm dia.	m	60	726.11	43,566.60	145.22	8,713.20	871.33	52,279.80
	Steel pipe,25mm dia.	m	120	0.00	0.00	59.87	7,184.40	59.87	7,184.40
	Precast concrete plate,50mm,baffle								
	1800mm x 6000mm	no.	4	0.00	0.00	5500.00	22,000.00	5500.00	22,000.00
	1800mm x 5000mm	no.	2	0.00	0.00	4600.00	9,200.00	4600.00	9,200.00
	1800mm x 4000mm	no.	2	0.00	0.00	3700.00	7,400.00	3700.00	7,400.00
	Adjustable penstock gate 450W,600H	no.	4	0.00	0.00	1800.00	7,200.00	1800.00	7,200.00
	Orifice gate,aluminium,450W,600H	no.	2	0.00	0.00	45000.00	90,000.00	45000.00	90,000.00
	Steel gate,900x900	no.	1	0.00	0.00	30000.00	30,000.00	30000.00	30,000.00
	Steel gate,700x700	no.	16	0.00	0.00	1200.00	19,200.00	1200.00	19,200.00
	Waterstop	m	50	156.00	7,800.00	31.20	1,560.00	187.20	9,360.00
	Joint filler	m2	10	218.40	2,184.00	43.68	436.80	262.08	2,620.80
	Others(5%)				94,703.24		55,364.05		150,067.29
	Subtotal (3)				1,988,768.04		1,162,645.05		3,151,413.09
4	Split Box for Primary Sedimentation Tank (3nos)								
	Excavation,common	m3	30	79.76	2,392.80	3.79	113.70	83.55	2,506.50
	Excavation, intermediate	m3	5	253.58	1,267.90	43.55	217.75	297.13	1,485.65
	Excavtion,hard rock	m3	0	334.58	0.00	44.53	0.00	379.11	0.00
	Backfill	m3	15	108.43	1,626.45	10.94	164.10	119.37	1,790.55
	Gravel bedding	m2	10	0.00	0.00	29.88	298.80	29.88	298.80
	Blinding concrete	m2	10	0.00	0.00	75.92	759.20	75.92	759.20
	Unreinforced concrete	m3	0	0.00	0.00	1012.31	0.00	1012.31	0.00
	Reinforced concrete	m3	10	152.33	1,523.30	1030.87	10,308.70	1183.20	11,832.00
	Reinforcement	kg	1,130	0.45	508.50	11.31	12,780.30	11.76	13,288.80
	Shuttering	m2	90	0.00	0.00	140.00	12,600.00	140.00	12,600.00
	Gate,aluminium,500W,600H	no.	2	0.00	0.00	1200.00	2,400.00	1200.00	2,400.00

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	Gate,aluminium,300W,600H	no.	6	0.00	0.00	700.00	4,200.00	700.00	4,200.00
	Others(5%)				365.95		2,192.13		2,558.08
	Subtotal (4)				7,684.90		46,034.68		53,719.58
5	Primary Sedimentation Tank (6nos)								
	Excavation,common	m3	0	79.75	0.00	3.79	0.00	83.54	0.00
	Excavation, intermediate	m3	1,010	253.58	256,115.80	43.55	43,985.50	297.13	300,101.30
	Excavtion,hard rock	m3	1,010	334.58	337,925.80	44.53	44,975.30	379.11	382,901.10
	Trimming	m2	1,240	11.32	14,036.80	55.34	68,621.60	66.66	82,658.40
	Blinding concrete	m2	2,300	0.00	0.00	75.92	174,616.00	75.92	174,616.00
	Unreinforced concrete	m3	0	0.00	0.00	1012.31	0.00	1012.31	0.00
	Reinforced concrete	m3	500	152.33	76,165.00	1030.87	515,435.00	1183.20	591,600.00
	Reinforcement	kg	54,300	0.45	24,435.00	11.31	614,133.00	11.76	638,568.00
	Shuttering	m2	3,240	0.00	0.00	140.00	453,600.00	140.00	453,600.00
	Mortar finishing	m2	1,530	0.00	0.00	22.00	33,660.00	22.00	33,660.00
	Precast concrete beam,600mmW, 200mmT,12500mmL	no.	6	0.00	0.00	10000.00	60,000.00	10000.00	60,000.00
	Stilling box,1600mm dia.,1800H	no.	6	0.00	0.00	36000.00	216,000.00	36000.00	216,000.00
	Scum baffle,steel,200H	m	230	0.00	0.00	200.00	46,000.00	200.00	46,000.00
	Scum skimer,300mm dia.,6100mm	no.	6	180000.00	1,080,000.00	20000.00	120,000.00	200000.00	1,200,000.00
	Influent pipe								
	CI pipe,300mm dia.	m	36	1505.63	54,202.68	301.13	10,840.68	1806.76	65,043.36
	90 deg.bend	no.	12	0.00	0.00	3306.16	39,673.92	3306.16	39,673.92
	Bellmouth end	no.	6	0.00	0.00	3306.16	19,836.96	3306.16	19,836.96
	Sludge drawoff pipe								
	CI pipe,150mm dia.	m	81	726.11	58,814.91	145.22	11,762.82	871.33	70,577.73
	45 deg.bend	no.	6	0.00	0.00	1200.16	7,200.96	1200.16	7,200.96
	Tee	no.	6	0.00	0.00	1356.16	8,136.96	1356.16	8,136.96
	Gate valve,150mm	no.	6	335.39	2,012.34	4607.43	27,644.58	4942.82	29,656.92
	Valve box,steel	no.	6	0.00	0.00	476.50	2,859.00	476.50	2,859.00
	Others(5%)				95,185.42		125,949.11		221,134.53
	Subtotal (5)				1,998,893.75		2,644,931.39		4,643,825.14
6	Confluence Box for Primary Sedimentation Tank (2nos)								
	Excavation,common	m3	20	79.76	1,595.20	3.79	75.80	83.55	1,671.00

Item No.	Description	Unit	Quanuty	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	Excavation, intermediate	m3	5	253.58	1,267.90	43.55	217.75	297.13	1,485.65
	Excavtion,hard rock	m3	0	334.58	0.00	44.53	0.00	379.11	0.00
	Backfill	m3	10	108.43	1,084.30	10.94	109.40	119.37	1,193.70
	Gravel bedding	m2	6	0.00	0.00	29.88	179.28	29.88	179.28
	Blinding concrete	m2	6	0.00	0.00	75.92	455.52	75.92	455.52
	Unreinforced concrete	m3	0	0.00	0.00	1012.31	0.00	1012.31	0.00
	Reinforced concrete	m3	10	152.33	1,523.30	1030.87	10,308.70	1183.20	11,832.00
	Reinforcement	kg	750	0.45	337.50	11.31	8,482.50	11.76	8,820.00
	Shuttering	m2	60	0.00	0.00	140.00	8,400.00	140.00	8,400.00
	Others(5%)				290.41		1,411.45		1,701.86
	Subtotal (6)				6,098.61		29,640.40		35,739.01
7	Biological Reactor (2nos)								
	Excavation,common	m3	6,160	73.34	451,774.40	3.44	21,190.40	76.78	472,964.80
	Excavation, intermediate	m3	12,320	95.13	1,172,001.60	4.38	53,961.60	99.51	1,225,963.20
	Excavtion,hard rock	m3	6,160	133.49	822,298.40	18.88	116,300.80	152.37	938,599.20
	Backfill	m3	3,850	108.43	417,455.50	10.94	42,119.00	119.37	459,574.50
	Gravel bedding	m2	5,410	0.00	0.00	29.88	161,650.80	29.88	161,650.80
	Blinding concrete	m2	5,410	0.00	0.00	75.92	410,727.20	75.92	410,727.20
	Unreinforced concrete	m3	0	0.00	0.00	1012.31	0.00	1012.31	0.00
	Reinforced concrete	m3	4,080	152.33	621,506.40	1030.87	4,205,949.60	1183.20	4,827,456.00
	Reinforcement	kg	489,130	0.45	220,108.50	11.31	5,532,060.30	11.76	5,752,168.80
	Shuttering	m2	7,310	0.00	0.00	140.00	1,023,400.00	140.00	1,023,400.00
	Supporting	m3	5,710	20.12	114,885.20	65.13	371,892.30	85.25	486,777.50
	Scaffolding	m2	6,220	22.24	138,332.80	32.96	205,011.20	55.20	343,344.00
	Waterstop	m	920	156.00	143,520.00	31.20	28,704.00	187.20	172,224.00
	Joint filler	m2	50	218.40	10,920.00	43.68	2,184.00	262.08	13,104.00
	Stair,steel,1900mmH,1200mmW	no.	8	0.00	0.00	2300.00	18,400.00	2300.00	18,400.00
	Handrail	m	1,540	0.00	0.00	1300.00	2,002,000.00	1300.00	2,002,000.00
	Stoplog,aluminium								
	500mmW,1000mmH	no.	12	0.00	0.00	1900.00	22,800.00	1900.00	22,800.00
	900mmW,1000mmH	no.	8	0.00	0.00	3400.00	27,200.00	3400.00	27,200.00
	Surface aerator,45kW (incl.motor,gear box,etc.)	no.	14	1080000.00	15,120,000.00	120000.00	1,680,000.00	1200000.00	16,800,000.00
	Surface aerator,22kW (incl.motor,gear box,etc.)	no.	2	540000.00	1,080,000.00	60000.00	120,000.00	600000.00	1,200,000.00

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	Mixer,3.7kW	no.	12	180000.00	2,160,000.00	20000.00	240,000.00	200000.00	2,400,000.00
	Recirculation pump								
	Pump,motor,panel,wiring,15kWx 6nos.	L.S.			1,918,800.00		0.00		1,918,800.00
	Valve,pipe,flange	L.S.			0.00		34,476.00		34,476.00
	Installation work	L.S.			0.00		257,400.00		257,400.00
	Control house	m2	18	0.00	0.00	3120.00	56,160.00	3120.00	56,160.00
	Electrical work	L.S.			3,819,600.00		424,400.00		4,244,000.00
	Others(5%)				1,410,560.14		852,899.36		2,263,459.50
	Subtotal (7)				29,621,762.94		17,910,886.56		47,532,649.50
8	Split Box for Final Sedimentation Tank (2nos)								
	Excavation,common	m3	20	79.76	1,595.20	3.79	75.80	83.55	1,671.00
	Excavation, intermediate	m3	5	253.58	1,267.90	43.55	217.75	297.13	1,485.65
	Excavtion,hard rock	m3	0	334.58	0.00	44.53	0.00	379.11	0.00
	Backfill	m3	10	108.43	1,084.30	10.94	109.40	119.37	1,193.70
	Gravel bedding	m2	6	0.00	0.00	29.88	179.28	29.88	179.28
	Blinding concrete	m2	6	0.00	0.00	75.92	455.52	75.92	455.52
	Unreinforced concrete	m3	0	0.00	0.00	1012.31	0.00	1012.31	0.00
	Reinforced concrete	m3	10	152.33	1,523.30	1030.87	10,308.70	1183.20	11,832.00
	Reinforcement	kg	750	0.45	337.50	11.31	8,482.50	11.76	8,820.00
	Shuttering	m2	60	0.00	0.00	140.00	8,400.00	140.00	8,400.00
	Others(5%)				290.41		1,411.45		1,701.86
	Subtotal (8)				6,098.61		29,640.40		35,739.01
9	Final Sedimentation Tank (4nos)								
	Excavation,common	m3	1,460	79.76	116,449.60	3.79	5,533.40	83.55	121,983.00
	Excavation, intermediate	m3	2,930	253.58	742,989.40	43.55	127,601.50	297.13	870,590.90
	Excavtion,hard rock	m3	1,460	334.58	488,486.80	44.53	65,013.80	379.11	553,500.60
	Trimming	m2	2,680	11.32	30,337.60	55.34	148,311.20	66.66	178,648.80
	Backfill	m3	300	108.43	32,529.00	10.94	3,282.00	119.37	35,811.00
	Gravel bedding	m2	2,680	0.00	0.00	29.88	80,078.40	29.88	80,078.40
	Blinding concrete	m2	2,680	0.00	0.00	75.92	203,465.60	75.92	203,465.60
	Unreinforced concrete	m3	0	0.00	0.00	1012.31	0.00	1012.31	0.00
	Reinforced concrete	m3	1,640	152.33	249,821.20	1030.87	1,690,626.80	1183.20	1,940,448.00
	Reinforcement	kg	180,800	0.45	81,360.00	11.31	2,044,848.00	11.76	2,126,208.00

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	Shuttering	m2	4,330	0.00	0.00	140.00	606,200.00	140.00	606,200.00
	Scaffolding	m2	3,220	22.24	71,612.80	32.96	106,131.20	55.20	177,744.00
	Influent pipe								
	CI pipe,350mm dia.	m	67	1756.18	117,664.06	351.24	23,533.08	2107.42	141,197.14
	90 deg.bend	no.	4	0.00	0.00	3306.16	13,224.64	3306.16	13,224.64
	Joint,CI,AC and CI pipes	no.	4	0.00	0.00	3306.16	13,224.64	3306.16	13,224.64
	Sludge drawoff pipe								
	CI pipe,300mm dia.	m	77	1505.63	115,933.51	301.13	23,187.01	1806.76	139,120.52
	Valve	no.	4	752.90	3,011.60	15198.24	60,792.96	15951.14	63,804.56
	Effluent weir,steel,200mmH	m	392	0.00	0.00	200.00	78,400.00	200.00	78,400.00
	Sludge collector with mechanical bridge,circumference device 26000mm dia.,4000mmH	no.	4	900000.00	3,600,000.00	100000.00	400,000.00	1000000.00	4,000,000.00
	Electrical work	L.S.			94,500.00		10,500.00		105,000.00
	Others(5%)				287,234.78		285,197.71		572,432.49
	Subtotal (9)				6,031,930.35		5,989,151.94		12,021,082.29
10	Confluence Box for Final Sedimentation Tank (2nos)								
	Excavation,common	m3	20	79.76	1,595.20	3.79	75.80	83.55	1,671.00
	Excavation, intermediate	m3	5	253.58	1,267.90	43.55	217.75	297.13	1,485.65
	Excavtion,hard rock	m3	0	334.58	0.00	44.53	0.00	379.11	0.00
	Backfill	m3	10	108.43	1,084.30	10.94	109.40	119.37	1,193.70
	Gravel bedding	m2	6	0.00	0.00	29.88	179.28	29.88	179.28
	Blinding concrete	m2	6	0.00	0.00	75.92	455.52	75.92	455.52
	Unreinforced concrete	m3	0	0.00	0.00	1012.31	0.00	1012.31	0.00
	Reinforced concrete	m3	10	152.33	1,523.30	1030.87	10,308.70	1183.20	11,832.00
	Reinforcement	kg	750	0.45	337.50	11.31	8,482.50	11.76	8,820.00
	Shuttering	m2	60	0.00	0.00	140.00	8,400.00	140.00	8,400.00
	Others(5%)				290.41		1,411.45		1,701.86
	Subtotal (10)				6,098.61		29,640.40		35,739.01
11	RAS/WAS Pump Station (2nos)								
	Excavation,common	m3	110	79.76	8,773.60	3.79	416.90	83.55	9,190.50
	Excavation, intermediate	m3	110	253.58	27,893.80	43.55	4,790.50	297.13	32,684.30
	Excavtion,hard rock	m3	0	334.58	0.00	44.53	0.00	379.11	0.00

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	Backfill	m3	80	108.43	8,674.40	10.94	875.20	119.37	9,549.60
	Gravel bedding	m2	150	0.00	0.00	29.88	4,482.00	29.88	4,482.00
	Blinding concrete	m2	150	0.00	0.00	75.92	11,388.00	75.92	11,388.00
	Unreinforced concrete	m3	20	0.00	0.00	1012.31	20,246.20	1012.31	20,246.20
	Reinforced concrete	m3	110	152.33	16,756.30	1030.87	113,395.70	1183.20	130,152.00
	Reinforcement	kg	12,100	0.45	5,445.00	11.31	136,851.00	11.76	142,296.00
	Shuttering	m2	420	0.00	0.00	140.00	58,800.00	140.00	58,800.00
	Roofing,incl.pillar,roof beam,tile	m2	100	0.00	0.00	1755.00	175,500.00	1755.00	175,500.00
	Handrail	m	70	0.00	0.00	1300.00	91,000.00	1300.00	91,000.00
	Stair,stell,2000mmH	no.	2	0.00	0.00	1200.00	2,400.00	1200.00	2,400.00
	RAS pump								
	Pump,motor,panel,wiring,15kWx 6nos.	L.S.			643,063.00		0.00		643,063.00
	Valve,pipe,flange	L.S.			0.00		567,429.00		567,429.00
	Electrical work	L.S.			472,500.00		0.00		472,500.00
	Installation work	L.S.			0.00		257,400.00		257,400.00
	WAS pump								
	Pump,motor,panel,wiring,3.7kWx 4nos	L.S.			354,536.00		0.00		354,536.00
	Valve,pipe,flange	L.S.			0.00		175,492.00		175,492.00
	Electrical work	L.S.			77,700.00		0.00		77,700.00
	Installation work	L.S.			0.00		124,800.00		124,800.00
	Others(5%)				80,767.11		87,263.33		168,030.43
	Subtotal (11)				1,696,109.21		1,832,529.83		3,528,639.03
12	Sludge Thickener (2nos)								
	Excavation,common	m3	150	79.76	11,964.00	3.79	568.50	83.55	12,532.50
	Excavation, intermediate	m3	380	253.58	96,360.40	43.55	16,549.00	297.13	112,909.40
	Excavtion,hard rock	m3	230	334.58	76,953.40	44.53	10,241.90	379.11	87,195.30
	Trimming	m2	430	11.32	4,867.60	55.34	23,796.20	66.66	28,663.80
	Blinding concrete	m2	430	0.00	0.00	75.92	32,645.60	75.92	32,645.60
	Unreinforced concrete	m3	0	0.00	0.00	1012.31	0.00	1012.31	0.00
	Reinforced concrete	m3	230	152.33	35,035.90	1030.87	237,100.10	1183.20	272,136.00
	Reinforcement	kg	25,300	0.45	11,385.00	11.31	286,143.00	11.76	297,528.00
	Shuttering	m2	1,270	0.00	0.00	140.00	177,800.00	140.00	177,800.00
	Mortar finishing	m2	430	0.00	0.00	22.00	9,460.00	22.00	9,460.00
	Precast concrete beam,600mmW, 200mmT,12000mmL	no.	2	0.00	0.00	10000.00	20,000.00	10000.00	20,000.00

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	Stilling box,1200mm dia.,1800mmH	no.	2	0.00	0.00	22000.00	44,000.00	22000.00	44,000.00
	Scum baffle,steel,200mmH	m	72	0.00	0.00	200.00	14,400.00	200.00	14,400.00
	Scum skimer,300mm dia.,5800mm	no.	2	180000.00	360,000.00	20000.00	40,000.00	200000.00	400,000.00
	Influent pipe								
	CI pipe,150mm dia.	m	16	726.11	11,617.76	145.22	2,323.52	871.33	13,941.28
	90 deg.bend	no.	6	0.00	0.00	1200.16	7,200.96	1200.16	7,200.96
	Bellmouth end	no.	2	0.00	0.00	1200.16	2,400.32	1200.16	2,400.32
	Sludge drawoff pipe								
	CI pipe,150mm dia.	m	106	726.11	76,967.66	145.22	15,393.32	871.33	92,360.98
	T-fitting	no.	2	0.00	0.00	1356.16	2,712.32	1356.16	2,712.32
	Y-fitting	no.	2	0.00	0.00	1356.16	2,712.32	1356.16	2,712.32
	Gate valve,150mm	no.	4	335.39	1,341.56	4607.43	18,429.72	4942.82	19,771.28
	Valve box,stell	no.	4	0.00	0.00	476.50	1,906.00	476.50	1,906.00
	Others(5%)				34,324.66		48,289.14		82,613.80
	Subtotal (12)				720,817.94		1,014,071.92		1,734,889.86
13	Pump Station for Sludge (1 no.)								
	Excavation,common	m3	50	79.76	3,988.00	3.79	189.50	83.55	4,177.50
	Excavation, intermediate	m3	5	253.58	1,267.90	43.55	217.75	297.13	1,485.65
	Excavtion,hard rock	m3	0	334.58	0.00	44.53	0.00	379.11	0.00
	Backfill	m3	25	108.43	2,710.75	10.94	273.50	119.37	2,984.25
	Gravel bedding	m2	25	0.00	0.00	29.88	747.00	29.88	747.00
	Blinding concrete	m2	25	0.00	0.00	75.92	1,898.00	75.92	1,898.00
	Unreinforced concrete	m3	5	0.00	0.00	1012.31	5,061.55	1012.31	5,061.55
	Reinforced concrete	m3	24	152.33	3,655.92	1030.87	24,740.88	1183.20	28,396.80
	Reinforcement	kg	2,640	0.45	1,188.00	11.31	29,858.40	11.76	31,046.40
	Shuttering	m2	110	0.00	0.00	140.00	15,400.00	140.00	15,400.00
	Roofing,incl.pillar,roof beam,tile	m2	20	0.00	0.00	1755.00	35,100.00	1755.00	35,100.00
	Handrail	m	14	0.00	0.00	1300.00	18,200.00	1300.00	18,200.00
	Stair,stell,2000mmH	no.	1	0.00	0.00	1200.00	1,200.00	1200.00	1,200.00
	Sludge pump								
	Pump,motor,panel,wiring,7.5kWx 2nos	L.S.			183,768.00		0.00		183,768.00
	Valve,pipe,flange	L.S.			0.00		88,422.00		88,422.00
	Electrical work	L.S.			78,750.00		0.00		78,750.00
	Installation work	L.S.			0.00		85,800.00		85,800.00
	Others(5%)				13,766.43		15,355.43		29,121.86

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	Reinforced concrete	m3	10	152.33	1,523.30	1030.87	10,308.70	1183.20	11,832.00
	Reinforcement	kg	800	0.45	360.00	11.31	9,048.00	11.76	9,408.00
	Shuttering	m2	15	0.00	0.00	140.00	2,100.00	140.00	2,100.00
	Gabion	m2	40	194.65	7,786.00	214.85	8,594.00	409.50	16,380.00
	Others(5%)				1,454.89		2,381.20		3,836.08
	Subtotal (19)				30,552.59		50,005.10		80,557.68
20	Interconnecting Pipe								
	Screen/Grit Chamber-Split Box								
	AC pipe,sewer,650mm dia.	m	90	189.02	17,011.80	883.53	79,517.70	1072.55	96,529.50
	Manhole	no.	1	1675.85	1,675.85	2002.19	2,002.19	3678.04	3,678.04
	AC pipe,sewer,500mm dia.	m	60	177.34	10,640.40	600.56	36,033.60	777.90	46,674.00
	New Grit Outlet-Existing Distribution Box								
	AC pipe,sewer,650mm dia.	m	30	189.02	5,670.60	883.53	26,505.90	1072.55	32,176.50
	Split Box-Primary Sedimentation Tank								
	AC pipe,sewer,300mm dia.	m	30	152.16	4,564.80	210.11	6,303.30	362.27	10,868.10
	Primary sedimentation Tank-Pump Station of PST Sludge (Sludge)								
	CI pipe,150mm	m	90	843.99	75,959.10	16.64	1,497.60	860.63	77,456.70
	Valve	no.	1	335.39	335.39	4607.43	4,607.43	4942.82	4,942.82
	Primary Sedimentation Tank-Pump Station of PST Sludge (Scum)								
	CI pipe,150mm	m	90	843.99	75,959.10	16.64	1,497.60	860.63	77,456.70
	Valve	no.	1	335.39	335.39	4607.43	4,607.43	4942.82	4,942.82
	Pump Station(Sludge)-Digestion Tank								
	Ac pipe,class 12,150mm dia.	m	245	117.88	28,880.60	128.17	31,401.65	246.05	60,282.25
	Mud outlet	no.	3	0.00	0.00	1000.00	3,000.00	1000.00	3,000.00
	Valve,mud outlet	no.	3	335.39	1,006.17	4607.43	13,822.29	4942.82	14,828.46
	Valve box	no.	3	0.00	0.00	476.50	1,429.50	476.50	1,429.50
	Digestion Tank-Sludge Drying Bed								
	CI pipe,150mm dia.	m	40	843.99	33,759.60	16.64	665.60	860.63	34,425.20
	Primary Sedimentation Tank-Confluence Box								
	AC pipe,sewer,300mm dia.	m	40	152.16	6,086.40	210.11	8,404.40	362.27	14,490.80
	Confluence Box-Biological Reactor								

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	AC pipe,sewer,500mm dia.	m	125	177.34	22,167.50	600.56	75,070.00	777.90	97,237.50
	Manhole	no.	3	1675.85	5,027.55	2002.19	6,006.57	3678.04	11,034.12
	Biological Reactor-Split Box								
	AC pipe,sewer,500mm dia.	m	180	177.34	31,921.20	600.56	108,100.80	777.90	140,022.00
	Manhole	no.	5	1675.85	8,379.25	2002.19	10,010.95	3678.04	18,390.20
	Split Box-Final Sedimentation Tank								
	AC pipe,sewer,350mm dia.	m	40	156.05	6,242.00	303.11	12,124.40	459.16	18,366.40
	Final Sedimentation Tank-Confluence Box								
	AC pipe,sewer,350mm dia.	m	40	156.05	6,242.00	303.11	12,124.40	459.16	18,366.40
	Confluence Box-Outlet Works								
	AC pipe,sewer,500mm dia.	m	70	177.34	12,413.80	600.56	42,039.20	777.90	54,453.00
	AC pipe,sewer,600mm dia.	m	255	185.12	47,205.60	731.85	186,621.75	916.97	233,827.35
	Manhole	no.	3	1675.85	5,027.55	2002.19	6,006.57	3678.04	11,034.12
	Final Sedimentation Tank-RAS/WAS (including FST pipe)								
	RAS/WAS-Biological Reactor								
	AC pipe,class 6,400mm dia.	m	255	169.55	43,235.25	480.00	122,400.00	649.55	165,635.25
	90 deg.bend	no.	6	0.00	0.00	3306.16	19,836.96	3306.16	19,836.96
	Mud outlet	no.	2	0.00	0.00	1000.00	2,000.00	1000.00	2,000.00
	Valve,mud outlet	no.	2	752.90	1,505.80	30148.24	60,296.48	30901.14	61,802.28
	Valve box	no.	2	0.00	0.00	2777.36	5,554.72	2777.36	5,554.72
	Nutrients Supply Pump Pit-BNR Reactor								
	AC pipe,class 12,200mm dia.	m	300	135.47	40,641.00	193.94	58,182.00	329.41	98,823.00
	90 deg.bend	no.	5	0.00	0.00	2136.16	10,680.80	2136.16	10,680.80
	Mud outlet	no.	2	0.00	0.00	1000.00	2,000.00	1000.00	2,000.00
	Valve,mud outlet	no.	2	499.66	999.32	7238.63	14,477.26	7738.29	15,476.58
	Valve box	no.	2	0.00	0.00	1688.20	3,376.40	1688.20	3,376.40
	Pump Station-Sludge Thickener								
	AC pipe,150mm dia.	m	170	117.88	20,039.60	74.41	12,649.70	192.29	32,689.30
	90 deg.bend	no.	2	0.00	0.00	1200.16	2,400.32	1200.16	2,400.32
	Mud outlet	no.	2	0.00	0.00	1000.00	2,000.00	1000.00	2,000.00
	Valve,mud outlet	no.	2	335.39	670.78	4607.43	9,214.86	4942.82	9,885.64
	Valve box	no.	2	0.00	0.00	476.50	953.00	476.50	953.00
	Sludge Thickener-Sludge Drying Bed								

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	CI pipe,150mm dia.	m	60	843.99	50,639.40	16.64	998.40	860.63	51,637.80
	Sludge Drying Bed-Infiltation Pit								
	AC pipe,sewer,150mm dia.	m	200	117.88	23,576.00	74.41	14,882.00	192.29	38,458.00
	Manhole	no.	2	1675.85	3,351.70	2002.19	4,004.38	3678.04	7,356.08
	Digestion tank-Infiltation Pit								
	AC pipe,sewer,150mm dia.	m	250	117.88	29,470.00	74.41	18,602.50	192.29	48,072.50
	Manhole	no.	6	1675.85	10,055.10	2002.19	12,013.14	3678.04	22,068.24
	Laboratory-Split Box No.1								
	AC pipe,sewer,150mm dia.	m	60	117.88	7,072.80	74.41	4,464.60	192.29	11,537.40
	Manhole	no.	2	1675.85	3,351.70	2002.19	4,004.38	3678.04	7,356.08
	Infiltation Pit-Existing AC Pipe								
	AC pipe,class 12,200mm dia.	m	90	135.47	12,192.30	193.94	17,454.60	329.41	29,646.90
	45 deg.bend	no.	1	0.00	0.00	2136.16	2,136.16	2136.16	2,136.16
	Infiltation Pit-Existing Land								
	AC pipe,class 12,200mm dia.	m	680	135.47	92,119.60	193.94	131,879.20	329.41	223,998.80
	90 deg.bend	no.	3	0.00	0.00	2136.16	6,408.48	2136.16	6,408.48
	Mud outlet	no.	2	0.00	0.00	1000.00	2,000.00	1000.00	2,000.00
	Valve,mud outlet	no.	2	499.66	999.32	7238.63	14,477.26	7738.29	15,476.58
	Valve box	no.	2	0.00	0.00	1688.20	3,376.40	1688.20	3,376.40
	Valve for water outflow	no.	3	335.39	1,006.17	2657.43	7,972.29	2992.82	8,978.46
	Others(5%)				37,371.87		62,504.86		99,876.73
	Subtotal (20)				784,809.36		1,312,601.98		2,097,411.34
21	Electric Control House								
	Excavation,common	m3	20	79.76	1,595.20	3.79	75.80	83.55	1,671.00
	Gravel bedding	m2	24	0.00	0.00	29.88	717.12	29.88	717.12
	Blinding concrete	m2	24	0.00	0.00	75.92	1,822.08	75.92	1,822.08
	Building work,precast concrete	m2	24	0.00	0.00	3120.00	74,880.00	3120.00	74,880.00
	Roofing	m2	24	0.00	0.00	1000.00	24,000.00	1000.00	24,000.00
	Interior work	L.S.			0.00		50,000.00		50,000.00
	Others(5%)				79.76		7,574.75		7,654.51
	Subtotal (21)				1,674.96		159,069.75		160,744.71
22	Site Works								
	Topsoil/tufting	m2	39,000	0.00	0.00	35.06	1,367,340.00	35.06	1,367,340.00
	Tree planting	L.S.			0.00		20,000.00		20,000.00

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	Fencing work	m	1,240	0.00	0.00	166.39	206,323.60	166.39	206,323.60
	Road gate,double leaf	no.	3	0.00	0.00	1869.47	5,608.41	1869.47	5,608.41
	Pedestrian gate,single leaf	no.	3	0.00	0.00	748.93	2,246.79	748.93	2,246.79
	Road pavement,DBST	m2	6,800	0.00	0.00	122.04	829,872.00	122.04	829,872.00
	Road kerb	m	3,400	0.00	0.00	89.79	305,286.00	89.79	305,286.00
	Stormwater,earth channel	m	2,000	21.11	42,220.00	0.92	1,840.00	22.03	44,060.00
	Distribution line	L.S.			0.00		500,000.00		500,000.00
	Lighting facilities	L.S.			0.00		200,000.00		200,000.00
	Administration building/block, precast concrete	m2	300	0.00	0.00	3510.00	1,053,000.00	3510.00	1,053,000.00
	Repair shop with roofing	m2	100	0.00	0.00	1000.00	100,000.00	1000.00	100,000.00
	Garage for maintenance equipment with roofing	m2	100	0.00	0.00	1755.00	175,500.00	1755.00	175,500.00
	Staff house	no.	6	0.00	0.00	168480.00	1,010,880.00	168480.00	1,010,880.00
	Gate house	no.	3	0.00	0.00	24570.00	73,710.00	24570.00	73,710.00
	Others(5%)				2,111.00		292,580.34		294,691.34
	Subtotal (22)				44,331.00		6,144,187.14		6,188,518.14
23	Plant/Equipment								
	Laboratory apparatus/equipment	L.S.			15,000,000.00		0.00		15,000,000.00
	Dumper,1m3	no.	2	265000.00	530,000.00	0.00	0.00	265000.00	530,000.00
	Backhoe,0.35m3	no.	1	1035000.00	1,035,000.00	0.00	0.00	1035000.00	1,035,000.00
	Dump truck,6t	no.	1	820000.00	820,000.00	0.00	0.00	820000.00	820,000.00
	Front end loader,1m3	no.	1	557000.00	557,000.00	0.00	0.00	557000.00	557,000.00
	Pedestrian movers	no.	3	15000.00	45,000.00	0.00	0.00	15000.00	45,000.00
	Pick-up	no.	3	173000.00	519,000.00	0.00	0.00	173000.00	519,000.00
	Motorcycle	no.	5	44000.00	220,000.00	0.00	0.00	44000.00	220,000.00
	Computer and printer	set	2	41000.00	82,000.00	0.00	0.00	41000.00	82,000.00
	Walky talkey	set	10	7475.00	74,750.00	0.00	0.00	7475.00	74,750.00
	VHF for vehicle	no.	3	7935.00	23,805.00	0.00	0.00	7935.00	23,805.00
	VHF,main	no.	1	20125.00	20,125.00	0.00	0.00	20125.00	20,125.00
	Subtotal (23)				18,926,680.00		0.00		18,926,680.00
	Total				82,702,390.22		55,934,843.73		138,637,233.93

Table 10.1.9 Detailed Construction Cost for Rehabilitation Works

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
1	Existing Sewage Treatment Works								
	(1) Preliminary and general (15%)	L.S.			337,086.57		768,822.12		1,105,908.69
	(2) Removal of unsuitable material in existing trickling filter								
	Removal,cleaning,filter process, drying and replacement	m3	21,750	0.00	0.00	180.18	3,918,915.00	180.18	3,918,915.00
	Supplemental material	m3	2,180	0.00	0.00	409.22	892,099.60	409.22	892,099.60
	Disposal of sludge	m3	1,220	73.34	89,474.80	3.44	4,196.80	76.78	93,671.60
	Subtotal				89,474.80		4,815,211.40		4,904,686.20
	(3) Removal of sludge from existing anaerobic pond	m3	13,600	73.34	997,424.00	3.44	46,784.00	76.78	1,044,208.00
	(4) Replacement of flow recorder	no.	2	126000.00	252,000.00	14000.00	28,000.00	140000.00	280,000.00
	(5) Sludge disposal pit adjacent to existing anaerobic pond								
	Site clearance	m2	10,000	5.34	53,400.00	0.69	6,900.00	6.03	60,300.00
	Excavation,common	m3	4,000	79.76	319,040.00	3.79	15,160.00	83.55	334,200.00
	Excavation,intermediate	m3	500	95.13	47,565.00	4.38	2,190.00	99.51	49,755.00
	Embankment	m3	4,000	33.72	134,880.00	2.01	8,040.00	35.73	142,920.00
	Scarify and shape formation	m2	6,000	19.03	114,180.00	1.44	8,640.00	20.47	122,820.00
	Slope protection	m2	3,200	0.00	0.00	20.02	64,064.00	20.02	64,064.00
	Covering soil	m2	6,000	39.88	239,280.00	1.90	11,400.00	41.78	250,680.00
	Fence	m	700	0.00	0.00	166.39	116,473.00	166.39	116,473.00
	Road gate	no.	1	0.00	0.00	1869.47	1,869.47	1869.47	1,869.47
	Pedestrian gate	no.	1	0.00	0.00	748.93	748.93	748.93	748.93
	Subtotal				908,345.00		235,485.40		1,143,830.40
	Total 1				2,584,330.37		5,894,302.92		8,478,633.29

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
2	Irrigation Facilities								
	(1) Preliminary and general (15%)	L.S.			100,434.75		21,888.75		122,323.50
	(2) Replacement of No.2 pump								
	Removal,disposal of old pump	L.S.			0.00		64,025.00		64,025.00
	Pump,motor,panel wiring,185kWx 1no	L.S.			601,250.00		0.00		601,250.00
	Valve	L.S.			0.00		39,000.00		39,000.00
	Electrical work	L.S.			68,315.00		0.00		68,315.00
	Installation work	L.S.			0.00		42,900.00		42,900.00
	Subtotal				669,565.00		145,925.00		815,490.00
	Total 2				769,999.75		167,813.75		937,813.50
3	Pre-treatment Facilities for Tilcor Industrial Area								
	(1) Preliminary and general (15%)	L.S.			48,739.29		39,855.87		88,595.16
	(2) Rehabilitation works								
	Removal of sludge in pond	m3	2,220	73.33	162,792.60	3.44	7,636.80	76.77	170,429.40
	Jet pipe in anaerobic pond								
	AC pipe,class 12,200mm dia.	m	720	135.47	97,538.40	193.94	139,636.80	329.41	237,175.20
	AC pipe,class 12,100mm dia.	m	520	117.88	61,297.60	91.57	47,616.40	209.45	108,914.00
	Skum jet,incl.GP,bend,valve, joint,nozzle	no.	36	0.00	0.00	1500.00	54,000.00	1500.00	54,000.00
	Access road,3m wide	m	50	66.00	3,300.00	120.10	6,005.00	186.10	9,305.00
	Slope forming	m2	540	0.00	0.00	20.02	10,810.80	20.02	10,810.80
	Subtotal				324,928.60		265,705.80		590,634.40
	Total 3				373,667.89		305,561.67		679,229.56
4	Sludge Disposal Pit								
	(1) Preliminary and general (15%)	L.S.			687,075.00		306,588.39		993,663.39

Item No.	Description	Unit	Quantity	Foreign Currency(Z$)		Local Currency(Z$)		Total (Z$)	
				Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	(2) For New Sewage Treatment Work								
	Site clearance	m2	17,000	5.34	90,780.00	0.69	11,730.00	6.03	102,510.00
	Excavation,commn	m3	9,000	79.76	717,840.00	3.79	34,110.00	83.55	751,950.00
	Excavation,intermediate	m3	1,000	95.13	95,130.00	4.38	4,380.00	99.51	99,510.00
	Embankment	m3	10,000	33.72	337,200.00	2.01	20,100.00	35.73	357,300.00
	Scarify and shape formation	m2	10,000	19.03	190,300.00	1.44	14,400.00	20.47	204,700.00
	Slope compaction	m2	11,000	0.00	0.00	20.02	220,220.00	20.02	220,220.00
	Soil cement	m3	1,500	206.00	309,000.00	232.00	348,000.00	438.00	657,000.00
	Fence	m	520	0.00	0.00	166.39	86,522.80	166.39	86,522.80
	Road gate	no.	1	0.00	0.00	1869.47	1,869.47	1869.47	1,869.47
	Pedestrian gate	no.	1	0.00	0.00	748.93	748.93	748.93	748.93
	Subtotal				1,740,250.00		742,081.20		2,482,331.20
	(3) For Existing Sewage Treatment Work								
	Site clearance	m2	27,000	5.34	144,180.00	0.69	18,630.00	6.03	162,810.00
	Excavation,common	m3	15,000	79.76	1,196,400.00	3.79	56,850.00	83.55	1,253,250.00
	Excavation,intermediate	m3	1,000	95.13	95,130.00	4.38	4,380.00	99.51	99,510.00
	Embankment	m3	15,000	33.72	505,800.00	2.01	30,150.00	35.73	535,950.00
	Scarify and shape formation	m2	18,000	19.03	342,540.00	1.44	25,920.00	20.47	368,460.00
	Slope compaction	m2	21,000	0.00	0.00	20.02	420,420.00	20.02	420,420.00
	Soil cement	m3	2,700	206.00	556,200.00	232.00	626,400.00	438.00	1,182,600.00
	Fence	m	700	0.00	0.00	166.39	116,473.00	166.39	116,473.00
	Road gate	no.	1	0.00	0.00	1869.47	1,869.47	1869.47	1,869.47
	Pedestrian gate	no.	1	0.00	0.00	748.93	748.93	748.93	748.93
	Subtotal				2,840,250.00		1,301,841.40		4,142,091.40
	Total 4				5,267,575.00		2,350,510.99		7,618,085.99
	Total (1,2,3 and 4)				8,995,573.01		8,718,189.33		17,713,762.34

Table 10.1.10 Detailed Disbursement Schedule

Unit : ZS

Description	Total			1997			1998			1999		
	F.C	L.C	Total	F.C	L.C	Total	F.C	L.C	Total	F.C	L.C	Total
I. Direct Construction Cost												
1 Sewer Reticulation												
Sewer	5,811,313	9,773,323	15,584,636	0	0	0	5,811,313	9,773,323	15,584,636	0	0	0
Pump Station at St.Mary's (New)	3,177,520	1,342,000	4,519,520	0	0	0	3,177,520	1,342,000	4,519,520	0	0	0
Rehabilitation of Pump Equipment												
St.Mary's No.1	1,984,009	951,952	2,935,961	0	0	0	1,984,009	951,952	2,935,961	0	0	0
St.Mary's No.2	650,868	500,563	1,151,431	0	0	0	650,868	500,563	1,151,431	0	0	0
Tilcor	1,719,264	919,914	2,639,178	0	0	0	1,719,264	919,914	2,639,178	0	0	0
(Subtotal)	4,354,141	2,372,429	6,726,570	0	0	0	4,354,141	2,372,429	6,726,570	0	0	0
Subtotal	13,342,974	13,487,752	26,830,726	0	0	0	13,342,974	13,487,752	26,830,726	0	0	0
2 Expansion of Sewage Treatment works												
Preliminary and General	10,787,268	7,295,849	18,083,117	0	0	0	10,787,268	7,295,849	18,083,117	0	0	0
Bulk Excavation	6,146,138	352,904	6,499,042	0	0	0	6,146,138	352,904	6,499,042	0	0	0
Screen and Grit Chamber	1,988,768	1,162,645	3,151,413	0	0	0	1,988,768	1,162,645	3,151,413	0	0	0
Split Box for Primary Sedimentation Tank	7,685	46,035	53,720	0	0	0	7,685	46,035	53,720	0	0	0
Primary Sedimentation Tank	1,998,894	2,644,931	4,643,825	0	0	0	1,998,894	2,644,931	4,643,825	0	0	0
Confluence Box for Primary	6,098	29,640	35,738	0	0	0	6,098	29,640	35,738	0	0	0
Biological Reactor	29,621,763	17,910,887	47,532,650	0	0	0	9,775,182	5,910,593	15,685,775	19,846,581	12,000,294	31,846,875
Split Box for Final Sedimentation Tank	6,099	29,640	35,739	0	0	0	6,099	29,640	35,739	0	0	0
Final Sedimentation Tank	6,031,930	5,989,152	12,021,082	0	0	0	1,749,260	1,736,854	3,486,114	4,282,670	4,252,298	8,534,968
Confluence Box for Final	6,099	29,641	35,740	0	0	0	6,099	29,641	35,740	0	0	0
RAS/WAS Pump Station	1,696,109	1,832,530	3,528,639	0	0	0	1,696,109	1,832,530	3,528,639	0	0	0
Sludge Thickener	720,818	1,014,072	1,734,890	0	0	0	482,948	679,428	1,162,376	237,870	334,644	572,514
Pump Station for Sludge	289,095	322,464	611,559	0	0	0	0	0	0	289,095	322,464	611,559
Sludge Digestion Tank	2,152,705	4,752,738	6,905,443	0	0	0	0	0	0	2,152,705	4,752,738	6,905,443
Nutrients Supply Pump Pit	336,241	311,133	647,374	0	0	0	0	0	0	336,241	311,133	647,374
Sludge Drying Bed	602,786	2,879,262	3,482,048	0	0	0	602,786	2,879,262	3,482,048	0	0	0
Infiltration Pump Pit	480,269	598,581	1,078,850	0	0	0	480,269	598,581	1,078,850	0	0	0
Sludge Storage Yard	35,577	1,066,876	1,102,453	0	0	0	35,577	1,066,876	1,102,453	0	0	0
Outlet Works	30,553	50,005	80,558	0	0	0	0	0	0	30,553	50,005	80,558
Interconnecting Pipe	784,809	1,312,602	2,097,411	0	0	0	156,962	262,520	419,482	627,847	1,050,082	1,677,929
Electric Control House	1,675	159,070	160,745	0	0	0	0	0	0	1,675	159,070	160,745
Site Works	44,331	6,144,187	6,188,518	0	0	0	0	0	0	44,331	6,144,187	6,188,518
Plant/Equipment	18,926,680	0	18,926,680	0	0	0	0	0	0	18,926,680	0	18,926,680
Subtotal	82,702,390	55,934,844	138,637,234	0	0	0	35,926,142	26,557,929	62,484,071	46,776,248	29,376,915	76,153,163
3 Rehabilitation Works												
Existing Sewage Treatment Works	2,586,330	5,894,303	8,478,633	0	0	0	1,292,165	2,947,152	4,239,317	1,292,165	2,947,151	4,239,316
Irrigation Facilities	770,000	167,814	937,814	0	0	0	0	0	0	770,000	167,814	937,814
Pre-treatment Facilities for Tilcor Industrial Area	373,668	305,561	679,229	0	0	0	373,668	305,561	679,229	0	0	0
Sludge Disposal Pit	5,267,575	2,350,511	7,618,086	0	0	0	2,633,788	1,175,256	3,809,044	2,633,787	1,175,255	3,809,042
Subtotal	8,995,573	8,718,189	17,713,762	0	0	0	4,299,621	4,427,969	8,727,590	4,695,952	4,290,220	8,986,172
Total (I)	105,040,937	78,140,785	183,181,722	0	0	0	53,568,737	44,473,650	98,042,387	51,472,200	33,667,135	85,139,335
II. Land Acquisition	0	0	0	0	0	0	0	0	0	0	0	0
III. Administration Expenses	0	4,000,000	4,000,000	0	0	0	0	2,000,000	2,000,000	0	2,000,000	2,000,000
IV. Engineering Services (9%)	14,013,402	2,472,953	16,486,355	5,605,361	989,181	6,594,542	4,204,021	741,886	4,945,907	4,204,020	741,886	4,945,906
Total (I,II,III and IV)	119,054,339	84,613,738	203,668,077	5,605,361	989,181	6,594,542	57,772,758	47,215,536	104,988,294	55,676,220	36,409,021	92,085,241
V. Physical Contingency (10%)	11,905,434	8,461,374	20,366,808	560,536	98,918	659,454	5,777,276	4,721,554	10,498,830	5,567,622	3,640,902	9,208,524
Total (I,II,III,IV and V)	130,959,773	93,075,112	224,034,885	6,165,897	1,088,099	7,253,996	63,550,034	51,937,090	115,487,124	61,243,842	40,049,923	101,293,765
VI. Price Escalation	7,688,000	51,588,000	59,276,000	92,000	136,000	228,000	2,892,000	21,102,000	23,994,000	4,704,000	30,350,000	35,054,000
Grand Total	138,647,773	144,663,112	283,310,885	6,257,897	1,224,099	7,481,996	66,442,034	73,039,090	139,481,124	65,947,842	70,399,923	136,347,765

10.2 Operation and Maintenance Cost

10.2 Sewage Treatment Works

Table 10.2.1 O & M Cost for Sewage Treatment Works

Item	BNR line	TF line	Remarks
Staff cost (Salaries and wages)	972,000	798,000	Table 10.2.2
Electricity charges	3,943,361	818,418	Table 10.2.3
Maintenance & repairs	788,672	163,684	Electricity charge x 0.2
Chemicals and cleaning materials	394,336	81,842	Electricity charge x 0.1
Sludge transportation and disposal	240,000	498,000	Table 10.2.4
Wastewater examination	7,480	9,191	Table 10.2.5
Others	194,400	159,600	Staff cost x 0.2
Total	6,540,249	2,528,734	

Table 10.2.2 Staff Cost (Salaries and wages)

Occupation title	Annual unit cost	BNR line		TF line		Total	
		personnel	Cost	personnel	Cost	personnel	Cost
	(Z$/person)	nos.	(Z$/year)	nos.	(Z$/year)	nos.	(Z$/year)
Sewage treatment works							
Superintendent	48,000	0	0	1	48,000		
Works attendant	36,000	1	36,000	1	36,000		
Assist. works attendant	30,000	1	30,000	2	60,000		
Operator	24,000	22	528,000	15	360,000		
Driver	18,000	1	18,000	3	54,000		
General hand (Laborer)	12,000	7	84,000	19	228,000		
Clerk	24,000	0	0	1	12,000		
Sub-total	-	32	696,000	42	798,000	74	1,494,000
Annex facilities							
Senior labo. analyst	36,000	1	36,000	0	0		
Junior labo. analyst	30,000	2	60,000	0	0		
Typist	24,000	1	24,000	0	0		
Trade Effluent inspector	36,000	1	36,000	0	0		
Assist. T.E. inspector	30,000	3	90,000	0	0		
Fitter machinist	30,000	1	30,000	0	0		
Sub-total	-	9	276,000	0	0	9	276,000
Grand total		41	972,000	42	798,000	83	1,770,000

Table 10.2.3 Electricity Charges

Facilities	Item	BNR line				TF line			
		kW	Number	Hours	kWH	kW	Number	Hours	kWH
Screen & Grit chamber	Compressor for air lift pump	22	2	2	88	18	2	2	72
Primary sedimentation tank	Sludge pump (to ADT)	7.5	1	4	30				
BNR Reactor	Aerator	45	14	24	15,120				
	Aerator	22	2	24	1,056				
	Mixer	3.7	10	24	888				
	Recirculation pump	15	4	24	1,440				
Final sedimentation tank	Drive unit	3.7	4	24	355				
	RAS pump	11	4	24	1,056				
	WAS pump	3.7	2	8	59				
Anaerobic digestion tank	Recirculation pump	5.5	4	12	264				
Infiltration pump pit	Infiltration pump	7.5	2	12	180				
Effluent pump house(Old)	Irrigation pump					185	2	0	0
	Recirculation pump					55	1	0	0
Effluent pump house(New)	Irrigation pump					150	2	8	2,400
	Recirculation pump					200	1	8	1,600
Others					240				240
Total(day)					20,776				4,312
Total(year)					7,583,386				1,573,880
Electlicity unit cost					0.52				0.52
Total cost (year)					3,943,361				818,418

Table 10.2.4 Sludge Disposal Cost

Item	Unit	BNR line	TF line	Remarks
Annual sludge volume	m3/year	4,000	8,300	*1
Unit cost	ZS/m^3	60	60	*2
Cost	ZS/year	240,000	498,000	

Note: *1 Assuming that landfill sludge volume at New STW is 1/2

*2 Including loading, hauling and spreading, haulage distance about 2 km

Table 10.2.5 Wastewater examination cost

Item	BNR line					TF line				
	Sampling point	Number	Annual exa. number	Unit cost	Cost (ZS/year)	Sampling point	Number	Annual exa. number	Unit cost	Cost (ZS/year)
pH	R, E	2	24	-	-	R, T, E	3	24	-	-
Settlable Solid	R	1	24	-	-	R	1	24	-	-
Suspended Solid	R, E	2	24	-	-	R, T, E	3	24	-	-
Permanganate Value (PV)	R	1	24	-	-	R	1	24	-	-
BOD	R, E	2	24	-	-	R, T, E	3	24	-	-
COD	R, E	2	24	-	-	R, T, E	3	24	-	-
DO	E	1	24	-	-	E	1	24	-	-
Chloride	E	1	24	25.3	607	E	1	24	25.3	607
Kjeldahl Nitrogen	R	1	24	54.05	1,297	R	1	24	54.05	1,297
Ammonia Nitrogen	R, E	2	24	32.2	1,546	R, T, E	3	24	32.2	2,318
Nitrite	E	1	24	32.2	773	E	1	24	32.2	773
Nitrate	E	1	24	32.2	773	E	1	24	32.2	773
Total Phosphate	R, E	2	24	39.1	1,877	R, T, E	3	24	39.1	2,815
MB Stability	E	1	24	25.3	607	E	1	24	25.3	607
Total					7,480					9,191

Note: Sampling point raw; R Tilcor trunk sewer; T Effluent; E

Unit costs include sales tax at 15%.