CHAPTER 13

COST ESTIMATE BY PUBLIC AND PRIVATE INVESTMENT AND FINANCIAL STUDY

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13.1 General

The total costs both for construction and O&M for the year 2005 and 2015 are estimated for the public sewerage projects, while the standard cost for other countermeasures is prepared as a reference. Other countermeasures considered are industrial/slaughterhouse wastewater treatment and solid waste leachate treatment.

The public sewerage projects are the sewage treatment works for the Scenario-1 and Scenario-2. The selected sewage treatment works are as follows:

Harare: Crowborough, Firle, Marlborough and Donnybrook
Harare Expansion: Harare South and Harare East
Norton: Norton
Ruwa: Ruwa
Chitungwiza: Zengeza

The sewage works comprise treatment facilities in application of BNR, TF or WSP and sewage collection system. The sewage treatment processes to be adopted are categorised into the following three systems.

- WSP + Irrigation pump facilities + Irrigation
- TF + Irrigation pump facilities + Irrigation
- BNR

The sewage collection system includes, trunk and lateral sewers, pump stations and service connections. The irrigation pump facilities include a pump station, force main and storage/maturation pond. The irrigation cost is not include in the construction cost of sewage treatment works.

13.2 Standard Sewage and Sludge Treatment Facilities

13.2.1 Public Sewage Works

The sewage treatment projects were planned in the previous section based on the expansion plan for projected sewage quantity, accounting for the design pollution load to be reduced by each target year (2005 and 2015). The cost functions were prepared based on the general design with standard capacities for concerned facilities. Cost requirements for the future are estimated covering sewage treatment and collection facilities.

The expansion of existing sewage treatment facilities is assumed to be arranged within the premises of the respective sewage treatment plants' areas. Generally, the construction areas are flat lands and fairy good in soil conditions.

(1) Sewage Collection System

Sewage collection system comprises trunk and lateral sewers, service connections, pump stations and force mains. The construction cost of sewage collection system is estimated using selected factors for major facilities as follows:

Trunk sewer:	Unit price per linear meter Asbestos cement pipe, RC pipe (Hume pipe) and Steel pipe
Lateral sewer and service connection:	Unit price per hectare (Dia.150mm, Asbestos cement pipe, 180m/ha)
Pump station:	Civil/building, Mechanical and Electrical works cost

(2) Sewage Treatment Facilities

Standard facilities by applicable treatment process were designed to come up with cost requirements based on estimated work quantities and unit prices.

1) Trickling Filter Process

The trickling filter process includes grit chamber and screen, primary sedimentation tank, trickling filter, secondary sedimentation tank, sludge thickener and sludge drying bed.

The standard trickling filter process was prepared for the four capacities of 2,500 m^3/day, 5,000 m^3/day, 10,000 m^3/day and 20,000 m^3/day.

2) Biological Nutrient Removal Process

The biological nutrient removal process includes grit chamber and screen, primary sedimentation tank, biological reactor (BNR), secondary sedimentation tank, sludge thickener and sludge drying bed.

The standard facilities with capacities of 5,000 m^3/day, 10,000m^3/day, 20,000 m^3/day and 50,000 m^3/day were designed.

3) Wastewater Stabilisation Pond

The wastewater stabilisation pond system includes grit chamber and screen, anaerobic pond, facultative pond and maturation pond.

The standard wastewater stabilisation pond system was designed for the four design capacities of 1,000m^3/day, 2,000 m^3/day, 5,000 m^3/day and 10,000 m^3/day.

4) Irrigation Pump Facilities

Irrigation pump facilities are planned succeeding to TF or WSP system. The construction cost is estimated using selected factors for the following major components.

Pump Station	:	Civil/building, Mechanical and Electrical works cost
Force main	:	Unit price per linear meter for each diameter, Steel pipe with the length of 3 km

Storage/maturation pond (standard pond capacity):

1,000 m^3, 2,000 m^3, 2,500 m^3, 5,000 m^3, 10,000 m^3 and 20,000 m^3

13.2.2 Industrial Wastewater Pre-treatment Facilities

The discharge of industrial wastewater into public sewers is restricted by the Urban Council Act. The pre-treatment facilities shall be provided by each private industrial company.

The construction cost for a typical design of industrial/slaughterhouse wastewater treatment facilities was estimated as a reference. The treatment process is assumed including anaerobic and facultative ponds. The standard capacities covered 500 m^3/day, 1,000 m^3/day and 2,000 m^3/day.

13.2.3 Solid Waste Leachate Treatment Facilities

City of Harare has two refuse dumping sites: namely Golden Quarry Dumping Site and Pomona Dumping Site. Chitungwiza Municipality and Norton Town have also their own refuse dumping sites near the existing sewage treatment works.

The solid waste collection and disposal are operated by respective private companies under local government authorities. A controlled tipping method; trench excavation/filling operation is employed at each dumping site. The solid waste leachate treatment facilities shall be provided by each local authority.

The standard cost for a typical leachate treatment facilities in application of stabilisation pond was estimated as a reference. The standard capacities considered are 100 m^3/day, 500 m^3/day and 1,000 m^3/day.

13.2.4 Procurement of Materials and Equipment

The sewage treatment works were mainly constructed by local contractors through the competitive tender procedure. There are many civil/building contractors registered in Zimbabwe capable for construction of sewerage facilities. The construction works for Firle V Sewerage Project, Harare City and Zengeza Sewer Argumentation Project have been undertaken by local contractors.

Most of the construction materials can be procured at local markets. These are cement, fuel, gasoline, reinforcement bar, asphalt bitumen, structural steel, explosives, timber, plywood, concrete pipe, asbestos fibre cement pipe, polyvinyl chloride pipe, ready mixed concrete, aggregate, sand, building materials. While, mechanical and electrical equipment for the works is imported as confirmed through the interview on the previous projects. Some construction materials such as sheet pile, steel pipe pile, H shape steel rib are also imported. The imported materials are transported by railway and trailer/truck from Port Durban (South Africa) and Beila (Mozambique) to Harare. The delivery conditions are fairly good both in railway and road.

The local contractors have their own construction equipment and can hire the equipment from lease/rental companies.

13.3 Unit Cost and Cost Functions for Construction/Rehabilitation of Facilities

13.3.1 Unit Cost

(1) Unit construction cost of the sewerage facilities

The following are reference materials to come up with unit construction cost. The applied unit costs for the cost estimate are included in Section 13.3, Chapter 2, Supporting Report.

- Harare Sewerage Firle V Project ; Lower Mukuvisi Outfall Sewer (3), November 1993
- Harare Sewerage Firle V Project ; Civil Engineering Works (2), July 1993
- Feasibility Study for New Sewerage Treatment Works, May 1996, Norton Town Council
- Project Proposals for the Sewerage Augmentation Scheme, February 1996, Municipality of Chitungwiza
- Unit price as of 1996 based on the interview from local contractors

(2) Labour Cost

The daily labour wage cost is collected from the National Employment Council and Zimbabwe contractors as shown in Table 13.3.1.

(3) Material Cost

The material cost was collected from the local suppliers in Harare as shown in Table 13.3.2.

(4) Equipment Cost

The equipment cost was collected from local contractors through an interview as shown in Table 13.3.3.

Table 13.3.1 Labor Cost

Labor Cost, National Epployment Council

Classification		Wage rate (Z$/day)
Worker	Grade 1	42.5
	Grade 2	44.5
	Grade 3	51.1
	Grade 4	61.5
Skilled worker	Grade 1	112.3
	Grade 2	95.5
	Grade 3	84.8
	Grade 4	64
Building,electrician installation		84.8
Floor layer		84.8

Data Source: National Employment Council for the Construction Industry of Zimbabwe, July 1996

Labor Cost,Contractor (Zimbabwe)

Classification	Contracto No.1 (Z$/day)	Contracto No.2 (Z$/day)	Contractor No.3 (Z$/day)	Contractor No.4 (Z$/day)	Contracto No.5 (Z$/day)
Foreman	182.24	283.44	80.82	552.60	323.00
Skilled labor	100.00	107.89	68.76	74.34	180.00
Unskilled labor	34.00	78.52	32.04	51.65	69.32
Operator,heavy	136.00	116.53	68.76	165.08	136.26
Operator,light	80.00	107.89	61.02	90.46	117.88
Electrician,Mechanic	200.00	116.53	68.76	281.25	332.89
Concrete worker	100.00	91.60	44.28		69.32
Reinforcing worker	80.00	91.60	44.28		109.01
Carpenter	80.00	165.13	61.02	139.76-82.15	180.35
Form worker	72.00	148.61	46.08		180.35
Welder	72.00	91.80	68.76		180.35
Masonry	96.00	191.05	44.28	138.98-81.37	180.35
Pavement	96.00	191.05	44.28		180.35
Plumber	80.00	148.61	61.02	139.76-82.15	180.35
Driver,dump truck	68.00	107.89	46.08	87.92	136.26
Driver,vehicle	68.00	107.89	46.08	74.34	136.26
Plasterer	109.12	165.13	46.08	137.42-79.81	180.35
Site engineer	308.00	779.45	280.00	258.72	425.00
Site manager	356.00	935.33	300.00	344.96-677.60	750.00
Administrator	256.00	389.72	240.00	115.47	1500.00 425.00
Typist	90.88	129.91	61.02	72.00	225.00
Drafts man	220.00	165.13	80.00		502.40
Guardman	45.00		30.00	144.34	91.70
Houseboy	28.80		20.00	39.26	91.70
Secretary	363.60	206.60	100.00		325.00
Clerk	113.60	107.89	150.00		175.00
Watchman	46.00	91.80	70.00		91.70

Data Source: No.1 Contractor under Chitungwiza Municipality
No.2 NISHIMATSU CONSTRUCTION CO., LTD
No.3 METALLURGICAL CONSTRUCTION CO., ZIMBABWE(PVT)LTD
No.4 COSTAIN (AFRICA) LIMITED
No.5 KONOIKE CONSTRUCTION CO., LTD

Table 13.3.2 (1) Matarial Cost

Material Cost, Harare City (Supplier)

Material		Unit	Cost (Z$)
Cement		ton	989.00
Reinforcing bar		ton	6647.00
Wire		ton	7730.00
Diesel		lit	2.83
Gasoline		lit	3.48
Lubricant		lit	17.25
Explosive		kg	13.40
ANFO		kg	8.00
Detonator		pc	16.00
Sand,river		m3	124.00
Sand,pit		m3	109.00
Stone		m3	159.00
Ready mixed concrete			
	10 MPA	m3	485.00
	15 MPA	m3	520.00
	20 MPA	m3	560.00
	25 MPA	m3	620.00
	30 MPA	m3	650.00
Timber		m3	3000-5000
Plywood	9mm	m2	123.40
	13mm	m2	132,60

Data Source: Local Material Suppliers in Harare

Asbestos Fibre Cement Pipe (Ex-factory Price) (Sewer)

Material	Unit	Cost (Z$)
	(l=4m/pc) (excl.Sales Tax)	
150mm	pc	177.75
200mm	pc	328.17
250mm	pc	439.51
300mm	pc	573.06
400mm	pc	1288.35
450mm	pc	1525.79
525mm	pc	1745.99
600mm	pc	2147.12
675mm	pc	2612.38
750mm	pc	2940.51
825mm	pc	3478.13

Data Source: TURNALL FIBRE CEMENT (PVT)

Asbestos Fibre Cement Pipe (Ex-factory Price) (Pressure)

Material	Unit	Cost (Z$)
	(l=4m/pc) (excl.Sales Tax)	
100mm	pc	299.82
125mm	pc	422.64
150mm	pc	585.94
175mm	pc	733.52
200mm	pc	774.37
225mm	pc	928.7
250mm	pc	1123.03
300mm	pc	1664.54
350mm	pc	1746.97
400mm	pc	2525.7
450mm	pc	3156.37
525mm	pc	4552.14
600mm	pc	4859.4
675mm	pc	5461.68
750mm	pc	7001.45

Data Source: TURNALL FIBRE CEMENT (PVT)

Concrete Pipe (Hume Pipe)

Material	Unit	Cost (Z$)
	(excl.Sales Tax)	
150mm	m	62.6
225mm	m	99.67
300mm	m	148.27
375mm	m	192.21
450mm	m	246
525mm	m	313.68
600mm	m	382.62
675mm	m	427.34
750mm	m	570.65
900mm	m	769.21
1050mm	m	1049.94
1200mm	m	1332.49
1350mm	m	1870.26

Data Source: HUME PIPE CO

Polyvinyl Chloride Pipe (Pressure)

Material	Unit	Cost (Z$)
	(excl.Sales Tax)	
100mm	m	46.37
150mm	m	99.82
200mm	m	154.63
250mm	m	239.39

Data Source: HYDRO QUIP

Table 13.3.2 (2) Material Cost

Contractor (Zimbabwe)

Material	Unit	Contractor No.1	Contractor No.2	Contractor No.3	Contractor No.4	Contractor No.5
Cement, ex-factory	ton		820.00	685.00	647.85	747.60
Sand, ex-quarry	m3	75.00	114.55	120.00	105.80	132.25
Aggregate, ex-quarry	m3	120.00	197.35	190.00	158.62	195.73
Transportation from quarry	m3.km	5.50	8.50	20.00		
Crusher-run, quarry	m3	114.00	197.35	170.00	100.80	
Reinforcement, deformed	ton	5920.00	7500.00	5800.00	5965.00	6612.50
Reinforcement, round	ton	5901.00	7159.00	5800.00	5965.00	6612.50
Asphalt, 80/100	lit		498.00		3.20	3.68
Cut back, emulsion	lit	5.60	59.52		4.00	5.58
Gasoline,blend	lit	3.80	3.63	3.76	3.76	4.32
Diesel	lit	3.34	3.11	3.00	3.03	3.48
Lubricant	lit	13.00	28.09	24.00	15.33	19.55
Grease	kg	55.00	48.76		35.48	31.05
Timber, hardwood	m2	98.95				
Timber, hardwood	m3		4122.00	3500.00	5250.00	4872.00
Timber, softwood	m2	75.00				
Timber, softwood	m3		3019.20	3500.00	4830.00	4872.00
Plywood	m2	(t=20) 110	(13) 130.72	(7.5) 62.00	(19) 81.70	(19) 190.6
Plywood	m3					
Structural steel	ton		17710.00	4500.00	12000.00	8555.00
Nail	kg	15.00	20.05		11.83	17.94
Wire, galvanized	kg	12.00	11.15		7.69	11.50
Turf	m2		39.60		3.00	57.50

Data Source: No.1 Contractor under Chitungwiza Municipality
No.2 NISHIMATSU CONSTRUCTION CO., LTD
No.3 METALLURGICAL CONSTRUCTION CO., ZIMBABWE(PVT)LTD
No.4 COSTAIN (AFRICA) LIMITED
No.5 KONOIKE CONSTRUCTION CO., LTD

Table 13.3.3 Equipment Cost

Equipment Cost, Contractor (Zimbabwe)

Material		Unit	Contractor No.1	Contractor No.2	Contractor No.3	Contractor No.4	Contractor No.5
Bulldozer	D8	Hr	720.00	511.50	625.00	581.32	1207.00
Bulldozer	D7	Hr	680.00	478.50	565.00	507.03	880.00
Tractor shovel	2m3	Hr	380.00	511.50			603.00
Wheel loader	3m3	Hr	480.00		580.00	311.63	718.00
Wheel loader	2m3	Hr	420.00	484.00	490.00	378.13	453.10
Backhoe	0.7m3	Hr	280.00	330.00	565.00	625.75	690.00
Backhoe	0.3m3	Hr	210.00	214.50	490.00	453.35	690.00
Dump truck	10ton	Hr	360.00		450.00	420.60	345.00
Dump truck	4ton	Hr	250.00	240.00	280.00		253.00
Ordinary truck	10ton	Hr	320.00	198.00	300.00		327.75
Motor grader	3.7m	Hr	400.00	484.00		544.46	517.50
Motor grader	3.1m	Hr	380.00	484.00			575.00
Truck crane	15ton	Hr	420.00	539.00	750.00	616.97	632.50
Vibrating roller	10ton	Hr	320.00	165.00	525.00	324.18	402.50
Vibrating roller	4ton	Hr	180.00	125.00	390.00		379.50
Tire roller	10-20ton	Hr	210.00	165.00		69.95	356.50
Macadom roller	10ton	Hr	320.00				316.25
Air compressor	5m3/min	Hr	120.00	126.50	150.00	134.84	172.50

Data Source: No.1 Comtractor under Chitungwiza Municipality
No.2 NISHIMATSU CONSTRUCTION CO.,
No.3 METALLURGICAL CONSTRUCTION CO.,
No.4 COSTAIN (AFRICA) LIMITED
No.5 KONOIKE CONSTRUCTION CO.,

13.3.2 Cost Functions for Construction of Facilities

The cost functions (Cost Formula) on a 1996 price base were established for the estimation of construction cost required for collection/treatment of sewage in application of selected factors, such as linear meter, service area and sewage treatment capacity.

(1) Sewage Treatment Facilities

The cost functions of the sewage treatment plant are based on model studies for some standard capacities of treatment facilities considering applicable secondary treatment processes; TF, BNR and WSP. The required cost of such standard facilities is estimated based on preliminary work quantity and unit price in full use of the experience of the similar projects in Zimbabwe.

The construction cost of each treatment facilities is included in Section 13.3, Chapter 2, Supporting Report. The basic assumptions for cost estimate are as follows:

- Site conditions; fairly good.
- Topographic conditions; generally flat area.
- Soil/geological conditions are good.
- Access is no problem from the existing trunk road.
- Transportation of material and equipment is easy.
- Preparatory works is not restricted.

1) Trickling Filter Process

The cost of trickling filter process (TF) is estimated by standard treatment capacity, detailed cost of which is included in Section 13.3, Chapter 2, Supporting Report.

Capacity (1000 m^3/day)	Construction Cost (Thousand US$)
2.5	2.031
5.0	3.432
10.0	5.632
20.0	10.347

The exponential function formula was obtained by a least square method, which is shown in Figure 13.3.1.

$$C = 0.9837\, Q^{0.7759}$$

where, C: Construction cost (Million US$)

Q: Treatment capacity (1000 m^3/day)

2) Biological Nutrient Removal Process

The cost of biological nutrient removal process (BNR) is estimated by standard treatment capacity. Detailed cost estimate is included in Section 13.3, Chapter 2, Supporting Report.

Capacity (1000 m^3/day)	Construction Cost (Thousand US$)
5.0	3.902
10.0	6.528
20.0	11.847
50.0	25.049

The exponential function formula was obtained by a least square method, which is shown in Figure 13.3.2

$$C = 1.0344\, Q^{0.8129}$$

where, C: Construction cost (Million US$)

Q: Treatment capacity (1000 m^3/day)

3) Wastewater Stabilisation Pond

The cost of wastewater stabilisation pond (WSP) is estimated by standard treatment capacity. Detailed cost estimate is included in Section 13.3, Chapter 2, Supporting Report.

Capacity (1000m^3/day)	Construction Cost (Million US$)
1.0	1.086
2.0	2.386
5.0	5.279
10.0	9.105

The exponential function formula was obtained by a least square method. Figure 13.3.3 presents the relationship between the two factors.

$$C = 1.1641\ Q^{0.9157}$$

where, C: Construction cost (Million US$)

Q: Treatment capacity (1000 m^3/day)

(2) Sewage Collection System

The unit costs per linear meter of trunk sewer and force main were estimated. The pipe material cost was obtained from the local market. The unit cost covers pipe and manhole; transportation; trench excavation, installation and backfill; and overhead and profit. Furthermore, 15% of direct unit cost is added for the need of engineering studies.

The unit cost per ha of lateral sewer (asbestos cement pipe of 150mm dia) and service connections was estimated. The standard length of lateral sewer was assumed to be 180m per ha.

Open trench cut method either by backhoe or manpower is applied for pipe laying without shuttering and the trench depth was assumed at 2 m to 3 m.

The unit cost of lateral sewer and service connections was estimated at 3,478 US$/ha. The relationship between pipe diameter and construction cost by pipe material is shown in Figure 13.3.4, which is expressed in exponential function and the cost function is obtained by a least square method as follows:

Concrete Pipe

150- 525mm $C = 0.1543\ D^{1.0083}$

600- 900mm $C = 0.002773\ D^{1.6462}$

1050-1350mm $C = 0.00006911\ D^{2.1694}$

where, C: Construction cost (US$/m)

D: Pipe diameter (mm)

Asbestos Fibre Cement Pipe (gravity)

150- 450mm $C = 0.01128\ D^{1.486}$

525- 825mm $C = 0.01846\ D^{1.4009}$

Asbestos Fibre Cement Pipe (Pressure)

100- 225mm $C = 0.1839\ D^{1.0905}$

250- 450mm $C = 0.01521\ D^{1.5176}$

525- 750mm $C = 0.2332\ D^{1.1282}$

Polyvinyl Chloride Pipe

100- 250mm $C = 0.02054\ D^{1.4651}$

Steel Pipe

150- 350mm $C = 1.2426\ D^{0.943}$

400- 700mm $C = 0.0587\ D^{1.469}$

800- 1500mm $C = 0.008315\ D^{1.762}$

(3) Storage/Maturation Pond

The cost of storage/maturation ponds to be provided after TF/WSP for the irrigation is estimated by standard treatment capacity. Detailed cost estimate is included in Section 13.3, Chapter 2, Supporting Report.

Capacity (1000 m^3/day)	Construction Cost (Thousand US$)
1.0	35
2.0	58
2.5	81
5.0	133
10.0	254
20.0	453

The exponential function formula was obtained by a least square method. Figure 13.3.5 presents the relationship between the two factors.

$C = 34.342\ Q^{0.8613}$

where, C: Construction cost (Thousand US$)
Q: Treatment capacity (100 m^3/day)

(4) Pump Station

The cost of pumping station is affected by pumping capacity (kW), number of pump units including a stand-by equipment, civil structure and foundation works, building works, etc. The construction cost of pump station for Master Plan level is estimated by major component.

- Cost of civil/building works
  A uniform unit cost of 2,440US$ per floor area (m^2) was applied to pump stations.
- Cost of pumping equipment including electrical motor.

  150 kW US$ 140,000/no.
  100 kW US$ 110,000/no.
  50 kW US$ 85,000/no.
  30 kW US$ 65,000/no.
  20 kW US$ 60,000/no.

  The cost function: C = 49,288 + 610 (kW)
  (as shown in Figure 13.3.6(1))
- Electrical works including transformer, switchgear, etc.: 50% of the cost of pump
- Engineering cost is estimated at 15% of the above two items.

Above cost estimate is applied for the pump station of sewer system, details of which are shown in Section 13.3, Chapter 2, Supporting Report.

The cost of irrigation pump facilities (provided after TF and WSP) is estimated analysing the relationship between treatment capacity and construction cost.

Pump Station (TF)		Pump Station (WSP)	
Capacity (1000m^3/day)	Construction Cost (Thousand US$)	Capacity (1000m^3/day)	Construction Cost (Thousand US$)
2.5	504	1.0	232
5.0	584	2.0	261
10.0	715	5.0	317
20.0	972	10.0	393

The exponential function formula was obtained by a least square method. Figures 13.3.6(2) and (3) present the relationship of the two factors.

$C = 364.2727\ Q^{0.3135}$ (TF)

$C = 227.0329\ Q^{0.2266}$ (WSP)

where, C: Construction cost (Thousand US$)

Q: Treatment capacity (1000 m^3/day)

(5) Industrial Wastewater Pre-treatment Facilities

The cost of industrial wastewater pre-treatment facilities (a combination of anaerobic pond and facultative pond) was estimated by standard treatment capacity. Detailed cost estimate is included in the Section 13.3, Chapter 2, Supporting Report.

Capacity ($100m^3$/day)	Construction Cost (Thousand US$)
5.0	412
10.0	726
20.0	1200

The exponential function formula was obtained by a least square method. Figure 13.3.7 shows the relationship between the two factors.

$C = 120.3648\ Q^{0.7712}$

where, C: Construction cost (Thousand US$)

Q: Treatment capacity (100 m^3/day)

(6) Solid Waste Leachate Treatment Facilities

The cost of solid waste leachate treatment facilities (wastewater stabilisation pond, WSP) was estimated by standard treatment capacity. Detailed cost estimate is included in Section 13.3, Chapter 2, Supporting Report.

Capacity (100m^3/day)	Construction Cost (Thousand US$)
1.0	302
5.0	633
10.0	1179

The exponential function formula was obtained by a least square method. Figure 13.3.8 shows the relationship between the two factors.

$$C = 290.0415\ Q^{0.5683}$$

where, C: Construction cost (Thousand US$)

Q: Treatment capacity (100 m^3/day)

13.4 Cost Requirements for Expansion of Sewerage Facilities

The construction cost for the two scenarios was estimated using cost functions for the proposed sewerage projects. The total cost consists of the following components.

(1) Direct construction cost
(2) Physical contingency (20%)
(3) Engineering cost (17%)

The construction cost is expressed in US Dollar/Zimbabwe Dollar (US$1.00=Z$9.50).

The land acquisition and compensation cost is not required for the sewage treatment works, since all the land is owned by the local authorities. The administration cost and price escalation are not considered.

The total construction costs from 2000 to 2015 by scenario are as follows (refer to Table 13.4.1):

Scenario-1 716.08 Mill US$ (6,802.76 Mill Z$)
Scenario-2 600.66 Mill US$ (5,706.27 Mill Z$)

The cost requirements by the target year of 2000, 2005 and 2015 for the two scenarios are summarised as shown below. Table 13.4.2 presents required cost by proposed project for the target years. Cost breakdown by sub-project for the two scenarios is included in Appendix A13.4.

Scenario-1	2000	56.95 Mill US$ (	541.02 Mill Z$)
	2005	388.31 Mill US$ (	3,688.95 Mill Z$)
	2015	270.82 Mill US$ (	2,572.79 Mill Z$)
Scenario-2	2000	64.60 Mill US$ (	613.70 Mill Z$)
	2005	288.68 Mill US$ (	2,742.46 Mill Z$)
	2015	247.38 Mill US$ (	2,350.11 Mill Z$)

Figure 13.3.1 Relationship between Treatment Capacity and Unit Construction Cost
(Trickling Filter Process)

Trickling Filter Process
Construction Cost -
Treatment Capacity

1000m³/d	Mill US$
2.5	2.031
5.0	3.432
10.0	5.623
20.0	10.347

$C = 0.9837\ Q^{0.7759}$

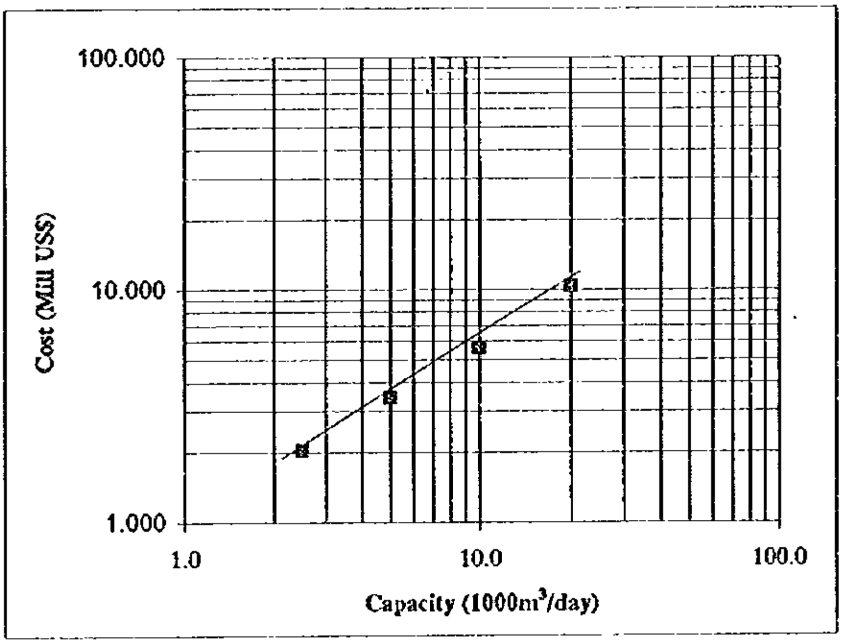


Figure 13.3.2 Relationship between Treatment Capacity and Unit Construction Cost
(Biological Nutrient Removal Process,BNR)

Biological Nutrient Removal
Process
Construction Cost -
Treatment Capacity

1000m³	Mill US$
5.0	3.902
10.0	6.528
20.0	11.847
50.0	25.049

$C = 1.0344\ Q^{0.8129}$

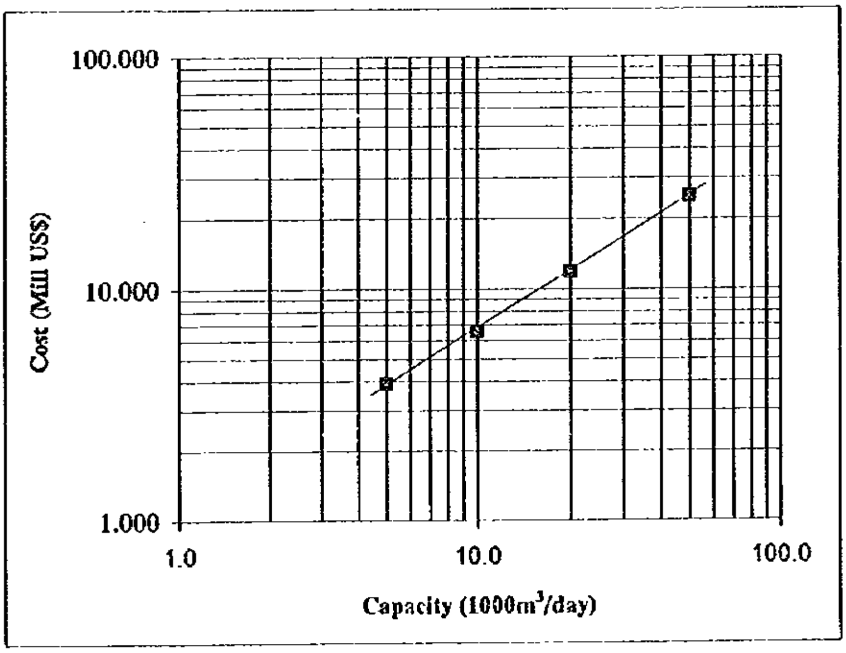


Figure 13.3.3 Relationship between Treatment Capacity and Unit Construction Cost (Wastewater Stabilization Pond)

Wastewater Stabilization Pond
Construction Cost - Treatment Capacity

$1000m^3$	Mill US$
1.0	1.086
2.0	2.386
5.0	5.279
10.0	9.105

$C = 1.1641\, Q^{0.9157}$

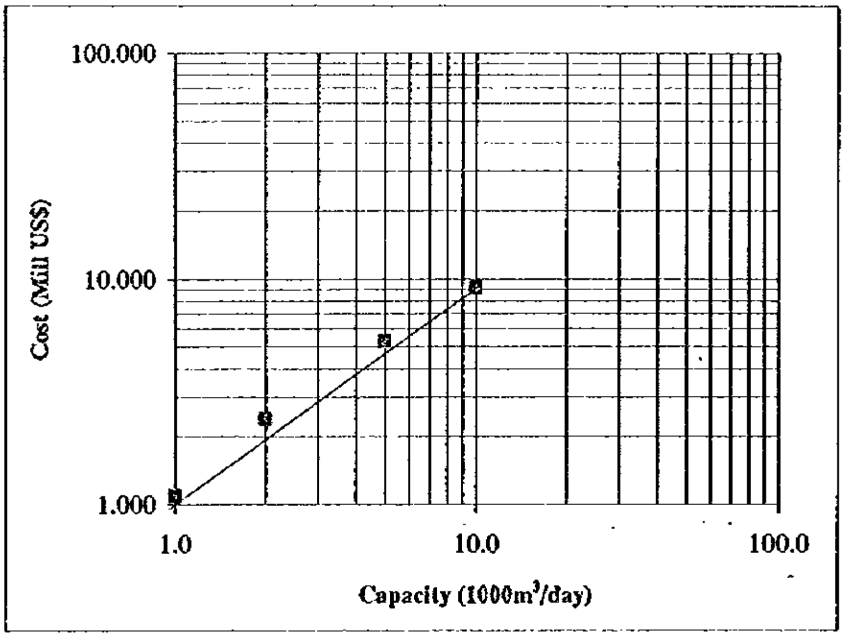
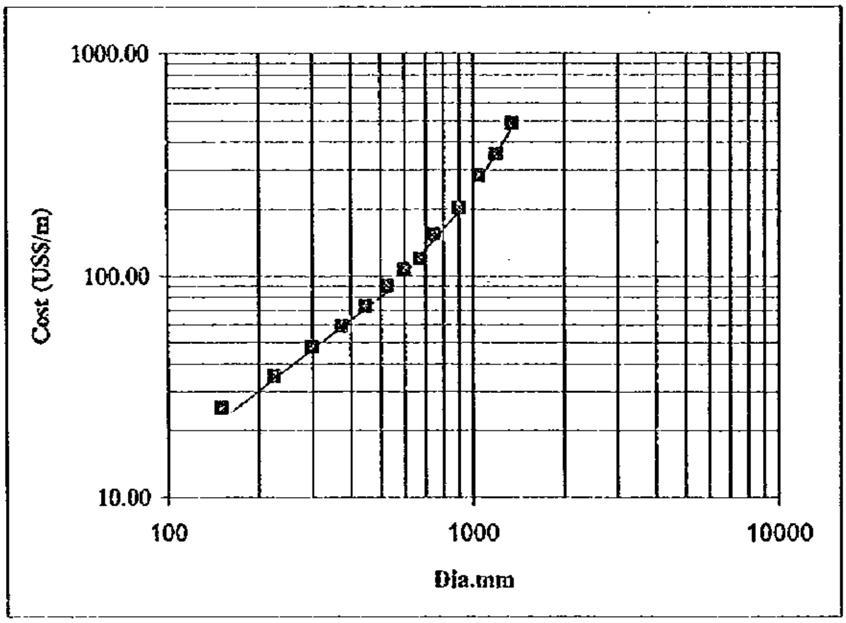


Figure 13.3.4(1) Relationship between Treatment Capacity and Unit Construction Cost (Concrete Pipe, Hume Pipe)

Concrete Pipe (Hume Pipe)
Construction Cost - Pipe Diameter

mm dia.	US$/m
150	25.18
225	35.06
300	47.42
375	58.96
450	72.74
525	89.70
600	107.09
675	118.83
750	153.80
900	203.12
1050	282.93
1200	353.21
1350	484.10



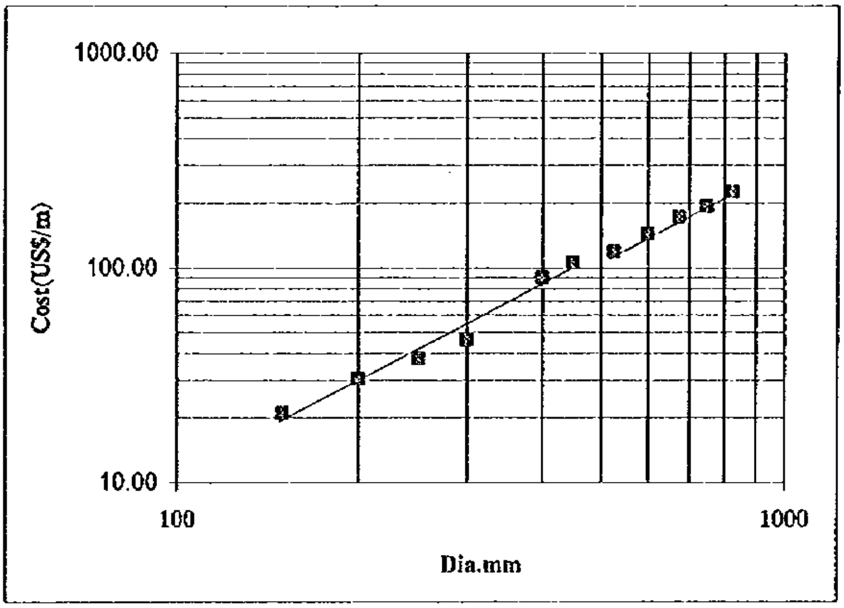
Concrete Pipe

150-525mm	$C = 0.1543\, D^{1.0083}$
600-900mm	$C = 0.002773\, D^{1.6462}$
1050-1350mm	$C = 0.0001043\, D^{2.1266}$

Figure 13.3.4(2) Relationship between Treatment Capacity and Unit Construction Cost (Asbestos Fibre Cement Pipe, Sewer)

Asbestos Fiber Cement Pipe
(Sewer Pipe)
Construction Cost -
Pipe Diameter

mm dia.	US$/m
150	20.98
200	30.38
250	37.71
300	46.23
400	90.11
450	105.05
525	118.97
600	143.91
675	172.52
750	193.00
825	226.16



Asbestos Fiber Cement Pipe (Sewer)

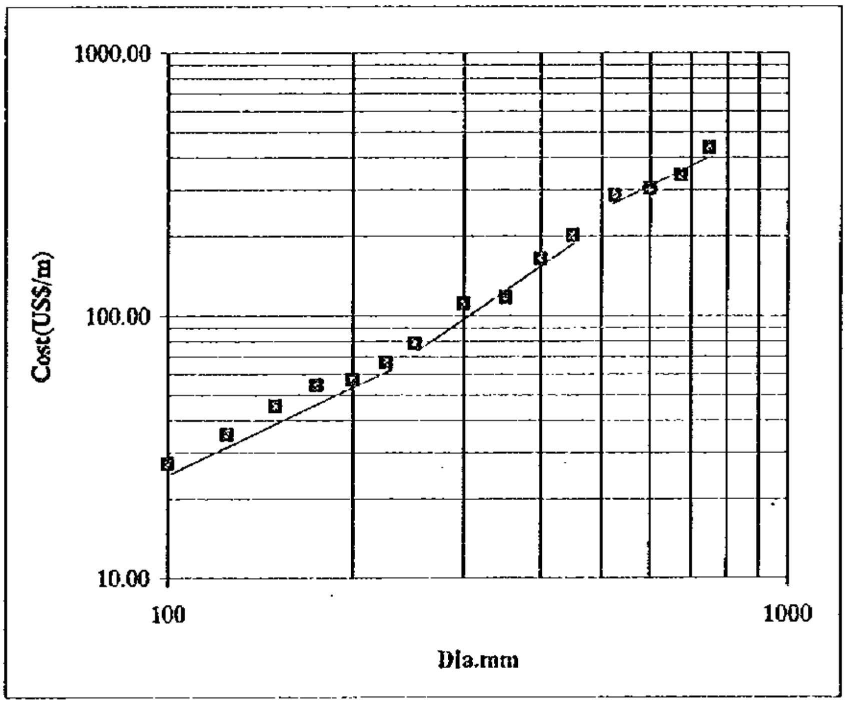
150-450mm $C = 0.01128\ D^{1.496}$

525-825mm $C = 0.01846\ D^{1.4009}$

Figure 13.3.4(3) Relationship between Treatment Capacity and Unit Construction Cost (Asbestos Fibre Cement Pipe, Pressure)

Asbestos Fiber Cement Pipe
(Pressure Pipe)
Construction Cost -
Pipe Diameter

mm dia.	US$/m
100	27.35
125	35.08
150	45.14
175	54.29
200	56.98
225	66.37
250	78.33
300	111.06
350	116.75
400	163.76
450	201.74
525	285.69
600	304.53
675	341.90
750	433.13



Asbestos Fiber Cement Pipe (Pressure)

100-225mm $C = 0.1839\ D^{1.0905}$

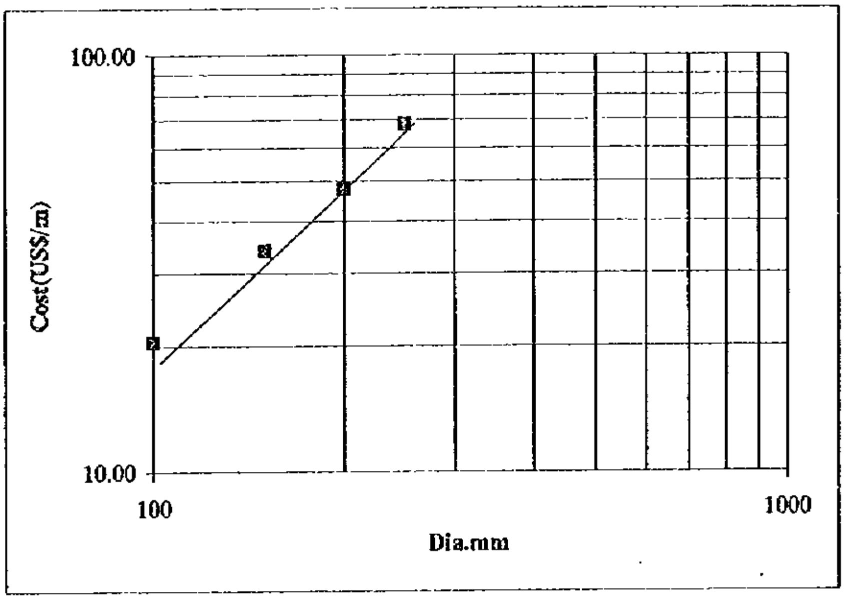
250-450mm $C = 0.01521\ D^{1.5476}$

525-750mm $C = 0.2332\ D^{1.1282}$

Figure 13.3.4(4) Relationship between Treatment Capacity and Unit Construction Cost (Polyvinyl Chloride Pipe, Pressure)

Polyvinyle Chloride Pipe
Construction Cost -
Pipe Diameter

mm dia.	US$/m
100	20.46
150	33.97
200	47.72
250	68.35

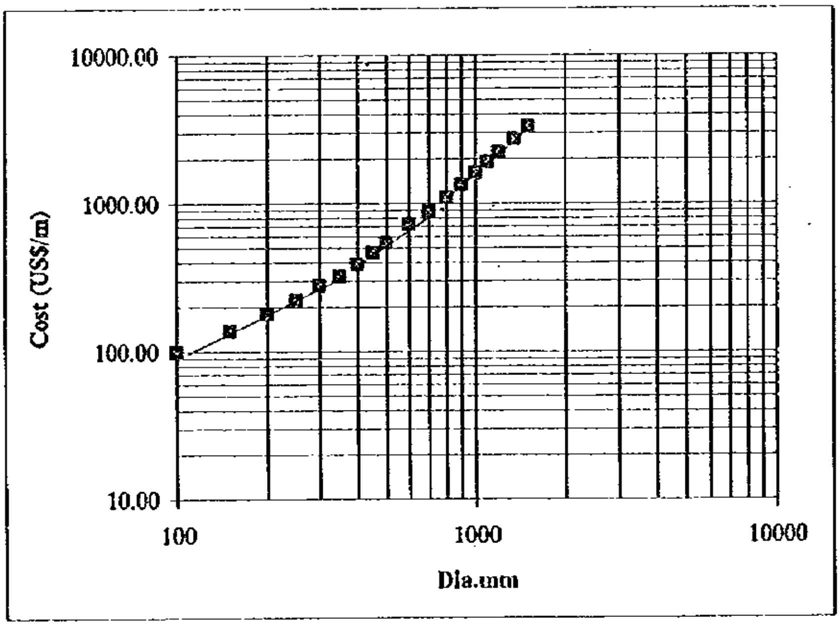


Polyvinyl Chloride Pipe
100-250mm $C = 0.02054\ D^{1.4651}$

Figure 13.3.4(5) Relationship between Treatment Capacity and Unit Construction Cost (Steel Pipe)

Steel Pipe
(Pumping main)
Construction Cost -
Pipe Diameter

mm dia.	US$/m
100	98.86
150	137.07
200	178.38
250	219.92
300	275.48
350	319.87
400	388.73
450	460.45
500	544.16
600	722.16
700	873.62
800	1088.38
900	1332.12
1000	1604.85
1100	1898.24
1200	2208.03
1350	2724.50
1500	3294.65



Steel Pipe
100-350mm $C = 1.2426\ D^{0.943}$
400-700mm $C = 0.0587\ D^{1.459}$
800-1500mm $C = 0.008315\ Q^{1.762}$

Figure 13.3.5 Relationship between Treatment Capacity and Unit Construction Cost (Storage Pond, Irrigation Area)

Storage Pond
Construction Cost -
Treatment Capacity

$1000m^3$	1000US$
1	35
2	58
2.5	81
5	133
10	254
20	453

$C = 34.342\ Q^{0.8613}$

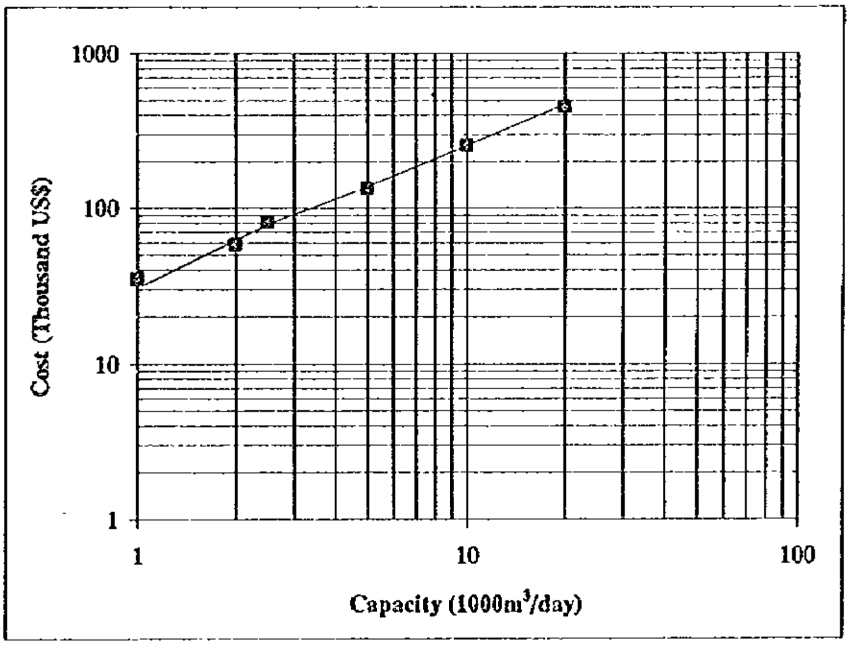


Figure 13.3.6(1) Relationship between Treatment Capacity and Unit Construction Cost (Pump Equipment)

Pump Equipment
Construction Cost -
Pump kW

kW	US$
150	140000
100	110000
50	85000
30	65000
20	60000

$C = 49288 + 610\ kW$

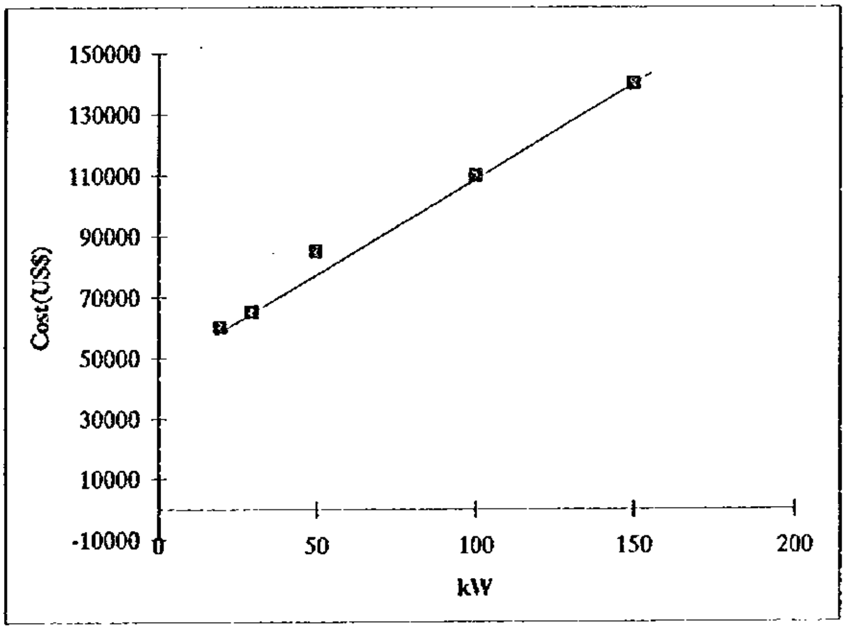


Figure 13.3.6(2) Relationship between Treatment Capacity and Unit Construction Cost (Pump Station,Irrigation, TF)

Pump Station (TF)
Construction Cost -
Treatment Capacity

1000m^3	1000US$
2.5	504
5	584
10	715
20	972

$C = 364.2727\ Q^{0.3135}$

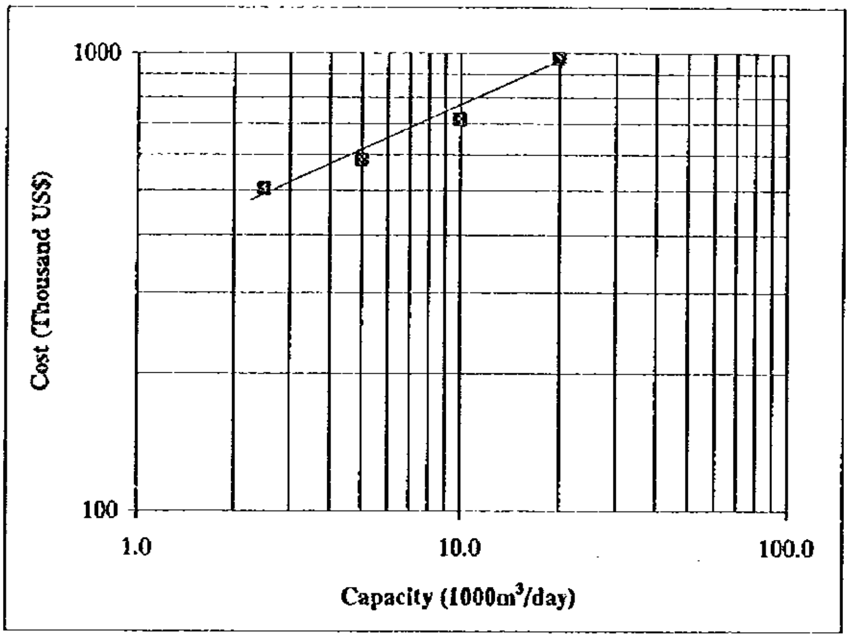


Figure 13.3.6(3) Relationship between Treatment Capacity and Unit Construction Cost (Pump Station,Irrigation, WSP)

Pump Station (WSP)
Construction Cost -
Treatment Capacity

1000m^3	1000US$
1	232
2	261
5	317
10	393

$C = 227.0329\ Q^{0.2266}$

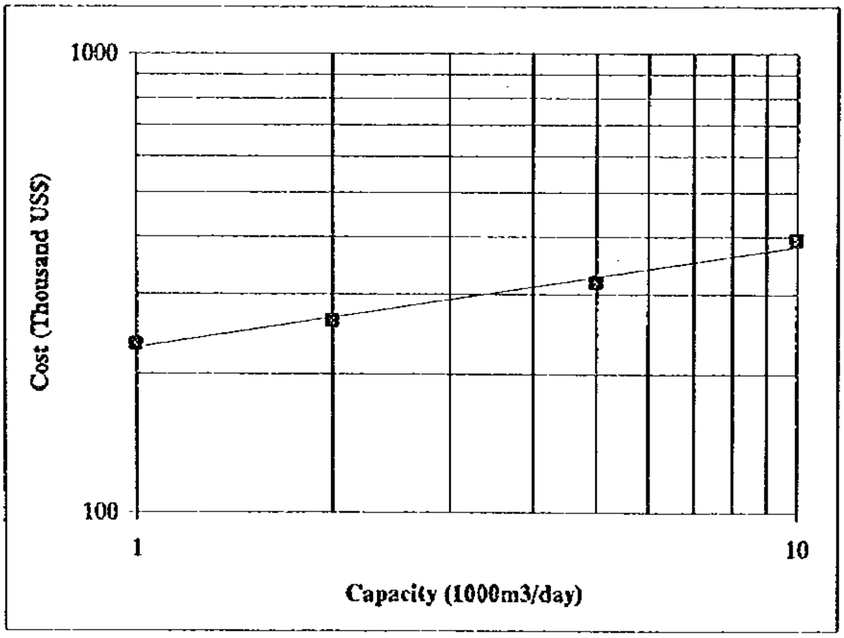


Figure 13.3.7 Relationship between Treatment Capacity and Unit Construction Cost (Industrial Wastewater Pre-treatment Facilities, Anaerobic Pond and Facultative Pond)

Industrial Wastewater
Pre-treatment Facilities
(Anaerobic Pond and
Facultative Pond)
Construction Cost -
Treatment Capacity

$100m^3$	1000US$
5	412
10	726
20	1200

$C = 120.3648\ Q^{0.7712}$

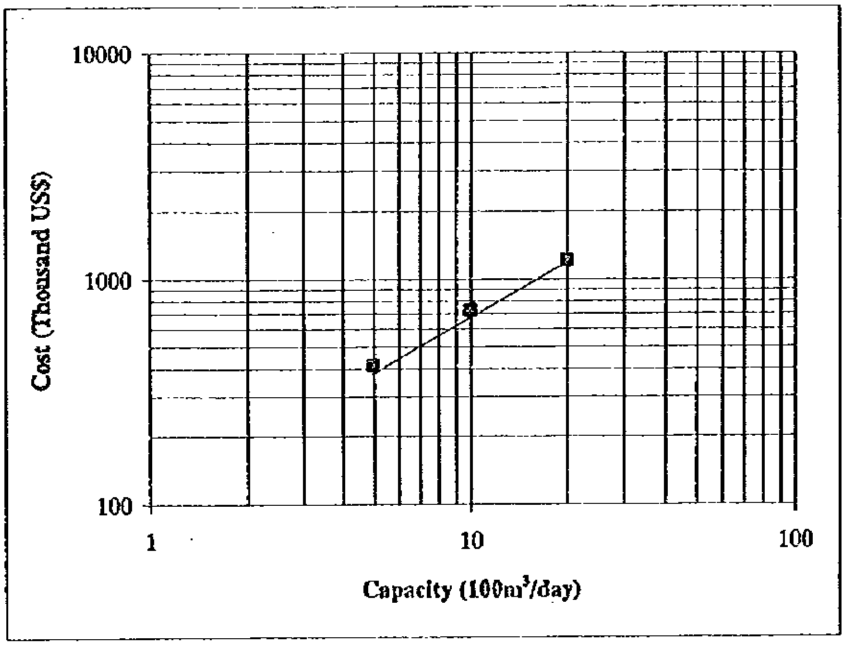


Figure 13.3.8 Relationship between Treatment Capacity and Unit Construction Cost (Solid Waste Leachate Treatment Facilities, WSP)

Solid Waste Leachate
Treatment Facilities (WSP)
Construction Cost -
Treatment Capacity

$100m^3$	1000US$
1	302
5	633
10	1179

$C = 290.0415\ Q^{0.5683}$

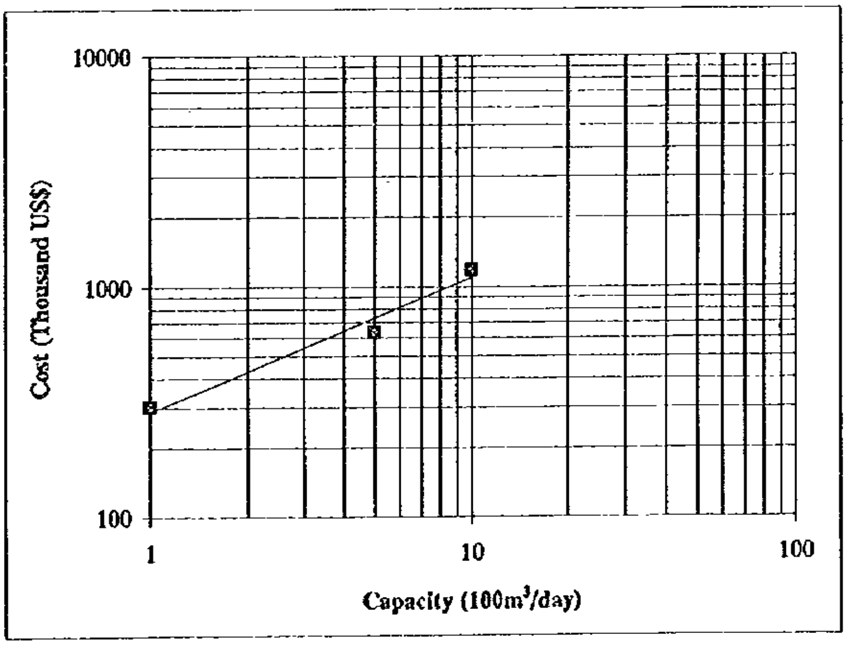


Table 13.4.1 Summary of Construction Cost for Sewage Treatment Works

Scenario	Authority	Sewage Works	onstruction Cost (Mill US$)
Scenario-1	Harare	Crowborough	135.55
		Firle	203.64
		Marlborough	8.87
		Donnybrook	13.61
		Total Cost	361.67
	Harare Expansion	Harare South	126.34
		Harare East	50.40
		Total Cost	176.74
	Norton	Norton	65.78
	Ruwa	Ruwa	42.10
	Chitungwiza	Zengeza	69.79
		Grand Total (Scenario-1)	716.08
Scenario-2	Harare	Crowborough	94.58
		Firle	183.98
		Marlborough	5.30
		Donnybrook	12.62
		Total Cost	296.48
	Harare Expansion	Harare South	85.87
		Harare East	50.40
		Total Cost	136.27
	Norton	Norton	50.12
	Ruwa	Ruwa	17.12
	Chitungwiza	Zengeza	100.67
		Grand Total (Scenario-2)	600.66

Remarks : Construction cost at each target year

Scenario-1	2000	56.95
	2005	388.31
	2015	270.82
	Total	716.08
Scenario-2	2000	64.60
	2005	288.68
	2015	247.38
	Total	600.66

Table 13.4.2(1) Construction Cost for Sewage Treatment Works (Scenario-1)

Authority	Sewage Works	Treatment Facility	Target Year	Construction Cost (Mill US$)	Rematks
Harare	Crowborough	BNR, 94,100m3/d	2005	66.46	BNR
		BNR, 30,800m3/d	2015	23.56	BNR
		Sewer, 6.75km2	2000	3.30	TS,CS,PS
		Sewer, 39.31km2	2005	35.99	TS,CS,PS
		Sewer, 12.78km2	2015	6.24	TS,CS,PS
		Total Cost		135.55	
	Firle	BNR, 176,100m3/	2005	125.37	BNR
		BNR, 61,600m3/d	2015	45.58	BNR
		Sewer, 13.11km2	2000	6.40	TS,CS,PS
		Sewer, 12.48km2	2005	21.50	TS,CS,PS
		Sewer, 6.55km2	2015	4.79	TS,CS,PS
		Total Cost		203.64	
	Marlborough	WSP, 0	2005	0.00	
		WSP, 2,800m3/d	2015	5.31	WSP,PS,PM,SP
		Sewer, 7.29km2	2015	3.56	TS,CS,PS
		Total Cost		8.87	
	Donnybrook	WSP, 2,400m3/d	2005	4.72	WSP,PS,PM,SP
		WSP, 4,400m3/d	2015	7.74	WSP,PS,PM,SP
		Sewer, 2.36km2	2015	1.15	TS,CS,PS
		Total Cost		13.61	
Harare Expansion	Harare South	BNR, 63,600m3/d	2005	47.05	BNR
		BNR, 28,500m3/d	2015	22.12	BNR
		Sewer, 27.36km2	2000	13.36	TS,CS,PS
		Sewer, 28.63km2	2005	28.42	TS,CS,PS
		Sewer, 31.51km2	2015	15.39	TS,CS,PS
		Total Cost		126.34	
	Harare East	BNR, 6,300m3/d	2005	6.48	BNR
		BNR, 31,300m3/d	2015	23.87	BNR
		Sewer, 11.10km2	2000	5.42	TS,CS,PS
		Sewer	2005	4.54	TS,CS,PS
		Sewer, 14.76km2	2015	10.09	TS,CS,PS
		Total Cost		50.40	
Norton	Norton	TF, 9,000m3/d	2005	9.89	TF,PS,PM,SP
		TF, 28,900m3/d	2015	26.88	TF,PS,PM,SP
		Sewer, 2.99km2	2000	1.46	TS,CS,PS
		Sewer, 6.56km2	2005	8.25	TS,CS,PS
		Sewer, 31.38km2	2015	19.30	TS,CS,PS
		Total Cost		65.78	
Ruwa	Ruwa	WSP, 7,900m3/d	2005	12.60	WSP,PS,PM,SP
		WSP, 5,200m3/d	2015	8.83	WSP,PS,PM,SP
		Sewer, 7.02km2	2000	3.43	TS,CS,PS
		Sewer, 7.57km2	2005	15.36	TS,CS,PS
		Sewer, 3.86km2	2015	1.88	TS,CS,PS
		Total Cost		42.10	
Chitungwi	Zengeza	BNR, 17,100m3/d	2000	14.60	BNR
		BNR, 1,200m3/d	2005	1.68	BNR
		BNR, 31,500m3/d	2015	23.99	BNR
		Sewer, 1.75km2	2000	8.98	TS,CS,PS
		Sewer, 20.56km2	2015	20.54	TS,CS,PS

Table 13.4.2(1) Construction Cost for Sewage Treatment Works (Scenario-1)

Authority	Sewage Works	Treatment Facility	Target Year	Construction Cost (Mill US$)	Rematks
		Total Cost		69.79	
		Grand Total		716.08	

Remarks: Above construction cost includes direct cost,contingency and engineering cost. The cost of price escalation and administration is not included.

BNR : Biological nutrient Removal Process
TS : Trunk Sewer
CS : Collection Sewer
PS : Pump Station
PM : Pumping Main
WSP : Wastewater Stabilization Pond
TF : Trickling Filter Process
SP : Storage Pond

Construction Cost at Each Target Year

2000 :	56.95
2005 :	388.31
2015 :	270.82
Total	716.08

Table 13.4.2(2) Construction Cost for Sewage Treatment Works (Scenario-2)

Authority	Sewage Works	Treatment Facility	Target Year	Construction Cost (Mill US$)	Rematks
Harare	Crowborough	BNR, 38,700m3/d	2005	28.36	BNR
		BNR, 31,500m3/d	2015	23.99	BNR
		Sewer, 6.75km2	2000	3.30	TS,CS,PS
		Sewer, 39.31km2	2005	32.69	TS,CS,PS
		Sewer, 12.78km2	2015	6.24	TS,CS,PS
		Total Cost		94.58	
	Firle	BNR, 133,300m3/	2005	94.95	BNR
		BNR, 72,600m3/d	2015	53.24	BNR
		Sewer, 13.11km2	2000	6.40	TS,CS,PS
		Sewer, 12.48km2	2005	24.60	TS,CS,PS
		Sewer, 6.55km2	2015	4.79	TS,CS,PS
		Total Cost		183.98	
	Marlborough	WSP, 0	2005	0.00	
		WSP, 600m3/d	2015	1.74	WSP,PS,PM,SP
		Sewer, 7.29km2	2015	3.56	TS,CS,PS
		Total Cost		5.30	
	Donnybrook	WSP, 2,900m3/d	2005	5.45	WSP,PS,PM,SP
		WSP, 3,300m3/d	2015	6.02	WSP,PS,PM,SP
		Sewer, 2.36km2	2015	1.15	TS,CS,PS
		Total Cost		12.62	
Harare Expansion	Harare South	BNR, 47,100m3/d	2005	33.27	BNR
		BNR, 300m3/d	2015	0.55	BNR
		Sewer, 27.36km2	2000	13.36	TS,CS,PS
		Sewer, 28.63km2	2005	23.30	TS,CS,PS
		Sewer, 31.51km2	2015	15.39	TS,CS,PS
		Total Cost		85.87	
	Harare East	BNR, 6,300m3/d	2005	6.48	BNR
		BNR, 31,300m3/d	2015	23.87	BNR
		Sewer, 11.10km2	2000	5.42	TS,CS,PS
		Sewer	2005	4.54	TS,CS,PS
		Sewer, 14.76km2	2015	10.09	TS,CS,PS
		Total Cost		50.40	
Norton	Norton	TF, 4,200m3/d	2005	5.95	TF,PS,PM,SP
		TF, 18,900m3/d	2015	17.04	TF,PS,PM,SP
		Sewer, 2.99km2	2000	1.46	TS,CS,PS
		Sewer, 6.56km2	2005	7.28	TS,CS,PS
		Sewer, 31.38km2	2015	18.39	TS,CS,PS
		Total Cost		50.12	
Ruwa	Ruwa	WSP, 0	2005	0.00	
		WSP, 400m3/d	2015	1.39	WSP,PS,PM,SP
		Sewer, 7.02km2	2000	3.43	TS,CS,PS
		Sewer, 7.57km2	2005	10.42	TS,CS,PS
		Sewer, 3.86km2	2015	1.88	TS,CS,PS
		Total Cost		17.12	
Chitungwi	Zengeza	BNR, 25,100m3/d	2000	19.95	BNR
		BNR, 12,600m3/d	2005	11.39	BNR
		BNR, 49,600m3/d	2015	34.70	BNR
		Sewer, 1.75km2	2000	11.28	TS,CS,PS
		Sewer, 20.56km2	2015	23.35	TS,CS,PS

Table 13.4.2(2) Construction Cost for Sewage Treatment Works (Scenario-2)

Authority	Sewage Works	Treatment Facility	Target Year	Construction Cost (Mill US$)	Rematks
		Total Cost		100.67	
		Grand Total		600.66	

Remarks: Above construction cost includes direct cost,contingency and engineering cost. The cost of price escalation and administration is not included.

BNR : Biological nutrient Removal Process
TS : Trunk Sewer
CS : Collection Sewer
PS : Pump Station
PM : Pumping Main
WSP : Wastewater Stabilization Pond
TF : Trickling Filter Process
SP : Storage Pond

Construction Cost at Each Target Year

2000 :	64.60
2005 :	288.68
2015 :	247.38
Total	600.66

Table 13.4.3(1) Construction Cost for Sewage Treatment Works (Scenario-1) 2000, 2005 and 2015

Target Year	Sewage Works	Treatment Facility	Construction Cost (Mill US$)
2000	Crowborough	Sewer, 6.75km2	3.30
	Firle	Sewer, 13.11km2	6.40
	Harare South	Sewer, 27.36km2	13.36
	Harare East	Sewer, 11.10km2	5.42
	Norton	Sewer, 2.99km2	1.46
	Ruwa	Sewer, 7.02km2	3.43
	Zengeza	BNR, 17,100m3/d	14.60
		Sewer, 1.75km2	8.98
	Total (2000)		56.95
2005	Crowborough	BNR, 94,100m3/d	66.46
		Sewer, 39.31km2	35.99
	Firle	BNR, 176,100m3/d	125.37
		Sewer, 12.48km2	21.50
	Donnybrook	WSP, 2,400m3/d	4.72
	Harare South	BNR, 63,600m3/d	47.05
		Sewer, 28.63km2	28.42
	Harare East	BNR, 6,300m3/d	6.48
		Sewer	4.54
	Norton	TF, 9,000m3/d	9.89
		Sewer, 6.56km2	8.25
	Ruwa	WSP, 7,900m3/d	12.60
		Sewer, 7.57km2	15.36
	Zengeza	BNR, 1,200m3/d	1.68
	Total (2005)		388.31
2015	Crowborough	BNR, 30,800m3/d	23.56
		Sewer, 12.78km2	6.24
	Firle	BNR, 61,600m3/d	45.58
		Sewer, 6.55km2	4.79
	Marlborough	WSP, 2,800m3/d	5.31
		Sewer, 7.29km2	3.56
	Donnybrook	WSP, 4,400m3/d	7.74
		Sewer, 2.36km2	1.15
	Harare South	BNR, 28,500m3/d	22.12
		Sewer, 31.51km2	15.39
	Harare East	BNR, 31,300m3/d	23.87
		Sewer, 14.76km2	10.09
	Norton	TF, 28,900m3/d	26.88
		Sewer, 31.38km2	19.30
	Ruwa	WSP, 5,200m3/d	8.83
		Sewer, 3.86km2	1.88
	Zengeza	BNR, 31,500m3/d	23.99
		Sewer, 20.56km2	20.54
	Total (2015)		270.82
	Grand Total		716.08

Table 13.4.3(2) Construction Cost for Sewage Treatment Works (Scenario-2) 2000, 2005 and 2015

Target Year	Sewage works	Treatment Facility	Construction Cost (Mill US$)
2000	Crowborough	Sewer, 6.75km2	3.30
	Firle	Sewer, 13.11km2	6.40
	Harare South	Sewer, 27.36km2	13.36
	Harere East	Sewer, 11.10km2	5.42
	Norton	Sewer, 2.99km2	1.46
	Ruwa	Sewer, 7.02km2	3.43
	Zengeza	BNR, 25,100m3/d	19.95
		Sewer, 1.75km2	11.28
	Total (2000)		64.60
2005	Crowborough	BNR, 38,700m3/d	28 36
		Sewer, 39.31km2	32.69
	Firle	BNR, 133,300m3/d	94.95
		Sewer, 12.48km2	24.60
	Donnybrook	WSP, 2,900m3/d	5.45
	Harare South	BNR, 47,100m3/d	33.27
		Sewer, 28.63km2	23.30
	Harare East	BNR, 6,300m3/d	6.48
		Sewer	4.54
	Norton	TF, 4,200m3/d	5.95
		Sewer, 6.56km2	7.28
	Ruwa	Sewer, 7.57km2	10.42
	Zengeza	BNR, 12,600m3/d	11.39
	Total (2005)		288.68
2015	Crowborough	BNR, 31,500m3/d	23.99
		Sewer, 12.78km2	6.24
	Firle	BNR, 72,600m3/d	53.24
		Sewer, 6.56km2	4.79
	Marlborough	WSP, 60m3/d	1.74
		Sewer, 7.29km2	3.56
	Donnybrook	WSP, 3,300m3/d	6.02
		Sewer, 2.36km2	1.15
	Harare South	BNR, 300m3/d	0.55
		Sewer, 31.51km2	15.39
	Harare East	BNR, 31,300m3/d	23.87
		Sewer, 14.76km2	10.09
	Norton	TF, 18,900m3/d	17.04
		Sewer, 31.38km2	18.39
	Ruwa	WSP, 400m3/d	1.39
		Sewer, 3.86km2	1.88
	Zengeza	BNR, 49,600m3/d	34.70
		Sewer, 20.56km2	23.35
	Total (2015)		247.38
	Grand Total		600.66

13.5 Operation and Maintenance Cost

Referring to the construction cost, the O & M costs were calculated for the following eight items.

(1) Trunk Sewer
(2) Collection Sewer
(3) Pump Station
(4) Wastewater Stabilization Pond (WSP) + Effluent Pump Facilities (EPF)
(5) Trickling Filter (TF) + Effluent Pump Facilities (EPF)
(6) Biological Nutrient Removal (BNR)
(7) Industrial Wastewater Pre-treatment Facilities (IWPTF)
(8) Solid Waste Leachate Treatment Facilities

O & M costs have not calculated for the existing sewage treatment facilities, but only for the future wastewater increment predicted in this Master Plan. O & M costs for daily operations are roughly calculated for some main cost items. Annual depreciation cost was estimated at 2% of the total construction cost.

To estimate the approximate costs for sewage treatment works and pump stations, the financial reports of each local authority were referred to and the major cost items selected are personnel expenses, electricity, maintenance & repair cost, material & chemical cost, administration charge and others.

Personnel expenses were calculated by multiplying the number of staff by a unit cost. Staff is divided into two categories: operation and maintenance. For each position of operation, 1 attendant and 3 operators (3 cycle shift) are assigned. The points of operation include inlet works, pump station, primary sedimentation tank, BNR (or TF), secondary sedimentation tank and effluent pump. Maintenance staff take charge of such tasks as weeding and cleaning tanks and they are allocated at a ratio of 1 foreman and 2 general staff (laborers) in proportion to each facility's scale.

The electricity costs are calculated by determining the necessary electrical equipment and multiplying the electric power of each equipment by its operation time and a unit cost.

The expenses/charges for maintenance and repairs, materials & chemicals, administration charge and others are calculated based on the ratios in the actual accounts of each local authority.

13.5.1 Standard Sewage and Sludge Treatment Facilities

(1) Trunk Sewer

The main O & M cost for the sewer is generated by the cleaning. However it is not necessary to count it for trunks sewer because there is normally a considerable flow, with self-cleaning capacity.

(2) Collection Sewer

The cleaning cost of the collection sewer is calculated on the assumption that cleaning will be conducted with a high pressure jet cleaning machine by once every five years.

(3) Pump Station

The standard pump station is designed in six design capacities of 1-3 m^3/min, 4-10 m^3/min, 11-20 m^3/min, 21-40 m^3/min, 41-60 m^3/min, over 61 m^3/min.

(4) Wastewater Stabilization Pond + Effluent Pump Facilities

The wastewater stabilization pond includes the following structures: screen and grit chamber, anaerobic pond, facultative pond and maturation pond. Effluent pump facilities comprises pump station, force main and storage pond. The standard wastewater stabilization pond is designed in four design capacities of 1,000 m^3/day, 2,000 m^3/day, 5,000 m^3/day and 10,000 m^3/day.

(5) Trickling Filter + Effluent Pump Facilities

Trickling filter includes the following major structures: screen and grit chamber, primary sedimentation tank, trickling filter, secondary sedimentation tank, sludge thickening tank and sludge drying bed. Effluent pump facilities comprises pump station, force main and storage pond. The standard trickling filter process is designed in four capacities of 2,500 m^3/day, 5,000 m^3/day, 10,000 m^3/day and 20,000 m^3/day.

(6) Biological Nutrient Removal

Biological nutrient removal includes the following major structures: screen and grit chamber, primary sedimentation tank, biological reactor (BNR), secondary sedimentation tank, sludge thickening tank and sludge drying bed. The standard biological removal process is designed in four capacities of 5,000 m^3/day, 10,000 m^3/day, 20,000 m^3/day and 50,000 m^3/day.

(7) Industrial Wastewater Pre-treatment Facilities

The O & M cost based on a standard model industrial/slaughterhouse wastewater treatment facilities is estimated as a reference. Industrial/slaughterhouse wastewater pre-treatment facilities (IWPTF) includes anaerobic and facultative pond. The standard capacity is designed in three capacities of 500 m^3/day, 1,000 m^3/day and 2,000 m^3/day.

(8) Solid Waste Leachate Treatment Facilities

The O & M cost based on a standard model solid waste leachate treatment facilities is estimated as a reference. The solid waste leachate treatment facilities are designed utilizing wastewater stabilization pond method. The standard capacity is designed three capacities of 100 m^3/day, 500 m^3/day and 1,000 m^3/day.

13.5.2 Unit Cost and Cost Functions for Operation and Maintenance

The unit costs are as follows:

Personnel cost		
Superintendent	: 24,000	Z$/person/year
Attendant	: 20,000	Z$/person/year
Operator	: 15,000	Z$/person/year
Foreman	: 12,000	Z$/person/year
General Staff	: 8,000	Z$/person/year
Unit electricity cost	: 0.45 Z$/kWH	

(1) Trunk Sewer

The cleaning cost of the trunks sewer is not calculated.

(2) Collection Sewer

The cost of collection sewer is estimated by ha as shown in Table 13.5.1, Section 13.5, Chapter 2, Supporting Report and the detailed cost estimate is listed in Section 13.5, Chapter 2, Supporting Report.

Sewer cleaning cost per ha US$7.45/ha/year

(3) Pump Station

The cost of pump station is estimated each standard pump capacity as shown in Table 13.5.2, Section 13.5, Chapter 2, Supporting Report and the detailed cost estimate is listed in Section 13.5, Chapter 2, Supporting Report. The relationship between pump station capacity and O & M cost is as follows:

Capacity (m^3/min)	Construction Cost (US$/year)
1 - 3	9,611
4 - 10	23,375
11 - 20	37,064
21 - 40	75,171
41 - 60	103,424
over61	123,586

The exponential function formula is obtained from the above Capacity (m^3/min) - US$/year relationship. Figure 13.5.1 shows this relationship and the cost function formula obtained by a least square method is as follows:

$$C = 6689.4\,Q^{0.6858}$$

where,

C : O & M cost (US$/year)

Q : Pump station capacity (m^3/min)

(4) Wastewater Stabilization Pond (WSP) + Effluent Pump Facilities (EPF) .

The cost of wastewater stabilization pond (WSP) is estimated at each standard treatment capacity as shown in Table 13.5.5 in Section 13.5, Chapter 2, Supporting Report and the detailed cost estimate is listed in Section 13.5, Chapter 2, Supporting Report.

The relationship between daily treatment capacity and O & M cost for WSP + EPF is as follows:

Capacity (m^3/day)	O & M Cost (US$/year)
1,000	32,844
2,000	42,844
5,000	103,098
10,000	154,878

The exponential function formula is obtained from the above Capacity (m^3/day) - US$ relationship. Figure 13.5.2 shows this relationship and the cost function formula obtained by a least square method is as follows:

$$C = 220.93\ Q^{0.7125}$$

where,

C : O & M cost (US$)

Q : Treatment capacity (m^3/day)

(5) Trickling Filter + Effluent Pump Facilities (EPF)

The cost of trickling filter process (TF) is estimated at each standard treatment capacity as shown in Table 13.5.5 in Section 13.5, Chapter 2, Supporting Report and the detailed cost estimate is listed in Section 13.5, Chapter 2, Supporting Report.

The relationship between daily treatment capacity and O & M cost for TF is as follows:

Capacity (m^3/day)	O & M Cost (US$)
2,500	83,241
5,000	116,348
10,000	205,075
20,000	320,163

The exponential function formula is obtained from the above Capacity (m^3/day) - US$ relationship. Figure 13.5.3 shows this relationship and the cost function formula obtained by a least square method is as follows:

$$C = 438.23\ Q^{0.6648}$$

where,

C : O & M cost (US$)

Q : Treatment capacity (m^3/min)

(6) Biological Nutrient Removal (BNR)

The cost of biological nutrient removal (BNR) is estimated at each standard treatment capacity as shown in Table 13.5.5 in Section 13.5, Chapter 2, Supporting Report and the detailed cost estimate is listed in Section 13.5, Chapter 2, Supporting Report.

The relationship between daily treatment capacity and O & M cost for WSP + EPF is as follows:

Capacity (m^3/day)	O & M (US$/year)

5,000	201,069
10,000	295,596
20,000	543,588
50,000	1,219,156

The exponential function formula is obtained from the above Capacity (m^3/day) - US$ relationship. Figure 13.5.4 shows this relationship and the cost function formula obtained by a least square method is as follows:

$$C = 212.88\ Q^{0.7954}$$

where,

C : O & M cost (Million US$)

Q : Treatment capacity (m^3/day)

(7) Industrial Wastewater Pre-treatment Facilities

The cost of industrial wastewater pre-treatment facilities (Anaerobic pond and facultative pond) is estimated at each standard treatment capacity as shown in Table 13.5.5, Section 13.5, Chapter 2, Supporting Report and the detailed cost estimate is listed in Section 13.5, Chapter 2, Supporting Report.

The relationship between daily treatment capacity and O & M cost is as follows:

Capacity (m^3/day)	O & M Cost (US$)
500	19,156
1,000	22,185
2,000	25,298

The exponential function formula is obtained from the above Capacity (m^3/day) - US$ relationship. Figure 13.5.5 shows this relationship and the cost function formula obtained by a least square method is as follows:

$$C = 5520.5\ Q^{0.2006}$$

where,

C : O & M cost (US$)

Q : Treatment capacity (m^3/day)

(8) Solid Waste Leachate Treatment Facilities

The cost of solid waste leachate treatment facilities (wastewater stabilization pond, WSP) is estimated at each standard treatment capacity as shown in Table 13.5.5 in Section 13.5, Chapter 2, Supporting Report and the detailed cost estimate is listed in Section 13.5, Chapter 2, Supporting Report.

The relationship between daily treatment capacity and O & M cost is as follows:

Capacity (m^3/day)	O & M Cost (US$)
100	18,534
500	22,946
1,000	27,491

The exponential function formula is obtained from the above Capacity (100 m^3/day) - US$ relationship. Figure 13.5.6 shows this relationship and the cost function formula obtained by a least square method is as follows:

$$C = 8589.5\ Q^{0.1644}$$

where,

C : O & M cost (US$)

Q : Treatment capacity (m^3/day)

13.5.3 Cost Requirement

The O & M cost at the target year of 2000, 2005 and 2015 are summarised below and are shown in Table 13.5.6 to Table 13.5.8 in Section 13.5, Chapter 2, Supporting Report. Price escalation is not included in the O & M cost.

Table 13.5.1 O & M Cost

Scenario	Year	O & M cost		Annual depreciation cost	
		Mill U$/year	(Mill Z$/year)	Mill U$/year	(Mill Z$/year)
Scenario - 1	2000	0.600	(5.700)	1.139	(10.821)
	2005	8.281	(78.670)	8.905	(84.598)
	2015	12.091	(114.865)	14.322	(136.059)
Scenario - 2	2000	0.795	(7.553)	1.292	(12.274)
	2005	6.527	(62.007)	7.533	(71.564)
	2015	10.215	(97.043)	12.012	(114.114)

Figure13.5.1 Sewage Pump Station Annual O & M Cost

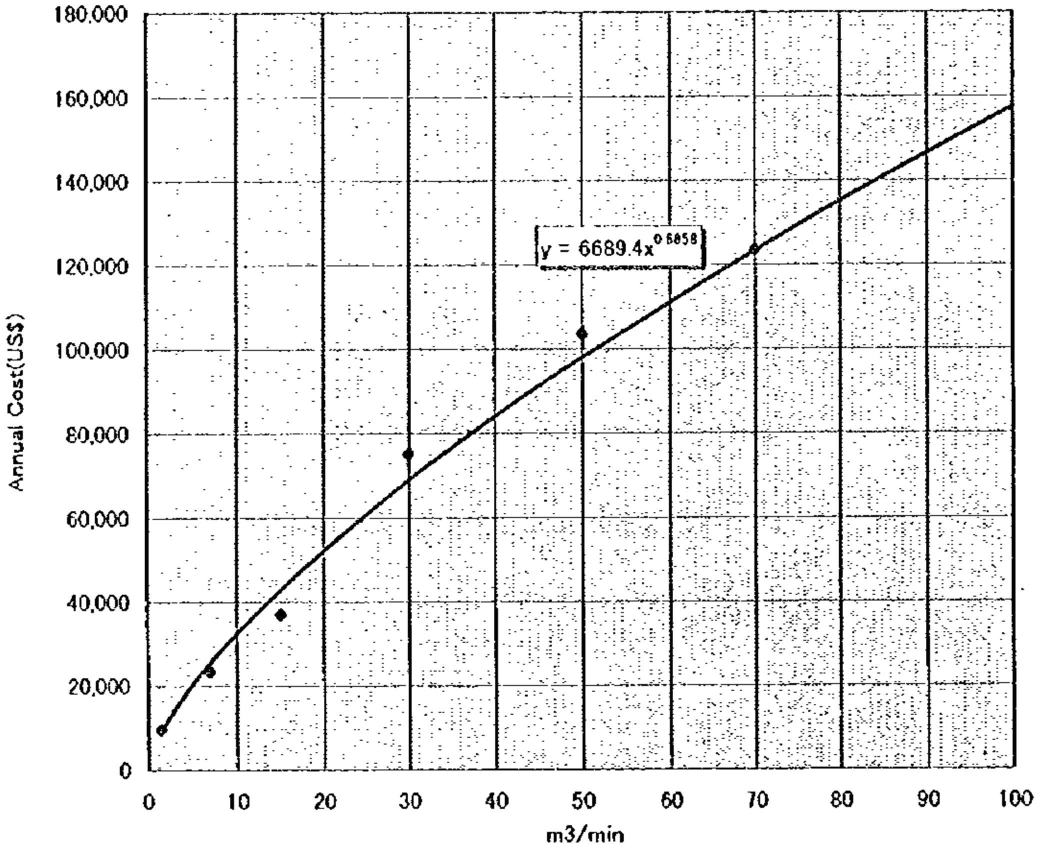


Figure 13.5.2 WSP Annual O & M Cost

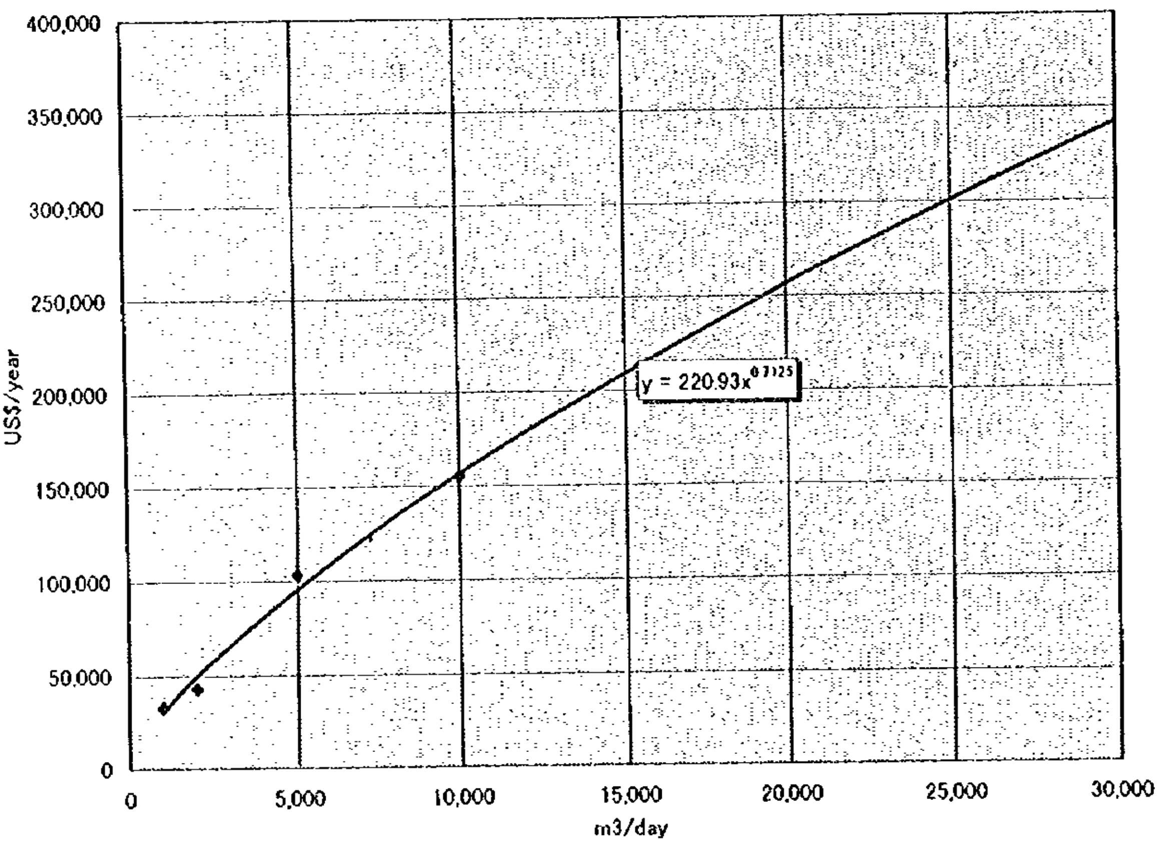


Figure 13.5.3 TF Annual O & M Cost

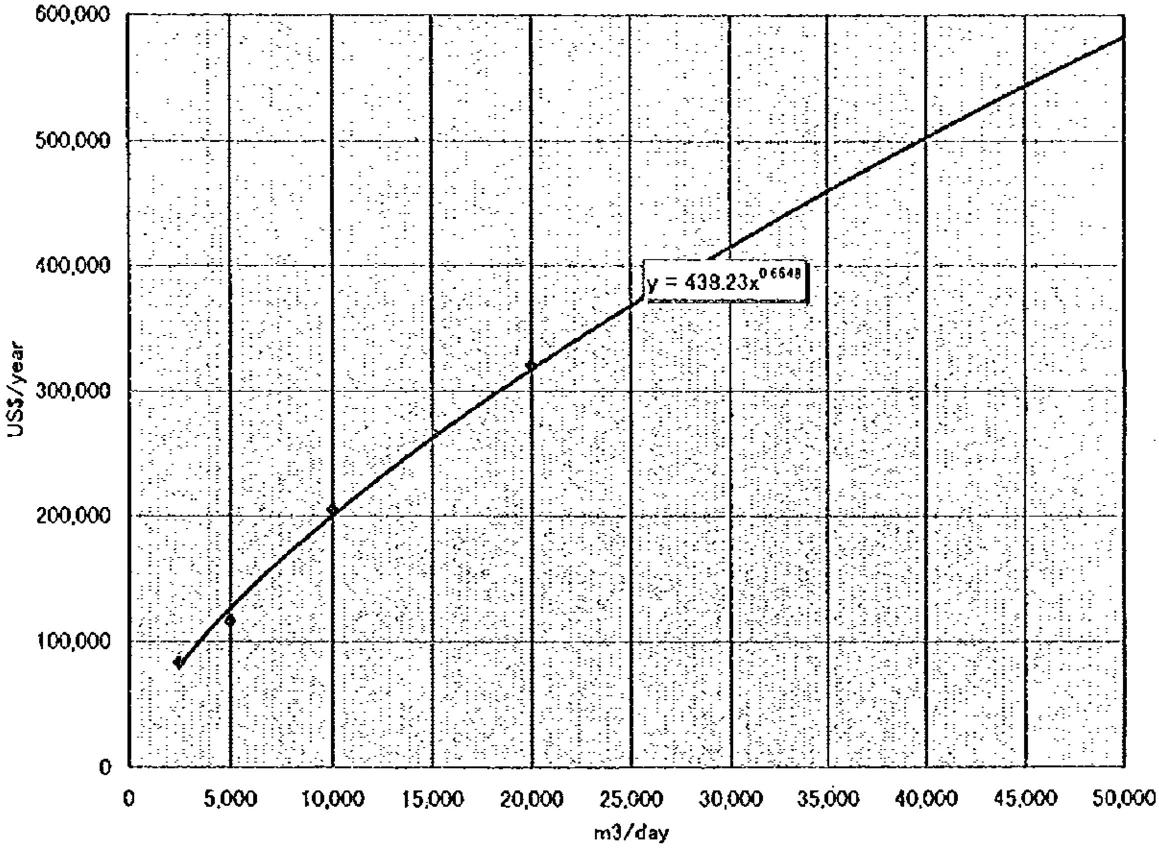


Figure 13.5.4 BNR Annual O & M Cost

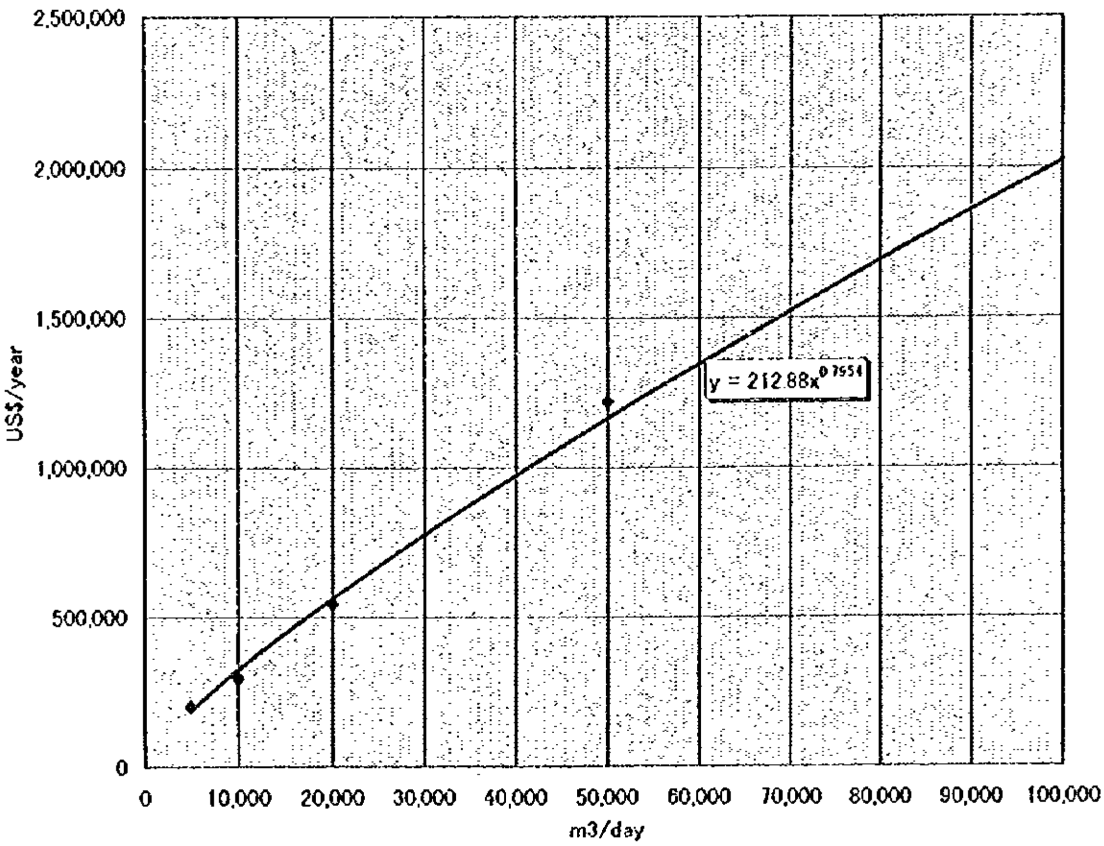


Figure 13.5.5 Industrial Wastewater Annual O & M Cost

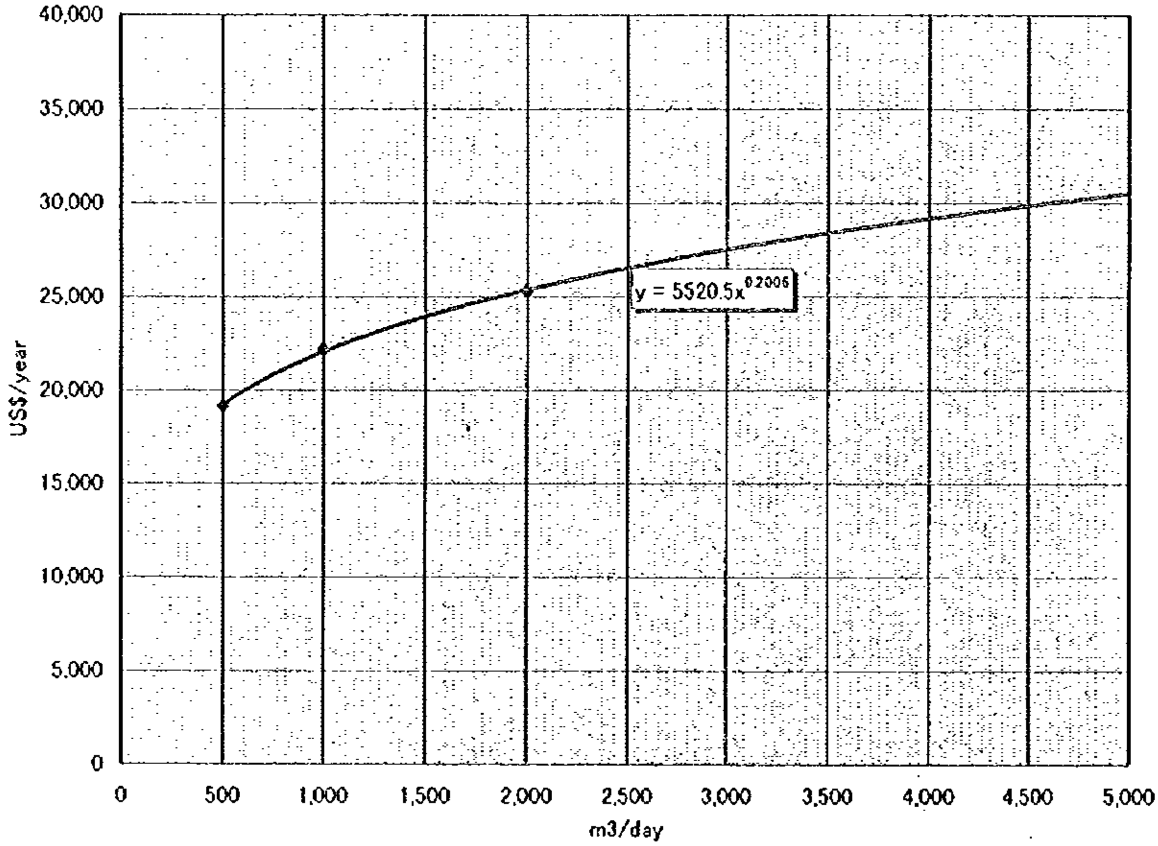
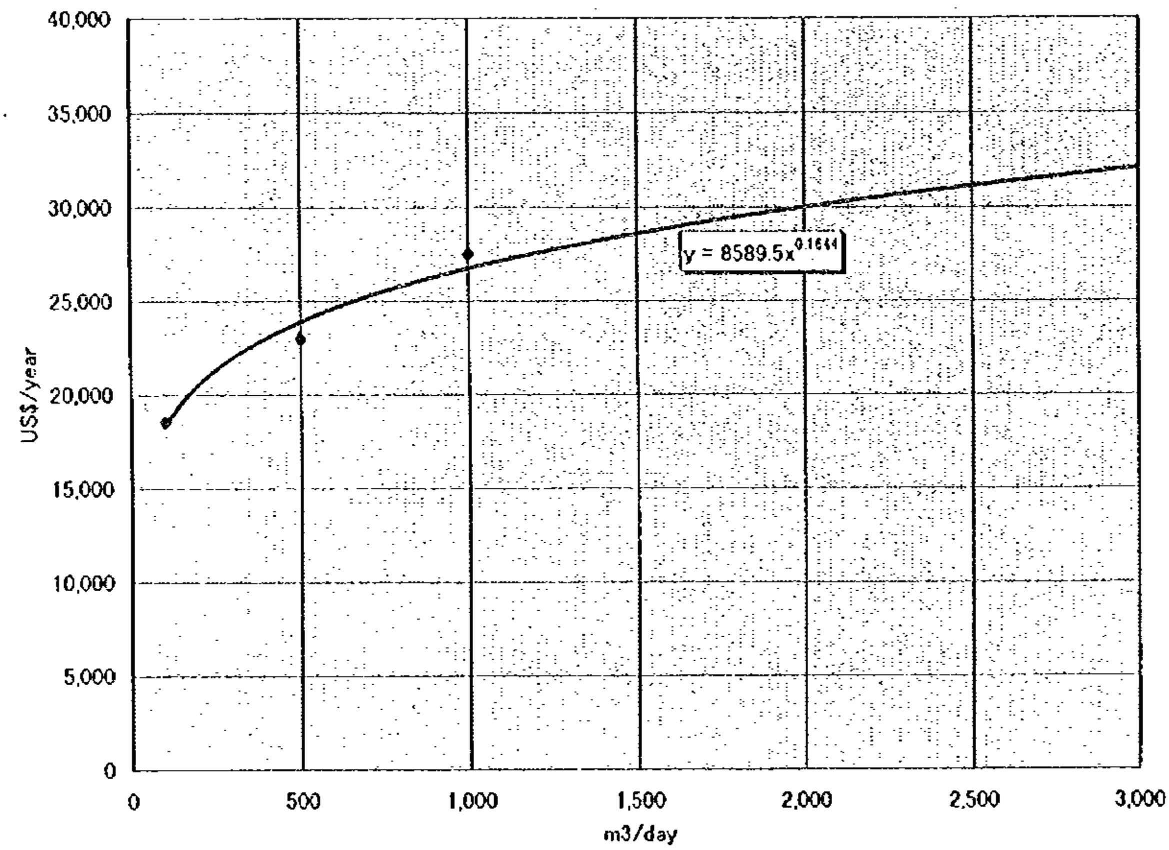


Figure 13.5.6 Solid Waste Leachate Annual O & M Cost



CHAPTER 14

IMPLEMENTATION PLAN FOR THE COUNTERMEASURES

CHAPTER 14 IMPLEMENTATION PLAN FOR THE COUNTERMEASURES

14.1 Basic Conditions

The implementation schedule of various countermeasures for water pollution control in the Study Area are worked out focusing on public sewage works proposed, and viable arrangement for institution, organization and financial arrangements. The following conditions are taken into account in order to prepare implementation plans.

Development/Expansion Phase

The development phases up to the target year 2015 of the Master Plan are assumed as follows:

First Phase (1997 - 2000)
Second Phase (2001 - 2005)
Third Phase (2006 - 2015)

The phased development/expansion of public sewage works was proposed to cover urbanized area by to reduce pollution target phase. Urgent projects were considered in the first phase.

Population Scenarios

Two alternatives of population projection in the Study Area were prepared as follows:

unit: person

Scenario	2000	2005	2015
Scenario-1	2,289,500	3,145,770	4,035,100
Scenario-2	2,319,790	2,707,120	3,575,880

Scenario 1 is based on the existing study "Master Plan for Water Distribution for the City of Harare, 1995", while Scenario 2 on "Harare Combination Master Plan, 1992".

Institutional Arrangement

Implementation of well-coordinated water pollution management by both the national and local authorities is a prerequisite. Review of the Water Act is one of the agenda to improve water management. The government is under planning to establish a national control body on the water resources development management, temporarily called "Zimbabwe National Water Authority (ZNWA)". The current direction of such institutional reform will have to be effectively utilized to realize the better management system of water pollution control.

Financial Arrangement

The cost requirements up to the target year 2015 in order to construct public sewage works are estimated as follows:

unit: Million Z$

Scenario-1	Scenario-2
6,800	5,706

In assumption that investment period would be 17 years from 1999 to 2015, the average annual investment requirement is about Z$400 million in scenario-1 and Z$335 million in scenario-2. The latest performance of average annual investment in the sewerage sector was Z$40 million during the period from 1991/92 to 1994/95 in the City of Harare, and Z$9 million in Chitungwiza during the same period. Obviously the fund requirements are well beyond local authority finance in terms average annual investment. Accordingly, debt service could not be repayable by sewerage revenue. In this connection, the role of the central government would be substantial in the form of financial assistance to local governments. Investment requirement was assumed to include direct construction cost, physical contingency and engineering service with the following composition.

No.	Cost Items	Composition
(1)	Direct construction cost	71%
(2)	Physical contingency	14%
(3)	Engineering service	15%
	Total	100%

Alternative Implementation Schedules

Two alternatives of implementation schedule are taken into account to develop physical plans of public sewage works. The first alternative is implementation of the proposed development plans for each development phase. The second alternative is intended to postpone in the third phase development. The second alternative is proposed mainly because of limited financial capabilities of local authorities. The middle-term development plans are assumed to implemente in the third phase.

Phase	Alternative Implementation Schedule	
	Alternative 1	Alternative 2
First	Short-term	Short-term
Second	Middle-term	--
Third	Long-term	Middle-term

14.2 Financial Arrangements by Local Authorities

The financial capability of local authority is the key element to determine implementable schedule of public sewage works. Local authorities need to have assistance at least for direct construction cost from the central government. Loan disbursement to the local authorities concerned by alternative implementation schedule would be presumed as shown below.

Alternative 1

unit: Million Z$

Phase	Scenario 1				Scenario 2			
	Harare	Chitungwiza	Norton	Ruwa	Harare	Chitungwiza	Norton	Ruwa
First	192	159	10	23	192	211	10	23
Second	2,297	11	122	189	1,711	77	89	70
Third	1,142	300	312	72	1,016	391	239	22

Remarks: Years of loan disbursement are assumed to be:
First phase : 1999, 2000 (2 years)
Second phase : 2002, 2003, 2004 (3 years)
Third phase : 2012, 2013, 2014 (3 years)

Alternative 2

unit: Million Z$

Phase	Scenario 1				Scenario 2			
	Harare	Chitungwiza	Norton	Ruwa	Harare	Chitungwiza	Norton	Ruwa
First	192	159	10	23	192	211	10	23
Third	2,297	11	122	189	1,711	77	89	70

Remarks: Years of loan disbursement are assumed to be:
First phase : 1999, 2000 (2 years)
Third phase : 2012, 2013, 2014 (3 years)

Whether debt service could be repayable or not was evaluated estimating the balance between sewerage revenue and expenditures as expressed by the following equation.

Balance = Sewerage Revenue - O & M cost - Debt Service

Cash flow statements were prepared to analyze loan repayment with the following assumptions:

1) Price

Revenue and expenditures of sewerage accounts are valued at 1996 constant price. The nominal values of revenue and operating expenses of sewerage account in 1996 are estimated based on the latest annual increase rate (60%) of revenue and expenditures. Price escalation after 1996 is not taken into account for preparation of cash flow statement.

unit: Million Z$

Local Authorities	1993	1994	1996
Harare			
Revenue		60.4	154.6
Expenditures		43.2	110.6
Chitungwiza			
Revenue		5.1	13.1
Expenditures		4.7	12.0
Norton			
Revenue		2.5	6.4
Expenditures		2.1	5.4
Ruwa			
Revenue	0.12		0.5
Expenses	0.10		0.4

2) Revenue projection

The constant value of revenue was assumed to increase in proportion to annual growth rate of population in the Study Area. While, annual growth rate (2%) of household expenditures was assumed based on last 5 years experience (1989 - 1993). The population growth rates per annum are shown as follows:

	1992	2000	2005	2015
Scenario 1	1,626,227	2,289,500	3,145,770	4,035,100
	(4.3)	(6.6)	(2.5)	
Scenario 2	1,626,227	2,319,790	2,707,120	3,575,880
	(4.5)	(3.1)	(2.8)	

3) Loan conditions

Loan will be on-lent from the central government to the concerned local authorities. Loan conditions are assumed as follows:

Interest rate : 12%
Grace period : 3 years
Repayment period : 25 years

4) Operation and maintenance cost

Annual operation and maintenance cost of development plans is summarized as follows:

Alternative 1 unit: Million Z$

Phase	Scenario 1				Scenario 2			
	Harare	Chitungwiza	Norton	Ruwa	Harare	Chitungwiza	Norton	Ruwa
First	0.4	5.2	0	0.1	0.4	7.1	0	0.1
Second	67.5	6.5	2.1	2.6	49.1	10.9	1.3	0.7
Third	93.4	12.7	5.5	3.1	72.7	19.4	4.0	0.9

Note: Disbursement of O & M cost is assumed to be:
First phase : 2000 onwards
Second phase : 2004 onwards
Third phase : 2014 onwards

Alternative 2 unit: Million Z$

Phase	Scenario 1				Scenario 2			
	Harare	Chitungwiza	Norton	Ruwa	Harare	Chitungwiza	Norton	Ruwa
First	0.4	5.2	0	0.1	0.4	7.1	0	0.1
Second	67.5	6.5	2.1	2.6	49.1	10.9	1.3	0.7

Note: Disbursement of O & M cost is assumed to be:
First phase : 2000 onwards
Second phase : 2014 onwards

Annual and accumulated balances shown in cash flow statements are summarized as follows:

Alternative 1, scenario 1

unit: Million Z$

	2000	2005	2010	2015
Harare				
Annual in Target Year	87.0	97.8	(127.7)	(59.9)
Accumulated	324.8	842.1	347.4	(70.3)
Chitungwiza				
Annual in Target Year	(0.4)	(13.8)	(8.9)	(0.9)
Accumulated	9.2	(33.2)	(89.4)	(110.7)
Norton				
Annual in Target Year	2.8	3.7	(9.2)	(8.7)
Accumulated	9.4	27.3	(9.2)	(50.8)
Ruwa				
Annual in Target Year	0.1	(5.0)	(29.5)	(29.7)
Accumulated	0.7	(11.6)	(135.0)	(282.7)

Alternative 1, scenario 2

unit: Million Z$

	2000	2005	2010	2015
Harare				
Annual in Target Year	88.6	71.9	(82.2)	(18.8)
Accumulated	328.4	764.1	431.9	226.5
Chitungwiza				
Annual in Target Year	(2.2)	(28.8)	(33.0)	(34.1)
Accumulated	7.6	(79.7)	(246.8)	(407.4)
Norton				
Annual in Target Year	2.9	2.6	(6.2)	(5.3)
Accumulated	9.5	24.1	(1.1)	(26.9)
Ruwa				
Annual in Target Year	0.1	(3.3)	(12.2)	(12.1)
Accumulated	0.8	(8.2)	(60.6)	(121.2)

Note: ( ) shows negative figure.

Alternative 2, scenario 1

unit: Million Z$

	2000	2005	2010	2015
Harare				
Annual in Target Year	87.0	164.9	239.9	266.4
Accumulated	324.8	976.3	2,018.9	3,356.7
Chitungwiza				
Annual in Target Year	(0.4)	(12.5)	(6.1)	(0.5)
Accumulated	9.2	(30.6)	(74.5)	(84.7)
Norton				
Annual in Target Year	2.8	5.8	8.9	10.6
Accumulated	9.4	31.5	69.3	120.7
Ruwa				
Annual in Target Year	0.1	(2.5)	(2.3)	(4.5)
Accumulated	0.7	(6.6)	(18.6)	(34.2)

Alternative 2, scenario 2

unit: Million Z$

	2000	2005	2010	2015
Harare				
Annual in Target Year	38.0	37.5	65.0	50.7
Accumulated	141.5	327.3	594.8	922.6
Chitungwiza				
Annual in Target Year	(2.2)	(25.0)	(19.1)	(15.6)
Accumulated	7.6	(72.1)	(180.0)	(261.8)
Norton				
Annual in Target Year	2.9	3.9	6.8	9.1
Accumulated	9.5	26.7	54.6	96.3
Ruwa				
Annual in Target Year	0.1	(2.7)	(2.5)	(2.8)
Accumulated	0.8	(7.0)	(19.8)	(32.4)

The results of cash flow statement can be summarized as follows:

<u>Alternative 1 Scenario 1</u>

Chitungwiza and Ruwa authorities would face the chronic balance deficit around the year of 2005 onwards and accumulation of deficit would increase substantially. Debt services of the long-term development plans are not generated in the cash flow statement. The burden of the further debt services after 2015 will certainly aggravate financial position of local governments concerned.

Alternative 1 Scenario 2

Though the scale of deficit finance would be less than that in scenario 1, the growing deficit would put a heavy burden on local governments. Harare could maintain self-finance, but sewerage account would certainly plunge into deficit finance due to the further debt services of the long-term development plans. The deficit to be owed by Chitungwiza will be tremendous, entirely beyond financial capability of Chitungwiza.

Alternative 2, Scenario 1

Both the City of Harare and Norton Town could maintain financial soundness up to the target year of 2015. The further debt services of the middle-term development plans after 2015 would not jeopardize financial position of sewerage accounts of both local authorities. On the other hand, Chitungwiza and Ruwa would face the chronic deficit around the year of 2005 onwards.

Alternative 2, Scenario 2

Financial conditions of local authorities appears to be almost the same as those in scenario 1. Nevertheless the less amount of surplus accumulation could not sustain the further debt services of the middle-term development plans after 2015.

14.3 Legal and Institutional Arrangements

The government of Zimbabwe has established management system for water pollution control under the Public Sector Investment Programme (PSIP). Using this system, the government has been implementing the sewerage development to tackle water pollution and associated problems in urban and rural areas. This system will be realized putting into practice the key institutional/administrative reforms presently contemplated by the government. Basic directions of such reforms are in the context of further decentralization of local authorities and establishment of institutional/legal frameworks to assume local development roles.

The management system was proposed based on the existing administrative structure and the envisioned reforms. The emphasis was placed on the strengthening of administrative and financial capacities of local authorities. The well-coordinated inter-agency bodies called "Upper Manyame River Basin Authority (UMRBA)" and "Water Pollution Control Board (WPCB)" shall be established. In addition, the institutional capabilities of the implementing agencies : MLGRUD and local authorities concerned shall be strengthened to ensure the smooth implementation of water pollution control projects.

In this connection, the institutional/legal measures proposed in this Master Plan are preferably taken within the Action Plan period up to the year 2000. The proposed institutional/legal arrangements with the priority order are as follows:

Legal Measures

1) Review of "Water Act"
2) Enactment of "Environmental Management Act"
3) Establishment of Environmental Water Quality Standards
4) Amendment of effluent regulations
5) Enactment of Trade Effluent Control by-laws

Institutional Measures

1) Creation of "Zimbabwe National Water Authority"
2) Establishment of the inter-agency coordination bodies for water pollution control in the upper Manyame river basin
3) Strengthening of institutional and financial capabilities of the implementing agencies concerned (MLGRUD and local authorities) through human resources development programs

Other Supporting Measures

1) Enhancement of water quality monitoring
2) Strengthening of water pollution control enforcement

14.4 Implementation Plan

Implementation plan of water pollution control in the upper Manyame river basin encompasses physical development plans, institutional arrangement and financial support programs. The two alternatives of implementation schedule are worked out on the basis of basic conditions and financial arrangements by local authorities.

(1) Action Programs

Institutional arrangement

The best way to strengthen water pollution control is to make the effective use of the current direction of institutional/legal reforms. Legal measures proposed in this Master Plan are to be preferably enacted as Action Programs during the period up to the year 2000.

	Legal Measures	Agencies Concerned
a)	Review of "Water Act"	Water Act Review Board, DWR, MLWR
b)	Enactment of "Environmental Management Act"	MET
c)	Establishment of Environmental Water Quality Standards	DWR, MLWR
d)	Amendment of effluent regulations	DWR, MLWR and MHCW
e)	Enactment of Trade Effluent Control By-laws	Local governments

The recent government action to establish the "Zimbabwe National Water Authority" will be the favorable condition to reinforce water management system. In line with this current direction of such a reform, the "Upper Manyame River Basin Authority (UMRBA) is recommended to be established as the inter-agency water management body exclusively in charge of the Study area. Under the UMRBA, the following four sub-organizations are to be established.

- Water Pollution Control Board
- Water Pollution control Coordinating committee
- Water Pollution Control Information Center
- Water Pollution Monitoring Unit

In order to smooth the establishment of the UMRBA, the following actions by the concerned agencies are necessary.

1) Preparation for UMRBA

a) Establishment of Working Committee

This Committee is designed to discuss legal justification, the role of the UMRBA, scope of works and legal process of establishment of the UMRBA.

b) Preparation of TOR for establishment of UMRBA

c) Employment of a consultant to carry out institutional study

d) Administrative/legal procedure for establishment of UMRBA

2) Preparation for training programs

a) Establishment of Working Committee

This Committee is intended to discuss contents and implementation schedule of training programs.

b) Employment of consultants/specialists for preparation of training programs

Training programs to upgrade technical capability of local government staffs in the field of water pollution control will be essential to conduct planning, design, operation and maintenance of public sewerage system and solid waste management. The Department of Development Planning and Coordination (DDPC), MLGRUD is requested to take the initiative in the implementation of training programs.

Financial Arrangements

Financial support system is absolutely necessary for implementation of public sewage works requiring a huge amount of capital. Since local authorities borrow funds from central government on a loan basis, financial assistance from central government would be vital to ease financial conditions of local governments. Financial instruments to alleviate financial burden on local governments are:

- import tax exemption
- Provision of low interest rate of on-lending loan
- Exemption of foreign exchange premium imposed on local governments

The central government may be necessary to finance a part of development costs (contingency and engineering service). The Ministry of Finance, as the lead agency to facilitate financial support system, is recommended to take the following preparatory actions.

1) Financial support system

   a) Preliminary study on impact of financial instruments on budget

   b) Financial study on creation of special account within fiscal budget

   c) Proposal of financial support system

   d) Approval of support system by the Members of Parliament

Feasibility study

Feasibility studies of development schemes for the phased projects should be conducted prior to the construction of the facilities. The study should consider updated socio-economic development plan. This is mainly because the development scale varies according to the development perspective. The central government may be required to seek for multi or bilateral sources of fund to carry out feasibility studies. Feasibility study would be preferably packaged so that a single donor could finance for several development schemes.

Detailed design

Immediately after completion of feasibility studies, the government shall proceed to the implementation of detailed design of the phased development plans.

(2) Implementation Schedule

The two alternatives of implementation schedule are prepared as explained in the preceding sub-section. The details of development schemes are presented in the following page. Implementation plan is depicted in Figure 14.1.

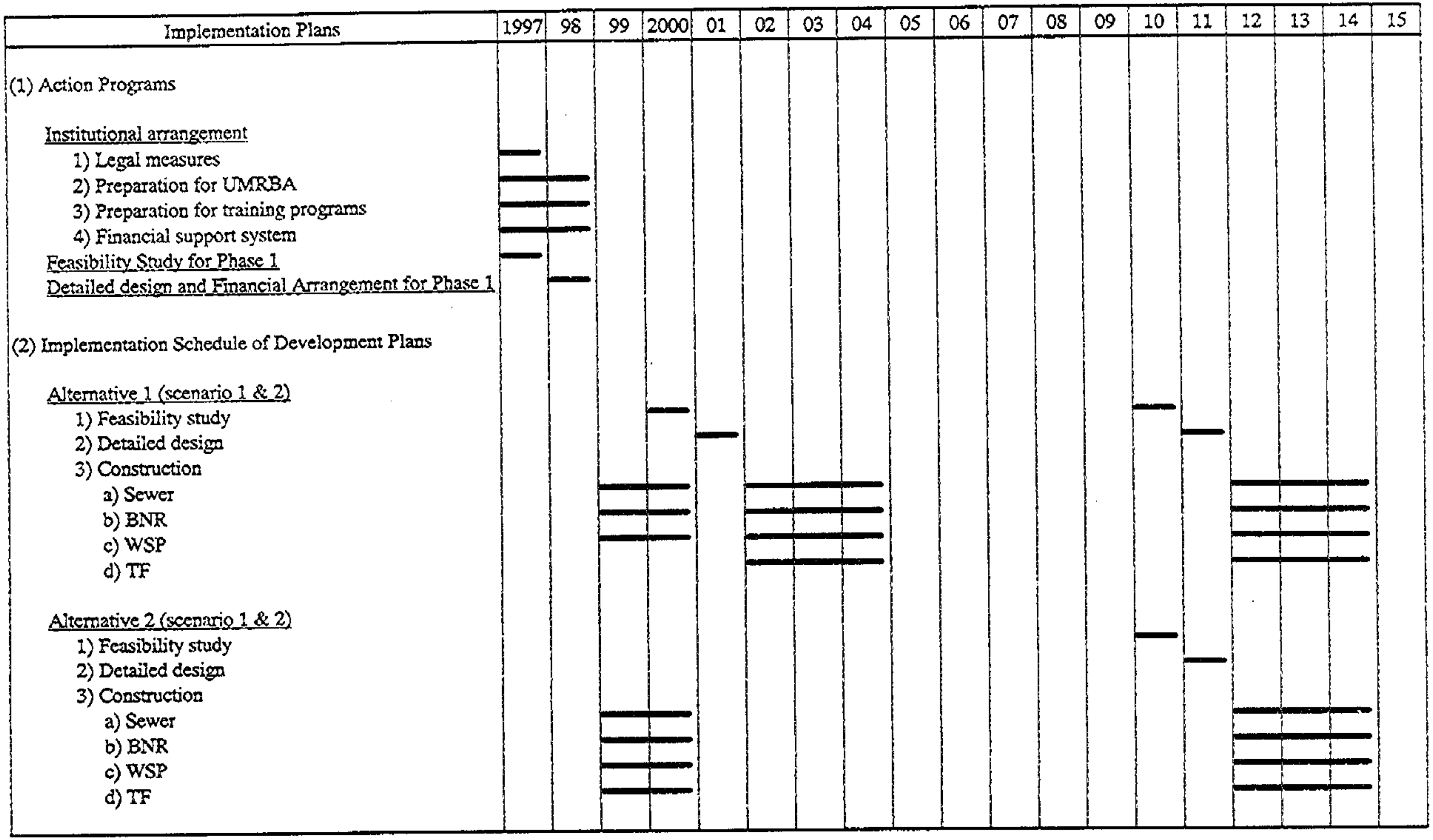
(1) Alternative 1, Scenario 1 & 2

First Phase - 2000	Second Phase 2001 - 2005	Third Phase 2006 - 2015
Short-term development	Middle-term development	Long-term development
Sewer	Sewer	Sewer
Harare (4 works)	Harare (4 works)	Harare (6 works)
Norton	Norton	Norton
Ruwa	Ruwa	Ruwa
Chitungwiza	Chitungwiza	Chitungwiza
BNR	BNR	BNR
Chitungwiza	Harare (4 works)	Harare (4 works)
	Chitungwiza	Chitungwiza
	WSP	WSP
	Harare	Harare (2 works)
	Ruwa	Ruwa
	TF	TF
	Norton	Norton

(2) Alternative 2, Scenario 1 & 2

First Phase - 2000	Second Phase 2001 - 2015
Short-term development	Middle-term development
Sewer	Sewer
Harare (4 works)	Harare (4 works)
Norton	Norton
Ruwa	Ruwa
Chitungwiza	Chitungwiza
BNR	BNR
Chitungwiza	Harare (4 works)
	Chitungwiza
	WSP
	Harare
	Ruwa
	TF
	Norton

Figure 14.4.1 Implementation Plans



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