12.2.4 Design Criteria and Planning for Sewage Collection System

1. Design Criteria

(1) Collection System

The plan and design of the sewage collection systems differ depending on sewage collection method employed. The two alternative collection systems, the separate and the combined systems, are comparatively studied. The characteristics of the two systems can be summarised as follows:

1) Separate system

A separate system has parallel collection systems for sanitary sewage and stormwater runoff, respectively. This system is advantageous to the surrounding environment and to water pollution control. It is also recommendable in an area where the existing collection facilities are maintained in relatively good condition.

2) Combined system

A combined system refers to a system to that collects sanitatory sewage and stormwater run-off by means of combined sewers. This system may be employed as a low-cost alternative to the separate sewer system under the following conditions:

- Discharge of sewage into public water bodies is acceptable during the rainy season.
- Existing drainage/channels presently collecting rain water and sullage can be used as combined sewers and/or receiving water courses for overflow water from diversion chambers.

According to the following reasons, the separate system was adopted:

- Effective water pollution control in the public water bodies.
- Full use of the existing sanitary sewage and drainage facilities to achieve low cost construction.

(2) Hydraulic Calculation for Sanitary Sewage

1) Equation for flow calculation

The Colebrook-White formula was adopted in the previous studies, while the Manning formula is also applicable for flow velocity calculation. Table 12.2.4.1 shows comparative flows by sewer diameter between the Colebrook-White and the Manning formula.

Table 12.2.4.1 Comparison of Velocity Formula

n	Diameter	200m	300m	400m	500m	600m	800mm
	Gradient	0.006	0.004	0.003	0.0025	0.002	0.0015
Velocity	Colebrook	0.94	0.99	1.03	1.08	1.08	1.12
	White						
(ni/sec)	Manning	0.81	0.87	0.91	0.96	0.97	1,02

Note: Roughness coefficient in Manning formula is assumed at 0.013

As a result of comparison, both values are almost the same. The Manning formula was adapted for this study as shown below.

$$V = (1/n) \times R^{(2/3)} \times I^{(1/2)}$$

 $Q = A \times V$

Where, V : velocity of flow (m/sec)

n : roughness coefficient
 R : hydraulic radius (m)
 1 : gradient in decimal
 A : section area (m²)

Standard roughness coefficients to be used by material type are shown in Table 12.2.4.2.

Table 12.2.4.2 Roughness Coefficient

	A
Type of Pipe	Roughness Coefficient
Asbestos Cement Pipe	0.013
Vitrified Clay Pipe	0,013
Plastic Pipe	0.010
Concrete Pipe/Conduit	0.013
Coated Steel Pipe	0.012

2) In-pipe velocity

Minimum Velocity

The design of sewers is made ensuring a minimum earth cover along the existing topography as much as possible. Sewers must be designed to convey peak flows. The sewer pipe size and gradient are selected to ensure the flow close to fullbore at

the ultimate flow, subject also to achieving self-cleansing velocities at least at peak daily flow. The minimum velocities to be used are employed referring to the practice in Zimbabwe (Sanitation Manual Design Procedures):

Reticulation and collector sewers : 0.75 m/sec

Trunk sewers

: 0.60 nt/sec

Maximum Velocity

Velocity shall not exceed 3.0 m/sec in any type of sewer to protect sewer erosion.

(3) Structural Design of Sewerage Facilities

The structural design criteria of the sewerage facilities are, in principle, referred to the "Sanitation Manual Design Procedures."

1) Earth cover of sewers

The minimum earth cover of the sewers should be determined in consideration of the permissible strength on the weight loading and sewer depth to connect to the house connections as shown in Table 12.2.4.3.

On the other hand, working at depths greater than about 3.5 m is costly and difficult; excavation at a depth in excess of 5.0 m is hazardous, requiring special and costly safety measures and should be avoided wherever possible.

Table 12.2.4.3 Minimum Earth Cover of Sewers

Location of Sewer
Sewer Servitude
Road Reserve

2) Minimum size of sewer

The smallest size of sewer to be used is 150 mm, but it is permissible to use 100 mm sewers where the grade is sufficiently steep. Manholes would, in any case, be spaced at a maximum of 30 m apart.

Such spacing would be affected not only due to alignment of sewers but whether or not the ground is excessively steep. The sewer extention from service connection may be 100 mm diameter, with a change to 150 mm diameter at the connecting manhole.

3) Manhole

The manholes are installed at the end of public sewers, the point where the sewer diameter changes, the junction of sewers and the changing point of the vertical and horizontal alignment. The maximum manhole spacing standards in Zimbabwe and Japanese (by sewer diameter) are shown in Table 12.2.4.4 and 12.2.4.5, respectively.

Table 12.2.4.4 Manhole Spacing Standard in Zimbabwe

Sewer Diameter (mm)	Maximum Manhole Spacing (m)
100	30
150 (high density areas)	75
150 (elsewhere)	90
200 to 250	100

Table 12.2.4.5 Manhole Spacing Standard in Japan

Sewer Diameter (mm)	Maximum Manhole Spacing (m)
Under 300	50
350 to 600	75
700 to 1,000	100
1,100 to 1,500	150
Over 1,500	200

4) Pumped system

A major problem in dealing with domestic sewage in Zimbabwe is the removal of the high quantities of sand and grit which occur due to the widespread use of sand for scouring pots and pans. It is essential to provide some form of grit removal system for the raw sewage collection sump to minimise wear of the pump casing and impellers and to prevent the pump sump from filling up with grit.

The design considerations of a sewage pump station including associated screen, grit chamber and force main are enumerated. The design of a conventional pump station with the capacity of more than 5 m³/min. is shown in Figure 12.2.4.1, while a manhole type pump station for those with the inflow of less than 5 m³/min. is shown in Figure 12.2.4.2.

- Design flow for capacity calculation: peak wet weather flow
- Force main

Minimum diameter of force main: 100 mm

Screen

Ramoval method of screening: basically manual rake system

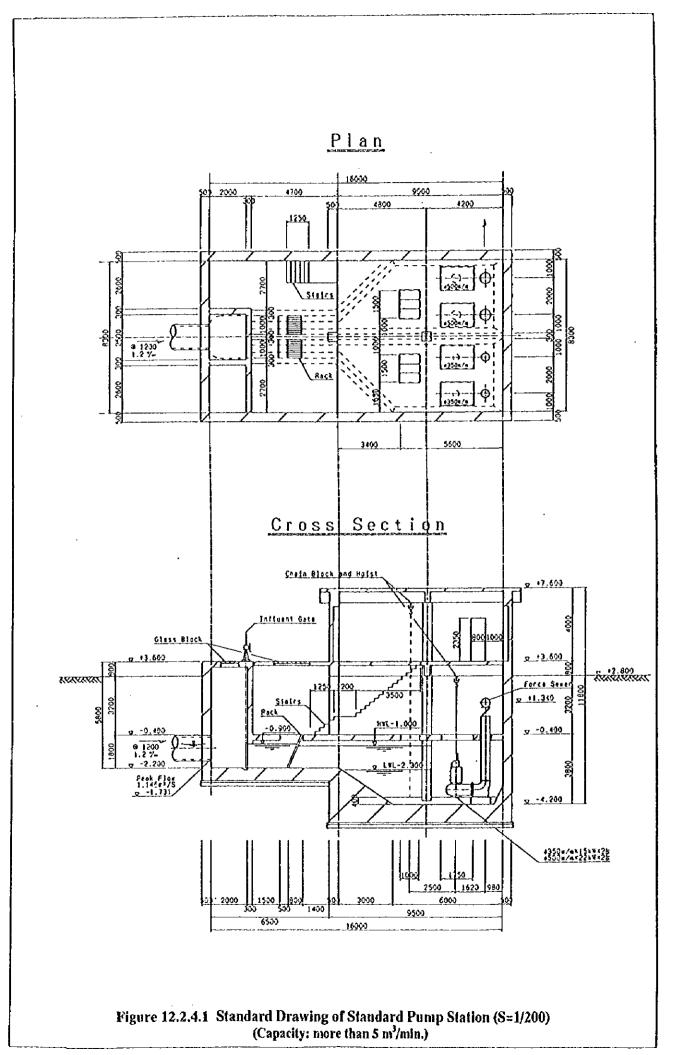
Grit chamber

Number of channels: more than 2 channels

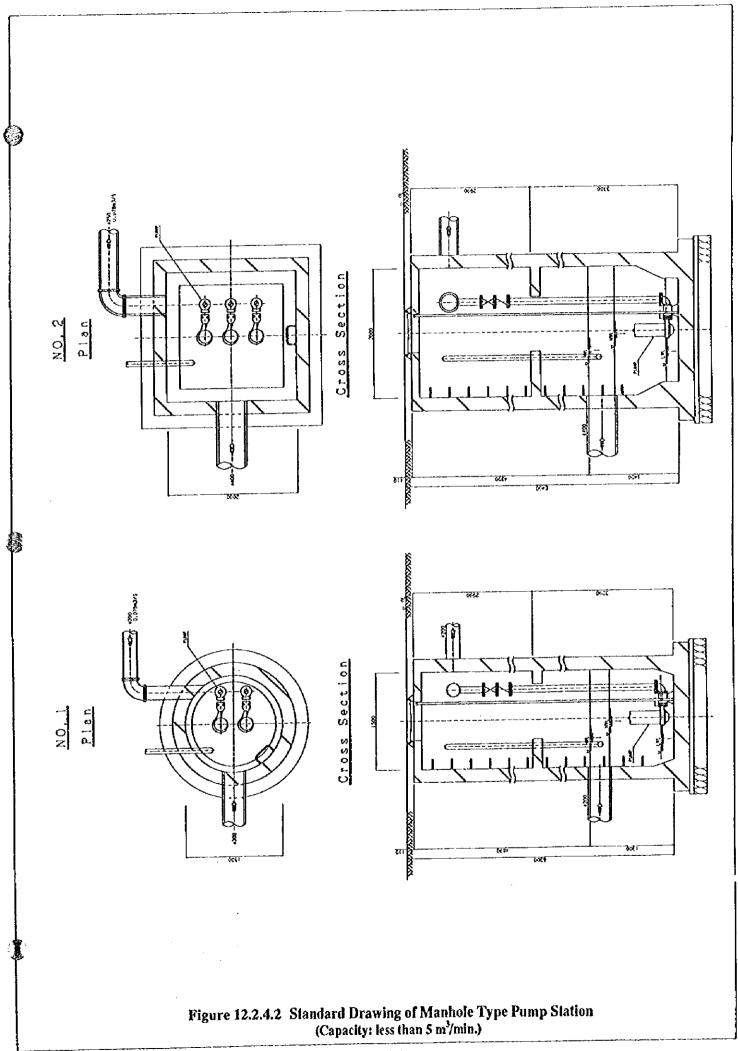
Water surface load: 1,800 m³/ m²/day
Optimum velocity: 0.25 to 0.30 m/sec

Pump equipment

Number of units: more than 2 sets (including 1 standby unit)



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2. Flow Calculation and Design for Trunk Sewers

Table 12.2.4.6 (1) Flow Calculation of Trunk Sewers for Crowborough Treatment Area in Harare

(Scenario-1)		Remarks			Pump Main Pipe					
	Construction	Time		2005	2005	2005	2005	2005	2005	2005
		Flow	(m ³ /sec)	0.591	0.373	0.810	2.135	0.207	1.383	1.607
	Design Sewers	Velocity	(m/sec)	1.18	1.32	1.27	1.49	1.05	1.45	1.42
	Design	Gradient	(1/1,000)	2.0	•	2.0	1.6	3.0	2.0	1.7
		Diameter	(mm)	800	009	006	1,350	200	1,100	1.200
	Sewer	Length	(<u>a</u>)	5.800	1,200	1.700	9.500	7,600	5,100	4,700
	Design Sewage	Quantity, PWWF	(m ³ /sec)	0.423	0.376	0.649	1.760	0.113	1.075	1.188
	Accumulated	Area	(km^2)	8.45	7.50	12.96	35.12	2.27	21.45	23.72
	T*	Area	(km²)	8.45	7.50	5.46	13.71	2.27	21.45	0.00
	Downstream	Sewer No.		4	3	7	MLS	7		STW
	Sewer No.			1	2	8	4	5	9	7

Note: Manning formular with roughness coefficient (0.013)

Unit design Quantity = $(536,800/86,400) / (174-49.87) = 0.0501 \text{ (m}^3/\text{sec}/\text{km}^2)$

*1: Measured values

Table 12.2.4.6 (2) Flow Calculation of Trunk Sewers for Crowborough Treatment Area in Harare

(Scenario-2)	Construction	Time Remarks		2005	2005 Pump Main Pipe	2005	2005	2005	2005	2005	
	8	Flow	(m³/sec)	0.414	0.267	0.591	1.607	0.123	0.929	1.197	
	Sewers	Velocity	(m/sec)	1.08	1.36	1.18	1.42	86.0	1.18	1.26	
	Design Sewers	Gradient	(1/1,000)	2.0	•	2.0	1.7	3.5	1.5	1.5	
		Diameter	(mm)	700	200	800	1,200	400	1,000	1.100	
	Sewer	Length	(H)	5,800	1,200	1,700	9,500	7,600	5.100	4.700	
	Design Sewage	Quantity, PWWF	(m ³ /sec)	0.293	0.260	0.450	1.219	0.079	0.744	0.823	
	Accumulated	Area	(km²)	8.45	7.50	12.96	35.12	2.27	21.45	23.72	(C = 0 0)
	1*	Area	(km²)	8.45	7.50	5,46	13.71	2.27	21.45	0.00	
	Downstream	Sewer No.		4	3	4	STW	7	7	N.I.S	
	Sewer No.			7	2	3	4	5	9	7	

Note: Manning formular with roughness coefficient (0.013)

Unit design Quantity = (372,500/86,400) / (174-49.87) = 0.0347 (m³/sec/km²)

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(Scenario-1)

Table 12.2.4.7 (1) Flow Calculation of Trunk Sewers for Firle Treatment Area in Harare

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1

Sewer No.	Downstream	Ľ#	Accumulated	Design Sewage	Sewer		Design Sewers	Sewers		Construction	
	Sewer No.	Arca	Area	Quantity, PWWF	Length	Diameter	Gradient	Velocity	Flow	Time	Remarks
-		(km²)	(km^2)	(m ³ /sec)	(m)	(mm)	(1/1,000)	(m/sec)	(m ³ /sec)		
r	2	10.10	10.10	569.0	9,200	1,000	1.5	1.18	0.929	2005	
2	3	4.76	14.86	1.022	6,900	1,200	1.3	1.24	1.406	2005	
m	STW	0.00	14.86	1.022	4.800	1,200	13	1.24	1,406	2005	
4	9	10.97	10.97	0.755	4,700	1.000	1.5	1.18	0.929	2005	
5	9	6.31	6.31	0.434	3,400	008	2.0	1.18	0.591	2015	
9	7	0.00	17.28	1.189	400	1,200	1.5	1.34	1.510	2005	
7	8	0.00	17.28	1.189	1,700	1.100	•	1.26	1.197	2005	Pump Main Pipe
8	STW	0.00	17.28	1.189	3.600	1,200	1.5	1.34	1.510	2005	
,											

Note: Maming formular with roughness coefficient (0.013)

Unit design Quantity = (836,200/86,400) / (194.35-52.20-1.46) = 0.0688 (m³/sec/km²)

*1: Measured values

Table 12.2.4.7 (2) Flow Calculation of Trunk Sewers for Firle Treatment Area in Harare

Pump Main Pipe Scenario-2) Remarks Construction 2005 2005 2005 2005 2015 (m³/sec) 1.406 406 1.406 1.072 0.929 .406 0.929 Flow 0.591 Velocity (m/sec) Design Sewers Gradient (1/1.000)Diameter 1,200 1,200 1.000 1,200 1,200 8 (BB) 88 Length 3,600 9,200 6,900 4,700 3,400 1,700 Sewer Ξ Quantity, PWWF Design Sewage (m³/sec) 0.623 0.917 0.917 0.389 1.066 0.677 1.066 Accumulated 17.28 10.10 17.28 17.28 14.86 14.86 10.97 Area (km²) 6.31 10.10 0.00 0.00 0.00 0.00 0.00 Gm? Downstream Sewer No. ST. STW Ø Q œ Sewer No. 4

Note: Manning formular with roughness coefficient (0.013)

Unit design Quantity = (750,300/86,400) / (194.35-52.20-1.46) = 0.0617 (m³/sec/km²)

Table 12.2.4.8 (1) Flow Calculation of Trunk Sewers for Harare South Treatment Area in Harare Expansion

1	7==			î .	7=	i .	i a	ř
(Scenario-1)		Remarks						
	Construction	Time		2005	2005	2005	2005	2005
		Flow	(m³/sec)	2.067	0.561	2.549	0.414	3.635
	Sewers	Velocity	(m/sec)	1.44	1.12	1.44	1.08	1.43
	Design Sewers	Gradient	(1/1,000)	1.5	1.8	1.3	2.0	1.0
		Diameter	(mm)	1,350	800	1.500	700	1,800
	Sewer	Length	(H)	6,800	3,900	4.000	3,000	2,800
	Design Sewage	Quantity	(m ³ /sec)	1.748	0.414	2,404	0.304	3.194
	Accumulated	Area	(km²)	47.90	11.34	65.87	8.33	87.50
	Ø [#	Area	(km²)	47.90	11.34	6.63	8.33	13.30
	Downstream	Sewer No.		3	ಜ	\$	\$	M.LS
	Sewer No.			F	2	3	4	5

Note: Manning formular with roughness coefficient (0.013)

Unit design Quantity = $(276,300/86,400) / 87.50 = 0.0365 \text{ (m}^3/\text{sec/km}^2)$

*1: Measured values

Table 12.2.4.8 (2) Flow Calculation of Trunk Sewers for Harare South Treatment Area in Harare Expansion

Design Sewage Sewer Design Sewers Construction Quantity Length Diameter Gradient Velocity Flow Time 0.901 6.800 1.100 1.5 1.26 1.197 2005 0.213 3.900 600 2.5 1.09 0.307 2005 1.238 4.000 1.200 1.5 1.34 1.510 2005 0.157 3.000 600 2.0 0.97 0.275 2005 1.645 2.800 1.350 1.5 1.44 2.067 2005												(Scenario-2)
Quantity Length Diameter Gradient Velocity Flow Time 0.901 6.800 1.100 1.5 1.26 1.197 2005 0.213 3.900 600 2.5 1.09 0.307 2005 1.238 4,000 1,200 1.5 1.34 1.510 2005 0.157 3.000 600 2.0 0.97 0.275 2005 1.645 2.800 1.350 1.5 1.44 2.067 2005		*1 Ac	Ac	*1 Accumulated	Design Sewage	Sewer		Design :	Sewers		Construction	
(m³/sec) (m) (mm) (1/1,000) (m/sec) (m³/sec) 0.901 6.800 1.100 1.5 1.26 1.197 0.213 3.900 600 2.5 1.09 0.307 1.238 4.000 1,200 1.5 1.34 1.510 0.157 3.000 600 2.0 0.97 0.275 1.645 2.800 1.350 1.5 1.44 2.067	Sewer No. Area	Area			Quantity	Length	Diameter	Gradient	Velocity	Flow	Time	Remarks
0.901 6,800 1,100 1.5 1.26 1.197 0.213 3,900 600 2.5 1.09 0.307 1.238 4,000 1,200 1.5 1.34 1.510 0.157 3,000 600 2.0 0.97 0.275 1.645 2,800 1,350 1.5 1.44 2.067	(km^2)			km²)	(m³/sec)	(H)	(mm)	(1/1,000)	(m/sec)	(m ³ /sec)		
0.213 3.900 600 2.5 1.09 0.307 1.238 4,000 1,200 1.5 1.34 1.510 0.157 3,000 600 2.0 0.97 0.275 1.645 2,800 1,350 1.5 1.44 2.067			4	7.90	0.901	6,800	1,100	1.5	1.26	1.197	2005	
1.238 4,000 1,200 1.5 1.34 1.510 0.157 3,000 600 2.0 0.97 0.275 1.645 2,800 1,350 1.5 1.44 2.067	3 11.34 1	_	1	1.34	0.213	3,900	009	2.5	1.09	0.307	2005	
0.157 3,000 600 2.0 0.97 0.275 1,645 2,800 1,350 1,5 1,44 2,067	5 6.63 6		9	5.87	1.238	4,000	1,200	1.5	1.34	1.510	2005	
1.645 2.800 1.350 1.5 1.44 2.067				3.33	0.157	3,000	009	2.0	0.97	0.275	2005	
	STW 13.30 8		8	7.50	1.645	2,800	1,350	1.5	1.44	2.067	2005	

Note: Manning formular with roughness coefficient (0.013)

Unit design Quantity = $(142,200/86,400)/87.50 = 0.0188 \text{ (m}^3/sec/km^2)$

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Table 12.2.4.9 (1) Flow Calculation of Trunk Sewers for Harare East Treatment Area in Harare Expansion

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(Scenario-1)

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ac	Remarks					
Construction	Time		2015	2005		2005
	Flow	(m ² /sec)	1.197	 0.768	ud S.	1.849
Design Sewers	Velocity	(m/sec)	1.26	1.21		1.29
Design	Diameter Gradient	(1/1,000)	 1.5	1.8		1.2
	Diameter	(mm)	 1,100	 006		1.350
Sewer	Length	(m)	6,700	4,900		400
Design Sewage	Quantity	(m³/sec)	0.833	0.473		1.306
*1 Accumulated	Area	(km²)	16.50	9:36		25.86
T.		(km²)	16.50	9:36		0.00
Sewer No. Downstream	Sewer No.		3	3		STW
Sewer No.			1	2		3

Note: Manning formular with roughness coefficient (0.013)

Unit design Quantity = $(112,900/86,400)/25.86 = 0.0505 \text{ (m}^3/\text{sec}/\text{km}^2)$

*1: Measured values

Table 12.2.4.9 (2) Flow Calculation of Trunk Sewers for Harare East Treatment Area in Harare Expansion

											(F 01 1911000)
		Accumulate	70	1 Accumulated Design Sewage	Sewer		Design Sewers	Sewers		Construction	
	Area	Area		Quantity	Length	Diameter	Gradient	Velocity	Flow	Time	Remarks
(km²) (km²)	(km²)	(lcm²)		(m ³ /sec)	(m)	(mm)	(1/1.000)	(m/sec)	(m³/sec)		
			}								
3 16.50 16.50		16.50	1	0.833	6,700	1,100	1.5	1.26	1.197	2015	
			-				-				
3 9.36 9.36		9:36		0.473	4,900	006	1.8	1.21	0.768	2005	
STW 0.00 25.86		25.86	Ļ	1.306	400	1,350	1.2	1.29	1.849	2005	
			Į,								

Note: Manning formular with roughness coefficient (0.013)

Unit design Quantity = $(112,900/86,400) / 25.86 = 0.0505 \text{ (m}^3/\text{sec}/\text{km}^2)$

Table 12.2.4.10. (1) Flow Calculation of Trunk Sewers for Zengeza Treatment Area in Chitungwiza

(Scenario-1)		Remarks	- ; .		ain Pipe		ain Pipe			OVER CO.				ain Pipe	
		Rei			Pump Main Pipe		Pump Main Pipe				_			Pump Main Pipe	
	Construction	Time		2000	2000	2000	2015	2015	2000	2015	2015	2015	2015	2015	
		Flow	(m^3/sec)	0.512	0.336	0.512	0.148	0.261	0.701	0.261	0.261	0.393	0.929	0.606	
	Sewers	Velocity	(m/sec)	1.02	1.19	1.02	0.93	0.92	1.10	0.92	0.92	1.02	1.18	1.21	
	Design Sewers	Gradient	(1/1,000)	1.5	,	1.5	,	1.8	1.5	1.8	1.8	1.8	1.5		
		Diameter	(mm)	800	8	800	450	009	006	009	009	7007	1,000	800	
	KEWG	Length	(m)	6,700	3,700	3,200	2.200	006	500	6,100	2,900	3,900	300	1,800	
	Design Sewage	Quantity, PWWH	(m³/sec)	0.334	0.334	0.334	0.147	0.147	0.482	0.180	0.156	0.278	0.614	0.614	
I	Accumulated	Area	(km²)	6.81	6.81	6.81	3.00	3.00	9.81	3.66	3.17	29.5	12.50	12.50	pefficient (0.013)
•		Arca	(Jenn ²)	6.81	0.00	0.00	3.00	00:00	0.00	3.66	3.17	2.67	0.00	0.00	with roughness c
	Downstream	Sewer No.		2	3	9	5	9	STW	10	10	10	11	STW	Note: Manning formular with roughness coefficient (0.013)
Norman No	Sewer No.			1	2	3	4	S	9	7	8	6	10	11	Note: N

Unit design Quantity = $(210,500/86,400)/49.61 = 0.0491 \text{ (m}^3/\text{sec}/\text{km}^2)$

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Table 12.2.4.10. (2) Flow Calculation of Trunk Sewers for Zengeza Treatment Area in Chitungwiza

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Downstream Area Area Quantity, PWWF Length Diameter Gradient Velocity Flow Time 2 6.81 (cm²) (m²/sec) (m) (1/1,000) (m/sec) (m³/sec) (m³/s		1	1									
Sewer No. Area Area Quantity, PWWF Length Diameter Gradient Velocity Flow Time 2 6.81 (81 (21 (20 (30 1.5 1.10 (701 2000 3 0.00 6.81 0.513 3.700 800 - 1.02 0.512 2000 6 0.00 6.81 0.513 3.200 900 1.5 1.10 0.701 2000 5 3.00 6.81 0.526 2.200 900 1.5 1.14 0.223 2015 5 3.00 3.00 0.226 2.200 500 - 1.14 0.223 2015 5 0.00 3.00 0.226 2.200 500 1.8 1.02 0.393 2015 5 0.00 3.00 0.226 900 700 1.8 1.02 0.393 2015 5 0.00 3.60 0.276 5.00	Seect No.	Downstream	7	Accumulated	Design Sewage	Sewer		Design	Sewers		Construction	
Charles		Sewer No.	Area	Arca	Quantity, PWWF	Length	Diameter	Gradient	Velocity	Flow	Time	Remarks
2 6.81 6.81 0.513 6.700 900 1.5 1.10 0.701 2000 2000 6.81 0.513 3.700 800 - 1.5 1.10 0.701 2000 2000 2.51 0.513 3.700 800 - 1.02 0.512 2000 2000 2.500 2.200 900 1.5 1.10 0.701 2000 2000 2.500 2.200 900 1.5 1.14 0.223 2015 2000 2.51 0.000 2.50			(km²)	(km²)	(m ³ /sec)	(E)	(mm)	(1/1,000)	(m/sec)	(m ³ /sec)		
3 0.00 6.81 0.513 3.700 800 - 1.02 0.512 2000 6 0.00 6.81 0.513 3.200 900 1.5 1.10 0.701 2000 5 3.00 3.00 0.226 2.200 500 - 1.14 0.223 2015 8TW 0.00 3.00 0.226 900 1.00 1.8 1.02 0.393 2015 8TW 0.00 9.81 0.740 500 1.00 1.8 1.02 0.393 2015 10 3.66 0.276 6,100 700 1.8 1.02 0.393 2015 10 5.67 5.67 0.428 3,900 900 1.5 1.10 0.701 2015 11 0.00 12.50 0.943 1,800 1,000 - 1.22 0.959 2015 11.3 distribution of the control of the co	1	2	18.9	6.81	0.513	6,700	006	1.5	1.10	0.701	2000	
6 0.00 6.81 0.513 3.200 900 1.5 1.10 0.701 2000 5 3.00 3.00 0.226 2.200 500 - 1.14 0.223 2015 5 0.00 3.00 0.226 900 700 1.8 1.02 0.393 2015 10 3.66 3.66 0.276 6,100 700 1.8 1.02 0.393 2015 10 3.17 3.17 0.239 5.900 700 1.8 1.02 0.393 2015 11 0.00 12.50 0.943 3.900 900 1.2 1.19 1.351 2015 5 5 5 5 5 5 5 5 5	2	3	0.00	6.81	0.513	3,700	88		1.02	0.512	2000	Pump Main Pipe
5 3.00 3.00 0.226 2.200 500 - 1.14 0.223 2015 STW 0.00 9.81 0.740 500 700 1.8 1.02 0.393 2015 10 3.66 3.66 0.276 6,100 700 1.8 1.02 0.393 2015 10 5.67 5.67 0.428 3,900 900 1.8 1.02 0.393 2015 11 0.00 12.50 0.943 3,900 900 1.5 1.10 0.701 2015 STW 0.00 12.50 0.943 1,800 1,000 - 1.25 0.959 2015 11 0.00 12.50 0.943 1,800 1,000 - 1.25 0.959 2015	3	9	0.00	6.81	0.513	3,200	006	1.5	1.10	0.701	2000	
6 0.00 3.00 0.226 900 700 1.8 1.02 0.393 2015 STW 0.00 9.81 0.740 500 1.000 1.5 1.18 0.929 2000 10 3.66 0.276 6,100 700 1.8 1.02 0.393 2015 10 3.17 0.239 5.900 700 1.8 1.02 0.393 2015 11 0.00 12.50 0.943 3.00 1.200 1.2 1.19 1.351 2015 STW 0.00 12.50 0.943 1.800 1.000 - 1.22 0.959 2015 11 0.00 12.50 0.943 1.800 1.000 - 1.22 0.959 2015 11 0.00 12.50 0.943 1.800 1.000 - 1.22 0.959 2015	4	5	3.00	3.00	0.226	2,200	2005		1.14	0.223	2015	Pump Main Pipe
STW 0.00 9.81 0.740 500 1.000 1.5 1.18 0.929 2000 1.00 3.66 0.276 6.100 700 1.8 1.02 0.393 2015 1.00 1.5 1.10 0.701 2015 1.00 1.2.50 0.943 3.900 9.00 1.2 1.19 1.351 2015 1.251 0.943 1.800 1.000 1.22 0.959 2015 1.251 0.955 2015 1.251 0.955 2015 1.251 0.955 2015 1.251 0.955 2015 1.251 0.955 2015 1.251 0.955 2015 1.251 0.955 2015 1.251 2015 1.251 2015 20	5	9	0.00	3.00	0.226	8	780	1.8	1.02	0.393	2015	
10 3.66 3.66 0.276 6,100 700 1.8 1.02 0.393 2015 1.0 3.17 3.17 0.239 5.900 700 1.8 1.02 0.393 2015 1.0 5.67 5.67 0.428 3,900 900 1.5 1.10 0.701 2015 2015 21W 0.00 12.50 0.943 3.00 1,200 1.20 1.351 2015	9	MIS	00.00	9.81	0.740	200	1,000	1.5	1.18	0.929	2000	
10 3.66 3.66 0.276 6,100 700 1.8 1.02 0.393 2015 10 3.17 3.17 0.239 5,900 700 1.8 1.02 0.393 2015 11 0.00 12.50 0.943 3.900 9.00 1.2 1.19 1.351 2015 STW 0.00 12.50 0.943 1,800 1,000 - 1.22 0.959 2015 Ote: Manning formular with roughness coefficient (0.013)												
10 3.17 3.17 0.239 5.900 700 1.8 1.02 0.393 2015 10 5.67 5.67 0.428 3.900 900 1.5 1.10 0.701 2015 11 0.00 12.50 0.943 3.00 1.200 1.2 1.19 1.351 2015 STW 0.00 12.50 0.943 1.800 1.000 - 1.22 0.959 2015 The daming formular with roughness coefficient (0.013)	7	10	3.66	3,66	0.276	6,100	700	1.8	1.02	0.393	2015	
10 5.67 5.67 0.428 3,900 900 1.5 1.10 0.701 2015 11 0.00 12.50 0.943 300 1,200 1.2 1.19 1.351 2015 STW 0.00 12.50 0.943 1,800 1,000 - 1.22 0.959 2015 Ote: Manning formular with roughness coefficient (0.013)	8	10	3.17	3.17	0.239	5,900	92	1.8	1.02	0.393	2015	
11 0.00 12.50 0.943 300 1,200 1.19 1,351 2015	6	10	5.67	2.67	0.428	3,900	88	1.5	1.10	0.701	2015	
0.943 1,800 1,000 - 1.22 0.959 2015	10	11	0.00	12.50	0.943	300	1,200	1.2	1.19	1.351	2015	
Note: Manning formular with roughness coefficient (0.013)	11	STW	0.00	12.50	0.943	1,800	1,000	,	1.22	0.959	2015	Pump Main Pipe
Table Andrew (2000) (2000) (2000) (2000) (2000) (2000) (2000)	Note:	Manning formular	with roughness ca	sefficient (0.013)								
	-	Thais decima Change	93/000 - CE) w.	0 - 13 08 / (MV)	Med (13/22012)							

Table 12.2.4.11. (1) Flow Calculation of Trunk Sewers for Norton Treatment Area in Norton

(Scenario-1)		Remarks			Pump Main Pipe			Pump Main Pipe						
	Construction	Time		2005	2015	2015	2005	2005	2005	2005	2005	2015	2015	
		Flow	(m ³ /sec)	0.701	0.092	0.393	0.061	0.233	0.393	0.156	1.197	0.207	0.561	
	Sewers	Velocity	(m/sec)	1.10	0.96	1.02	0.87	1.19	1.02	0.98	1.26	1.05	1.12	
	Design Sewers	Gradient	(1/1,000)	1.5	-	1.8	4.0	•	1.8	3.0	1.5	3.0	1.8	
		Diameter	(mm)	006	350	700	300	200	700	450	1,100	200	800	
	Sewer	Length	(m)	6,400	1.600	2,100	1,900	1,200	1.700	2,600	1.800	2,100	4.900	
	Design Sewage	Quantity, PWWF	(m ³ /sec)	0.514	0.000	0.207	0.027	0.234	0.234	0.079	0.827	0.128	0.331	
	Accumulated	Area	(km²)	18.18	3.17	7.30	96:0	8.26	8.26	5.79	29.23	4.51	11.70	
	ĭ	Area	(km²)	18.18	3.17	4.13	96'0	0.00	0.00	2.79	0.00	4.51	7.19	
	Downstream	Sewer No.		8	3	5	S	9	8	8	MLS	10	MLS	
	Sewer No.			1	2	3	7	5	9	7	8	6	10	

Note: Manning formular with roughness coefficient (0.013) Unit design Quantity = $(123,900/86,400) / 50.63 = 0.0283 \text{ (m}^3/\text{sec}/\text{km}^2)$

Table 12.2.4.11. (2) Flow Calculation of Trunk Sewers for Norton Treatment Area in Norton

1

(Scenario-2)

Sewer No.	Downstream	1.	Accumulated	Design Sewage	Sewer		Design Sewers	Sewers		Construction	
	Sewer No.	Area	Area	Quantity, PWWF	Length	Diameter	Gradient	Velocity	Flow	Time	Remarks
		(km²)	(km²)	(m ³ /sec)	(m)	(mm)	(1/1,000)	(m/sec)	(m ³ /sec)		
	8	18.18	18.18	0.331	6,400	800	1.8	1.12	0.561	2005	
2	3	3.17	3.17	0.058	1,600	300	-	0.82	0.058	2015	Pump Main Pipe
60	5	4.13	7.30	0.133	2,100	200	3.0	1.05	0.207	2015	
4	5	0.96	0.96	0.017	1,900	250	5.0	98'0	0.042	2002	
8	9	00.00	8.26	0.150	1,200	450	,	0.95	0.151	2005	Pump Main Pipe
9	8	00.00	8.26	0.150	1,700	009	2.0	0.97	0.275	2002	
1	8	2.79	2.79	0.051	2,600	400	3.0	0.91	0.114	2005	
∞	WIS	0.00	29.23	0.532	1.800	006	1.5	1.10	0.701	2005	
6	10	4.51	4.51	0.082	2,100	450	3.0	86'0	0.156	2015	
10	STW	7.19	11.70	0.213	4,900	909	2.5	1.09	0.307	2015	
Note:	Note - Manning formular with roughness coefficient (0.013)	r with ronotiness	poefficient (0.013								

Note: Manning formular with roughness coefficient (0.013)

Unit design Quantity = (79,400/86,400) / 50.63 = 0.0182 ($m^3/scc/km^2$)
*1: Measured values

Table 12.2.4.12. (1) Flow Calculation of Trunk Sewers for Ruwa Treatment Area in Ruwa

Sewer No. Downstream *1 Accumulated Design Sewage Sewer No. Design Sewers Sewer No. Area Area Quantity, PWWF Length Lingth Diameter Diameter Diameter Gradient Diameter Gradient Velocity Flow Flow Flow Time Time Remarks 1 2 1.50 0.046 1.800 250 - 0.94 0.046 2.005 Pump Main Pipe 2 4 0.00 1.50 0.046 2.500 350 4.0 0.94 0.046 2.005 Pump Main Pipe 3 4 0.00 1.50 0.046 2.500 350 4.0 0.95 0.092 2005 Pump Main Pipe 4 10 0.00 5.82 0.132 2.400 - 1.06 0.133 2.005 Pump Main Pipe 5 6 0.09 5.82 0.178 700 60 2.5 1.09 0.305 Pump Main Pipe 6 9 4.49 5.48 0.168 2.700 600 2.5												(Scenario-1)
Sewer No. Area Area Quantity, PWWF Length Diameter Diameter of Tadient Gradient Velocity Flow Time Time 2 (km²) (km²) (m³/sec) (m) (1/1,000) (m³/sec) (m³/sec)	Sewer No.	Downstream	7		Design Sewage	Sewer		Design	Scwers		Construction	
(km²) (km²) (m³/sec) (m) (1/1,000) (m/sec) (m³/sec) 2 1.50 1.50 0.046 1.800 250 - 0.94 0.046 2.05 4 0.00 1.50 0.046 2.500 350 4.0 0.96 0.095 2005 10 0.00 1.50 0.046 2.500 350 4.0 0.96 0.095 2005 10 0.00 5.82 0.178 700 600 2.5 1.09 0.307 2005 5 0.99 0.99 0.030 1,600 2.0 2.5 1.09 0.307 2005 9 4.49 5.48 0.168 2,700 600 2.5 1.09 0.307 2005 9 2.60 2.60 0.080 2,800 4.0 1.13 0.189 2.05 10 0.00 11.52 0.353 1,500 4.0 1.18 0.560 2.05		Sewer No.	Area	Area	Quantity, PWWF	Length	Diameter	Gradient	Velocity	Flow	Time	Remarks
2 1.50 0.046 1.800 250 - 0.94 0.046 2.500 350 - 0.94 0.046 2.500 350 - 0.94 0.092 2.005 4 0.00 1.50 0.046 2.500 350 - 0.94 0.092 2.005 10 0.00 5.82 0.178 700 600 2.5 1.06 0.133 2005 9 4.49 5.48 0.030 1,600 2.0 - 0.96 0.307 2005 9 3.44 3.44 0.105 3.300 450 2.5 1.09 0.307 2005 9 2.60 2.60 0.080 2.800 450 3.5 1.06 0.169 2005 10 0.00 11.52 0.353 1,500 800 2.0 1.11 0.169 2.005 11 1.11 18.45 0.565 2.200 800 1.12 0.105			(km²)	(km^2)	(m³/sec)	(m)	(mm)	(1/1,000)	(m/sec)	(m ³ /sec)		
4 0.00 1.50 0.046 2,500 350 4.0 0.96 0.092 2005 4 4.32 4.32 0.132 2,400 400 - 1.06 0.133 2005 10 0.00 5.82 0.132 2,400 600 2.5 1.09 0.307 2005 6 0.09 6.09 0.030 1,600 200 - 0.96 0.030 2005 2005 2005 9 4.49 5.48 0.168 2,700 600 2.5 1.09 0.307 2005 9 2.40 3.44 0.105 3,300 450 2.5 1.13 0.180 2.005 9 2.60 1.550 800 2.5 1.06 0.189 2.005 10 0.00 11.5 0.080 2.800 450 2.5 1.18 0.189 2.05 11 1.11 18.45 0.565 1.300 1.00	F	2	1.50	1.50	0.046	1,800	250		0.94	0.046	2005	Pump Main Pipe
4 4.32 6.132 2.400 400 - 1.06 0.133 2005 10 0.00 5.82 0.178 700 600 2.5 1.09 0.307 2005 6 0.99 0.030 0.168 2,700 600 2.5 1.09 0.307 2005 9 3.44 3.44 0.105 3,300 450 3.5 1.09 0.307 2005 9 2.60 2.60 0.080 2.800 450 3.5 1.06 0.169 2.005 10 0.00 11.52 0.353 1,500 800 2.0 1.18 0.591 2005 11 1.11 18.45 0.565 1,300 1.00 1.12 0.560 2.00 STW 0.00 18.45 0.565 2,200 9.0 - 1.12 0.560 2.005	2	4	00:00	1.50	0.046	2,500	350	4.0	96.0	0.092	2005	
10 0.00 5.82 0.178 700 600 2.5 1.09 0.307 2005 6 0.99 0.030 1,600 200 - 0.96 0.030 2005 9 4.49 5.48 0.105 3,300 450 4.0 1.13 0.180 2005 9 2.60 2.60 0.080 2,800 450 3.5 1.06 0.169 2005 10 0.00 11.52 0.353 1,500 800 2.0 1.18 0.591 2005 11 1.11 18.45 0.565 1,300 1.00 1.8 1.30 1.016 2050 STW 0.00 18.45 0.565 2,200 800 - 1.12 0.560 2005	3	4	4.32	4.32	0.132	2,400	400	•	1.06	0.133	2005	Pump Main Pipe
6 0.99 0.090 0.030 1,600 200 - 0.096 0.030 2005 9 4.49 5.48 0.168 2,700 600 2.5 1.09 0.307 2005 9 3.44 3.44 0.105 2,800 450 4.0 1.13 0.180 2005 10 0.00 11.52 0.353 1,500 800 2.0 1.18 0.591 2005 11 1.11 18.45 0.565 1,300 1.00 1.8 1.30 1.010 1.11 2005 STW 0.00 18.45 0.565 2,200 800 - 1.12 0.560 2005	4	10	0.00	5.82	0.178	700	009	2.5	1.09	0.307	2005	
9 4.49 5.48 0.168 2,700 600 2.5 1.09 0.307 2005 9 2.60 2.60 0.080 2,800 450 4.0 1.13 0.169 2005 10 0.00 11.52 0.353 1,500 800 2.0 1.18 0.591 2005 11 1.11 18.45 0.565 1,300 1,000 1.8 1.12 0.560 2005 STW 0.00 18.45 0.565 2,200 800 - 1.12 0.560 2005	5	9	0.99	0.99	0:030	1,600	200	•	96'0	0:030	2005	Pump Main Pipe
9 3.44 3.44 0.105 3.300 450 4.0 1.13 0.180 2005 9 2.60 2.60 0.080 2.800 450 3.5 1.06 0.169 2005 10 0.00 11.52 0.353 1,500 800 2.0 1.18 0.591 2005 11 1.11 18.45 0.565 1,300 1,000 1.8 1.30 1.016 2005 STW 0.00 18.45 0.565 2,200 800 - 1.12 0.560 2005	9	6	4.49	5.48	0.168	2,700	009	2.5	1.09	0.307	2005	
9 2.60 2.60 0.080 2.800 450 3.5 1.06 0.169 2005 10 0.00 11.52 0.353 1,500 800 2.0 1.18 0.591 2005 11 1.11 18.45 0.565 1,300 1.00 1.8 1.016 2005 STW 0.00 18.45 0.565 2,200 800 - 1.12 0.560 2005		6	3.44	3.44	0.105	3,300	450	4.0	1.13	0.180	2005	
10 0.00 11.52 0.353 1,500 800 2.0 1.18 0.591 2005 11 1.11 18.45 0.565 1,300 1,000 1.8 1.30 1,016 2005 STW 0.00 18.45 0.565 2,200 800 - 1.12 0.560 2005	8	6	2.60	2.60	0.080	2,800	450	3.5	1.06	0.169	2002	
11 1.11 18.45 0.565 1,300 1,000 1.8 1.30 1.016 2005 STW 0.00 18.45 0.565 2,200 800 - 1.12 0.560 2005	6	10	0.00	11.52	0.353	1,500	008	2.0	1.18	0.591	2005	
0.00 18.45 0.565 2.200 800 - 1.12 0.560 2005	10	11	1.11	18.45	0.565	1,300	1,000	1.8	1.30	1.016	2005	
	11	STW	0.00	18.45	0.565	2,200	008		1.12	0.560	2005	Pump Main Pipe

Note: Manning formular with roughness coefficient (0.013)
Unit design Quantity = (68,900/86,400) / 26.10 = 0.0306 (m³/sec/km²)

*1 : Measured values

8

8

Table 12.2.4.12. (2) Flow Calculation of Trunk Sewers for Ruwa Treatment Area in Ruwa

· T

(Scenario-2)

9

Area Ouantity, PWWF
<u> </u>
1.50 0.017
1.50 0.017
4.32 0.049
5.82 0.066
0.99 0.011
5.48 0.062
3.44 0.039
2.60 0.029
11.52 0.130
18.45 0.208
18.45 0.208

Note: Manning formular with roughness coefficient (0.013)

Unit design Quantity = (25,500/86,400) / 26.10 = 0.0113 (m³/sec/km²)

1: Measured values

3. Capacity Calculation of Proposed Pump Station

Table 12.2.4.13 (1) Capacity Calculation of Pump Station in Crowborough Treatment Area (Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec	-	0.423
	Q2	m³/min	Q1 x 60	25.38

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Турс		-	Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec	-	0.423
	Q2	m³/đay	Q1 x 86,400	36,547
Water Surface Load	WSL	m³/m²/day	-	1,800
Required Surface Area	RSA	m²	Q2 / WSL	20.30
Basin Number	BN	basin	-	2
Average Velocity	Y	m/sec	-	0.30
Depth	II	m	-	0.50
Width	W1	m	Q1 / (V x H)	2.82
Therefore	W2	m	-	3.00
Length	Ll	m	RSA / W2	6.77
Therefore	L2	m	-	7.00
Screen Type		-	Manual Removal Type Bar Sci	reen
(Dimension)				
Width	W2	m	W2/BN	1.50
Length	L2	m	•	7.00
Depth	Н	m	-	0.50
Basin Number	BN	-	-	2

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	36,547
	Q2	m³/min	Q1 / 1,440	25.38
Pump Unit	PU	unit	(Including 1 Stand By Pump)	5
Pump Discharge per Unit	DU1	m³/min	Q2 / (PU - 1)	6.35
Therefore	DU2	m³/min	-	6.40
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	234
Therefore	D2	mm		250
Required Pump Total Head	TH	m	assumption	20.00
Required Pump Power	PP1	kw	$(0.163 \times DU2 \times TH / 0.7) \times 1.1$	34.28
Therefore	PP2	kw	-	37
(Dimension)			•	
Diameter	D2	mm	-	250
Pump Discharge per Unit	DU2	m³/min	-	6.40
Pump Total Head	TH	m	•	20.00
Pump Power	PP2	kw	•	37
Pump Unit	PU	unit	(Including 1 Stand By Pump)	5



Table 12.2.4.13 (2) Capacity Calculation of Pump Station in Crowborough Treatment Area (Scenario-2)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec	•	0.293
	Q2		Q1 x 60	17.58

(2) Grit Chamber and Screen

Grit Chamber and Screen	Carry Company of the		o ya magaan lar dayya ku ku tu wa ya qa ahaa ku tu da ahaa ahaa ku ku tu ku k Agaa katu ku gaya ga ay ay ay ay ay ay ku ku tu da ahaa ahaa ku tu da ahaa ahaa ahaa ku ku ku ku ku ku ku ku k	
Item	Symbol	Unit	Calculation	Adoption
Туре		-	Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec	-	0.293
,	Q2	m³/day	Q1 x 86,400	25,315
Water Surface Load	WSL	m³/m²/day		1,800
Required Surface Area	RSA	m²	Q2 / WSL	14.06
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	Н	m	-	0.50
Width	WI	m	Q1/(V x H)	1.95
Therefore	W2	m	•	2.00
Length	Ll	m	RSA / W2	7.03
Therefore	L2	m	•	7.00
Screen Type	-		Manual Removal Type Bar Sci	reen
(Dimension)				
Width	W2	m	W2/BN	1.00
Length	L2	m.		7.00
Depth	Н	m	_	0.50
Basin Number	BN	-		2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	25,315
	Q2	m³/min	Q1 / 1,440	17.58
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4
Pump Discharge per Unit	DU1	m³/min	Q2/(PU-1)	5.86
Therefore	DU2	m³/min		6.00
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	226
Therefore	D2	mm	•	250
Required Pump Total Head	TH	m	assumption	20.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	32.13
Therefore	PP2	kw		37
(Dimension)				0.50
Diameter	D2	mm	-	250
Pump Discharge per Unit	DU2	m³/min		6.00
Pump Total Head	ТН	m		20.00
Pump Power	PP2	kw		37
Pomp Unit	PU	unit	(Including 1 Stand By Pump)	4

Table 12.2.4.14 (1) Capacity Calculation of Pump Station in Firle Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec	=	1.189
	Q2	m³/min	Q1 x 60	71.34

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Гуре	-		Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec		1.189
	Q2	m³/day	Q1 x 86,400	102,730
Water Surface Load	WSL	m³/m²/day	_	1,800
Required Surface Area	RSA	m²	Q2 / WSL	57.07
Basin Number	BN	basin	-	6
Average Velocity	V	m/sec	_	0.30
Depth	Н	m	•	0.50
Width	W1	m	Q1/(V x H)	7.93
Therefore	W2	m	•	8.00
Length	Ll	m	RSA/W2	7.13
Therefore	L2	m		7.50
Screen Type	•	-	Manual Removal Type Bar Sci	een
(Dimension)				
Width	W2	m	W2/BN	1.33
Length	L2	m		7.50
Depth	Н	m	a second	0.50
Basin Number	BN	-	The state of the s	6

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	102,730
	Q2	m³/min	Q1/1,440	71.34
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6
Pump Discharge per Unit	DUI	m³/min	Q2/(PU-1)	14.27
Therefore	DU2	m³/min	<u> </u>	14.30
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	349
Therefore	D2	mm		350
Required Pump Total Head	TH	m	assumption	30.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	114.88
Therefore	PP2	kw	-	110
(Dimension)				
Diameter	D2	mm	•	350
Pump Discharge per Unit	DU2	m³/min	-	14.30
Pump Total Head	TH	m	-	30.00
Pump Power	PP2	kw		110
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6

(4) Construction Time:

2005;

Pump equipment = 4 units

2015;

Pump equipment = 2 units

Table 12.2.4.14 (2) Capacity Calculation of Pump Station in Firle Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec	-	1.066
	Q2	m³/min	Q1 x 60	63.96

(2) Grit Chamber and Screen

Gril Chamber and Screen						
Item	Symbol	Unit	Calculation	Adoption		
Туре		<u> </u>	Parallel Flow Type			
Design Sewage Quantity	Q1	m³/sec	•	1.066		
	Q2	m³/day	Q1 x 86,400	92,102		
Water Surface Load	WSL	m³/m²/day	•	1,800		
Required Surface Area	RSA	m²	Q2/WSL	51.17		
Basin Number	BN	basin	-	6		
Average Velocity	V	m/sec	-	0.30		
Depth	Н	m	•	0.50		
Width	WI	m	Q1 / (V x H)	7.11		
Therefore	W2	m	-	7.20		
Length	L1	m	RSA/W2	7.11		
Therefore	L2	m	-	7.00		
Screen Type	-	-	Manual Removal Type Bar Sc	een		
(Dimension)						
Width	W2	m	W2/BN	1,20		
Length	L2	m		7.00		
Depth	H	m	-	0.50		
Basin Number	BN	· ·	-	6		

(3) Capacity Calculation of Pump Equipment

<u> Item</u>	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	92,102
<i>3 3</i> - <i>7</i>	Q2	m³/min	Q1 / 1,440	63.96
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6
Pump Discharge per Unit	DU1	m³/min	Q2/(PU - 1)	12.79
Therefore	DU2	m³/min	<u>-</u>	12.80
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	330
Therefore	D2	mm		350
Required Pump Total Head	TH	m	assumption	30.00
Required Pump Power	PP1	kw	$(0.163 \times DU2 \times TH / 0.7) \times 1.1$	102.83
Therefore	PP2	kw	_	110
(Dimension)				,
Diameter	D2	mm	•	350
Pump Discharge per Unit	DU2	m³/min	-	12.80
Pump Total Head	TH	m	-	30.00
Pump Power	PP2	kw	-	110
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6

(4) Construction Time:

2005;

Pump equipment = 4 units

2015;

Pump equipment = 2 units

Table 12.2.4.15 (1) Capacity Calculation of Pump Station in Harare South Treatment Area (Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec	-	0.493
	Q2	m³/min	Q1 x 60	29.58

 $Q = 13.5 \text{ km}^2 \times 0.0365 \text{ m}^3/\text{sec/km}^2 = 0.493 \text{ m}^3/\text{sec}$

(2) Grit Chamber and Screen

Grit Chamber and Screen				
Item	Symbol	Unit	Calculation	Adoption
Туре	-		Parallel Flow Type	
Design Sewage Quantity	Qí	m³/sec	-	0.493
	Q2	m³/day	Q1 x 86,400	42,595
Water Surface Load	WSL	m³/m²/day	-	1,800
Required Surface Area	RSA	m²	Q2/WSL	23.66
Basin Number	BN	basin	-	3
Average Velocity	V	m/sec	•	0.30
Depth	Н	m	· •	0.50
Width	W1	m	Q1 / (V x H)	3.29
Therefore	W2	m	-	3.30
Length	L1	m	RSA/W2	7.17
Therefore	L2	m	-	7.50
Screen Type	-		Manual Removal Type Bar Sci	reen
(Dimension)				
Width	W2	៣	W2/BN	1.10
Length	L2	m	•	7.50
Depth	31	m	•	0.50
Basin Number	BN			3

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	42,595
	Q2	m³/min	Q1 / 1,440	29.58
Pump Unit	PU	unit	(Including 1 Stand By Pump)	5
Pump Discharge per Unit	DU1	m³/min	Q2 / (PU - 1)	7.40
Therefore	DU2	m³/min	•	7.50
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	253
Therefore	D2	mm	-	250
Required Pump Total Head	TH	m	assumption	20.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	40.17
Therefore	PP2	kw	•	37
(Dimension)				
Diameter	D2	mm	-	250
Pump Discharge per Unit	DU2	m³/min	-	7.50
Pump Total Head	TH	m		20.00
Pump Power	PP2	kw	-	37
Punip Unit	PU	unit	(Including 1 Stand By Pump)	5

Table 12.2.4.15 (2) Capacity Calculation of Pump Station in Harare South Treatment Area

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec	+	0.254
	Q2		Q1 x 60	15.24

 $Q = 13.5 \text{ km}^2 \times 0.0188 \text{ m}^3/\text{sec/km}^2 = 0.254 \text{ m}^3/\text{sec}$

(2) Grit Chamber and Screen

Item Symbol Unit Calculation Adoption						
<u>Item</u>	Symbol	Unit	Calculation	Adoption		
Гуре	-		Parallel Flow Type			
Design Sewage Quantity	Q1	m³/sec	•	0.254		
ottigu osmogi ta 117	Q2	m³/day	Q1 x 86,400	21,946		
Water Surface Load	WSL	m³/m²/day		1,800		
Required Surface Area	RSA	m²	Q2/WSL	12.19		
Basin Number	BN	basin		2		
Average Velocity	v	m/sec	<u>-</u>	0.30		
Depth	H	m	•	0.50		
Width	W1	m	Q1 / (V x H)	1.69		
Therefore	W2	m	-	1.80		
Length	L1	m	RSA / W2	6.77		
Therefore	L2	m	-	7.00		
Screen Type	-	<u>-</u>	Manual Removal Type Bar Sci	reen		
(Dimension)				THE PERSON NAMED IN COLUMN TWO IS NOT THE OWNER.		
Width	W2	m	W2/BN	0.90		
Length	L2	m		7.00		
Depth	Н	m	_	0.50		
Basin Number	BN	•	_	2		

(3) Capacity Calculation of Pump Equipment

ltem	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	21,946
Design de mage Quantity	Q2	m³/min	Q1 / 1,440	15.24
Pump Unit	PU	unit	(Including 1 Stand By Pump)	5
Pump Discharge per Unit	DU1	m³/min	Q2/(PU - 1)	3.81
Therefore	DU2	m³/mio	-	4.00
Required Pump Diameter	D1	ומות	146 x (DU2 / V) 1/2	185
Therefore	D2	mm	-	200
Required Pump Total Head	TH	m	assumption	20.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	21.42
Therefore	PP2	kw		22
(Dimension)		ang a samuel and the same of t		
Diameter	D2 ·	mm	*	200
Pump Discharge per Unit	DU2	m³/min	-	4.00
Pump Total Head	TH	m	-	20.00
Pump Power	PP2	kw		22
Pump Unit	PU	vnit	(Including 1 Stand By Pump)	5

Table 12.2.4.16 (1) Capacity Calculation of PI Pump Station in Zengeza Treatment Area (Scenario-1)

 Item
 Symbol
 Unit
 Calculation
 Adoption

 Design Sewage Quantity
 Q1
 m³/sec
 0.334

 Q2
 m³/min
 Q1 x 60
 20.04

(2) Grit Chamber and Screen

Offi Chamber and Scieen				
Item	Symbol	Unit	Calculation	Adoption
Гуре	-	_	Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec	-	0.334
	Q2	m³/day	Q1 x 86,400	28,858
Water Surface Load	WSL	m³/m²/day	-	1,800
Required Surface Area	RSA	m²	Q2 / WSL	16.03
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	Wi	m	Q1 / (V x H)	2.23
Therefore	W2	ĐĴ	•	2.20
Length	Li	m	RSA/W2	7.29
Therefore	L2	m	-	7.50
Screen Type	<u> </u>		Manual Removal Type Bar Scr	een
(Dimension)				
Width	W2	m	W2/BN	1.10
Length	J.2	m	-	7.50
Depth	Н	m	•	0.50
Basin Number	BN		-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	28,858
	Q2	m³/min	Q1 / 1,440	20.04
Pump Unit	PU	unit	(Including 1 Stand By Pump)	5
Pump Discharge per Unit	DU1	m³/min	Q2/(PU - 1)	5.01
Therefore	DU2	m³/mio	•	5.00
Required Pump Diameter	D1	מומ	146 x (DU2 / V) 1/2	206
Therefore	D2	mm	•	200
Required Pump Total Head	TH	m	assumption	40.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	53.56
Therefore	PP2	kw	•	55
(Dimension)				
Diameter	D2	nm	•	200
Pump Discharge per Unit	DU2	m³/min	•	5.00
Pump Total Head	TH	m	-	40.00
Pump Power	PP2	kw	•	55 <u>·</u>
Pump Unit	PU	unit	(Including 1 Stand By Pump)	5

Table 12.2.4.16 (2) Capacity Calculation of P1 Pump Station in Zengeza Treatment Area (Scenario-2)

Design Sewage Quantity				
Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec		0.513
	Q2	m³/min	Q1 x 60	30.78

(2) Grit Chamber and Screen

Offi Chambel and Selecti				
Item	Symbol	Unit	Calculation	Adoption
Туре	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec	•	0.513
	Q2	m³/day	Q1 x 86,400	44,323
Water Surface Load	WSL	m³/m²/day		1,800
Required Surface Area	RSA	m ²	Q2/WSL	24.62
Basin Number	BN	basin	-	3
Average Velocity	V	m/sec	•	0.30
Depth	Н	m	-	0.50
Width	W1	m	Q1 / (V x H)	3.42
Therefore	W2	m	-	3.50
Length	L1	m	RSA/W2	7.04
Therefore	L2	m	-	7.00
Screen Type	-	-	Manual Removal Type Bar Sci	een
(Dimension)				فعالما والمعالم المادرة والمواجع والمادرة والماد
Width	W2	m	W2/BN	1.17
Length	L2	m		7.00
Depth	H	m	_	0.50
Basin Number	BN	-	-	3

(3) Capacity Calculation of Pump Equipment

8

1

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	44,323
	Q2	m³/min	Q1 / 1,440	30.78
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6
Pump Discharge per Unit	DU1	m³/min	Q2/(PU · 1)	6.16
Therefore	DU2	m³/min	-	6.20
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	230
Therefore	D2	mm	-	250
Required Pump Total Head	TH	m	assumption	40.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	66.41
Therefore	PP2	kw		75
(Dimension)				
Diameter	D2	mm	•	250
Pump Discharge per Unit	DU2	m³/min	-	6.20
Pump Total Head	TH	m	-	40.00
Pump Power	PP2	kw	· -	75
Pump Unit	PU	บnit	(Including 1 Stand By Pump)	6

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec	*	0.147
	Q2	m³/min	Q1 x 60	8.82

(2) Grit Chamber and Screen

Offi Chamber and Screen				
Item	Symbol	Unit	Calculation	Adoption
Туре		-	Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec	-	0.147
	Q2	m³/day	Q1 x 86,400	12,701
Water Surface Load	WSŁ	m³/m²/day	•	1,800
Required Surface Area	RSA	m²	Q2/WSL	7.06
Basin Number	BN	basin	•	2
Average Velocity	V	m/sec	-	0.30
Depth	Н	ทา	<u>-</u>	0.50
Width	Wi	m	Q1 / (V x H)	0.98
Therefore	W2	m	•	1.00
Length	L1	m	RSA / W2	7.06
Therefore	L2	m	-	7.00
Screen Type	•	-	Manual Removal Type Bar Sc	reen
(Dimension)	AND MAKE AND ASSESSMENT OF THE PARTY OF THE		·	
Width	W2	m	W2/BN	0.50
Length	1.2	m	•	7.00
Depth	Н	m	•	0.50
Basin Number	BN	l		2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	12,701
	Q2	m³/min	Q1 / 1,440	8.82
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4
Pump Discharge per Unit	DU1	m³/min	Q2/(PU-1)	2.94
Therefore	DU2	m³/min	-	3.00
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	160
Therefore	D2	mm		150
Required Pump Total Head	TH	m	assumption	25.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	20.08
Therefore	PP2	kw	•	22
(Dimension)				
Diameter	D2	mm	•	150
Pump Discharge per Unit	DU2	m³/min	-	3.00
Pump Total Head	TH	m		25.00
Pump Power	PP2	kw	•	22
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4

Table 12.2.4.17 (2) Capacity Calculation of P2 Pump Station in Zengeza Treatment Area (Scenario-2)

9

^	Item	Symbol	Unit	Calculation	Adoption
**********	Sewage Quantity	Q1	m³/sec		0.226
	,	Q2	**********	Q1 x 60	13,56

(2) Grit Chamber and Screen

Symbol	Unit	Calculation	Adoption
-	•	Parallel Flow Type	
Q1	m³/sec	•	0.226
Q2	m³/day	Q1 x 86,400	19,526
WSL	m³/m²/day	-	1,800
RSA	m ²	Q2/WSL	10.85
BN	basin	-	2
V	ni/sec		0.30
Н	m	<u>-</u>	0.50
W1	m	Q1 / (V x H)	1.51
W2	m	_	1.60
L1	ກາ	RSA / W2	6.78
L2	m	_	7.00
-	-	Manual Removal Type Bar Sci	reen
W2	m	W2/BN	0.80
L2	m	_	7.00
H	m	_	0.50
BN			2
	O1 Q2 WSL RSA BN V H W1 L1 L2 - W2 L1 L2 -	Q1 m³/sec Q2 m³/day WSL m³/m²/day RSA m² BN basin V m/sec H m W1 m W2 m L1 m L2 m W2 m L1 m L2 m L2 m L1 m	- Parallel Flow Type Q1 m³/sec - Q2 m³/day Q1 x 86,400 WSL m³/m²/day - RSA m² Q2 / WSL BN basin - V m/sec - H m - W1 m Q1 / (V x H) W2 m - L1 m RSA / W2 L2 m Manual Removal Type Bar Sci

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	T Q1	m³/day	Peak Wet Weather Flow	19,526
Dosign Domago Quantity	Q2	m³/min	Q1 / 1,440	13.56
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4
Pump Discharge per Unit	DU1	m³/min	Q2/(PU-1)	4.52
Therefore	DU2	m³/min	•	4.50
Required Pump Diameter	Di	mm	146 x (DU2 / V) 1/2	196
Therefore	D2	mm		200
Required Pump Total Head	TH	m	assumption	25.00
Required Pump Power	PP1	kw	$(0.163 \times DU2 \times TH / 0.7) \times 1.$	30.13
Therefore	PP2	kw	_	30
(Dimension)				
Diameter	D2	mm		200
Pump Discharge per Unit	DU2	m³/min	_	4.50
Pump Total Head	TH	m)		25.00
Pump Power	PP2	kw		30
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4

Table 12.2.4.18 (1) Capacity Calculation of P3 Pump Station in Zengeza Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec	The state of the s	0.614
	Q2		Q1 x 60	36.84

(2) Grit Chamber and Screen

Ont Chamber and Screen				
Item	Symbol	Unit	Calculation	Adoption
Туре	<u> </u>	_	Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec	-	0.614
<u> </u>	Q2	m³/day	Q1 x 86,400	53,050
Water Surface Load	WSL	m³/m²/day		1,800
Required Surface Area	RSA	m²	Q2/WSL	29.47
Basin Number	BN	basin	•	3
Average Velocity	V	m/sec	-	0.30
Depth	H	m	•	0.50
Width	Wi	m	Q1 / (V x H)	4.09
Therefore	W2	m	•	4.20
Length	L1	nı	RSA/W2	7.02
Therefore	1.2	m	-	7.00
Screen Type	-	-	Manual Removal Type Bar Sc	reen
(Dimension)				
Width	W2	m	W2/BN	1.40
Length	L2	m	-	7.00
Depth	H	m		0.50
Basin Number	BN	-		3

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	53,050
	Q2	m³/min	Q1 / 1,440	36.84
Pump Unit	PU	บกit	(Including 1 Stand By Pump)	6
Pump Discharge per Unit	DU1	m³/min	Q2 / (PU - 1)	7.37
Therefore	DU2	m³/min	-	7.40
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	251
Therefore	D2	mm		250
Required Pump Total Head	TH	m	assumption	35.00
Required Pump Power	PP1	kw	$(0.163 \times DU2 \times TH / 0.7) \times 1.$	69.36
Therefore	PP2	kw	-	75
(Dimension)				
Diameter	D2	mm	-	250
Pump Discharge per Unit	DU2	m³/min	•	7.40
Pump Total Head	TH	n		35.00
Pump Power	PP2	kw	-	75
Pomp Unit	PU	unit	(Including 1 Stand By Pump)	6



Table 12.2.4.18 (2) Capacity Calculation of P3 Pump Station in Zengeza Treatment Area (Scenario-2)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec	-	0.943
	Q2		Q1 x 60	56.58

Grit Chamber and Screen		Y		A de alle a
<u> Item</u>	Symbol	Unit	Calculation	Adoption
Гуре			Parallei Flow Type	
Design Sewage Quantity	Q1	m³/sec	_	0.943
	Q2	m³/day	Q1 x 86,400	81,475
Water Surface Load	WSL	m³/m²/day		1,800
Required Surface Area	RSA	m²	Q2 / WSL	45.26
Basin Number	BN	basin	-	6
Average Velocity	V	m/sec		0.30
Depth	Н	m	•	0.50
Width	WI	m	Q1 / (V x H)	6.29
Therefore	W2	m		6.30
Length	L1	ns .	RSA/W2	7.18
Therefore	L2	m	-	7.50
Screen Type	•	-	Manual Removal Type Bar Sc	reen
(Dimension)				
Width	W2	m	W2/BN	1.05
Length	1.2	m		7.50
Depth	H	m		0.50
Basin Number	BN	-	•	6

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	81,475
	Q2	m³/min	Q1 / 1,440	56.58
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6
Pump Discharge per Unit	DU1	m³/min	Q2 / (PU - 1)	11.32
Therefore	DU2	m³/min	-	11.40
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	312
Therefore	D2	mm		300
Required Pump Total Head	TH	m	assumption	35.00
Required Pump Power	PPi	kw	(0.163 x DU2 x TH / 0.7) x 1.	106.85
Therefore	PP2	kw		110
(Dimension)				
Diameter	D2	mm		300
Pump Discharge per Unit	DU2	m³/min		11.40
Pump Total Head	TH	m	•	35.00
Pump Power	PP2	kw	_	110
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6

(4) Construction Time: 2015

1

Table 12.2.4.19 (1) Capacity Calculation of P1 Pump Station in Norton Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec		0.090
	Q2	m³/min	Q1 x 60	5.4

(2) Grit Chamber and Screen

Offi Chambel and Selecti				
Item	Symbol	Unit	Calculation	Adoption
Туре		-	Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec		0.090
	Q2	m³/day	Q1 x 86,400	7,776
Water Surface Load	WSL	m³/m²/day	-	1,800
Required Surface Area	RSA	m ²	Q2/WSL	4.32
Basin Number	BN	basin		2
Average Velocity	V	m/sec	•	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1/(V x H)	0.60
Therefore	W2	m	-	1.00
Length	L1	m	RSA / W2	4.32
Therefore	L2	m		4.50
Screen Type	-]	Manual Removal Type Bar Sc	reen
(Dimension)				
Width	W2	m	W2/BN	0.50
Length	L2	m		4.50
Depth	Н	m	-	0.50
Basin Number	BN			2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	7,776
	Q2	m³/min	Q1 / 1,440	5.40
Pump Unit	PU	uni!	(Including 1 Stand By Pump)	3
Pump Discharge per Unit	DU1	m³/min	Q2 / (PU - 1)	2.70
Therefore	DU2	m³/min	•	2.70
Required Pump Diameter	D1	nım	146 x (DU2 / V) 1/2	152
Therefore	D2	mm	-	150
Required Pump Total Head	TH	m	assumption	15.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	10.85
Therefore	PP2	kw	•	11
(Dimension)				
Diameter	D2	mm		150
Pump Discharge per Unit	DU2	m³/min	<u>-</u>	2.70
Pump Total Head	TH	m		15.00
Pump Power	PP2	kw	-	11
Pump Unit	PU	unit	(Including 1 Stand By Pump)	3

Table 12.2.4.19 (2) Capacity Calculation of P1 Pump Station in Norton Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

9

Item	Symbol	Unit		Adoption
Design Sewage Quantity	Q1	m³/sec	-	0.058
	Q2		Q1 x 60	3.48

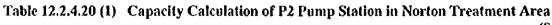
(2) Grit Chamber and Screen

Grit Chamber and Screen			و المنظمية المالية المنظم المنظمية والمنظم المنظم	
Item	Symbol	Unit	Calculation	Adoption
Туре	•	•	Parallel Flow Type	
Design Sewage Quantity	Qì	m³/sec	*	0.058
	Q2	m³/day	Q1 x 86,400	5,011
Water Surface Load	WSL	m³/m²/day	A STATE OF THE PARTY OF THE PAR	1,800
Required Surface Area	RSA	m²	Q2 / WSL	2.78
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	Н	m	_	0.50
Width	WI	m	Q1 / (V x H)	0.39
Therefore	W2	m		1.00
Length	L1	m	RSA / W2	2.78
Therefore	1.2	m		3.00
Screen Type	•	-	Manual Removal Type Bar Sc	reen
(Dimension)				
Width	W2	m	W2/BN	0.50
Length	L2	m	-	3.00
Depth	Н	m		0.50
Basin Number	BN	<u> </u>	_	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	5,011
,	Q2	m³/min	Q1 / 1,440	3.48
Pump Unit	PU	unit	(Including 1 Stand By Pump)	3
Pump Discharge per Unit	DU1	m³/min	Q2 / (PU - 1)	1.74
Therefore	DU2	m³/min	-	1.80
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	124
Therefore	D2	mm	-	100
Required Pump Total Head	TH	m	assumption	15.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	7.23
Therefore	PP2	kw	-	88
(Dimension)				
Diameter	D2	mm	•	100
Pump Discharge per Unit	DU2	m³/min		1.80
Pump Total Head	TH	m	•	15.00
Pump Power	PP2	kw	-	8
Pump Unit	PU	unit	(Including 1 Stand By Pump)	3

(4) Construction Time: 2015



(Scenario-1)

1

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec		0.234
	Q2	m³/min	Q1 x 60	14.04

(2) Grit Chamber and Screen

On Change and Detect				
Item	Symbol	Unit	Calculation	Adoption
Гуре	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec	•	0.234
	Q2	m³/day	Q1 x 86,400	20,218
Water Surface Load	WSL	m³/m²/day	_	1,800
Required Surface Area	RSA	m²	Q2 / WSL	11.23
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	Н	m	-	0.50
Width	W1	m	Q1/(V x H)	1.56
Therefore	W2	m	-	1.60
Length	L1	m	RSA / W2	7.02
Therefore	L2	m	-	7.00
Screen Type	-	•	Manual Removal Type Bar Sci	reen
(Dimension)				
Width	W2	m	W2/BN	0.80
Length	L2	m	•	7.00
Depth	Н	m		0.50
Basin Number	BN	-	•	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	20,218
	Q2	ro³/min	Q1 / 1,440	14.04
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4
Pump Discharge per Unit	DU1	m³/min	Q2/(PU - 1)	4.68
Therefore	DU2	m³/min	-	4.70
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	200
Therefore	D2	mm	-	200
Required Pump Total Head	TH	m	assumption	25.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	31.46
Therefore	PP2	kw	-	37
(Dimension)				
Diameter	D2	mm		200
Pump Discharge per Unit	DU2	m³/min	<u>-</u>	4.70
Pump Total Head	ТН	m	•	25.00
Pump Power	PP2	kw	-	37
Punip Unit	PU	unit	(Including 1 Stand By Pump)	4

(4) Construction Time:

2005; Pump equipment = 2 units

2015; Pump equipment = 2 units

Table 12.2.4.20 (2) Capacity Calculation of P2 Pump Station in Norton Treatment Area (Scenario-2)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec	-	0.150
	Q2	m³/min	Q1 x 60	9.00

(2) Grit Chamber and Screen

Grit Chamber and Screen			and the second s	
Item	Symbol	Unit	Calculation	Adoption
Туре	•	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec	-	0.150
	Q2	nı³/day	Q1 x 86,400	12,960
Water Surface Load	WSL	m³/m²/day		1,800
Required Surface Area	RSA	m²	Q2/WSL	7.20
Basin Number	BN	basin	•	2
Average Velocity	V	m/sec	_	0.30
Depth	Н	m		0.50
Width	W1	m	Q1/(V x H)	1.00
Therefore	W2	m	•	1.00
Length	L1	m	RSA / W2	7.20
Therefore	L2	m .		7.50
Screen Type	-		Manual Removal Type Bar Sc	een
(Dimension)				
Width	W2	m	W2/BN	0.50
Length	L2	m	-	7.50
Depth	Н	m	•	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	12,960
oonga dammi,	Q2	m³/min	Q1/1,440	9.00
Pump Unit	PU	ยกit	(Including 1 Stand By Pump)	4
Pump Discharge per Unit	DUI	m³/min	Q2/(PU-1)	3.00
Therefore	DU2	m³/min	•	3.00
Required Pump Diameter	D1	mm	146 x (DU2/V) 1/2	160
Therefore	D2	mm	-	150
Required Pump Total Head	TH	m	assumption	25.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	20.08
Therefore	PP2	kw	-	22
(Dimension)				
Diameter	D2	mm		150
Pump Discharge per Unit	DU2	m³/min	•	3.00
Pump Total Head	TH	m		25.00
Pump Power	PP2	kw	_	22
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4

(4) Construction Time:

2005;

Pump equipment = 2 units

2015;

Pump equipment = 2 units

Table 12.2.4.21 (1) Capacity Calculation of PI Pump Station in Ruwa Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec	•	0.046
	Q2		Q1 x 60	2.76

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Туре			Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec	-	0.046
	Q2	m³/day	Q1 x 86,400	3,974
Water Surface Load	WSL	m³/m²/day	-	1,800
Required Surface Area	RSA	m²	Q2/WSL	2.21
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	Н	m	-	0.50
Width	W1	m	Q1/(V x H)	0.31
Therefore	W2	m	<u>-</u>	1.00
Length	L1	m	RSA/W2	2.21
Therefore	L2	m	•	2.50
Screen Type	-	-	Manual Removal Type Bar Sci	een
(Dimension)				
Width	W2	m	W2/BN	0.50
Length	L2	m	-	2.50
Depth	Н	m	-	0.50
Basin Number	BN	-	•	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	3,974
-	Q2	m³/min	Q1 / 1,440	2.76
Pump Unit	PU	unit	(Including 1 Stand By Pump)	3
Pump Discharge per Unit	DU1	m³/min	Q2/(PU-1)	1.38
Therefore	DU2	m³/min	-	1.40
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	109
Therefore	D2	mm	•	100
Required Pump Total Head	TH	m	assumption	35.00
Required Pump Power	PPi	kw	$(0.163 \times DU2 \times TH / 0.7) \times 1.1$	13.12
Therefore	PP2	kw	-	15
(Dimension)				-
Diameter	D2	mm	-	100
Pump Discharge per Unit	DU2	m³/min	-	1.40
Pump Total Head	TH	nı	-	35.00
Pump Power	PP2	kw	•	15
Pump Unit	PU	unit	(Including 1 Stand By Pump)	3



Table 12.2.4.21 (2) Capacity Calculation of P1 Pump Station in Ruwa Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation 1	Adoption
Design Sewage Quantity	Q1	m³/sec	+	0.017
	Q2	.,, ,	Q1 x 60	1.02

(2) Grit Chamber and Screen

Grit Chamber and Screen				A
Item	Symbol	Unit	Calculation	Adoption
Гуре	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec	-	0.017
	Q2	m³/day	Q1 x 86,400	1,469
Water Surface Load	WSL	m³/m²/day	•	1,800
Required Surface Area	RSA	m²	Q2 / WSL	0.82
Basin Number	BN	basin		2
Average Velocity	V	nvsec		0.30
Depth	H	m		0.50
Width	Wi	m	Q1 / (V x H)	0.11
Therefore	W2	m	-	1.00
Length	Ll	m	RSA / W2	0.82
Therefore	L2	m	-	1.00
Screen Type	-	•	Manual Removal Type Bar Sci	een
(Dimension)				
Width	W2	m	W2/BN	0.50
Length	1.2	m		1.00
Depth	H	m	-	0.50
Basin Number	BN	<u> </u>		2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	1,469
250.6.1 201.080 4501	Q2	m³/min	Q1 / 1,440	1.02
Pump Unit	PU	unit	(Including 1 Stand By Pump)	2
Pump Discharge per Unit	DU1	m³/min	Q2/(PU-1)	1.02
Therefore	DU2	m³/min	-	1.00
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	92
Therefore	D2	mm		100
Required Pump Total Head	TH	m	assumption	35.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	9.37
Therefore	PP2	kw		11
(Dimension)				
Diameter	D2	mm	-	100
Pump Discharge per Unit	DU2	m³/min		1.00
Pump Total Head	TH	m	-	35.00
Pump Power	PP2	kw		11
Pump Unit	PU	unit	(Including 1 Stand By Pump)	2

Table 12.2.4.22 (1) Capacity Calculation of P2 Pump Station in Ruwa Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec	P.	0.132
	Q2	/	Q1 x 60	7.92

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Туре	-		Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec		0.132
	Q2	m³/đay	Q1 x 86,400	11,405
Water Surface Load	WSL	m³/m²/day	-	1,800
Required Surface Area	RSA	m²	Q2 / WSL	6.34
Basin Number	BN	basin	-	2
Average Velocity	v	nı/sec	-	0.30
Depth	Н	m	-	0.50
Width	W1	m	Q1 / (V x H)	0.88
Therefore	W2	m	-	1.00
Length	L1	n	RSA/W2	6.34
Therefore	L2	m	•	6.50
Screen Type	-	•	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2/BN	0.50
Length	L2	m		6.50
Depth	Н	m	-	0.50
Basin Number	BN	-	=	2

(3) Capacity Calculation of Pump Equipment

<u>Item</u>	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	11,405
	Q2	m³/min	Q1 / 1,440	7.92
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4
Punip Discharge per Unit	DU1	m³/min	Q2/(PU - 1)	2.64
Therefore	DU2	m³/min	-	2.70
Required Pump Diameter	D1	ກາດາ	146 x (DU2 / V) 1/2	152
Therefore	D2	mm	•	150
Required Pump Total Head	TH	m	assumption	40.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	28.92
Therefore	PP2	kw	-	30
(Dimension)				
Diameter	D2	mm	•	150
Pump Discharge per Unit	DU2	m³/min	-	2,70
Pump Total Head	TH	m		40.00
Pump Power	PP2	kw	•	30
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4

Table 12.2.4.22 (2) Capacity Calculation of P2 Pump Station in Ruwa Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec		0.049
	Q2	m³/min	Q1 x 60	2.94

(2) Grit Chamber and Screen

Grit Chamber and Screen			and the state of t	
Item	Symbol	Unit	Calculation	Adoption
Туре	-		Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec	•	0.049
	Q2	m³/day	Q1 x 86,400	4,234
Water Surface Load	WSL	m ³ /m ² /day		1,800
Required Surface Area	RSA	m²	Q2 / WSL	2.35
Basin Number	BN	basin	<u>-</u>	2
Average Velocity	V	m/sec	-	0.30
Depth	Н	m	-	0.50
Width	W1	m	Q1/(V x H)	0.33
Therefore	W2	m		1.00
Length	Ll	m	RSA / W2	2.35
Therefore	L2	m		2.50
Screen Type	-	-	Manual Removal Type Bar Sci	een
(Dimension)				
Width	W2	m	W2/BN	0.50
Length	L2	m		2.50
Depth	Н	m		0.50
Basin Number	BN	<u> </u>		2

Item .	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Ql	m³/day	Peak Wet Weather Flow	4,234
g ,	Q2	m³/min	Q1 / 1,440	2.94
Pump Unit	PU	unit	(Including 1 Stand By Pump)	3
Pump Discharge per Unit	DU1	m³/min	Q2/(PU-1)	1.47
Therefore	DU2	m³/min	-	1.50
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	113
Therefore	D2	mm	-	100
Required Pump Total Head	TH	m	assumption	40.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH/0.7) x 1.1	16.07
Therefore	PP2	kw		22
(Dimension)				
Diameter	D2	mm	-	100
Pump Discharge per Unit	DU2	m³/min		1.50
Pump Total Head	TH	m	•	40.00
Pump Power	PP2	kw	-	22
Pump Unit	PU	unit	(Including 1 Stand By Pump)	3

Table 12.2.4.23 (1) Capacity Calculation of P3 Pump Station in Ruwa Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec	•	0.03
	Q2	4	Q1 x 60	1.8

(2) Grit Chamber and Screen

Grit Chamber and Screen				
Item	Symbol	Unit	Calculation	Adoption
Туре		1 .	Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec		0.030
	Q2	m³/day	Q1 x 86,400	2,592
Water Surface Load	WSL	m³/m²/day	-	1,800
Required Surface Area	RSA	m²	Q2/WSL	1.44
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	Wi	m	Q1 / (V x H)	0.20
Therefore	W2	m	-	1.00
Length	L1	m	RSA/W2	1.44
Therefore	L2	m	-	1.50
Screen Type	-	-	Manual Removal Type Bar Sc	reen
(Dimension)				
Width	W2	m	W2/BN	0.50
Length	L2	m	-	1.50
Depth	Н	m		0.50
Basin Number	BN		-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	2,592
	Q2	m³/min	Q1 / 1,440	1.80
Punip Unit	PU	unit	(Including 1 Stand By Pump)	2
Pump Discharge per Unit	DU1	m³/min	Q2/(PU - 1)	1.80
Therefore	DU2	m³/min	-	1.80
Required Pump Diameter	Di	mm	146 x (DU2 / V) 1/2	124
Therefore	D2	mm	•	150
Required Pump Total Head	TH	m	assumption	20.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH/0.7) x 1.1	9.64
Therefore	PP2	kw		11
(Dimension)				
Diameter	D2	mm		150
Pump Discharge per Unit	DU2	m³/min	-	1.80
Pump Total Head	TH	m	-	20.00
Pump Power	PP2	kw	-	11
Pump Unit	PU	unit	(Including 1 Stand By Pump)	2

Table 12.2.4.23 (2) Capacity Calculation of P3 Pump Station in Ruwa Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec	-	0.011
,	Q2	m³/min	Q1 x 60	0.66

(2) Grit Chamber and Screen

Grit Chamber and Screen			A AT NEW YORK ON A PART OF THE	
Item	Symbol	Unit	Calculation	Adoption
Туре	-		Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec	<u>-</u>	0.011
	Q2	m³/day	Q1 x 86,400	950
Water Surface Load	WSL	m³/m²/day	-	1,800
Required Surface Area	RSA	m²	Q2 / WSL	0.53
Basin Number	BN	basin	•	2
Average Velocity	v	m/sec	•	0.30
Depth	Н	m	-	0.50
Width	WI	m	Q1 / (V x H)	0.07
Therefore	W2	m	-	1.00
Length	L1	m	RSA/W2	0.53
Therefore	L2	m		1.00
Screen Type	•	-	Manual Removal Type Bar Sc	reen
(Dimension)				
Width	W2	m	W2/BN	0.50
Length	L2	m		1.00
Depth	Н	nı	_	0.50
Basin Number	BN			2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	950
bosigi. do nugo Quanno,	Q2	ni³/min	Q1 / 1,440	0.66
Pump Unit	PU	unit	(Including 1 Stand By Pump)	2
Pump Discharge per Unit	DU1	m³/min	Q2/(PU - 1)	0.66
Therefore	DU2	m³/min	_	0.70
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	77
Therefore	D2	mm		100
Required Pump Total Head	ТН	m	assumption	20.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	3.75
Therefore	PP2	kw		3.7
(Dimension)				
Diameter	D2	mm	-	100
Pump Discharge per Unit	DU2	m³/min		0.70
Pump Total Head	TH	m		20.00
Pump Power	PP2	kw	_	3.7
Pump Unit	PU	unit	(Including 1 Stand By Pump)	2

Table 12.2.4.24 (1) Capacity Calculation of P4 Pump Station in Ruwa Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec	-	0.565
	Q2	m³/min	Q1 x 60	33.9

(2) Grit Chamber and Screen

Oin Chamber and Screen				
Item	Symbol	Unit	Calculation	Adoption
Гуре	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m³/sec	-	0.565
-	Q2	m³/day	Q1 x 86,400	48,816
Water Surface Load	WSL	m³/m²/day	-	1,800
Required Surface Area	RSA	m²	Q2/WSL	27.12
Basin Number	BN	basin	0 •	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1/(V x H)	3.77
Therefore	W2	m	-	3.80
Length	L1	m	RSA/W2	7.14
Therefore	L2	m	-	7.50
Screen Type	-	-	Manual Removal Type Bar So	reen
(Dimension)				
Width	W2	m	W2/BN	1.90
Length	L2	m	-	7.50
Depth	Н	m		0.50
Basin Number	BN		·	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	nı³/day	Peak Wet Weather Flow	48,816
	Q2	m³/min	Q1 / 1,440	33.90
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6
Pump Discharge per Unit	DUI	m³/min	Q2/(PU-1)	6.78
Therefore	DU2	m³/min	<u>-</u>	6.80
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	241
Therefore	D2	mm		250
Required Pump Total Head	TH	m	assumption	20.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	36.42
Therefore	PP2	kw	•	37
(Dimension)				
Diameter	D2	mm	-	250
Pump Discharge per Unit	DU2	m³/min	•	6.80
Pump Total Head	TH	m	•	20.00
Pump Power	PP2	kw	-	. 37
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6

Table 12.2.4.24 (2) Capacity Calculation of P4 Pump Station in Ruwa Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/sec		0.208
	Q2		Q1 x 60	12.48

Grit Chamber and Screen Item	Symbol	Unit	Calculation	Adoption
Туре	-	-	Parallel Flow Type	,
Design Sewage Quantity	Q1	m³/sec	-	0.208
Dosign downeys warming	Q2	m³/day	Q1 x 86,400	17,971
Water Surface Load	WSL	m³/m²/day		1,800
Required Surface Area	RSA	m²	Q2 / WSL	9.98
Basin Number	BN	basin		2
Average Velocity	V	m/sec	_	0.30
Depth	Н	m	_	0.50
Width	WI	m	Q1 / (V x H)	1.39
Therefore	W2	m		1.40
Length	L1	m	RSA / W2	7.13
Therefore	1.2	m	-	7.50
Screen Type			Manual Removal Type Bar	Screen
(Dimension)				
Width	W2	m	W2/BN	0.70
Length	L2	m		7.50
Depth	Н	m		0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m³/day	Peak Wet Weather Flow	17,971
Design deviage deaming	Q2	m³/min	Q1 / 1,440	12.48
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4
Pump Discharge per Unit	DUI	m³/min	Q2/(PU-1)	4.16
Therefore	DU2	m³/min	-	4.20
Required Pump Diameter	D1	mm	146 x (DU2 / V) 1/2	189
Therefore	D2	וחות		200
Required Pump Total Head	TH	nı	assumption	20.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	22.49
Therefore	PP2	kw		22
(Dimension)				200
Diameter	D2	nım	-	200
Pump Discharge per Unit	DU2	m³/min_	-	4.20
Pump Total Head	TH	m	_	20.00
Pump Power	PP2	kw		22
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4

(4) Construction Time: 2005

12.2.5 Design Criteria and Planning for Sewage Treatment Facilitie

12.2.5.1 Design Criteria for Sewage Treatment Facilities

(1) Sewage Treatment Process

The existing sewage treatment works in the study area employ three kind of secondary treatment processes; Wastewater Stabilisation Pond (WSP), Trickling Filter (TF) and Biological Nutrient Removal (BNR). The design criteria of each process are shown below.

WSP process

a) Design flow for capacity calculation: average dry weather flow

b) Anaerobic Pond

Pond depth: At least 3 m

Optimum detention time: 1 - 5 days

Volumetric BOD loading: 400 g/m³/day

c) Facultative Pond

Pond depth: 1.2 to 1.5 m (Zimbabwe standard)

Optimum detention time: 4 - 10 days

Depends on the climatic condition and essential

BOD removal ratio

 $K_T = K_{20^{\circ}C} \times \theta^{T-20}$ (Wehner and Wilhelm formula)

Where K_{20°C}; 0.25 d⁻¹

 θ ; temperature coefficient = 1.06 at 20°C

T; temperature of the coldest month = 14°C

BOD surface loading $L = 20 \times T - 120 = 160 \text{ kg/ha/day}$

d) Maturation Pond

Pond depth: 1.2 to 1.5 m (Zimbabwe standard)

Optimum detention time: 6 days

TF process

a) Design flow for capacity calculation

Primary and Secondary Sedimentation Tank: average dry weather flow

Trickling Filter: average dry weather flow

b) Primary and Secondary Sedimentation Tank

Surface loading: $1.2 \text{ m}^3/\text{m}^2/\text{hr} = 29 \text{ m}^3/\text{m}^2/\text{day}$

c) Trickling Filter

Depth of filter: 3 to 4 m

BOD loading: 0.1 kg/m3/day in the single pass without recirculation

0.2 kg/m3/day in the single pass with recirculation

Hydraulic loading: 0.5 m³/m³/day without recirculation (Zimbabwe

standard)

BNR process

a) Design flow for capacity calculation

Primary and Secondary Sedimentation Tank: average dry weather flow

Biological Filter: average dry weather flow

b) Primary sedimentation tank

Surface loading: $1.2 \text{m}^3/\text{m}^2/\text{hr} = 29 \text{ m}^3/\text{m}^2/\text{day}$

Retention time: 1.5 hr

c) Biological reactor (BNR)

Depth of basin: 4 m

MLSS (mixed liquor suspended solids): 3,000 - 3,600 mg/l

Retention time: total 1.7 days; anaerobic tank 0.10 day

anoxic tank 0.20 day

aerobic tank 1.40 days

Sludge retention time: 12 days

Source: Norton Town Council, Report on the Feasibility Study for New Sewage

Treatment Works, May 1996, Appendix D

d) Secondary sedimentation tank

Surface loading: 10 m³/m²/day

Japanese standard of Anaerobic-Anoxic-Aerobic process, similar to the BNR process is as follows:

Influent quality to basin after primary treatment: BOD = 130 mg/l

Final effluent quality: BOD = 10 mg/l

Recirculation Ratio: 150%

MLSS: 3,000 mg/l

Retention time: total 13.2 hr: anaerobic tank 1.2 hr

anoxic tank 4.8 hr

aerobic tank 7.2 hr

Sludge retention time: 14 days

(2) Sludge treatment process

a) Sludge thickening

Depth of basin: 4 m

Solid matter loading: 60 to 90 kg/m³/day

Source: Japanese standard

b) Sludge drying bed

Required bed area: 0.08 m²/person

12.2.5.2 Capacity Calculation of Sewage Treatment Facility

Table 12.2.5.1 (1) Capacity Calculation of BNR in 124,900 m³/day, Crowborough, 2015

(1) Grit Chamber and Screen (Peak Wet Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Туре		-	Parallel Flow Type	
Design Sewage Quantity	Q1	m³/day	124,900 x 3.00	374,700
	Q2	m³/sec	Q1 / 86,400	4.337
Water Surface Load	WSL	m³/m²/day	•	1,800
Required Surface Area	RSA	m²	Q1/WSL	208.17
Basin Number	BN	basin	-	16
Average Velocity	V	m/sec	•	0.30
Depth	H	W	-	0.50
Width	W1	m	Q2/(V x H)	28.91
Therefore	W2	m	•	28.80
Length	Li	m	RSA / W2	7.23
Therefore	L2	m	•	7.30
Screen Type	-	-	Manual Removal Type Bar Sci	reen
(Dimension)				
Width	W2	m	W2/BN	1.80
Length	L2	m	-	7.30
Depth	H	m	-	0.50
Basin Number	BN	<u> </u>		16

(2) Primary Sedimentation Tank (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	T Q	m³/day	-	124,900
Retention Time	T	hr	-	1.5
Water Surface Load	WSL	m³/m²/day	•	29
Required Surface Area	RSA	m²	Q/WSL	4306.90
Basin Number	BN	basin	-	24
Diameter	D1	m	(RSA / (BN x 3.14)) ^{1/2} x 2	15.12
Therefore	D2	m		15.00
Depth	Н	m	•	
(Dimension)				
Diameter	D2	m		15.00
Depth	Н	m	•	0.00
Basin Number	BN	<u> </u>		24





(cont'd)

Table 12.2.5.1 (2) Capacity Calculation of BNR in 124,900 m³/day,Crowborough,2015

(3) Biological Reactor (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m³/day	-	124,900
Retention Time	Ti	day	Anaerobic Tank	0.1
	T2	đay	Anoxic Tank	0.2
	T3	day	Aerobic Tank	1.4
	T4	day	Total	1.7
Required Volume	RV	m³	Q x T4	212,330
Depth	Н	nî	-	4.00
MLSS	MLSS	mg/l	3,000 to 3,600	3,500
Required Surface Area	RSA	m²	RV/H	53,083
Basin Number	BN	basin	_	8
Width	W	m		480.00
Length	L1	m	RSA/W	110.59
Therefore	1.2	m		110.00
(Dimension)			and the second s	AND REAL PROPERTY OF THE PARTY
Width	W	m	W/BN	60.00
Length	L2	m		110.00
Depth	Н	m		4.00
Basin Number	BN	<u> </u>		8

(4) Secondary Sedimentation Tank (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m³/day		124,900
Retention Time	T	hr		1.5
Water Surface Load	WSL	m³/n1²/day		10
Required Surface Area	RSA	m ²	Q/WSL	12490.00
Basin Number	BN	basin	-	24
Diameter	D1	m	(RSA / (BN x 3.14)) ^{1/2} x 2	25.75
Therefore	D2	m	•	26.00
Depth	Н	m		3.00
(Dimension)				
Diameter	D2	m	_	26.00
Depth	H	m		3.00
Basin Number	BN		<u> </u>	24

Table 12.2.5.1 (3) Capacity Calculation of BNR in 124,900 m³/day, Crowborough, 2015

(5) Sludge Thickening Tank (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m³/day	•	124,900
Inlet BOD Water Quality	WQ	mg/l	500-10	490
Inlet BOD	В	kg/day	Q x WQ/1000	61,201
Solid Matter Load	SML	kg/m2/day	60 to 90	60
Required Volume	RV	m³		
Depth	Н	m	-	4.00
Required Surface Area	RSA	m²	B/SML	1020.02
Basin Number	BN	basin		8
Diameter	D1	m	(RSA / (BN x 3.14)) ^{1/2} x 2	12.74
Therefore	D2	m	-	13.00
(Dimension)				·
Diameter	D2	m	-	13.00
Depth	H	m	•	4.00
Basin Number	BN	•		8

(6) Sludge Drying Bed (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m³/day	-	124,900
Unit Sewage Quantity	USQ	l/capita/day	Assumption	100
Served Population	SP	person	Q x 10 ³ / USQ	1,249,000
Unit Required Bed Area	URBA	m²/person		0.08
Required Bed Area	RBA	m ²	SP x URBA	99,920
Width	W	m		170.00
Length	Li	m	RBA / W	587.76
Therefore	L2	m	•	600.00
(Dimension)				
Width	W	n	•	170.00
Length	L2	m		600.00

(7) Required Land Area

Grit Chamber and Screen	A1	m²	W2 x L2 x BN	210
Primary Sedimentation Tank	A2	m²	$(D2/2)^2 \times 3.14 \times BN$	4,239
Biological Reactor	A3	m²	W x L2 x BN	52,800
Secondary Sedimentation Tank	A4	m²	$(D2/2)^2 \times 3.14 \times BN$	12,736
Sludge Thickening Tank	A5	m²	$(D2/2)^2 \times 3.14 \times BN$	1061.32
Sludge Drying Bed	A6	m²	W x L2	102,000
Sub-Total	A7	m²	A1 + A2 + A3 + A4 A5 + A6	173,046
Maintenance and Green Belt	A8	m²	A7 x 1	173,046
Total	A	m²	A7 + A8	346,093





Table 12.2.5.2 (1) Capacity Calculation of BNR in 237,700 m³/day,Firle,2015 237,700-72,000=165,700

(1) Grit Chamber and Screen (Peak Wet Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Туре	-	_	Parallel Flow Type	
Design Sewage Quantity	Q1	m³/day	165,700 x 2.70	447,390
,	Q2	m³/sec	Q1 / 86,400	5.178
Water Surface Load	WSL	m³/m²/day		1,800
Required Surface Area	RSA	m²	Q1 / WSL	248.55
Basin Number	BN	basin	•	16
Average Velocity	v	nı/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q2 / (V x H)	34.52
Therefore	W2	m	•	35.20
Length	Li	m	RSA / W2	7.06
Therefore	L2	n)	-	7.00
Screen Type	-	-	Manual Removal Type Bar Sc	reen
(Dimension)				
Width	W2	m	W2/BN	2.20
Length	L2	m	-	7.00
Depth	Н	m		0.50
Basin Number	BN			16

(2) Primary Sedimentation Tank (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	T o	m³/day	•	165,700
Retention Time	T	hr		1.5
Water Surface Load	WSL	m³/m²/day	•	29
Required Surface Area	RSA	m ²	Q/WSL	5713.79
Basin Number	BN	basin	*	32
Diameter	D1	m	(RSA / (BN x 3.14)) ^{1/2} x 2	15.08
Therefore	D2	m	•	15.00
Depth	Н	m	-	
(Dimension)				
Diameter	D2	m		15.00
Depth	Н	m		0.00
Basin Number	BN	-	-	32

(cont'd)

Table 12.2.5.2 (2) Capacity Calculation of BNR in 237,700 m³/day,Firle,2015

(3) Biological Reactor (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m³/day	-	165,700
Retention Time	T1	day	Anaerobic Tank	0.1
	T2	day	Anoxic Tank	0.2
	T3	day	Aerobic Tank	1.4
	T4	day	Total	1.7
Required Volume	RV	m³	Q x T4	281,690
Depth	Н	m	•	4.00
MLSS	MLSS	mg/l	3,000 to 3,600	3,500
Required Surface Area	RSA	m ²	RV/H	70,423
Basin Number	BN	basin	-	8
Width	W	m	-	520.00
Length	L1	m	RSA/W	135.43
Therefore	L2	m	-	135.00
(Dimension)				-
Width	W	m	W/BN	65.00
Length	L2	m		135.00
Depth	H	m	•	4.00
Basin Number	BN	-	-	8

(4) Secondary Sedimentation Tank (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m³/day		165,700
Retention Time	Т	hr		1.5
Water Surface Load	WSL	m³/m²/day	-	10
Required Surface Area	RSA	m²	Q/WSL	16570.00
Basin Number	BN	basin	-	24
Diameter	D1	m	(RSA / (BN x 3.14)) ^{1/2} x 2	29.66
Therefore	D2	m	-	30.00
Depth	H	m	•	3.00
(Dimension)				
Diameter	D2	m	-	30.00
Depth	H	m	-	3.00
Basin Number	BN			24



Table 12.2.5.2 (3) Capacity Calculation of BNR in 237,700 m³/day,Firle,2015

(5) Sludge Thickening Tank (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m³/day	-	165,700
Inlet BOD Water Quality	WQ	mg/l	550-10	540
Inlet BOD	В	kg/day	Q x WQ / 1000	89,478
Solid Matter Load	SML	kg/m2/day	60 to 90	60
Required Volume	RV	m³		
Depth	H	m	-	4.00
Required Surface Area	RSA	m²	B/SML	1491.30
Basin Number	BN	basin	(Including 1 Standby)	8
Diameter	D1	m	$(RSA/(BN \times 3.14))^{1/2} \times 2$	15.41
Therefore	D2	m	-	15.40
(Dimension)				
Diameter	D2	m	-	15.40
Depth	Н	េ	•	4.00
Basin Number	BN		(Including 1 Standby)	8

(6) Sludge Drying Bed (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m³/day	•	165,700
Unit Sewage Quantity	USQ	l/capita/day	Assumption	100
Served Population	SP	person	Q x 10 ³ / USQ	1,657,000
Unit Required Bed Area	URBA	m ² /person	-	0.08
Required Bed Area	RBA	m²	SP x URBA	132,560
Width	W	m		180.00
Length	L1	m	RBA / W	736.44
Therefore	L2	m	-	740.00
(Dimension)				and the second s
Width	W	m		180.00
Length	L2	m		740.00

(7) Required Land Area

Grit Chamber and Screen	A1	m ²	W2 x L2 x BN	246
Primary Sedimentation Tank	A2	m²	$(D2/2)^2 \times 3.14 \times BN$	5,652
Biological Reactor	A3	m²	W x L2 x BN	70,200
Secondary Sedimentation Tank	A4	m²	$(D2/2)^2 \times 3.14 \times BN$	16,956
Sludge Thickening Tank	A5	m ²	$(D2/2)^2 \times 3.14 \times BN$	1489.3648
Sludge Drying Bed	A6	m²	W x L2	133,200
Sub-Total	A7	m²	A1 + A2 + A3 + A4 A5 + A6	227,744
Maintenance and Green Belt	A8	m²	A7 x 1	227,744
Total	Α	m²	A7 + A8	455,488

Table 12.2.5.3 (1) Capacity Calculation of WSP in 2,800 m³/day,Marłborough,2015

(1) Grit Chamber and Screen (Peak Wet Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Туре	•	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m³/day	2,800 x 4.50	12,600
	Q2	m³/sec	Q1 / 86,400	0.146
Water Surface Load	WSL	m³/m²/day	•	1,800
Required Surface Area	RSA	m²	Q1/WSL	7.00
Basin Number	BN	basin	(Including 1 By-pass)	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	•	0.50
Width	W1	m	Q2 / (V x H)	0.97
Therefore	W2	m	•	1.00
Length	Li	m	RSA/W2	7.00
Therefore	L2	m	•	7.00
Screen Type	-	-	Manual Removal Type Bar Sc	reen
(Dimension)				
Width	W2	m	-	1.00
Length	L2	m	-	7.00
Depth	Н	U)	-	0.50
Basin Number	BN		(Including 1 By-pass)	2

(2) Anaerobic Pond (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m³/day	•	2,800
Retention Time	T	day	BOD Removal = 30 %	1
Required Volume	V	m ³	QxT	2,800
Depth	Н	m	At least 3 m	3.00
Required Surface Area	RSA	m²	V/H	933
Width	W	m	•	30.00
Length	L1	m	RSA/W	31.11
Therefore	L2	m	-	32.00
Basin Number	BN	basin	-	1
(Dimension)				-
Width	W	m	-	30.00
Length	L2	m	L2/BN	32.00
Depth	Н	m	•	3.00
Basin Number	BN	_		1







Table 12.2.5.3 (2) Capacity Calculation of WSP in 2,800 m³/day,Marlborough,2015

(3) Facultative Pond (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m³/day	-	2,800
Retention Time	Т	day	BOD Removal = 50 %	4
Required Volume	v	m³	QxT	11,200
Depth	Н	m	1.2 to 1.5 m	1.50
Required Surface Area	RSA	m²	V/H	7,467
Width	W	m	W	60.00
Length	LA	m	RSA/W	124.44
Therefore	L2	m	•	125.00
Basin Number	BN	basin	_	111
(Dimension)		·		(0.00
Width	W	m	-	60.00
Length	L2	m	L2/BN	125.00
Depth	H	m	-	1.50
Basin Number	BN			

(4) Maturation Pond (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m³/day		2,800
Basin Number	BN	basin	•	3
Retention Time	TI	day	6 days at 3 ponds	6
Therefore	T2	day/basin	TI/BN	2
Required Volume	V	m³	Q x T2	5,600
Depth	Н	នា	1.2 to 1.5 m	1.50
Required Surface Area	RSA	m ²	V/H	3,733
Width	w	m	-	45.00
Length	L1	m	RSA / W	82.96
Therefore	1.2	m	-	90.00
(Dimension)				
Width	W	m		45.00
Length	1.2	m		90.00
Depth	H	m	-	1.50
Basin Number	BN	-		3

(5) Required Land Area

A1	m²	W2 x L2 x BN	14
A2	m²	W x L2 x BN	960
A3	m²	W x L2 x BN	7,500
A4	m²	W x L2 x BN	12,150
A5	m ²	A1 + A2 + A3 + A4	20,624
A6	m²	Same as A5	20,624
l A	m²	A5 + A6	46,812
	A1 A2 A3 A4 A5 A6	Al m ²	A2 m ² W x L2 x BN A3 m ² W x L2 x BN A4 m ² W x L2 x BN A5 m ² A1 + A2 + A3 + A4 A6 m ² Same as A5

Table 12.2.5.4 (1) Capacity Calculation of WSP in 6,800 m³/day,Donnybrook,2015

(1) Grit Chamber and Screen (Peak Wet Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Туре	•		Parallel Flow Type	
Design Sewage Quantity	Q1	m³/day	6,800 x 3.75	25,500
	Q2	m³/sec	Q1 / 86,400	0.295
Water Surface Load	WSL	m³/m²/đay	-	1,800
Required Surface Area	RSA	m²	Q1 / WSL	14.17
Basin Number	BN	basin	(Including 1 By-pass)	2
Average Velocity	V	m/sec		0.30
Depth	H	m	-	0.50
Width	W1	m	Q2 / (V x H)	1.97
Therefore	W2	m		2.00
Length	L1	m	RSA / W2	7.08
Therefore	L2	m	•	7.10
Screen Type	-	-	Manual Removal Type Bar Sci	reen
(Dimension)	_			
Width	W2	m	•	2.00
Length	L2	m	•	7.10
Depth	Н	m	-	0.50
Basin Number	BN		(Including 1 By-pass)	2

(2) Anaerobic Pond (Average Dry Weather Flow)

<u>Item</u>	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m³/day	-	6,800
Retention Time	T	day	BOD Removal = 60 %	5
Required Volume	V	m ³	QxT	34,000
Depth	Н	m	At least 3 m	3.00
Required Surface Area	RSA	m²	V/H	11,333
Width	W	m	-	75.00
Length	Ll	m	RSA/W	151.11
Therefore	L2	m	-	150.00
Basin Number	BN	basin	-	2
(Dimension)				
Width	W	រា	-	75.00
Length	L2	m	L2/BN	75.00
Depth	Н	m	•	3.00
Basin Number	BN		_	2