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GORE FLORENCE HALL DEVELOPMENT

FCS # 0827/76/C

ENGINEERING REPORT
Sewage Treatment System

Prepared for: GORE DEVELOPMENTS LIMITED
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KINGSTON 10

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Overview

This engineering report describes the sewerage treatment designs for the 866 two bedroom house development at Florence Hall Trelawny.

Sewerage Treatment Design

Design References

The sewage treatment design was prepared with reference to the developers manual Volume 3 Section 4 "Minimum Requirements for Waste Water Treatment Systems and Excreta Management in Jamaica" provided by the Ministry of Health& Environment – Environmental Health Unit; and EPA Technology Assessment: Subsurface Flow – Constructed Wetlands for Wastewater Treatment - EPA/832-R-93-008.

Design Criteria

The basic criteria used in the design is that influent to the treatment plant is typical of medium strength domestic sewage. The treatment plant effluent will meet NEPA 2004 standards for direct discharge.

Table 1: Sewage Treatment Plant Wastewater Characteristics

Parameter	Units	Influent	Effluent
COD	mg/l	500	100
BOD	mg/l	250	20
TSS	mg/l	220	20
TKN	mg/l	40	10
P	mg/l	8	4
FC	MPN/100ml	10^7 -10^8	200

Sewage Treatment Plant Components

The sewage treatment plant consists of the following components:

1. Grit removal chamber
2. Septic tank
3. Distribution box
4. Reed beds with Bulrush (Scirpus)
5. Chlorination chamber

The size of each component is shown in the table below.

Table 2: Sewage Treatment Plant Components

Florence Hall Sewage Treatment Plant			
Septic Tank, Reed Bed and Chlorination Chamber		Qty	Unit
1	Headworks including screen and grit removal structure		
2	Hydraulic retention time for Septic Tanks	1.5	Days
3	Septic Tank capacity	1,447.98	m^3/d
4	Number of septic tank trains	6	No.
5	Capacity of each tank	245	m^3/d
6	Dimensions of each Tank, Depth	3	m
7	Width	5	m
8	Length	16.6	m
9	Volume of each tank	249	m^3
10	Total septic volume	1,494	m^3
11	Effluent from septic tank flows into a distribution box that spreads flow into three reed beds		
12	Reed bed loading	90	L/m^2
13	Reed bed size	10,725.75	m^2
14	Reed bed depth	0.7	m
15	Voids in bed	0.5	
16	Number of reed bed trains	3	
17	Area of each bed	3,575.25	m^2
18	Length	120	m
19	Width	30	m
20	L/W	5	#
21	Total Reed bed area	10,800	m^2
22	Reed bed setback	20	m
23	Contact Chlorine chamber HRT	25	min
24	Volume required	25.14	m^3
25	D	0.9	m
26	W	2	m
27	L	14	m
28	Discharge into wetland		

Biochemical Processes

The septic tanks will have a hydraulic retention time of 1.5 days; during which the COD and BOD will be reduced to 300 and 150 mg/l respectively. The septic tanks will also remove the majority of the TSS and fecal coli form by about 1 log.

Table 3: Reed Bed Waste Water Influent

Parameter	Units	Influent	Effluent
COD	mg/l	300	<100
BOD	mg/l	150	20
TSS	mg/l	100	20
TKN	mg/l	40	10
P	mg/l	8	4
FC	MPN/100ml	$1.9x10^6$	$1.9x10^4$

The reed bed is designed to have a minimum hydraulic retention time of 5.8 days. A hydraulic retention time of 2.8 days is required to reduce the oxygen demand to NEPA standards.

The BOD removal follows the 1st order plug flow reaction

$$L_t=Le^{-kt}$$

where L_t is the concentration of BOD at any time.

The reaction constant $k_T = k_{20}\,\Theta^{(T-20)}$

where k_{20} = Rate Constant at 20^o C

k_{20} = = 1.104

Θ = 1.06

The average temperature for this site is 27 degrees Celsius. COD removal is at the same rate as BOD removal and COD is generally twice the BOD concentration.

The TSS will be removed within the first few metres of the reed bed (EPA/832-R-93-008).

The nitrogen entering wetland systems can be measured as organic nitrogen and ammonia (expressed as TKN), or as nitrate, or a combination of both nitrogen measurements. The organic N entering a reed bed is typically associated with particulate matter such as organic wastewater solids. Decomposition and mineralization processes in the wetland will convert a significant part of this organic N to ammonia (EPA/832-R-93-008).

Nitrogen removal by wetland plants ranges from 0.2 to 2.25 g/m^2/day. In order to achieve required total nitrogen concentration of 10 mg/l; an additional 3 days of retention time is necessary for reduction by plant uptake.

Phosphorous removal by wetland plants ranges from 0.05 to 0.5 g/m^2/day. Using an average of 0.25/m^2/day, the phosphorous will be below acceptable levels within the 5.8 days of retention. Phosphorous reduction will occur via plant uptake and sedimentation of PO4.

Fecal coliform levels are expected to have a 2 log reduction in 5.8 days. Chlorination for 25 minutes in a contact chamber will reduce FC to acceptable levels.

Discharge from the chlorination chamber will be to a wetland north of the North Coast Highway.

Constructions details are included in the enclosed drawings.

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APPENDIX

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Project: Proposed residential development
Project No. 0827/76/C

WETLAND DESIGN

Input Data:

Design Flow Rate,Q: **252549** **GPD** (33760.84) ft.^{3} (955.644) m^3

Req'd BOD_5 Removal (%): **85**

Depth of Wetland, d: **3** **ft**
Type of soil in wetland: **Medium Gravel**
Gradation of particles: **35mm - 75mm**
Porosity of gravel/stones, n: **40** **%**
Slope of bottom of wetland: **0.4** **%**

Calculate Temperature Dependent Rate Constant

Enter Avg. Temperature of location: **27** **°**

K_T = Rate Constant at Temperature T
= $K_{20}\,\Theta^{(T-20)}$

where K_{20} = Rate Constant at 20° C = 1.104
Θ = 1.06

$\rightarrow K_T = 1.104 \times (1.06)^{7}$
$= 1.66$

Calculate Area of Reed Bed required for BOD removal

$$A = \frac{Q\,[\ln(C_o/C_e)}{K_T dn}$$

where C_o = Influent BOD_5 (150mg/l)
C_e = Effluent BOD_5 (<20mg/l)
so C_o/C_e = Ratio of Influent: Effluent = 150 ÷ (100 - % Reduction)
= 6.67

Area = [33760.84 x ln (6.67)] ÷ [1.66 x 3 x 0.4]
= 32152.64 sq. ft

Calculate Hydraulic Retention Time Required for BOD Removal

From the equation : $C_e/C_o = e^{(K_T t)}$

Hydraulic retention time, t = $[\ln(C_e/C_o)] \div K_T$

= 2.77 days

Calculate Area of Reed Bed required for Nitrogen removal

Nitrogen Removal Obtained in First 2.77 days = 29 %

Additional % Nitrogen Removal Req'd: **31** %

Specify Plant Type: **Bulrush (Scirpus)**

Oxygen available = depth x available oxygen per unit vol. for specified plant

= 0.91 m x 7.5 $gm/m^3/d$

= 6.86 $gm/m^2/d$

Assume 5mg/L of oxygen to react with 1mg of Ammonia to form Nitrate
Assume 100mg/L BOD influent and apply % reduction above
Therefore, Use NH influent as 15 mg/L

Oxygen Required = 5 x Q x (Nitrogen to be removed)

= 5 x 955.644 m^3 /d x 4.65 mg/L

= 22219 gm/d

Area Required = Oxygen required/Oxygen Available

= 3240 m^2 (34860.505) sq.ft

Calculate Total Area and Retention time

TOTAL AREA REQUIRED = 32152.64 + #### = 67013.1 sq.ft

Using a 2:1 Length to Width ratio, Dimensions are:

Length	**=**	**366.10**	**ft**	**Width =**	**183.05**	**ft**	**Depth =**	**3**	**ft**
	=	**111.59**	**m**	**=**	**55.79**	**m**	**=**	**0.91**	**m**

Total HRT = 2.77 + 3.00

= 5.8 days

References: - EPA Technology Assessment: Subsurface Flow - Constructed Wetlands for Wastewater Treatment - EPA/832-R-93-008