Appendix B-2

Hydraulic Calculations for Sewage Treatment Plant

Appendix.B.2 HYDRAULIC CALCULATION OF SEWAGE TREATMENT PLANT

Basic Design Conditions

(1) Name of STP ASTANA STP

(2) Sewage collectio Separate sewer system

(3) Design sewage flow

		Proposed Design Flow	
		m^3/d	m^3/s
Daily Average Flow	Q1	114,000	1.319
Design Daily Flow	Q2	136,000	1.574
Maximum Flow	Q3	200,000	2.315

(4) Incoming pipe

Pipe diameter		ϕ 1400mm
Slope		
Invert level		
Water level	Daily average	
	Hourly maximum	
Full flow		

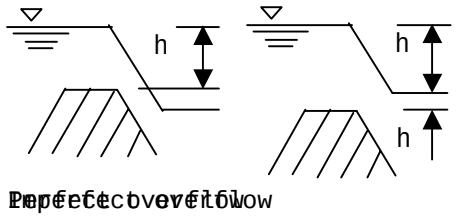
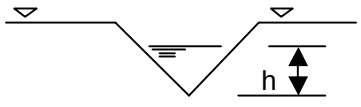
(5) Effluent discharg

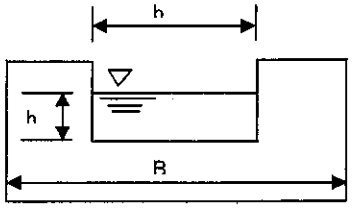
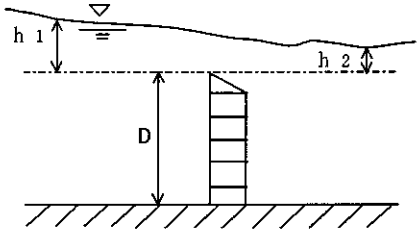
Discharge point/river	Taldy Kol Reservoir
Maximum high water level (HHWL)	+346.700m
Design high water level (HWL)	+346.700m
Design river bed level	
Present river bed level	
Pump Pit Water Level	+338.900m
	(Existing)

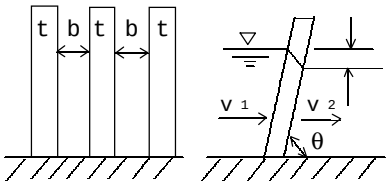
(6) Design ground level of STP

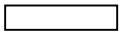
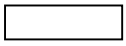
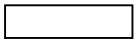
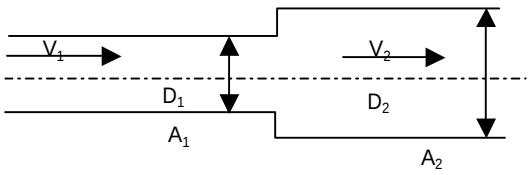
+345.0 ～ +351.3 m

LIST OF FORMULA

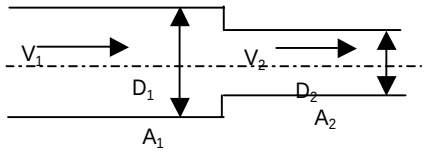
Name of formula	Formula	Application
(1) Manning (Formula -1)	$V = \frac{1}{n} R^{2/3} I^{1/2}$ V: Velocity (m/sec) n: Roughness coefficient i: Grade R: Mean Depth (m)	RC pipe
(2) Darcy Weisbach (Formula -2)	$h_f = f \frac{L}{D} \frac{V^2}{2g}$ f : Friction loss coefficient $\left[0.2 + \frac{1}{2000\ D}\right]$ L : Length (m) D : Diameter (m)	DCIP or Mortar Lined Pipe
(3) Francis (Formula -3)	$L = \frac{Q}{1.8h^{3/2}}$: Perfect overflow $L = \frac{Q}{1.84\left(h_1 + 1.4h_2\right)\sqrt{h_1}}$: Imperfect overflow L: Weir width (m) Q : Flow (m^3/sec) h, h_1 ,h_2 :Overflow depth (m)  Perfect overflow Imperfect overflow	Broad-Cresterd weir
(4) Thomson (Formula -4)	$Q = 1.42\ h^{5/2}$ h: Overflow depth 	Right angle Triangular weir

Name of formula	Formula	Application
(5) Thomson	$Q = 1.84\ bh^{3/2}$  b : Weir width (m) h : Overflow height (m)	Rectangular weir
(6) Bilmont	$Q = Q_1\left\{1-\left(\frac{h2}{h1}\right)^n\right\}^{0.385}$ Q1: Flow when free overflow depth is h_1 (m3/sec) h_1 :Upstream depth above weir top (m) h_2 :Down stream depth above weir top (m) n :Coefficient by shape of weir (Broad-Crested Weir, Rectangular Weir, Triangular Weir) 1.50 1.45 2.50  	Submerged sharp-edged weir
(7) Thomas-Kamp (Formula -5)	$h_0 = \sqrt{3}hc\,\ell$: Freefall at downstream $h_0 = \sqrt{\frac{2hc\,\ell^3}{h\ell}+h\ell^2}$: Submerged at downstream h_0 : Depth at upstream (m) hc*l* : Critical depth (m) h*l* :Depth at downstream (m) $hc\ \ell = \sqrt[3]{\frac{\alpha Q^2}{gB^2}}$ α : Coefficient (=1) Q; Total flow at down stream (m^3/sec) B: Trough width (m) Note: Trough bottom is level	Outlet trough in sedimentation tank

<table>
<tr><th>Name of formula</th><th>Formula</th><th>Application</th></tr>
<tr><td>(8) Kirshemire</td><td>$$h = \beta \sin\theta \left(\frac{t}{b}\right)^{4/3} \frac{V_1^2}{2g}$$
h : Screen loss (m)
β : Coefficient by shape of screen bar
θ : Screen setting angle(°)
t : Screen bar thickness (mm)
b : Screen bar spacing (mm)
 

Plan Section
(a)  β = 1.60
(b)  β = 1.77
(c)  β = 2.34
(d)  β = 1.73</td><td>Screen
Accounting obstruction by screenings, loss of 10cm can be expected</td></tr>
<tr><td>(9) Borda</td><td>Magnification
$$hse = fse \frac{V_1^2}{2g}$$
h se : Magnification loss (m)
f se; Coefficient = $(1-A_1/A_2)^2$
 

<table><tr><td>D 1 /D 2</td><td>0</td><td>0,1</td><td>0,2</td><td>0,3</td><td>0,4</td><td>0,5</td></tr><tr><td>A 1 /A 2</td><td>0</td><td>0,01</td><td>0,04</td><td>0,09</td><td>0,16</td><td>0,25</td></tr><tr><td>fse</td><td>1.0</td><td>0,98</td><td>0,92</td><td>0,82</td><td>0,7</td><td>0,56</td></tr><tr><td>D 1 /D 2</td><td>0,6</td><td>0,7</td><td>0,8</td><td>0,9</td><td>1,0</td><td></td></tr><tr><td>A 1 /A 2</td><td>0,36</td><td>0,49</td><td>0,64</td><td>0,81</td><td>1,0</td><td></td></tr><tr><td>fse</td><td>0,41</td><td>0,26</td><td>0,13</td><td>0,04</td><td>0</td><td></td></tr></table></td><td></td></tr>
</table>

<table>
<tr><th>Name of formula</th><th>Formula</th><th>Application</th></tr>
<tr><td>(10) King</td><td>Shrinkage
$hsc = fsc \frac{V_1^2}{2g}$
h sc: Shrinkage loss (m)
f sc: Coefficient
 

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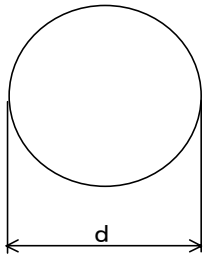
<tr><td>D 2 /D 1</td><td>0</td><td>0,1</td><td>0,2</td><td>0,3</td><td>0,4</td><td>0,5</td></tr>
<tr><td>A 2 /A 1</td><td>0</td><td>0,01</td><td>0,04</td><td>0,09</td><td>0,16</td><td>0,25</td></tr>
<tr><td>fsc</td><td>0,5</td><td>0,5</td><td>0,49</td><td>0,49</td><td>0,46</td><td>0,43</td></tr>
<tr><td>D 2 /D 1</td><td>0,6</td><td>0,7</td><td>0,8</td><td>0,9</td><td>1,0</td><td></td></tr>
<tr><td>A 2 /A 1</td><td>0,36</td><td>0,49</td><td>0,64</td><td>0,81</td><td>1,0</td><td></td></tr>
<tr><td>fsc</td><td>0,38</td><td>0,29</td><td>0,18</td><td>0,07</td><td>0</td><td></td></tr>
</table></td><td></td></tr>
<tr><td>(11) Weisbach</td><td>Shape loss
$h = f \frac{V^2}{2g}$
f : Coefficient (= 1)
<table>
<tr><th></th><th></th><th>f Value</th></tr>
<tr><td>(1) Outlet</td><td></td><td>1.0</td></tr>
<tr><td>(2) Retraction</td><td>(90°)</td><td>1.0</td></tr>
<tr><td></td><td>(180°)</td><td>1.0</td></tr>
<tr><td>(3) Bend</td><td>(45°)</td><td>0.13 (CIP 900)</td></tr>
<tr><td></td><td>(90°)</td><td>0.20 (CIP 900)</td></tr>
<tr><td>(4) Orifice</td><td></td><td>3.0</td></tr>
<tr><td>(5) Inlet</td><td></td><td>0.5</td></tr>
</table></td><td></td></tr>
</table>

Summary Table for Hydraulic Calculation

Sheet No.	Facility	Upstream water level (m) Daily ave. H(DA)	Daily max. H(DM)	Hourly max. H(HM)		Bottom level of facility (m)	Formula
01	Effluent Discharge Pipe (6/6) φ1500 (Existing)	339.070	339.140	339.420			Formula－1.3 (Manning's formula/Circular pipe)
02	Effluent Discharge Pipe (5/6) φ1500 (Existing)	339.110	339.190	339.520			Formula－1.3 (Manning's formula/Circular pipe)
03	Effluent Discharge Pipe (4/6) φ1500 (Existing)	339.120	339.210	339.550			Formula－1.3 (Manning's formula/Circular pipe)
04	Effluent Discharge Pipe (3/6) φ1500 (Existing)	339.130	339.220	339.570			Formula－1.3 (Manning's formula/Circular pipe)
05	Effluent Discharge Pipe (2/6) φ1200	339.140	339.230	339.590			Formula－1.3 (Manning's formula/Circular pipe)
06	Effluent Discharge Pipe (1/6) φ800 (Existing)	339.150	339.240	339.610			Formula－1.3 (Manning's formula/Circular pipe)
07	Secondary Sedimentation Tank Outlet trough 600W	344.870	344.890	344.940		344.700	Formula－5 (Thomas-Camp's formula)
08	Secondary Sedimentation Tank Weir (V-notch)	345.300	345.300	345.310		345.260	Formula－4 (Thomson/Right-angle rectangular weir)
09	Secondary Sedimentation Tank Inlet Pipe φ1200 (Existing)	345.310	345.310	345.320			Formula－2.1 (Darcy-Weisbach's formula)
10	Distribution Tank (for SST) Gate 900W	345.360	345.360	345.400			Formula－6.1 (Orifice/Rectangular opening)
11	Aeration Tank □(Outlet Pit) φ1800 (Existing)	345.390	345.390	345.450			Formula－2.1 (Darcy-Weisbach's formula)
12	Aeration Tank Outlet weir 4800W	346.690	346.700	346.730		346.500	Formula－3 (Francis's formula/Full width weir)
13	Aeration Tank Inlet Channel	346.730	346.750	346.800		342.900	Formula－1.1 (Manning's formula/Rectangular open channel)
14	Primary Sedimentation Tank Outlet pipe (3/3) φ1500	346.770	346.800	346.900			Formula－2.1 (Darcy-Weisbach's formula)
15	Primary Sedimentation Tank Outlet pipe (2/3) φ1200	346.780	346.820	346.930			Formula－2.1 (Darcy-Weisbach's formula)
16	Primary Sedimentation Tank Outlet pipe (1/3) φ800	346.800	346.840	346.980			Formula－2.1 (Darcy-Weisbach's formula)
17	Primary Sedimentation Tank Outlet trough 600W	346.920	346.950	347.050		346.700	Formula－5 (Thomas-Camp's formula)
18	Primary Sedimentation Tank Weir (V-notch)	347.400	347.400	347.410		347.350	Formula－4 (Thomson/Right-angle rectangular weir)
19	Primary Sedimentation Tank Inlet pipe (2/2) φ500 (Existing)	347.540	347.600	347.840			Formula－2.1 (Darcy-Weisbach's formula)
20	Distribution Tank (for PST) Gate 600W	347.570	347.640	347.920			Formula－6.1 (Orifice/Rectangular opening)
21	Primary Sedimentation Tank Inlet pipe (1/2) φ1200	347.680	347.790	348.240			Formula－2.1 (Darcy-Weisbach's formula)
22	Grit Chamber Distribution Weir 3400W	348.600	348.630	348.700		348.370	Formula－3 (Francis's formula/Full width weir)
23	Grit Chamber Weir 3440W	348.670	348.700	348.800		348.200	Formula－3 (Francis's formula/Full width weir)
24	Grit Chamber Inlet channel 1700W	348.760	348.790	348.900		347.750	Formula－1.1 (Manning's formula/Rectangular open channel)
25	Grit Chamber Gate 1000 W	348.770	348.800	348.910			Formula－1.1 (Manning's formula/Rectangular open channel)

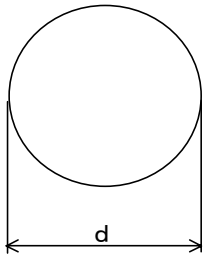
Formula－1.3（Manning's formula/Circular pipe） NO.1

Facility		Effluent Discharge Pipe (6/6)		φ1500 (Existing)		
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	1	1	1		
Unit flow (m^3/s)	q	1.319	1.574	2.315		
Dimensions						
Roughness coef.	n	0.014				
Pipe diameter	d	1.500	m (Existing)			
Cross-section area	AW	1.767	m^2			
Hydraulic radius	R	0.375	m			
Pipe length	L	100.000	m			
Downstream water level (m)	Ho	338.900	338.900	338.900		
Flow velocity (m/s)	V	0.746	0.891	1.310		V=q/AW
Velocity head (m)	$\frac{V^2}{2g}$	0.028	0.040	0.088		
Hydraulic gradient (‰)	I	0.404	0.575	1.244		
Friction loss (m)	h_f	0.040	0.058	0.124		$h_f = I \times L$
Inlet loss (m)	h_i	0.043	0.061	0.131		f = 0.50 n = 3
Outlet loss (m)	h_o	0.085	0.121	0.263		f = 1.00 n = 3
Bend loss (m)	h_b					f = n =
Other losses(m)	h_e					f = n =
Total (m)	Σh	0.168	0.240	0.518		
Head loss (m)	h	0.170	0.240	0.520		Round up to cm
Upstream water level (m)	H	339.070	339.140	339.420		$H=H_0+h$

Formula－1.3（Manning's formula/Circular pipe）

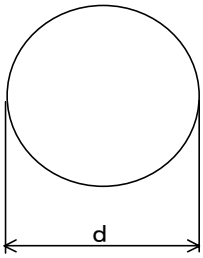
NO.2

Facility		Effluent Discharge Pipe (5/6)		φ1500 (Existing)		
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	1.5	1.5	1.5		8/12 tanks
Unit flow (m^3/s)	q	0.879	1.049	1.543		
Dimensions						
Roughness coef.	n	0.014				
Pipe diameter	d	1.500	m (Existing)			
Cross-section area	AW	1.767	m^2			
Hydraulic radius	R	0.375	m			
Pipe length	L	65.000	m			
Downstream water level (m)	Ho	339.070	339.140	339.420		
Flow velocity (m/s)	V	0.497	0.594	0.873		V=q/AW
Velocity head (m)	$\frac{V^2}{2g}$	0.013	0.018	0.039		
Hydraulic gradient (‰)	I	0.179	0.255	0.553		
Friction loss (m)	h_f	0.012	0.017	0.036		$h_f = I \times L$
Inlet loss (m)	h_i	0.006	0.009	0.019		f = 0.50 n = 1
Outlet loss (m)	h_o	0.013	0.018	0.039		f = 1.00 n = 1
Bend loss (m)	h_b					f = n =
Other losses(m)	h_e					f = n =
Total (m)	Σh	0.031	0.044	0.094		
Head loss (m)	h	0.040	0.050	0.100		Round up to cm
Upstream water level (m)	H	339.110	339.190	339.520		$H=H_0+h$



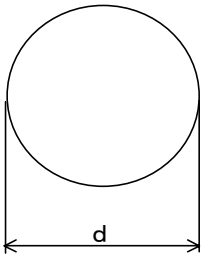
Formula－1.3（Manning's formula/Circular pipe） NO.3

Facility		Effluent Discharge Pipe (4/6)		φ1500 (Existing)		
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	3	3	3		4/12 tanks
Unit flow (m^3/s)	q	0.440	0.525	0.772		
Dimensions						
Roughness coef.	n	0.014				
Pipe diameter	d	1.500	m (Existing)			
Cross-section area	AW	1.767	m^2			
Hydraulic radius	R	0.375	m			
Pipe length	L	65.000	m			
Downstream water level (m)	Ho	339.110	339.190	339.520		
Flow velocity (m/s)	V	0.249	0.297	0.437		V=q/AW
Velocity head (m)	$\frac{V^2}{2g}$	0.003	0.005	0.010		
Hydraulic gradient (‰)	I	0.045	0.064	0.138		
Friction loss (m)	h_f	0.003	0.004	0.009		$h_f = I \times L$
Inlet loss (m)	h_i	0.002	0.002	0.005		f = 0.50, n = 1
Outlet loss (m)	h_o	0.003	0.005	0.010		f = 1.00, n = 1
Bend loss (m)	h_b					f = , n =
Other losses(m)	h_e					f = , n =
Total (m)	Σh	0.008	0.011	0.024		
Head loss (m)	h	0.010	0.020	0.030		Round up to cm
Upstream water level (m)	H	339.120	339.210	339.550		$H=H_0+h$



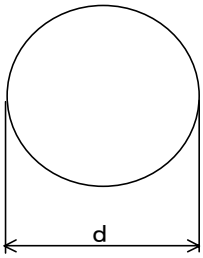
Formula－1.3（Manning's formula/Circular pipe） NO.4

Facility		Effluent Discharge Pipe (3/6)		φ1500 (Existing)		
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	3	3	3		4/12 tanks
Unit flow (m^3/s)	q	0.440	0.525	0.772		
Dimensions						
Roughness coef.	n	0.014				
Pipe diameter	d	1.500	m (Existing)			
Cross-section area	AW	1.767	m^2			
Hydraulic radius	R	0.375	m			
Pipe length	L	10.000	m			
Downstream water level (m)	Ho	339.120	339.210	339.550		
Flow velocity (m/s)	V	0.249	0.297	0.437		V=q/AW
Velocity head (m)	$\frac{V^2}{2g}$	0.003	0.005	0.010		
Hydraulic gradient (‰)	I	0.045	0.064	0.138		
Friction loss (m)	h_f	0.000	0.001	0.001		$h_f = I \times L$
Inlet loss (m)	h_i	0.002	0.002	0.005		f = 0.50 n = 1
Outlet loss (m)	h_o	0.003	0.005	0.010		f = 1.00 n = 1
Bend loss (m)	h_b					f = n =
Other losses(m)	h_e					f = n =
Total (m)	Σh	0.005	0.008	0.016		
Head loss (m)	h	0.010	0.010	0.020		Round up to cm
Upstream water level (m)	H	339.130	339.220	339.570		$H=H_0+h$



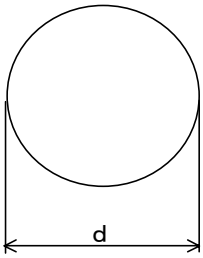
Formula－1.3（Manning's formula/Circular pipe） NO.5

Facility	Effluent Discharge Pipe (2/6) φ1200					
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	6	6	6		2/12 tanks
Unit flow (m^3/s)	q	0.220	0.262	0.386		
Dimensions						
Roughness coef.	n	0.014				
Pipe diameter	d	1.200	m (Existing)			
Cross-section area	AW	1.131	m^2			
Hydraulic radius	R	0.300	m			
Pipe length	L	25.000	m			
Downstream water level (m)	Ho	339.130	339.220	339.570		
Flow velocity (m/s)	V	0.195	0.232	0.341		V=q/AW
Velocity head (m)	$\frac{V^2}{2g}$	0.002	0.003	0.006		
Hydraulic gradient (‰)	I	0.037	0.052	0.114		
Friction loss (m)	h_f	0.001	0.001	0.003		$h_f = I \times L$
Inlet loss (m)	h_i	0.001	0.001	0.003		f = 0.50 n = 1
Outlet loss (m)	h_o	0.002	0.003	0.006		f = 1.00 n = 1
Bend loss (m)	h_b					f = n =
Other losses(m)	h_e					f = n =
Total (m)	Σh	0.004	0.005	0.012		
Head loss (m)	h	0.010	0.010	0.020		Round up to cm
Upstream water level (m)	H	339.140	339.230	339.590		$H=H_0+h$



Formula－1.3（Manning's formula/Circular pipe） NO.6

Facility		Effluent Discharge Pipe (1/6)		φ800 (Existing)		
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	12	12	12		1/12 tanks
Unit flow (m^3/s)	q	0.110	0.131	0.193		
Dimensions						
Roughness coef.	n	0.014				
Pipe diameter	d	0.800	m (Existing)			
Cross-section area	AW	0.503	m^2			
Hydraulic radius	R	0.200	m			
Pipe length	L	15.000	m			
Downstream water level (m)	Ho	339.140	339.230	339.590		
Flow velocity (m/s)	V	0.219	0.261	0.384		V=q/AW
Velocity head (m)	$\frac{V^2}{2g}$	0.002	0.003	0.008		
Hydraulic gradient (‰)	I	0.080	0.114	0.247		
Friction loss (m)	h_f	0.001	0.002	0.004		$h_f = I \times L$
Inlet loss (m)	h_i	0.001	0.002	0.004		f = 0.50 n = 1
Outlet loss (m)	h_o	0.002	0.003	0.008		f = 1.00 n = 1
Bend loss (m)	h_b					f = n =
Other losses(m)	h_e					f = n =
Total (m)	Σh	0.004	0.007	0.016		
Head loss (m)	h	0.010	0.010	0.020		Round up to cm
Upstream water level (m)	H	339.150	339.240	339.610		$H=H_0+h$



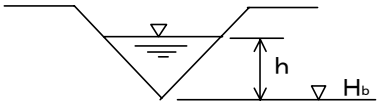
Formula－5（Thomas-Camp's formula）

NO.7

Facility		Secondary Sedimentation Tank				Outlet trough 600W
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	24	24	24		12 Tanks x 2 Troughs
Unit flow (m^3/s)	q	0.055	0.066	0.096		
Dimensions						
Trough width	B	0.60 m				
Trough length	L	42.00 m	(28 - 0.60 x 2) x 3.14 /2			
Trough slope	i	0.00 ‰				
Trough bottom level	H_b	+344.700 m	(Existing trough level)			
Downstream water level (m)	H_0	339.150	339.240	339.610		
Trough bottom level (m)	H_b	344.700	344.700	344.700		
Water depth at end of trough	h_1					
Critical depth (m)	h_{cl}	0.095	0.107	0.138		
Water depth at start of trough	h_0	0.165	0.186	0.239		
Friction loss (m)	h_f	0.165	0.186	0.239		$i \times L + h_o$
Total (m)	Σh	0.165	0.186	0.239		
Head loss (m)	h	0.170	0.190	0.240		Round up to cm
Upstream water level (m)	H	344.870	344.890	344.940		$H=H_0+h$

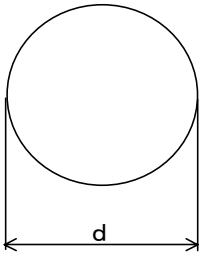
Formula－4（Thomson/Right-angle rectangular weir)

NO.8

Facility		Secondary Sedimentation Tank		Weir (V-notch)		
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	4039	4039	4039		N = (28 - 0.6 x 2) x 3.14 x 12tanks x 4 unit/m = 4039
Unit flow (m^3/s)	q	$\times 10^{-4}$ 3.266	$\times 10^{-4}$ 3.897	$\times 10^{-4}$ 5.732		
Dimensions Notch level	H_b	+345.260 m				
Downstream water level (m)	H_0	344.870	344.890	344.940		
Notch level (m)	H_b	345.260	345.260	345.260		
Overflow depth (m)	h	0.035	0.038	0.044		$h=(q/1.42)^{2/5}$
Total (m)	Σh	0.035	0.038	0.044		
Head loss (m)	h	0.040	0.040	0.050		Round up to cm
Upstream water level (m)	H	345.300	345.300	345.310		$H=H_0+h$

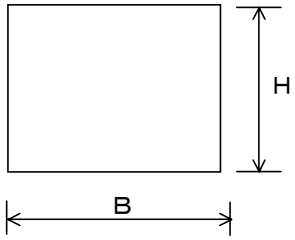
Formula－2.1（Darcy-Weisbach's formula）

NO.9

Facility		Secondary Sedimentation Tank				Inlet Pipe φ1200 (Existing)
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	2.893	3.148	3.889		Q1' = Q1 + Q2 x 1 Q2' = Q2 + Q2 x 1
Number of units	N	12	12	12		Q3' = Q3 + Q2 x 1
Unit flow (m^3/s)	q	0.241	0.262	0.324		
Dimensions Pipe diameter Cross-section area Pipe length Friction loss coef	 d AW L f	 1.200 m (Existing) 1.131 m^2 20.00 m 0.031				
Downstream water level (m)	Ho	345.300	345.300	345.310		
Flow velocity (m/s)	V	0.213	0.232	0.286		V=q／AW
Velocity head (m)	$\frac{V^2}{2g}$	0.002	0.003	0.004		
Straight pipe loss (m)	h_{fl}	0.001	0.001	0.002		
Inlet loss (m)	h_i	0.001	0.001	0.002		f = 0.50 n = 1
Outlet loss (m)	h_o	0.002	0.003	0.004		f = 1.00 n = 1
Bend loss (m)	h_b	0.001	0.001	0.002		f = 0.20 n = 2
Other losses	h_e					f = n =
Total (m)	Σh	0.005	0.006	0.010		
Head loss (m)	h	0.010	0.010	0.010		Round up to cm
Upstream water level (m)	H	345.310	345.310	345.320		H=Ho＋h

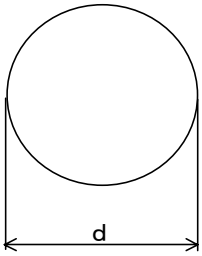
Formula－6.1（Orifice/Rectangular opening）

NO.10

Facility		Distribution Tank (for SST)				Gate 900W
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	2.893	3.148	3.889		Q1' = Q1 + Q2 x 1 Q2' = Q2 + Q2 x 1
Number of openings		12	12	12		Q3' = Q3 + Q2 x 1
Unit flow (m^3/s)	q	0.241	0.262	0.324		
Dimensions (for opening) Width Height Cross-section area	 B H Aw	 0.900 m 0.500 m 0.450 ㎡				
Downstream water level (m)	H_0	345.310	345.310	345.320		
Flow velocity (m/s)	V	0.536	0.583	0.720		V=q／Aw
Velocity head (m)	$\frac{V^2}{2g}$	0.015	0.017	0.026		
Head loss (m)	h_f	0.041	0.048	0.074		$h_f=3.0\times n\times V^2/2g$
Total	Σh	0.041	0.048	0.074		
Head loss	h	0.050	0.050	0.080		Round up to cm
Upstream water level (m)	H	345.360	345.360	345.400		$H=H_0+h$

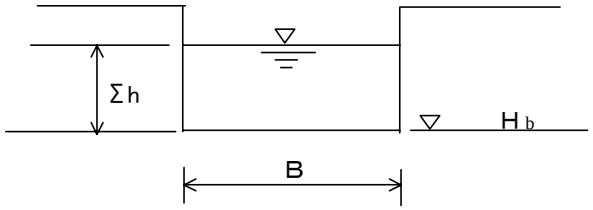
Formula－2.1（Darcy-Weisbach's formula）

NO.11

Facility		Aeration Tank (Outlet Pit)			φ1800 (Existing)	
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	2.893	3.148	3.889		Q1' = Q1 + Q2 x 1 Q2' = Q2 + Q2 x 1
Number of units	N	3	3	3		Q3' = Q3 + Q2 x 1
Unit flow (m^3/s)	q	0.964	1.049	1.296		
Dimensions Pipe diameter Cross-section area Pipe length Friction loss coef	 d AW L f	 1.800 m (Existing) 2.545 m^2 90.00 m 0.030				
Downstream water level (m)	Ho	345.360	345.360	345.400		
Flow velocity (m/s)	V	0.379	0.412	0.509		V=q／AW
Velocity head (m)	$\frac{V^2}{2g}$	0.007	0.009	0.013		
Straight pipe loss (m)	h_{fl}	0.011	0.013	0.020		
Inlet loss (m)	h_i	0.004	0.004	0.007		f = 0.50 n = 1
Outlet loss (m)	h_o	0.007	0.009	0.013		f = 1.00 n = 1
Bend loss (m)	h_b	0.003	0.003	0.005		f = 0.20 n = 2
Other losses	h_e					f = n =
Total (m)	Σh	0.025	0.029	0.045		
Head loss (m)	h	0.030	0.030	0.050		Round up to cm
Upstream water level (m)	H	345.390	345.390	345.450		H=Ho＋h

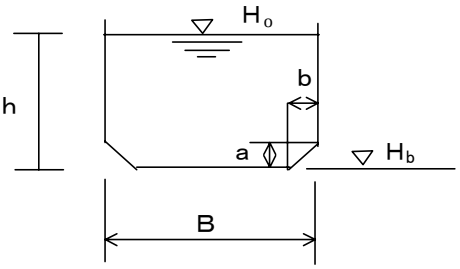
Formula－3（Francis's formula/Full width weir)

NO.12

Facility		Aeration Tank				Outlet weir 4800W
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	2.893	3.148	3.889		Q1' = Q1 + Q2 x 1 Q2' = Q2 + Q2 x 1
Number of units	N	4	4	4		Q3' = Q3 + Q2 x 1
Unit flow (m^3/s)	q	0.723	0.787	0.972		
Dimensions Weir width Weir height	 B H_b	 4.80 m (Existing) +346.500 m				
Downstream water level (m)	H_0	345.390	345.390	345.450		
Weir height (m)	H_b	346.500	346.500	346.500		
Downstream depth above weir	h_2					$h_2=H_o-H_b$
Upstream depth (m)	h_1	0.189	0.200	0.230		
Total (m)	Σh	0.189	0.200	0.230		
Head loss (m)	h	0.190	0.200	0.230		Round up to cm
Upstream water level (m)	H	346.690	346.700	346.730		$H=H_0+h$

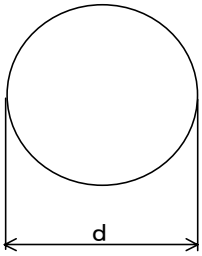
Formula－1.1（Manning's formula/Rectangular open channel） NO.13

Facility		Aeration Tank				Inlet Channel
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	1	1	1		
Unit flow (m^3/s)	q	1.319	1.574	2.315		
Dimensions						
Roughness coef.	n	0.014				
Channel width	B	1.500	m	(Existing)		
Channel length	L	200.00	m			
Haunch height	a	0.00	m			
Haunch width	b	0.00	m			
Bottom level	H_b	342.900	m			
Downstream water level (m)	H_0	346.690	346.700	346.730		
Channel bottom level (m)	H_b	342.900	342.900	342.900		
Effective depth (m)	h	3.790	3.800	3.830		$h = H_0 - H_b$
Cross-section area (m^2)	AW	5.685	5.700	5.745		$WA=B\times h - (a\times b)$
Hydraulic radius (m)	R	0.626	0.626	0.627		$R=\frac{AW}{(2h+B-2(a+b)+2\sqrt{(a^2+b^2)})}$
Hydraulic radius (m)	$R^{4/3}$	0.536	0.536	0.537		
Flow velocity (m/s)	V	0.232	0.276	0.403		$V=\frac{q}{AW}$
Velocity head (m)	$\frac{V^2}{2g}$	0.003	0.004	0.008		
Hydraulic gradient (‰)	I	0.020	0.028	0.059		$I = (n\cdot V / R^{2/3})^2$
Friction loss (m)	h_f	0.004	0.006	0.012		$h_f = I \times L$
Head loss (m) (Out)	hse	0.001	0.002	0.004		f = 0.5, n = 1
Head loss (m) (Contraction)	hsc					f =, n =
Bend loss (m)	h_b	0.005	0.008	0.017		f = 1, n = 2
Other losses (m)	h_e	0.030	0.030	0.030		f =, n =
Total (m)	$\sum h$	0.040	0.046	0.063		
Head loss (m)	h	0.040	0.050	0.070		Round up to cm
Upstream water level (m)	H	346.730	346.750	346.800		

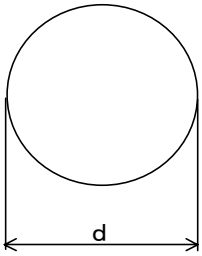


Formula－2.1（Darcy-Weisbach's formula） NO.14

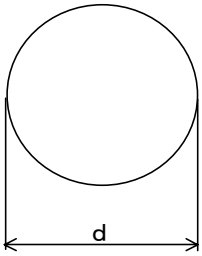
Facility		Primary Sedimentation Tank				Outlet pipe (3/3) φ1500
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	2	2	2		
Unit flow (m^3/s)	q	0.660	0.787	1.158		
Dimensions						
Pipe diameter	d	1.500 m				
Cross-section area	AW	1.767 m^2				
Pipe length	L	70.00 m				
Friction loss coef	f	0.030				
Downstream water level (m)	Ho	346.730	346.750	346.800		
Flow velocity (m/s)	V	0.373	0.445	0.655		V=q／AW
Velocity head (m)	$\frac{V^2}{2g}$	0.007	0.010	0.022		
Straight pipe loss (m)	h_{fl}	0.010	0.014	0.031		
Inlet loss (m)	h_i	0.007	0.010	0.022		f = 0.50 n = 2
Outlet loss (m)	h_o	0.014	0.020	0.044		f = 1.00 n = 2
Bend loss (m)	h_b					f = n =
Other losses	h_e					f = n =
Total (m)	Σh	0.031	0.044	0.097		
Head loss (m)	h	0.040	0.050	0.100		Round up to cm
Upstream water level (m)	H	346.770	346.800	346.900		H=Ho+h



Formula－2.1（Darcy-Weisbach's formula） NO.15

Facility		Primary Sedimentation Tank				Outlet pipe (2/3) φ1200
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	4	4	4		2/8 tanks
Unit flow (m^3/s)	q	0.330	0.394	0.579		
Dimensions Pipe diameter Cross-section area Pipe length Friction loss coef	 d AW L f	 1.200 m 1.131 m^2 20.00 m 0.031				
Downstream water level (m)	Ho	346.770	346.800	346.900		
Flow velocity (m/s)	V	0.292	0.348	0.512		V=q／AW
Velocity head (m)	$\frac{V^2}{2g}$	0.004	0.006	0.013		
Straight pipe loss (m)	h_{fl}	0.002	0.003	0.007		
Inlet loss (m)	h_i	0.002	0.003	0.007		f = 0.50 n = 1
Outlet loss (m)	h_o	0.004	0.006	0.013		f = 1.00 n = 1
Bend loss (m)	h_b					f = n =
Other losses	h_e					f = n =
Total (m)	Σh	0.008	0.012	0.027		
Head loss (m)	h	0.010	0.020	0.030		Round up to cm
Upstream water level (m)	H	346.780	346.820	346.930		H=Ho+h

Formula－2.1（Darcy-Weisbach's formula） NO.16

Facility		Primary Sedimentation Tank				Outlet pipe (1/3) φ800
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	8	8	8		1/8 tanks
Unit flow (m^3/s)	q	0.165	0.197	0.289		
Dimensions Pipe diameter Cross-section area Pipe length Friction loss coef	 d AW L f	 0.800 m 0.503 m^2 25.00 m 0.031				
Downstream water level (m)	Ho	346.780	346.820	346.930		
Flow velocity (m/s)	V	0.328	0.392	0.575		V=q／AW
Velocity head (m)	$\frac{V^2}{2g}$	0.005	0.008	0.017		
Straight pipe loss (m)	h_{fl}	0.005	0.008	0.016		
Inlet loss (m)	h_i	0.003	0.004	0.008		f = 0.50 n = 1
Outlet loss (m)	h_o	0.005	0.008	0.017		f = 1.00 n = 1
Bend loss (m)	h_b					f = n =
Other losses	h_e					f = n =
Total (m)	Σh	0.013	0.020	0.041		
Head loss (m)	h	0.020	0.020	0.050		Round up to cm
Upstream water level (m)	H	346.800	346.840	346.980		H=Ho+h

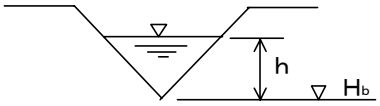
Formula－5（Thomas-Camp's formula）

NO.17

Facility		Primary Sedimentation Tank				Outlet trough 600W
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	16	16	16		8 Tanks x 2 Troughs
Unit flow (m^3/s)	q	0.082	0.098	0.145		
Dimensions						
Trough width	B	0.60 m				
Trough length	L	40.00 m	(28 - 0.6) x 3.14 /2			
Trough slope	i	0.00 ‰				
Trough bottom level	H_b	+346.700 m	(Existing trough level)			
Downstream water level (m)	H_0	346.800	346.840	346.980		
Trough bottom level (m)	H_b	346.700	346.700	346.700		
Water depth at end of trough	h_1	0.100	0.140	0.280		
Critical depth (m)	h_{cl}	0.124	0.140	0.181		
Water depth at start of trough	h_0	0.219	0.242	0.348		
Friction loss (m)	h_f	0.219	0.242	0.348		$i \times L + h_o$
Total (m)	Σh	0.219	0.242	0.348		
Head loss (m)	h	0.220	0.250	0.350		Round up to cm
Upstream water level (m)	H	346.920	346.950	347.050		$H=H_0+h$

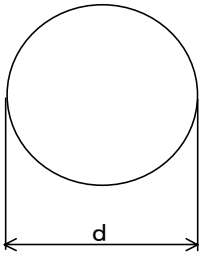
Formula－4（Thomson/Right-angle rectangular weir)

NO.18

Facility		Primary Sedimentation Tank				Weir (V-notch)
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	2692	2692	2692		N = (28 - 0.6 x 2) x 3.14 x 8tanks x 4 unit/m = 2692
Unit flow (m^3/s)	q	$\times 10^{-4}$ 4.900	$\times 10^{-4}$ 5.847	$\times 10^{-4}$ 8.600		
Dimensions Notch level	H_b	+347.350 m (Existing Level) 				
Downstream water level (m)	H_0	346.920	346.950	347.050		
Notch level (m)	H_b	347.350	347.350	347.350		
Overflow depth (m)	h	0.041	0.044	0.052		$h=(q/1.42)^{2/5}$
Total (m)	Σh	0.041	0.044	0.052		
Head loss (m)	h	0.050	0.050	0.060		Round up to cm
Upstream water level (m)	H	347.400	347.400	347.410		$H=H_0+h$

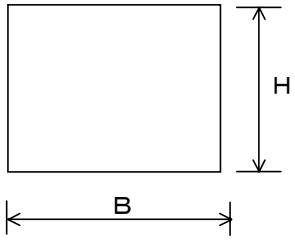
Formula－2.1（Darcy-Weisbach's formula） NO.19

Facility		Primary Sedimentation Tank				Inlet pipe (2/2) φ500 (Existing)
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	8	8	8		1/8 tanks
Unit flow (m^3/s)	q	0.165	0.197	0.289		
Dimensions						
Pipe diameter	d	0.500	m (Existing)			
Cross-section area	AW	0.196	m^2			
Pipe length	L	28.00	m			
Friction loss coef	f	0.031				
Downstream water level (m)	Ho	347.400	347.400	347.410		
Flow velocity (m/s)	V	0.840	1.003	1.472		V=q／AW
Velocity head (m)	$\frac{V^2}{2g}$	0.036	0.051	0.111		
Straight pipe loss (m)	h_{fl}	0.063	0.089	0.192		
Inlet loss (m)	h_i	0.018	0.026	0.055		f = 0.50 n = 1
Outlet loss (m)	h_o	0.036	0.051	0.111		f = 1.00 n = 1
Bend loss (m)	h_b	0.022	0.031	0.066		f = 0.20 n = 3
Other losses	h_e					f = n =
Total (m)	Σh	0.139	0.197	0.424		
Head loss (m)	h	0.140	0.200	0.430		Round up to cm
Upstream water level (m)	H	347.540	347.600	347.840		H=Ho+h

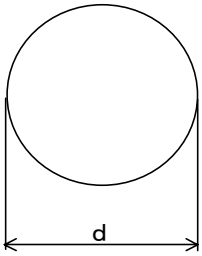


Formula－6.1（Orifice/Rectangular opening）

NO.20

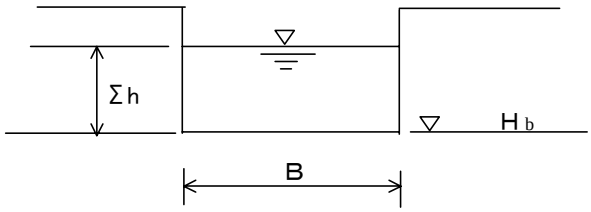
Facility	Distribution Tank (for PST)				Gate 600W
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3	Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315	
Number of openings		8	8	8	
Unit flow (m^3/s)	q	0.165	0.197	0.289	
Dimensions (for opening) Width Height Cross-section area	 B H Aw	 0.600 m 0.650 m 0.390 ㎡			
Downstream water level (m)	H_0	347.540	347.600	347.840	
Flow velocity (m/s)	V	0.423	0.504	0.742	V=q／Aw
Velocity head (m)	$\frac{V^2}{2g}$	0.009	0.013	0.028	
Head loss (m)	h_f	0.025	0.036	0.078	$h_f=3.0\times n\times V^2/2g$
Total	Σh	0.025	0.036	0.078	
Head loss	h	0.030	0.040	0.080	Round up to cm
Upstream water level (m)	H	347.570	347.640	347.920	$H=H_0+h$

Formula－2.1（Darcy-Weisbach's formula） NO.21

Facility		Primary Sedimentation Tank				Inlet pipe (1/2) φ1200
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	2	2	2		4/8 tanks
Unit flow (m^3/s)	q	0.660	0.787	1.158		
Dimensions Pipe diameter Cross-section area Pipe length Friction loss coef	 d AW L f	 1.200 m (New) 1.131 m^2 145.00 m 0.031				
Downstream water level (m)	Ho	347.570	347.640	347.920		
Flow velocity (m/s)	V	0.584	0.696	1.024		V=q／AW
Velocity head (m)	$\frac{V^2}{2g}$	0.017	0.025	0.053		
Straight pipe loss (m)	h_{fl}	0.065	0.093	0.200		
Inlet loss (m)	h_i	0.009	0.012	0.027		f = 0.50 n = 1
Outlet loss (m)	h_o	0.017	0.025	0.053		f = 1.00 n = 1
Bend loss (m)	h_b	0.010	0.015	0.032		f = 0.20 n = 3
Other losses	h_e					f = n =
Total (m)	Σh	0.101	0.145	0.312		
Head loss (m)	h	0.110	0.150	0.320		Round up to cm
Upstream water level (m)	H	347.680	347.790	348.240		H=Ho+h

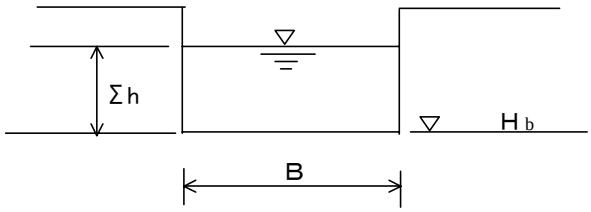
Formula－3（Francis's formula/Full width weir)

NO.22

Facility		Grit Chamber				Distribution Weir 3400W
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	2	2	2		
Unit flow (m^3/s)	q	0.660	0.787	1.158		
Dimensions Weir width Weir height	 B H_b	 3.40 m +348.370 m				
Downstream water level (m)	H_0	347.680	347.790	348.240		
Weir height (m)	H_b	348.370	348.370	348.370		
Downstream depth above weir	h_2					$h_2=H_o-H_b$
Upstream depth (m)	h_1	0.223	0.251	0.325		
Total (m)	Σh	0.223	0.251	0.325		
Head loss (m)	h	0.230	0.260	0.330		Round up to cm
Upstream water level (m)	H	348.600	348.630	348.700		$H=H_0+h$

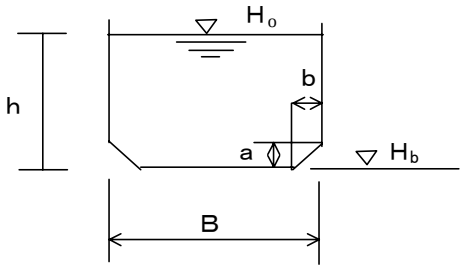
Formula－3（Francis's formula/Full width weir)

NO.23

Facility		Grit Chamber				Weir 3440W
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	2	2	2		
Unit flow (m^3/s)	q	0.660	0.787	1.158		
Dimensions Weir width Weir height	 B H_b	 3.44 m +348.200 m				
Downstream water level (m)	H_0	348.600	348.630	348.700		
Weir height (m)	H_b	348.200	348.200	348.200		
Downstream depth above weir	h_2	0.400	0.430	0.500		$h_2=H_o-H_b$
Upstream depth (m)	h_1	0.031	0.038	0.061		
Total (m)	Σh	0.031	0.038	0.061		
Head loss (m)	h	0.070	0.070	0.100		Round up to cm
Upstream water level (m)	H	348.670	348.700	348.800		$H=H_0+h$

Formula－1.1（Manning's formula/Rectangular open channel） NO.24

Facility		Grit Chamber			Inlet channel 1700W	
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	2	2	2		
Unit flow (m^3/s)	q	0.660	0.787	1.158		
Dimensions						
Roughness coef.	n	0.013				
Channel width	B	1.700 m				
Channel length	L	6.00 m				
Haunch height	a	0.00 m				
Haunch width	b	0.00 m				
Bottom level	H_b	347.750 m				
Downstream water level (m)	H_0	348.670	348.700	348.800		
Channel bottom level (m)	H_b	347.750	347.750	347.750		
Effective depth (m)	h	0.920	0.950	1.050		$h = H_0 - H_b$
Cross-section area (m^2)	AW	1.564	1.615	1.785		$WA=B\times h - (a\times b)$
Hydraulic radius (m)	R	0.442	0.449	0.470		$R=\frac{AW}{(2h+B-2(a+b)+2\sqrt{(a^2+b^2)})}$
Hydraulic radius (m)	$R^{4/3}$	0.336	0.343	0.365		
Flow velocity (m/s)	V	0.422	0.487	0.649		$V = \frac{q}{AW}$
Velocity head (m)	$\frac{V^2}{2g}$	0.009	0.012	0.021		
Hydraulic gradient (‰)	I	0.089	0.117	0.195		$I = (n\cdot V / R^{2/3})^2$
Friction loss (m)	h_f	0.001	0.001	0.001		$h_f = I \times L$
Head loss (m) (Out)	hse	0.005	0.006	0.011		f = 0.5 n = 1
Head loss (m) (Contraction)	hsc					f = n =
Bend loss (m)	h_b					f = n =
Other losses (m)	h_e	0.080	0.080	0.080		f = n =
Total (m)	$\sum h$	0.086	0.087	0.092		
Head loss (m)	h	0.090	0.090	0.100		Round up to cm
Upstream water level (m)	H	348.760	348.790	348.900		



Formula－1.1（Manning's formula/Rectangular open channel） NO.25

Facility		Grit Chamber			Gate 1000 W	
Item	Sign	Daily Flow Q1	Design Flow Q2	Maxi. Flow Q3		Remarks
Flow (m^3/s)	Q	1.319	1.574	2.315		
Number of units	N	4	4	4		
Unit flow (m^3/s)	q	0.330	0.394	0.579		
Dimensions						
Roughness coef.	n	0.014				
Channel width	B	1.200 m				
Channel length	L	0.50 m				
Haunch height	a	0.00 m				
Haunch width	b	0.00 m				
Bottom level	H_b	346.950 m				
Downstream water level (m)	H_0	348.760	348.790	348.900		
Channel bottom level (m)	H_b	346.950	346.950	346.950		
Effective depth (m)	h	1.810	1.840	1.950		$h = H_0 - H_b$
Cross-section area (m^2)	AW	2.172	2.208	2.340		$WA=B\times h - (a\times b)$
Hydraulic radius (m)	R	0.451	0.452	0.459		$R=\frac{AW}{(2h+B-2(a+b)+2\sqrt{(a^2+b^2)})}$
Hydraulic radius (m)	$R^{4/3}$	0.345	0.347	0.354		
Flow velocity (m/s)	V	0.152	0.178	0.247		$V = \frac{q}{AW}$
Velocity head (m)	$\frac{V^2}{2g}$	0.001	0.002	0.003		
Hydraulic gradient (‰)	I	0.013	0.018	0.034		$I = (n\cdot V / R^{2/3})^2$
Friction loss (m)	h_f	0.000	0.000	0.000		$h_f = I \times L$
Head loss (m) (Gate)	hse	0.002	0.002	0.005		f = 1.5 n = 1
Head loss (m) (Contraction)	hsc					f = n =
Bend loss (m)	h_b					f = n =
Other losses (m)	h_e					f = n =
Total (m)	$\sum h$	0.002	0.002	0.005		
Head loss (m)	h	0.010	0.010	0.010		Round up to cm
Upstream water level (m)	H	348.770	348.800	348.910