JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE GENERAL DIRECTION OF CONSTRUCTION AND HYDRAULIC OPERATION (DGCOH)
GENERAL SECRETARIAT OF WORKS
THE FEDERAL DISTRICT OF MEXICO

THE FEASIBILITY STUDY ON WASTEWATER TREATMENT IN THE FEDERAL DISTRICT OF MEXICO

DATA BOOK

DECEMBER 1994

PACIFIC CONSULTANTS INTERNATIONAL, TOKYO

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DATA / CALCULATIONS

DECEMBER 1994

JAPAN INTERNATIONAL COOPERATION AGENCY

DESIGN CALCULATION

FOR

WASTEWATER TREATMENT PLANT

DECEMBER 1994

JAPAN INTERNATIONAL COOPERATION AGENCY

Design Calculation for Wastewater Treatment Plant

Design Condition

Design Condition		Unit	Final Project	Urgent Project
Design Flow Rate	Qd	m3/d	3,456,000	3,024,000
(Daily Average)	Qm	m3/min.	2,400	2,100
	Qs	m3/sec.	40.0	35.0
Number of Unit	Nu	unit	8	2
Design Flow Rate per 1 Unit	Qd'	m3/d	432,000	1,512,000
(Daily Average)	Qm'	m3/min.	300	1,050
	Qs'	m3/sec.	5.0	17.5
Influent Water Quality (BOD)	Cbod	mg/l	245	220
(SS)	Css	mg/l	260	235

1) Primary Sedimentation Tank

	Design Item			Unit	Final Project	Urgent Project
Design Calculation	Surface Loading		Ls	m3/m2•d	35	---
	Required Surface Area		A=Qm'/Ls	m2	12,343	---
Verification		Effective Width	B	m	5	5
	Size of Structure	Effective Length	L	m	39	39
		Effective Depth	H	m	3	3
	No. of Basin per 1 Unit		-	basin	16	16
	No. of Channel per 1 Basin		-	channel	4	4
	No. of Channel per 1 Unit		n	channel	64	64
	Surface Loading ≤ Ls		Ls'=Qd'/B/L/n	m3/m2•d	34.62	121.15
	Surface Area ≥ A		A'=B x L x n	m2	12,480	12,480
	Average Velocity		Vps'=Qm'/B/H/n	m/min.	0.31	1.09
	Settling Time		T=L/Vps'	hr.	2.1	0.6

2) Aeration Tank

	Design Item		Unit	Final Project	Urgent Project
Design Calculation	Influent Water Quality (BOD)	Cboda	mg/l	196	220
	(SS)	Cssa	mg/l	156	235
	F : M	Rfm	-	0.30	1.5 - 5.0
	BOD Volumetric Load	Lv'	BODkg/m3•d	0.32 - 0.64	1.2 - 2.4
	Return Sludge Solid Concentration	Cr	mg/l	8,000	6,500
	Return Sludge Ratio	Rs	-	35%	10%
	MLSS Concentration	Cmlss Cmlss=(Cssa+Cr x Rs/100)/(1+Rs/100)	mg/l	2,190	805
	MLVSS Concentration	Cmlvss = 0.75 x Cmlss	mg/l	1,643	604
	Required Tank Volume	Va Va=(Qd' x Cboda)/(Rfm x Cmlvss)	m3	171,836	---

Verification	Size of Structure	Effective Width	B=H x (1 ~ 2)	m	10.3	10.3
		Effective Length	L	m	89	89
		Effective Depth	H	m	6	6
	No. of Basin		n	basin	32	32
	Cross Section per 1 Basin		As=B x H - 2	m2	59.8	59.8
	Volume per 1 Unit		Va'=As x L x n	m2	170,310	170,310
	F : M		Rfm'=(Qd' x Cboda)/Va'/Cmlvss	-	0.30	3.23
	BOD Volumetric Load		Lv=(Qd' x Cboda)/ Va'/1,000	BODkg/m3•d	0.50	1.95
	Aeration Time		Ta=Va'/Qd' x 24	hr.	9.5	2.7
	Sludge Age		Sa=(Cmlss x Va')/Qd'/Cssa	day	5.53	0.39

3) Secondary Sedimentation Tank

Design Item				Unit	Final Project	Urgent Project
Design Calculation	Surface Loading		Ls	m3/m2•d	25	---
	Required Surface Area		A=Qm'/Ls	m2	17,280	---
Verification	Size of Structure	Effective Width	B	m	5	5
		Effective Length	L=B' x (3 ~ 4)	m	54	54
		Effective Depth	H	m	3.5	3.5
	No. of Basin per 1 Unit		-	basin	16	16
	No. of Channel per 1 Basin		-	channel	4	4
	No. of Channel per 1 Unit		n	channel	64	64
	Surface Loading ≤ Ls		Ls'=Qd'/B/L/n	m3/m2•d	25.00	87.50
	Surface Area ≥ A		A'=B x L x n	m2	17,280	17,280
	Average Velocity		Vps'=Qm'/B/H/n	m/min.	0.27	0.94
	Solid Loading		LDss=(Qd' x Cmlss x 1,000)/A'	kg/m2•d	54.8	70.4
	Settling Time		T=L/Vps'	hr.	3.3	1.0

4) Gravity Thickener

Design Item				Unit	Final Project	Urgent Project
Design Calculation	Primary Sludge		Dpv	m3/d	2,010	---
			Dps	t/d	60.22	---
	Solid Loading		LDgs	kg/m2•d	110	---
	Required Surface Area		Ag=Dps/LDgs	m2	547.5	---
Verification	Size of Structure	Diameter	Dg	m	19	---
		Depth	Hg	m	4	---
	No. of Tank		ng	tank	2	---
	Effective Surface Area		Ag'	m2	567.1	---
	Effective Volume		Vg=Ag' x Hg	m3	2,268.4	---
	Solid Loading		LDgs'=Dps x 1,000 / Ag'	kg/m2•d	106.2	---
	Retention Time		Tg'=Vg/Dpv	day	1.13	---

5) Centrifugal Thickener

	Design Item		Unit	Final Project	Urgent Project
Design Calculation	Activated Sludge	Dsv	m3/d	9,670	35,240
		Dss	t/d	77.38	229.09
	Capacity of 1 Set	Vc	m3/hr.	170	170
	Operation Hour per Day	Hc	hr.	24	24
	Operation Efficiency	Ect	--	80%	80%
Verification	No. of Set	n	set	3	11
	Capacity of 1 Unit	Vc'	m3/d	9,792	35,904

6) Anaerobic Digester

	Design Item			Unit	Final Project	Urgent Project
Design Calculation	Primary Sludge from		Dgv	m3/d	800	---
	Gravity Thickener		Dgs	t/d	48.18	---
	Activated Sludge from		Dcv	m3/d	1,160	3,440
	Centrifugal Thickener		Dcs	t/d	69.64	206.18
	Total Sludge		Dtv	m3/d	1,960	3,440
			Dts	t/d	117.82	206.18
	Retention Time		Tr	day	20	20
Verification	Size of Structure	Diameter	Da	m	26	26
		Depth	Ha	m	12.5	12.5
	Capacity of 1 Set		Va	m3	6,636.6	6,636.6
	No. of Set		n	set	6	10
	Capacity of 1 Unit		Va'	m3	39,819.6	66,366.0
	Retention Time		Tr'	day	20.3	19.3

7) Belt Filter Press

	Design Item		Unit	Final Project	Urgent Project
Design Calculation	Digested Sludge from	Ddv	m3/d	1,110	1,950
	Anaerobic Digester	Dds	t/d	66.77	116.83
	Sludge Loading per Belt Width	Lbs	kg/hr•m	250	250
	Operation Time per Day	To	hr.	12	12
	Operation Efficiency	Eb	--	80%	80%
Verification	Belt Width	Wb	m	3	3
	Capacity of 1 Set	Cb	kg/set/d	7,200	7,200
	No. of Set	n	set	10	16
	Capacity of 1 Unit	Vb'	t/d	72.00	115.20

HYDRAULIC CALCULATION

FOR

URGENT PROJECT

DECEMBER 1994

JAPAN INTERNATIONAL COOPERATION AGENCY

Hydraulic Calculation for Urgent Project

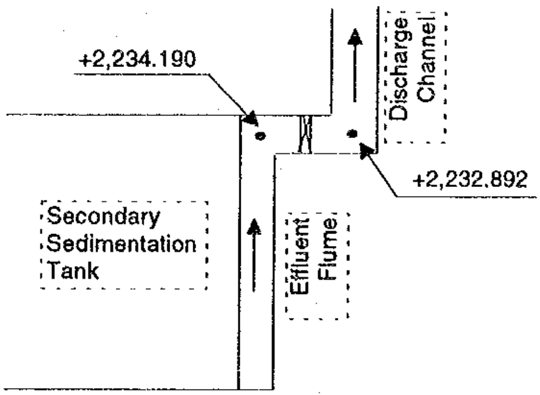
1) Connection Channel from Effluent Flume to Discharge Channel

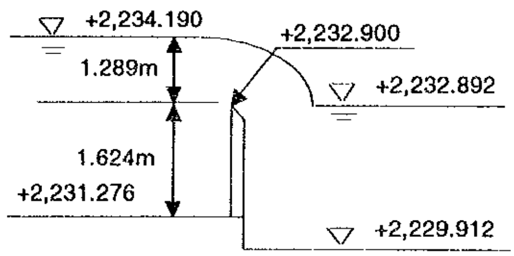
Calculation Condition

Flow Rate per 1 Unit	Q'	17.5 m3/s
Width of Weir	B	6.5 m
Water Depth of Discharge Channel	H	2.980 m
Height of Weir	Hw	1.624 m
Invert Elevation of Upstream of Discharge Channel	+	2,229.912 m
Water Surface Elevation of Upstream of Discharge Channel	+	2,232.892 m

Calculation

Head over Weir Crest	hc	1.289 m
hc=(Q/1.84/B)^(2/3)		
Water Surface Elevation of Downstream of Effluent Flume	+	2,232.825 m
	=	2,234.190 m





2) Effluent Flume of Secondary Sedimentation Tank

< Section a-a >

Calculation Condition

Flow Rate per 1 Unit	Qa	17.5 m3/s
Width of Flume	B	3.0 m
Length of Flume	L	93.2 m
Invert Elevation of Downstream of Flume	+	2,231.276 m
Water Surface Elevation of Downstream of Flume	+	2,234.190 m
Water Depth of Flume	H	2.914 m

Calculation

Cross-sectional Area in Flume	A=BxH	A	8.742 m2
Wetted Perimeter	P=B+2xH	P	8.828 m
Hydraulic Radius	R=A/P	R	0.990 m
Velocity in Flume	v=Qa/A	v	2.002 m/s
Friction Head		hfa-a	0.064 m

hfa-a=((n x v)^2)/(R^(4/3))			
Difference of Invert Level between Downstream and Section a-a		+	0.504 m
Invert Elevation of Section a-a of Flume		+	2,231.780 m
Water Surface Elevation of Section a-a of Flume		+	2,234.254 m

< Section b-b >

Calculation Condition

Flow Rate	Qb=Qa x 3/4	Qb	13.125 m3/s
Width of Flume		B	3.0 m
Length of Flume		L	93.2 m
Water Depth of Flume		H	2.474 m

Calculation

Cross-sectional Area in Flume	A=BxH	A	7.422 m2
Wetted Perimeter	P=B+2xH	P	7.948 m
Hydraulic Radius	R=A/P	R	0.934 m
Velocity in Flume	v=Qa/A	v	1.768 m/s
Friction Head		hfb-b	0.054 m
hfb-b=Lx((n x v)^2)/(R^(4/3))			
Difference of Invert Level between Section a-a and Section b-b		+	0.500 m
Invert Elevation of Section b-b of Flume		+	2,232.280 m
Water Surface Elevation of Section b-b of Flume		+	2,234.308 m

< Section c-c >

Calculation Condition

Flow Rate	Qc=Qa x 2/4	Qc	8.750 m3/s
Width of Flume		B	3.0 m
Length of Flume		L	93.2 m
Water Depth of Flume		H	2.028 m

Calculation

Cross-sectional Area in Flume	A=BxH	A	6.084 m2
Wetted Perimeter	P=B+2xH	P	7.056 m
Hydraulic Radius	R=A/P	R	0.862 m
Velocity in Flume	v=Qa/A	v	1.438 m/s
Friction Head		hfc-c	0.040 m
hfc-c=Lx((n x v)^2)/(R^(4/3))			
Difference of Invert Level between Section b-b and Section c-c		+	0.500 m
Invert Elevation of Section c-c of Flume		+	2,232.780 m
Water Surface Elevation of Section c-c of Flume		+	2,234.348 m

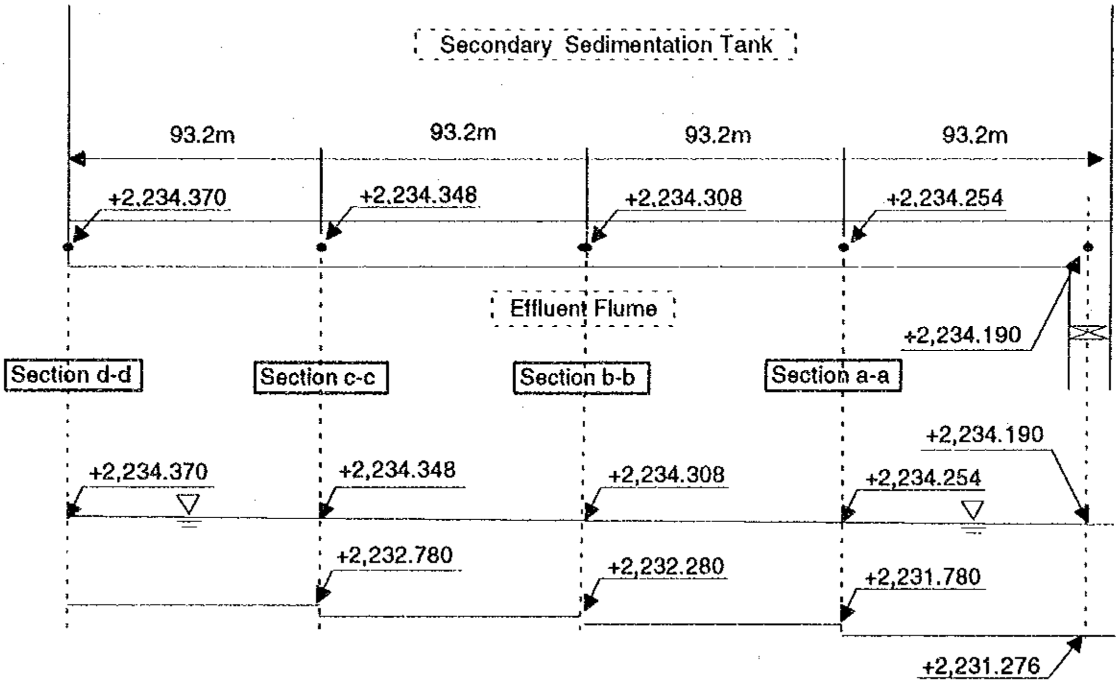
< Section d-d >

Calculation Condition

Flow Rate	Qd=Qa x a/4	Qd	4.375 m3/s
Width of Flume		B	3.0 m
Length of Flume		L	93.2 m
Water Depth of Flume		H	1.568 m

Calculation

Cross-sectional Area in Flume	A=BxH	A	4.704	m2
Wetted Perimeter	P=B+2xH	P	6.136	m
Hydraulic Radius	R=A/P	R	0.767	m
Velocity in Flume	v=Qa/A	v	0.930	m/s
Friction Head		hfd-d	0.019	m
hfd-d=Lx((n x v)^2)/(R^(4/3))				
Invert Elevation of Section d-d of Flume		+	2,232.780	m
Water Surface Elevation of Section d-d of Flume		+	2,234.367	m
		=	2,234.370	m



3) Effluent Collection Trough

< Effluent Collection Trough >

Calculation Condition

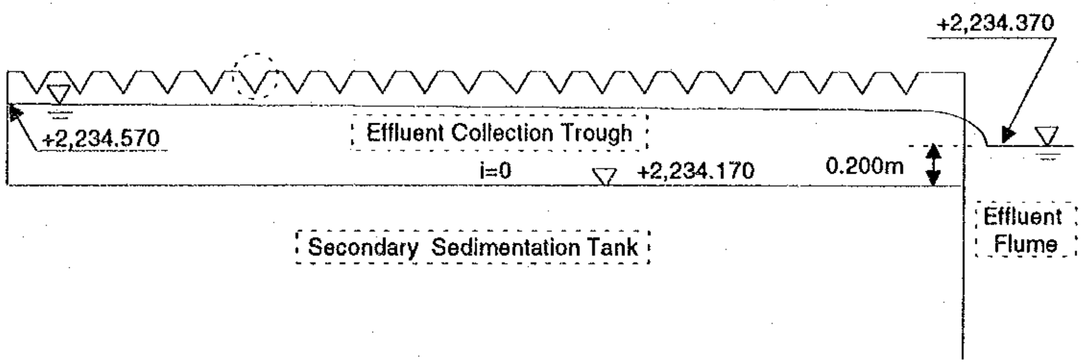
Flow Rate per 1 Unit		Q'	17.5	m3/s
Number of Channel per 1 Unit		n1	64	
Number of Trough per 1 Channel		n2	2	
Flow Rate per 1 Trough		Q	0.137	m3/s
	Q=Q'/(n1 x n2)			
Width of Trough		B	0.4	m
Invert Gradient		i	0.00	
Water Surface Elevation of Section d-d of Flume		+	2,234.370	m

Calculation

Overflow Depth of Downstream of Effluent Collection Trough	he	0.200	m
Head over Weir Crest	hc	0.229	m

hc=(1 x Q^2/9.8/B^2)^(1/3)

Water Depth of Upstream of Effluent Collection Trough	ho	0.4 m
ho=(2 x hc^3)/(hc + hc^2)^(1/2)		
Invert Elevation of Effluent Collection Trough	+	2,234.170 m
Water Surface Elevation of Upstream of Effluent Collection Trough	+	2,234.570 m



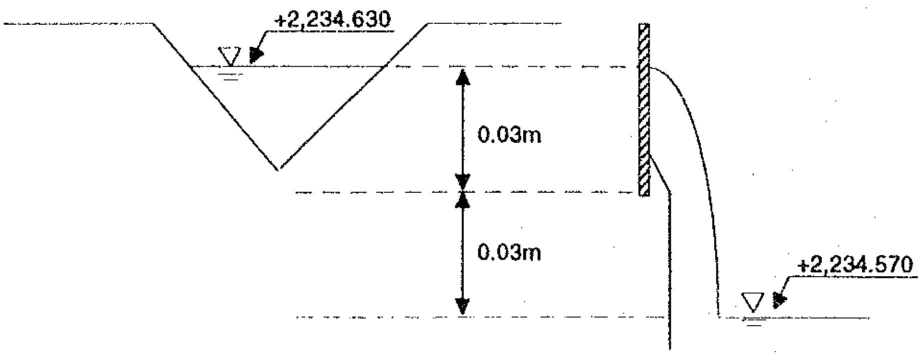
< V-notch Weir >

Calculation Condition

Flow Rate per 1 Unit	Q'	17.5 m3/s
Number of Channel per 1 Unit	n1	64 channel(s)
Flow Rate per 1 Channel	Q1	0.273 m3/s
Q1=Q'/n1		
Weir Over Flow Loading	Wl	190 m3/m•d

Calculation

Width of V-notch Weir	Bw	0.125 m
Required Length of Trough per 1 Channel	Lt	125 m
Number of V-notch Weir per 1 Channel	Nn	1,000
Flow Rate through 1 V-notch Weir	Qw	0.000273 m3/s
Head over V-notch Weir Crest	h	0.03 m
h=(Q/1.42)^(2/5)		
Allowance of Height of V-notch Weir	ha	0.03 m
Water Surface Elevation of Secondary Sedimentation Tank	+	2,234.630 m



4) Connection Channel between Aeration Tank and Secondary Sedimentation Tank

Calculation Condition

Allowance of Head Loss between Connection Channel and Aeration Tank	ha	0.050 m
Invert Elevation of Connection Channel	+	2,234.100 m
Water Surface Elevation of Upstream of Connection Channel	+	2,234.680 m

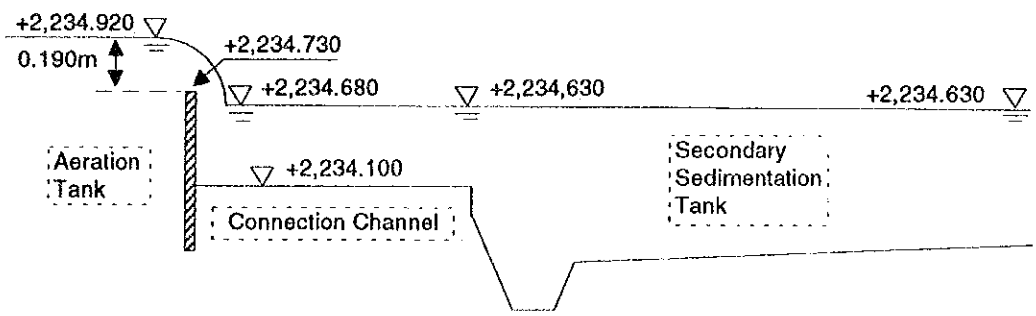
5) Weir of Aeration Tank

Calculation Condition

Flow Rate per 1 Unit	Q'	17.5 m3/s
Return Sludge Ratio	Rs	10 %
Flow Rate Q1=Q' x (1 + Rs/100)	Q1	19.25 m3/s
Number of Channel per 1 Basin	n1	2 channel(s)
Number of Basin per 1 Unit	n2	16 basin(s)
Number of Channel per 1 Unit	n3	32 channel(s)
Design Flow Rate per 1 Channel Q=Q'/n3	Q	0.602 m3/s

Calculation

Width of Weir	B	4.0 m
Type of Weir		Rectangular
Head over the Weir Crest	hc	0.188 m
hc=(Q/1.84/B)^(2/3)	=	0.190 m
Allowance of Weir Height		0.050 m
Elevation of Weir of Aeration Tank	+	2,234.730 m
Water Surface Elevation of Downstream of Weir of Aeration Tank	+	2,234.920 m



6) Distribution Channel

< Distribution Channel 1 >

Calculation Condition

Flow Rate per 1 Unit	Q'	17.5	m3/s
Number of Distribution Channel 1	n1	8	
Flow Rate per 1 Distribution Channel 1 Q1=Q'/n1	Q1	2.188	m3/s
Width of Distribution Channel 1	B1	2.0	m
Length of Distribution Channel 1	L1	28	m
Channel Slope	i1	0.75	‰
Allowance between Water Surface Elevation of Aeration Tank and Invert Elevation of Distribution Channel 1	+	0.080	m
Invert Elevation of Distribution Channel 1	+	2,235.000	m

Calculation

Water Depth in Distribution Channel 1	H1	0.866	m
Cross-sectional Area of Distribution Channel 1	A1	1.732	m2
Wetted Perimeter P1=B1+2xH1	P1	3.732	m
Hydraulic Radius R1=A1/P1	R1	0.464	m
Velocity in Channel 1 v1=1/n*(R1^(2/3)*(i1^(1/2))	v1	1.263	m/s
(Flow Rate in Channel 1	Q1'	2.188	m3/s)
Head loss in Bend hi1=1.0 x (v1^2)/2/9.8	hi1	0.081	m
Invert Elevation of Upstream of Distribution Channel 1	+	2,235.021	m
Water Surface Elevation of Upstream of Distribution Channel 1	+	2,235.968	m

< Distribution Channel 2 >

Calculation Condition

Flow Rate per 1 Unit	Q'	17.5	m3/s
Number of Distribution Channel 2	n2	4	
Flow Rate per 1 Distribution Channel 2 Q2=Q'/n2	Q2	4.375	m3/s
Width of Distribution Channel 2	B2	2.5	m
Length of Distribution Channel 2	L2	43	m
Channel Slope	i2	0.75	‰

Calculation

Water Depth in Inlet Channel 2	H2	1.164	m
Cross-sectional Area of Distribution Channel 2	A2	2.909	m2
Wetted Perimeter P2=B2+2xH2	P2	4.827	m
Hydraulic Radius R2=A2/P2	R2	0.603	m
Velocity in Channel 2 v2=1/n*(R2^(2/3)*(i2^(1/2))	v2	1.504	m/s
(Flow Rate in Channel 2	Q2'	4.375	m3/s)
Head loss in Bend hi2=1.0 x (v1^2)/2/9.8	hi2	0.115	m

Invert Elevation of Upstream of Distribution Channel 2	+	2,235.053	m
Water Surface Elevation of Upstream of Distribution Channel 2	+	2,236.332	m

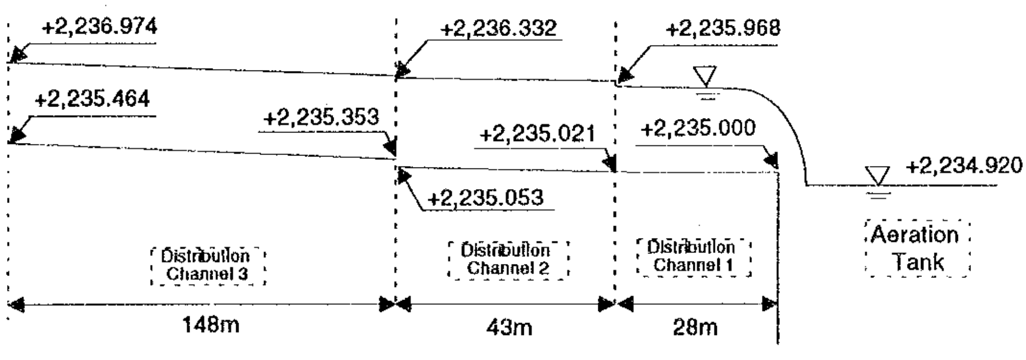
< Distribution Channel 3 >

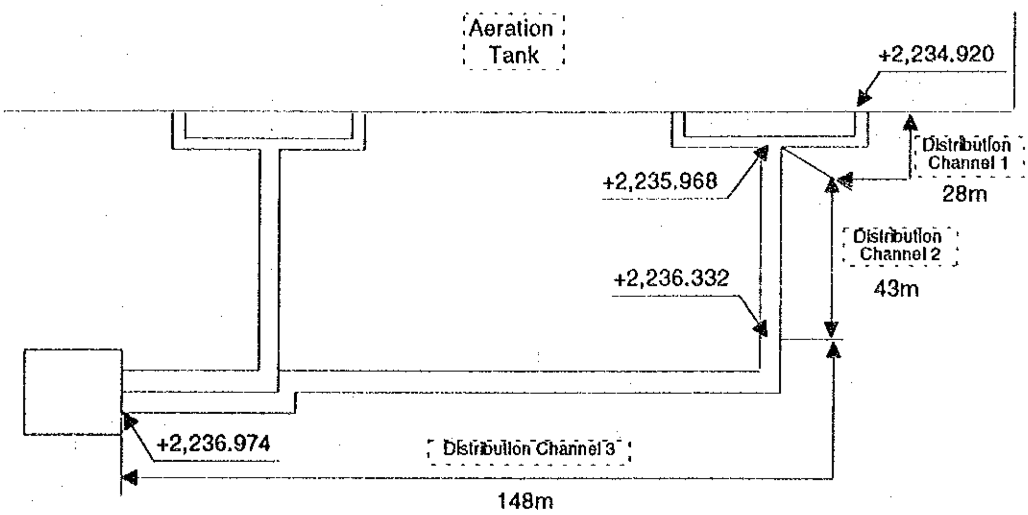
Calculation Condition

Flow Rate per 1 Unit	Q'	17.5	m3/s
Number of Distribution Channel 3	n3	4	
Flow Rate per 1 Distribution Channel 3 Q3=Q'/n3	Q3	4.375	m3/s
Width of Distribution Channel 3	B3	2.5	m
Length of Distribution Channel 3	L3	148	m
Channel Slope	i3	0.75	‰
Allowance of Invert Elevation between Distribution Channel 2 and Channel 3		0.300	m
Invert Elevation of Downstream of Distribution Channel 3	+	2,235.353	m

Calculation

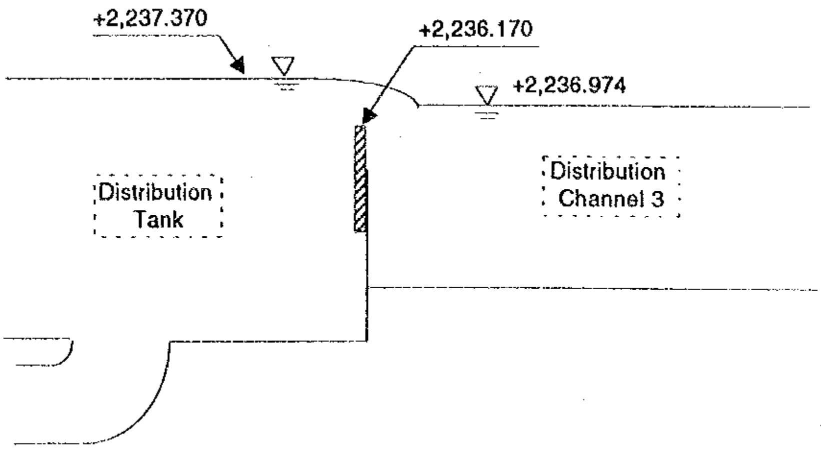
Water Depth in Inlet Channel 2	H3	1.164	m
Cross-sectional Area of Distribution Channel 3	A3	2.909	m2
Wetted Perimeter P3=B3+2xH3	P3	4.827	m
Hydraulic Radius R3=A3/P3	R3	0.603	m
Velocity in Channel 3 v3=1/n*(R^3(2/3)*(i3^(1/2))	v3	1.504	m/s
(Flow Rate in Channel 3	Q3	4.375	m3/s)
Head loss in Bend hi3=(v3^2)/2/9.8 x 3 places	hi3	0.346	m
Invert Elevation of Upstream of Distribution Channel 3	+	2,235.464	m
Water Surface Elevation of Upstream of Distribution Channel 3	+	2,236.974	m





7) Distribution Tank

Calculation Condition		
Flow Rate	Q'	17.5 m3/s
Number of Weir of Distribution Tank	n1	4
Flow Rate per 1 Weir	Q	4.375 m3/s
Q=Q'/n1		
Width of Weir	B1	2.5 m
Calculation		
Head over Crest of Upstream of Weir	h1	1.196 m
Head over Crest of Downstream of Weir	h2	0.804
Flow Rate over Submersible Weir	Q'	4.375 m
Elevation of Weir of Distribution Tank	+	2,236.170 m
Water Surface Elevation of Distribution Tank	+	2,237.370 m



8) Receiving Tank

< Connection Pipe between Distribution Tank and Receiving Tank >

Calculation Condition

Flow Rate per 1 Unit		Q'	17.5 m3/s
Diameter of Connection Pipe from Receiving Tank to Distribution Tank		D	2.8 m
Pipe Length		L	750 m

Calculation

Cross-sectional Area of Pipe		A	6.16 m
Velocity	v=Q'/A	v	2.841 m/s
Hydraulic Radius	R=D/4	R	0.7 m
Surface Roughness Coefficient		Ch	130
Friction Head in Pipe		hl	1.301 m
hl=10.666 x Ch^(-1.85) x D^(-4.87) x Q^1.85 x L			
Enterance Loss	he=0.5 x v^2/2/9.8	he	0.206 m
Exit Loss	ho=1.0 x v^2/2/9.8	ho	0.412 m
Total Head Loss in Connection Pipe between Distribution Tank and Receiving Tank		ht	1.919 m
		=	1.920
Water Surface Elevation of Downstream of Receiving Tank		+	2,239.290 m

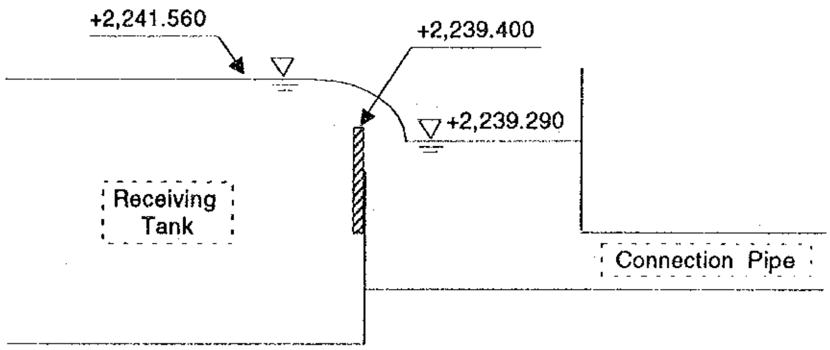
< Receiving Tank >

Calculation Condition

Flow Rate		Q'	35.0 m3/s
Number of Weir		n1	2 weir(s)
Design Flow Rate per 1 Channel		Q	17.5 m3/s
	Q=Q'/n1		

Calculation

Width of Weir		B	3.0 m
Type of Weir			Rectangular
Head over the Weir Crest		hc	2.158 m
	hc=(Q/1.84/B)^(2/3)	=	2.160 m
Allowance of Weir Height			0.050 m
Elevation of Weir Crest		+	2,239.400 m
Water Surface Elevation of Upwnstream of Weir		+	2,241.560 m



HYDRAULIC CALCULATION

FOR

FINAL PROJECT

DECEMBER 1994

JAPAN INTERNATIONAL COOPERATION AGENCY

Hydraulic Calculation for Final Project

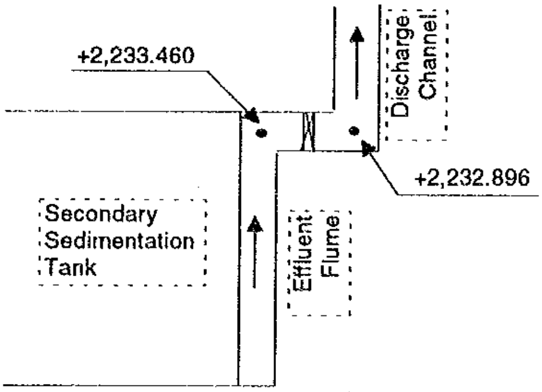
1) Connection Channel from Effluent Flume to Discharge Channel

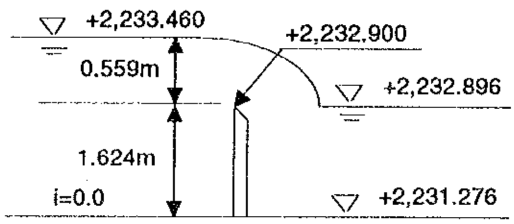
Calculation Condition

Flow Rate per 1 Unit	Q'	5.0 m3/s
Width of Weir	B	6.5 m
Water Depth of Discharge Channel	H	1.620 m
Height of Weir	Hw	1.624 m
Invert Elevation of Upstream of Discharge Channel	+	2,231.276 m
Water Surface Elevation of Upstream of Discharge Channel	+	2,232.896 m

Calculation

Head over Weir Crest	hc	0.559 m
hc=(Q/1.84/B)^(2/3)		
Water Surface Elevation of Downstream of Effluent Flume	+	2,233.459 m
	=	2,233.460 m





2) Effluent Flume of Final Sedimentation Tank

< Section a-a >

Calculation Condition

Flow Rate per 1 Unit	Qa	5.0 m3/s
Width of Flume	B	3.0 m
Length of Flume	L	93.2 m
Invert Elevation of Downstream of Flume	+	2,231.276 m
Water Surface Elevation of Downstream of Flume	+	2,233.460 m
Water Depth of Flume	H	2.184 m

Calculation

Cross-sectional Area in Flume	A=BxH	A	6.552 m2
Wetted Perimeter	P=B+2xH	P	7.368 m
Hydraulic Radius	R=A/P	R	0.889 m
Velocity in Flume	v=Qa/A	v	0.763 m/s
Friction Head		hfa-a	0.011 m

hfa-a=((n x v)^2)/(R^(4/3))

Difference of Invert Level between Downstream and Section a-a		+	0.504 m
Invert Elevation of Section a-a of Flume		+	2,231.780 m
Water Surface Elevation of Section a-a of Flume		+	2,233.471 m

< Section b-b >

Calculation Condition

Flow Rate	Qb=Qa x 3/4	Qb	3.750 m3/s
Width of Flume		B	3.0 m
Length of Flume		L	93.2 m
Water Depth of Flume		H	1.691 m

Calculation

Cross-sectional Area in Flume	A=BxH	A	5.073 m2
Wetted Perimeter	P=B+2xH	P	6.382 m
Hydraulic Radius	R=A/P	R	0.795 m
Velocity in Flume	v=Qa/A	v	0.739 m/s
Friction Head		hfb-b	0.012 m
hfb-b=Lx((n x v)^2)/(R^(4/3))			
Difference of Invert Level between Section a-a and Section b-b		+	0.500 m
Invert Elevation of Section b-b of Flume		+	2,232.280 m
Water Surface Elevation of Section b-b of Flume		+	2,233.483 m

< Section c-c >

Calculation Condition

Flow Rate	Qc=Qa x 2/4	Qc	2.500 m3/s
Width of Flume		B	3.0 m
Length of Flume		L	93.2 m
Water Depth of Flume		H	1.203 m

Calculation

Cross-sectional Area in Flume	A=BxH	A	3.609 m2
Wetted Perimeter	P=B+2xH	P	5.406 m
Hydraulic Radius	R=A/P	R	0.668 m
Velocity in Flume	v=Qa/A	v	0.693 m/s
Friction Head		hfc-c	0.013 m
hfc-c=Lx((n x v)^2)/(R^(4/3))			
Difference of Invert Level between Section b-b and Section c-c		+	0.500 m
Invert Elevation of Section c-c of Flume		+	2,232.780 m
Water Surface Elevation of Section c-c of Flume		+	2,233.496 m

< Section d-d >

Calculation Condition

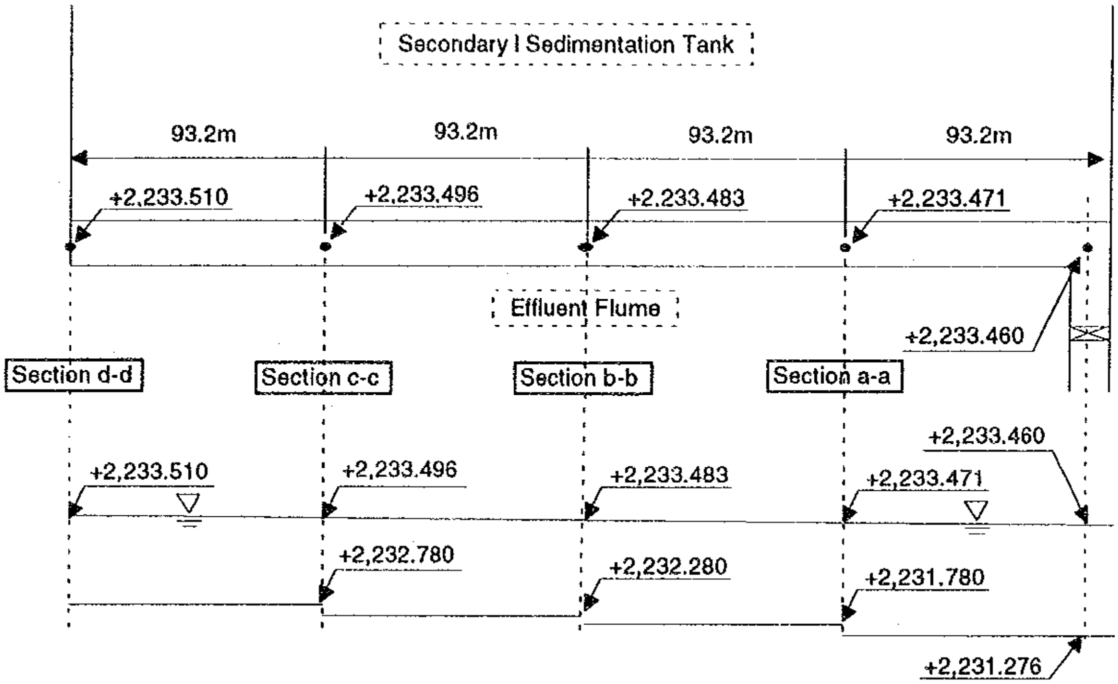
Flow Rate	Qd=Qa x a/4	Qd	1.250 m3/s
Width of Flume		B	3.0 m
Length of Flume		L	93.2 m
Water Depth of Flume		H	0.716 m

Calculation

Cross-sectional Area in Flume	A=BxH	A	2.148 m2
Wetted Perimeter	P=B+2xH	P	4.432 m
Hydraulic Radius	R=A/P	R	0.485 m
Velocity in Flume	v=Qa/A	v	0.582 m/s
Friction Head		hfd-d	0.014 m

hfd-d=Lx((n x v)^2)/(R^(4/3))

Invert Elevation of Section d-d of Flume	+	2,232.780 m
Water Surface Elevation of Section d-d of Flume	+	2,233.510 m
	=	2,233.510 m



3) Effluent Collection Trough of Secondary Sedimentation Tank

< Effluent Collection Trough >

Calculation Condition

Flow Rate per 1 Unit	Q'	5.0 m3/s
Number of Channel per 1 Unit	n1	64
Number of Trough per 1 Channel	n2	2
Flow Rate per 1 Trough	Q	0.039 m3/s

Q=Q'/(n1 x n2)

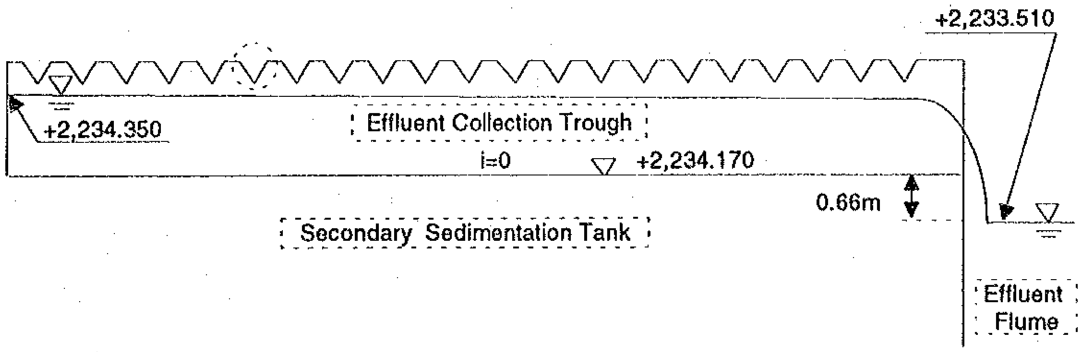
Width of Trough	B	0.4 m
Length of Trough	L	54.0 m
Invert Gradient	i	0.00
Water Surface Elevation of Section d-d of Flume	+	2,233.510 m

Calculation

Critical Depth	hc	0.099 m

hc=(1 x Q^2/9.8/B^2)^(1/3)

Water Depth of Upstream of Effluent Collection Trough	ho	0.180	m
ho=(3 x hc^2)^(1/2)			
Invert Elevation of Effluent Collection Trough	+	2,234.170	m
Water Surface Elevation of Upstream of Effluent Collection Trough	+	2,234.350	m



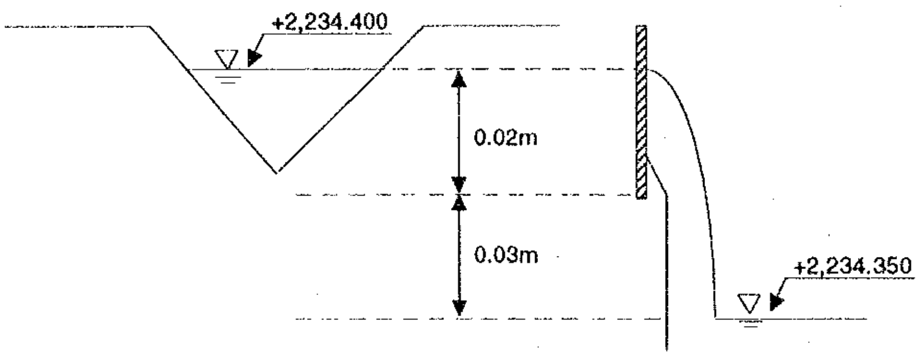
< V-notch Weir >

Calculation Condition

Flow Rate per 1 Unit	Q'	5.0	m3/s
Number of Channel per 1 Unit	n1	64	channel(s)
Flow Rate per 1 Channel	Q1	0.078	m3/s
Q1=Q'/n1			

Calculation

Width of V-notch Weir	Bw	0.125	m
Required Length of Trough per 1 Channel	Lt	125	m
Weir Over Flow Loading	Wl	54	m3/m
Number of V-notch Weir per 1 Channel	Nn	1,000	
Flow Rate through 1 V-notch Weir	Qw	0.000078	m3/s
Head over V-notch Weir Crest	h	0.02	m
h=(Q/1.42)^(2/5)			
Allowance of Height of V-notch Weir	ha	0.03	m
Water Surface Elevation of Final Sedimentation Tank	+	2,234.400	m



4) Connection Channel between Aeration Tank and Secondary Sedimentation Tank

Calculation Condition

Allowance of Head Loss between Connection Channel and Aeration Tank	ha	0.050 m
Invert Elevation of Connection Channel	+	2,234.100 m
Water Surface Elevation of Upstream of Connection Channel	+	2,234.450 m

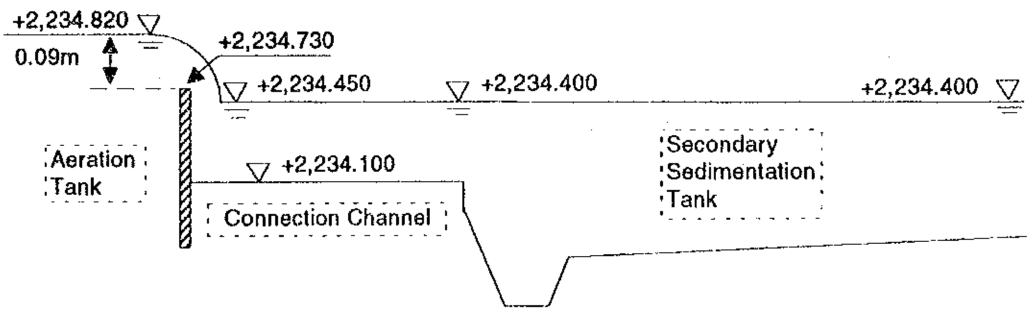
5) Weir of Aeration Tank

Calculation Condition

Flow Rate per 1 Unit	Q'	5.0 m3/s
Return Sludge Ratio	Rs	10 %
Flow Rate Q1=Q' x (1 + Rs/100)	Q1	5.50 m3/s
Number of Channel per 1 Basin	n1	2 channel(s)
Number of Basin per 1 Unit	n2	16 basin(s)
Number of Channel per 1 Unit	n3	32 channel(s)
Design Flow Rate per 1 Channel Q=Q'/n3	Q	0.172 m3/s

Calculation

Width of Weir	B	4.0 m
Type of Weir		Rectangular
Head over the Weir Crest	hc	0.082 m
hc=(Q/1.84/B)^(2/3)	=	0.090 m
Allowance of Weir Height		0.280 m
Elevation of Weir of Aeration Tank	+	2,234.730 m
Water Surface Elevation of Upstream of Weir of Aeration Tank	+	2,234.820 m



6) Connection Channel between Aeration Tank and Primary Sedimentation Tank

Calculation Condition

Allowance of Head Loss between Aeration Tank and Primary sedimentation Tank	ha	0.050 m
Invert Elevation of Connection Channel	+	m
Water Surface Elevation of Upstream of Connection Channel	+	2,234.870 m

7) Effluent Collection Trough of Primary Sedimentation Tank

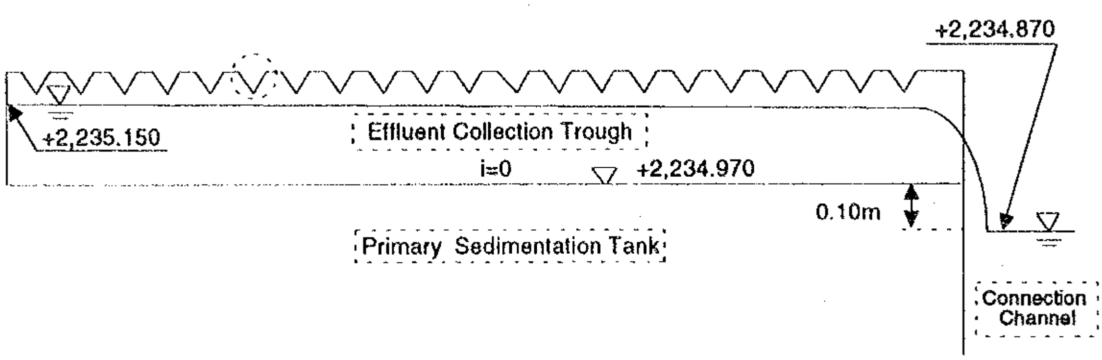
< Effluent Collection Trough >

Calculation Condition

Flow Rate per 1 Unit	Q'	5.0 m3/s
Number of Channel per 1 Unit	n1	64
Number of Trough per 1 Channel	n2	2
Flow Rate per 1 Trough	Q	0.039 m3/s
Q=Q'/(n1 x n2)		
Width of Trough	B	0.4 m
Invert Gradient	i	0.00
Water Surface Elevation of Upstream of Aeration Tank	+	0.172 m

Calculation

Critical Depth	hc	0.099 m
hc=(1 x Q^2/9.8/B^2)^(1/3)		
Water Depth of Upstream of Effluent Collection Trough	ho	0.18 m
ho=(3 x hc^2)^(1/2)		
Alllowance between Invert Elevation of Effluent Collection Trough and Connection Channel	+	0.100 m
Invert Elevation of Effluent Collection Trough	+	2,234.970 m
Water Surface Elevation of Upstream of Effluent Collection Trough	+	2,235.150 m



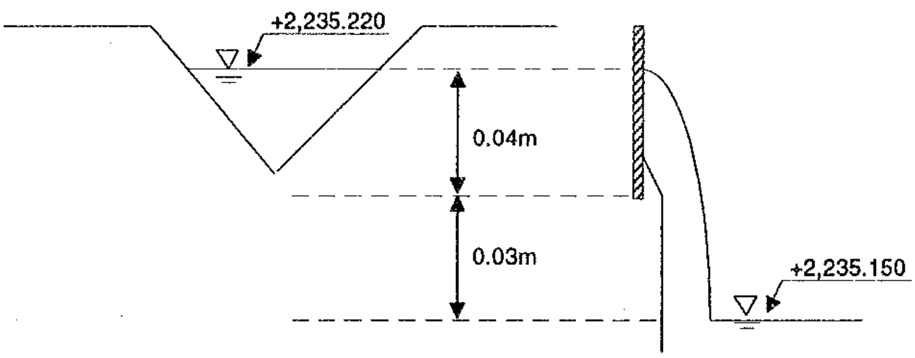
< V-notch Weir >

Calculation Condition

Flow Rate per 1 Unit	Q'	5.0 m3/d
Number of Channel per 1 Unit	n1	64 channel(s)
Flow Rate per 1 Channel	Q1	0.078 m3/s
Q1=Q'/n1		

Calculation

Width of V-notch Weir	Bw	0.125 m
Required Length of Trough per 1 Channel	Lt	13.5 m
Number of V-notch Weir per 1 Channel	Nn	108
Flow Rate through 1 V-notch Weir	Qw	0.000361 m3/s
Head over V-notch Weir Crest	h	0.04 m
h=(Q/1.42)^(2/5)		
Allowance of Height of V-notch Weir	ha	0.03 m
Water Surface Elevation of Primary Sedimentation Tank	+	2,235.220 m



8) Distribution Channel

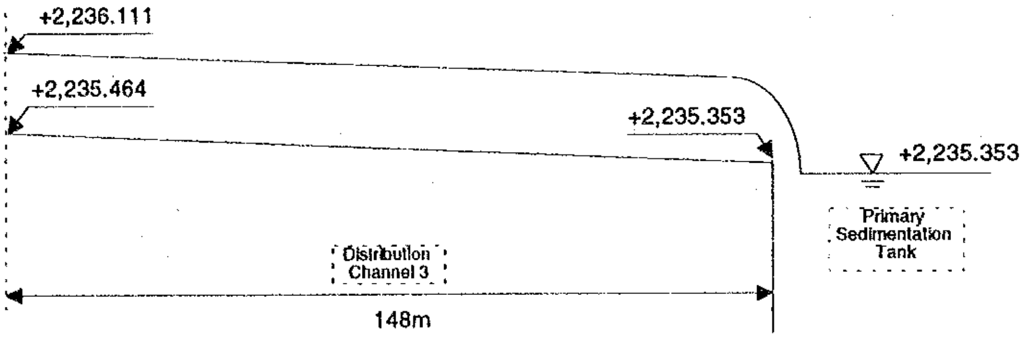
< Distribution Channel 3 >

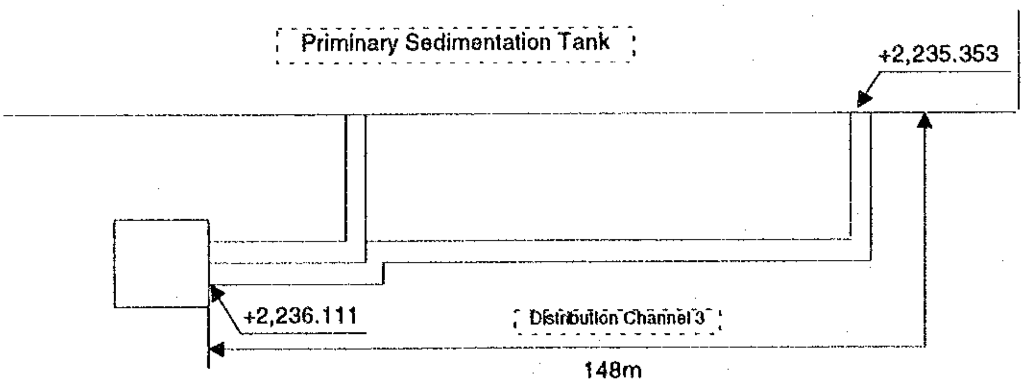
Calculation Condition

Flow Rate per 1 Unit	Q'	5.0 m3/s
Number of Distribution Channel 3	n3	4
Flow Rate per 1 Distribution Channel 3	Q3	1.250 m3/s
Q3=Q'/n3		
Width of Distribution Channel 3	B3	2.5 m
Length of Distribution Channel 3	L3	148 m
Channel Slope	i3	0.75 ‰
Allowance of Head Loss between Primary Sedimentation Tank and Distribution Channel	ha	0.050 m
Allowance between of Water Surface Elevation of Primary Sedimentation Tank and Invert Elevation of Downstream of Distribution Channel 3	+	0.100 m
Invert Elevation of Downstream of Distribution Channel 3	+	2,235.353 m

Calculation

Water Depth in Inlet Channel 2		H3	0.481 m
Cross-sectional Area of Distribution Channel 3		A3	1.202 m2
Wetted Perimeter	P3=B3+2xH3	P3	3.461 m
Hydraulic Radius	R3=A3/P3	R3	0.347 m
Velocity in Channel 3		v3	1.040 m/s
v3=1/n*(R^3(2/3)*(i3^(1/2))			
(Flow Rate in Channel 3		Q3	1.250 m3/s)
Head loss in Bend		hi3	0.166 m
hi3=1.0 x (v3^2)/2/9.8 x 3 places			
Invert Elevation of Upstream of Distribution Channel 3		+	2,235.464 m
Water Surface Elevation of Upstream of Distribution Channel 3		+	2,236.111 m





8) Distribution Tank

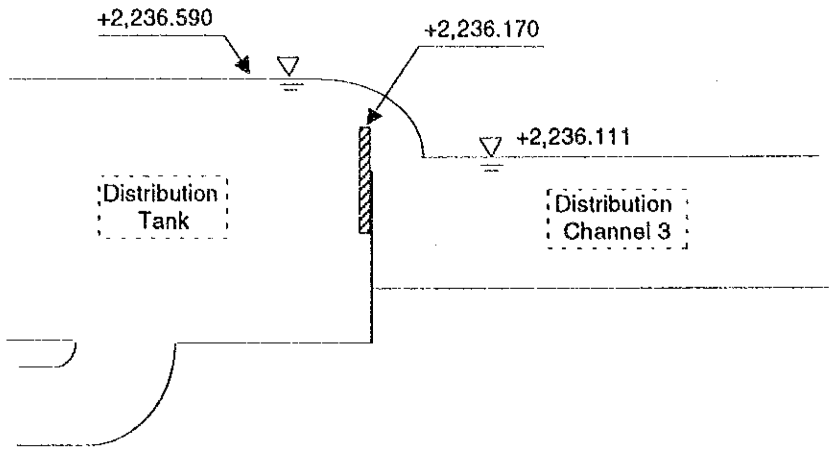
Calculation Condition

Flow Rate		Q'	5.0 m3/s
Number of Weir of Distribution Tank		n1	4
Flow Rate per 1 Weir	Q=Q'/n1	Q	1.250 m3/s
Width of Weir		B1	2.5 m

Calculation

Head over Weir Crest	h	0.417 m

h=(Q/1.86/B)^(2/3)		=	0.420
Allowance of Weir Height		ha	0.050 m
Elevation of Weir of Distribution Tank		+	2,236.170 m
Water Surface Elevation of Distribution Tank		+	2,236.590 m



8) Receiving Tank

< Connection Pipe between Distribution Tank and Receiving Tank >

Calculation Condition

Flow Rate per 1 Unit		Q'	5.0 m3/s
Diameter of Connection Pipe from Receiving Tank to Distribution TAnk		D	2.0 m
Pipe Length		L	2,140 m

Calculation

Cross-sectional Area of Pipe		A	3.14 m
Velocity	v=Q'/A	v	1.592 m/s
Hydraulic Radius	R=D/4	R	0.5 m
Surface Roughness Coefficient		Ch	110
Friction Head in Pipe		hl	2.564 m
hl=10.666 x Ch^(-1.85) x D^(-4.87) x Q^1.85 x L			
Enterance Loss	he=0.5 x v^2/2/9.8	he	0.065 m
Exit Loss	ho=1.0 x v^2/2/9.8	ho	0.129 m
Total Head Loss of Connection Pipe between Distribution Tank and Receiving Tank		ht	2.758 m
		=	2.760
Water Surface Elevation of Distribution Tank		+	2,239.350 m

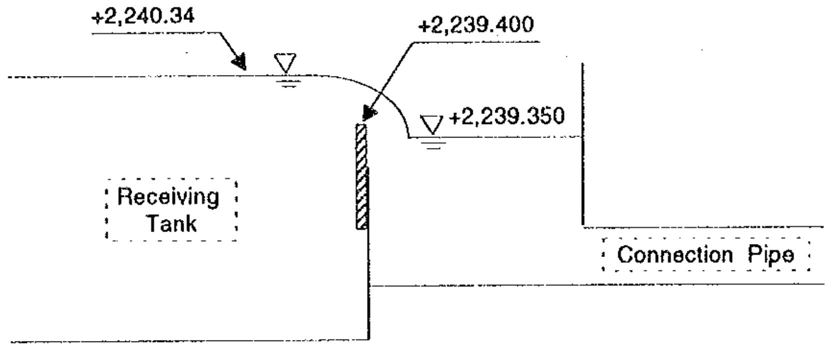
< Receiving Tank >

Calculation Condition

Flow Rate		Q'	40.0 m3/s
Number of Weir		n1	8 weir(s)
Design Flow Rate per 1 Channel		Q	5.0 m3/s
	Q=Q'/n1		

Calculation

Width of Weir	B	3.0 m
Type of Weir		Rectangular
Head over the Weir Crest	hc	0.936 m
hc=(Q/1.84/B)^(2/3)	=	0.940 m
Allowance of Weir Height		0.050 m
Elevation of Weir Crest	+	2,239.400 m
Water Surface Elevation of Upwnstream of Weir	+	2,240.340 m



BILL OF QUANTITIES

DECEMBER 1994

JAPAN INTERNATIONAL COOPERATION AGENCY

Bill of Quantities

Item	Equation	Quantity	Remarks
1. Westewater Treatment			
1-1 Receiving Tank			
1) Cast-in-place Concrete Pile			
	Ø 800, ℓ = 24.6 m	26 piles	
	Ø 800, ℓ = 29.4 m	35 piles	
2) Earth Work			
(1) Excavation			
	4.8 x 4.8 x 11.0 x 2 = 507		
	6.4 x 33.6 x 4.8 = 1,032		
	23.6 x 33.6 x 1.3 = 1,031		
	2,570		
	1/2 x (1.0+7.1) x 6.1 = 19.44 m2		
	19.44 x (6.4+6.4+33.6) = 902.016	902 m3	
	1/2 x (1.0+5.8) x 4.8 x 33.6 = 548.352	548 m3	
	1/2 x (1.0+5.8) x 4.8 = 13.92 m2		
	13.92 x (11.0 x 4 + 4.8 x 2) = 746.112	746 m3	
	19.44 x 4.8 x 2 = 186.624	187 m3	
	1/2 x (0.5+1.8) x 1.3 = 1.495 m2		
	1.495 x (33.6 - 2 x 4.8 + 17.2 x 2) = 34.164	87 m3	
	Total	5,040 m3	
(2) Back Filling			
	5.040 - 2,570 = 2,470	2,470 m3	
(3) Surplus Soil		5,040 m3	
3) Concrete Work (σ ck = 250 kg/cm2)			
wall	5.0 x 0.6 x 12.0 x 7 = 252	252 m3	
bottom	23.6 x 33.6 x 1.0 = 792.96	793 m3	
wall	(7.4 x 33.6 - 5.0 x 32.2) x 4.8 = 420.672	421 m3	
wall	(33.6x 23.6 - 32 x 21.5) x 7.2 = 755.712	756 m3	
	Total	2,222 m3	
4) Form of Concrete Work (σ ck = 250 kg/cm2)			
inside	2 x (3.4 + 5.0) x 12.0 x 6 = 1,209.600		
inside	2 x (15.4 +16.2 + 16.5 x 2) x 7.2 = 930.240		
inside	2 x (3.8 + 5.0) x 12.0 x 2 = 422.400		
outside	2 x (13.0 + 33.6 + 7.2 x 23.6) = 1,213.440		
outside	2 x 6.4 x 4.8 = 61.440		
	Total 3,837.120		

Bill of Quantities

Item	Equation	Quantity	Remarks
	3,837.12 x 1.1 = 4,220.832	4,221 m2	
5) Reinforced Bar			
	2,222 x 0.1 t/m3 = 222	222 t	
6) Lean Concrete (σ ck = 100 kg/cm2)			
	33.8 x 23.8 x 0.1 = 80.444	80 m3	
7) Form of Lean Concrete (σ ck = 100 kg/cm2)			
	2 x (7.4 + 33.8) x 0.1 = 8.240	8 m2	
	(2 x 15.0 + 33.8) x 0.1 = 6.380	6 m2	
	Total	14 m2	
8) Cobble Stone			
	33.8 x 23.8 x 0.2 = 160.888	161 m3	
9) Concrete Work (σ ck = 160 kg/cm2)			
	4.8 x 4.8 x 11.0 x 2 = 506.880	507 m3	
	$- \pi/4 \times 3.6^2 \times 12.5 \times 2 = - 254.469$	-254 m3	
	Total	253 m3	
10) Form of Concrete Work (σ ck = 160 kg/cm2)			
	2 x (11.0 + 4.8) x 4.8 x 2 = 303.360	303 m2	
	$- \pi/4 \times 3.6^2 \times 2 = - 81.430$	-81 m2	
	Total	222 m2	
11) Pipe			
	inlet Ø 3,600	25 m	
	Connecting pipe Ø 2,000		
	ℓ = 1.5 with Blind Flange	6 pieces	
12) Accessory Work			
		1 ℓs	
1-2 Connecting Pipe			
	Total laying length	1,040 m	
1) Earth Work			
(1) Excavation			
	1/2 x (4.2 + 9.4) x 5.2 x 1,040 = 36,774.4	36,774 m3	

Bill of Quantities

Item	Equation	Quantity	Remarks
(2) Surplus Soil			
		36,774 m3	
(3) Back Filling			
	$3.4 \times 1.1 + \pi/4 \times 2.8^2 = 9.897$ m2		
	36,774 - 9.897 x 1,040 =26,481	26,481 m3	
2) Cobble Stone			
	3.4 x 0.2 x 1,040 = 707.2	707 m3	
3) Lean Concrete (σ ck = 100 kg/cm2)			
	3.4 x 0.1 x 1,040 = 353.6	354 m3	
4) Form of Lean Concrete (σ ck = 100 kg/cm2)			
	0.2 x 1,040 = 208	208 m3	
5) Concrete Work (σ ck = 210 kg/cm2)			
	3.4 x 0.8 x 1,040 = 2,828.8	2,829 m3	
6) Form of Concrete Work (σ ck = 210 kg/cm2)			
	0.8 x 2 x 1040 = 1664	1,664 m2	
7) Pile	Ø 600, ℓ = 25.5 m		
	1,040 / 5.0 = 208	208 piles	
8) Steel Pipe			
	Ø 2,800	1,040 m	
1-3 Distribution Tank (per 1 unit)			
1) Cast-in-place Concrete Pile			
	Ø 600, ℓ = 23.8 m	3 piles	
	Ø 600, ℓ = 27.5 m	17 piles	
2) Earth Work			
(1) Excavation			
	5.0 x 9.0 x 3.7 = 166.500	167 m3	
	13.2 x 13.2 x 3.1 = 540.144	540 m3	
	1/2 x (0.5 + 3.6) x 3.1 x 12.2 x 4 = 310	310 m3	
	Total	1,017 m3	
(2) Surplus Soil			
		1,017 m3	

Bill of Quantities

Item	Equation	Quantity	Remarks
(3) Back Filling			
	4.0 x 8.5 x 3.7 = 126		
	12.2 x 12.2 x 3.1 = 461		
	1017 - (126 + 461) = 430	430 m3	
3) Concrete Work (σ ck = 250 kg/cm2)			
bottom	12.2^2 x 0.8 = 119		
wall	(12.2^2 - 11.2^2) x 5.0 = 117		
	(119 + 117) x 1.1 = 259.6	260 m3	
4) Form of Concrete Work (σck = 250 kg/cm2)			
outside	12.2 x 5.8 x 4 = 283.040		
inside	11.2 x 4.8 x 4 = 215.040		
	(283.040 + 215.040) x 1.1 = 547.888	548 m2	
5) Reinforced Bar			
	260 x 0.1 t/m3 = 26	26 t	
6) Concrete Work (σ ck = 160 kg/cm2)			
	4.0 x 3.7 x 8.5 = 125.800		
	- π/4 x 2.8^2x 7.9 = - 48.644		
		77 m3	
7) Form of Concrete Work (σ ck = 160 kg/cm2)			
	2 x (4.0 + 8.5) x 3.7 = 92.500		
	- π/4 x 2.8^2= - 6.158		
		86 m2	
8) Lean Concrete (σ ck = 100 kg/cm2)			
	12.4^2 x 0.1 = 15.376	15 m3	
9) Form of Lean Concrete (σ ck = 100 kg/cm2)			
	4 x 12.4 x 0.1 = 4.960	5 m2	
10) Cobble Stone			
	12.4 x 12.4 x 0.2 = 30.752	31 m3	
11) Accessory Work			
		1 ℓs	

Bill of Quantities

Item	Equation	Quantity	Remarks
1-4 Influent Channel (per 1 unit)			
	width = 2.5m		
	93.2 x 3 - 11.2 = 268.400		
	93.2 - 11.2 = 82.000		
	50 x 4 = 200.000		
	550.400		
	width = 2.0m		
	56 x 4 = 224		
1) Concrete Work (σ ck = 250 kg/cm2)			
w = 2.5m	0.4 x 5.9 x 43 x 2 = 202.960	203 m3	
w = 2.5m	0.3 x 1.95 x 3 x 43 x 2 = 150.930	151 m3	
w = 2.5m	0.4 x 3.1 x 464.4 = 575.856	576 m3	
w = 2.5m	0.3 x 1.95 x 2 x 464.4 = 543.348	543 m3	
w = 2.0m	0.4 x 2.6 x 224 = 232.960	233 m3	
w = 2.0m	0.3 x 1.5 x 2 x 224 = 201.600	202 m3	
	Total	1,908 m3	
2) Form of Concrete Work (σ ck = 250 kg/cm2)			
w=2.5m inside	1.95 x 86 x 4 = 670.800	671 m2	
w=2.5m inside	1.95 x 464.4 x 2 = 1,811.160	1,811 m2	
w=2.5m outside	2.35 x (93.2 x 3 -11.2) x 2 = 1,261.480	1,261 m2	
w=2.5m outside	2.35 x 50 x 2 x 4 = 840.000	940 m2	
w=2.0m inside	1.5 x 2 x 224 = 672.000	672 m2	
w=2.0m inside	1.9 x 2 x 224 = 851.000	851 m2	
	Total	6,207 m2	
3) Reinforced Bar			
	1,908 x 0.1 t/m3 = 190.800	191 t	
4) Lean Concrete (σ ck = 100 kg/cm2)			
	t = 5 cm		
w = 2.5m	5.9 x 43 x 2 x 0.05 = 25.370	25 m3	
w = 2.5m	3.1 x 464.4 x 0.05 = 71.982	72 m3	
w = 2.0m	2.6 x 224.0 x 0.1 = 58.240	58 m3	
	Total	155 m3	
5) Form of Lean Concrete (σ ck = 100 kg/cm2)			
	43 x 2 x 0.05 x 2 = 8.600	9 m2	
	464.4 x 2 x 0.05 x 2 = 92.880	93 m2	
	224.0 x 2 x 0.05 = 22.400	22 m2	
	Total	124 m2	

Bill of Quantities

Item	Equation			Quantity	Remarks
6) Cobble Stone	t = 10 cm				
	156 x 2 = 312			312 m3	
7) Cast-in-place Concrete Pile					
	Ø 600, ℓ = 30 m				
	32 + 56 = 88			88 piles	
5. Wastewater Treatment Facility (per 1 unit)					
1) Aeration Tank					
(1) Concrete Work (σck = 250 kg/cm2)					
wall	(36.4 - 28.92) x 372.8 x 0.6 x 2	=	3,346		
bottom	(89.6 + 6.6) x 372.8 x 1.0	=	35,863		
	(35.8 - 28.92) x 89.6 x 0.5 x 37	=	11,404		
	6.6 x 0.3 x 372.8 x 2	=	1,476		
	10.3 x 6.1 x 0.3 x 3 x 32	=	1,810		
			52,089		
	52,089 x 1.1 = 57,298			57,298 m3	
(2) Reinforced Bar					
	57,298x 0.1 t/m3 = 5,730			5,730 t	
(3) Form of Concrete Work (σck = 250 kg/cm2)					
inside	6.6 x 372.8 x 2	=	4,921		
wall inside	5.6 x 372.8 x 3	=	6,263		
wall	(35.8-28.92) x 89.6 x 37 x 2	=	45,617		
	89.6 x 6.6 x 4	=	2,365		
wall	6.1 x 10.3 x 3 x 2 x 32	=	12,063		
wall outside	8.2 x 372.8	=	3,057		
			74,287		
	74,287 x 1.2 = 89,144			89,144 m2	
(4) Lean Concrete (σ ck = 100 kg/cm2)					
	372.8 x (89.6 + 6.6) x 0.1 = 3,586			3,586 m3	
(5) Form of Lean Concrete (σ ck = 100 kg/cm2)					
	0.1 x (96.2 x 2 + 372.8) = 56.520			57 m2	
(6) Cobble Stone					
	3,586 x 2 = 7,172			7,172 m3	

Bill of Quantities

Item	Equation			Quantity	Remarks
(7) Cost-in-place Concrete Pile					
	ℓ = 23.5 m				
	33 x 103 = 3,399			3,399 piles	
(8) Accessory Work					
				1 ℓs	
2) Secondary Sedimentation Tank					
(1) Concrete Work (σ ck = 250 kg/cm2)					
bottom	(3.4 + 54.6 + 7.6) x 372.8 x 0.8	=	19,565		
	8.5 x 372.8 x 0.6 x 2	=	3,803		
	7.6 x 372.8 x 0.4 x 2	=	2,267		
	4.0 x 372.8 x 0.4 x 2	=	1,193		
effluent channel	3.4 x 0.3 x 372.8	=	380		
	0.4 x 4.2 x 54.6 x 69	=	6,329		
	54.6 x 6.8 x 0.4 x 4	=	594		
			34,131		
	34,131 x 1.1 = 37,544			37,544 m3	
(2) Reinforced Bar					
	37,544 x 0.1 = 3,754			3,754 t	
(3) Form of Concrete Work (σ ck = 250 kg/cm2)					
wall	8.5 x 372.8 x 4	=	12,675		
slab	7.6 x 372.8 x 2	=	5,667		
slab	(7.0 + 3.4) x 372.8	=	3,877		
wall	4.0 x 372.8 x 4	=	5,965		
wall	4.2 x 54.6 x 2 x 69	=	31,646		
slab	6.0 x 54.6 x 4	=	1,310		
			61,140		
	61,140 x 1.2 = 73,368			73,368 m2	
(4) Lean Concrete (σ ck = 100 kg/cm2)					
	(7.6 + 54.6 + 3.4) x 372.8 x 0.1 = 2,445.568			2,446 m3	
(5) Form of Lean Concrete (σ ck = 100 kg/cm2)					
	2 x (372.8 + 65.6) x 0.1 = 87.680			88 m2	
(6) Cobble Stone					
	2,446 x 2 = 4,892			4,892 m3	

Bill of Quantities

Item	Equation		Quantity	Remarks
(7) Cost-in-Place Concrete Pile				
	Ø 600, ℓ= 23.3 m 372.8 / 5.4 = 69			
	69 x 3 = 207		207 piles	
	Ø 600, ℓ= 25.5 m			
	69 x 26 = 1,794		1,794 piles	
(8) Accessory Work			1 ℓs	
6. Discharge Channel				
1) Cast-in -place Concrete Pile				
	1 pile / 2.9 m x 476 = 164			
	1 pile /1.6 m x 70m = 44			
	1 pile / 1.6m x 300m = 188			
	3 piles / 2 m x 70 = 105			
		Total	501 piles	
2) Earth Work				
(1) Excavation	1/2 x (4.8 + 10) x 5.7 x 476 = 20,078			
	1/2 x (6.4 + 12.8) x 6.3 x 70 = 4,234			
	1/2 x (8.4 + 14.8) x 6.4 x 300 = 22,272			
	1/2 x (10.2 + 17.7) x 8.0 x 70 = 7,812			
		Total	54,396 m3	
(2) Back Filling	20,078 - 3.8 x 5.7 x 476 = 9,768			
	4,234 - 5.4 x 6.3 x 70 = 1,853			
	22,272 - 7.4 x 8.0 x 300 = 4,512			
	7,812 - 9.2 x 3.9 x 70 = 5,300			
		Total	21,432 m3	
(3) Surplus Soil			54,396 m3	
3) Concrete Work (σ ck = 250 kg/cm2)				
	3.8 x 0.4 x 476 = 724			
	5.2 x 0.4 x 476 x 2 = 1,980			
	5.4 x 0.4 x 70 = 151			
	5.8 x 0.4 x 70 x 2 = 324			
	7.4 x 0.4 x 300 = 888			
	5.9 x 0.4 x 300 x 2 = 1,416			
	9.2 x 0.4 x 2 x 70 = 515			
	3.0 x 0.4 x 3 x 70 = 252			
		Total	6,250 m3	

Bill of Quantities

Item	Equation		Quantity	Remarks
4) Form of Concrete Work (σck = 250 kg/cm2)				
	5.6 x 476 x 2 = 5,331			
	5.2 x 476 x 2 = 4,950			
	6.3 x 70 x 2 = 882			
	5.8 x 70 x 2 = 812			
	6.4 x 70 x 2 = 896			
	5.9 x 70 x 2 = 826			
	3.8 x 70 x 2 = 532			
	3.0 x 70 x 4 = 840			
	4.0 x 70 x 2 = 560			
		Total	15,629 m2	
5) Reinforced Bar				
	0.1 x 2704 = 270			
	0.1 x 476 = 48			
	0.1 x 2,304 = 230			
	0.1 x 767.2 = 77			
		Total	625 t	
6) Supporting Work	4.0 x 3.0 x 7.0 x 2 = 1,680		1,680 m3	
7) Lean Concrete (σ ck = 100 kg/cm2)				
	3.8 x 0.1 x 476 = 181			
	5.4 x 0.1 x 70 = 38			
	7.4 x 0.1 x 300 = 222			
	9.2 x 0.1 x 70 = 64.4			
		Total	505 m3	
8) Form of Lean Concrete (σ ck = 100 kg/cm2)				
	0.1 x 476 = 48			
	0.1 x 70 = 7			
	0.1 x 300 = 30			
	0.1 x 70 = 7			
		Total	92 m2	
7. Digestion Tank (per 1 tank)				
1) Concrete Work (σ ck=250 kg/cm2)				
	$\pi/4 \times 29^2 \times 1.0$ =	661		
	$1/2 \times 1.5 \times 5.0 \times \pi \times 27$ =	318		
	$\pi/4 \times (27^2 - 26^2) \times 11.0$ =	458		
	$\pi/4 \times 26^2 \times 0.4$ =	212		
		1,649		
	1,649 x 1.3 = 2,144		2,144 m3	

Bill of Quantities

Item	Equation	Quantity	Remarks
2) Cast-in-place Concrete Pile			
	Ø 800, ℓ = 23 m	90 piles	
3) Form of Concrete Work (σ ck=250 kg/cm2)			
	π x 29 x 1.5 = 136.659		
	π x (26.0 + 27.0) x 11.0 = 1,831.549		
	π/4 x 26 ^{2} = 530.929		
	2,499.137		
	2,499.137 x 1.05 = 2,624.094	2,624 m2	
4) Reinforced Bar			
	2,144 x 0.12 t/m3 = 257	257 t	
5) Supporting Work			
	π/4 x 29.0 ^{2}x 13.0 = 8,586.758	8,587 m3	
6) Lean Concrete (σ ck=100 kg/cm2)			
	π/4 x 29.0 ^{2}x 0.1 = 66.143	66 m3	
7) Form of Lean Concrete (σ ck=100 kg/cm2)			
	π x 29.0 x 0.1 = 9.123	9 m2	
8) Cobble Stone			
	π/4 x 29.0 ^{2}x 0.2 = 132.286	132 m3	
9) Pipe Gellary			
	7.0 x 12.0 = 84.0	84 m2	
10) Accessory Work			
		1 s	
8. Other Work			
8-1 Preparatory Work			
1) Remove of Existing Concrete Structure			
	280 x 150 x 0.2 = 8,400	8,400 m3	
2) Cutting of Stacked Lime			
	1/2 x 240 x 150 x 10.0 = 180,000	180,000 m3	
	1/2 x 100 x 100 x 10.0 = 50,000	50,000 m3	
	Total	230,000 m3	

Bill of Quantities

Item	Equation	Quantity	Remarks
8-2 Main Earth Work			
1) Excavation			
(1) Wastewater Treatment Facility			
	(89.6 + 6.6 + 4.5) x (372.8 + 9.0) = 38,447.26 m2		
AT unit 1	38447.26 x (34.9 - 27.82) = 272,206.601	272,207 m3	
AT unit 2	38447.26 x (34.5 - 27.82) = 256,827.697	256,828 m3	
SST PIT	14.0 x (372.8 - 6.8 x 4 + 9.0) = 4,964.4 m2		
unit 1	4,964.4 x (34.9 - 25.9) = 44,679.600	44,680 m3	
unit 2	4,964.4 x (34.5 - 25.9) = 42,694.840	42,694 m3	
SST pipe gallery	(7.6 + 54.6) x 6.8 x 4 = 1,691.84 m2		
unit 1	1,691.84 x (34.9 - 27.82) = 11,978.227	11,978 m3	
unit 2	1,691.84 x (34.5 - 27.82) = 11,301.491	11,301 m3	
SST	(65.6 - 14.0+3.5) x (372.8-6.8 x 4+7.0) =19,428.260 m2		
unit 1	19,428.26 x (34.9 - 29.7) =10,10276.952	101,027 m3	
unit 2	19,428.26 x (34.5 - 29.7) = 93,255.648	93,256 m3	
	Sub Total	833,971 m3	
(2) Sludge Treatment Facility			
	(120 x 150 - 40 x 80) x 7.0 x 2 = 207,200	207,200 m3	
pipe gallery	1/2 x (7.0+13.0) x 6.0 x 220 x 2 = 26,400	26,400 m3	
	Sub Total	233,600 m3	
	Total	1,067,571 m3	
2) Back Filling			
Wastewater	1/2 x (1.0 + 8.2) x 7.2 = 33.12 m2		
Treatment Facility	33.12 x 2 x (372.8 + 161.9) x 2 = 70,837.056	70,837 m3	
AD	$\pi/4$ x 27^2 x 7.0 x 10 x 2 = 80,157.737		
AD	12.0 x 13.0 x 7.0 x 5 x 2 = 10,920.000		
pipe gallery	10 x (28.0 x 3 + 10.0 x 2) x 7.0 x 2 = 14,560.000		
pipe gallery	7.0 x 4.0 x 180 x 2 = 10,080.000		
pipe gallery	6.0 x 5.0 x 220 x 2 = 13,200.000		
	128,917.737		
	223,600 - 128,917.737 = 94,682.263	94,682 m3	
	Total	165,519 m3	

BILL OF QUANTITIES (PRICED)

DECEMBER 1994

JAPAN INTERNATIONAL COOPERATION AGENCY

Bill of Quantities (Priced)

Item	Quantity	Unit Cost	Cost (Mill. N$)	Remarks
1. Wastewater Treatment				
1-1 Receiving Tank				
1) Cast-in-place Concrete Pile				
Ø 800, ℓ = 24.6 m	26 piles	9,388.00	0.244	
Ø 800, ℓ = 29.4 m	35 piles	11,059.60	0.387	
2) Earth Work				
(1) Excavation	5,040 m3	12.04	0.061	
(2) Back Filling	2,470 m3	55.11	0.136	
(3) Surplus Soil	5,040 m3	10.49	0.053	
3) Concrete work (σ ck = 250 kg/cm2)	2,222 m3	440.11	0.978	
4) Form of Concrete work (σck = 250 kg/cm2)	4,221 m2	26.87	0.113	
5) Reinforced Bar	222 t	1,970.00	0.437	
6) Lean Concrete (σ ck = 100 kg/cm2)	80 m3	15.63	0.001	
7) Form of Lean Concrete (σck = 100 kg/cm2)	14 m2	24.11	0.001	
8) Cobble Stone	161 m3	52.56	0.008	
9) Concrete Work (σck = 160 kg/cm2)	253 m3	305.92	0.077	
10) Form of Concrete Work (σck = 160 kg/cm2)	222 m2	26.89	0.006	
11) Pipe Inlet Ø 3,600	1 ℓs	–	0.153	
Connecting Pipe Ø 2,000, ℓ = 1.5 with Blind Flange	1 ℓs	–	0.036	
12) Accessory Work	1 ℓs	–	0.269	
Sub-Total of 1-1 Receiving Tank			2.960	
1-2 Connecting Pipe				
1) Earth Work				
(1) Excavation	36,774 m3	15.33	0.564	
(2) Surplus Soil	36,774 m3	10.49	0.386	
(3) Back Filling	26,481 m3	55.11	1.459	
2) Cobble Stone	707 m3	52.56	0.037	
3) Lean Concrete	354 m3	15.63	0.006	
4) Form of Lean Concrete	208 m3	24.11	0.005	
5) Concrete Work (σ ck = 210 kg/cm2)	2,829 m3	321.80	0.910	
6) Form of Concrete Work (σ ck = 210 kg/cm2)	1,664 m3	26.87	0.045	
7) Cast-in-Place Concrete Pile				
Ø 600, ℓ = 25.5 m				
1,040 / 5.0 = 208	208 piles	6,969.20	1.450	
8) Steel Pipe Ø 2,800	1,040 m	5,800.00	6.032	
Sub-Total of 1-2 Connecting Pipe			10.894	

Bill of Quantities (Priced)

Item	Quantity	Unit Cost	Cost (Mill. N$)	Remarks
1-3 Distribution Tank (per 1 unit)				
1) Cast-in place Concrete Pile				
Ø 600, ℓ= 23.8 m	3 piles	10,090.60	0.030	
Ø 600, ℓ= 27.5 m	17 piles	8,112.10	0.138	
2) Earth Work				
(1) Excavation	1,017 m3	12.40	0.013	
(2) Surplus Soil	1,017 m3	10.49	0.011	
(3) Backfilling	430 m3	55.11	0.024	
3) Concrete Work (σ ck = 250 kg/cm2)	260 m3	440.11	0.114	
4) Form of Concrete Work (σ ck = 250 kg/cm2)	548 m2	26.87	0.015	
5) Reinforced Bar	26 t	1,970.00	0.051	
6) Concrete Work (σ ck = 160 kg/cm2)	77 m3	305.92	0.024	
7) Form of Concrete Work (σ ck = 160 kg/cm2)	86 m2	26.87	0.002	
8) Lean Concrete (σ ck = 100 kg/cm2)	15 m3	15.63	0.001	
9) Form of Lean Concrete (σ ck = 100 kg/cm2)	5 m2	24.11	0.001	
10) Cobble Stone	31 m3	52.56	0.002	
11) Accessory Work	1 s	–	0.043	
Sub-Total of 1-3 Distribution Tank			0.469	
1-4 Influent Channel (per 1 unit)				
1) Concrete Work (σ ck = 250 kg/cm2)	1,908 m3	440.11	0.840	
2) Form of Concrete Work (σ ck = 250 kg/cm2)	6,207 m2	26.87	0.167	
3) Rainforced Bar	191 t	1,970.00	0.376	
4) Lean Concrete (σ ck = 100 kg/cm2) t = 5 cm	155 m3	15.63	0.002	
5) Form of Lean Concrete (σ ck = 100 kg/cm2)	124 m2	24.11	0.003	
6) Cobble Stone t = 10 cm				
156 x 2 = 312	312 m3	52.56	0.016	
7) Cast-in-place Concrete Pile				
Ø 600, ℓ= 30 m	88 piles	7,542.10	0.664	
32 + 56 = 88				
Sub-Total of 1-4 Influent Channel			2.068	
5. Wastewater Treatment Facility (per 1 unit)				
1) Aeration Tank				
(1) Concrete Work (σ ck = 250 kg/cm2)	57,298 m3	440.11	25.217	
(2) Reinforced Bar	5,730 t	1,970.00	11.288	
(3) Form of Concrete Work (σ ck = 250 kg/cm2)	89,144 m2	26.87	2.395	
(4) Lean Concrete (σ ck = 100 kg/cm2)	3,586 m3	15.63	0.056	
(5) Form of Lean Concrete (σ ck = 100 kg/cm2)	57 m2	24.11	0.001	
(6) Cobble Stone	7,172 m3	52.56	0.377	
(7) Cast-in-place Concrete Pile				
Ø 600, ℓ= 23.5 m	3,399 piles	6,367.40	21.643	
33 x 103 = 3,399				
(8) Accessory Work	1 ℓs	–	6.098	
Sub-Total of 1) Aeration Tank			67.075	

Bill of Quantities (Priced)

Item	Quantity	Unit Cost	Cost (Mill. N$)	Remarks
2) Secondary Sedimentation Tank				
(1) Concrete Work (σ ck = 250 kg/cm2)	37,544 m3	440.11	16.523	
(2) Reinforced Bar	3,754 t	1,970.00	7.395	
(3) Form of Concrete (σ ck = 250 kg/cm2)	73,368 m2	26.87	1.971	
(4) Lean Concrete (σ ck = 100 kg/cm2)	2,446 m3	15.63	0.038	
(5) Form of Lean Concrete (σ ck = 100 kg/cm2)	88 m2	24.11	0.002	
(6) Cobble Stone	4,892 m3	52.56	0.257	
(7) Cast-in-place Concrete Pile				
Ø 600, ℓ= 23.3 m	207 piles	6,361.80	1.317	
372.8 / 5.4 = 69, 69 x 3 = 207				
Ø 600, ℓ= 25.5 m	1,794 piles	6,922.70	12.419	
69 x 26 = 1,794				
(8) Accessory Work	1 ℓs	–	3.992	
Sub-Total of 2) Secondary Sedimentation Tank			43.914	
Sub-Total of 5. Wastewater Treatment Plant			110.989	
6. Discharge Channel				
1) Cast-in-place Concrete Pile	501 piles	8,181.70	4.099	
2) Earth Work				
(1) Excavation	54,396 m3	6.39	0.348	
(2) Backfilling	21,432 m3	55.11	1.181	
(3) Surplus Soil	54,396 m3	10.49	0.571	
3) Concrete Work (σ ck=250 kg/cm2)	6,250 m3	440.11	2.751	
4) Form of Concrete Work (σ ck=250 kg/cm2)	15,629 m2	26.87	0.420	
5) Rainforced Bar	625 t	1,970.00	1.231	
6) Supporting Work	1,680 m3	269.17	0.452	
7) Lean Concrete (σ ck = 100 kg/cm2)	505 m3	15.63	0.008	
8) Form of Lean Concrete (σ ck = 100 kg/cm2)	92 m2	24.11	0.002	
Sub-Total of 6. Discharge Channel			11.063	
7. Digestion Tank (per 1 tank)				
1) Concrete Work (σ ck=250 kg/cm2)	2,144 m3	440.11	0.944	
2) Cast-in-place Concrete Pile				
Ø 800, ℓ= 23 m	90 piles	8,495.90	0.765	
3) Form of Concrete (σck=250 kg/cm2)	2,624 m2	26.87	0.071	
4) Rainforced Bar	257 t	1,970.00	0.506	
5) Supporting Work	8,587 m3	269.17	2.311	
6) Lean Concrete (σ ck=100 kg/cm2)	66 m3	15.63	0.001	
7) Form of Lean Concrete (σ ck=100 kg/cm2)	9 m2	24.11	0.001	
8) Cobble Stone	132 m3	52.56	0.007	
9) Pipe Gellary	84 m2	2,000.00	0.168	
10) Accessory Work	1 s	–	0.955	
Sub-Total of 7. Digestion Tank			5.729	

Bill of Quantities (Priced)

Item	Quantity	Unit Cost	Cost (Mill. N$)	Remarks
8. Other Work				
8-1 Preparatory Work				
1) Remove of Existing Concrete Structure	8,400 m3	46.22	0.388	
2) Cutting of Stacked Lime	230,000 m3	12.90	2.967	
Sub-Total of 8-1 Preparatory Work			3.355	
8-2 Main Earth Work				
1) Excavation	1,067,571 m3	3.59	3.833	
2) Back Filling	165,519 m3	55.11	9.122	
Sub-Total of 8-2 Main Earth Work			12.955	

Table Break-down of Construction Cost for Electrical Work

(Unit : Million N$)

Description	Urgent Project (1st Stage)			2nd~4th Stage			Total
	Quantity	Unit Cost	Const. Cost	Quantity	Unit Cost	Const. Cost	
1) Wastewater Treatment							
(1) Extra-high Tension	1 ls.	-	5.2	-	-		5.2
(2) Power Board	1 ls.	-	9.6	1 ls.	-	26.4	36.0
(3) Blower House	2 unit	5.15	10.3	6 unit	5.15	30.9	41.2
(4) Secondary Sed. Tank	2 unit	5.15	10.3	6 unit	5.15	30.9	41.2
(5) Disinfection & Treated Wastewater Supply	2 unit	2.38	4.8	6 unit	2.38	14.3	19.1
Sub-Total	-	-	40.2			102.5	142.7
2) Sludge							
(1) Centrifugal Thickener House	2 unit	9.51	19.0	2 unit	9.51	19.0	38.0
(2) Gravity Thickener	- unit	-	-	4 unit	2.03	8.1	8.1
(3) Anaerobic Digester	2 unit	4.19	8.4	2 unit	4.19	8.4	16.8
(4) Mechanical Dewatering	2 unit	8.90	17.8	2 unit	8.90	17.8	35.6
(5) Generator House	2 unit	7.10	14.2	2 unit	7.10	14.2	28.4
(6) Others	2 unit	3.57	7.1	2 unit	3.57	7.1	14.2
Sub-Total			66.5			74.6	141.1

WASTEWATER AND SLUDGE TREATMENT SYSTEM PROPOSED BY CNA

DECEMBER 1994

JAPAN INTERNATIONAL COOPERATION AGENCY

Wastewater and Sludge Treatment System Propoed by CNA

Wastewater and Sludge Treatment System

Treatment efficiency in terms of BOD_5 removal efficiency and SS removal efficiency of the wastewater treatment system, consisting of primary sedimentation with coagulation and filtration, has been analyzed. The flow diagram of the treatment system is shown in Fig. S.1.

Usually filtration is employed as one of the tertiary treatment unit after secondary treatment process. And no data has been reported related to the treatment system employing primary sedimentation with coagulation followed by sand filter or multimedia filter.

Generally, Soluble BOD_5 can not be removed by physical and chemical treatment processes. Only Non Filtrate BOD_5 (due to suspended solids) can be removed by physical and chemical treatment processes such as sedimentation and filtration.

The typical municipal wastewater has 68 % of Non Filtrate BOD_5 and 32% of Soluble BOD_5.

Expected BOD_5 and SS removal efficiency in each step of above mentioned treatment process is described below.

Parameter	Expected removal efficiency (%)		Total expected removal efficiency (%)
	Primary Sedimentation with Coagulation	Multi Media Filter	
BOD_5	50	15*	57.5
SS	80	16	83.2

* Only non filtrate BOD_5 removal is taken into account, as Soluble BOD_5 removal should be avoided for efficient functioning of filter unit.

If this process is adopted for Texcoco wastewater treatment plant, expected treated wastewater quality will be as follows.

Year	Influent Wastewater Quality (mg/l)		Effluent Wastewater Quality (mg/l)	
	BOD_5	SS	BOD_5	SS
1997	220	235	77	9.4
2015	245	260	86	10.4

Hence this wastewater system cannot meet the design effluent quality requirements for the Final Project and is not recommended for the Final Project (Year 2015).

However for the reference, this treatment system is designed to meet the design conditions for the year of 1997. Detailed dimensions, of each facility, are shown in Table S.1.

Direct construction cost of this system for treating 35 m^3/sec of wastewater is estimated to be N$ 2,087.5 million and an annual O/M cost is estimated to be N$ 294.5 million. The break-down of the construction cost and O/M cost is shown in Tables S.2 and Table S.3 respectively.

Table S.1 Basis of Facility Design

Item	Design Criteria	Estimation of Facility Dimension	Configuration
1.Wastewater Treatment			
1)Receiving Tank	retention time (T) T=1.5min	35m3/s*60*1.5min=3150m3 3150m3*1 ls	48m*16m*5.1m
2)Distribution Tank	T=1.5min	5m3/s*60*1.5min=450m3 450m3*7unit	16m*8m*3.5m
3)Preaeration Tank	T=15min	5m3/s*60*15min=4500m3 4500m3*7unit	10m*29m*4m*4 basin
4)Mixing Tank	T=15min	5m3/s*60*3min=900m3 900m3*7unit	12m*6m*3.2m*4 basin
5)Flocculation Chamber	T=30min	5m3/s*60*30min=9000m3 9000m3*7unit	10m*80m*3m*4 basin
6) Primary Sedimentation Tank	Overflow Rate 35m3/m2 d	432000m3/35=12343m2 12343m2*7unit	10m*39m*3m*32basin
7)Chlorine Dosage to Primary Effluent	Dosing Rate 5mg/l	–	–
8)Maltimedium Filter	Filtration Rate 120m3/m2 d	432000m3/120=3600m2 3600m2*7unit	12m*12m*3.5m*25basin
9)Filtered Water Reservoir		content : equivalent to backwash water of 2 basins 144m2*1m3/m2 min*6min*2basins =1728m3 1728m3*7unit	15m*30m*2m*2basin
10)Effluent Disinfection	Dosing Rate 2mg/l	–	–
11)Effluent Conduit		(Dia.) 4.0m*2pipes*1.5km	
12)Blower		5m3/s*60*1.3=390m3 390m3/min*7unit	100m3/min*110kw*4set
2.Sludge Treatment			
1)G/T for PRI Sludge	Solid Loading 30kg/m2	required surface area;(A) A=122940/30=4098m2 4098m2*7unit	(Dia.) 24m*9tanks
2)Mixing Tank for Lime Stabilization	Mixing Duaration ; 30min	2460m3/(24*2)=51m3 51m*7unit	3m*3m*3.5m*3 basin
3)Pressure Filter Press	Solid Loading 5kg/m2	required Filter area;(A) A=113310kg/(5*9.6hr)=2361m2 2361m2*7unit	200m2*12set
4)Backwash Water Storage	T=24 hr	3600m2*1m3/m2 min*6min*1time/d =21600m3 21600m3*7unit	51m*51m*4m*2basin
5)G/T for Backwash water	Solid Loading 30kg/m2	required surface area;(A) A=26410kg/30=880m2 880m2*7unit	(Dia.) 24m*2tanks
6)Belt Filter Press	Solid Loading per Belt Width ; 150kg/m2 hr	required Belt Width;(W) W=21130kg/(150*9.6hr)=14.7m 14.7m*7unit	(W)3m/set*5set
7)Sanitary Landfill		disposal volume (340+100)m3/d*365=160,600m3/unit 160600m3*7unit	Total of 7 unit 1,124,200m3/year

Table S.2 Construction Cost of Wastewater Treatment Plant (35m3/s)

(Unit : Million N$)

Item	Civil / Architect				Mechanical / Electrical				Construction Cost
	Quantity		Unit Cost	Construction Cost	Quantity		Unit Cost	Construction Cost	
1. Wastewater Treatment									
1) Receiving Tank(48m*16m*5.1m)	1	ls.	---	3.0	1	ls.	---	0.9	3.9
2) Distribution Tank (V=450m3)	7	Unit	0.500	3.5	7	Unit	0.0	0.0	3.5
3) Preaeration Tank (V=4500m3)	7	Unit	3.825	26.8	7	Unit	0.8	5.6	32.4
4) Mixing Tank (12m*6m*3.2m*4basin)	7	Unit	1.106	7.7	7	Unit	0.8	5.6	13.3
5) Flocculation Chamber (10m*80m*3m*4basin)	7	Unit	8.160	57.1	---	---	---	---	57.1
6) P/S(10m*80m*3m*4basin)	7	Unit	32.100	224.7	7	Unit	20.8	145.8	370.5
7) Blower (100m3*4set)	---	---	---	---	7	Unit	4.4	30.8	30.8
8) Maltimedium Filter(12m*12m*25basin)	7	Unit	26.775	187.4	7	Unit	13.4	93.8	281.2
9) Filtered Water Reservoir (V=1800m3)	7	Unit	1.530	10.7	7	Unit	1.9	13.3	24.0
10) Effluent Disinfection	---	---	---	---	7	Unit	1.0	7.0	7.0
11) Discharge Channel	1	ls.	---	22.2	1	ls.	---	0.0	22.2
Sub-total				543.1				302.8	845.9
12) Electrical Work	---	---	---	---	1	ls.	---	60.6	60.6
Total of 1. Wastewater Treatment				543.1				363.4	906.5
2. Sludge Treatment									
1) Gravity Thickener (ø24 m x 11 tanks x 7units)	7	Unit	28.600	200.2	7	Unit	16.5	115.5	315.7
2) Belt Filter Press (width 3.0 m x 5 sets x 7units)	---	---	---	---	7	Unit	7.85	55.0	55.0
3) Pressure Filter Press (200m2*12set*7unit)	---	---	---	---	7	Unit	61.0	427.0	427.0
4) Backwash Sludge Basin (51m*51m*4m*2basin*7unit)	7	Unit	16.548	115.8	7	Unit	1.7	11.9	127.7
5) Mixing for Lime Stabilization (3m*3m*3.5m*3basin*7unit)	---	---	---	---	7	Unit	0.8	5.6	5.6
Sub-total				316.0				615.0	931.0
5) Electrical Work	---	---	---	---	1	ls.	---	123.0	123.0
Total of 2. Sludge Treatment				316.0				738.0	1,054.0
3. Building									
1) Administrative Building (2800m2)	1	Unit	5.600	5.6	---	---	---	---	5.6
2) Control Building (1800m2)	6	Unit	3.600	21.6	---	---	---	---	21.6
3) Blower Building (300m2)	7	Unit	0.600	4.2	---	---	---	---	4.2
4) Sludge Processing Building (3800m2)	7	Unit	7.600	53.2	---	---	---	---	53.2
Total of 3. Building				84.6					84.6
4. Other Work (Access Road and Site Preparation)	1	ls.	---	42.4	---	---	---	---	42.4
Total Construction Cost of Wastewater Treatment Plant				986.1				1,101.4	2,087.5

Table S.3 Breakdown of Operation & Maintenance Cost (35m3/s)

1. Personnel Expenditure

Item	No. of Employee	Unit Cost (N$/year)	Personnel Expenditure (Million N$)
Employee	590	17,000	10.0

2. Electrical Cost

Item	Estimation	Electrical Cost (Million N$/year)
Basic Charge	19,000kw * 24N$/mon. kw * 12mon./year = 5.5Million N$	
Consumption	407000kwh/d * 365days * 0.14N$/kwh = 20.8Million N$	26.3

3. Chemical Cost

Chemical	Quantity (ton/year)	Unit Cost (N$/ton)	Chemical Cost (Million N$)
Anionic Polymer	823	30,000	24.7
$Ca(OH)_2$	37,711	190	7.2
$FeCl_3$	55,188	1,540	85.0
Gas (Cl_2)	7,726	1,700	13.1
Total			130

4. Sludge Disposal Cost

Landfill Type	Cake Volume (m3/year)	Unit Cost (N$/m3)	Disposal Cost (Million N$)	Remarks
Disposal	1,124,200	65	73.1	include land aquisition cost (equivalent to 15N$/cake volume)

5.Repairing Cost

assume to 5% of Mechanical/Electrical work 1,101.4*0.05 = 55.1

6. Total of Operation & Maintenance cost 294.5

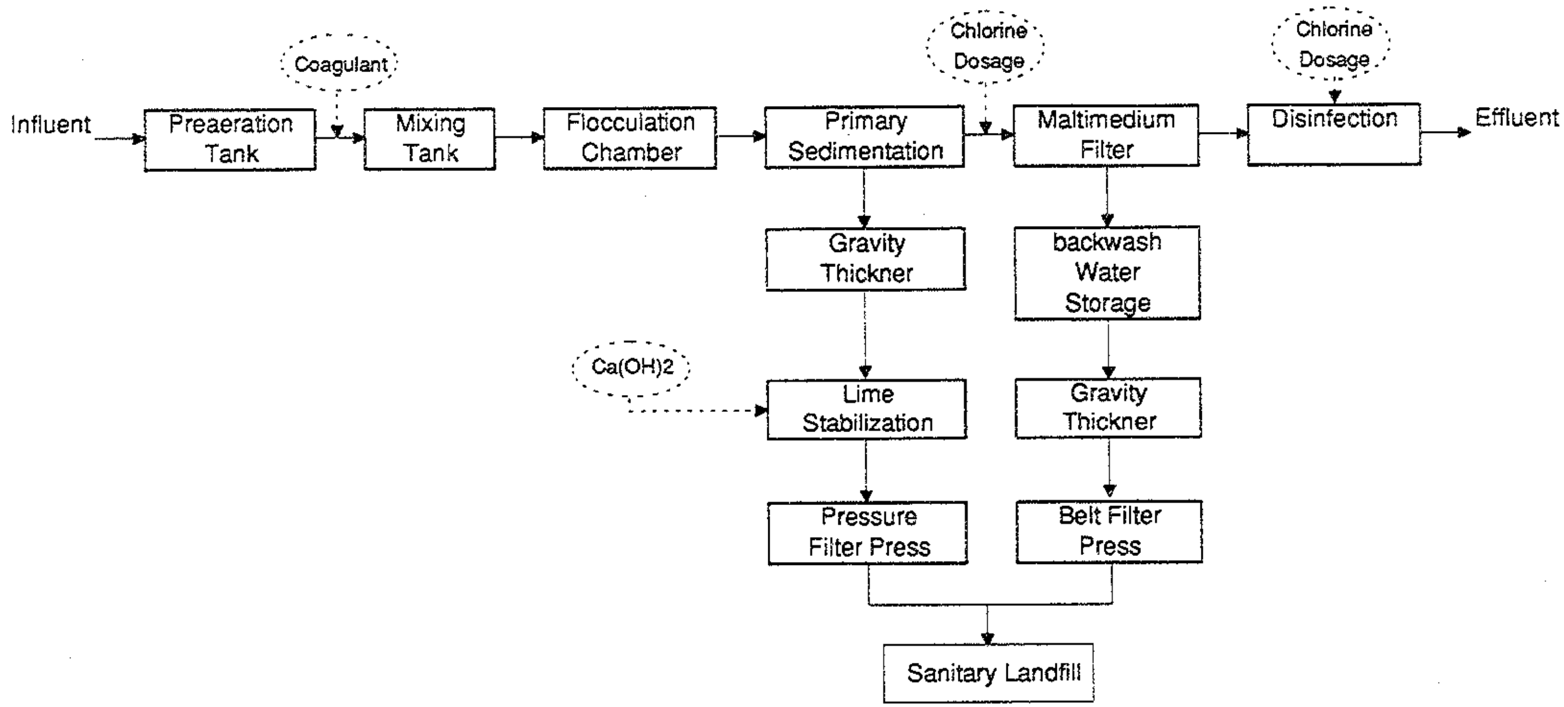


Fig. S.1 Flow of Treatment System

THE FEASIBILITY STUDY ON WASTEWATER TREATMENT IN THE FEDERAL DISTRICT OF MEXICO