APPENDIX 3, PART II (F/S)

Preliminary Design of Central WWTP

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APPENDIX 3 PRELIMINARY DESIGN OF CENTRAL WWTP

3.1 Process Calculation

Design Flow	Flow	166,000	m3/day
	BOD	240	mg/l
	SS	270	mg/l
Sidestream DS	Input	7,608	kg/day
	Calculate	7,608	kg/day
Adjudication		○	
Sidestream Flow	Input	4,570	m3/day
	Calculate	4,570	m3/day
Adjudication		○	

DS of Inflow	44,820
DS of waste sludge	4,052
	0
DS of coagulant	0
Total	48,872
DS of effluent	5,760
DS of sludge cake	28,023
DS of Digested gas	15,089
Total	48,872

Primary Settling

＜SS removal rate 40 %＞

Flow/Quality	Flow m3/day	SS mg/l	DS kg/day
① Inflow			
Inflow	166,000	270	44,820
Sidestream	4,570	1,665	7,608
Total	170,570	307	52,428
② Outflow			
Outflow	169,521	184	31,457
Raw sludge	Flow m3/day	Concentration %	DS kg/day
Generation	1,049	98.0	20,971

Design quality

Design Flow		166,000	m3/day
WWTP Inflow Quality	BOD	240	mg/l
	SS	270	mg/l
Design Quality	BOD	273	mg/l
	SS	307	mg/l
Aeration Tank Inflow Quality	BOD	164	mg/l
	SS	184	mg/l
Effluent Quality	BOD	25	mg/l
	SS	35	mg/l

Removal rate of SS

First Setting	40	%
Final Setting	81	%

Removal rate of BOD

First Setting	40	%
Final Setting	85	%

Coefficient of waste sludge generation

Detention Time	6.0	hr
a	0.5	
b	0.95	
c	0.04	

Return sludge

Return Rate	45	%
Density of Sludge	6,000	mg/l
MLSS	2,000	mg/l

Percentage of water content

Raw Sludge	98.0	%
Waste Sludge	99.4	%
Gravity Thickened	97.0	%
Digested Sludge	98.0	%
Dried Sludge	65.0	%

Recovery rate of DS

Gravity Thickener	85	%
		%
		%

Coefficient of digestion

Organic rate	70	%
Digestion rate	50	%

Injection rate of coagulant

		%

Water consumption for cleaning equipment

Total	0	m3/day

Aeration Tank / Secondary Settling

＜Return rate 45 %＞

＜SS removal rate 84 %＞

	Flow m3/day	SS mg/l	DS kg/day
① Inflow			
Inflow	169,521	184	31,457
Waste sludge	169,521		35,509
Total	169,521	209	35,509
Return sludge	76,963	6,000	461,778
② Outflow			
Outflow	164,563	35	5,760
Waste sludge	Flow m3/day	Concentration %	DS kg/day
Generation	4,958	99.4	29,749

Gravity Thickener

＜Recovery rate 85 %＞

Sludge	Flow m3/day	Concentration %	DS kg/day
Raw sludge	1,049	98.0	20,971
Waste sludge	4,958	99.4	29,749
Thickened sludge	1,437	97.0	43,112
Sidestream	Flow m3/day	SS mg/l	DS kg/day
Sidestream	4,570	1,665	7,608

Digestion Tank

＜Organic rate 70 %＞

＜Digestion rate 50 %＞

Sludge	Flow m3/day	Concentration %	DS kg/day
Feeded sludge	1,437	97.0	43,112
Digested sludge	1,437	98.0	28,023
Digested gas	DS kg/day	Generation m3/day	
Digested gas	15,089	15,089	

Design Flow / Quality	Flow m3/day	BOD mg/l	SS mg/l	
WWTP Inflow	166,000	240	270	
Design quality		273	307	
Design Flow / Quality	Flow m3/day	BOD mg/l	SS mg/l	DS kg/day
First Setting	170,570	273	307	52,428
Aeration Tank	169,521	164	184	31,457
Final Setting	169,521	164	184	31,457
(Return Sludge)	76,963		6,000	461,778
Design Amount / DS	Flow m3/day	Concentration %	DS kg/day	
Gravity Thickener	1,049	98.0	20,971	
Mechanical Thickener	0	0.0	0	
Digestion Tank	1,437	97.0	43,112	
Mechanical Dewater	0	0.0	0	

Thickener

	Flow m3/day	Concentration %	DS kg/day
Gravity Thickened	1,437	97.0	43,112
Mixed Thickened	1,437	97.0	43,112
Distribution of sludge	Rate	Flow m3/day	DS kg/day
Digestion Tank	1	1,437	43,112
Sidestream	Flow m3/day	SS mg/l	DS kg/day
Gravity thickener	4,570	1,665	7,608
Total	4,570	1,665	7,608

Drying Bed

Sludge	Amount m3/day	Concentration %	DS kg/day
Dried cake	80	65.0	28,023

※ Sidestream

	Flow m3/day	SS mg/l	DS kg/day
＜Sidestream from thickening＞			
Gravity Thickener	4,570	1,665	7,608
＜Sidestream from dewatering＞			
＜Washing water＞			
Total	4,570	1,665	7,608

1 DESIGN PARAMETERS AND CRITERIA

1.1 Wastewater Quantity and Characteristics

Desgin flow (Average daily flow)	Q_{ad} =	166,000	m^3/d
BOD concentration	=	240	mg/L
SS concentration	=	270	mg/L

1.2 Pollutants Removal Efficiencies

BOD concentration including sidestream flow	=	273	mg/L
BOD concentration treated with primary system	=	164	mg/L
BOD removal efficiency with primary system	=	40	%
BOD removal efficiency with secondary system	=	85	%
Overall BOD removal efficiency	=	91	%
SS concentration including sidestream flow	=	307	mg/L
SS concentration treated with primary system	=	184	mg/L
SS removal efficiency with primary system	=	40	%
SS removal eficiency with secondary system	=	81	%
Overall SS removal efficiency	=	89	%

1.3 Effluent Qualities

BOD concentration	=	25	mg/L
SS concentration	=	35	mg/L

1.4 Component Facilities

(a) Grit Chamber			
Average flow rate (0.3)	=	0.3	m/s
Hydraulic overflow rate (1,800)	=	1,800	$m^3/m^2/d$
Hydraulic retention time (30～60)	=	47	s
(b) Primary Setting			
Hydraulic overflow rate (35～70)	=	50	$m^3/m^2/d$
Hydraulic retention time	=	1.5	hr
Effective depth (2.5～4.0)	=	3.0	m
Sludge solids cocentration	=	2.0	%
(c) Aeration Tank			
MLSS concentration (1,500～2,000)	=	2,000	mg/L
Dissolved oxygen in mixed liquor (2～3)	=	2.0	mg/L
HRT(Hydraulic retention time)	=	6.0	hr
Solids content in return sludge	=	0.6	%
Return sludge ratio	=	45	%
(d) Final Setting			
Hydraulic overflow rate (20～30)	=	25	$m^3/m^2/d$
Hydraulic retention time (3～4)	=	3.1	hr
Effective depth (2.5～4.0)	=	3.0	m
Excess sludge solids concentration	=	0.6	%
(e) Disinfection			
Maximum Chlorine dosign rate	=	15.0	mg/L
Average Chlorine dosign rate	=	5.0	mg/L
Chlorine contact time	=	15.0	minutes
(f) Air Requirements			
Oxygen required to remove BOD (0.5～0.7)	=	0.6	kgO_2/kgBOD
Oxygen required for endogenous (0.05～0.15)	=	0.10	kgO_2/MLVSS/day
(g) Gravity Sludge Thickeners			
Thicken sludge solids concentration	=	3.0	%
Solids recovery rate (80%～90%)	=	85	%
Solids surface loading (60～90)	=	75	$kg/m^2/day$
Effective depth	=	4.0	m
(h) Anaerobic Sludge Digester			
Hydraulic retention time (20～30)	=	20	days
Sludge heating temperature (30～37)	=	35	℃
Volatile material contents	=	70	%
Digestion rate	=	50	%
Gas production rate (0.35～0.55)	=	0.50	m^3/kg
(i) Drying Bed			
Depth of sludge layor (25～45)	=	20	cm
Drying priod (14)	=	14	days
Sludge solids cocentration (30～40)	=	35.0	%

2 DESIGN CALCULATIONS OF WATER TREATMENT FACILITIES

2.1 Grit Chamber

(1) Design Bases

Desgin flow rate	Q_{ad} =	170,570	m^3/d			
Hydraulic overflow rate	q_o =	1800	$m^3/m^2/d$			
Average flow rate	v_o =	0.3	m/s			
Total number of chambers	n =	3	units			
Hydraulic load on each basin is	=	170,570	/ 3	=	56,857	m^3/d
Required surface area of each tank	=	56,857	/ 1800	=	31.6	m^2

(2) Tank Geometry

Width of chamber	W =	2.0	m
Effective depth	d =	1.0	m
Lenght of chanber	L =	15.5	m
Hydraulic capacity of a basin	Q_p=	31	m^3

(3) Check for Hydraulic Conditions

HRT for design flow rate	T_{ad}. =	31	/	56,857	= 47	s
Overflow rate for desgin flow rate	Q_{md} =	170,570	/ 93.0 =	1834		$m^3/m^2.d$

(4) Tank Shape and Dimension

Tank Shape and Dimensions

Width of chamber	2.0 m
Effective depth	1.0 m
Length of chamber	15.5 m
Capacity of chamber	31.0 m^3
Number of Units	3 units

2.2 Primary Setting

(1) Design Bases

Design flow rate	Q_{ad} =	170,570	m^3/d					
Hydraulic overflow rate	q_o =	50	$m^3/m^2/d$					
Total number of clarifiers	n =	8	units		4	clusters x	2	tank
Hydraulic load on each basin is	=	170,570	/ 8	=	21,321	m^3/d		
Required surface area of each tank	=	21,321	/ 50	=	426.4	m^2		

(2) Tank Geometry

Internal diameter	D =	24.0	m
Effective depth	d =	3.0	m
Number of basins	n =	8	units
Required surface area of each tank	A =	452	m^2
Hydraulic capacity of a basin	Q_p=	1,357	m^3

(3) Check for Hydraulic Conditions

HRT for average design flow rate	T_{ad}. =	1,357	x 24 /	21,321	= 1.53	hr
Overflow rate for desgin flow rate	Q_{md} =	21,321	/ 452.4 =	47.1		$m^3/m^2.d$

(4) Tank Shape and Dimension

Tank Shape and Dimensions

Internal diameter	24.0 m
Effective depth	3.0 m
Tank capacity	1,357 m^3
Number of Units	2 tanks x 4 clusters

2.3 Aeration Tank

(1) Design Bases

Design flow	Q_{in} =	169,521	m^3/d
BOD concentration	$C_{BOD, in}$ =	164	mg/L
S-BOD concentration (= 66.7%)	$C_{S\text{-}BOD, in}$ =	109	mg/L
SS concentration	$C_{SS, in}$ =	184	mg/L
MLSS concentration	X=	2,000	mg/L
HRT (Hydraulic retention time)	θ=	6.0	hour

(2) Check for effluent Qualities

The volume of waste sludge can be estimated by the following equation:

$$Q_w \cdot X_w = (a \cdot C_{S\text{-}BOD,\,in} + b \cdot C_{SS,\,in} - c \cdot \theta \cdot X)\,Q_{in}$$

where,

Q_w :	Excess sludge volume (m^3/d)			
X_w :	Average solids concentration of waste sludge	=	0.6	%
Q_{in} :	Inflow rate to reactor basins	=	169,521	m^3/d
X :	MLSS concentration in reactor basins	=	2,000	mg/L
$C_{S\text{-}BOD,\,in}$:	Influent S-BOD concentration to reactor basins	=	109	mg/L
$C_{SS,\,in}$:	Influent SS concentration to reactor basins	=	184	mg/L
a :	Biomass yield coefficient of S-BOD (0.4～0.6)	=	0.5	mg MLSS/mg BOD
b :	Biomass yield coefficient of SS (0.9～1.0)	=	0.95	mg MLSS/mg SS
c :	Sludge reduction coefficient due to endogenous respiration of micro-organisms (0.03～0.05)	=	0.04	L/d
θ :	Hydraulic retention time (HRT) in reactors	=	6.0	hour

$Q_w X_w$ = 35,509 kg/d

SRT of reactor can be estimated by the following equation:

$$SRT = \theta \cdot X / (a \cdot C_{S\text{-}BOD,\,in} + b \cdot C_{SS,\,in} - c \cdot \theta \cdot X)$$

SRT = 2.4 d

C-BOD of effluent qualities can be estimated by the following equation:

$C_{C\text{-}BOD}$ = $13.73 \cdot SRT^{-0.554}$ (Lowest =12℃ < 15℃)

$C_{C\text{-}BOD}$ = 8.5 mg/l

C_{BOD} = 25.4 mg/l

$C_{C\text{-}BOD}$ = $9.75 \cdot SRT^{-0.671}$ (15℃ < Average =16℃ < 20℃)

$C_{C\text{-}BOD}$ = 5.4 mg/l

C_{BOD} = 16.3 mg/l

$C_{C\text{-}BOD}$ = $9.75 \cdot SRT^{-0.671}$ (15℃ < Highest =20℃ < 20℃)

$C_{C\text{-}BOD}$ = 5.4 mg/l

C_{BOD} = 16.3 mg/l

Nitration can be estimated by the following equation:

Required SRT = *20.65*exp(-0.0639*Temperature)*

Highest Sewage Temperature = 20 ℃

= 5.8 d > 2.4 d

Therefore, nitration is not expeced to occur.

(3) Tank Dimensions

Tank width	W =	16.0 m						
Tank effective depth	d =	5.0 m						
Tank cross sectional area	A =	5.0 x	16					
	=	80.0	m^2					
Number of tanks	n =	2	tank	x	4	clusters =	8	tank units
Capacity of each tank	V_e =	42,380 / 8 =		5,298	m^3			
Tank length		5,298 / 80 =		66.2	m	→	67 m	

Tank Shape and Dimensions

Width	16.0 m
Depth	5.0 m
Tank capacity	5,360 m^3
Tank length	67 m
No. of tank units and clusters	2 tanks x 4 clusters

Check actual aeration time under the average daily flow rate condition.

Tank capacity	V =	80 x 67 x 8 = 42,880 m^3
Aeration time	T_a =	42,880 x 24 / 169,521 = 6.1 hr.

BOD to SS Loads : $L_{BOD/X}$ (kg BOD / kgMLSS・d)

$L_{BOD/X}$ = Q_{in} ・ $C_{BOD,in}$ / X ・ V

$L_{BOD/X}$ = 0.32 kg BOD / kgMLSS・d

BOD to Volume Loads : $L_{BOD/V}$ (kg BOD / m^3 ・d)

$L_{BOD/V}$ = Q_{in} ・ $C_{BOD,in}$ / V $*10^{-3}$

$L_{BOD/V}$ = 0.65 kg BOD / m3 / d

2.4 Secondary Setting

(1) Tank Dimensions

Design flow rate	Q_{ad} =	169,521 m^3/d		
Hydraulic overflow rate	=	25 $m^3/m^2/d$		
Total number of clarifiers	n =	16 units	4 clusters x	4 tanks
Hydraulic load on each basin is	=	169,521 / 16 =	10,595 m^3/d	
Required tank surface area	A =	10,595 / 25 =	424 m^2	

(2) Tank Geometry

Internal diameter	D =	24.0 m
Effective depth	d =	3.0 m
Number of basins	n =	16 units
Surface area of each tank	A_e =	452 m^2
Hydraulic capacity of a tank	V_{fc} =	1,357 m^3

(3) Check for Hydraulic Conditions

HRT for Design flow	T_{ad} =	1,357 x 24 / 10,595 = 3.1 hr
Overflow rate for Design flow	Q_{md} =	10,595 / 452 = 23.4 $m^3/m^2.d$

Tank Shape and Dimensions

Internal diameter	24.0 m
Efficent depth	3.0 m
Tank capacity	1,357 m^3
No. of tank units and clusters	4 tanks x 4 clusters

2.5 Chlorine Contact Tank

(1) Tank Dimension

Design flow	=	166,000 m^3/d (Q_{md})	
Chlorine contact time	=	15 minutes	
Required tank capacity	=	166,000 /1,440 x 15 =	1,729 m^3
Channel width:	=	10.0 m	
Effective depth:	=	2.0 m	
Tank length:	=	1,729 / 10.0 / 2.0 =	86.5 m
Number of tanks	=	1 tanks	
Length channel	=	86 m/tanks	
No. of lines		86 m x	1 lines
Capacity of Tank	=	1,729 m^3	

(2) Check for Contact Time

Contact time for Design flow T_{ad} = 1,729 x 1440 / 166,000 = 15.0 minutes

Tank Shape and Dimensions

Width	10.0 m
Depth	2.0 m
Tank capacity	1,729 m^3
Tank length	86 m
No. of tank units	1 tanks

3 DESIGN CALCULATION OF REQUIRED AERATION

3.1 AOR (Actual Oxygen Rewuirement) for Aeration Tank

Required oxygen O_2 for aeration is estimated as:

$$AOR = OD_1 + OD_2 + OD_3$$

where

OD_1 = Oxygen required for BOD oxygenation (kg/day)

OD_2 = Oxygen required for endogenous respiration (kg/day)

OD_3 = Oxygen to be utilized for maintaining required desolved oxygen level (kg/day)

3.2 Oxygen for BOD Oxidation, OD_1 (cell synthesis)

OD_1 = A (kg O_2/kg BOD) x BOD removed (kg BOD/day)

where

A = Oxygen required to remove BOD (kgO_2/kgBOD, 0.5～0.7)

= 0.6 kgO_2/kgBOD

Q = 169,521 m^3/d

BOD = 164 - 25 = 139 mg/L

OD_1 = 0.6 x Q x 139 x 10^{-3}

= 0.083 Q kgO_2/d

3.3 Oxygen for Endogenous Respiration OD_2

OD_2 = B (kgO_2/kg MLVSS/day) × V_A (m_3) x MLVSS (kg MLVSS/m_3)

where

B = Oxygen required for endogenous respiration per MLVSS (kgO_2/MLVSS/day, 0.05～0.15)

= 0.1 kgO_2/MLVSS/day

V_A = Capacity of aerobic zone of reactor 6 ÷ 24 = 0.25 Q (m^3)

$MLVSS/MLSS$ = 0.8

OD_2 = 0.1 x 0.25 x Q x 2,000 x 10^{-3} x 0.8

= 0.040 Q kgO_2/d

3.4 Oxygen for Maintaining Dissolved Oxigen Level OD_3

OD_3 = $C_{O,A}$ x (Q + Qr) x 10^{-3} (kg BOD/day)

where

C_{OA} = Dissolved oxygen concentration in tank 2.0 mg/L

Qr = Returned sludge = 0.45 x Q

OD_3 = 2.0 x (Q + Qr) x 10^{-3}

= 0.003 x Q kg O_2/d

3.5 Total AOR

AOR = OD_1 + OD_2 + OD_3

= 0.083 Q + 0.040 Q + 0.003 Q

= 0.126 Q (kgO_2/d)

3.6 SOR (Standard Oxygen Requirement) for Aeration Tank

Required oxygen O_2 for aeration in the condition (clean water, 20℃and 1atm) is estimated as:

$$SOR = \frac{AOR \times Csw \times \gamma}{1.024^{(T-20)} \times \alpha(\beta \times Cs \times \gamma - C_{OA})} \times \frac{101.3}{P}$$

where

$C\,sw$ =	Oxygen saturation concentration in clean water at temperature at 20℃	8.84	mg/L
$C\,s$ =	Oxygen saturation concentration in clean water at temperature at T℃	10.43	mg/L
α =	Correction Factor	0.83	
β =	Correction Factor	0.95	
γ =	Correction Factor for CS by Water Depth		
	γ = 1+(h/2)/10.332	1.242	
H =	water depth	5	m
P =	Atmospheric Factor	101.3	kPa
T =	Minimum Temperature of Waste Water	12	℃

SOR＝ 33,224 kgO2/d

3.7 Aeration Requirement

Oxygen transfer efficiency of aerator is estimated as:

Ea= Ea(5.0) × (H - 5)^0.7

where

Ea=	Oxygen transfer Efficiency in clean Water		
Ea(5.0)=	Oxygen transfer Efficiency in clean Water at 5m depth	15	%

Ea= 15 %

Required total air demand (GS) for aeration is estimated as:

$$GS = \frac{SOR \times (273+20)}{Ea \times 10^{-2} \times \rho \times Ow \times 273 \times 60 \times 24}$$

where

ρ=	Air Density	1.292	kg/Nm^3
Ow=	Oxygen Weight per Unit Air	0.232	kg-O2/kg-air

GS= 552 m^3/min

4 DESIGN CALCULATIONS OF SLUDGE TREATMENT FACILITIES

4.1 Design Bases

(1) Raw Sludge

Sludge solids production	=	170,570 x 307 x 10^{-6} x 0.40	
	=	20,971 kg/d	
Solids concentration of sludge	=	2.0 %	
Raw sludge generation	=	20,971 / 10 / 2.0 =	1,049 m^3/d

(2) Waste Sludge

The volume of waste sludge can be estimated by the following equation:

$$Q_w \cdot X_w = (a \cdot C_{S\text{-}BOD,\,in} + b \cdot C_{SS,\,in} - c \cdot \theta \cdot X)\,Q_{in}$$

where,

Q_w :	Excess sludge volume (m^3/d)			
X_w :	Average solids concentration of waste sludge	=	0.6	%
Q_{in} :	Inflow rate to reactor basisns	=	169,521	m^3/d
X :	MLSS concentration in reactor basins	=	2,000	mg/L
$C_{S\text{-}BOD,\,in}$:	Influent S-BOD concentration to reactor basins	=	109	mg/L
$C_{SS,\,in}$:	Influent SS concentration to reactor basins	=	184	mg/L
a :	Biomass yield coefficient of S-BOD (0.4～0.6)	=	0.5	mg MLSS/mg BOI
b :	Biomass yield coefficient of SS (0.9～1.0)	=	0.95	mg MLSS/mg SS
c :	Sludge reduction coefficient due to endogenous respiration of micro-organisms (0.03～0.05)	=	0.04	L/d
θ :	Hydraulic retention time (HRT) in reactors	=	6.0	day

$Q_w X_w$ = 35,509 kg/d

Sludge solids in effluence flow	=	164,563 x 35 x 10^{-6} =	5,760 kg/d
Sludge solids production	=	29,749 kg/d	
Solids concentration of sludge	=	0.6 %	
Waste sludge generation	=	29,749 / 10 / 0.6 =	4,958 m^3/d

4.2 Gravity Sludge Thickener

(1) Design Bases

Input sludge solids	=	50,720	kg/d
Input sludge Volume	=	6,007	m^3/d
Input sludge solids concetration	=	0.8	%
Thicken sludge solids concentrat	=	3.0	%
Solids recovery rate	=	85	%
Solids surface loading	=	75	kg/m2/day
Required surface area	=	676	m^2

(2) Tank Geometry

Internal diameter	=	21.0	m
Effective depth	=	4.0	m
Number of tanks	=	2	tanks
Water surface area	=	692	m^2
Hydraulic retention time	=	11.1	hr.

Tank Shape and Dimensions

Internal diameter	21.0 m
Efficent depth	4.0 m
Tank capacity	1,385 m^3
No. of tank units	2 tanks

(3) Thickened Sludge

Output sludge solids	=	43,112	kg/d
Output sludge volume	=	1,437	m^3/d

(4) Waste Water

Sludge solids in waste water	=	7,608	kg/d
Waste water volume	=	4,570	m^3/d

4.3 Anaerobic Sludge Digester

(1) Design Bases

Thicken Sludge from Gravity Sludge Thickner

Input sludge solids	=	43,112	kg/d
Input sludge volume	=	1,437	m^3/d
Input sludge solids concetration	=	3.0	%
Hydraulic retention time	=	20	days
Sludge heating temperature	=	35	℃
Volatile material contents	=	70	%
Digestion rate	=	50	%
Required digester tank capacity	=	28,742	m^3
Gas production rate	=	0.50	m^3/kg-vs

(2) Tank Geometry

Number of tanks	=	4	tanks
Required capacity of each tank	=	7,185	m^3
Internal diameter	=	26.0	m
Effective depth	=	14.0	m
Digester tank capacity	=	7,429	m^3

Tank Shape and Dimensions

Internal diameter	26.0 m
Efficent depth	14.0 m
Tank capacity	7,429 m^3
No. of tank units	4 tanks

(3) Digested Sludge

Digested sludge solids	=	43,112	x	(1.0 -	0.7	x 0.5	) =		28,023	kg/d
Digested sludge volume	=	1,437	m^3/d							
Digested sludge solids concetratio	=	2.0	%							

(4) Gas Holder

Maximun gas production	=	43,112	x 0.7	x 0.50		
	=	15,089 m^3/d				
Gas retention time in tank	=	12 hr				
Storage capacity	=	15,089	x 12 / 24	=	7,545	m^3/d

Gas Holder Shape and Dimensions

Type	Water Seal Type
Internal diameter	16.0 m
Effective depth	10.0 m
Tank capacity	2,000 m^3
No. of Gas Holder	4 tanks

4.4 Drying Beds

(1) Design Bases

Digested Sludge from Anaerobic Sludge Digester

Input sludge solids	=	28,023	kg/d
Input sludge volume	=	1,437	m^3/d
Input sludge solids concetration	=	2.0	%
Depth of sludge layor	=	20	cm
Drying priod	=	14	days
Sludge solids cocentration	=	35	%
Required area of drying bed	=	100,596	m^2 = 10.1 ha

Tank Shape and Dimensions

Area	10.1 ha
Depth of sludge layor	20.0 cm
Drying period	14 days

(2) Dried Sludge Cake

Dried sludge volume = 80.1 m^3/d

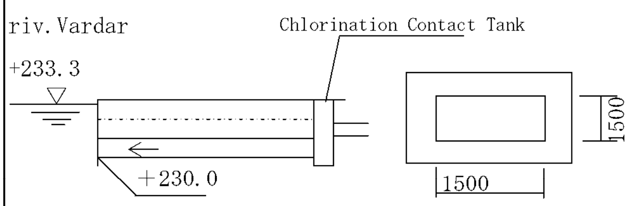
3.2 Hydraulic Calculation

(1) Discharge Opening ～ Chlorination Contact Tank

item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q	309,600	237,900	166,000	135,000	
	(m^3/sec)		3.588	2.749	1.920	1.560	
number of pond	(vol)	N	1	1	1	1	
unit quantity	(m^3/sec)	q	3.588	2.749	1.920	1.560	Q／N

shape

B 1500 ×H 1500、L=80.0m



water flow in pressure n ＝ 0.013

$$\triangle h_1 = n^2 \cdot V^2 \cdot L / R^{4/3}$$

$$\triangle h_2 = \Sigma f \cdot V^2 / 2g$$

item			symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
water level (downstream)		(m)	H_0	233.30	233.30	233.30	233.30	
effectve water level		(m)	H′	1.500	1.500	1.500	1.500	
cross section area		(m^2)	A	2.250	2.250	2.250	2.250	
liquid length		(m)	P	6.000	6.000	6.000	6.000	
inside diameter of depth		(m)	R	0.375	0.375	0.375	0.375	A／P
flow velocity		(m／sec)	V	1.595	1.222	0.853	0.693	q／A
friction loss		(m)	$\triangle h_1$	0.127	0.075	0.036	0.024	$n^2 \cdot V^2 \cdot L/R^{4/3}$
shepe loss	inflow	(place)	f_1	1	1	1	1	0.500
	outflow	(place)	f_2	1	1	1	1	1.000
	bend 90°	(place)	f_3	0	0	0	0	0.990
	bend 45°	(place)	f_4	0	0	0	0	0.183
	shape loss	(m)	$\triangle h_2$	0.195	0.114	0.056	0.037	$\Sigma f \cdot V^2/2g$
add		(m)	$\triangle h$	0.322	0.189	0.092	0.061	$\triangle h_1 + \triangle h_2$
water level		(m)	H	+233.622	+233.489	+233.392	+233.361	$H_0 + \triangle h$

(2) Chlorination Contact Tank : outlet head

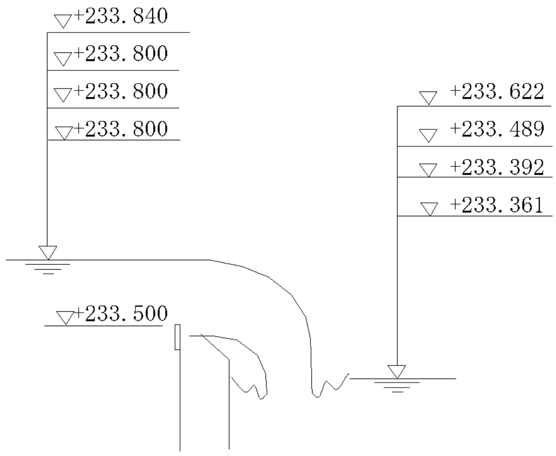
item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q	309,600	237,900	166,000	135,000	
	(m^3/sec)		3.588	2.749	1.920	1.560	
number of pond (vol)		N	1	1	1	1	
unit quantity (m^3/sec)		q	3.588	2.749	1.920	1.560	

formula of Francis

$$Q = 1.84 \cdot B \cdot h^{3/2}$$

$$h = \left(\frac{Q}{1.84 \cdot B} \right)^{2/3}$$

B : overflow width 10.00m



item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
water level (downstream)	(m)	H_0	+233.622	+233.489	+233.392	+233.361	
flow volume	(m^3／s)	q_1	3.588	2.749	1.920	1.560	
over flow depth	(m)	h	0.336	0.282	0.222	0.193	
margin	(m)	α	0.004	0.018	0.078	0.107	
water level (upstream)	(m)	H	+233.840	+233.800	+233.800	+233.800	
			water level of daily average(for wet) is ＋233.800m				

(3) transition pipe：Chlorination Contact Tank ～secondary settling tank

item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q	237,900	237,900	166,000	135,000	
	(m^3/sec)		2.749	2.749	1.920	1.560	
number of pond (vol)		N	1	1	1	1	
unit quantity (m^3/sec)		q	2.749	2.749	1.920	1.560	Q／N

shape

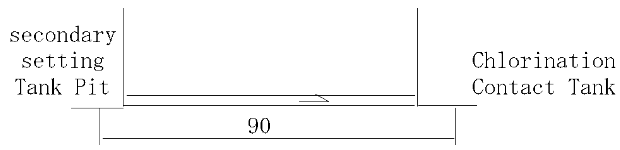
ϕ1,500 concrete pipe (n＝0.015)

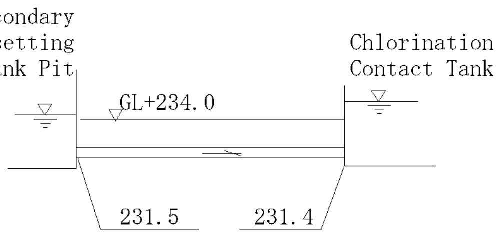
cross section area：WA＝ 1.7671

liquid length：WP＝ 4.7124

inside diameter of depth：R ＝ 0.375

L＝ 90.0m





water flow in pressure

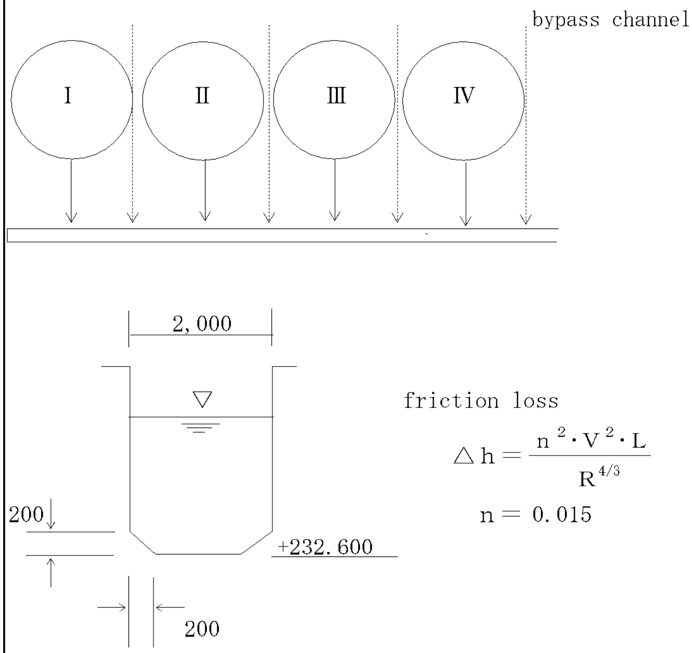
$\triangle h_1 = n^2 \cdot V^2 \cdot L / R^{4/3}$

$\triangle h_2 = \Sigma f \cdot V^2 / 2g$

Emergency flow is in the case of hourly maxflow

item		unit	symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
water level (downstream)		(m)	H_0	+233.840	+233.800	+233.800	+233.800	
flow velocity		(m／s)	V	1.556	1.556	1.087	0.883	
friction loss		(m)	$\triangle h_1$	0.181	0.181	0.088	0.058	
shepe loss	inflow	(place)	f_1	1	1	1	1	0.5
	outflow	(place)	f_2	1	1	1	1	1
	bend 90°	(place)	f_3	0	0	0	0	0.99
	bend 45°	(place)	f_4	0	0	0	0	0.183
	sum		Σf	1.5	1.5	1.5	1.5	
	shape loss	(m)	$\triangle h_2$	0.185	0.185	0.09	0.06	
add		(m)	$\triangle h$	0.366	0.366	0.178	0.118	
water level		(m)	H	+234.206	+234.166	+233.978	+233.918	

(4) secondary settling tank backside channel

item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q	309,600	237,900	166,000	135,000	
	(m^3/sec)		3.583	2.753	1.921	1.563	
number of pond (vol)		N	1	1	1	1	
unit quantity (m^3/sec)		q	3.583	2.753	1.921	1.563	
shape							
secondary setting tank pit ～ channel 290m							
water level (downstream) (m)		H_0	+234.206	+234.166	+233.978	+233.918	
water depth (m)		h	1.606	1.566	1.378	1.318	
flow area (m^2)		A	3.172	3.092	2.716	2.596	
flow velocity (m／s)		V	1.13	0.89	0.707	0.602	
wetted perimeter (m)		P	4.978	4.898	4.522	4.402	
inside diameter of depth (m)		R	0.637	0.631	0.601	0.59	
$R^{4/3}$			0.548	0.541	0.507	0.495	
friction loss (m)		△h	0.152	0.096	0.064	0.048	
water level (m)		H	+234.358	+234.262	+234.042	+233.966	

friction loss

$$\triangle h = \frac{n^2 \cdot V^2 \cdot L}{R^{4/3}}$$

n = 0.015

(5) secondary settling tank : overflow trough

item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q	237,900	237,900	166,000	135,000	
	(m^3/sec)		2.753	2.753	1.921	1.563	
number of pond (vol)		N	16	16	16	16	
unit quantity (m^3/sec)		q	0.172	0.172	0.120	0.098	

water level of overflow trough

formula of Thomas Camp

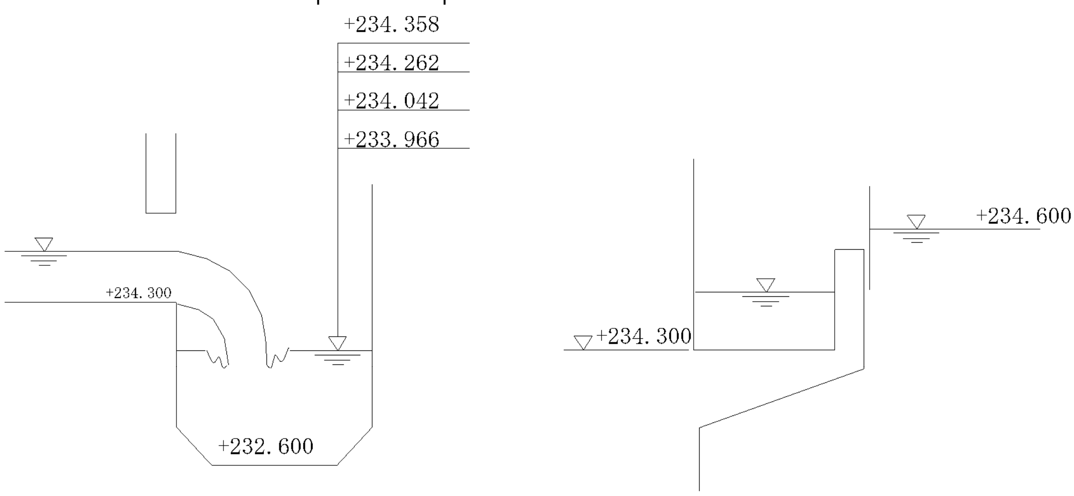
in case of free fall

$$h_0 = \sqrt{2h_c^2 + h_c^2} = \sqrt{3h_c^2}$$

in case of not free fall

$$h_0 = \sqrt{\frac{2h_c^3}{he} + he^2}$$

$$h_c = \sqrt[3]{\frac{Q^2}{g \cdot B^2}} \qquad (B = 1.50m)$$



water level (downstream) (m)	H_0	+234.358	+234.262	+234.042	+233.966	
marginal depth (m)	h_c	0.11	0.11	0.087	0.076	
water depth (downstream) (m)	h_e	0.058	0.000	0.000	0.000	
adjudication		not free fall	free fall	free fall	free fall	
		$h_c > h_e$	–	–	–	
		0.11	0.11	0.087	0.076	
	h_0	0.191	0.191	0.151	0.132	
water level (upstream) (m)	H	+234.491	+234.491	+234.451	+234.432	

(6) secondary settling tank : overflow ingate

item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q		237, 900	166, 000	135, 000	
	(m^3/sec)			2. 753	1. 921	1. 563	
number of pond (vol)		N		16	16	16	
unit quantity (m^3/sec)		q		0. 172	0. 120	0. 098	

formula of Tomson

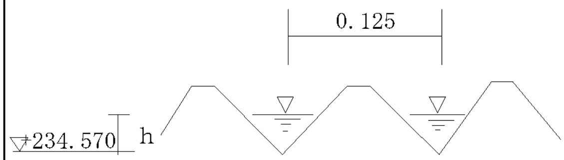
$$Q = 1.42\,h^{5/2}$$

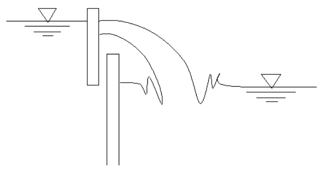
$$h = \left(\frac{Q}{1.42}\right)^{2/5}$$

h = water depht of overflow

length of overflow ingate 72. 3 m

number of ingate $\frac{72.30}{0.125}$ =578nos





item	symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
water level (downstream) (m)	H_0		+234. 491	+234. 451	+234. 432	
flow per one trough (m^3/ s)	q_o		0. 172	0. 12	0. 098	
water flow per one trauph (m^3/ s)	q		0. 0003	0. 00021	0. 00017	
water depth of overflow (m)	h		0. 034	0. 029	0. 027	
			≒0. 040	≒0. 030	≒0. 030	
water level (m)	H		+234. 610	+234. 600	+234. 600	

(7) transition pipe : Aerstion Tank ～secondary settling tank

item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q		237,900	166,000	135,000	
	(m^3/sec)			2.753	1.921	1.563	
number of pond (vol)		N		16	16	16	
unit quantity (m^3/sec)		q		0.172	0.120	0.098	Q／N

shape

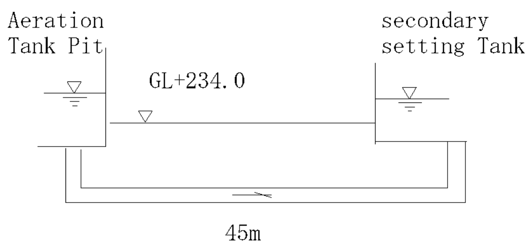
φ500 iron pipe (n =0.013)

cross section area : WA= 0.1963

liquid length : WP= 1.5708

inside diameter of depth : R = 0.125

L = 45.0m



$\triangle h_1 = n^2 \cdot V^2 \cdot L / R^{4/3}$

$\triangle h_2 = \Sigma f \cdot V^2 / 2g$

item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
water level (downstream)	(m)	H_0		+234.610	+234.600	+234.600	
flow velocity	(m／s)	V		0.876	0.611	0.499	
friction loss	(m)	$\triangle h_1$		0.093	0.045	0.03	
shepe loss: inflow	(place)	f_1		1	1	1	0.5
outflow	(place)	f_2		1	1	1	1
bend 90°	(place)	f_3		2	2	2	0.99
bend 45°	(place)	f_4		0	0	0	0.183
sum		Σ f		3.48	3.48	3.48	
shape loss	(m)	$\triangle h_2$		0.136	0.07	0.04	
add	(m)	△h		0.229	0.111	0.074	
water level	(m)	H		+234.839	+234.711	+234.674	

(8) Aeration tank : outlet head

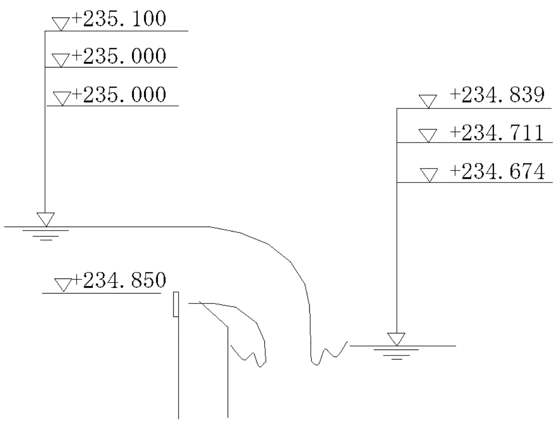
item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q		237,900	166,000	135,000	
	(m^3/sec)			2.753	1.921	1.563	
number of pond (vol)		N		8	8	8	
unit quantity (m^3/sec)		q		0.344	0.240	0.195	
water level (downstream)	(m)	H_0		+234.839	+234.711	+234.674	
flow volume	(m^3／s)	q_1		0.344	0.240	0.195	
over flow depth	(m)	h		0.178	0.14	0.122	
margin	(m)	α		0.072	0.01	0.028	
water level (upstream)	(m)	H		+235.100	+235.000	+235.000	
			water level of daily average(for wet) is +235.000m				

formula of Francis

$$Q = 1.84 \cdot B \cdot h^{3/2}$$

$$h = \left(\frac{Q}{1.84 \cdot B} \right)^{2/3}$$

B : overflow width 2.50m



(9) Aeration tank inflow (in case of conventional)

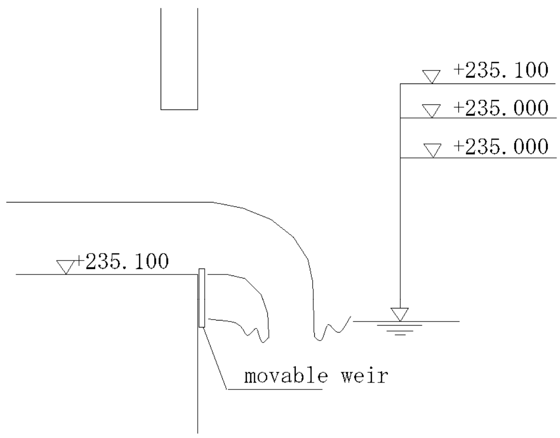
item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q		237,900	166,000	135,000	
	(m^3/sec)			2.753	1.921	1.563	
number of pond (vol)		N		8	8	8	
unit quantity (m^3/sec)		q		0.344	0.240	0.195	

formula of Francis

$$Q = 1.84 \cdot B \cdot h^{3/2}$$

$$h = \left(\frac{Q}{1.84 \cdot B} \right)^{2/3}$$

($B = 1.500$m)



item	symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
water level (downstream) (m)	H_0		+235.100	+235.000	+235.000	
water drpth of overflow (m)	h		0.25	0.196	0.171	
water level (upstream) (m)	H		+235.350	+235.296	+235.271	

(10) Aeration tank inflow (in case of step channel)

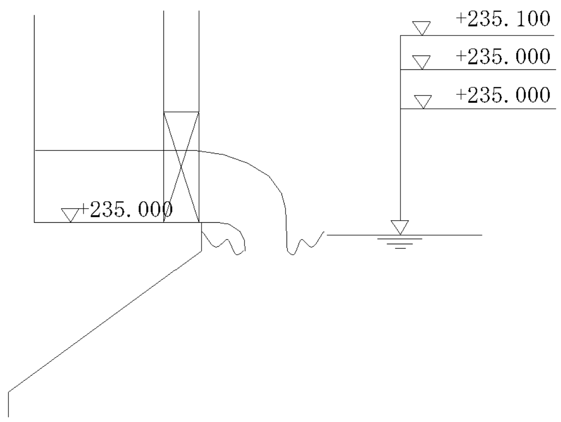
item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q		237,900	166,000	135,000	
	(m^3/sec)			2.753	1.921	1.563	
number of pond (vol)		N		8	8	8	
unit quantity (m^3/sec)		q		0.344	0.240	0.195	
water level (downstream) (m)		H_0		+235.100	+235.000	+235.000	
water drpth of overflow (m)		h		0.327	0.257	0.224	
water level (upstream) (m)		H		+235.327	+235.257	+235.224	

formula of Francis

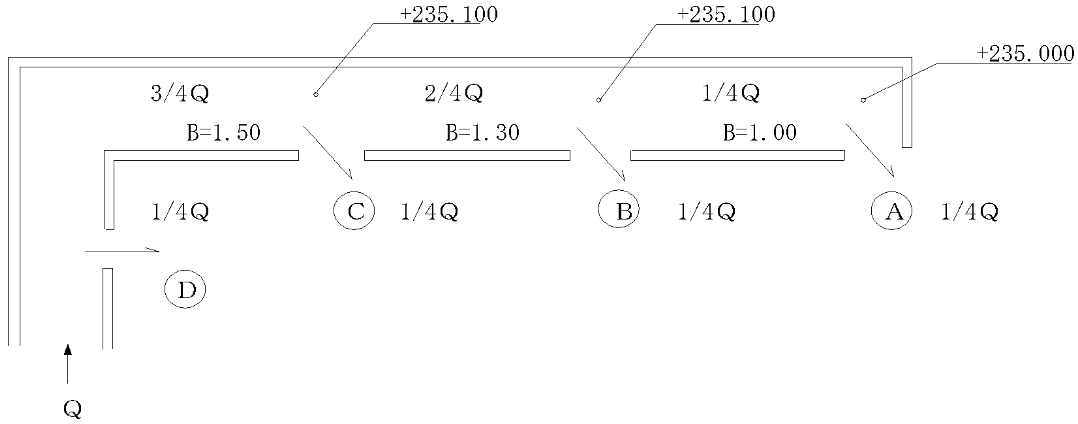
$$Q = 1.84 \cdot B \cdot h^{3/2}$$

$$h = \left(\frac{Q}{1.84 \cdot B} \right)^{2/3}$$

($B = 1.000m$)



step inflow channel



A～B : 20 m
B～C : 20 m
C～D : 25 m

head loss $$h = \frac{n^2 \cdot V^2 \cdot L}{R^{4/3}}$$

n : roughness coefficient (0.015)
V : flow velocity (V＝Q/A) (m/s)
L : length (m)
R : hydraulic radius R＝A/P
P : wetted perimeter (m)
A : flow area

A～B

	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)
Flow Q (m^3/s)		0.344	0.24	0.195
Water depth H (m)		0.327	0.257	0.224
wetted perimeter P (m)		1.654	1.514	1.448
flow area A (m^2)		0.327	0.257	0.224
hydraulic radius R=A/P (m)		0.198	0.17	0.155
$R^{4/3}$		0.115	0.094	0.083
Flow velocity V=Q/A (m/s)		1.052	0.934	0.871
head loss h (m)		0.043	0.042	0.041
water level (upstream) (m)		+235.470	+235.399	+235.365
buttom level point B +235.100				

B～C

	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)
Flow Q (m^3/s)		0.688	0.48	0.39
Water depth H (m)		0.37	0.299	0.265
wetted perimeter P (m)		2.04	1.898	1.83
flow area A (m^2)		0.4810	0.3887	0.3445
hydraulic radius R=A/P (m)		0.236	0.205	0.188
$R^{4/3}$		0.146	0.121	0.108
Flow velocity V=Q/A (m/s)		1.43	1.235	1.132
head loss h (m)		0.063	0.057	0.053
water level (upstream) (m)		+235.533	+235.456	+235.418
buttom level point C +235.100				

C～D

	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)
Flow Q (m^3/s)		1.032	0.72	0.585
Water depth H (m)		0.433	0.356	0.318
wetted perimeter P (m)		2.366	2.212	2.136
flow area A (m^2)		0.6495	0.5340	0.4770
hydraulic radius R=A/P (m)		0.275	0.241	0.223
$R^{4/3}$		0.179	0.15	0.135
Flow velocity V=Q/A (m/s)		1.589	1.348	1.226
head loss h (m)		0.079	0.068	0.063
water level (upstream) (m)		+235.612	+235.524	+235.481

water level at aeration tank inlet

	emergency	Hourly max	Daily average (in rain)	Daily average (in fine)
In case of conventional		+235.350	+235.296	+235.271
In case of step channel		+235.612	+235.524	+235.481
via bypass channel	+235.612	—	—	—

embrace water level of first settling tank

emergency	Hourly max	Daily average (for wet)	Daily average (for dry)
+235.612	+235.612	+235.524	+235.481

(11) Primary settling tank : overflow trough

item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q	309,600	237,900	166,000	135,000	
	(m^3/sec)		3.583	2.753	1.921	1.563	
number of pond (vol)		N	8	8	8	8	
unit quantity (m^3/sec)		q	0.448	0.344	0.240	0.195	

water level of overflow trough

formula of Thomas Camp

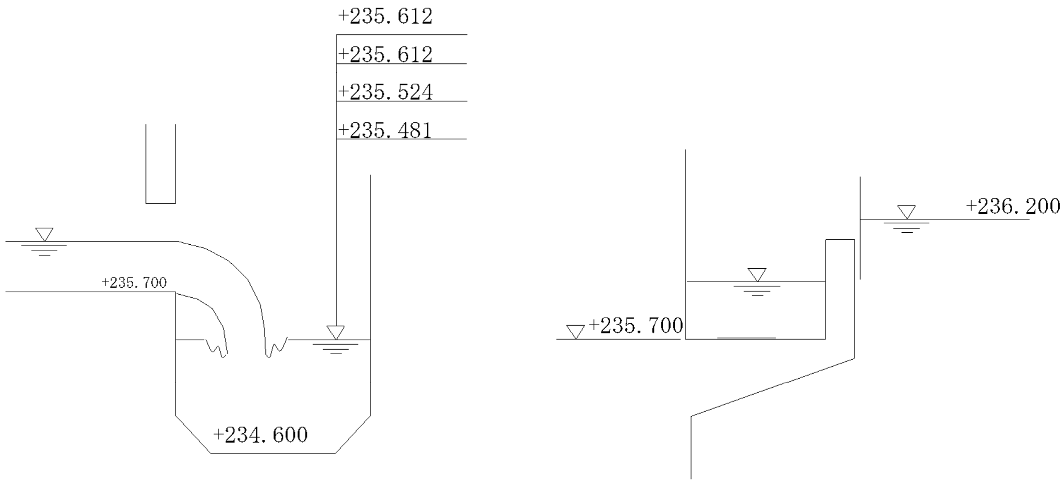
in case of free fall

$$h_0 = \sqrt{2h_c^2 + h_c^2} = \sqrt{3h_c^2}$$

in case of not free fall

$$h_0 = \sqrt{\frac{2h_c^3}{he} + he^2}$$

$$h_c = \sqrt[3]{\frac{Q^2}{g \cdot B^2}} \qquad (B = 2.00m)$$



water level (downstream) (m)	H_0	+235.612	+235.612	+235.524	+235.481	
marginal depth (m)	h_c	0.172	0.145	0.114	0.099	
water depth (downstream) (m)	h_e	–	–	–	–	
adjudication		free fall	free fall	free fall	free fall	
		–	–	–	–	
(m)		0.172	0.145	0.114	0.099	
(m)	h_0	0.298	0.251	0.197	0.171	
water level (upstream) (m)	H	+235.998	+235.951	+235.897	+235.871	

(12) Primary settling tank : overflow ingate

item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q	309, 600	237, 900	166, 000	135, 000	
	(m^3/sec)		3. 583	2. 753	1. 921	1. 563	
number of pond (vol)		N	8	8	8	8	
unit quantity (m^3/sec)		q	0. 448	0. 344	0. 240	0. 195	

formula of Tomson

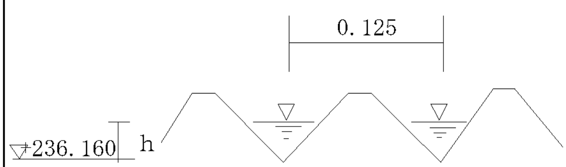
$$Q = 1.42\,h^{5/2}$$

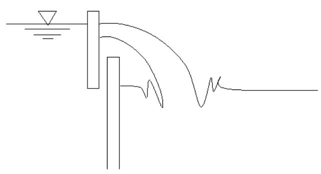
$$h = \left(\frac{Q}{1.42}\right)^{2/5}$$

h = water depth of overflow

length of overflow ingate 72. 30m

number of ingate $\frac{72.3}{0.125}$ =578nos





water level (downstream) (m)	H_0	+235. 998	+235. 951	+235. 897	+235. 871	
flow per one trough (m^3／s)	q	0. 448	0. 344	0. 24	0. 195	
flow per one ingate (m／s)	q_o	0. 00078	0. 0006	0. 00042	0. 00034	
water depth of overflow (m)	h	0. 05	0. 045	0. 039	0. 036	
		≒0. 050	≒0. 050	≒0. 040	≒0. 040	
water level (upstream) (m)	H	+236. 210	+236. 210	+236. 200	+236. 200	

(13) transition pipe : primary settling tank ～ Charging tank

item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q	309,600	237,900	166,000	135,000	
	(m^3/sec)		3.583	2.753	1.921	1.563	
number of pond (vol)		N	8	8	8	8	
unit quantity (m^3/sec)		q	0.448	0.344	0.240	0.195	Q／N

shape

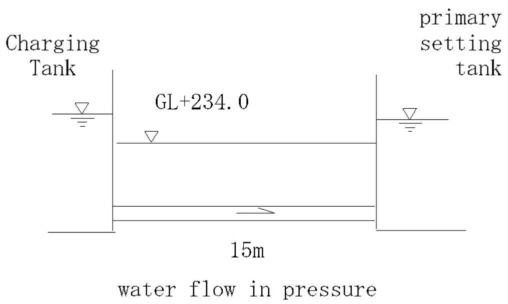
φ700 iron pipe (n =0.013)

cross section area : WA= 0.3848

liquid length : WP= 2.1991

inside diameter of depth : R = 0.175

L= 15.0m



$$\triangle h_1 = n^2 \cdot V^2 \cdot L / R^{4/3}$$

$$\triangle h_2 = \Sigma f \cdot V^2 / 2g$$

item			symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
water level (downstream)		(m)	H_0	+236.210	+236.210	+236.200	+236.200	
flow velocity		(m／s)	V	1.164	0.894	0.624	0.507	
friction loss		(m)	$\triangle h_1$	0.035	0.021	0.01	0.007	
shape loss	inflow	(place)	f_1	1	1	1	1	0.5
	outflow	(place)	f_2	1	1	1	1	1
	bend 90°	(place)	f_3	0	0	0	0	0.99
	bend 45°	(place)	f_4	1	1	1	1	0.183
	sum		Σf	1.683	1.683	1.683	1.683	
	shape loss	(m)	$\triangle h_2$	0.116	0.07	0.03	0.02	
add		(m)	$\triangle h$	0.151	0.09	0.043	0.029	
water level		(m)	H	+236.361	+236.300	+236.243	+236.229	

(14) transition pipe : Charging tank ～ Distrabution tank

item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q	309,600	237,900	166,000	135,000	
	(m^3/sec)		3.583	2.753	1.921	1.563	
number of pond (vol)		N	4	4	4	4	
unit quantity (m^3/sec)		q	0.896	0.688	0.480	0.391	Q／N

shape

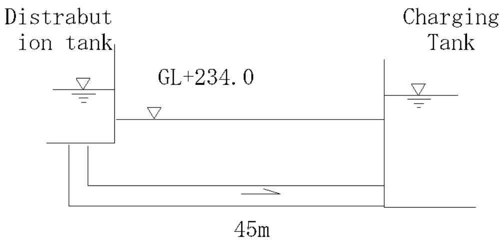
ϕ1,100 iron pipe (n＝0.013)

cross section area : WA＝ 0.9503

liquid length : WP＝ 3.4558

inside diameter of depth : R ＝ 0.275

L＝ 45.0m



water flow in pressure

$\triangle h_1 = n^2 \cdot V^2 \cdot L / R^{4/3}$

$\triangle h_2 = \Sigma f \cdot V^2 / 2g$

item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
water level (downstream)	(m)	H_0	+236.361	+236.300	+236.243	+236.229	
flow velocity	(m／s)	V	0.943	0.724	0.505	0.411	
friction loss	(m)	$\triangle h_1$	0.023	0.014	0.007	0.004	
shepe loss: inflow	(place)	f_1	1	1	1	1	0.5
shepe loss: outflow	(place)	f_2	1	1	1	1	1
shepe loss: bend 90°	(place)	f_3	3	3	3	3	0.99
shepe loss: bend 45°	(place)	f_4	0	0	0	0	0.183
shepe loss: sum		Σ f	4.47	4.47	4.47	4.47	
shepe loss: shape loss	(m)	$\triangle h_2$	0.203	0.12	0.06	0.04	
add	(m)	△h	0.226	0.134	0.065	0.043	
water level	(m)	H	+236.587	+236.434	+236.308	+236.272	

(15) Distrabution tank : outflow

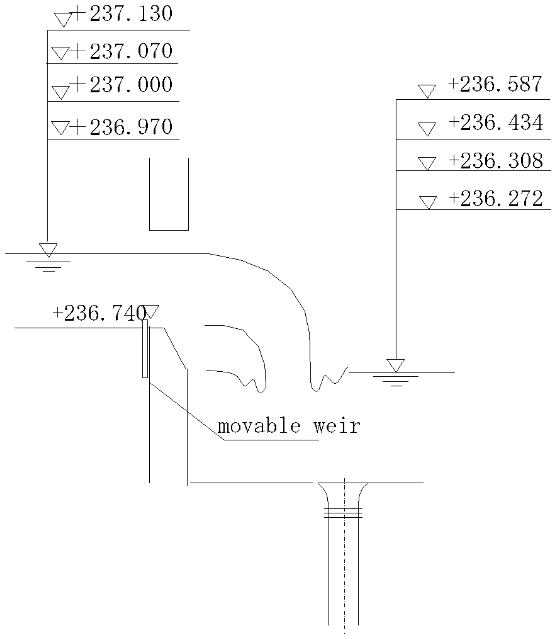
item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q	309,600	237,900	166,000	135,000	
	(m^3/sec)		3.583	2.753	1.921	1.563	
number of pond (vol)		N	4	4	4	4	
unit quantity (m^3/sec)		q	0.896	0.688	0.480	0.391	Q／N

formula of Francis

$$Q = 1.84 \cdot B \cdot h^{3/2}$$

$$h = \left(\frac{Q}{1.84 \cdot B} \right)^{2/3}$$

$(B = 2.000m)$



item	symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
water level (downstream) (m)	H_0	+236.587	+236.434	+236.308	+236.272	
water level of overflow (m)	h	0.39	0.327	0.257	0.224	
margin (m)	α		0.003	0.003	0.006	
water level (upstream) (m)	H	+237.130	+237.070	+237.000	+236.970	

(16) Distrabution tank : outflow

item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q	309,600	237,900	166,000	135,000	
	(m^3/sec)		3.583	2.753	1.921	1.563	
number of pond (vol)		N	1	1	1	1	
unit quantity (m^3/sec)		q	3.583	2.753	1.921	1.563	Q／N

head loss

$$h = \frac{1}{C^2} \cdot \frac{V^2}{2g}$$

C : coefficient of flow (0.6)

A : area of opening

$A = 21.0 \times 1.5$

$\pi / 4 \times 0.15^2 \times 320$

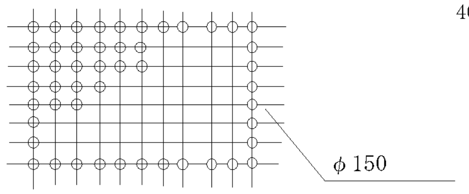
$= 37.155 m^2$

percentage of opening in baffle wall

$$= \frac{37.155}{21 \times 4} = 0.14 \ (\fallingdotseq 14\%)$$

40line×8column

=320 nos



item	symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
water level (downstream) (m)	H_0	+237.130	+237.070	+237.000	+236.970	
inlet velocity (m^3/ s)	V	0.096	0.074	0.052	0.042	
head loss (m)	h	0.001	0.001	0.000	0.000	
water level (upstream) (m)	H	+237.131	+237.071	+237.000	+236.970	

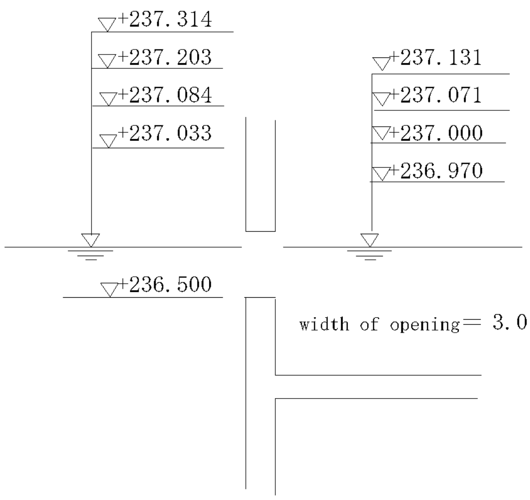
(17) Distrabution tank : inflow

item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q	309,600	237,900	166,000	135,000	
	(m^3/sec)		3.583	2.753	1.921	1.563	
number of pond (vol)		N	1	1	1	1	
unit quantity (m^3/sec)		q	3.583	2.753	1.921	1.563	Q／N

head loss $\triangle h$ = runoff coefficient

$(f_0 = 1.0)$

$$= 1.00 \frac{V^2}{2g}$$



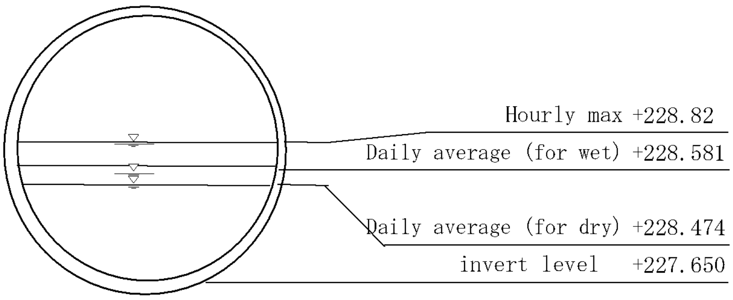
item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
water level (downstream)	(m)	H_0	+237.131	+237.071	+237.000	+236.970	
flow	(m^3／s)	q_1	3.583	2.753	1.921	1.563	
water level (downstream)	(m)	h_1	0.631	0.571	0.500	0.470	
flow area of opening	(m^2)	A	1.893	1.713	1.500	1.410	
flow velocity	(m／s)	V	1.893	1.607	1.281	1.109	
head loss	(m)	$\triangle h$	0.183	0.132	0.084	0.063	
margin	(m)	α					
water level (upstream)	(m)	H	+237.314	+237.203	+237.084	+237.033	water level of chamber

(18) Distrabution tank : inflow

item		symbol	emergency	Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q		237,900	166,000	135,000	
	(m^3/sec)			2.753	1.921	1.563	
number of pond (vol)		N		1	1	1	
unit quantity (m^3/sec)		q		2.753	1.921	1.563	Q／N

main collector

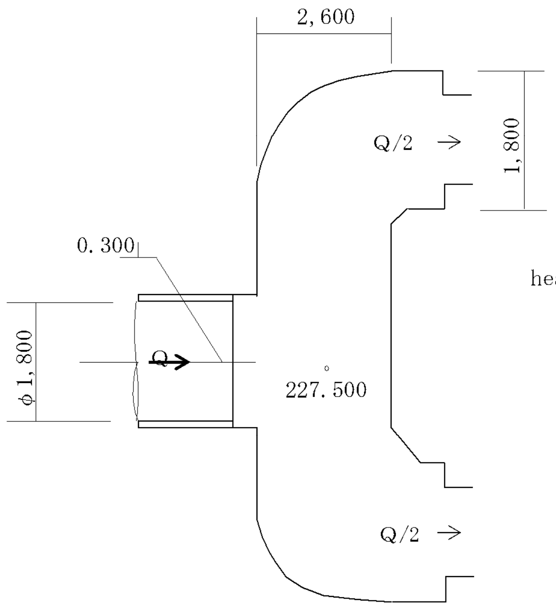
diameter	φ1,800mm
grade	1.0‰
bottom level	+227.650
design flow	3.635m3/s (manning n=0.013)
design velocity	1.428m/s



flow ratio			0.757	0.528	0.430	
velocity ratio			1.000	1.000	0.960	
actual velocity V	m/S		1.428	1.428	1.371	
water depth ratio			0.650	0.517	0.458	
actual water depth H	m		1.170	0.931	0.824	
water level	m		+228.82	+228.581	+228.474	

(19) pomping station : inflow

item		symbol		Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q		237,900	166,000	135,000	
	(m^3/sec)			2.753	1.921	1.563	
number of pond (vol)		N		1	1	1	
unit quantity (m^3/sec)		q		2.753	1.921	1.563	



head loss (h)
=huge expansion loss
$=1.0\times V^2/2g$

item	symbol		Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
velocity V	m/S		1.428	1.428	1.371	
head loss h	m		0.104	0.104	0.096	
water level upstream	m		+228.820	+228.581	+228.474	
water depth H	m		1.170	0.931	0.824	
water level downstream	m		+228.67	+228.431	+228.324	

water level= (227.500)+(water level at down stream)

(20) pomping station : inflow gate

item		symbol		Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q		237,900	166,000	135,000	
	(m^3/sec)			2.753	1.921	1.563	
number of pond (vol)		N		2	2	2	
unit quantity (m^3/sec)		q		1.377	0.961	0.782	

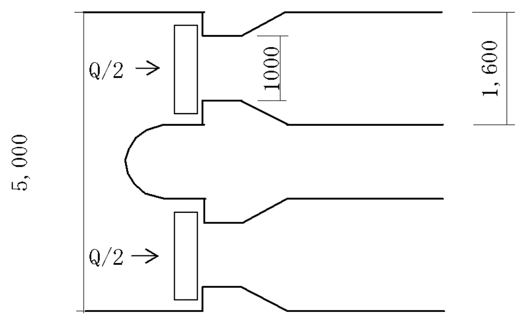
size of gate 1,200×1,200

head loss (△h) =sudden contraction loss+huge expansion loss

$= (fse + fse) \times V^2/2g$ $\qquad fse=(1/0.63-1)^2=0.34$

$= (0.34 + 0.14) \times V^2/2g$ $\qquad \therefore (A_2/A_1=1.0/1.6=0.63)$

$= 0.48 \times V^2/2g$ $\qquad fse=(1-1.00/1.60)^2=0.14$



item	symbol		Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
water depth H	m		1.170	0.931	0.824	
flow area A	m^2		1.170	0.931	0.824	
velocity V=Q/A	m/S		1.177	1.032	0.949	
head loss h	m		0.034	0.026	0.022	
water level (upstream)	m		+228.670	+228.431	+228.324	
water level (downstream)	m		+228.636	+228.405	228.302	

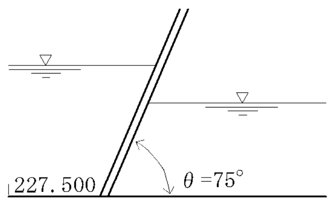
(21) pomping station : screen

item		symbol		Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q		237,900	166,000	135,000	
	(m^3/sec)			2.753	1.921	1.563	
number of pond (vol)		N		3	3	3	
unit quantity (m^3/sec)		q		0.918	0.640	0.521	

head loss ($\triangle h$) =variation of screen (h_1) +variation of choke (h_2)

$$h_1 = \beta \sin\theta \ (t/a)^{4/3} \cdot V_1^2 / 2g = 2.34 \cdot \sin 75° \cdot (9/25)^{4/3} \cdot V_1^2/2g$$
$$= 0.579 \cdot V_1^2/2g$$

$$h_2 = 1/C^2 \cdot V_2^2 / 2g = 1/0.6^2 \cdot V_2^2/2g = 2.778 \cdot V_2^2/2g$$



β ; shape loss of screen 2.34

t ; thick of screen bar 75×9

d ; scale spacing of screen 25

C ; coefficient os flow 0.60

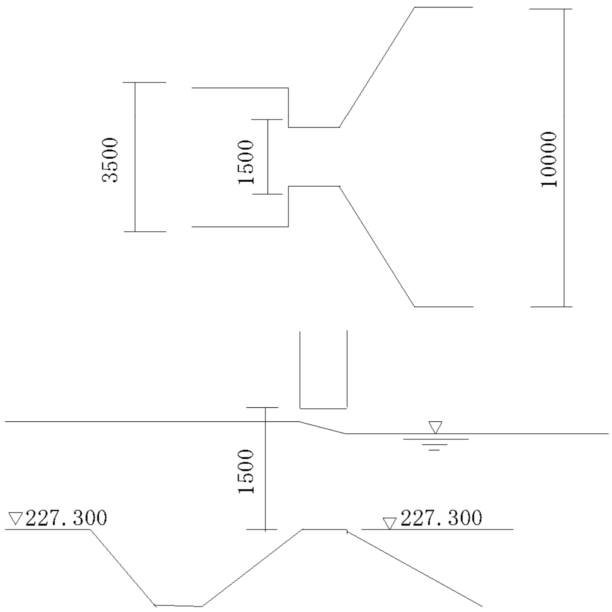
width of tank= 2.00m

item	symbol		Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
water depth H	m		1.136	0.905	0.802	
flow area A	m^2		2.272	1.810	1.604	
water velocity V_1	m/S		0.404	0.354	0.325	
velocity $V_2 = V_1 \times (9+25)/25$	m/S		0.549	0.481	0.442	
head loss h_1	m		0.005	0.004	0.003	
head loss h_2	m		0.043	0.033	0.028	
head loss total h	m		0.048	0.037	0.031	
water level (upstream)	m		+228.636	+228.405	+228.302	
water level (downstream)	m		+228.588	+228.368	228.271	

(22) pomping station : pump

item		symbol		Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
flow volume	(m^3/day)	Q		237,900	166,000	135,000	
	(m^3/sec)			2.753	1.921	1.563	
number of pond (vol)		N		1	1	1	
unit quantity (m^3/sec)		q		2.753	1.921	1.563	

(width) (height)
size of opening 1700×1500
head loss (△h) $=1.5+V^2/2g$



item	symbol		Hourly max	Daily average (for wet)	Daily average (for dry)	remarks
water depth H	m		1.288	1.068	0.971	
flow area A	m^2		1.932	1.602	1.456	
velocity V=Q/A	m/S		1.425	1.199	1.073	
head loss h	m		0.155	0.110	0.088	
water level (upstream)	m		+228.588	+228.368	228.271	
water level (downstream)	m		+228.433	+228.258	228.183	

3.3 Drawings

No.	DRAWING NAME
1	WATER TREATMENT FACILITY - FLOW SHEET
2	SLUDGE TREATMENT FACILITY - FLOW SHEET
3	PRIMARY SETTLING TANK
4	AERATION TANK
5	FINAL SETTLING TANKS
6	SLUDGE THICKENER
7	SLUDGE DIGESTER

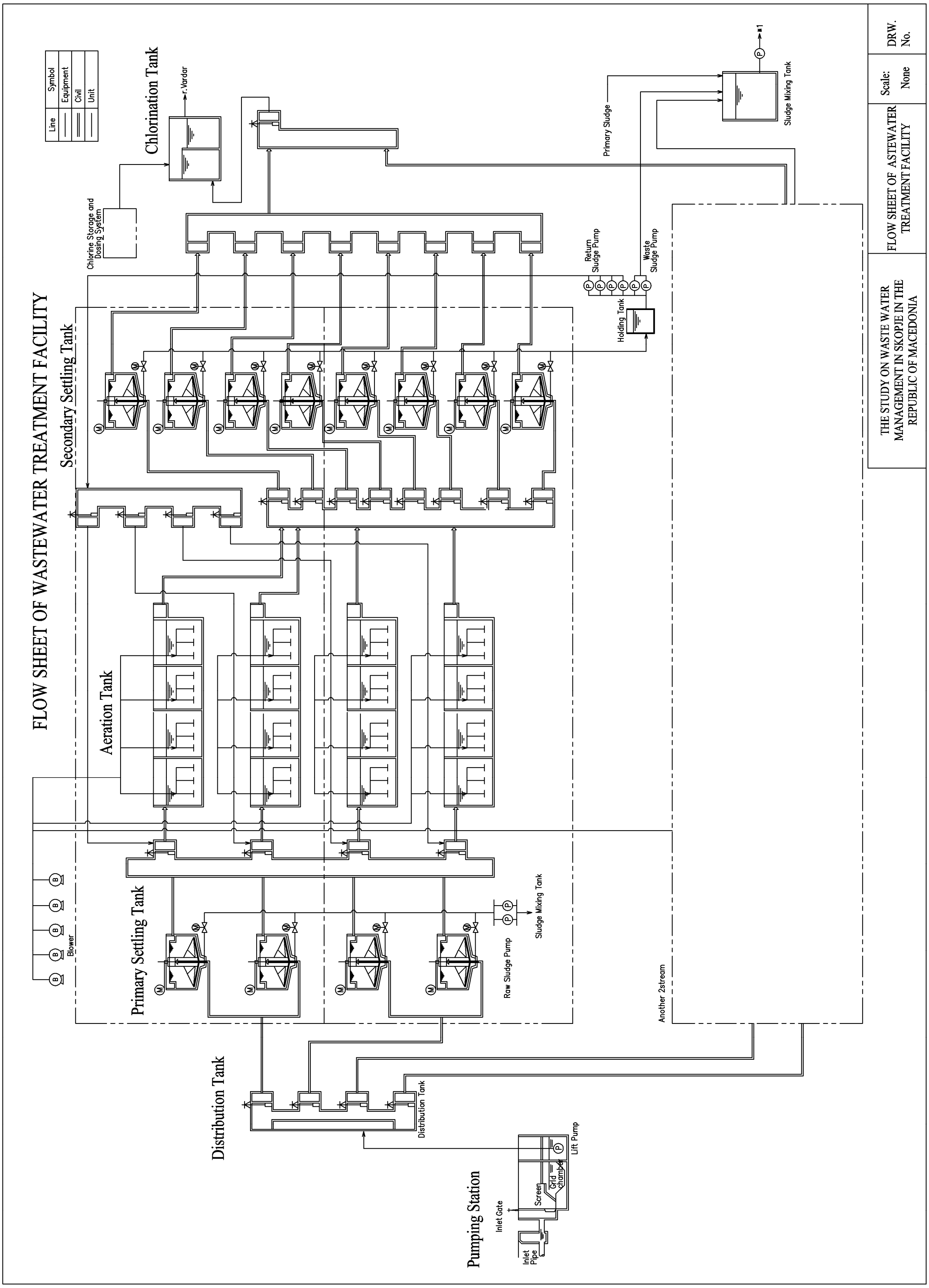


Figure 3.1 No,1 Flow Sheet of Waste Water Treatment Facility

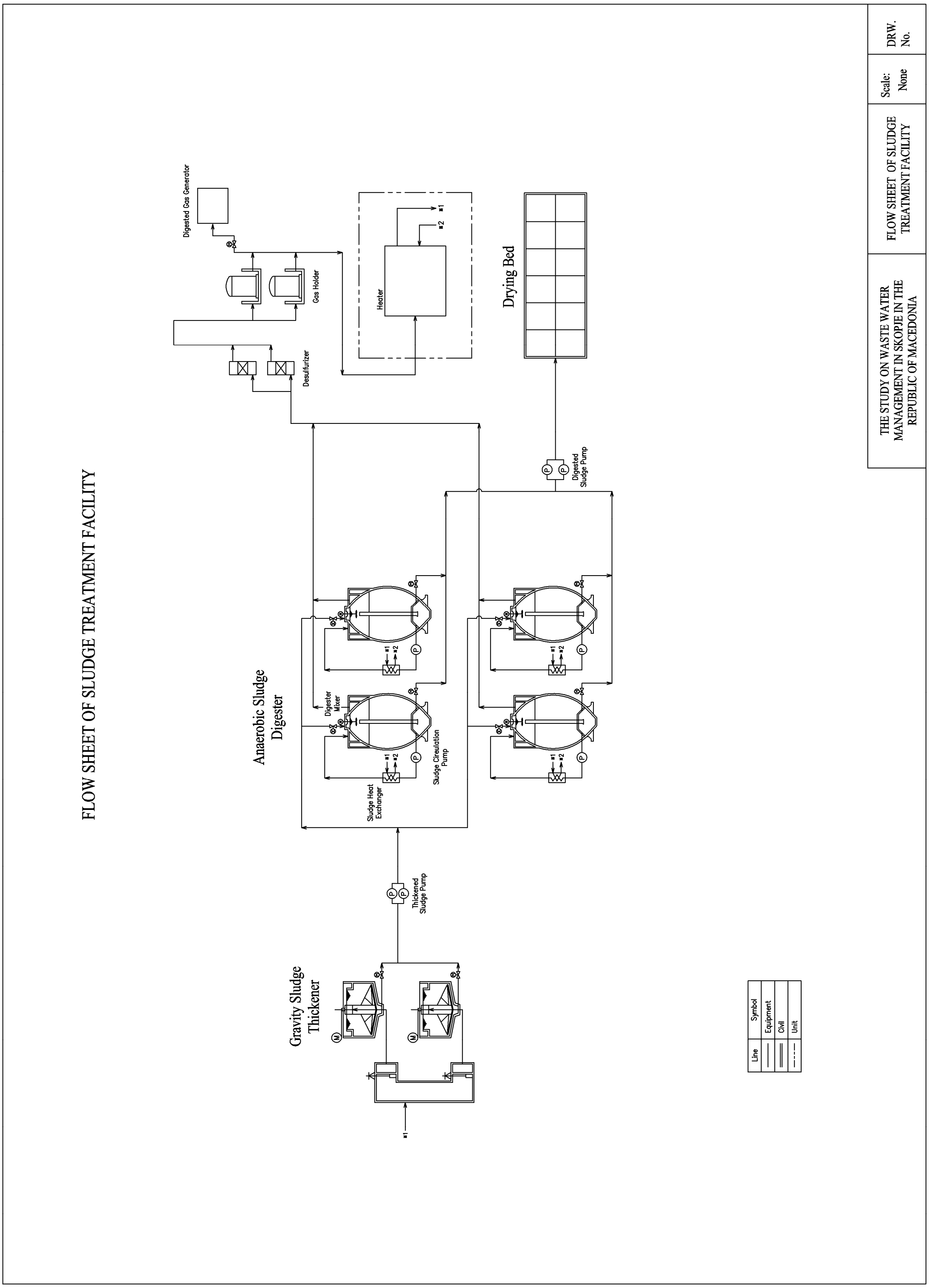


Figure 3.2 No,2 Flow Sheet of Waste Water Treatment Facility

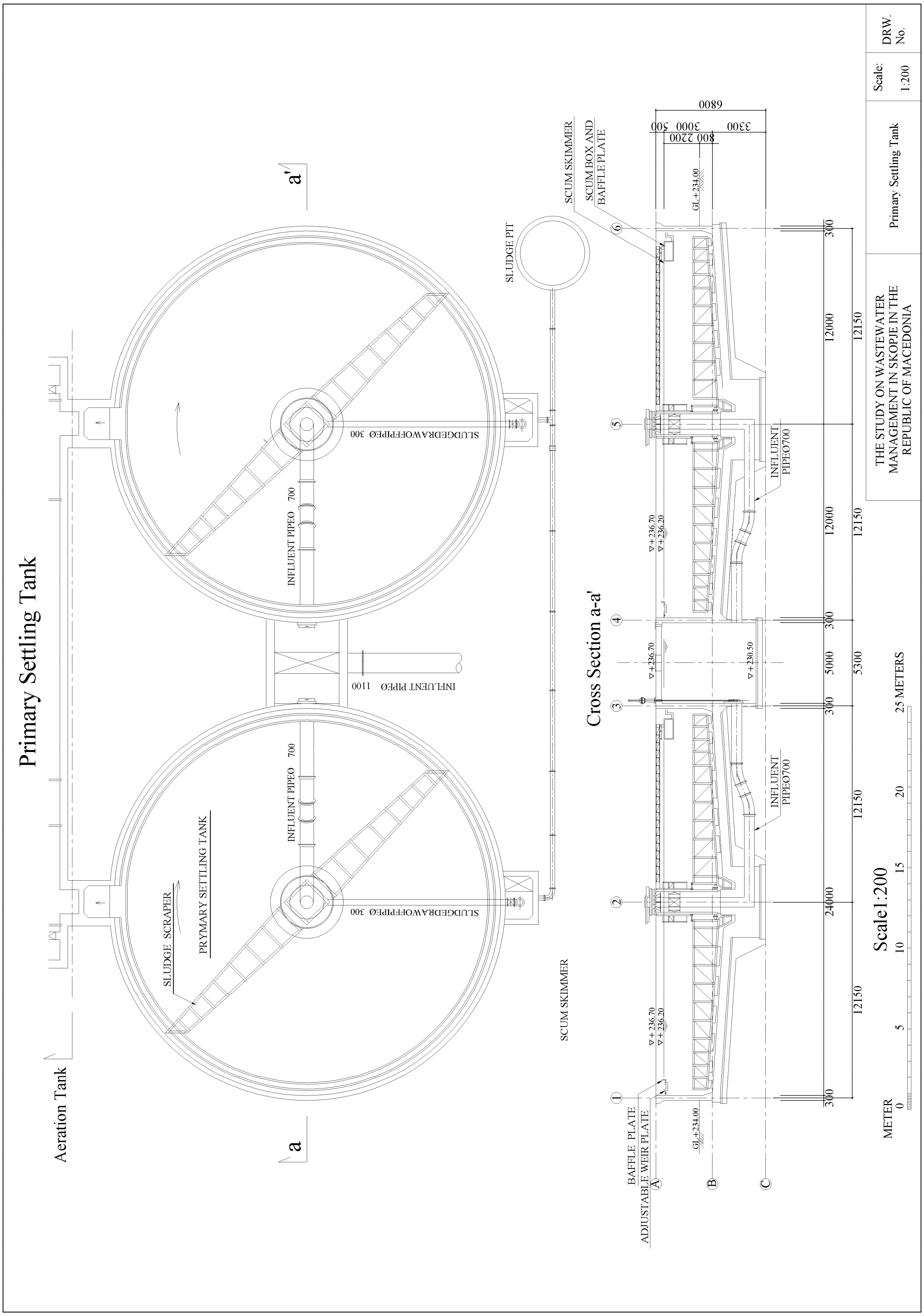


Figure 3.3 No,3 Primary Settling Tank

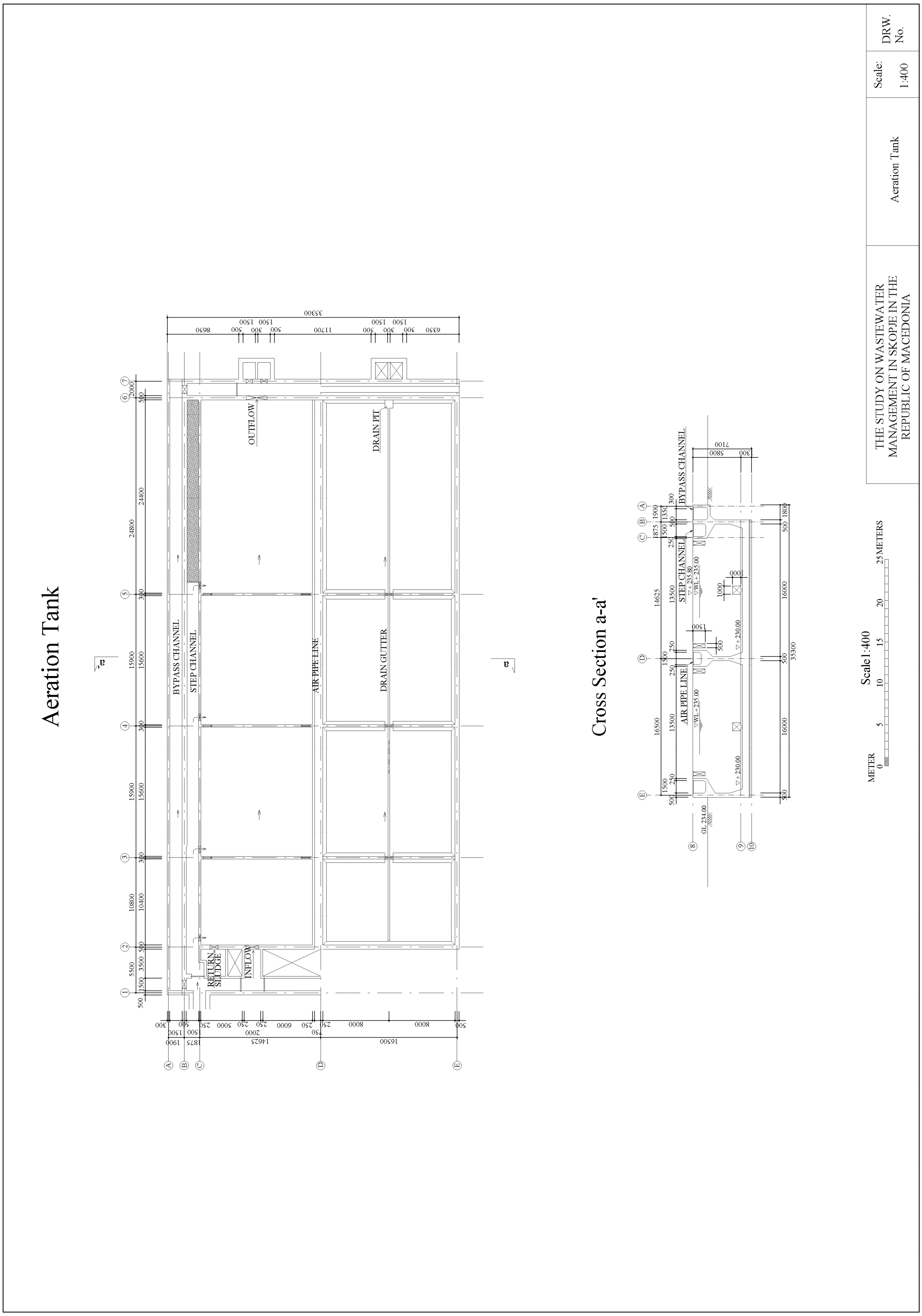


Figure 3.4 No,4 Aeration Tank

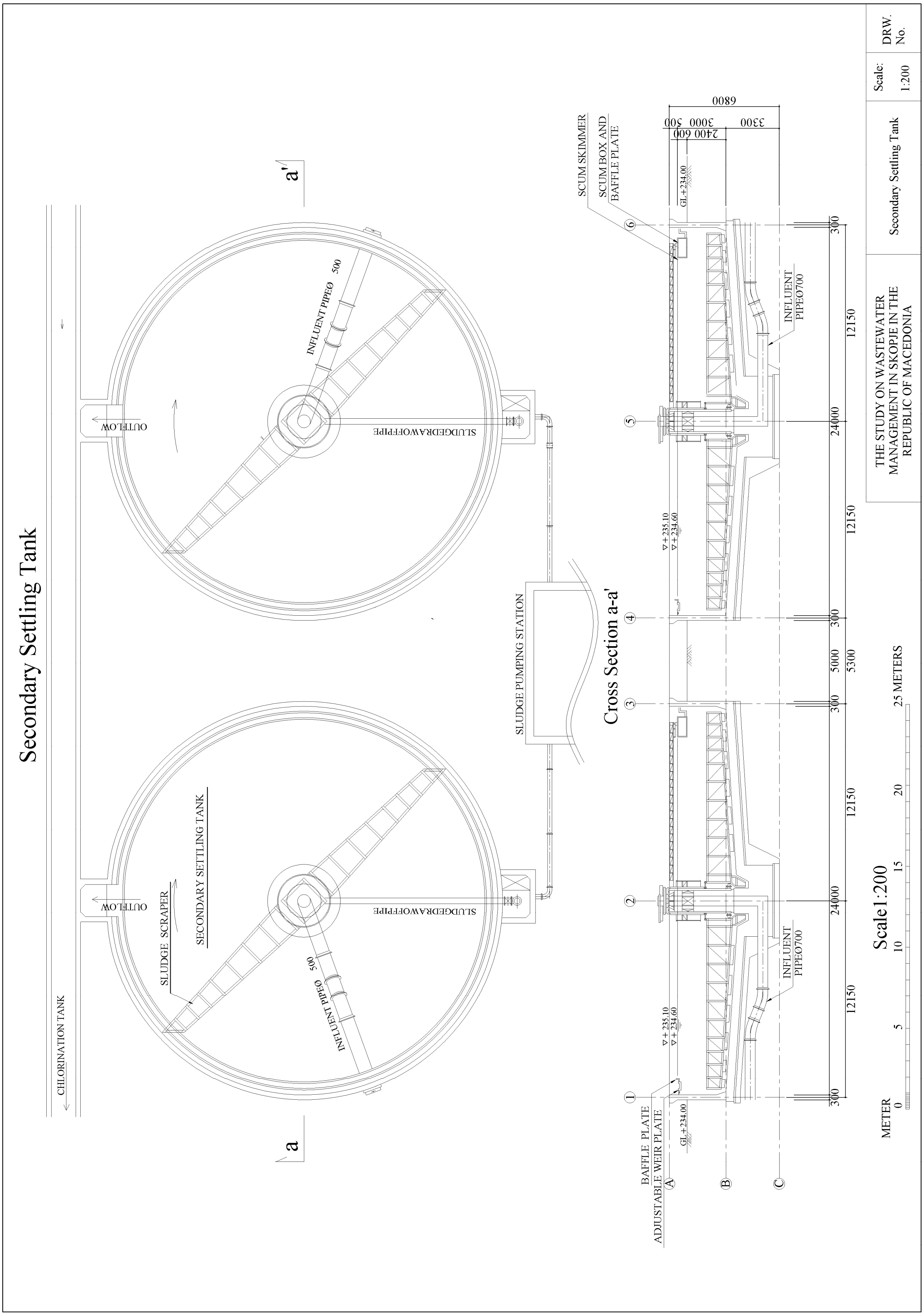


Figure 3.5 No,5 Secondary Settling Tank

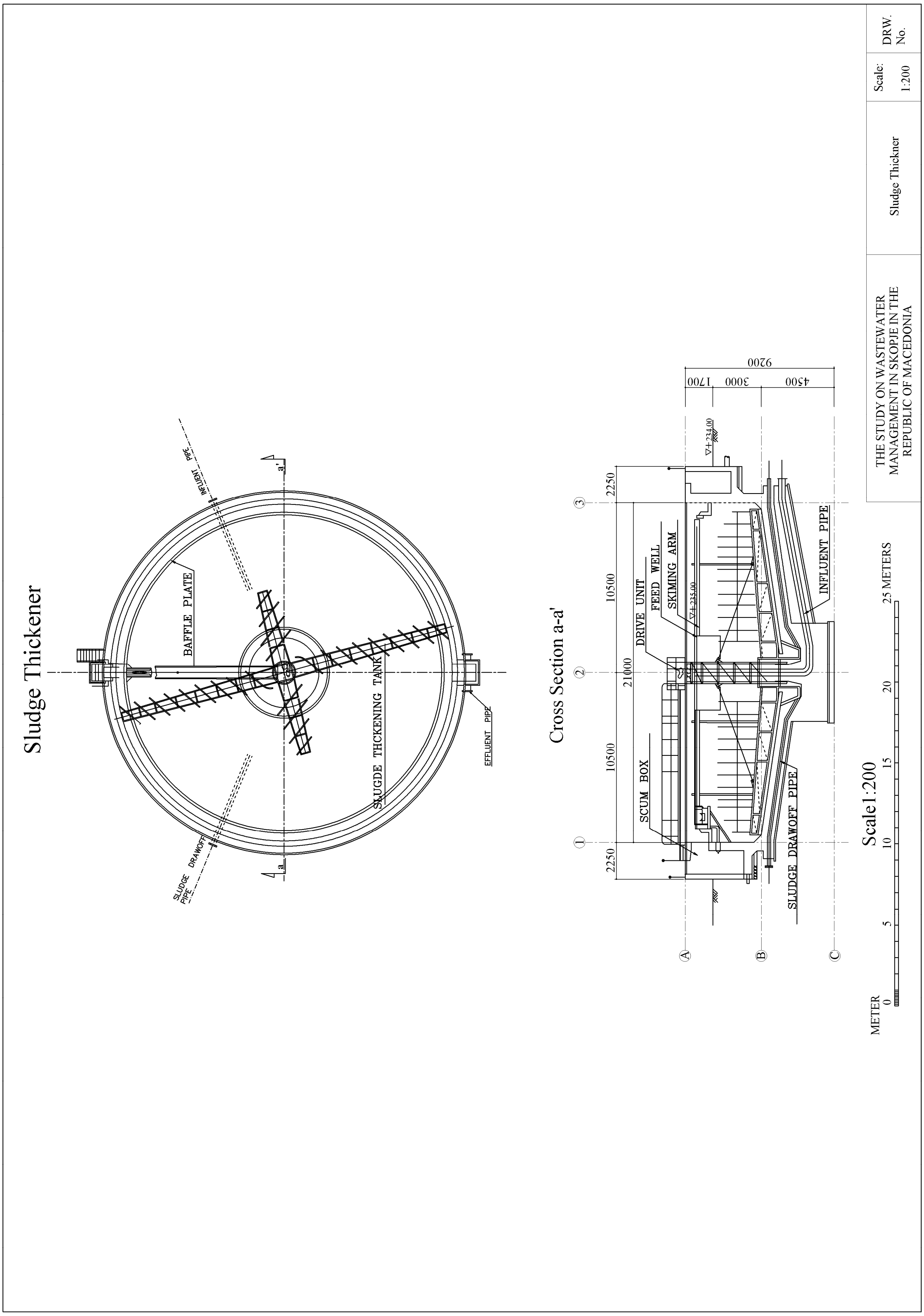


Figure 3.6 No,6 Sludge Thickener

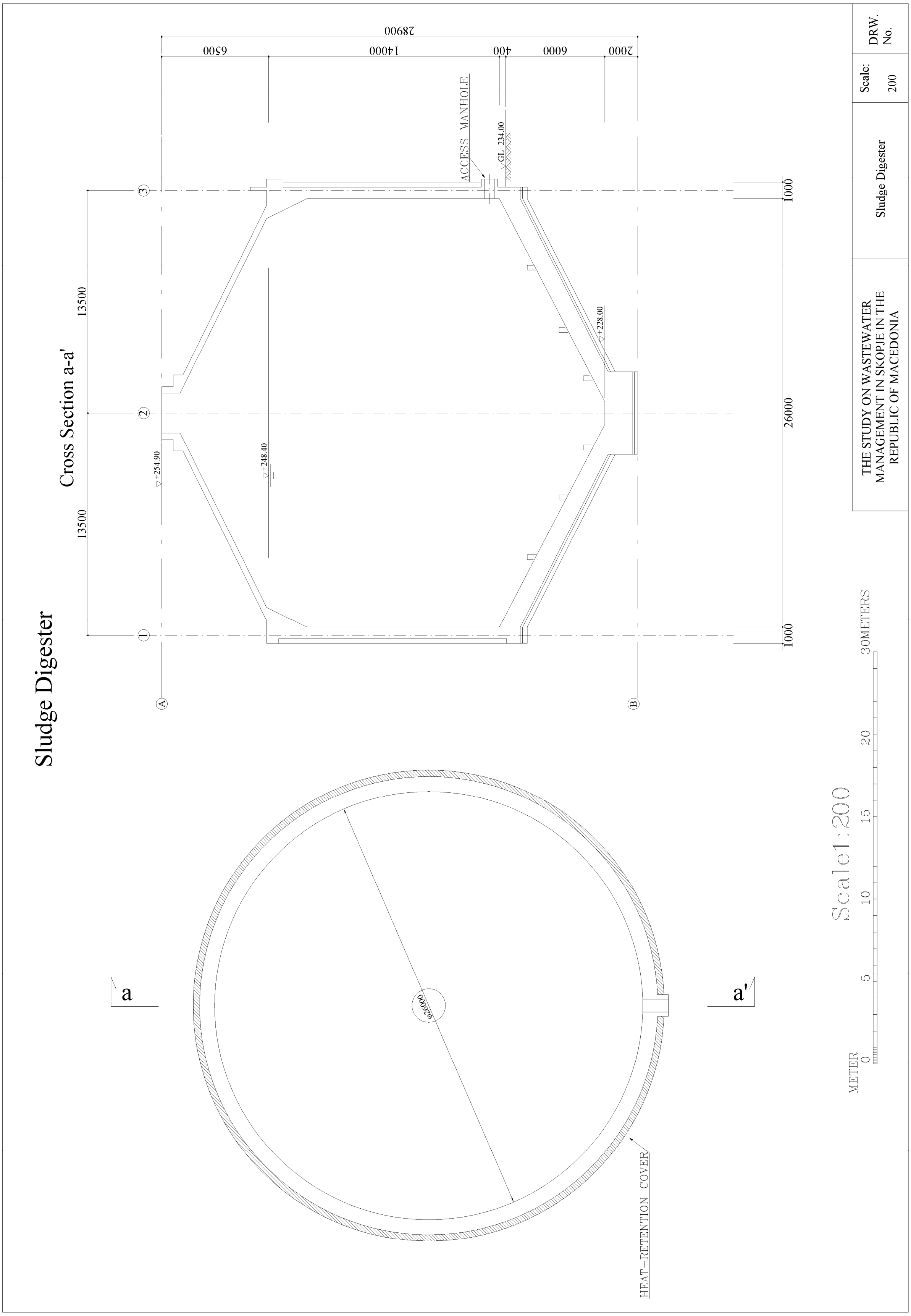


Figure 3.7 No,7 Sludge Digester

3.4 CDM

3.4.1 ACM0014: Avoided methane emissions form wastewater treatment

UNFCCC/CCNUCC

CDM – Executive Board

ACM0014 / Version 01
Sectoral Scope: 13
EB 36

Approved consolidated baseline and monitoring methodology ACM0014

"Avoided methane emissions from wastewater treatment"

I. SOURCE, DEFINITIONS AND APPLICABILITY

Sources

This consolidated methodology is based on the following submissions:

- NM0038-rev: Methane Gas Capture and Electricity Production at Chisinau Wastewater Treatment Plant project, Moldova prepared by COWI A/S, Denmark
- NM0039: Bumibiopower Methane Extraction and Power Generation Project, Malaysia, prepared by Mitsubishi Securities
- NM0085: Vinasse Anaerobic Treatment Project prepared by Compañía Licorera de Nicaragua, S. A.
- NM0041-rev2: Korat Waste To Energy Project, Thailand, prepared by EcoSecurities Ltd.

and the following approved methodologies:

- AM0013: Avoided methane emissions from organic waste-water treatment - Version 4
- AM0022: Avoided Wastewater and On-site Energy Use Emissions in the Industrial Sector - Version 4

This methodology also refers to the latest approved versions of the following:

- "Tool for the demonstration and assessment of additionality";
- "Tool to determine project emissions from flaring gases containing methane";
- "Tool to calculate the emission factor for an electricity system";
- "Tool to calculate project emissions from electricity consumption";
- "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"

For more information regarding the proposals and its considerations by the Executive Board please refer to: http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html.

Selected approach from paragraph 48 of the CDM modalities and procedures

"Existing actual or historical emissions, as applicable"; or

"Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment".

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Definitions

For the purpose of this methodology, the following definitions apply:

Sludge pits. A pit or tank where untreated liquid sludge is pumped and stored for at least one year. Anaerobic bacteria decompose the liquid sludge and decrease the organic matter content, resulting in emissions of CO_2, CH_4, hydrogen sulphide (H_2S) and ammonia. Once the pits are dried out and the sludge is stable, the solids are removed and used, e.g., as fertiliser for non-food crops.

Anaerobic digester it refers to the facility, introduced by the project, where anaerobic digestion of the organic matter contained in the wastewater sludge takes place. Anaerobic digestion is a process in which microorganisms break down biodegradable material in the absence of oxygen, so they are converted into CH_4 and CO_2. These gases (biogas) are collected in a controlled manner in the anaerobic digester and can be used for electricity production, for heating purposes, or it can be flared. After being anaerobically digested, the stable sludge can be dewatered and used for land application.

Applicability

This methodology is applicable to project activities that avoid methane emissions from wastewater treatment by introducing a new treatment system in existing wastewater treatment facilities. The methodology is applicable to the scenarios described in Table 1.[1]

Table 1: Scenarios applicable to the methodology

Scenario	Description of the historical situation	Description of the project activity
1	The wastewater is not treated, but directed to open lagoons that have clearly anaerobic conditions.	The wastewater is treated in a new anaerobic digester. The biogas extracted from the anaerobic digester is flared and/or used to generate electricity and/or heat. The residual from the anaerobic digester after treatment is directed to open lagoons or is treated under clearly aerobic conditions (e.g. dewatering and land application).
2	The wastewater is treated in a wastewater treatment plant. Sludge is generated from primary and/or secondary settlers. The sludge is directed to sludge pit(s) that have clearly anaerobic conditions.	The wastewater continues to be treated in the same plant wastewater treatment plant. The sludge from primary and/or secondary settler is treated in one or both of the following ways: (a) The sludge is treated in a new anaerobic digester. The biogas extracted from the anaerobic digester is flared and/or used to generate electricity and/or heat. The residual from the anaerobic digester after treatment is directed to open lagoons or is treated under clearly aerobic conditions (e.g. dewatering and land application). (b) The sludge is treated under clearly aerobic conditions (e.g. dewatering and land application).

1 Note that the most likely baseline scenario is an outcome of the application of the procedure to select the most plausible baseline scenario, as described below.

Typical configurations for these scenarios are illustrated in Appendix I. Project participants should document in the CDM-PDD which scenario applies and clearly describe the situation before and after the start of implementation of the project activity, preferably by providing similar diagrams as contained in Appendix I.

The following applicability conditions are for all scenarios:

- The average depth of the open lagoons or sludge pits is at least 1 m.[2]
- Heat and electricity requirements per unit input of the water treatment facility remain largely unchanged before and after the project activity start.
- Data requirements as laid out in this methodology are fulfilled.

The following applicability conditions are for scenario 1:

- The residence time of the organic matter in the open lagoon system should be at least 30 days.
- Local regulations do not prevent discharge of wastewater in open lagoons.

The following applicability condition is for scenario 2:

- The sludge produced during the implementation of the project activity is not stored onsite before land application to avoid any possible methane emissions from anaerobic degradation.

II. BASELINE METHODOLOGY

Project boundary

The spatial extent of the project boundary includes:

- The site where the wastewater is/was treated prior to and after the start of the implementation of the project activity;
- The sites where any sludge is applied to lands;
- Any on-site power plants that supply electricity to the wastewater or sludge treatment system;
- Any on-site facilities to generate heat that is used by the wastewater or sludge treatment systems;
- If applicable, the anaerobic digester, the power and/or heat generation equipment and/or the flare installed under the project activity;
- If applicable, any dewatering system installed under the project activity;

[2] In particular, loading in the wastewater streams has to be high enough to assure that the lagoon develops an anaerobic bottom layer and that algal oxygen production can be ruled out.

- If grid electricity is displaced from electricity generation with biogas from an aerobic digester: the power plants connected to the grid, with the geographical boundary as specified in the latest approved version of the "Tool to calculate the emission factor for an electricity system".

The emission sources included in the project boundary are described in Table 2 below.

Table 2: Emission sources included and excluded from the project boundary

	Source	Gas		Justification / Explanation
Baseline	Wastewater treatment processes or sludge disposal	CH_4	Included	The major source of emissions in the baseline from open lagoons (scenario 1) or disposal of sludge (scenario 2)
		N_2O	Excluded	Excluded for simplification. This is conservative.
		CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted for.
	Electricity consumption / generation	CO_2	Included	Electricity may be consumed for the operation of the wastewater or sludge treatment system in the baseline scenario. If electricity is generated with biogas from an anaerobic digester under the project activity, electricity generation in the grid or on-site is displaced by the project activity.
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
	Thermal energy generation	CO_2	Included	If thermal energy is generated with biogas from an anaerobic digester under the project activity, on-site thermal energy generation is displaced by the project activity
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
Project Activity	Wastewater treatment processes or sludge treatment process	CH_4	Included	The treatment of wastewater or sludge under the project activity may cause different emissions: (i) Methane emissions from the lagoons (if effluent from the treatment under the project activity is directed to lagoons) (ii) Physical leakage of methane from the digester system; (iii) Methane emissions from flaring (if biogas from the digester is flared); (iv) Methane emissions from land application of sludge; (v) Methane emissions from wastewater removed in the dewatering process.
		CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted for.
		N_2O	Included	In case of projects that involve land application of sludge

	On-site electricity use	CO_2	Included	May be an important emission source. If electricity is generated with biogas from an anaerobic digester, these emissions are not accounted for. Any on-site electricity consumption should be subtracted from the electricity generation of the digester.
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
	On-site fossil fuel consumption	CO_2	Included	May be an important emission source.
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.

Procedure for the identification of the most plausible baseline scenario

Project participants shall determine the most plausible baseline scenario through the application of the following steps.

Step 1: Identification of alternative scenarios

Depending on the type of a project activity (i.e. whether scenario 1 or 2 applies, whether electricity is generated, etc), project participants shall identify realistic and credible alternatives with regard to the possible scenarios that would occur in the absence of the project activity. Make sure that all scenarios include the proposed project activity not being registered under the CDM.

For all project configurations, plausible alternative scenarios for the treatment of wastewater (W) should be determined. These may include, but are not limited to, the following:

- W1. The use of open lagoons for the treatment of the wastewater;
- W2. Direct release of wastewaters to a nearby water body;
- W3. Aerobic wastewater treatment facilities (e.g., activated sludge or filter bed type treatment);
- W4. Anaerobic digester with methane recovery and flaring;
- W5. Anaerobic digester with methane recovery and utilization for electricity or heat generation.

In case of scenario 2, plausible alternative scenarios for the treatment of sludge (S) should be determined. These may include, but are not limited to, the following:

- S1. Disposal of sludge in sludge pits under clearly anaerobic conditions;
- S2. Land application of the sludge;
- S3. Landfilling;
- S4. Composting;
- S5. Aerobic composting;
- S6. Mineralization.

If the project activity includes electricity generation with biogas from a new anaerobic digester, plausible alternative scenarios for the generation of electricity should be determined. These may include, but are not limited to, the following:

E1. Power generation using fossil fuels in a captive power plant;
E2. Electricity generation in the grid;
E3. Electricity generation using renewable sources.

If the project activity includes heat generation with biogas from a new anaerobic digester, plausible alternative scenarios for the generation of heat should be determined. These may include, but are not limited to, the following:

H1. Co-generation of heat using fossil fuels in a captive cogeneration power plant;
H2. Heat generation using fossil fuels in a boiler;
H3. Heat generation using renewable sources.

The suggested list of alternatives is only indicative. Project participants may propose other plausible alternatives and/or eliminate some of the ones listed above, based on documented evidence.

Identify realistic and credible combinations of scenarios for wastewater treatment (W) and, where applicable, the treatment of sludge (S), the generation of electricity (E) and the generation of heat (H). These combinations should be considered in the next steps.

Step 2: Eliminate alternatives that are not complying with applicable laws and regulations

Eliminate alternatives that are not in compliance with all applicable legal and regulatory requirements. Apply Sub-step 1b of the latest version of the "Tool for the demonstration and assessment of additionality" agreed by the CDM Executive Board.

Step 3: Eliminate alternatives that face prohibitive barriers

Scenarios that face prohibitive barriers should be eliminated by applying step 3 of the latest version of the "Tool for the demonstration and assessment of additionality" agreed by the CDM Executive Board.

If only one alternative remains, this can be considered the baseline. If more than one alternative remains, proceed to step 4.

Step 4: Compare economic attractiveness of remaining alternatives

Compare the economic attractiveness without revenues from CERs for all alternatives that are remaining by applying Step 2 of the latest approved version of the "Tool for the demonstration and assessment of additionality". In applying the investment analysis, the IRR should be used as indicator. The following parameters should explicitly be documented:

- Engineering, Procurement and Construction cost;
- Labour cost;

- Operation and Maintenance cost;
- Administration cost;
- Fuel cost;
- Capital cost and interest;
- Revenue from electricity sales;
- All other costs of implementing the technology of the each alternative option.
- All revenues generated by the implementation of the proposed technology except for carbon credits revenues.

In the case that there are several alternatives remaining after step 2 and that at least two alternatives are associated with costs, an investment comparison analysis should be conducted. In doing so, compare the IRR of the different alternatives and select the most cost-effective alternative (i.e. with the highest IRR) as the baseline scenario. Include a sensitivity analysis applying Sub-step 2d of the latest version of the "Tool for the demonstration and assessment of additionality" agreed by the CDM Executive Board. The investment comparison analysis provides a valid argument that the most cost-effective scenario is the baseline scenario if it consistently supports (for a realistic range of assumptions) this conclusion. In case the sensitivity analysis is not fully conclusive, select the baseline scenario alternative with least emissions among the alternatives that are the most economically attractive according to the investment analysis and the sensitivity analysis.

In the case the project undertaken without being registered is the only remaining alternative with associated costs, a benchmark analysis is to be used to demonstrate its profitability or non-profitability. If the project is profitable, it is to be considered as the baseline scenario. If not, the continuation of the current situation is the baseline.

The methodology is only applicable if it can be demonstrated that the baseline scenario corresponds to the scenario described in Table 1 above and if the following baseline scenarios are most likely:

- For scenario 1: W1 for the treatment of wastewater and, if applicable, E1 / E2 for the generation of electricity.
- For scenario 2: W3 for the treatment of wastewater, S1 for the use of the sludge and, if applicable, E1 / E2 for the generation of electricity.

Additionality

Use the latest version of the "Tool for the demonstration and assessment of additionality" agreed by the CDM Executive Board. In doing so, ensure consistency with the guidance provided in the "Procedure for the identification of the most plausible baseline scenario".

Baseline emissions

Baseline emissions are estimated as follows:

$$BE_y = BE_{CH4,y} + BE_{EL,y} + BE_{HG,y} \quad (1)$$

Where:

BE_y	=	Baseline emissions in year y (tCO_2e/yr)
BE_{CH4}	=	Methane emissions from anaerobic treatment of the wastewater in open lagoons (scenario 1) or the anaerobic treatment of sludge in sludge pits (scenario 2) in the absence of the project activity in year y (tCO_2e/yr)
$BE_{EL,y}$	=	CO_2 emissions associated with electricity generation that is displaced by the project activity and/or electricity consumption in the absence of the project activity in year y (tCO_2/yr)
$BE_{HG,y}$	=	CO_2 emissions associated with fossil fuel combustion for heating equipment that is displaced by the project in year y (tCO_2/yr)

Baseline emissions are calculated in three steps, as follows:

Step 1: Calculation of baseline emissions from anaerobic treatment of the wastewater or sludge
Step 2: Calculation of baseline emissions from generation and consumption of electricity (if applicable)
Step 3: Calculation of baseline emissions from heat generation (if applicable)
Steps 2 and 3 are only applicable if electricity or heat is generated from biogas generated in the anaerobic digester.

Step 1: Calculation of baseline emissions from anaerobic treatment of the wastewater or sludge

The methodology proposes two alternative methods for the estimation of methane emissions from open lagoons:

(a) The Methane Conversion Factor Method (described in step 1a); and
(b) The Organic Removal Ratio method (described in step 1b).

Project participants should document in the CDM-PDD which method is applied. The method chosen should be applied throughout all crediting periods.

Step 1a: Methane Conversion Factor Method

The baseline methane emissions from anaerobic treatment of the wastewater in open lagoons (scenario 1) or the anaerobic treatment of sludge in sludge pits (scenario 2) are estimated based on the chemical oxygen demand (COD) of the wastewater that would enter the lagoon in the absence of the project activity ($COD_{BL,y}$), the maximum methane producing capacity (B_o) and a methane conversion factor ($MCF_{BL,y}$) which expresses the proportion of the wastewater that would decay to methane, as follows:

$$BE_{CH4,y} = GWP_{CH4} \times MCF_{BL,y} \times B_o \times COD_{BL,y} \quad (2)$$

Where:

BE_{CH4}	=	Methane emissions from anaerobic treatment of the wastewater in open lagoons (scenario 1) or the anaerobic treatment of sludge in sludge pits (scenario 2) in the absence of the project activity in year y (tCO_2e/yr)
GWP_{CH4}	=	Global Warming Potential of methane valid for the commitment period (tCO_2e/tCH_4)
B_o	=	Maximum methane producing capacity, expressing the maximum amount of CH_4 that can be produced from a given quantity of chemical oxygen demand ($tCH_4/tCOD$)
$MCF_{BL,y}$	=	Average baseline methane conversion factor (fraction) in year y, representing the fraction of ($COD_{PJ,y}$ x B_o) that would be degraded to CH_4 in the absence of the project activity
$COD_{BL,y}$	=	Quantity of chemical oxygen demand that would be treated in open lagoons (scenario 1) or in sludge pits (scenario 2) in the absence of the project activity in year y (tCOD/yr)

Determination of $COD_{BL,y}$

In principle, the baseline chemical oxygen demand ($COD_{BL,y}$) corresponds to the chemical oxygen demand that is treated under the project activity ($COD_{PJ,y}$) because the wastewater (scenario 1) or sludge (scenario 2) treated under the project activity would in the absence of the project activity be directed to the open lagoon (scenario 1) or the sludge pit (scenario 2), and thus $COD_{BL,y} = COD_{PJ,y}$.

If there would be an effluent from the lagoons (scenario 1) or the sludge pit (scenario 2) in the baseline, COD_{BL} should be adjusted by an effluent adjustment factor which relates the COD supplied to the lagoon or sludge pit with the COD in the effluent, as follows:

$$COD_{BL,y} = AD_{BL} \times COD_{PJ,y} \quad \text{with} \tag{3}$$

$$AD_{BL} = 1 - \frac{COD_{out,x}}{COD_{in,x}} \quad \text{and} \tag{4}$$

$$COD_{PJ,y} = \sum_{m=1}^{12} F_{PJ,dig,m} \times w_{COD,dig,m} \tag{5}$$

Where:

$COD_{BL,y}$	=	Quantity of chemical oxygen demand that would be treated in open lagoons (scenario 1) or in sludge pits (scenario 2) in the absence of the project activity in year y (t COD/yr)
$COD_{PJ,y}$	=	Quantity of chemical oxygen demand that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in year y (t COD/yr)
AD_{BL}	=	Effluent adjustment factor expression the percentage of COD that is degraded in open lagoons (scenario 1) or in sludge pits (scenario 2) in the absence of the project activity
$COD_{out,x}$	=	COD of the effluent in the period x (t COD)
$COD_{in,x}$	=	COD directed to the open lagoons (scenario 1) or in sludge pits (scenario 2) in the period x (t COD)
$F_{PJ,dig,m}$	=	Quantity of wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m (m^3/month)

$w_{COD,dig,m}$ = Average chemical oxygen demand in the wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m (t COD / m³)
x = Representative historical reference period (at least one year)
m = Months of year y of the crediting period

Determination of $MCF_{BL,y}$

The quantity of methane generated from COD disposed to the open lagoon (scenario 1) or in sludge pits (scenario 2) depends mainly on the temperature and the depth of the lagoon or sludge pit. Accordingly, the methane conversion factor is calculated based on a factor f_d, expressing the influence of the depth of the lagoon or sludge pit on methane generation, and a factor $f_{T,y}$ expressing the influence of the temperature on the methane generation. In addition, a conservativeness factor of 0.89 is applied to account for the considerable uncertainty associated with this approach. $MCF_{BL,y}$ is calculated as follows:

$$MCF_{BL,y} = f_d \times f_{T,y} \times 0.89 \quad (6)$$

Where:
$MCF_{BL,y}$ = Average baseline methane conversion factor (fraction) in year y, representing the fraction of ($COD_{PJ,y}$ x B_o) that would be degraded to CH_4 in the absence of the project activity
f_d = Factor expressing the influence of the depth of the lagoon or sludge pit on methane generation
$f_{T,y}$ = Factor expressing the influence of the temperature on the methane generation in year y
0.89 = Conservativeness factor

Determination of $f_{T,y}$

In some regions, the ambient temperature varies significantly over the year. Therefore, the factor $f_{T,y}$ is calculated with the help of a monthly stock change model which aims at assessing how much COD degrades in each month. For each month m, the quantity of wastewater directed to the lagoon or sludge directed to a pit, the quantity of organic compounds that decay and the quantity of any effluent water from the lagoon is balanced, giving the quantity of COD that is available for degradation in the next month: The amount of organic matter available for degradation to methane ($COD_{available,m}$) is assumed to be equal to the amount of organic matter directed to the open lagoon or sludge pit, less any effluent, plus the COD that may have remained in the lagoon or sludge pit from previous months, as follows:

$$COD_{available,m} = COD_{BL,m} + (1 - f_{T,m}) \times COD_{available,m-1} \quad \text{with} \quad (7)$$

$$COD_{BL,m} = AD_{BL} \times COD_{PJ,m} \quad \text{and} \quad (8)$$

$$COD_{PJ,m} = F_{PJ,dig,m} \times w_{COD,dig,m} \quad (9)$$

Where:

$COD_{available,m}$ = Quantity of chemical oxygen demand available for degradation in the open lagoon or sludge pit in month m (t COD/month)
$COD_{BL,m}$ = Quantity of chemical oxygen demand that would be treated in open lagoons (scenario 1) or in sludge pits (scenario 2) in the absence of the project activity in month m (t COD/month)
$COD_{PJ,m}$ = Quantity of chemical oxygen demand that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m (t COD/month)
AD_{BL} = Effluent adjustment factor expressing the percentage of COD that is degraded in open lagoons (scenario 1) or in sludge pits (scenario 2) in the absence of the project activity
$F_{PJ,dig,m}$ = Quantity of wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m (m^3/month)
$w_{COD,dig,m}$ = Average chemical oxygen demand in the wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m (t COD / m^3)
$f_{T,m}$ = Factor expressing the influence of the temperature on the methane generation in month m
m = Months of year y of the crediting period

The carry-over calculations are limited to a maximum of one year. In case the residence time in the open lagoon or the sludge pit is less than one year, carry-on calculations are limited to the period where the wastewater remains in the lagoon or the sludge remains in the sludge pit. I.e., in the case of the emptying of a sludge pit, the accumulation of organic matter restarts with the next inflow and the COD available from the previous month should be set to zero. Project participants should provide evidence of the typical residence time of the organic matter in the lagoon or the sludge pit.

The monthly factor to account for the influence of the temperature on methane generation is calculated based on the following "van't Hoff – Arrhenius" approach:

$$f_{T,m} = \begin{cases} 0 & \text{if} \quad T_{2,m} < 283\,K \\ \exp\left(\dfrac{E*(T_{2,m} - T_1)}{R*T_1*T_{2,m}}\right) & \text{if} \quad 283\,K < T_{2,m} < 303\,K \\ 1 & \text{if} \quad T_{2,m} > 303\,K \end{cases} \qquad (10)$$

Where:

$f_{T,m}$ = Factor expressing the influence of the temperature on the methane generation in month m
E = Activation energy constant (15,175 cal/mol).
$T_{2,m}$ = Average temperature at the project site in month m (K)
T_1 = 303.16 K (273.16 K + 30 K)
R = Ideal gas constant (1.987 cal / K mol)
m = Months of year y of the crediting period

As indicated in equation (10) above, the value of $f_{T,m}$ cannot exceed 1 and should be assumed to be zero if the ambient temperature is below 10°C.

Based on the monthly values $f_{T,m}$ the annual value $f_{T,y}$ is calculated as follows:

$$f_{T,y} = \frac{\sum_{m=1}^{12} f_{T,m} \times COD_{availble,m}}{\sum_{m=1}^{12} COD_{BL,m}} \tag{11}$$

where:

$f_{T,y}$ = Factor expressing the influence of the temperature on the methane generation in year y

$f_{T,m}$ = Factor expressing the influence of the temperature on the methane generation in month m

$COD_{available,m}$ = Quantity of chemical oxygen demand available for degradation in the open lagoon or sludge pit in month m (t COD/month)

$COD_{BL,m}$ = Quantity of chemical oxygen demand that would be treated in open lagoons (scenario 1) or in sludge pits (scenario 2) in the absence of the project activity in month m (t COD/month)

m = Months of year y of the crediting period

Step 1b: Organic removal ratio (ORR) method

The organic removal ratio method measures the reduction of chemical oxygen demand (COD) in a wastewater or sludge stream between its entry into and exit from the treatment system (the open lagoon or the sludge pit). The organic removal ratio is a project specific factor expressing the fraction of COD that is degraded in the open lagoon or sludge pit (i.e. between the entry and exit points).

Losses of COD in a sludge pit or lagoon system occur through three main routes:

- Anaerobic decomposition (and consequently methane emissions)
- Oxidative decomposition, either aerobic at the pond surface, or through chemical oxidation where there is a presence of an oxidizing product, such as sulphate from sulphuric acid (SO_4^{2-} from H_2SO_4);
- Sedimentation of certain suspended materials that can be lost through other routes, and settle to the lagoon bottom, remaining on a more or less permanent basis.

The organic removal ratio method acknowledges these different losses of COD. Baseline methane emissions from anaerobic treatment of the wastewater in open lagoons (scenario 1) or the anaerobic treatment of sludge in sludge pits (scenario 2) are estimated based on a mass balance of the organic matter, as follows:

$$BE_{CH4,y} = GWP_{CH4} \times B_o \times \left(COD_{BL,y} - COD_{aerobic,BL} - COD_{OX,BL,y} - COD_{sedim,BL,y}\right) \tag{12}$$

Where:

$BE_{CH4,y}$ = Methane emissions from anaerobic treatment of the wastewater in open lagoons (scenario 1) or the anaerobic treatment of sludge in sludge pits (scenario 2) in the absence of the project activity in year y (tCO_2e/yr)

GWP_{CH4} = Global Warming Potential of methane valid for the commitment period (tCO_2e/tCH_4)

B_o = Maximum methane producing capacity, expressing the maximum amount of CH_4 that can be produced from a given quantity of chemical oxygen demand ($tCH_4/tCOD$)

$COD_{BL,y}$ = Quantity of chemical oxygen demand that would be treated in open lagoons (scenario 1) or in sludge pits (scenario 2) in the absence of the project activity in year y (t COD/yr)
$COD_{aerobic,BL}$ = Annual quantity of chemical oxygen demand that would degrade aerobically in the lagoon or sludge pit (t COD/yr)
$COD_{OX,BL,y}$ = Annual quantity of chemical oxygen demand that would be chemically oxidised through sulphate in the wastewater or sludge in year y (t COD/yr)
$COD_{sedim,BL,y}$ = Amount of chemical oxygen demand lost through sedimentation in the lagoon or sludge pit (t COD/yr)

$COD_{BL,y}$ is determined as per equations (3), (4) and (5) for the methane conversion factor method.

Determination of $COD_{aerobic,BL}$

$COD_{aerobic,BL}$ is calculated based on the surface of the lagoon or sludge pit and a default value for the amount of COD per hectare that degrades under aerobic conditions, as follows:

$$COD_{aerobic,BL} = A \times f_{COD,aerobic} \qquad (13)$$

Where:
$COD_{aerobic,BL}$ = Annual quantity of chemical oxygen demand that would degrade aerobically in the lagoon or sludge pit (t COD/yr)
A = Surface of the lagoon or sludge pit (ha)
$f_{COD,aerobic}$ = Quantity of chemical oxygen demand degraded to CO_2 under aerobic conditions per surface area of the lagoon or sludge pit (t COD / ha yr)

Determination of $COD_{OX,BL,y}$

The determination of this parameter is relevant if the wastewater or sludge contains chemical substances that chemically oxidize organic matter in the wastewater or sludge. The most likely chemical substance that may be present is the sulphate ion (SO_4^{2-}) from use in the process of sulphuric acid. Project participants should identify which chemical substances are relevant for the wastewater or sludge type. The concentration of these chemical substances is monitored and the reduction in chemical oxygen demand due to the chemical oxidation of organic matter is then determined as follows:

$$COD_{OX,BL,y} = F_{PJ,y} \times \sum_{s} w_{s,y} \times R_s \times 0.001 \qquad (14)$$

Where:
$COD_{OX,BL,y}$ = Annual quantity of chemical oxygen demand that would be chemically oxidised through sulphate in the wastewater or sludge in year y (t COD/yr)
$F_{PJ,y}$ = Quantity of wastewater or sludge treated in the digester in year y (m^3/yr)
$w_{s,y}$ = Average concentration of chemical oxidative substance s in the wastewater or sludge treated in the digester in year y (kg/m^3)
R_s = Specific reduction in chemical oxygen demand by substance s (t COD / t substance)
s = Substances in the wastewater or sludge that can chemically oxidize organic matter

Determination of $COD_{sedimBL}$

To determine $COD_{sedimBL,y}$ the procedure in Appendix II shall be applied.

Step 2: Baseline emissions from generation and/or consumption of electricity

In this step, baseline emissions from the following sources are estimated:

- Baseline emissions from consumption of electricity associated with the treatment of wastewater (scenario 1) or the treatment of sludge (scenario 2);

- If electricity is generated with biogas from a new anaerobic digester under the project activity: baseline emissions from the generation of electricity in the grid (E2) and/or with a captive fossil fuel fired power plant (E1) in the absence of the electricity generation with biogas.

As a simplification, project participants may neglect one or both emission sources. Baseline emissions from the generation and/or consumption of electricity are calculated as follows:

$$BE_{EL,y} = \left(EC_{BL,y} + EG_{PJ,y}\right) \times EF_{BL,EL,y} \tag{15}$$

Where:

$BE_{EL,y}$	=	CO_2 emissions associated with electricity generation that is displaced by the project activity and/or electricity consumption in the absence of the project activity in year y (tCO_2/yr)
EC_{BL}	=	Annual quantity of electricity that would be consumed in the absence of the project activity for the treatment of the wastewater (scenario 1) or the treatment of the sludge (scenario 2) (MWh/yr)
$EG_{PJ,y}$	=	Net quantity of electricity generated in year y with biogas from the new anaerobic biodigester (MWh/yr)
$EF_{BL,EL,y}$	=	Baseline emission factor for electricity generated and/or consumed in the absence of the project activity in year y (tCO_2/MWh)

The determination of $EF_{BL,EL,y}$ depends on the baseline scenario and the configuration at the project site. The grid emission factor should be used ($EF_{BL,EL,y} = EF_{grid,y}$) if the baseline scenario for displacement of electricity generated with biogas from the anaerobic digester is E2 or, in the case that no electricity is generated at the project site, if no captive fossil fuel fired power plant is operating at the project site in year y. In all other cases, the lower emission factor between the grid emission factor and the emission factor of the captive power plant should be used as a conservative simplification[3], as follows:

[3] This conservative simplification has been made because it is depends on the exact configuration of the project activity to which extent electricity is displaced in the captive fossil fuel fired power plant and/or the grid. For example:

- The biogas from the digester may be co-fired in an existing captive power plant. The co-firing may partly displace the use of fossil fuels and may partly result in an increased level of electricity generation, thereby displacing grid electricity.

$$EF_{BL,EL,y} = MIN(EF_{grid,y}; EF_{BL,EL,captive}) \quad (16)$$

Where:

$EF_{BL,EL,y}$ = Baseline emission factor for electricity generated and/or consumed in the absence of the project activity in year y (tCO_2/MWh)
$EF_{grid,y}$ = Grid emission factor in year y (tCO_2/MWh)
$EF_{CO2,FF,captive}$ = CO_2 emission factor of the fossil fuel type used in the captive power plant (tCO_2/TJ)
$\eta_{captive}$ = Efficiency of the fossil fuel fired captive power plant

The emission factor of the captive power plant ($EF_{BL,EL,captive}$) may be determined using one of the following options:

- In case of diesel generators: use the value the default emission factor for a diesel generator with a capacity of more than 200 kW for small-scale project activities (0.8 tCO_2/MWh, see AMS I-D.1 in the simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories);
- Calculate $EF_{BL,EL,captive}$ as follows:

$$EF_{BL,EL,captive} = \frac{EF_{CO2,FF,captive}}{\eta_{EL,captive}} \times 3.6 \quad (17)$$

Where:

$EF_{BL,EL,y}$ = Baseline emission factor for electricity generated and/or consumed in the absence of the project activity in year y (tCO_2/MWh)
$EF_{grid,y}$ = Grid emission factor in year y (tCO_2/MWh)
$EF_{CO2,FF,captive}$ = CO_2 emission factor of the fossil fuel type used in the captive power plant (tCO_2/TJ)
$\eta_{EL,captive}$ = Efficiency of electricity generation of the fossil fuel fired captive power plant

Step 3: Baseline emissions from the generation of heat

This step is applicable if the biogas captured from the new anaerobic digester is utilized in the project scenario for heat generation. If the baseline scenarios H1 or H3 apply, $BE_{HG,y} = 0$.[4] If scenario H2 applies, fossil fuels from the generation of heat in boilers are displaced and baseline emissions are calculated as follows:

- Under the project activity, a new power plant is installed which displaces an existing captive fossil fuel power plant. In this case, it would be necessary to compare the electricity generation capacity of the new and the existing plant and to determine the remaining technical lifetime of the existing power plant to assess how long and to what extent the continued operation of the existing plant is a reasonable baseline scenario.

Project participants may request for a revision of this methodology to cover their specific project configuration in a more appropriate manner. This may require developing more detailed scenarios (see, for example, ACM0006).

[4] In case of cogeneration in the absence of the project activity (H1), the emission reductions from using the biogas in a cogeneration plant are already reflected in step 2.

$$BE_{HG,y} = \frac{HG_{PJ,y} \times EF_{CO2,FF,boiler}}{\eta_{BL,boiler}} \quad (18)$$

Where:

$BE_{HG,y}$ = CO_2 emissions associated with fossil fuel combustion for heating equipment that is displaced by the project in year y (tCO_2/yr)

$HG_{PJ,y}$ = Net quantity of heat generated in year y with biogas from the new anaerobic digester (TJ)

$EF_{CO2,FF,boiler}$ = CO_2 emission factor of the fossil fuel type used in the boiler for heat generation in the absence of the project activity (tCO_2/TJ)

η_{boiler} = Efficiency of the boiler that would be used for heat generation in the absence of the project activity

Project emissions

Emissions attributed to the project activity depend on which scenario in Table 1 applies and the configuration of the project activity.

(i) Methane emissions from the lagoons or dewatering process (applicable if effluent from the treatment under the project activity is directed to either a lagoon system or to a dewatering facility);

In the case of project activities that introduce an anaerobic digester for the treatment of wastewater or sludge:

(ii) Physical leakage of methane from the digester system;
(iii) Methane emissions from flaring (applicable if biogas from the digester is flared);

In the case of projects that introduce a treatment of sludge:

(iv) Methane and nitrous oxide emissions from land application of sludge (if applicable);

In the case of projects that consume electricity or heat under the project activity:

(v) CO_2 emissions from consumption of electricity and or fossil fuels in the project activity.

Project participants should document and justify in the CDM-PDD which emission sources are applicable in the context of their project activity. Project emissions are calculated as follows:

$$PE_y = PE_{CH4,effluent,y} + PE_{CH4,digest,y} + PE_{flare,y} + PE_{sludge,LA,y} + PE_{EC,y} + PE_{FC,y} \quad (19)$$

Where:

PE_y = Project emissions in year y (tCO_2e/yr)

$PE_{CH4,effluent,y}$ = Project emissions from treatment of wastewater effluent from the anaerobic digester in year y (tCO_2e/yr)

$PE_{CH4,digest,y}$	=	Project emissions from physical leakage of methane from the anaerobic digester in year y (tCO_2e/yr)
$PE_{flare,y}$	=	Project emissions from flaring of biogas generated in the anaerobic digester in year y (tCO_2e/yr)
$PE_{sludge,LA,y}$	=	Project emissions from land application of sludge in year y (tCO_2e/yr)
$PE_{EC,y}$	=	Project emissions from electricity consumption in year y (tCO_2e/yr)
$PE_{FC,y}$	=	Project emissions from fossil fuel consumption in year y (tCO_2e/yr)

(i) Project methane emissions from effluent from the digester

This step is applicable if a new digester is installed under the project activity and if the effluent from this digester is directed to open lagoons or a dewatering facility (see scenario 1 and scenario 2, project activity b in Table 1 of the Applicability conditions).

A significant amount of the COD load is usually degraded in the new anaerobic digester and open lagoons can be expected to operate under largely aerobic conditions. However, due to the uncertainty regarding the exact extent of aerobic/anaerobic degradation after project implementation, the calculation of any CH_4 emissions is conservatively carried out in the same way as for the baseline, using either the methane conversion factor method or the organic removal ratio method. The same method as for the baseline emissions shall be applied.

<u>Methane conversion factor method</u>

Project methane emissions from treatment of the effluent from the digester are estimated as follows:

$$PE_{CH4,effluent,y} = GWP_{CH4} \times MCF_{PJ,y} \times B_o \times \left(COD_{PJ,effl,dig,y} - COD_{PJ,effl,lag,y}\right) \quad \text{with} \tag{20}$$

$$COD_{PJ,effl,dig,y} = \sum_{m=1}^{12} F_{PJ,effl,dig,m} \times w_{COD,effl,dig,m} \quad \text{and} \tag{21}$$

$$COD_{PJ,effl,lag,y} = \sum_{m=1}^{12} F_{PJ,effl,lag,m} \times w_{COD,effl,lag,m} \tag{22}$$

Where:

$PE_{CH4,effluent,y}$	=	Project emissions from treatment of wastewater effluent from the anaerobic digester in year y (tCO_2e/yr)
GWP_{CH4}	=	Global Warming Potential of methane valid for the commitment period (tCO_2e/tCH_4)
$MCF_{PJ,y}$	=	Project methane conversion factor (fraction) in year y, representing the fraction of ($COD_{PJ,effluent,y}$ x B_o) that degradeds to CH_4
B_o	=	Maximum methane producing capacity, expressing the maximum amount of CH_4 that can be produced from a given quantity of chemical oxygen demand ($tCH_4/tCOD$)
$COD_{PJ,effl,dig,y}$	=	Quantity of chemical oxygen demand in the effluent from the digester in year y (tCOD/yr)
$COD_{PJ,effl,lag,y}$	=	Quantity of chemical oxygen demand in the effluent of the open lagoon or dewatering

facility in which the effluent from the digester is treated in year y (tCOD/yr)

$F_{PJ,effl,dig,m}$ = Quantity of effluent from the digester in month m (m^3/month)
$w_{COD,effl,dig,m}$ = Average chemical oxygen demand in the effluent from the digester in month m (t COD / m^3)
$F_{PJ,effl,lag,m}$ = Quantity of effluent from the open lagoon or dewatering facility in which the effluent from the digester is treated in month m (m^3/month)
$w_{COD,effl,lag,m}$ = Average chemical oxygen demand in the effluent from the open lagoon or dewatering facility in which the effluent from the digester is treated in month m (t COD / m^3)

The quantity of methane generated from COD disposed to the open lagoon or in dewatering facility is calculated as follows:

$$MCF_{PJ,y} = f_d \times f_{PJ,T,y} \quad (23)$$

Where:
$MCF_{PJ,y}$ = Project methane conversion factor (fraction) in year y, representing the fraction of ($COD_{PJ,effluent,y}$ x B_o) that degrades to CH_4
f_d = Factor expressing the influence of the depth of the lagoon or dewatering facility on methane generation
$f_{PJ,T,y}$ = Factor expression the influence of the temperature on the methane generation under the project activity in year y

The factor $f_{T,PJ,y}$ is calculated, as under baseline emissions, with the help of a monthly stock change model which aims at assessing how much COD degrades in each month, as follows:

$$COD_{PJ,available,m} = \left(COD_{PJ,effl,dig,m} - COD_{PJ,effl,lag,m}\right) + (1 - f_{T,m}) \times COD_{PJ,available,m-1} \quad \text{with} \quad (24)$$

$$COD_{PJ,effl,dig,y} = F_{PJ,effl,dig,m} \times w_{COD,effl,dig,m} \quad \text{and} \quad (25)$$

$$COD_{PJ,effl,lag,y} = F_{PJ,effl,lag,m} \times w_{COD,effl,lag,m} \quad (26)$$

Where:
$COD_{PJ,available,m}$ = Quantity of chemical oxygen demand available for degradation in the open lagoon or dewatering facility under the project activity in month m (t COD/month)
$COD_{PJ,effl,dig,m}$ = Quantity of chemical oxygen demand in the effluent from the digester in month m (tCOD/month)
$COD_{PJ,effl,lag,m}$ = Quantity of chemical oxygen demand in the effluent of the open lagoon or dewatering facility in which the effluent from the digester is treated in month m (tCOD/month)
$F_{PJ,effl,dig,m}$ = Quantity of effluent from the digester in month m (m^3/month)
$w_{COD,effl,dig,m}$ = Average chemical oxygen demand in the effluent from the digester in month m (t COD / m^3)
$F_{PJ,effl,lag,m}$ = Quantity of effluent from the open lagoon or dewatering facility in which the effluent from the digester is treated in month m (m^3/month)
$w_{COD,effl,lag,m}$ = Average chemical oxygen demand in the effluent from the open lagoon or dewatering facility in which the effluent from the digester is treated in month m (t COD / m^3)

$f_{T,m}$ = Factor expressing the influence of the temperature on the methane generation in month m
m = Months of year y of the crediting period

As for the baseline emissions, the carry-over calculations are limited to a maximum of one year. In case the residence time in the open lagoon or the dewatering facility is less than one year, carry-on calculations are limited to the period where the wastewater remains in the lagoon or dewatering facility. Project participants should provide evidence of the typical residence time of the organic matter in the lagoon or the dewatering facility.

The monthly factor to account for the influence of the temperature on methane generation is calculated as per equation (10) above.

Based on the monthly values $f_{T,m}$ the annual value $f_{T,PJ,y}$ is calculated as follows:

$$f_{PJ,T,y} = \frac{\sum_{m=1}^{12} f_{T,m} \times COD_{PJ,avaialble,m}}{\sum_{m=1}^{12} \left(COD_{PJ,effl,dig,m} - COD_{PJ,effl,lag,m}\right)} \quad (27)$$

Where:
$f_{PJ,T,y}$ = Factor expressing the influence of the temperature on the methane generation under the project activity in year y
$f_{T,m}$ = Factor expressing the influence of the temperature on the methane generation in month m
$COD_{PJ,available,m}$ = Quantity of chemical oxygen demand available for degradation in the open lagoon or dewatering facility under the project activity in month m (t COD/month)
$COD_{PJ,effl,dig,m}$ = Quantity of chemical oxygen demand in the effluent from the digester in month m (tCOD/month)
$COD_{PJ,effl,lag,m}$ = Quantity of chemical oxygen demand in the effluent of the open lagoon or dewatering facility in which the effluent from the digester is treated in month m (tCOD/month)
m = Months of year y of the crediting period

<u>Organic removal ratio method</u>

As for baseline emissions, methane emissions from anaerobic treatment of the effluent from the digester are estimated based on a mass balance of the organic matter, as follows:

$$PE_{CH4,effluent,y} = GWP_{CH4} \times B_o \times \left(COD_{PJ,effl,dig,y} - COD_{PJ,aerobic} - COD_{PJ,OX,y} - COD_{PJ,sedim,y} - COD_{PJ,effl,lag,y}\right) \quad (28)$$

Where:
$PE_{CH4,effluent,y}$ = Project emissions from treatment of wastewater effluent from the anaerobic digester in year y (tCO_2e/yr)

GWP_{CH4} = Global Warming Potential of methane valid for the commitment period (tCO_2e/tCH_4)
B_o = Maximum methane producing capacity, expressing the maximum amount of CH_4 that can be produced from a given quantity of chemical oxygen demand ($tCH_4/tCOD$)
$COD_{PJ,effl,dig,y}$ = Quantity of chemical oxygen demand in the effluent from the digester in year y (t COD/yr)
$COD_{PJ,aerobic}$ = Annual quantity of chemical oxygen demand that degrades aerobically in the lagoon or sludge pit under the project activity (t COD/yr)
$COD_{PJ,OX,y}$ = Annual quantity of chemical oxygen demand that is chemically oxidised through oxidizing substances in the effluent from the digester in year y (t COD/yr)
$COD_{PJ,sedim,y}$ = Amount of chemical oxygen demand lost through sedimentation in the lagoon or sludge pit under the project activity (t COD/yr)
$COD_{PJ,effl,lag,}$ = Quantity of chemical oxygen demand in the effluent of the open lagoon or dewatering facility in which the effluent from the digester is treated in year y (t COD/yr)

$COD_{PJ,effl,dig,y}$ and $COD_{PJ,effl,lag,y}$ are determined as per equations (3), (4) and (5) for the methane conversion factor method. $COD_{PJ,aerobic}$ is determined as per equation (13) under baseline emissions. To determine $COD_{sedim,BL,y}$ the procedure in Appendix II shall be applied. $COD_{PJ,OX,y}$ is determined, as under baseline emissions, as follows:

$$COD_{PJ,OX,y} = F_{PJ,effl,dig,y} \times \sum_{s} w_{s,effl,y} \times R_s \times 0.001 \quad (29)$$

Where:
$COD_{PJ,OX,y}$ = Annual quantity of chemical oxygen demand that is chemically oxidised through oxidizing substances in the effluent from the digester in year y (t COD/yr)
$F_{PJ,effl,dig,y}$ = Quantity of effluent from the digester in year y (m^3/yr)
$w_{s,effl,y}$ = Average concentration of chemical oxidative substance s in the effluent from the digester in year y (kg/m^3)
R_s = Specific reduction in chemical oxygen demand by substance s (t COD / t substance)
s = Substances in the effluent of the digester that can chemically oxidize organic matter

(ii) Project emissions related to physical leakage from the digester

This step is applicable if the project activity includes the construction of a new anaerobic digester. The emissions directly associated with the operation of digesters involve the physical leakage of methane from the digester system. Methane emissions from the new digester are calculated as follows:

$$PE_{CH4,digest} = F_{biogas,y} \times EF_{CH4,digest} \times w_{CH4,biogas,y} \times GWP_{CH4} \times 0.001 \quad (30)$$

Where:
$PE_{CH4,digest}$ = Project emissions from physical leakage of methane from the anaerobic digester (tCO_2e/yr)
$F_{biogas,y}$ = Amount of biogas collected in the outlet of the new digester in year y (m^3/yr)
$EF_{CH4,digest}$ = Fraction of biogas that leaks from the digester (m^3 biogas leaked / m^3 biogas produced)
$w_{CH4,biogas,y}$ = Concentration of methane in the biogas in the outlet of the new digester ($kg\ CH_4/m^3$)
GWP_{CH4} = Global Warming Potential of methane valid for the commitment period (tCO_2e/tCH_4)

(iii) Methane emissions from flaring

This step is applicable if under the project activity biogas is generated in a new anaerobic digester and if all or a part of the biogas is flared. Methane may be released as a result of incomplete combustion in the flare. To calculate project emissions from flaring of the biogas (PE_{flare}) apply the latest approved version of the "Tool to determine project emissions from flaring gases containing methane".

(iv) Project emissions from land application of sludge

This step is applicable if under the project activity sludge is applied on lands. For conservativeness, an MCF of 0.05 is to be used to estimate possible methane emissions from the land application treatment process to account for any possible anaerobic pockets. These emissions are to be estimated from the following equation:

$$PE_{sludge,LA,y} = COD_{sludge,LA,y} \times B_o \times MCF_{sludge,LA} \times GWP_{CH4} + S_{LA,y} \times w_{N,sludge,y} \times EF_{N2O,LA,sludge} \quad (31)$$

Where:

$PE_{sludge,LA,y}$	=	Project emissions from land application of sludge in year y (tCO_2e/yr)
$COD_{sludge,LA,y}$	=	Chemical oxygen demand (COD) of the sludge applied to land after the dewatering process in year y (tCOD/yr)
$MCF_{sludge,LA}$	=	Methane conversion factor for the application of sludge to lands
GWP_{CH4}	=	Global Warming Potential of methane valid for the applicable commitment period (tCO_2e/tCH_4)
$S_{LA,y}$	=	Amount of sludge applied to land in year y (t/yr)
$w_{N,sludge,y}$	=	Mass fraction of nitrogen in the sludge applied to land in year y (t N/t sludge)
$EF_{N2O,LA,sludge}$	=	N_2O emission factor for nitrogen from sludge applied to land (t N_2O/t N)

(v) Project emissions from electricity consumption and combustion of fossil fuels in the project

This emission source includes CO_2 emissions from the consumption of electricity or combustion of fossil fuels for the operation of the project activity. This may, for example, include the operation of pumps or the combustion of fossil fuels for the heat generation.

If electricity is generated with biogas under the project activity, the electricity consumption for the operation of the project activity should be subtracted from the total on-site electricity generation with biogas in calculating $EG_{PJ,y}$ (i.e. $EG_{PJ,y}$ only includes the net electricity generation resulting from the project activity). Otherwise, the latest approved version of the "Tool to calculate project emissions from electricity consumption" should be applied to calculate project emissions from electricity consumption ($PE_{EC,y}$).

If fossil fuels are combusted for the purpose of the project activity, CO_2 emission from fossil fuel combustion ($PE_{FC,y}$) should be calculated using the latest approved version of the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion".

Leakage

No leakage is estimated.

Emission Reductions

Emission reductions for any given year of the crediting period are obtained by subtracting project emissions from baseline emissions:

$$ER_y = BE_y - PE_y \quad (32)$$

Where:

ER_y	=	Emissions reductions of the project activity in year y (tCO_2e/year)
BE_y	=	Baseline emissions in year y (tCO_2e/year)
PE_y	=	Project emissions in year y (tCO_2e/year)

Changes required for methodology implementation in 2nd and 3rd crediting periods

Consistent with guidance by the Executive Board, project participants shall assess the continued validity of the identified baseline scenarios and update the baseline parameters.

Data and parameters not monitored

In addition to the data and parameters listed below, the guidance on "data and parameters not monitored" in all tools to which this methodology refers applies.

Parameter:	B_o
Data unit:	$tCH_4/tCOD$
Description:	Maximum methane producing capacity, expressing the maximum amount of CH_4 that can be produced from a given quantity of chemical oxygen demand (COD)
Source of data:	2006 IPCC Guidelines
Value to be applied:	The default IPCC value for B_o is 0.25 kg CH_4/kg COD. Taking into account the uncertainty of this estimate, project participants should use a value of 0.21 kg CH_4/kg COD as a conservative assumption for B_o. If the methodology is used for wastewater containing materials not akin to simple sugars, a CH_4 emissions factor different from 0.21 $tCH_4/tCOD$ has to be estimated and applied.
Any comment:	

Parameter:	f_d
Data unit:	-
Description:	Factor expressing the influence of the depth of the lagoon or sludge pit on methane generation
Source of data:	Apply the following values for the corresponding average depth of the open lagoon or the sludge pit: Depth > 5 m: 70% Depth 1 – 5 m: 50% Depth < 1 m: 0%
Measurement procedures (if any):	-
Any comment:	Applicable to the methane conversion factor method

Parameter:	$f_{COD,aerobic}$
Data unit:	t COD / ha yr
Description:	Quantity of chemical oxygen demand degraded to CO_2 under aerobic conditions per surface area of the lagoon or sludge pit
Source of data:	Experiments have to be conducted
Value to be applied:	92.7 t COD / ha yr (= 254 kg COD / ha day)
Any comment:	Applicable to the organic removal ratio method

Parameter:	D
Data unit:	m
Description:	Depth of the lagoon or sludge pit
Source of data:	Measurements
Measurement procedures (if any):	Determine the average depths of the whole lagoon / sludge pit under normal operating conditions
Any comment:	

Parameter:	EC_{BL}
Data unit:	MWh/yr
Description:	Annual quantity of electricity that would be consumed in the absence of the project activity for the treatment of the wastewater (scenario 1) or the treatment of the sludge (scenario 2)
Source of data:	Historical records
Measurement procedures (if any):	Based on three years of historical data
Any comment:	Estimation is based on three years data prior to start of the project. Electricity meters will undergo maintenance/calibration subject to appropriate industry standards. The accuracy of the meter readings will be verified by receipts issued by the purchasing power company. Uncertainty of the meters to be obtained from the manufacturers.

Parameter:	- $EF_{grid,y}$ - $EF_{BL,EL,y}$
Data unit:	tCO_2/MWh
Description:	- Grid emission factor in year y - Baseline emission factor for electricity generated and/or consumed in the absence of the project activity in year y (tCO_2/MWh)
Source of data:	
Measurement procedures (if any):	
Any comment:	Calculated in accordance with the latest approved version of the "Tool to calculate the emission factor for an electricity system"

Parameter:	- $EF_{CO2,FF,captive}$ - $EF_{CO2,FF,boiler}$
Data unit:	tCO_2/TJ
Description:	- CO_2 emission factor of the fossil fuel type used in the captive power plant - CO_2 emission factor of the fossil fuel type used in the boiler for heat generation in the absence of the project activity
Source of data:	Actual measured or local data is to be used. If not available, regional data should be used and, in its absence, IPCC defaults can be used from the most recent version of IPCC Guidelines for National Greenhouse Gas Inventories.
Measurement procedures (if any):	
Any comment:	If the measurement results differ significantly from previous measurements or other relevant data sources, conduct additional measurements. Double-checked against IPCC defaults (for consistency) if data is local or regional.

Parameter:	- $\eta_{EL,captive}$ - η_{boiler}
Data unit:	%
Description:	- Efficiency of the fossil fuel fired captive power plant - Efficiency of the boiler that would be used for heat generation in the absence of the project activity
Source of data:	
Measurement procedures (if any):	Depending on which option is chosen, the source will be either of the following: • Measured efficiency prior to project implementation; • Measured efficiency during monitoring; • Manufacturer nameplate data for efficiency of the existing equipment
Any comment:	

Parameter:	$EF_{CH4,digest,y}$
Data unit:	m^3 biogas leaked / m^3 biogas produced
Description:	Fraction of biogas that leaks from the digester
Source of data:	Either use a default value of 0.15 (based on the 2006) IPCC guidelines or undertake measurements
Value to be applied:	
Any comment:	Applicable if a new digester is installed under the project activity

Parameter:	$EF_{N2O,LA,sludge}$
Data unit:	t N_2O/t N
Description:	Emission factor of nitrogen from sludge applied to land to be assumed
Source of data:	Stehfest, E. and Bouwman, A.F. N_2O and NO emission from agricultural fields and soils under natural vegetation: summarizing available measurement data and modelling of global annual emissions. Nutr. Cycl. 29 Agroecosyst., in press. The average emission factor used is 0.01 kg N_2O-N / kg N (= 0.016 kg N_2O / kg N).
Value to be applied:	0.016
Any comment:	Applicable if sludge is applied on lands under the project activity

Parameter:	MCF_{la}
Data unit:	--------
Description:	Methane conversion factor for sludge used for land application
Source of data:	
Measurement procedures (if any):	
Any comment:	

Parameter:	GWP_{CH4}
Data unit:	tCO_2e/tCH_4
Description:	Global warming potential for CH_4
Source of data:	IPCC
Measurement procedures (if any):	Default to be applied 21 for the first commitment period.
Any comment:	Shall be updated according to any future COP/MOP decisions.

III. MONITORING METHODOLOGY

Monitoring procedures

The monitoring methodology is schematically represented in the diagram contained in Annex III, showing the flows between the different parts of the project. `

The parameters used to determine the project emissions from flaring of the residual gas stream in year y should be monitored as per the: "Tool to determine project emissions from flaring gases containing Methane".

Similarly, for parameters to be monitored for the calculation of project emissions related to the consumption of electricity and heat please refer to the latest approved version of:

- "Tool to calculate project emissions from electricity consumption"
- "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"

Data and parameters monitored

Parameters used for determination of baseline emissions

Data / Parameter:	- $COD_{BL,y}$ - $COD_{PJ,y}$ - $COD_{out,x}$ - $COD_{in,x}$ - $COD_{BL,m}$ - $COD_{PJ,m}$
Data unit:	ton COD/unit of time (year, month)
Description:	- Quantity of chemical oxygen demand that would be treated in open lagoons (scenario 1) or in sludge pits (scenario 2) in the absence of the project activity in year y - Chemical oxygen demand that is treated under the project activity - COD of the effluent in the period x - COD directed to the open lagoons (scenario 1) or in sludge pits (scenario 2) in the period x - Quantity of chemical oxygen demand that would be treated in open lagoons (scenario 1) or in sludge pits (scenario 2) in the absence of the project activity in month m - Quantity of chemical oxygen demand that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m

Source of data:	Measured
Measurement procedures (if any):	COD concentration is to be measured monthly using sampling techniques and flow rate is to be measured continuously. Sampling to be carried out adhering to internationally recognized procedures.
Monitoring frequency:	Monthly
QA/QC procedures:	Flow meters undergo maintenance/calibration subject to appropriate industry standards.
Any comment:	y = Year of the project activity x = Representative historical reference period (at least one year) m = Months of year y of the crediting period Note: annual values are derived from the monthly measures (m) Note: In principle, the baseline chemical oxygen demand ($COD_{BL,y}$) corresponds to the chemical oxygen demand that is treated under the project activity ($COD_{PJ,y}$) because the wastewater (scenario 1) or sludge (scenario 2) treated under the project would in the absence of the project activity be directed to the open lagoon (scenario 1) or the sludge pit (scenario 2), and thus $COD_{BL,y} = COD_{PJ,y}$

Data / Parameter:	$F_{PJ,dig,m}$
Data unit:	m^3/month
Description:	Quantity of wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m
Source of data:	Measured
Measurement procedures (if any):	
Monitoring frequency:	Parameter monitored continuously but aggregated annually for calculations
QA/QC procedures:	
Any comment:	

Data / Parameter:	$w_{COD,dig,m}$
Data unit:	t COD / m^3
Description:	Average chemical oxygen demand in the wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m
Source of data:	Measurements
Measurement procedures (if any):	Measure the COD according to national or international standards
Monitoring frequency:	Regularly, calculate average monthly and annual values
QA/QC procedures:	
Any comment:	

Data / Parameter:	$w_{S,y}$
Data unit:	t COD / m³
Description:	Average chemical oxygen demand in the wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m
Source of data:	Measurements
Measurement procedures (if any):	Measure the COD according to national or international standards
Monitoring frequency:	Regularly, calculate average monthly and annual values
QA/QC procedures:	
Any comment:	

Data / Parameter:	$T_{2,m}$
Data unit:	K
Description:	Average temperature at the project site in month m
Source of data:	National or regional weather statistics
Measurement procedures (if any):	-
Monitoring frequency:	Continuously, aggregated in monthly average values
QA/QC procedures:	-
Any comment:	Applicable for the methane conversion factor method

Data / Parameter:	$EG_{PJ,y}$
Data unit:	MWh/year
Description:	Net quantity of electricity generated in year y with biogas from the new anaerobic
Source of data:	Calculated based on the measurement of the amount of biogas captured used for heat generation, the methane content of the gas and the NCV of the methane or directly measured from the heat received by the heated process
Measurement procedures (if any):	
Monitoring frequency:	Monitored daily
QA/QC procedures:	
Any comment:	

Data / Parameter:	$HG_{BL,y}$
Data unit:	TJ/year
Description:	Net quantity of heat generated in year y with biogas from the new anaerobic digester
Source of data:	Calculated based on the measurement of the amount of biogas captured used for heat generation, the methane content of the gas and the NCV of the methane or directly measured from the heat received by the heated process
Measurement procedures (if any):	
Monitoring frequency:	Monitored daily
QA/QC procedures:	
Any comment:	

Parameters applied for determination of project emissionsData / Parameter:	- $COD_{PJ,effl,dig,y}$ - $COD_{PJ,effl,lag,y}$ - $COD_{PJ,effl,dig,m}$ - $COD_{PJ,effl,lag,m}$ - $COD_{sludge,LA,y}$
Data unit:	ton COD/unit of time (year, month)
Description:	- Quantity of chemical oxygen demand in the effluent from the digester in year y - Quantity of chemical oxygen demand in the effluent of the open lagoon or dewatering facility in which the effluent from the digester is treated in year y - Quantity of chemical oxygen demand in the effluent from the digester in month m - Quantity of chemical oxygen demand in the effluent of the open lagoon or dewatering facility in which the effluent from the digester is treated in month m - Quantity chemical oxygen demand of the sludge applied to land after the dewatering process in year y
Source of data:	Measured
Measurement procedures (if any):	COD concentration is to be measured monthly using sampling techniques and flow rate is to be measured continuously. Sampling to be carried out adhering to internationally recognized procedures.
Monitoring frequency:	Monthly
QA/QC procedures:	Flow meters undergo maintenance/calibration subject to appropriate industry standards.
Any comment:	y = Year of the project activity m = Months of year y of the crediting period Note: annual values are derived from the monthly measures (m)

Data / Parameter:	- $F_{PJ,effl,dig,m}$ - $F_{PJ,effl,dig,m}$ - $S_{LA,y}$
Data unit:	m^3/month
Description:	- Quantity of effluent from the digester in month m - Quantity of effluent from the open lagoon or dewatering facility in which the effluent from the digester is treated in month m - Quantity of sludge applied to land in year
Source of data:	Measured
Measurement procedures (if any):	
Monitoring frequency:	Parameter monitored continuously but aggregated annually for calculations
QA/QC procedures:	
Any comment:	y = Year of the project activity m = Months of year y of the crediting period Note: annual values are derived from the monthly measures (m)

Data / Parameter:	- $w_{COD,effl,dig,m}$ - $w_{COD,effl,lag,m}$
Data unit:	t COD / m^3
Description:	- Average chemical oxygen demand in the effluent from the digester in month m - Average chemical oxygen demand in the effluent from the open lagoon or dewatering facility in which the effluent from the digester is treated in month m
Source of data:	Measurements
Measurement procedures (if any):	Measure the COD according to national or international standards
Monitoring frequency:	Regularly, calculate average monthly and annual values
QA/QC procedures:	
Any comment:	

Data / Parameter:	$w_{S,eff,y}$
Data unit:	Kg / m^3
Description:	Average concentration of chemical oxidative substance s in the effluent from the digester in year y
Source of data:	Measurements
Measurement procedures (if any):	Measure according to national or international standards
Monitoring frequency:	Regularly, calculate average monthly and annual values
QA/QC procedures:	
Any comment:	

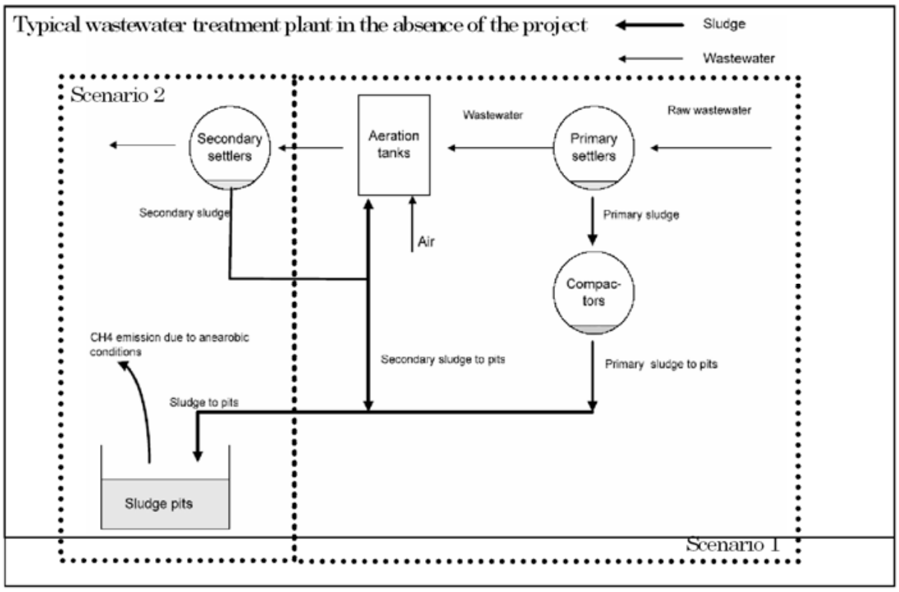
Data / Parameter:	$w_{N,sludge,y}$
Data unit:	t N/t sludge
Description:	Mass fraction of nitrogen in the sludge applied to land in year y
Source of data:	Measurements
Measurement procedures (if any):	Measure according to national or international standards
Monitoring frequency:	Regularly, calculate average monthly and annual values
QA/QC procedures:	
Any comment:	

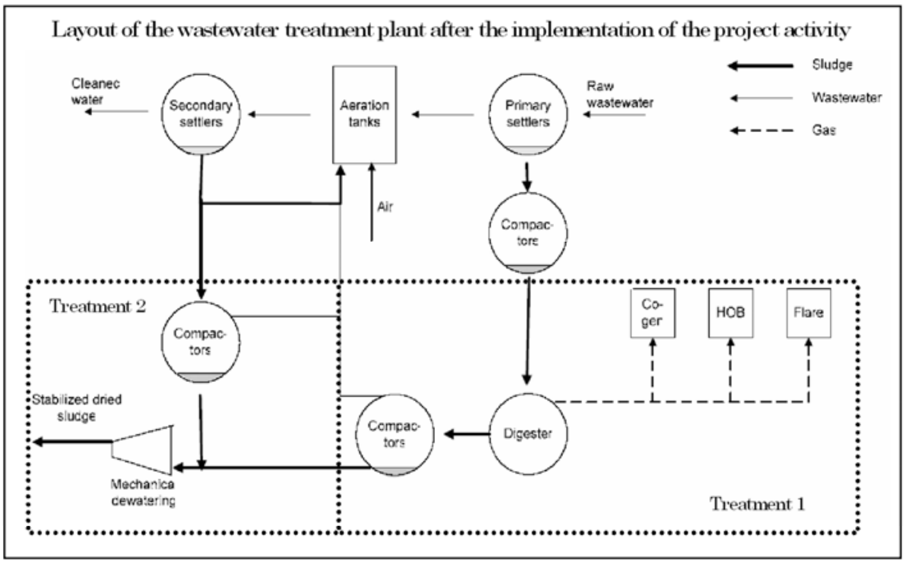
Data / Parameter:	$F_{biogas,y}$
Data unit:	m^3/yr
Description:	Amount of biogas collected in the outlet of the new digester in year y
Source of data:	Measured
Measurement procedures (if any):	
Monitoring frequency:	Parameter monitored continuously but aggregated annually for calculations
QA/QC procedures:	Flow meters will undergo maintenance/calibration subject to appropriate industry standards. The frequency of calibration and control procedures would be different for each application. This maintenance/calibration practice should be clearly stated in the CDM-PDD.
Any comment:	Applied to estimate emissions associated with physical leakage from the digester

Data / Parameter:	$P_{CH4,bio}$
Data unit:	m^3 biogas leaked / m^3 biogas produced
Description:	Fraction of biogas that leaks from the digester
Source of data:	Measured
Measurement procedures (if any):	Using calibrated portable gas meters. To be measured at wet basis
Monitoring frequency:	Either with continuous analyzer or alternatively with periodical measurement at 95% confidence level
QA/QC procedures:	The project proponents shall define the variability of the concentration. They shall also define the error in estimate for different level of measurement frequency. The level of accuracy will be deducted from average concentration of measurement.
Any comment:	Applied to estimate emissions associated with physical leakage from the digester

Data / Parameter:	T_{lag}
Data unit:	K
Description:	Temperature of lagoon
Source of data:	Measured
Measurement procedures (if any):	
Monitoring frequency:	Daily average is monitored but monthly average is used in the calculations
QA/QC procedures:	
Any comment:	

APPENDIX I: Illustration of the project activity and the historical situation





APPENDIX II: Determining rates of sedimentation

To estimate the amount of Chemical Oxygen Demand that is lost through sedimentation, the first step is to characterise the type of organic waste material in order to determine the likelihood of any sedimentation actually taking place. In addition, the conditions in the existing lagoon system must also be assessed to determine the lagoon dynamics in relation to mixing. Those lagoons so identified as highly anaerobically active have the characteristic to keep all the material that would sediment in a state of permanent suspension, this material is then anaerobically degraded.Where such characteristics of sedimentation are identified, the fraction of Chemical Oxygen Demand lost to sedimentation is determined by monitoring the rate of COD entering the pond system and the rate at which pond depth alters over time. Then, a relationship between pond depth and sedimentation can be established.

Pond Based Sedimentation Determination

Daily pond sedimentation rates vary in a seasonally operated industry. There are no hard average numbers for the dynamic deposition rate to be expected. Project proponents should determine whether the wastewater contains material that is likely to sediment, and assess whether the pond dynamics are such that such sedimentation will occur. Where these conditions occur, an analysis must be carried out as to the rate of this sedimentation. Having verified these conditions, project proponents shouldmeasure the net annual effect of the COD deposition into the sediment of individual ponds at long time intervals because the pond sediment sludge amount accumulates gradually over the years. This is often shown by the historic evidence of gradually shrinking working volumes of the treatment pond(s) in question.

Approach to determine the net annual COD sedimentation in wastewater treatment ponds

A GPS grid of at least 20 sampling points/pond will be put over each pond that is monitored. The distance of the GPS points from the pond bank needs to be at least 2 m. Twice a year (start of season and end of season) the following protocol will be performed:

(a) At each sampling time, determine pond water level height at all four corners of the pond by theodolite against an absolute height reference, ideally a concrete wall (accuracy > +/- 5 mm).

(b) Using an immersible turbidimeter mounted on a calibrated depth probe chain measure the sediment surface height relative to the water surface at the points indicated by the GPS grid.

<u>NOTE</u>: Gas masks/face shields need to be worn for this task due to the risk of H2S poisoning and high temperatures. There is also a high fire risk on the pond surface. Thus under no circumstances can flammable items, cellphones or other equipment that could trigger a spark be brought onto the pond surface. This instruction must be obeyed at all times.

With a rowing boat determine at each GPS point the relative pond water column depth relative to the absolute height reference determined under (a). Calculate the relative increase/decrease in the average sediment height of the pond system twice/year, i.e. at the beginning and the end of a season determining the change in between seasons by calculation.

(c) Obtain a 10 cm diam x 40 cm core of the sediment layer at each GPS point with a core sampler (4 " plastic pipe). Combine the 0-20 cm layer cores and the 20-40 cm layer cores for all 20 points into a large drum. Mix the combined 0-20 cm (fraction A) and 20-40 cm samples (fraction B) with a metal or plastic rod. Take four random sub-samples of each of the two combined samples to determine VSS, TSS and COD. Carry out the sediment composition analysis in an experienced laboratory such as Waste Solutions Ltd, Analytical Laboratory.

(d) Calculate the mean+/- SD for COD, VSS, TSS of each group. Perform a test of statistical significance of any observed changes (t-test, paired) by comparing the paired pre-season/pre-season and paired post-season/ post-season samples for two consecutive years. Any real COD accumulation/deposition trend (if real) must be visible in the paired pre-season/pre-season and paired post-season/ post-season time points. The net COD deposition relative for the methane abatement balance in a season is determined by comparing the net sediment mass (COD, VSS, TSS) in the pond at the beginning of a new season with the previously measured pre-existing net deposition at the beginning of the previous season. It is assumed that the net sediment COD deposition by sedimentation in a steady state situation has the composition of the sediment material of the B-fraction because the B-fraction is the actual accumulating stable end product in the pond sediment.

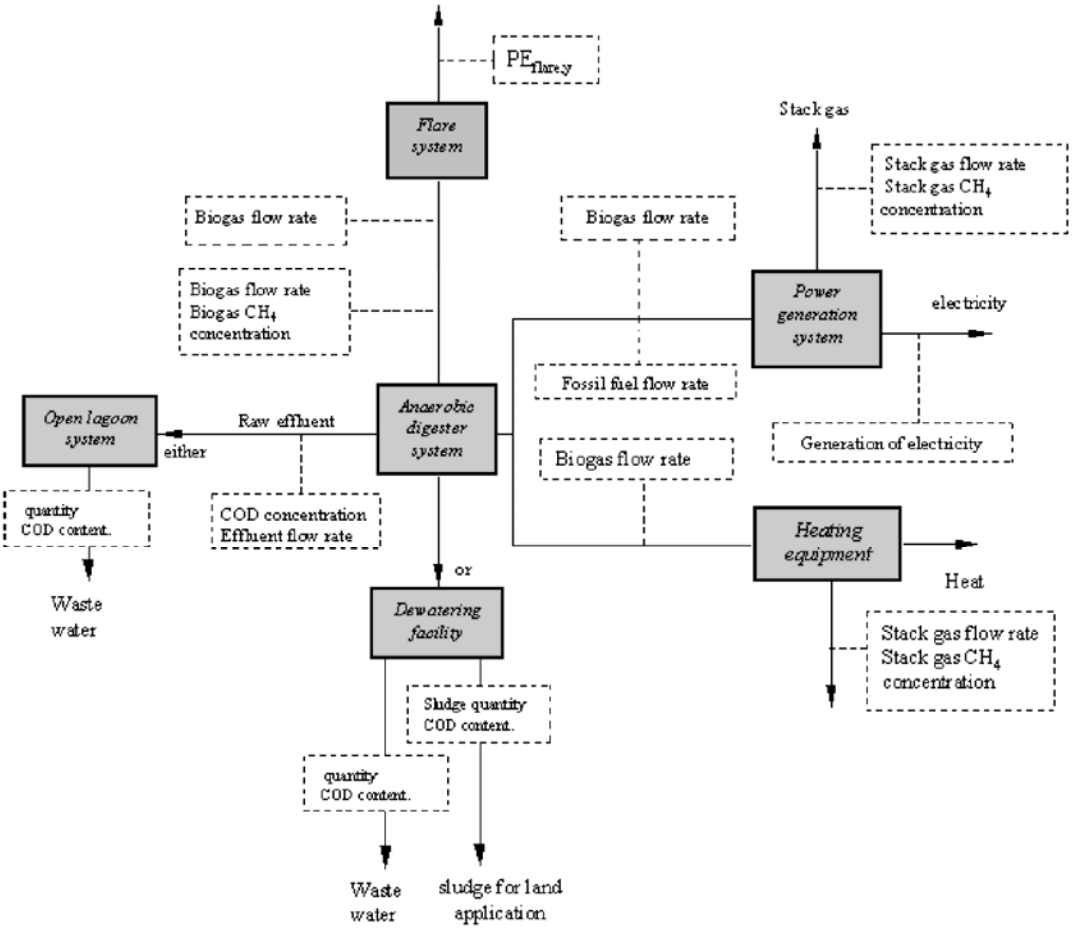
(e) The amount of accumulated sediment COD/pond deposited every year is then determined as follows.

- Determine B-fraction COD content (g COD/g sediment; wet basis))
- Calculate the net accumulated COD in pond (Mg/pond/year) as:

Accumulated COD = [area (m2) x increase (m/year)] x sediment density x COD content B-fraction (gCOD/gwet)

APPENDIX III: Illustration of the parameters to be monitored

The parameters for each of the flows to be monitored are shown in dashed boxes.



Note: in case of scenario 2, option (b) (See Table 1 in the Applicability conditions), the lagoon system takes the place of the anaerobic digester system in the diagram.

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History of the document

Version	Date	Nature of revision
01	EB 36, Annex 14 30 November 2007	Initial adoption