

Affordable and Sustainable Water Recycling through Optimal Technology Integration Project (ASWROTI)

Capital and Operating Cost Estimate of Options (10 ML/d and 100 ML/d)

Limitations	
Purpose	This high level cost estimation was developed to demonstrate novel treatment processes; Option 1 - Sidestream Anammox and Option 2 - Mainstream Anammox, can achieve a water quality fit for recycling at a lower energy/chemical input and reduced capital and operating costs compared to current schemes; Basecase option. The cost estimation was developed for Stage 1: Carbon Removal Processes and Stage 2: Nitrogen Removal Processes of the treatment processes and does not include Stage 3: Polishing Processes. Refer to process flow diagrams for process boundaries.
Accuracy	<i>GHD has prepared</i> cost estimates using information reasonably available to the GHD employee(s) and based on assumptions and judgments made by GHD from recent past similar projects. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified, no detailed quotation has been obtained for costed items. GHD does not represent, warrant or guarantee that the project can or will be undertaken at a cost which is the same or less than the Cost Estimate. Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.
Basis	Greenfield estimate, no retrofit.
Exclusions	Costing was completed on exception & does not include items common/similar to all options. e.g. common items such as Control room, inlet works etc. not costed OPEX Major items excluded: labour, maintenance, operations staff, renewal. CAPEX Major items excluded: inlet works, control room, tertiary treatment, decommissioning.

Reference Material (Attached)	
Cost Estimate	Summary of Capital and Operating Cost Estimate (10ML/d) Summary of Capital and Operating Cost Estimate (100ML/d)
Design Criteria Process Flow Diagrams	Basecase Option Option 1 - Sidestream Anammox Option 2 - Mainstream Anammox
Process Schematics	Basecase Option Option 1 - Sidestream Anammox Option 2 - Mainstream Anammox

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Discount Rate Adopted:	7%
Investment (Base) Year:	2012
Residual Year:	2062
Design Flowrate (ML/d)	10

Summary of Capital and Operating Cost Estimate of Options (10 ML/d)

Option No.	Description of Options	Capital Cost (inc oncosts+contingency) (\$M)	Operating Costs (\$M/y)	NPV (\$M)	Saving compared to Base Case
1	Basecase	\$31	\$1.22	\$48	-
2	Option 1: Sidestream Anammox	\$35	\$0.53	\$43	10%
3	Option 2: Mainstream Anammox	\$36	-\$0.02	\$36	25%

ASWROTI**Summary of Capital and Operating Cost Estimate****Basecase(10ML/d)**

ITEM			CAPEX				
			Qty	Size	Unit Rate	Total	
1.0	Oxidation Ditch with diffused aeration (1no., 9 ML, 4m depth)						\$ 5,055,000
2.0	Clarifier (2no. +standby, 4.1ML per unit, 32m diam, 5m depth)						\$ 3,300,000
3.0	Gravity Drainage Deck (1no. +standby, 84kg/hr)						\$ 300,000
4.0	Aerobic Digester (1no., total 2.02ML)						\$ 3,000,000
5.0	Dewatering Centrifuge (SLR: 67 kg total/hr, 1no. +standby)						\$ 2,936,000
6.0	Polymer Dosing (67 kg/hr to centrifuge + 84 kg/hr to GDD)						\$ 177,000
7.0	Pump Stations (WAS, RAS, Site)						\$ 610,000
8.0	Other items						\$ 3,075,600
8.1		Electrical and control allowance	20%	of process unit cost	\$15,378,000		\$ 3,075,600
Sub-total							\$ 18,454,000
Engineering 20%							\$ 3,700,000
Contingency 50%							\$ 9,300,000
TOTAL							\$ 31,460,000

ITEM			OPEX			
						Total
1.0		Power Consumption				\$ 498,000
						6,800 kWh/day
1.1		Energy per volume treated				680 kWh/ML
2.0		Power Production				\$ -
3.0		Sludge Disposal				\$ 260,000
4.0		Struvite				\$ -
5.0		Chemical Use (polymer)				\$ 40,000
Sub-total						\$ 807,000
Contingency 50%						\$ 404,000
TOTAL						\$ 1,220,000

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Summary of Capital and Operating Cost Estimate

Option 1: Sidestream Anammox(10ML/d)

ITEM		CAPEX					
		Qty	Unit	Size	Unit Rate	Total	
1.0	High Rate Aerobic Tank (A Process - 1 no., total 0.425 ML (100m3 An. 325m3 Aer), 4.5 m depth)						\$ 638,000
2.0	A-Stage Clarifier (1 no. plus standby, 22 m diameter, 5m side depth)						\$ 1,500,000
3.0	B-Stage SBR (2no., total 10.50ML, 4.5 m side depth)						\$ 5,100,000
4.0	Thickening Centrifuge 1 (SLR: 134 kg total/hr, 1no. +standby)						\$ 1,170,000
5.0	Thickening Centrifuge 2 (SLR: 110 kg total/hr, 1no. +standby)						As above
6.0	Two-Phase Anaerobic Digestion (1st - 750 m3, 4.5 m depth, 2nd - 900 m3, 8m depth)						\$ 4,325,000
7.0	Dewatering Centrifuge (81.3 kg/hr, 1no. +standby)						\$ 3,108,800
8.0	Struvite Crystalliser (12 kL system)						\$ 104,000
9.0	Anammox Granular SBR						\$ 375,000
10.0	Pump Stations (WAS (2no., A-stage, B-stage), RAS, Site)						\$ 650,000
11.0	RAS Pump Station						\$ 410,000
11.0	Other items						\$ 3,734,000
11.1	Electrical and control allowance	22%		of process unit cost	\$16,969,856	\$ 3,733,368	
Sub-total							\$ 20,704,000
Engineering 20%							\$ 4,150,000
Contingency 50%							\$ 10,360,000
TOTAL							\$ 35,300,000

ITEM		OPEX		
				Total
1.0	Power Consumption			\$ 292,000
1.1	Energy per volume treated			4,000 kWh/day
				400 kWh/ML
2.0	Power Production			-\$ 140,000
3.0	Sludge Disposal			\$ 190,000
4.0	Struvite			-\$ 59,000
5.0	Chemical Use (polymer & MHS)			\$ 67,000
Sub-total				\$ 352,000
Contingency 50%				\$ 176,000
TOTAL				\$ 528,000

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Summary of Capital and Operating Cost Estimate

Option 2: Mainstream Anammox(10ML/d)

ITEM		CAPEX					Total
		Qty	Unit	Size	Unit Rate		
1.0	High Rate Anaerobic MBR (4 no., total 1.083 ML, 4.5 m depth)						\$ 8,346,000
2.0	Methane Stripping Column (1no., 1.3m3/s)						\$ 600,000
3.0	Nit. Anammox MBBR with Aeration Zone (1no., total 1.38ML)						\$ 2,770,000
4.0	Flocculated Settling Clarifier (1 no. plus standby, 5.0ML per unit, 36 m diameter, 5m side depth)						\$ 2,900,000
5.0	Dewatering Centrifuge (1no. +standby, 45 kg/hr)						\$ 2,504,000
6.0	Pump Stations (WAS, Site)						\$ 300,000
7.0	RAS Pump Station						\$ -
8.0	Other items						\$ 3,659,000
Sub-total							\$ 21,078,000
Engineering						20%	\$ 4,300,000
Contingency						50%	\$ 10,600,000
TOTAL							\$ 35,980,000

ITEM		OPEX		Total
1.0	Power Consumption			\$ 252,000
1.1	Energy per volume treated			3,500 kWh/day
				350 kWh/ML
2.0	Power Production			-\$ 571,700
3.0	Sludge Disposal			\$ 105,200
4.0	Struvite			\$ -
5.0	Chemical Use (ethanol, polymer, alum, MHS)			\$ 204,100
Sub-total				-\$ 10,400
Contingency				50%
TOTAL				-\$ 15,600

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Discount Rate Adopted:	7%
Investment (Base) Year:	2012
Residual Year:	2062
Design Flowrate (ML/d)	100

Summary of Capital and Operating Cost Estimate of Options (100 ML/d)

Option No.	Description of Options	Capital Cost (inc oncosts+contingency) (\$M)	Operating Costs (\$M/y)	NPV (\$M)	Saving compared to Base Case
1	Basecase	\$138	\$9.6	\$270	-
2	Option 1: Sidestream Anammox	\$139	\$4.1	\$196	27%
3	Option 2: Mainstream Anammox	\$136	\$0.7	\$145	46%

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Summary of Capital and Operating Cost Estimate

Basecase (100ML/d)

ITEM		CAPEX					Total
		Qty		Size	Unit Rate		
1.0	Oxidation Ditch with diffused aeration (4no., total 90 ML)						\$ 25,302,000
2.0	Clarifier (11no. +standby, 7.4ML per unit, 43m diam, 5m depth)						\$ 13,100,000
3.0	Gravity Drainage Deck (1 no. +standby, 840kg/hr)						\$ 2,300,000
4.0	Aerobic Digester (2no., total 20.2ML)						\$ 21,000,000
5.0	Dewatering Centrifuge (SLR: 670 kg total/hr, 3no. +standby)						\$ 5,872,000
6.0	Polymer Dosing (670 kg/hr to centrifuge + 840 kg/hr to GDD)						\$ 783,000
7.0	Pump Stations (RAS, WAS, Site, etc.)						\$ 2,429,000
8.0	Other items						\$ 10,618,000
8.1	Electrical and control allowance	15%		of process unit cost	\$70,785,454	\$ 10,617,818	
Sub-total							\$ 81,404,000
Engineering						20%	\$ 16,290,000
Contingency						50%	\$ 40,710,000
TOTAL							\$ 138,410,000

ITEM		OPEX			Total
1.0	Power Consumption				\$ 3,384,000
1.1	Energy per volume treated			58,000 kWh/day	
				580 kWh/ML	
2.0	Power Production				\$ -
3.0	Sludge Disposal				\$ 2,600,000
4.0	Struvite				\$ -
5.0	Chemical Use (polymer)				\$ 391,000
Sub-total					\$ 6,380,000
Contingency				50%	\$ 3,190,000
TOTAL					\$ 9,570,000

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Summary of Capital and Operating Cost Estimate

Option 1: Sidestream Anammox (100ML/d)

ITEM			CAPEX				
Qty	Unit	Size	Unit Rate		Total		
1.0	High Rate Aerobic Tank (A Process - 2 no., total 4.25 ML (1000m3 An. 3250m3 Aer), 4.5 m depth)						\$ 4,000,000
2.0	A-Stage Clarifier (3 no. plus standby, 40 m diameter, 5m side depth)						\$ 5,500,000
3.0	B-Stage SBR (4no., total 105.0ML, 4.5 m side depth)						\$ 26,000,000
4.0	Thickening Centrifuge 1 (SLR: 1340 kg total/hr, 3no. +standby)						\$ 5,436,000
5.0	Thickening Centrifuge 2 (SLR: 1100 kg total/hr, 3no. +standby)						As above
6.0	Two-Phase Anaerobic Digestion (1st - 7500 m3, 4.5 m depth, 2nd - 9000 m3, 8m depth)						\$ 17,915,000
7.0	Dewatering Centrifuge (813 kg/hr)						\$ 6,520,000
8.0	Struvite Crystalliser						\$ 524,000
9.0	Anammox Granular SBR						\$ 1,542,000
10.0	Pump Stations (WAS (2no., A-stage, B-stage), RAS, Site)						\$ 2,590,000
11.0	Other items						\$ 11,905,000
11.1	Electrical and control allowance	17%	of process unit cost	\$ 70,027,000	\$ 11,904,590		
Sub-total						\$ 81,932,000	
Engineering 20%						\$ 16,400,000	
Contingency 50%						\$ 41,000,000	
TOTAL						\$ 139,400,000	

ITEM			OPEX		
			Total		
1.0	Power Consumption		\$	1,774,000	
1.1	Energy per volume treated			30,400 kWh/day	
				304 kWh/ML	
2.0	Power Production		-\$	1,113,000	
3.0	Sludge Disposal		\$	1,898,000	
4.0	Struvite		-\$	588,000	
5.0	Chemical Use (polymer & MHS)		\$	664,000	
Sub-total			\$	2,738,000	
Contingency 50%			\$	1,369,000	
TOTAL			\$	4,107,000	

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Summary of Capital and Operating Cost Estimate

Option 2: Mainstream Anammox (100ML/d)

ITEM		CAPEX					Total
		Qty	Unit	Size	Unit Rate		
1.0	High Rate Anaerobic MBR (4 no., total 10.83 ML, 4.5 m depth)						\$ 31,109,000
2.0	Methane Stripping Column (1no., 1.3m3/s)						\$ 5,100,000
3.0	Nit. Anammox MBBR with Aeration Zone (2no., total 13.8ML)						\$ 17,340,000
4.0	Flocculated Settling Clarifier (7 no. plus standby, 7.14ML per unit, 43 m diameter, 5m side depth)						\$ 9,800,000
5.0	Dewatering Centrifuge (2no. +standby, 450 kg/hr)						\$ 4,404,000
6.0	Pump Stations (WAS, Site)						\$ 501,200
7.0	RAS Pump Station						\$ -
8.0	Site Pump Station						\$ 501,187
9.0	Other items						\$ 11,000,860
9.1	Electrical and control allowance	16%		of process unit cost	\$ 68,755,374	\$ 11,000,860	
Sub-total							\$ 79,757,000
Engineering 20%							\$ 16,000,000
Contingency 50%							\$ 39,900,000
TOTAL							\$ 135,700,000

ITEM		OPEX			Total
1.0	Power Consumption				\$ 1,929,000
1.1	Energy per volume treated			33,100 kWh/day	
				331 kWh/ML	
2.0	Power Production				-\$ 4,573,000
3.0	Sludge Disposal				\$ 1,052,000
4.0	Struvite				\$ -
5.0	Chemical Use (ethanol, polymer, alum, MHS)				\$ 2,041,000
Sub-total					\$ 452,000
Contingency 50%					\$ 226,000
TOTAL					\$ 678,000

Table 1 Assessment Parameters

Criteria	Value
Discount Rate	7%
Assessment period	50 years
Operational site attendance	
10 MLD case	8 hrs/day
100 MLD case	24 hrs/day
Sewage Temperature	22 °C average
Per Capita Flow (L/EP/d)	200
Peak Flow Full Treatment (PFFT)	3 x ADWF
OTR:SOTR	
Bioreactor	0.5
Aerobic digester	0.2
Aeration wire to water efficiency	3 kg.O ₂ /kWh
Electricity cost (import & export)	
10 MLD case	\$0.20/kWh
100 MLD case	\$0.16/kWh
Methane specific energy	55.6 MJ/kg.CH ₄
Cogen gas to power efficiency	39%
Struvite (export)	\$1000/t.DS
Polymer dose rates	
Dewatering centrifuge	7 kg.polymer/t.DS
Thickening	2 kg.polymer/t.DS
Sludge disposal cost	\$80/wet tonne
Chemical costs	
Magnesium (MHS60)	\$500/t
Alum	\$170/t
Polymer	\$7/kg
Ethanol	\$1.70/L
INFLUENT	
COD (mg/L)	650
(g/EP/d)	130
BOD-5 (mg/L)	300
(g/EP/d)	60
TKN (mg/L)	55
(g/EP/d)	11
TP (mg/L)	11
(g/EP/d)	2.2
Alkalinity (mg/L)	300
Calcium (mg/L)	50
Magnesium (mg/L)	40
Readily biodegradable COD (mg/L)	120
VFA (mgCOD/L)	30
Soluble unbiodegradable COD (mg/L)	30
Soluble unbiodegradable organic Nitrogen (mg/L)	1.5
TSS (mg/L)	325
(g/EP/d)	65
VSS (mg/L)	270
VSS/TSS	0.83
EFFLUENT	
TN (mg/L)	5
TP (mg/L)	2
BOD-5 (mg/L)	20
TSS (mg/L)	30
Effluent Class	B
Biosolids Class	B

Table 2 Base Case: 10 ML/day and 100 ML/day

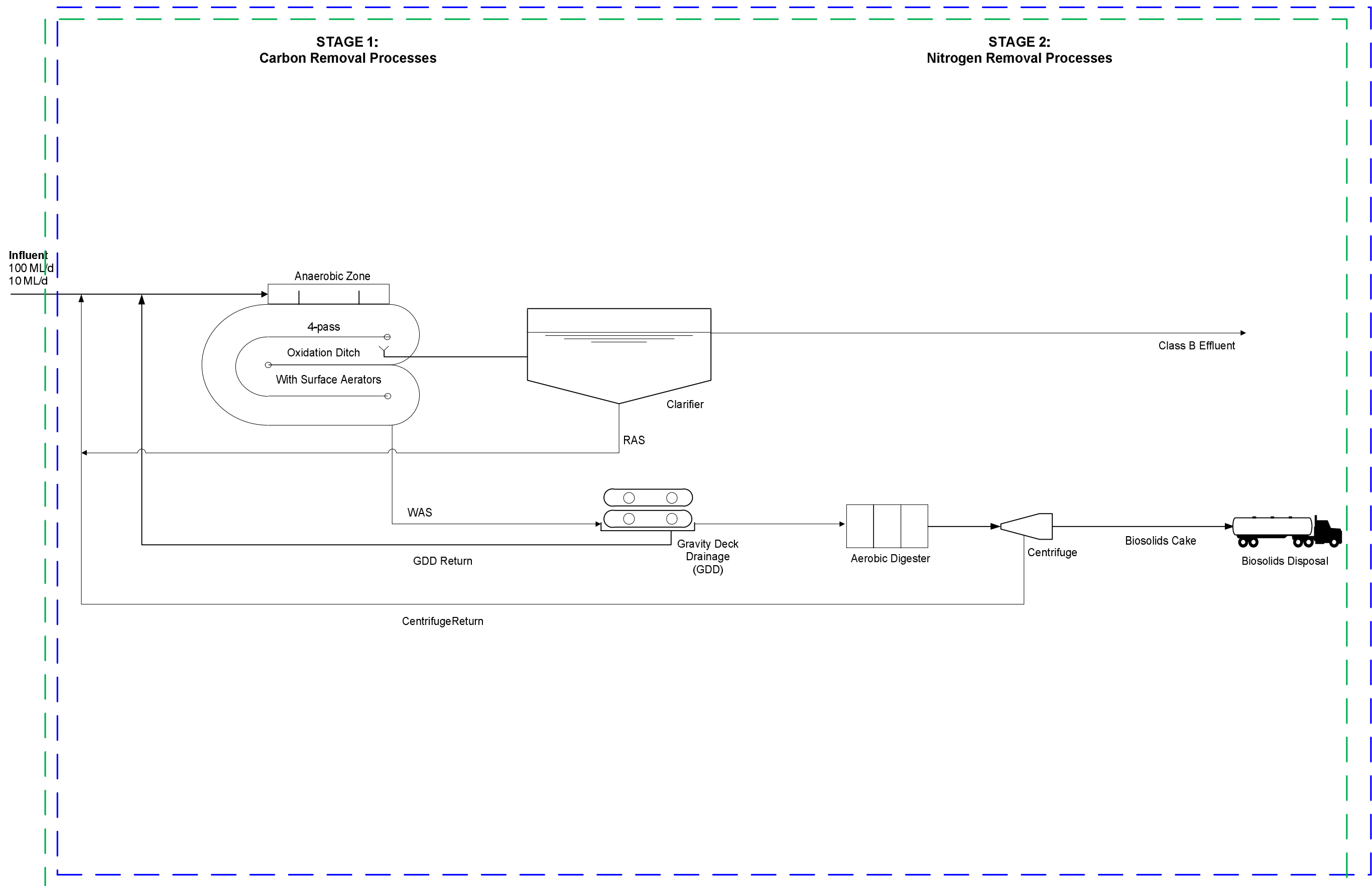
Unit	Design Parameters	
Oxidation Ditch	Units	Value
SRT	d	20
MLSS	mg/L	3500 (average)
HRT	h	24
RAS	% of influent	70 - 100
Circulation velocity	m/s	0.3
Anaerobic Selector Zone Mass Fraction	%	6
Clarifiers	Units	Value
Depth	m	5
Stirred SVI	mL/g	120
Settling Velocity, V_o	m/h	5.4
n	m ³ /kg	0.43
Aerobic Digestion	Units	Value
SRT at 20°C	d	25
VS reduction	%	28
Minimum SOUR @ 20°C	mg O ₂ /hr/g.TS	1.5
Dewatering	Units	Value
Dewatered cake DS	%DS	18

Table 3 Option 1: 10 ML/day and 100 ML/day

Unit	Design Parameters	
High Rate Activated Sludge	Units	Value
SRT	h	12
HRT	h	0.25
RAS	% of influent	70
Primary 'A' Clarifier	Units	Value
Depth	m	4.5
Stirred SVI	mL/g	80
Settling Velocity, V_o	m/h	7.0
n	m ³ /kg	0.34
Anoxic/ Aerobic SBR	Units	Value
SRT	d	20
Cycle time	h	6
Nitrification/Anammox	Units	Value
SRT	d	Infinite
Nitrogen loading	kg.N/m ³ /d	1
HRT	h	24
Sludge yield	kg.SS/d	Insignificant
Effluent NO ₃	% of influent TN	10
Struvite Crystallizer	Units	Value
Type	-	Up-flow fluidised bed reactor
HRT	h	6
Recirculation rate	% of inflow	300
Anaerobic Digestion	Units	Value
Type	-	TPAD (thermophilic primary; mesophilic secondary)
HRT/SRT		
Total	d	13
Primary		3
Secondary		10
Effective volume	%	90
Mixing power	W/m ³	4
Temperature	°C	
Primary		39
Secondary		65
VS destruction	%	55
Dewatering	Units	Value
Dewatered cake DS	%DS	30

Table 4 Option 2: 10 ML/day and 100 ML/day


Unit	Design Parameters	
Anaerobic MBR	Units	Value
COD loading	kg COD/ m ³ .d	6
Solids yield	g VSS/ g COD	0.02
MLSS	g/L	15
VS (or COD) destruction	%	80
Nitrification/Anammox Combined MBBR	Units	Value
SRT	d	Infinite
Media Type	-	AnoxKaldnes
Media fill	%	40
Nitrogen loading	kg.N/m ³ /d	0.5
Sludge yield	kg.SS/d	Insignificant
Effluent NO ₃	% of influent TN	10
MBBR for Denitrification	Units	Value
SRT	d	Infinite
Media Type	-	AnoxKaldnes
Media fill	%	35
Nitrogen loading	kg.N/m ³ /d	0.6
COD dosed	g COD/g NO ³ -N	3
Sludge yield	g SS/g COD dosed	0.35
Clarifiers	Units	Value
Coagulant Dose	Mol Al:Mol P	1.5
Overflow Rate	m ³ /m ² .h	1
Depth	m	5
Dewatering	Units	Value
Dewatered cake DS	%DS	30

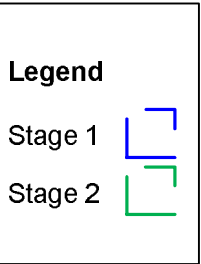
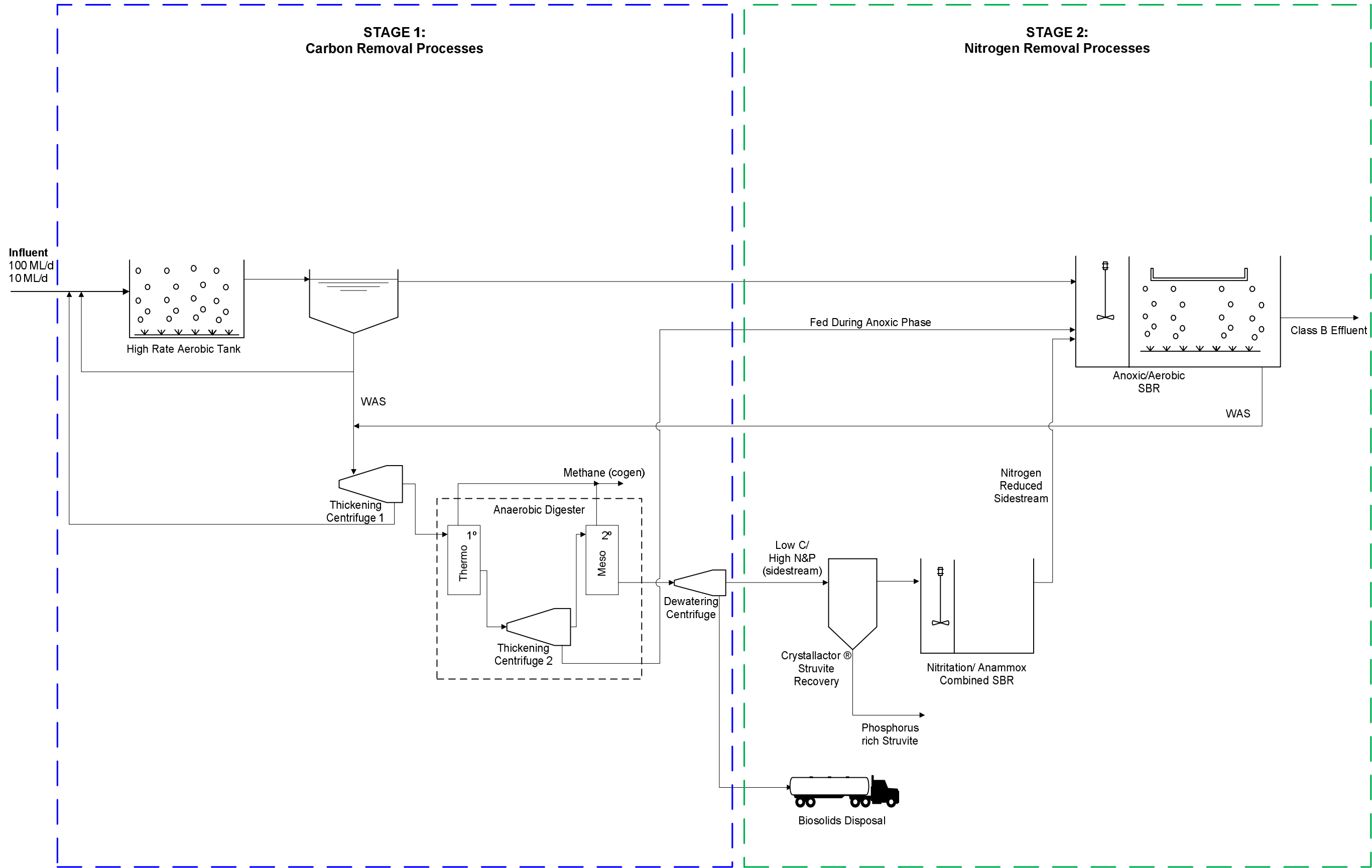



Legend

Stage 1 ┌

Stage 2 ┌

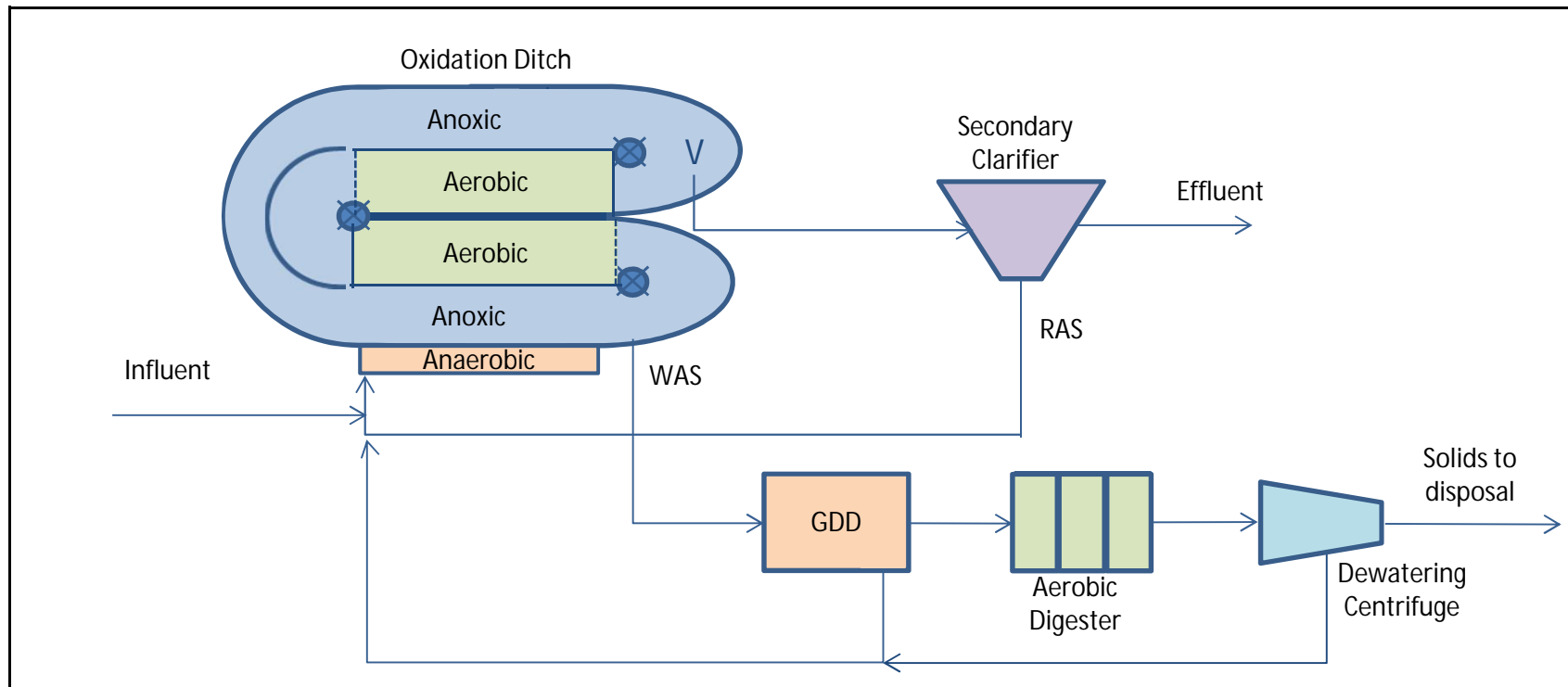
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						Date:	25/02/2013		Rev. No.	A



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						Approved:			
						Date:	25/02/2013	Drawing No.	Rev. No.

ASWROTI: Basecase Option (10ML/d & 100ML/d)

Process Flow Schematic



ASWROTI: Option 2 (100ML/d and 10ML/d)

Process Flow Schematic

