EVOQUA WATER TECHNOLOGIES LLC

Lyons, GA WWTP Upgrade
DAVCO BIOLOGICAL TREATMENT SYSTEMS
PRELIMINARY DESIGN SUMMARY
March 24, 2016

Rev No: 0
Prep By: Mike Bennett
Proposal #: 120142-A05B

I. DESIGN BASIS:

Total Design Flow: 1.100 MGD
Design Flow/FETP (Q): 1.100 MGD
Peaking Factor: 2.0
Total Peak Flow: 2.200 MGD
Peak Flow/FETP: 2.200 MGD

	Influent	
	Conc. (mg/L)	Load/FETP (lbs/day)
BOD	350	3,211
TSS	350	3,211
NH3-N	30	275
TKN	45	413
NO3-N	--	--
TP	10	92

	Secondary Clarifier Effluent		
	Conc. (mg/L)	Expected (mg/L)	
CBOD	20.0	< 20.0	
TSS	20.0	< 20.0	
NH3-N	1.0	< 1.0	
TN	3.0	< 3.0	*
NO3-N		not req'd	
TP	1.0	< 1.0	*

** Chemical addition and/or filtration may be required.*

Maximum Water Temperature: 25 °C 77 °F
Minimum Water Temperature: 15 °C 59 °F
Site Elevation: 180 ft. MSL
Use NO3 or TN for design? TN
Effluent N Conc. for Design: 3.0 mg/L

II. PROCESS ASSUMPTIONS & VARIABLES:

Influent VSS Fraction: 80%
Design MLSS: 3,500 mg/L
% MLVSS: 75%
Design MLVSS: 2,625 mg/L
Biosolids Yield Factor: 0.65 lbsVSS/lbsBOD
Design DO Conc: 2.0 mg/L
RAS Rate, %Q: 50%
Anoxic Recycle Ratio to Q: 3
Anoxic DO: 0.1 mg/L
Max Water Level (Bio): 19.000 ft
Freeboard (Bio): 1.500 ft

Recommended Clarifier Hydraulic Loading: 1,000 gpd/ft2 (at Peak flow)

III. PROCESS DESIGN PARAMETERS:

Anaerobic Basin 30.0 °

Number of Anaerobic Basins:	3	Anaerobic Volume per Basin:	47,988 gallons
Total Anaerobic Volume:	143,964 gallons	Total Anaerobic HRT:	3.1 hours @ Q

Pre-Anoxic Basin 38.0 °

Number of Pre-Anoxic Basins:	2	Pre-Anoxic Volume per Basin:	91,176 gallons
Pre-Anoxic Volume:	182,352 gallons	Pre-Anoxic HRT:	4.0 hours @ Q

Aeration Basin 218.0 °

Number of Aeration Basins:	1	Aerobic Volume per Basin:	1,046,130 gallons
Total Aerobic Volume:	1,046,130 gallons	AOR:	5,053 lbs. O2/day
Aerobic SRT:	11.6 days	SOR:	13,232 lbs. O2/day*
Aerobic HRT:	22.8 hours @ Q	Air Flow Required:	1,631 SCFM*
BOD Loading:	23.0 lbs BOD/1000cf/day	Aeration Diffuser Type:	Fine Bubble
Aerobic F/M:	0.140 lbs BOD/lbs MLVSS	**Diffuser supplier to confirm SOR/SCFM values at final design*	

Post-Anoxic Basin 74.0 °

Number of Post-Anoxic Basins:	1	Post-Anoxic HRT:	6.96 hours @ Q
Total Post-Anoxic Volume:	319,118 gallons		
Post-Anoxic Volume per Basin:	319,118 gallons		

Re-Aeration Basin

Number of Re-Aeration Basins:	1	Re-Aeration Volume per Basin:	35,991 gallons
Re-Aeration Volume:	35,991 gallons	Air Flow Required:	145 SCFM*
Re-Aeration HRT:	0.7852582 hours @ Q	**Assumes 30 SCFM/1000 cuft & coarse bubble*	

Secondary Clarifier

Clarifier Diameter:	62.00 feet	Surface Overflow Rate:	364 gpd/ft^2 (avg)
Sludge Production:	2,537 lbs/day		729 gpd/ft^2 (peak)
Clarifier Surface Area:	3,019.1 ft^2	Solids Loading Rate:	16 lb/day/ft^2 (avg)
Total Clarifier Volume:	362,170 gallons		32 lb/day/ft^2 (peak)

Tank Sizing & Air Flow

Plant O.W. Diameter:	139.00 feet	Total SCFM Required*:	1,776 SCFM
Plant I.W. Diameter:	62.00 feet	**Excluding Airlifts*	74 SCFM
Bulkhead Length:	38.50 feet	Total SCFM w/ Airlifts	1,850 SCFM
Total Bio Process (no EQ) Volume:	1.728 MG		

Note: In order to guarantee the process, all values for Design Basis, Process Assumptions and Process Parameters must be verified by Owner/Consultant prior to final design.

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DESIGN CALCULATIONS
March 24, 2016

I. DESIGN BASIS:

Total Design Flow:	1.100 MGD	Peaking Factor:	2.00	Total Peak Flow:	2.200 MGD
Design Flow (Q):	1.100 MGD			Peak Flow (Q_{pk}):	2.200 MGD

Influent		Secondary Clarifier Effluent
BOD_{in} = 350 mg/L	$BOD_{\#}$ = 3211 lb/day	$CBOD_{ef}$ = < 20.0 mg/L
TSS_{in} = 350 mg/L	$TSS_{\#}$ = 3211 lb/day	TSS_{ef} = < 20.0 mg/L
$NH3\text{-}N_{in}$ = 30.0 mg/L	$NH3\text{-}N_{\#}$ = 275 lb/day	$NH_3\text{-}N_{ef}$ = < 1.0 mg/L
TKN_{in} = 45.0 mg/L	$TKN_{\#}$ = 413 lb/day	TN_{ef} = < 3.0 mg/L
$NO3\text{-}N_{in}$ = --	$NO3\text{-}N_{\#}$ = --	$NO_3\text{-}N_{ef}$ = Not Required
TP_{in} = 10 mg/L	$TP_{\#}$ = 92 lb/day	TP_{ef} = < 1.0 mg/L
Maximum Temperature:	25 °C 77 °F	Site Elevation: 180 ft. MSL
Minimum Temperature:	15 °C 59 °F	

II. PROCESS ASSUMPTIONS

* All design characteristics, assumptions and calculations shall be verified by Client/Consulting Engineer prior to final design.
* The Influent will be free from grit, trash and large objects by an upstream headwork structure (by others).
* The Influent is defined as the raw sewage plus any sidestreams, such as sludge dewatering or plant drains, but before RAS or internal recycle.
* Sufficient nutrients (e.g., N and P) and alkalinity shall be available from influent or supplied by others to support adequate biological conditions
* No inhibitory/toxic compounds or conditions that may be detrimental to adequate biological conditions are present.
* The entire influent BOD is available for utilization as food.
* Air calculations shall be verified by diffuser manufacturer prior to final design.
* Sufficient readily biodegradable (soluble) COD (or volatile fatty acids) and magnesium, potassium, and calcium are present in the Influent.
* Minimal levels of DO (< 0.5 mg/L) and nitrate enter the anaerobic zone.
* Sludge is NOT held under anaerobic conditions causing phosphorus release.
* Stand-by chemical feed is strongly recommended for Effluent TP ≤ 1.0 mg/L; provided by Others.
* Tertiary Filtration is typically required for Effluent TP ≤ 1.0 mg/L.
* The TKN in the influent is 94% hydrolyzed to ammonia in the aeration tank and ammonia is 100% nitrified.
* The Influent Total Refractory Organic Nitrogen concentration is < 1.5 mg/L.
* Nitrate concentration in the RAS stream is same as that in the Effluent.
* The influent BOD/TKN ratio is ≥ 6.
* Post-Anoxic denitrification is achieved endogenously, no external carbon source is used.
* Stand-by supplemental carbon feed for Post-Anoxic is recommended; provided by Others.

III. PROCESS VARIABLES:

Influent VSS Fraction "VSS":	80%	Design DO Conc:	2.0 mg/L
Design MLSS:	3,500 mg/L	RAS Rate, 'R' as %Q:	50%
% MLVSS:	75%	Anoxic Recycle Ratio 'IR' to Q:	3
Design MLVSS:	2,625 mg/L	Anoxic Recycle DO:	0.1 mg/L
Biosolids Yield Factor "Y":	0.65 lbsVSS/lbsBOD/d	Max Water Level:	19 ft.
Suggested Clarifier Hydraulic Loading:	1,000 gdp/ft2 (peak - design)	Diffuser Elevation:	1 ft.

IV. PROCESS DESIGN CALCULATIONS:

Anaerobic Basin Volume

The flow into the Anaerobic Selector/Zone (Q_{an}) = Influent Flow (Q) =	1.100 MGD
Therefore, Q_{an} =	45,833 gallons/hour
The design HRT for the Anaerobic Zone =	3.1 hours
Therefore, the Total Anaerobic Selector/Zone Volume =	143,964 gallons

Pre-Anoxic Basin Volume

Assuming 94% influent TKN will be hydrolyzed to ammonia, then 100% nitrified.

Thus, the potential nitrate-N concentration, NO_x = TKN_{in} * 0.94 =	42.3 mg/L
The Mixed Liquor Recycle Stream Nitrate-N concentration, N_{ir} = $NO_x/(1+R+IR)$ =	9.4 mg/L

Reference: Metcalf & Eddy, 4th ed., Eq 8-48

The Mixed Liquor Recycle Stream Flow Q_{ir} = Q * IR = 3.30 MGD

The Nitrate-N Load to the Pre-Anoxic Zone $N_{in1} = ((N_{ir} * Q_{ir})+(N_{ef}*Q_{ras})) * 8.34$ =	272.5 lbs/day
Assuming WAS contains 6% N, then the amount of N removed in WAS, $N_{was} = (BOD_{in}-BOD_{ef})*Y*Q* 0.06$ =	118.1 lbs/day
Therefore, the N to be denitrified in the Pre-Anoxic Zone $N_{dn1} = N_{in1} - N_{was}$ =	154.4 lbs/day
Typical specific denitrification rate using wastewater as carbon source, U_{dn}=	0.100 lbsNO3-N/lbsMLVSS/day
	Reference: Metcalf & Eddy, 3rd ed., Table 11-19
The Overall Denitrification Rate in the Pre-Anoxic Zone, corrected for temperature and DO, $ODNR_{pre}$ =	0.058 lbsNO3-N/lbsMLVSS/day
Where $ODNR_{pre} = (U_{dn} * 1.09^{(T-20)}) * (1-DO)$	
	Reference: Metcalf & Eddy, 3rd ed., Eq 11-6
Therefore,the Recommended Pre-Anoxic Volume, $V_{anx1r} = N_{dn1}/(ODNR_{pre} * MLVSS * 8.34)$ =	120,570 gallons
	Reference: Metcalf & Eddy, 4th ed., Eq 8-41
Total Design Pre-Anoxic Volume, $V_{anx1} = V_{anx1r} * SF$ =	182,352 gallons
Where Safety Factor (SF) =	1.512
At Average Daily Flow, the Pre-Anoxic HRT =	4.0 hours

Aerobic Basin Volume

The Specific Growth Rate of Nitrifiers, $U_n = (U_{nmax}*NH3_e)/(K_n+NH3_e))*(DO/(K_o+DO))-k_d$ =	0.206 $days^{-1}$
	Reference: Metcalf & Eddy, 4th ed., Eq 7-93
Given the temperature corrected constants of:	
U_{nmax} =	0.535
K_n =	0.572
K_o =	0.500
k_d =	0.066
	Reference: Metcalf & Eddy, 4th ed., Table 8-11
The Minimum Aerobic Solids Retention Time, $SRT_{min} = 1/U_n$ =	4.84 days
The Design Aerobic Solids Retention Time, $SRT = SRT_{min} * SF$ =	11.64 days
Where SF = Safety Factor =	2.40
	Reference: Metcalf & Eddy, 4th ed., Eq 7-37 & Eq 7-71
Biomass Formed, $dXv = (BOD_{in}-BOD_{ef})*Y*Q$ =	1,968 lbs/day
The required aerobic biomass inventory, $MLVSS_{\#} = dXv*SRT$ =	22,902 lbs
The total aerobic volume required $V_{ae} = MLVSS/(MLVSS_{\#} * 8.34)$ =	1,046,130 gallons
At Average Daily Flow, the Aerobic HRT =	22.8 hours

Aerobic Basin Air Calcs

Oxygen required for BOD oxidation =	1.25 lbs O_2/lbs BOD
Oxygen required for TKN oxidation =	4.60 lbs O_2/lbs TKN
Oxygen credit for Denitrification =	2.86 lbs O_2/lbs NO3-N
Actual Oxygen Required, AOR = (BOD# * 1.25) + (TKN# * 4.6) - (NO3-N# * 2.86) =	5,053 lbs O_2/day
Standard Oxygen Rate, $SOR = \frac{AOR * C_s}{a * (\beta C_{sd} - DO) * \emptyset^{(T-20)}}$ =	13,232 lbs O_2/day
	551 lbs O_2/hr
Where:	
C_s = DO Saturation conc at Standard Conditions =	11.10
a = Mass Transfer Correction Factor =	0.50
ß = Wastewater Conversion Factor =	0.95
C_{sd} = DO Saturation conc corrected for Temp & Elevation =	10.03
Ø = Oxygen Transfer Coefficient =	1.024
T = Maximum Design Temperature =	25 °C
DO = Design residual dissolved oxygen concentration =	2.0
	Reference: Metcalf & Eddy, 4th ed., Equation 5-55
SCFM = (SOR * C_d)/%Eff =	1,631 SCFM
Where C_d = (1 hr/60 min)*(1mol O_2/32 lbs O_2)*(100 mol Air/21 mol O_2)*(385 cuft Air/mol Air) =	0.955
Where Fine Bubble %Eff = (Max SWD - Diffuser Elevation) * 1.8 =	32.40 %

Post-Anoxic Basin Volume

The Nitrate-N Load to the Post-Anoxic Zone N_{in2} = = $N_{ir} * (Q + Q_{ras}) * 8.34$ =	129 lbs/day
The Nitrate-N Load Leaving in the Effluent = $N_{eff} = N_{ef} * Q * 8.34$ =	28 lbs/day
N to be denitrified in the Post-Anoxic Zone $N_{dn2} = N_{in2} - N_{eff}$ =	102 lbs/day
Typical denitrification rate using Endogenous carbon source, Udnpst=	0.050 lbsNO3-N/lbsMLVSS/day
	Reference: Metcalf & Eddy, 3rd ed., Table 11-19
The Overall Denitrification Rate in the Post-Anoxic Zone, corrected for temperature and DO, $ODNR_{pst}$ =	0.029 lbsNO3-N/lbsMLVSS/day
Where $ODNR_{pst} = (U_{dnpst} * 1.09^{(T-20)}) * (1-DO)$	
	Reference: Metcalf & Eddy, 3rd ed., Eq 11-6
Therefore,the Recommended Post-Anoxic Volume, $V_{anx2r} = N_{dn2}/(ODNR_{pst} * MLVSS * 8.34)$ =	159,040 gallons
	Reference: Metcalf & Eddy, 3rd ed., Eq 8-45
Total Design Post-Anoxic Volume, $V_{anx2} = V_{anx2r} * SF$ =	319,118 gallons

Note: In order to guarantee the process, all values for Design Basis, Process Assumptions and Process Parameters must be verified by Owner/Consultant prior to final design.

Where Safety Factor (SF) = 2.007
At Average Daily Flow, the Post-Anoxic HRT = 7.0 hours

Note: In order to guarantee the process, all values for Design Basis, Process Assumptions and Process Parameters must be verified by Owner/Consultant prior to final design.