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-A04B

I. DESIGN BASIS:

Total Design Flow: 0.400 MGD
Design Flow/FETP (Q): 0.400 MGD
Peaking Factor: 2.0
Total Peak Flow: 0.800 MGD
Peak Flow/FETP: 0.800 MGD

	Influent	
	Conc. (mg/L)	Load/FETP (lbs/day)
BOD	350	1,168
TSS	350	1,168
NH3-N	30	100
TKN	45	150
NO3-N	--	--
TP	10	33

	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): 15.250 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:	17,420 gallons
Total Anaerobic Volume:	52,260 gallons	Total Anaerobic HRT:	3.1 hours @ Q

Pre-Anoxic Basin 38.0 °

Number of Pre-Anoxic Basins:	2	Pre-Anoxic Volume per Basin:	33,099 gallons
Pre-Anoxic Volume:	66,198 gallons	Pre-Anoxic HRT:	4.0 hours @ Q

Aeration Basin 218.0 °

Number of Aeration Basins:	1	Aerobic Volume per Basin:	379,764 gallons
Total Aerobic Volume:	379,764 gallons	AOR:	1,838 lbs. O2/day
Aerobic SRT:	11.6 days	SOR:	4,861 lbs. O2/day*
Aerobic HRT:	22.8 hours @ Q	Air Flow Required:	757 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:	6.95 hours @ Q
Total Post-Anoxic Volume:	115,845 gallons		
Post-Anoxic Volume per Basin:	115,845 gallons		

Re-Aeration Basin

Number of Re-Aeration Basins:	1	Re-Aeration Volume per Basin:	13,065 gallons
Re-Aeration Volume:	13,065 gallons	Air Flow Required:	53 SCFM*
Re-Aeration HRT:	0.7839 hours @ Q	**Assumes 30 SCFM/1000 cuft & coarse bubble*	

Secondary Clarifier

Clarifier Diameter:	45.00 feet	Surface Overflow Rate:	252 gpd/ft^2 (avg)
Sludge Production:	922 lbs/day		503 gpd/ft^2 (peak)
Clarifier Surface Area:	1,590.4 ft^2	Solids Loading Rate:	11 lb/day/ft^2 (avg)
Total Clarifier Volume:	154,767 gallons		22 lb/day/ft^2 (peak)

Tank Sizing & Air Flow

Plant O.W. Diameter:	95.00 feet	Total SCFM Required*:	810 SCFM
Plant I.W. Diameter:	45.00 feet	**Excluding Airlifts*	40 SCFM
Bulkhead Length:	25.00 feet	Total SCFM w/ Airlifts	850 SCFM
Total Bio Process (no EQ) Volume:	0.627 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:	**0.400 MGD**	**Peaking Factor: 2.00**		**Total Peak Flow:**	**0.800 MGD**
Design Flow (Q):	**0.400 MGD**			**Peak Flow (Q_{pk}):**	**0.800 MGD**

Influent		Secondary Clarifier Effluent
BOD_{in} = 350 mg/L	**$BOD_{\#}$ = 1168 lb/day**	**$CBOD_{ef}$ = < 20.0 mg/L**
TSS_{in} = 350 mg/L	**$TSS_{\#}$ = 1168 lb/day**	**TSS_{ef} = < 20.0 mg/L**
$NH3\text{-}N_{in}$ = 30.0 mg/L	**$NH3\text{-}N_{\#}$ = 100 lb/day**	**$NH_3\text{-}N_{ef}$ = < 1.0 mg/L**
TKN_{in} = 45.0 mg/L	**$TKN_{\#}$ = 150 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	**$TP_{\#}$ = 33 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:**	**15.25 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) =	0.400 MGD
Therefore, Q_{an} =	16,667 gallons/hour
The design HRT for the Anaerobic Zone =	3.1 hours
Therefore, the Total Anaerobic Selector/Zone Volume =	52,260 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 $Q_{ir} = Q * IR$ = 1.20 MGD

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.

The Nitrate-N Load to the Pre-Anoxic Zone $N_{in1} = ((N_{ir} * Q_{ir})+(N_{ef}*Q_{ras})) * 8.34$ =	99.1	lbs/day
Assuming WAS contains 6% N, then the amount of N removed in WAS, $N_{was} = (BOD_{in}-BOD_{ef})*Y*Q* 0.06$ =	42.9	lbs/day
Therefore, the N to be denitrified in the Pre-Anoxic Zone $N_{dn1} = N_{in1} - N_{was}$ =	56.1	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, $V_{anx1r} = N_{dn1}/(ODNR_{pre} * MLVSS * 8.34)$ =	43,843	gallons
	Reference: Metcalf & Eddy, 4th ed., Eq 8-41	
Total Design Pre-Anoxic Volume, $V_{anx1} = V_{anx1r} * SF$ =	66,198	gallons
Where Safety Factor (SF) =	1.510	
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, $SRT = SRT_{min} * SF$ =	11.62	days
Where SF = Safety Factor =	2.40	
	Reference: Metcalf & Eddy, 4th ed., Eq 7-37 & Eq 7-71	
Biomass Formed, $dXv = (BOD_{in}-BOD_{ef})*Y*Q$ =	716	lbs/day
The required aerobic biomass inventory, $MLVSS_{\#} = dXv*SRT$ =	8,314	lbs
The total aerobic volume required $V_{ae} = MLVSS/(MLVSS_{\#} * 8.34)$ =	379,764	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) =	1,838	lbs O_2/day
Standard Oxygen Rate, $SOR = \frac{AOR * C_s}{a * (\beta C_{sd} - DO) * \emptyset^{(T-20)}}$ =	4,861	lbs O_2/day
	203	lbs O_2/hr
Where:		
C_s = DO Saturation conc at Standard Conditions =	10.70	
a = Mass Transfer Correction Factor =	0.50	
ß = Wastewater Conversion Factor =	0.95	
C_{sd} = DO Saturation conc corrected for Temp & Elevation =	9.67	
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 =	757	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 =	25.65	%

Post-Anoxic Basin Volume

The Nitrate-N Load to the Post-Anoxic Zone N_{in2} = = $N_{ir} * (Q + Q_{ras}) * 8.34$ =	47	lbs/day
The Nitrate-N Load Leaving in the Effluent = $N_{eff} = N_{ef} * Q * 8.34$ =	10	lbs/day
N to be denitrified in the Post-Anoxic Zone $N_{dn2} = N_{in2} - N_{eff}$ =	37	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, $V_{anx2r} = N_{dn2}/(ODNR_{pst} * MLVSS * 8.34)$ =	57,833	gallons
	Reference: Metcalf & Eddy, 3rd ed., Eq 8-45	
Total Design Post-Anoxic Volume, $V_{anx2} = V_{anx2r} * SF$ =	115,845	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) = 2.003
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.