APPENDIX N

SBR DESIGN SPREADSHEET MODEL
AND
ACTIVATED SLUDGE SPREADSHEET MODEL

City of Woodland
General Sewer Plan

SBR Design Spreadsheet Model

Parameter	Recent (2009-13) Annual Avg.	Projected 2033	Maximum Capacity	Comments
Max Month Flow, MGD	**0.504**	**0.960**	**2.000**	
BOD, mg/L	271	279	159	
BOD, lb/day	**1141**	**2237**	**2650**	
sBOD, lb/day	251	492	583	
COD, lb/day	2510	4921	5830	
bCOD, lb/day	1826	3579	4240	
sCOD, lb/day	552	1083	1283	
TSS, mg/L	335	325	189	
TSS, lb/day	**1407**	**2602**	**3160**	
VSS, lb/day	1126	2082	2528	
TKN, mg/L	50	51	30	
TKN, lb/day	**209**	**405**	**500**	
Inert TSS, mg/L	281	520	632	
nbVSS, lb/day	307	568	689	
Temperature, C	10	10	10	Winter design temp = 10C, summer design temp = 22C
Elevation, ft	30	30	30	
Kinetic and Stoichiometric Values				
Influent VSS/TSS ratio	0.80	0.80	0.8	
Influent COD/BOD5 ratio	2.20	2.20	2.20	Typical value
Influent bCOD/BOD5 ratio	1.60	1.60	1.60	
Influent sBOD5/BOD5 ratio	0.22	0.22	0.22	
Influent sCOD/COD ratio	0.22	0.22	0.22	
Influent rbCOD/COD ratio	0.155	0.155	0.155	
Influent NH4/TKN ratio	0.67	0.67	0.67	
Y (lb VSS/lb bCOD)	0.45	0.45	0.45	M&E, 5th Ed., Table 8-14
kd(20) (1/d)	0.12	0.12	0.12	M&E, 5th Ed., Table 8-14
kd(T) (1/d)	0.081	0.081	0.081	[kd(20)] * (1.04 ^ ([T]-20))
f-d	0.15	0.15	0.15	M&E, 5th Ed., Table 8-14
Yn (lb VSS/lb TKN)	0.15	0.15	0.15	M&E, 5th Ed., Table 8-14
Un-max(20)	0.9	0.9	0.9	M&E, 5th Ed., Table 8-14

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Un-max(T)	0.449	0.449	0.449	[Umax(20)] * (1.072 ^ ([T]-20))
kdn(20) (1/d) (Aerobic)	0.17	0.17	0.17	M&E, 5th Ed., Table 8-14
kdn(T) (1/d) (Aerobic)	0.128	0.128	0.128	[kdn(20)] * (1.029 ^ ([T]-20))
kdn(20) (1/d) (Anoxic)	0.07	0.07	0.07	M&E, 5th Ed., Page 777
kdn(T) (1/d) (Anoxic)	0.053	0.053	0.053	[kdn(20)] * (1.029 ^ ([T]-20))
kdn(T) (1/d) (Cycle Avg.)	0.090	0.090	0.090	
MLSS NH4 (mg/L)	1	1	1	
MLSS DO (mg/L)	2	2	2	
KsNH4(20) (mg/L)	0.5	0.5	0.5	M&E, 5th Ed., Table 8-14
KsNH4(T) (mg/L)	0.50	0.50	0.50	[KsNH4(20)] * (1.0 ^ ([T]-20))
KsDO (mg/L)	0.5	0.5	0.5	M&E, 5th Ed., Table 8-14
Unet(T)	0.15	0.15	0.15	{Umax(T)*([NH4]/([NH4]+KsNH4(T)))*([DO]/([DO]+KsDO))}-kd
EFFLUENT CRITERIA				
Effluent BOD, mg/L	10	10	10	
Effluent TSS, mg/L	10	10	10	
Effluent NH4-N, mg/L	1	1	1	
PHYSICAL LAYOUT				
Number of Tanks	2	3	3	
Min. Liquid Depth, ft	13	13	13	
Max. Liquid Depth, ft	21	21	21	
Min. Volume per Tank, MG	0.348	0.348	0.348	
Max. Volume per Tank, MG	0.562	0.562	0.562	
OPERATIONAL DESIGN				
# of Cycles/day	4	5	5	
Cycle Time, Tc,hr	6.0	4.8	4.8	
Select Fill/Denit Time, Tf,hr	1.25	0.45	0.45	
Select Fill/Aerate Time, Tfa,hr	1.75	1.15	1.15	
React/Aerate Time, Ta, hr	1.25	1.25	1.25	
Settle Time, Ts, hr	0.92	0.95	0.95	
Decant Time, Tw, hr	0.83	1.00	1.00	
Idle Time, Ti, hr	0.00	0.00	0.00	
Total Fill time, hr	3.00	1.60	1.60	
Total Aeration time, hr	3.00	2.40	2.40	

Parameter	Recent (2009-13) Annual Avg.	Projected 2033	Maximum Capacity	Comments
INITIAL DESIGN CRITERIA				
Max High water MLSS, mg/L	3000	3000	3000	G&O Design Criteria based on Operational History
Design Max SVI, ml/g	155	155	155	90%ile SVI at Woodland = 152
Selected max. decant fraction	33%	33%	33%	From Figure 8-21, M&E 5th Ed. (4000 mg/L & SVI=155)
RESULTS				
Total Cycles per Day	8	15	15	
Fill Volume per Cycle, MG	0.063	0.064	0.1333	
Fill Vol/Total Vol	11%	11%	24%	
Min. Volume per Tank, MG	0.499	0.498	0.429	
Min. Water Level, ft	18.6	18.6	16.0	
HRT at Max. Volume, hr	53.5	42.1	20.2	
Max. Sludge Mass per tank, lbs	14058	14058	14058	At max level
Oxic Phase Design				
Min Aerobic SRT (calc) (d)	6.70	6.70	6.70	1 / [Unet(T)]
Min Aerobic SRT (safety) (d)	8.4	8.4	8.4	[SRT (calc)] * 1.25
SRT (design) (d)	28.7	21.5	17.28	
SRT (design) (d)	**28.7**	**21.5**	**17.28**	Iterated with Px-TSS to match mass
Aerobic SRT (design) (d)	**14.4**	**10.8**	**8.6**	Based on ratio of aerated to total cycle time
Effl sbCOD (mg/L)	8	8	8	
Effl sbCOD S-o (lb/day)	34	64	133	[Effl sbCOD] * [Q] * 8.34)
Effl TKN (mg/L)	3	3	3	
WAS Org-N (lb/day)	40.0	89.1	114.1	
TKN-ox (lb/day) (calc'd)	156.4	291.9	336	
TKN-ox (lb/day) (iter.)	156.4	291.8	336	[Infl TKN] - ([Effl TKN] * [Q] * 8.34)
Px (lb TSS/day)	**981**	**1961**	**2440**	
Px-VSS (lb VSS/day)	641	1310	1641	$\frac{[Y]*([\text{Infl bCOD}]-[\text{Effl sbCOD}])}{(1+([k_{d(T)}]*[SRT]))*v}+\frac{[f_d]*[k_{d()}]*[Y]*([\text{Infl bCOD}]-[\text{Effl sbCOD}])*[\text{SRT}]}{(1+([k_{d(T)}]*[SRT]))*v}+\frac{[Y_n]*[TKN_{ox}]}{(1+([k_{dN(T)}]*[SRT]))*v}+[nbVSS]+[iTSS]$
Px-bio (lb VSS/day)	333.5	742.3	951	
MLVSS (mg/L)	1961	2004	2017	
MLVSS/MLSS ratio	0.65	0.67	0.67	
TKN-ox per cycle (lb)	19.6	19.5	22.4	
NH4 left after decant (lb)	4	4	4	
Initial NH4 conc (mg/L)	5.1	5.0	5.5	
Nitrifier conc (mg/L)	40	68	73	
Min. aeration time (hr)	1.22	0.71	0.74	

Parameter	Recent (2009-13) Annual Avg.	Projected 2033	Maximum Capacity	Comments
Px {A}	242	577	770	
Px {B}	85	151	162	
Px-N {C}	6.5	14.9	19.7	
Px {nbVSS}	307	568	689	
Px {iTSS}	281	520	632	
Denitification Design (Pre-Denit in Mixed Fill Phase)				
Effluent Nitrate conc. (mg/L)	4.2	4.2	4.8	
Nitrate after decant (lbs/cycle)	17.4	17.2	17.1	
Xb biomass conc. (mg/L)	742	882	946	
F/Mb during fill	0.33	0.54	0.60	
SDNR during mixed fill	0.077	0.093	0.116	M&E, 5th Ed., Fig. 8-31 , rbCOD = 0.15
Max Nox-R per cycle (lb/cycle)	14	7	10	
Actual Nox-R per cycle (lb/cycle)	14.0	7.2	9.6	
Nox Remaining after cycle (lbs)	6	12	13	
Decant Rate, GPM	1260	1067	2222	
Current Decant Capacity, GPM	3333	3333	3333	
Aeration Requirement				
Actual Oxygen Req AOR (lb/day)	1712	3486	3878	Includes denit credit
AOR per cycle (lb/cycle)	214	232	259	
AOR rate (lb/hr)	71	97	108	
AOR peaking factor	1.67	1.67	1.67	Per M&E, 5th Ed., for high demand at start of cycle, peak loadings
Design AOR rate (lb/hr)	119	162	180	
Ecology Design Criteria				
Mass loading rate (lbs BOD5/day/1000 ft3	9	11	**15**	At low water level, max = 15
F/M ratio (lb BOD5/lb MLVSS)	0.06	0.08	**0.09**	At max water level, max = 0.10

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Activated Sludge Spreadsheet Model

			Recent (2009-13) Annual Avg.	Projected 2033	Maximum Capacity	Comment
Oxygen Requirements						
1	AOR per cycle	lb/hr	119	162	180	AOR per basin during the aerated periods
	Standard Oxygen Requirement					
	AOR = SOR * alpha((beta*CSW - CL)/CST)*1.024^(T-20)					
2	alpha		0.85	0.85	0.85	O2 transfer in WW/O2 transfer in clean water (0.85 per Aqua Aerobics
3	beta		0.96	0.96	0.96	O2 saturation in WW/O2 saturation in clean water
4	CSW	mg/L	11.28	11.28	11.28	Saturation of O2 at operating temperature and pressure
5	CL	mg/L	2.00	2.00	2.00	Desired Operating O2 concentration
6	CST	mg/L	9.08	9.08	9.08	Saturation of O2 at sea level at 20°C
7	T	°C	10	10	10	Winter minimum temperature
8	AOR/SOR Ratio		0.65	0.65	0.65	[2]*(([3]*[4]-[5])/[6])*1.024^([7]-20)
9	**SOR per basin**	**lb/hr**	**183**	**248**	**276**	standard oxygen requirement per basin during the aerated periods
	Fine Bubble Diffuser Efficiency					
10	Per-Foot Diffuser Efficiency	ft^{-1}	0.87%	0.87%	0.87%	Transmax - per Aqua Aerobic calcs
11	Avg. Depth of Basin	ft	18	18	18	Avg. Side water depth (LWL = 13', HWL = 21')
12	Depth of Submergence	ft	17	17	17	[12]-1
13	Fine Bubble Diffuser Efficiency		15%	15%	15%	[10]*[12]
14	**Air Flow Required/Basin**	**scfm**	**1190**	**1616**	**1797**	[9]*(1 scf/0.0173 lb O2)*(1 d/1440 min)/[13]
15	Maximum basins in aeration simult.		1	2	2	
16	Ratio of aerated react time to meet SOR		63%	86%	96%	With 1 set of blowers in service
17	Quantity of blowers		3	5	5	
18	Air Flow Required per 50 hp Blower	scfm	397	539	599	at standard temperature and pressure
19	Air Flow Required per 75 hp Blower	scfm		808	899	at standard temperature and pressure
	Inlet Volume of Atmospheric Air					Va=Vs*((Ps-(RHs*PVs))/(Pb-(RHa*PVa)))*(Ta/Ts)*(Pb/Pa)
20	Vs	scfm	1190	1616	1797	Inlet flow of air at standard temperature and pressure
21	Ps	psi	14.7	14.7	14.7	standard pressure of air (=1.0 atm)
22	RHs		0.36	0.36	0.36	standard relative humidity
23	PVs	psi	0.26	0.26	0.26	vapor pressure of water @ std temperature and pressure
24	Pb	psi	14.69	14.69	14.69	design atmospheric pressure

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				Recent (2009-13) Annual Avg.	Projected 2033	Maximum Capacity	Comment
Oxygen Requirements							
25		RHa		0.80	0.80	0.80	design relative humidity
26		PVa	psi	0.95	0.95	0.95	vapor pressure of water at design temperature and pressure
27		Ta	°R	550	550	550	design temperature (=100°F)
28		Ts	°R	520	520	520	standard temperature (=60°F)
29		Pa	psi	14.68	14.68	14.68	design pressure at inlet
30		Va	icfm	1322	1793	1995	Inlet flow of air at design conditions, from above equation
	Blower Discharge Pressure						
31	Max. Diffuser submergence		ft	20	20	20	1' above bottom of aeration basins
32	static submergence pressure		psi	8.70	8.70	8.70	[31]/2.3
33	Equivalent length of 6" pipe		ft	100	100	100	approximate - pipe not designed yet
34	Unit Headloss in 6" pipe		psi/100ft	0.3	0.3	0.3	from friction loss chart
35	Friction headloss		psi	0.3	0.3	0.3	
36	Silencer headloss		psi	0.1	0.1	0.1	
37	Air filter pressure drop		psi	0.1	0.1	0.1	
38	Air diffuser headloss		psi	0.5	0.5	0.5	
39	Discharge Pressure		psi	9.70	9.70	9.70	rounded up to nearest 0.1 psi