WASTEWATER TREATMENT PLANT IMPROVEMENT PROJECT

For the City of "H" Wastewater Treatment Plant

CE 485 Design Project

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MEMORANDUM

INTRODUCTION

The City of “H” (City) owns and operates the “H” (city) Wastewater Treatment Plant (Plant), a secondary treatment facility. The City provides wastewater treatment to “H” city and some surrounding communities. The City is permitted to discharge treated wastewater to the the Pear Drain, a tributary of the Alamo River, which drains into the Salton Sea, and is subject to the requirements set forth by the California Regional Water Quality Control Board (RWQCB), Colorado River Basin Region and National Pollutant Discharge Elimination System (NPDES) Permit. The City has commissioned the USC Design Team to provide preliminary design services for improvements to the existing wastewater treatment facility, and the city will construct the necessary plant upgrades and improvements.

This Project Memorandum (PM) will provide an overview of the existing HWTP and the new project goals, as well as describe how the USC Design Team addressed the items for plant improvements project, how the proposed treatment meets the regulatory requirements, and how the generated sludge is processed and handled.

EXISTING WASTEWATER SYSTEM

The existing City of “H” (City) Wastewater Treatment Plant (Plant) is a secondary treatment facility having an average flow capacity of 0.85 million gallons/day (mgd) and consists of a headworks bar screen, three circular primary clarifiers (one 28 foot diameter and two 18 foot diameter units), a trickling filter (80 foot diameter with 7 feet of rock media), three secondary clarifiers (one 38 foot diameter and two 18 foot diameter units), three continuous backwash upflow (DynaSand) filters, a UV disinfection module bank, effluent flow metering, an aerobic digester, and three sludge drying beds. Leachate from the sludge drying beds is returned to the plant headworks for treatment. Sludge is dried and stored on-site prior to final disposal at a landfill. The plant also receives septage at the headworks, as the city allows recreational vehicles to dump wastewater into the city collection system at designated stations.

Figure 1 presents the existing Plant facilities and yard piping and the existing plant design data is summarized in Table 1.

PROJECT OVERVIEW

To meet the fast increase in wastewater flow, the City will have to expand the plant treatment capacity from an average of 0.85 to 1.8 mgd, with a new peak hourly flow estimated at 3.6 mgd. Under the proposed NPDES permit requirements for a number of priority pollutants and ammonia, the expanded and upgraded plant must also be able to meet the new effluent ammonia concentration limits (monthly average of 1.9 mg/L and maximum daily of 3.6 mg/L).

Because the Plant has experienced effluent quality problems, including toxicity violations during the winter months when the temperature drops, which also coincides with the arrival of seasonal residents, the existing plant facilities will be assessed, and recommendations will be made to improve the Plant performance with respect to secondary effluent quality and treatment efficiency. USC Design Team will also consider the cost-effective incorporation of the existing facilities, to the extent possible, into the final upgraded plant.

ADDRESSING THE PLANT IMPROVEMENTS

- Headworks: The existing headworks will be demolished and new headworks will be constructed to meet the new desired treatment capacity. The headworks will be a new concrete structure consisting of a 25,000-gallon capacity septage holding tank with a septage pump, a Parshall flume flow meter, and a screening removal and disposal system that will replace the existing non-operating bar screens.

- Vortex Grit Removal: Two vortex grit removal tanks, two grit pumps and a grit washer/classifier will be provided to remove grit from the increased wastewater flow.
- Primary Clarifiers: The existing three (3) primary clarifiers cannot handle the anticipated average flow of 1.8 mgd and peak hourly flow of 3.6 mgd, and therefore will be demolished so that two (2) new rectangular primary clarifiers, 60ft long by 15ft wide, assuming side water depth (SWD) of 15ft, and a Flow Distribution Box (DB1) will be provided.
- MLE Process and Secondary Clarifiers: The existing trickling filter secondary treatment has a limited capacity to remove ammonia, probably because the organic overloading of the trickling filter at low temperatures, so they will be demolished and a modified ludzack-ettinger (MLE) activated sludge process will be designed to meet the ammonia effluent limit specified in the proposed NPDES permit. The Flow Distribution Box for Aeration Tanks (DB2) is followed by MLE Aeration Units, consisting of a pre-anoxic zone and aerobic zone, then a Flow Distribution Box for Secondary Clarifiers (DB3). A Return Activated Sludge/Waste Activated Sludge (RAS/WAS) Pump Station will be provided to remove or recycle sludge from the Secondary clarifiers.
- Secondary Clarifiers: The existing three small-diameter secondary clarifiers have a number of problems and deficiencies. Under the anticipated flow increase, flow distribution among these three clarifiers is almost impossible and the RAS/WAS pumping systems must be replaced. The existing three secondary clarifiers will be abandoned and two larger circular secondary clarifiers of diameter 45ft (typically 30-100ft) will be constructed.
- Secondary Effluent Pump Station: To meet increased flow demands, the two existing constant speed pumps will be replaced with four new pumping units driven through a variable frequency drive to convey the flow to the filters.
- Effluent Polishing Filters: Three more continuous backwash upflow (DynaSand) filters identical to the existing will be added to provide the filtering rates of 2.7 and 5.3 gpm/sf at average and peak flows, respectively, to meet new flow capacity.
- UV Disinfection: The existing Trojan UV3000 plus ultraviolet disinfection system with 36 UV bulbs is to remain in service. To meet anticipated flow increase, a new Trojan UV3000 plus system with an additional 36 UV bulbs will be placed upstream of the existing UV system in series. With a new UV system added, the total UV system capacity will be 3.2 mgd based on 60% UV transmittance. If the UV transmittance increases to 65%, the UV system can handle a peak design flow of 3.6 mgd.
- Sludge Treatment Facilities: Sludge treatment and handling facilities consisting of WAS thickening, anaerobic digestion, and mechanical dewatering will be provided. Mechanically dewatered sludge will be solar dried and stored on the existing sludge drying beds prior to final disposal at a landfill.

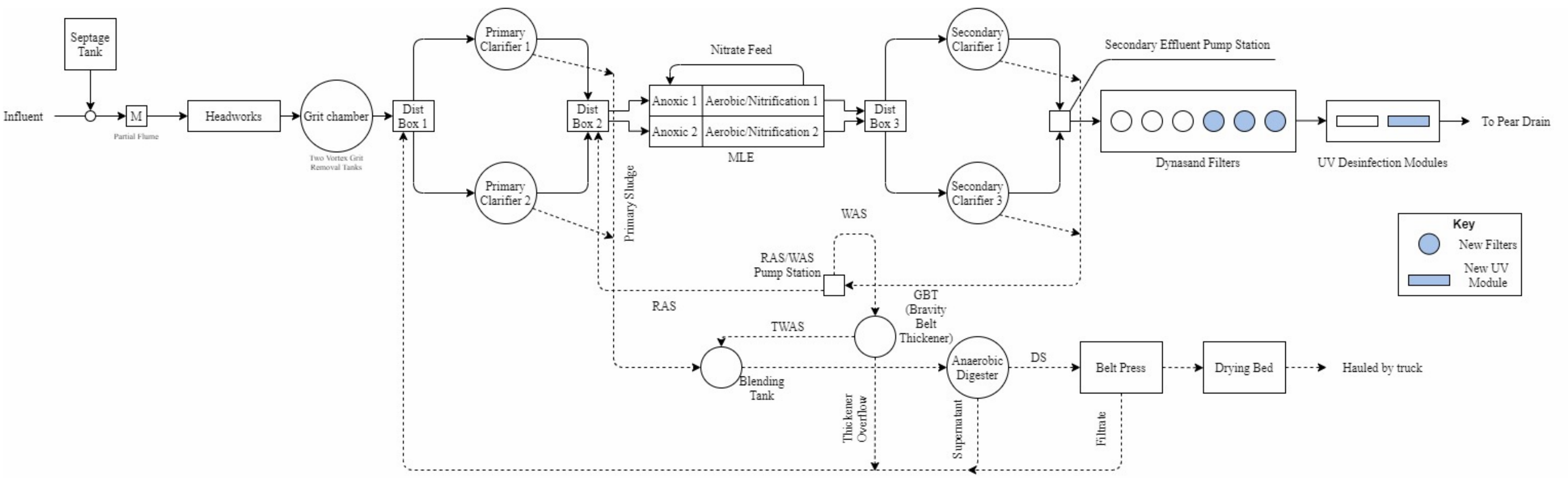
ADDRESSING THE REGULATORY REQUIREMENTS

- Under the NPDES Permit and Final Effluent Limitations, the effluent parameters of BOD (5-day @ 20°C), TSS, and Ammonia, Total (as N) will remain under their respective limits due to the implementation of the new MLE process and secondary clarifiers. Ammonia removal will increase in the MLE activated sludge process to meet the NPDES standards.
- The Escherichia coli (E. Coli) parameter will be achieved by the addition of 36 new disinfecting UV lamps (in series with the existing 36 lamps) for a total of 72 UV lamps in the disinfection process.
- Total Chlorine Residual of the effluent will be eliminated due to the use of UV disinfection rather than chlorine disinfection.

SLUDGE PROCESSING AND HANDLING

Sludge treatment and handling facilities consist of a RAS/WAS pump station, following the secondary clarifiers. The WAS from the pump station is thickened and becomes TWAS, which is blended with sludge from the primary clarifiers in a blending tank and then enters the anaerobic digestion tank(s). After digestion, the digested sludge (DS) undergoes mechanical dewatering by belt press. The dewatered sludge will be solar dried and stored on the existing sludge drying beds prior to final disposal at a landfill. The RAS from RAS/WAS pump station is returned to the DB2 where it will be recycled to the activated sludge process. The thickener overflow from gravity belt thickener (GBT), supernatant from digestion, and centrate from belt press will all be pumped to the DB1 and recycled back to the primary clarifiers.

PROCESS FLOW DIAGRAM



DESIGN CRITERIA

Table 1. New Wastewater Plant Design Criteria

Facility	Value	Remarks
Wastewater Flow		
Plant Flow, Average, mgd	1.8	New design flows
Plant Flow, Peak Day, mgd	3.6	New design flows
Primary Clarifiers		
Number, each	2	
Diameter, feet	35	
MLE Process		
Aerobic Zone		
Width of each tank, feet	30	2 tanks side by side
Aeration Tank Volume, cf	102266	Approx. 0.765 Mgal
Length of each tank, feet	90	
Anoxic Zone		
L x W x SWD, feet	45 x 30 x 20	
Secondary Clarifiers		
Number, each	2	
Diameter, feet	45	
Effluent Filter Feed Pump Station		
Number, each	4	2 existing are replaced with 4 new
Dyna-sand Filtration		
Number, each	6	3 existing, 3 new
Diameter, feet	10	78.5 sf/filter
Loading, 6 filters in Service, gpm/sf	2.7	At 1.8 mgd
Loading, 5 filters in Service, gpm/sf	3.24	At 1.8 mgd
UV Disinfection		
Number of UV banks, each	4	2 existing, 2 new
Number of Modules/bank, each	3	6 bulbs/module and 250 watts/bulb
Number of bulbs, total	72	Doubled existing
UV Transmission, %	65	At wavelength 254 nm
Miscellaneous		
Effluent Flow Meter, each	1	6 inch magnetic
Sludge Drying Beds (existing), each	3	Each 70 ft x 36 ft
Aerobic Digester Volume, cf	22,670	Approx. 150,000 gallon working volume

DESIGN CALCULATIONS

Primary Clarifier (2)

- Shape: Circular
- Average flow, mgd = 1.8
- Peak flow, mgd = 3.6
- SWD = 12 feet
- Overflow rate, avg, gal/ft^2-d = 1000
- Overflow rate, peak, gal/ft^2-d = 2500

Calculations

Area

- *Avg flow: A =* → *use this value*
- *Peak flow: A =*

For 2 clarifiers:

For circular clarifier:

900 sf =

Volume of each clarifier = ***=86355 gallons***

HRT:

- *Avg flow =*
- *Peak flow =*

MLE Process/Aeration Tank Volume

- SRT = 10 days
- SWD = 20 feet
- Width = 30 feet
- MLSS = 3,500 mg/L

Table 2. Kinetic Coefficients

Y	0.45
b	0.12 d-1
fd	0.15
Yn	0.15
bn	0.17 d-1

Wastewater table

Calculate nbVSS

$bCOD = 1.6(195) = \mathbf{312\ mg/L}$

$nbsCODe = sCOD – 1.6sBOD = 192 – 1.6*113 = \mathbf{11\ mg/L}$

$nbpCOD = COD\text{-}bCOD\text{-}nbsCODe = 443 - 312 –11 = \mathbf{110\ mg/L}$

$VSS_{COD}=$

$nbVSS =$

Calculate $P_{x,VSS}$

$P_{x,VSS} =$

$=$

$= 958 + 172 + 23 + 646 = \mathbf{1,804\ lb\ VSS/d}$

Checking NOX assumption

$NOX = TKN\text{-}Ne\text{-}0.12P_{x,bio}/Q = 43\text{-}0.4\text{-}0.12*(1134+204+24)/(1.8*8.34) = \mathbf{33.4\ mg/L \sim 34\ mg/L\ ok}$

Calculate $P_{x,TSS}$

$P_{x,TSS}=$

$= 1127 + 202 + 33 + 646 + 225 = \mathbf{2233\ lb\ TSS/d}$

Calculate Q for WAS

$P_{x,TSS} = Q_w X_r$

Calculate Volume

Aeration tank volume =

Secondary Clarifiers (2)

- Shape: Circular
- $Flow_{peak}$ = 3.6 mgd
- $Flow_{average}$ = 1.8 mgd
- SWD = 15 ft
- SOR = 600 gal/ft^2-d
- MLSS = 3500 mg/L
- X_R = 7000 mg/L

Calculations

Diameter (clarifier) = 45 ft²

Total Area = 3181 ft²

SOR/SLR Check

SOR (2 clarifiers, peak flow) =

SOR (2 clarifiers, avg flow) =

R =

SLR (2 clarifiers, peak flow*)* =

SLR (2 clarifiers, avg flow) =

Dyna-sand Filters

Average Loading, all filters in service

Average Loading, one filter out of service

Peak Loading, all filters in service

Peak Loading, one filter out of service

UV Disinfection

CALCULATIONS FOR OXYGEN DEMAND AND AIR FLOW RATE

Aeration tank volume (ft^3) =

Oxygen Requirement (O_2/d)

$R_o = Q(S - S_o) - 1.42P_{X,Bio} + 4.57Q(NO_x)$
R_o = (1.8 mgd) * (312 mg/L – 0) * 8.34 – 1.42 * [(958 + 172) lb/d] + 4.57 * (1.8 mgd) * (34 mg/L) * 8.34
R_o = **5,412 lb O_2/d = 226 lb O_2/h** (=OTR_f)

Air flowrate (cfm)

Assuming:

- SOTR = 2.5 * OTR_f
- Air density at 20ºC = 0.0745 lb/ft^3
- Oxygen transfer efficiency (SOTE) = 38%

SOTR = 2.5 * OTR_f = 2.5 * 226 lb O_2/h = 565 lb/h

Air flowrate =

Air flowrate = **86,098 ft^3/h = 1,435 ft^3/min**

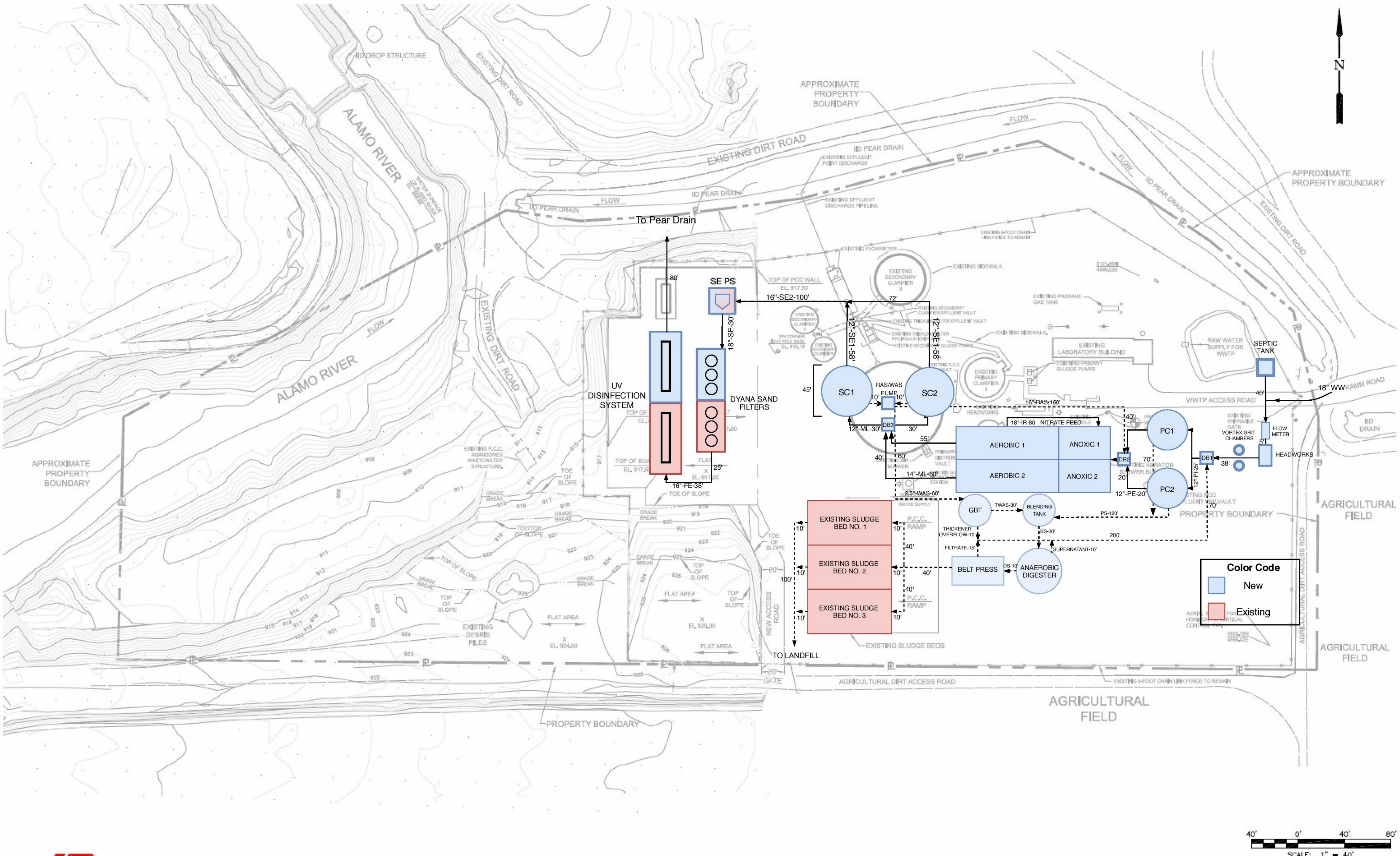
PIPE SIZING

Table 3. Pipe Sizing

Average PE, SE	1.8	mgd					
Peak PE, Se	3.6	mgd					
Peak RAS	3.6	mgd					
Peak ML	7.2	mgd					
WAS	0.03825	mgd					
Pipe	**Peak Q (mgd)**	**split**	**Q each (mgd)**	**Q each (cfs)**	**Diameter (inch)**	**Area (sf)**	**Velocity (ft/s)**
Wastewater	3.6	**1**	3.6	5.571	**18**	1.7671	3.15
PI or PE	3.6	**2**	1.8	2.7855	**12**	0.7854	3.55
ML	7.2	**2**	3.6	5.571	**14**	1.0690	5.21
IR	10.8	**2**	5.4	8.3565	**18**	1.7671	4.73
SE 1	3.6	**2**	1.8	2.7855	**12**	0.7854	3.55
SE 2	3.6	**1**	3.6	5.571	**16**	1.3963	3.99
RAS	3.6	**1**	3.6	5.571	**16**	1.3963	3.99
WAS	0.03825	**1**	0.03825	0.059191875	**2.5**	0.0341	1.74
Secondary sludge	3.6	**3**	1.2	1.857	**10**	0.5454	3.40

GENERAL SITE LAYOUT

See next page.



DWG R:\Job 401-499\441\CADD\441\01\FIG 15-4 SITE LAYOUT PHASE II EXPANSION.dwg USER: Daniel Park
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MASS BALANCE

Primary Influent and Primary Effluent

PI

BOD = (300 mg/L) * (1.8 mgd) * 8.34 = **4,504 lb/d**
TSS = (276 mg/L) * (1.8 mgd) * 8.34 = **4,143 lb/d**

PE

BOD = (195 mg/L) * (1.8 mgd) * 8.34 = **2,927 lb/d**
TSS = (110 mg/L) * (1.8 mgd) * 8.34 = **1,651 lb/d**

Primary Sludge

PS

BOD = 4,504 lb/d - 2,927 lb/d = **1,577 lb/d**
TSS = 4,143 lb/d - 1,651 lb/d = **2,492 lb/d**
Q_{PS} = (2,492 lb/d) / (30,00 mg/L * 8.34) = **0.00996 mgd = 9,960 gpd**
BOD = (1,577 lb/d) / (0.00996 mgd *8.34) = **18,985 mg/L**

WAS, RAS, Mixed Liquor, and Secondary Effluent

WAS

VSS = (7,000 mg/L) * (1,804 lb/d) / (2,233 lb/d) = **5,655 mg/L**
Q_{WAS} = (2,233 lb/d) / (7,000 lb/d * 8.34) = **0.0382 mgd = 38249 gpd**

RAS

R = 1 (See Secondary Clarifier Calculation)
TSS = (7,000 mg/L) * (1.8 mgd) * 8.34 = **105,084 lb/d**
VSS = (5,655 mg/L) * (1.8 mgd) * 8.34 = **84,893 lb/d**
Q_r = Q = **1.8 mgd**
VSS = **5,655 mg/L**

ML

Q_{ML} = Q_{PE} + Q_r = 1.8 mgd + 1.8 mgd = 3.6 mgd = **3,600,000 gpd**
TSS = (3,500 mg/L) * (3.6 mgd) * 8.34 = **105,084 lb/d**

Secondary Effluent

Q_{SE} = Q_{ML} - Q_r - Q_{WAS} = 3,600,000 gpd - 1,800,000 gpd - 38249 gpd = **1,761,751 gpd**
TSS = (10 mg/L) * (1.761751 mgd) * 8.34 = **147 lb/d**

TWAS

TWAS

TSS = (0.96) * (2,233 lb/d) = **2,144 lb/d**
Q_{TWAS} = (2,144 lb/d) / (50,000 mg/L * 8.34) = **0.00514 mgd = 5,141 gpd**
VSS = (50,000 mg/L) * (1,804 lb/d / 2,233 lb/d) = **40,349 mg/L**

VSS = (1,804 lb/d) * (0.96) = **1,732 lb/d**

Blended Sludge

BS (PS + TWAS)

$Q_{BS} = Q_{PS} + Q_{TWAS}$ = 9,960 gpd + 5,141 gpd = **15,101 gpd**
TSS = 2,144 lb/d + 2,492 lb/d = **4,636 lb/d**
TSS = (4,636 lb/d) / (0.015101 mgd * 8.34) = **36,810 mg/L**
VSS = 0.75 * (2,492 lb/d) + 1,732 lb/d = **3,601 lb/d**
VSS = (3,601 lb/d) / (0.015101 mgd * 8.34) = **28,592 mg/L**

Digested Sludge

DS

$Q_{BS} = Q_{DS}$ = **15,101 gpd**
VSS = (0.45) * (3,601 lb/d) = **1,620 lb/d**
VSS = (1,620 lb/d) / (0.015101 mgd * 8.34) = **12,867 mg/L**
TSS = 4,636 lb/d - (3,601 lb/d - 1,620 lb/d) = **2,655 lb/d**
TSS = (2,655 lb/d) / (0.015101 mgd * 8.34) = **21,081 mg/L**

Mechanically Dewatered Sludge and Filtrate

MDS

TSS = (0.95) * (2,655 lb/d) = **2,522 lb/d**
Q_{MDS} = (2,522 lb/d) / (240,000 mg/L * 8.34) = **0.0012599 mgd = 1,260 gpd**

Filtrate

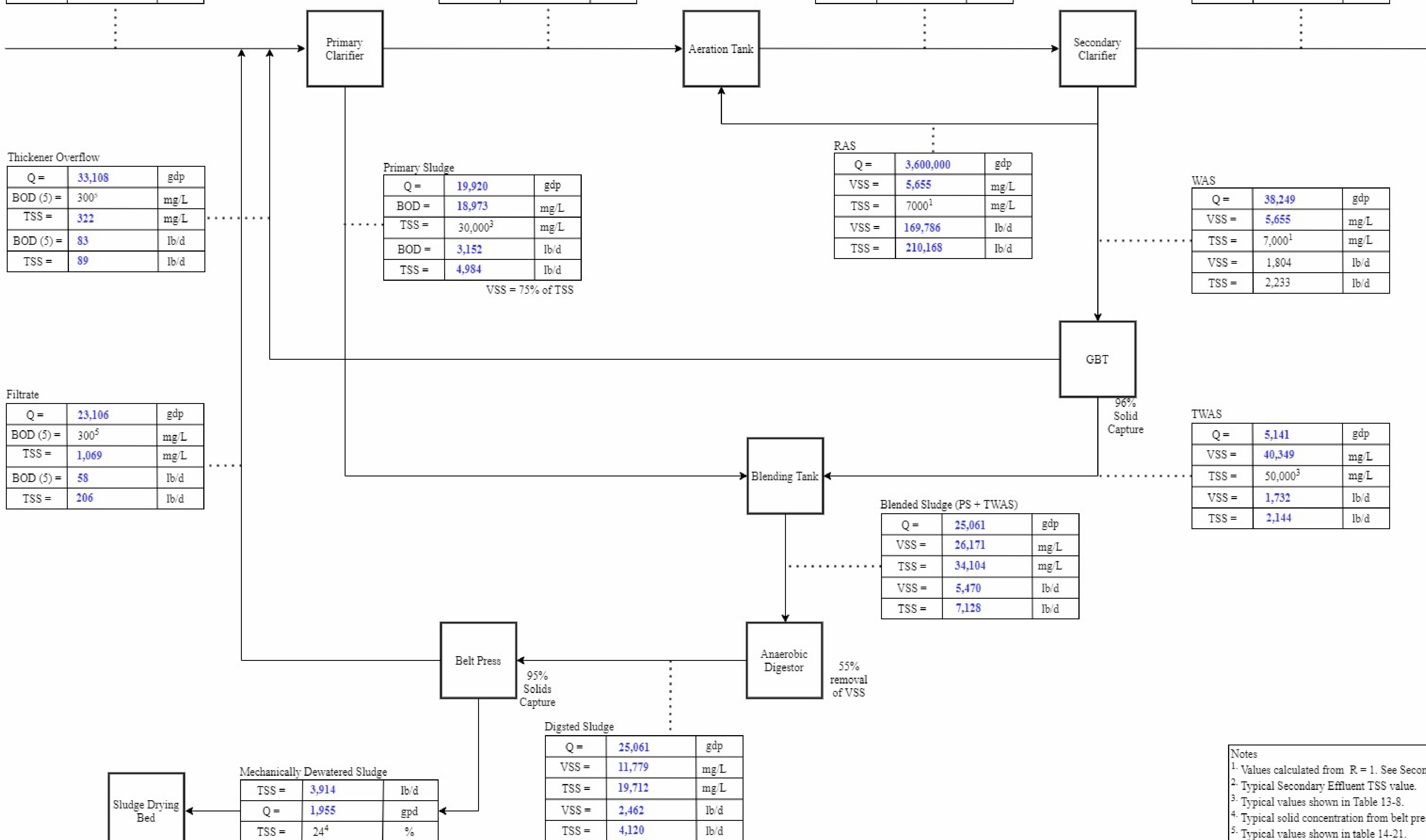
$Q_F = Q_{DS} - Q_{MDS}$ = 15,101 gpd - 1,260 gpd = **13,841 gpd**
TSS = 2,655 lb/d - 2,522 = **133 lb/d**
TSS = (133 lb/d) / (0.013841 mgd * 8.34) = **1,152 mg/L**
BOD = (300 mg/L) * (0.013841 mgd) * 8.34 = **35 lb/d**

Thickener Overflow

TO

$Q_{TO} = Q_{WAS} - Q_{TWAS}$ = 38,249 gpd - 5,141 gpd = **33,108 gpd**
TSS = 2,233 lb/d - 2,144 lb/d = **89 lb/d**
TSS = (89 lb/d) / (0.033108 mgd * 8.34) = **322 mg/L**
BOD = (300 mg/L) * (0.033108 mgd) * 8.34 = **83 lb/d**

1st Iteration without considering sidestream under Monthly Peak Loading Conditions



Influent w/o considering sidestream

Q =	3,600,000	gdp
BOD (5) =	300	mg/L
TSS =	276	mg/L
BOD (5) =	9,007	lb/d
TSS =	8,287	lb/d

Primary Effluent

Q =	3,600,000	gdp
BOD =	195	mg/L
TSS =	110	mg/L
BOD =	5,855	lb/d
TSS =	3,303	lb/d

Mixed Liquor

Q =	7,200,000	gdp
BOD =	-	mg/L
TSS =	3,500[1]	mg/L
BOD =	-	lb/d
TSS =	210,168	lb/d

Secondary Effluent

Q =	3,561,751	gdp
BOD =	-	mg/L
TSS =	10[2]	mg/L
BOD =	-	lb/d
TSS =	297	lb/d

Thickener Overflow

Q =	33,108	gdp
BOD (5) =	300[5]	mg/L
TSS =	322	mg/L
BOD (5) =	83	lb/d
TSS =	89	lb/d

Primary Sludge

Q =	19,920	gdp
BOD =	18,973	mg/L
TSS =	30,000[3]	mg/L
BOD =	3,152	lb/d
TSS =	4,984	lb/d

VSS = 75% of TSS

RAS

Q =	3,600,000	gdp
VSS =	5,655	mg/L
TSS =	7000[1]	mg/L
VSS =	169,786	lb/d
TSS =	210,168	lb/d

WAS

Q =	38,249	gdp
VSS =	5,655	mg/L
TSS =	7,000[1]	mg/L
VSS =	1,804	lb/d
TSS =	2,233	lb/d

Filtrate

Q =	23,106	gdp
BOD (5) =	300[5]	mg/L
TSS =	1,069	mg/L
BOD (5) =	58	lb/d
TSS =	206	lb/d

TWAS

Q =	5,141	gdp
VSS =	40,349	mg/L
TSS =	50,000[3]	mg/L
VSS =	1,732	lb/d
TSS =	2,144	lb/d

Blended Sludge (PS + TWAS)

Q =	25,061	gdp
VSS =	26,171	mg/L
TSS =	34,104	mg/L
VSS =	5,470	lb/d
TSS =	7,128	lb/d

Digsted Sludge

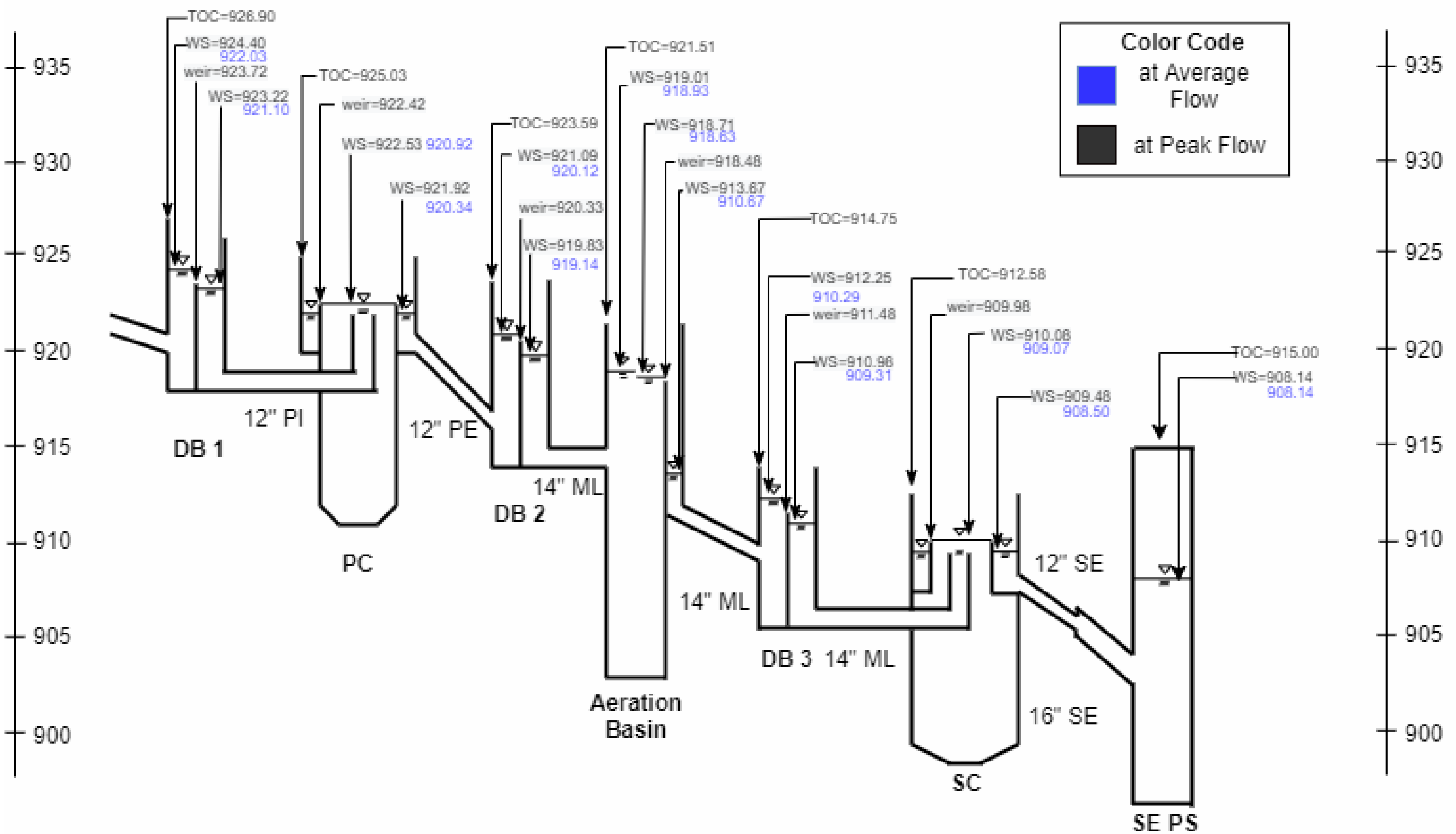
Q =	25,061	gdp
VSS =	11,779	mg/L
TSS =	19,712	mg/L
VSS =	2,462	lb/d
TSS =	4,120	lb/d

Mechanically Dewatered Sludge

TSS =	3,914	lb/d
Q =	1,955	gpd
TSS =	24[4]	%

Notes
1. Values calculated from R = 1. See Secondary Clarifier calculation.
2. Typical Secondary Effluent TSS value.
3. Typical values shown in Table 13-8.
4. Typical solid concentration from belt press o dewatered sludge cake.
5. Typical values shown in table 14-21.

HYDRAULIC GRADE-LINE



Hydraulic Profile Calculation Sheet

Wastewater Treatment Plant

Peak RS Flow, mgd =	1.8
Peak RS Flow, cfs =	2.79
RAS Flow, mgd =	1.8
RAS Flow, cfs =	2.79

LOCATION/COMPONENTS				HL	HGL	h_v	EGL	REMARKS OR REV.
High WS EL of SE PS					**908.14**		**908.14**	
	SE PS TOC =	**915.00**						
	Freeboard =	6.86	ft					
Compute for WS EL Downstream of SC V-Notch Weir								
Pipe from SC to SE PS								
A. 16" HDPE (High Density Polyethylene, AWWA C906)								
	Split Factor =	**1**						
Flow	Q=	1,250	gpm					
	D=	**16**	inch					
Velocity	v =	1.99	ft/s					
Velocity head	$v^2/2g$=	0.062	ft					
Pipe Length	L=	**90**	ft					Hazen-Williams Eq.
C value	C =	120						Friction Headloss
Friction Headloss:	h_f=	0.10	ft					
Minor headlosses:								$0.002083\ L\ \frac{100}{C}^{1.85}\ \frac{Q^{1.85}}{D^{4.8655}}$
		k	No.					
	Exit of pipe =	1.00	1					Minor Headloss
	Entrance of pipe =	0.50						
	90 elbow =	0.19	1					$h_m\ \ k\frac{v^2}{2g}$
	Butterfly valve =	0.30	0					
	Sum =	1.19						
Minor headlosses:	h_m=	0.07	ft					
Total headlosses:	h_T=	**0.17**	ft	0.17				
B. 12" HDPE (AWWA C906)								
	Split Factor =	**2**						
Flow	Q=	625	gpm					
Diameter	D=	**12**	inch					
Velocity	v =	1.77	ft/s					
Velocity head	$v^2/2g$=	0.049						
Pipe Length	L=	**110**	ft					
C value	C =	120						
Friction Headloss:	h_f=	**0.14**	ft					
Minor headlosses:								
		k	No.					
	Exit of pipe =	1.00	0					
	Entrance of pipe =	0.50	1					
	90 elbow =	0.19	1					
	16"-12" Reducer =	0.30	1					
	Sum =	0.99						
Minor headlosses:	h_m=	**0.05**						
Total headlosses:	h_T=	**0.18**		0.18				
WS EL Downstream of SC V-Notch Weir					**908.50**		**908.50**	
	V-Notch Weir EL at SC =	**909.00**						
Compute for WS EL at SC								
90-deg V-notch Weir								pg. 30, Isco Open
Clarifier diameter	=	**60**	ft					
Weir diameter	=	56	ft					
Weir Nos.	=	352						6" interval v-notch weirs
$Q = 2.5H^{2.5}$								pg. 30, Isco Open

	Split Factor =	**2**						Channel Flow
	Flow per Clarifier =	1.3925	cfs					Measurement Handbook
	Flow per Weir =	0.004	cfs					3rd Ed.
	Head on weir, H =	**0.08**	ft	0.08				
WS EL at SC					**909.07**		**909.07**	
	Secondary Clarifier TOC =	**911.57**						
	Freeboard =	2.50	ft					
Compute for WS EL Downstream of DB3 Weir								
Pipe from SC to DB3								
16" HDPE (AWWAC906)								
	Split Factor =	**2**						
	ML (Q+RAS) Flow per SC =	1,250	gpm					
	D =	**16**	inch					
Velocity	v =	1.99	ft/s					
Velocity head	$v^2/2g$=	0.062						
Pipe Length	L=	**80**	ft					
C value	C =	120						
Friction Headloss:	h_f=	**0.09**						
Minor headlosses:								
		k	No.					
	Exit of pipe =	1.00	1					
	Entrance of pipe =	0.50	1					
	90 elbow =	0.19	3					
	Buttrefly valve =	0.30	1					
	Sum =	2.37						
Minor headlosses:	h_m=	0.15						
Total headlosses:	h_T=	**0.2345**		0.23				
WS EL Downstream of DB3 Weir					**909.31**		**909.31**	
	Weir EL at DB3 =	**909.81**						
Compute for WS EL Upstream of DB3 Weir								
	ML (Q+RAS) =	5.57	cfs					pg. 34, Isco Open
Rectuangular weir w/o end contractions								Channel Flow
$Q = 3.330LH^{1.5}$								Measurement Handbook
	Length of weir, L =	**5**	ft					
	Head on weir, H =	**0.48**	ft	0.48				
WS EL Upstream of DB3 Weir					**910.29**		**910.29**	
	DB3 TOC =	**912.79**						
	Freeboard =	2.50	ft					
Compute for WS EL downstream of Aeration Tank Weir								
Pipe from DB3 to Aeration Tank								
16" HDPE (AWWAC906)								
	Split Factor =	**2**						
	(Q+RAS) per Aeration Tank =	1,250	gpm					
	D=	**16**	inch					
Velocity	v =	1.99	ft/s					
Velocity head	$v^2/2g$=	0.062	ft					
Pipe Length	L=	**210**	ft					
C value	C =	120						
Friction Headloss:	h_f=	**0.23**						
Minor headlosses:								

		k	No.					
	Exit of pipe =	1.00	1					
	Entrance of pipe =	0.50	1					
	90 elbow =	0.19	3					
	Buttrefly valve =	0.30	1					
	Sum =	2.37						
Minor headlosses:	h_m=	0.15						
Total headlosses:	h_T=	**0.38**		0.38				
WS EL Downstream of Aeration Tank Weir					**910.67**		**910.67**	
	Weir EL at Aeration Tank =	**918.48**						
Compute for WS EL of Aeration Tank (Upstream of Weir)								
	ML (Q + Q_r) =	5.57	cfs					pg. 34, Isco Open
Rectuangular weir w/o end contractions								Channel Flow
Q = 3.330L$H^{1.5}$								Measurement Handbook
	Length of weir, L =	**30**	ft					
	Head on weir, H =	**0.15**	ft	0.15				
WS EL at Aeration Tank (Upstream of Aeration Tank Weir)					**918.63**		**918.63**	
	Headloss through Aeration Tanks =	**0.30**	ft	0.3000				Assumed
WS EL at Anoxic Zone					**918.93**		**918.93**	
	Aeration Tank TOC =	**921.43**						
	Freeboard =	2.50	ft					
Compute for WS EL Downstream of DB2 Weir								
Pipe from Aeration Tank to DB2								
16" HDPE (AWWAC906)								
	Split Factor =	**2**						
	ML (Q + Q_r) per Aeration Tank =	1,250	gpm					
	D=	**16**	inch					
Velocity	v =	1.99	ft/s					
Velocity head	$v^2/2g$=	0.062	ft					
Pipe Length	L=	**70**	ft					
C value	C =	120						
Friction Headloss:	h_f=	**0.08**						
Minor headlosses:								
		k	No.					
	Exit of pipe =	1.00	1					
	Entrance of pipe =	0.50	1					
	90 elbow =	0.19	2					
	butterfly valve =	0.30	1					
	Sum =	2.18						
Minor headlosses:	h_m=	0.13						
Total headlosses:	h_T=	**0.21**		0.21				
WS EL Downstream of DB2 Weir					**919.14**		**919.14**	
	Weir EL at DB2 =	**919.64**						
Compute for WS EL Upstream of DB2 Weir								
	ML (Q + Q_r) =	5.57	cfs					pg. 34, Isco Open
Rectuangular weir w/o end contractions								Channel Flow
Q = 3.330L$H^{1.5}$								Measurement Handbook
	Length of weir, L =	**5**	ft					

	Head on weir, H =	**0.48**	ft	0.48				
WS EL Upstream of DB2 Weir					**920.12**		**920.12**	
	DB2 TOC =	**922.62**						
	Freeboard =	**2.50**	**ft**					
Compute for WS EL Downstream of PC V-Notch Weir								
Pipe from DB2 to Primary Clarifier								
12" HDPE (AWWAC906)								
	Split Factor =	**2**						
	Q per PC =	625	gpm					
	D=	**12**	inch					
Velocity	v =	1.77	ft/s					
Velocity head	$v^2/2g$=	0.049	ft					
Pipe Length	L=	**90**	ft					
C value	C =	120						
Friction Headloss:	h_f=	**0.11**						
Minor headlosses:								
		k	No.					
	Exit of pipe =	1.00	1					
	Entrance of pipe =	0.50	1					
	90 elbow =	0.19	2					
	butterfly valve =	0.30	1					
	Sum =	2.18						
Minor headlosses:	h_m=	0.11						
Total headlosses:	h_T=	**0.22**		0.22				
WS EL Downstream of Primary Clarifier V-Notch Weir					**920.34**		**920.34**	
	V-Notch Weir EL at PC =	**920.84**						
Compute for WS EL at PC (Upstream of PC V-Notch Weir)								
90-deg V-notch Weir								pg. 30, Isco Open
PC diameter	=	**50**	ft					
Weir diameter	=	46	ft					
Weir Nos.	=	289						6" interval v-notch weirs
$Q = 2.5H^{2.5}$								pg. 30, Isco Open
	Split Factor =	**2**						Channel Flow
	Flow per Clarifier =	1.3925	cfs					Measurement Handbook
	Flow per Weir =	0.005	cfs					3rd Ed.
	Head on weir, H =	**0.08**	ft	0.08				
WS EL at PC					**920.92**		**920.92**	
	Primary Clarifier TOC =	**923.42**						
	Freeboard =	2.50	ft					
Compute for WS EL Downstream of DB1 Weir								
Pipe from PC to DB1								
12" HDPE (AWWAC906)								
	Split Factor =	**2**						
	(Q+RAS) per PC =	625	gpm					
	D=	**12**	inch					
Velocity	v =	1.77	ft/s					
Velocity head	$v^2/2g$=	0.049	ft					
Pipe Length	L=	**60**	ft					
C value	C =	120						

Friction Headloss:	h_f=	**0.07**						
Minor headlosses:								
		k	No.					
	Exit of pipe =	1.00	1					
	Entrance of pipe =	0.50	1					
	90 elbow =	0.19	2					
	butterfly valve =	0.30	1					
	Sum =	2.18						
Minor headlosses:	h_m=	0.11						
Total headlosses:	h_T=	**0.18**		0.18				
WS EL Downstream of DB1 Weir					**921.10**		**921.10**	
	Weir EL at DB1 =	**921.60**						
Compute for WS EL Upstream of DB1 Weir								
	Q =	2.79	cfs					pg. 34, Isco Open
Rectuangular weir w/o end contractions								Channel Flow
$Q = 3.330LH^{1.5}$								Measurement Handbook
	Length of weir, L =	**3**	ft					
	Head on weir, H =	**0.43**	ft	0.43				
WS EL Upstream of DB1 Weir					**922.03**		**922.03**	
	DB1 TOC =	**924.53**						
	Freeboard =	2.50	ft					

Hydraulic Profile Calculation Sheet

Wastewater Treatment Plant

Peak RS Flow, mgd =	3.6
Peak RS Flow, cfs =	5.57
RAS Flow, mgd =	3.6
RAS Flow, cfs =	5.57

LOCATION/COMPONENTS					HL	HGL	h_v	EGL	REMARKS OR REV.
High WS EL of SE PS						**908.14**		**908.14**	
	SE PS TOC =	**915.00**							
	Freeboard =	6.86	ft						
Compute for WS EL Downstream of SC V-Notch Weir									
Pipe from SC to SE PS									
A. 16" HDPE (High Density Polyethylene, AWWA C906)									
	Split Factor =	**1**							
Flow	Q=	2,500	gpm						
	D=	**16**	inch						
Velocity	v =	3.99	ft/s						
Velocity head	$v^2/2g$=	0.247	ft						
Pipe Length	L=	**90**	ft						Hazen-Williams Eq.
C value	C =	120							Friction Headloss
Friction Headloss:	h_f=	0.36	ft						
Minor headlosses:									$0.002083\ L \left(\frac{100}{C}\right)^{1.85} \frac{Q^{1.85}}{D^{4.8655}}$
		k		No.					
	Exit of pipe =	1.00		1					Minor Headloss
	Entrance of pipe =	0.50							
	90 elbow =	0.19		1					$h_m \quad k\frac{v^2}{2g}$
	Butterfly valve =	0.30		0					
	Sum =	1.19							
Minor headlosses:	h_m=	0.29	ft						
Total headlosses:	h_T=	**0.65**	ft		0.65				
B. 12" HDPE (AWWA C906)									
	Split Factor =	**2**							
Flow	Q=	1,250	gpm						
Diameter	D=	**12**	inch						
Velocity	v =	3.54	ft/s						
Velocity head	$v^2/2g$=	0.195							
Pipe Length	L=	**110**	ft						
C value	C =	120							
Friction Headloss:	h_f=	**0.49**	ft						
Minor headlosses:									
		k		No.					
	Exit of pipe =	1.00		0					
	Entrance of pipe =	0.50		1					
	90 elbow =	0.19		1					
	16"-12" Reducer =	0.30		1					
	Sum =	0.99							
Minor headlosses:	h_m=	**0.19**							
Total headlosses:	h_T=	**0.69**			0.69				
WS EL Downstream of SC V-Notch Weir						**909.48**		**909.48**	
	V-Notch Weir EL at SC =	**909.98**							
Compute for WS EL at SC									
90-deg V-notch Weir									pg. 30, Isco Open
Clarifier diameter	=	**60**	ft						
Weir diameter	=	56	ft						
Weir Nos.	=	352							6" interval v-notch weirs
$Q = 2.5H^{2.5}$									pg. 30, Isco Open

	Split Factor =	**2**						Channel Flow
	Flow per Clarifier =	2.7850	cfs					Measurement Handbook
	Flow per Weir =	0.008	cfs					3rd Ed.
	Head on weir, H =	**0.10**	ft	0.10				
WS EL at SC					**910.08**		**910.08**	
	Secondary Clarifier TOC =	**912.58**						
	Freeboard =	2.50	ft					
Compute for WS EL Downstream of DB3 Weir								
Pipe from SC to DB3								
16" HDPE (AWWAC906)								
	Split Factor =	**2**						
	ML (Q+RAS) Flow per SC =	2,500	gpm					
	D =	**16**	inch					
Velocity	v =	3.99	ft/s					
Velocity head	$v^2/2g$=	0.247						
Pipe Length	L=	**80**	ft					
C value	C =	120						
Friction Headloss:	h_f=	**0.32**						
Minor headlosses:								
		k	No.					
	Exit of pipe =	1.00	1					
	Entrance of pipe =	0.50	1					
	90 elbow =	0.19	3					
	Buttrefly valve =	0.30	1					
	Sum =	2.37						
Minor headlosses:	h_m=	0.58						
Total headlosses:	h_T=	**0.9033**		0.90				
WS EL Downstream of DB3 Weir					**910.98**		**910.98**	
	Weir EL at DB3 =	**911.48**						
Compute for WS EL Upstream of DB3 Weir								
	ML (Q+RAS) =	11.14	cfs					pg. 34, Isco Open
Rectuangular weir w/o end contractions								Channel Flow
$Q = 3.330LH^{1.5}$								Measurement Handbook
	Length of weir, L =	**5**	ft					
	Head on weir, H =	**0.76**	ft	0.76				
WS EL Upstream of DB3 Weir					**912.25**		**912.25**	
	DB3 TOC =	**914.75**						
	Freeboard =	2.50	ft					
Compute for WS EL downstream of Aeration Tank Weir								
Pipe from DB3 to Aeration Tank								
16" HDPE (AWWAC906)								
	Split Factor =	**2**						
	(Q+RAS) per Aeration Tank =	2,500	gpm					
	D=	**16**	inch					
Velocity	v =	3.99	ft/s					
Velocity head	$v^2/2g$=	0.247	ft					
Pipe Length	L=	**210**	ft					
C value	C =	120						
Friction Headloss:	h_f=	**0.84**						
Minor headlosses:								

		k	No.					
	Exit of pipe =	1.00	1					
	Entrance of pipe =	0.50	1					
	90 elbow =	0.19	3					
	Buttrefly valve =	0.30	1					
	Sum =	2.37						
Minor headlosses:	h_m=	0.58						
Total headlosses:	h_T=	**1.42**		1.42				
WS EL Downstream of Aeration Tank Weir					**913.67**		**913.67**	
	Weir EL at Aeration Tank =	**918.48**						
Compute for WS EL of Aeration Tank (Upstream of Weir)								
	ML $(Q + Q_r)$ =	11.14	cfs					pg. 34, Isco Open
Rectuangular weir w/o end contractions								Channel Flow
$Q = 3.330LH^{1.5}$								Measurement Handbook
	Length of weir, L =	**30**	ft					
	Head on weir, H =	**0.23**	ft	0.23				
WS EL at Aeration Tank (Upstream of Aeration Tank Weir)					**918.71**		**918.71**	
	Headloss through Aeration Tanks =	**0.30**	ft	0.3000				Assumed
WS EL at Anoxic Zone					**919.01**		**919.01**	
	Aeration Tank TOC =	**921.51**						
	Freeboard =	2.50	ft					
Compute for WS EL Downstream of DB2 Weir								
Pipe from Aeration Tank to DB2								
16" HDPE (AWWAC906)								
	Split Factor =	**2**						
	ML $(Q + Q_r)$ per Aeration Tank =	2,500	gpm					
	D=	**16**	inch					
Velocity	v =	3.99	ft/s					
Velocity head	$v^2/2g$=	0.247	ft					
Pipe Length	L=	**70**	ft					
C value	C =	120						
Friction Headloss:	h_f=	**0.28**						
Minor headlosses:								
		k	No.					
	Exit of pipe =	1.00	1					
	Entrance of pipe =	0.50	1					
	90 elbow =	0.19	2					
	butterfly valve =	0.30	1					
	Sum =	2.18						
Minor headlosses:	h_m=	0.54						
Total headlosses:	h_T=	**0.82**		0.82				
WS EL Downstream of DB2 Weir					**919.83**		**919.83**	
	Weir EL at DB2 =	**920.33**						
Compute for WS EL Upstream of DB2 Weir								
	ML $(Q + Q_r)$ =	11.14	cfs					pg. 34, Isco Open
Rectuangular weir w/o end contractions								Channel Flow
$Q = 3.330LH^{1.5}$								Measurement Handbook
	Length of weir, L =	**5**	ft					

	Head on weir, H =	**0.76**	ft	0.76				
WS EL Upstream of DB2 Weir					**921.09**		**921.09**	
	DB2 TOC =	**923.59**						
	Freeboard =	**2.50**	**ft**					
Compute for WS EL Downstream of PC V-Notch Weir								
Pipe from DB2 to Primary Clarifier								
12" HDPE (AWWAC906)								
	Split Factor =	2						
	Q per PC =	1,250	gpm					
	D=	12	inch					
Velocity	v =	3.54	ft/s					
Velocity head	$v^2/2g$=	0.195	ft					
Pipe Length	L=	90	ft					
C value	C =	120						
Friction Headloss:	h_f=	**0.40**						
Minor headlosses:								
		k	No.					
	Exit of pipe =	1.00	1					
	Entrance of pipe =	0.50	1					
	90 elbow =	0.19	2					
	butterfly valve =	0.30	1					
	Sum =	2.18						
Minor headlosses:	h_m=	0.43						
Total headlosses:	h_T=	**0.83**		0.83				
WS EL Downstream of Primary Clarifier V-Notch Weir					**921.92**		**921.92**	
	V-Notch Weir EL at PC =	**922.42**						
Compute for WS EL at PC (Upstream of PC V-Notch Weir)								
90-deg V-notch Weir								pg. 30, Isco Open
PC diameter	=	50	ft					
Weir diameter	=	46	ft					
Weir Nos.	=	289						6" interval v-notch weirs
$Q = 2.5H^{2.5}$								pg. 30, Isco Open
	Split Factor =	2						Channel Flow
	Flow per Clarifier =	2.7850	cfs					Measurement Handbook
	Flow per Weir =	0.010	cfs					3rd Ed.
	Head on weir, H =	**0.11**	ft	0.11				
WS EL at PC					**922.53**		**922.53**	
	Primary Clarifier TOC =	**925.03**						
	Freeboard =	2.50	ft					
Compute for WS EL Downstream of DB1 Weir								
Pipe from PC to DB1								
12" HDPE (AWWAC906)								
	Split Factor =	2						
	(Q+RAS) per PC =	1,250	gpm					
	D=	12	inch					
Velocity	v =	3.54	ft/s					
Velocity head	$v^2/2g$=	0.195	ft					
Pipe Length	L=	60	ft					
C value	C =	120						

Friction Headloss:	h_f=	**0.27**						
Minor headlosses:								
		k	No.					
	Exit of pipe =	1.00	1					
	Entrance of pipe =	0.50	1					
	90 elbow =	0.19	2					
	butterfly valve =	0.30	1					
	Sum =	2.18						
Minor headlosses:	h_m=	0.43						
Total headlosses:	h_T=	**0.69**		0.69				
WS EL Downstream of DB1 Weir					**923.22**		**923.22**	
	Weir EL at DB1 =	**923.72**						
Compute for WS EL Upstream of DB1 Weir								
	Q =	5.57	cfs					pg. 34, Isco Open
Rectuangular weir w/o end contractions								Channel Flow
$Q = 3.330LH^{1.5}$								Measurement Handbook
	Length of weir, L =	**3**	ft					
	Head on weir, H =	**0.68**	ft	0.68				
WS EL Upstream of DB1 Weir					**924.40**		**924.40**	
	DB1 TOC =	**926.90**						
	Freeboard =	2.50	ft					

APPENDIX: DESIGN PROJECT ASSIGNMENT