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CITY OF SUNNYVALE

MASTER PLAN AND PRIMARY TREATMENT DESIGN

TECHNICAL MEMORANDUM
SECONDARY TREATMENT:
MASTER PLAN
FINAL

September 2014

carollo in association with HDR

CITY OF SUNNYVALE

MASTER PLAN AND PRIMARY TREATMENT DESIGN

TECHNICAL MEMORANDUM

SECONDARY TREATMENT:
MASTER PLAN

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1.0 INTRODUCTION

This technical memorandum (TM) presents an analysis and selection of process alternatives for secondary treatment at the City of Sunnyvale's (City's) Water Pollution Control Plant (WPCP). The selected secondary treatment process proposed for the WPCP is based on providing the needed improvements through buildout (2035) to meet the City's goals and objectives. The recommendations presented herein are an update to and expansion of the recommendations included in the City's WPCP Strategic Infrastructure Plan (SIP).

The evaluation was completed using a three step process: (1) a one-week internal peer review was held on September 9th through 12th, 2013 which was attended by process experts from the Carollo/HDR team; (2) a two-day workshop on October 14th and 15th, 2013, during which time the Carollo/HDR team presented the recommended liquid and solids treatment processes to the City staff and (3) a one-day workshop on January 24, 2014, during which time the Carollo team presented the split-treatment alternatives. The key findings and recommendations developed for the secondary treatment process are summarized in this TM, as well as in the October workshop meeting minutes and presentation slides included in Appendix A.

2.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS

The key findings and recommendations for the secondary treatment process include:

- A conventional Modified Ludzack Ettinger (MLE) activated sludge (CAS) process provides the process needs to accommodate future regulatory limits for nitrogen, and combined with chemically enhanced primary treatment (CEPT), will be able to accommodate future regulatory limits for phosphorus. In addition, the CAS alternative has the lowest net present value (NPV) when compared to the membrane bioreactor (MBR) alternative, therefore the CAS process will be utilized for finalizing the site layout considerations.
- To minimize site impacts, 8 million gallons (MGal) of diurnal equalization is recommended within the existing pond space.
- The project team recommends setting aside footprint for a fifth aeration basin that would provide the additional aeration basin capacity should the projected 2035 ammonia loads be higher than the 4,850 ppd anticipated with the design ammonia load scenario. The fifth aeration basin would provide capacity to treat the projected 2035 high ammonia load scenario of 6,200 ppd.

- The project team recommends setting aside footprint for a future denitrification filter that could provide the ability to meet possible future total nitrogen limits of 3 milligrams per liter (mg/L).
- Due to uncertainties in flow and load projections as well as future regulations, the City has tentatively decided to phase in secondary treatment by utilizing a split-flow treatment approach to better manage cash flow expenditures. This approach would allow the City to initially build a smaller CAS facility and continue to use their existing process to treat a portion of the flow.

Table 1 provides a comparison of the secondary treatment recommendations presented in this TM with the Plant Replacement – CAS alterative from the SIP.

Table 1 Comparison of Master Plan and SIP Recommendations
Master Plan and Primary Treatment Design
City of Sunnyvale

Process/ Technology	SIP (2011)	Master Plan (this Study) (2014)	Reason for difference
Secondary Treatment	• CAS	• CAS	No difference
Aeration Basins	• 7 x 2 MGal basins	• 4 x 2.6 MGal basins	• CaRRB increases inventory • Lower assumed Yield in Master Plan
Blowers Building and Blowers	• 1000 sf building • 2 x 525 hp (5500 scfm) blowers	• 4800 sf building • 6 x 300 hp (3000 scfm) blowers, 5 duty, 1 standby	Basis for original SIP assumptions unknown.
Secondary Clarifiers	• 3 x 9503 sf clarifiers	• 6 x 6400 sf clarifiers	Basis for original SIP assumptions unknown.
Return Activated Sludge (RAS) Pump Station	• 5 x 50 hp, 3 duty, 2 standby	• 5 x 50 hp, 4 duty, 1 standby	Basis for original SIP assumptions unknown.
Waste Activated Sludge (WAS) Pump Station	• No information available	• 3 x 15 hp (540 gpm), 2 duty, 1 standby	Basis for original SIP assumptions unknown.

3.0 BACKGROUND

Secondary treatment at the WPCP occurs in a mixed system consisting of natural and engineered processes. Currently primary effluent is sent to a 440-acre facultative pond system that was constructed in 1965. The two facultative ponds provide biological oxidation of the soluble organic material that remains in the wastewater after primary clarification. The ponds also play an important role in the conversion of ammonia to nitrate during the warm summer months. Typically, the pond effluent is then pumped to one of three fixed growth reactors (FGRs) constructed in 1975. The FGRs are designed to further nitrify the wastewater prior to discharge. Typically, the FGR effluent then flows to the dissolved air flotation thickening (AFT) process, also constructed in 1975. The AFTs are used to remove suspended solids, consisting primarily of algae cells produced in the ponds and bacterial solids that have sloughed off the media in the FGRs. The current process flow diagram is summarized in Figure 1.

This section will summarize the current and future regulatory considerations, the secondary treatment recommendations from the SIP, the SIP Peer Review and other secondary treatment alternatives recommended at the internal peer review *CAMP*®.

3.1 Regulatory Considerations/Implications

The City's current NPDES permit was issued in 2009 and expires in 2014. Table 2 summarizes the effluent limits for total suspended solids (TSS), carbonaceous biochemical oxygen demand (CBOD) and ammonia. The City has been in discussions with the Regional Board and believes that the upcoming permit (2014) would have similar effluent limits and would impose no total nitrogen (TN) limits. The team believes that the next permit (to be issued around the year 2019) will probably hold the effluent TN load to current levels. It is anticipated that the following permit (issued around the year 2024) would probably give the City a 10-year compliance period to meet a new TN limit, with a new limit in place by the year 2034. Figure 2 summarizes the project teams current understanding of the progression in nitrogen regulations over-layed by the City's permitting cycle.

Table 2 Effluent Quality Goals
Master Plan and Primary Treatment Design
City of Sunnyvale

Description	Current Permit	Anticipated ~ 2035	Possible ~ 2050
TSS	20 mg/L monthly 30 mg/L daily	No change	No change
CBOD	10 mg/L monthly 20 mg/L daily	No change	No change
Ammonia – winter (October – May)	18 mg/L monthly 26 mg/L daily	2 mg/L monthly 5 mg/L daily	No change
Ammonia – summer (June – September)	2 mg/L monthly 5 mg/L daily	2 mg/L monthly 5 mg/L daily	No change
Total Nitrogen	NA	8 mg/L	3 mg/L
Total Phosphorus	NA	1 mg/L	No change

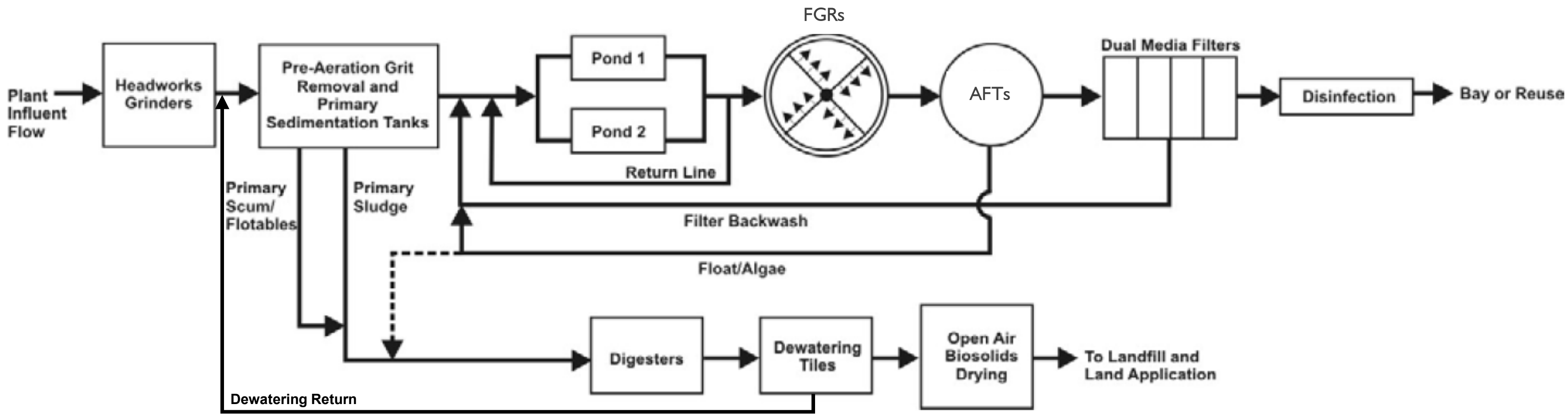

Figure 1
EXISTING PLANT PROCESS FLOW DIAGRAM
SECONDARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

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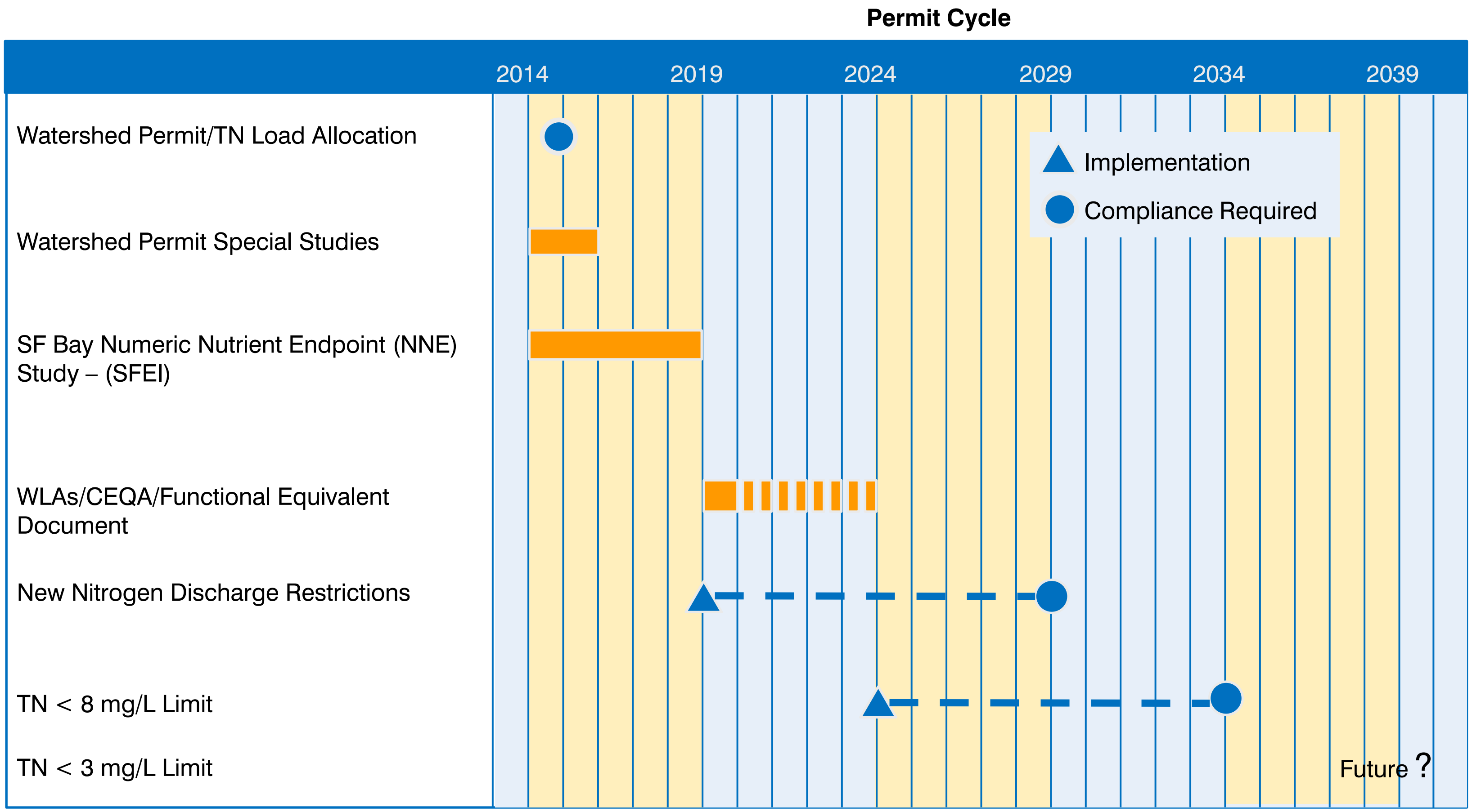

Figure 2
ANTICIPATED NITROGEN COMPLIANCE SCHEDULE
SECONDARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

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It is anticipated that a new secondary treatment process would be online by approximately 2023, and that sometime between 2023 and 2034 the WPCP would need to meet a year round ammonia limit of 2 mg/L. Additionally, by 2034 a year round total nitrogen limit of 8 mg/L would need to be met. Figure 3 describes the assumed compliance schedule.

3.2 SIP Recommendations

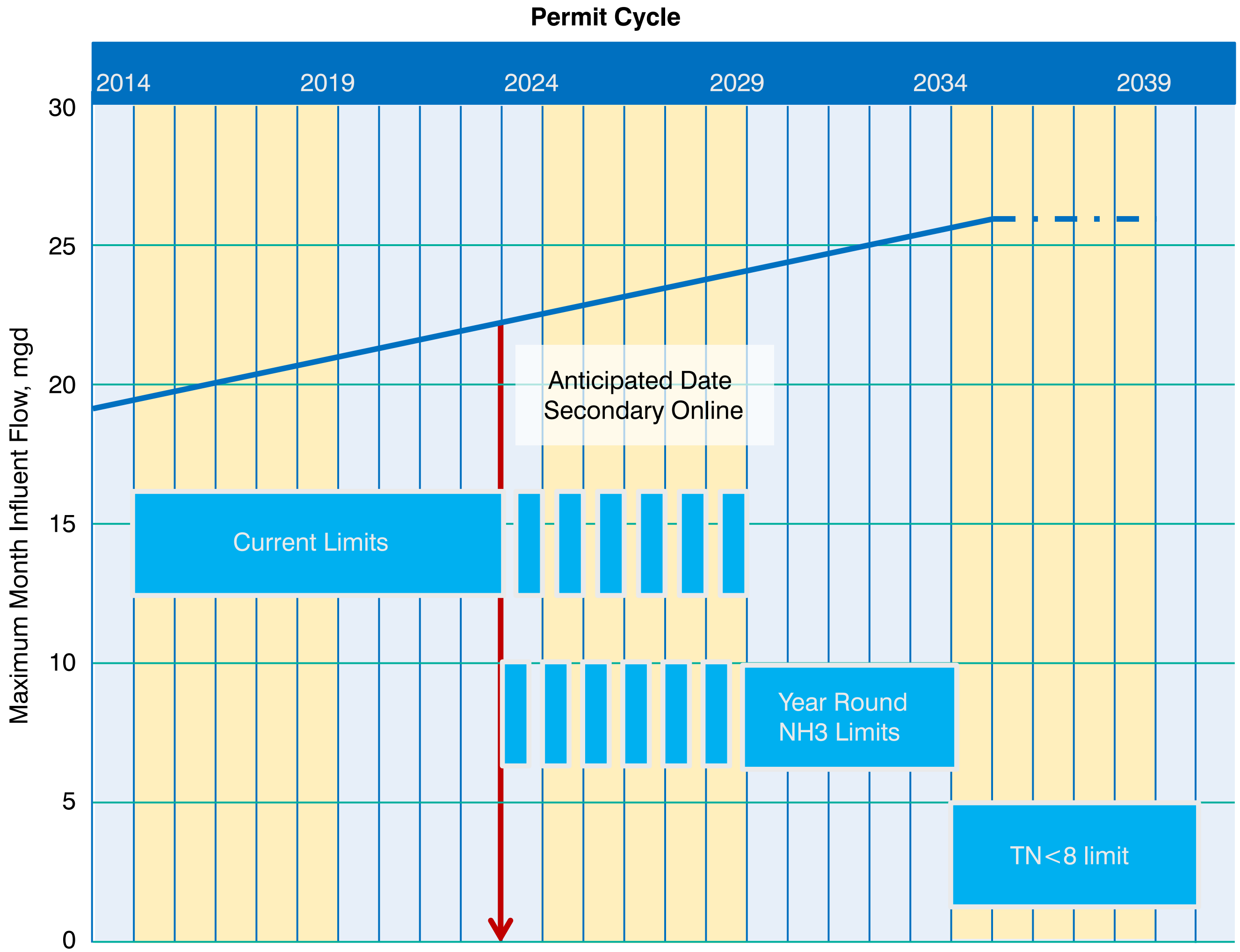
The SIP considered a variety of options to provide process reliability to meet nitrification requirements and to allow the plant to expand to meet projected flows and loads. The SIP considered options to rehabilitate the existing plant and to replace the plant. For plant replacement the SIP considered CAS, MBR, integrated fixed film activated sludge (IFAS) and biological aerated filters (BAFs) as potential treatment technologies. The SIP found that the CAS alternative had the largest footprint and the lowest projected life cycle costs and lowest project resource consumption. Since the CAS alterative had the lowest cost, the SIP selected this technology for one of their plant replacement alternatives. The SIP selected a MBR process as a more compact alternative to the CAS should the footprint associated with the CAS alternative make this alternative infeasible. The four alternatives carried forward by the SIP for further analysis included:

1. **Plant Rehabilitation.** This alternative includes rebuilding the plant facilities without making any significant change to the processes. The core secondary treatment process, includes a combination of 440-acres of facultative ponds, AFTs, and FGRs.
2. **Plant Replacement** – CAS. This alternative includes replacing the core secondary treatment process with a CAS process for secondary treatment and nitrification (Figure 4).
3. **Plant Replacement –MBR**. This alternative includes replacing the core secondary treatment process with a MBR process for secondary treatment and nitrification.
4. **Plant Rehabilitation – Hybrid Pond and CAS System (Hybrid)**. This alternative includes implementing an CAS process that would treat a portion of the organic load in combination with the facultative ponds.

The SIP recommended the City move forward with the Plant Rehabilitation alternative (Alternative 1). Should the nitrification performance of the existing WPCP secondary process prove to be insufficient to meet water quality requirements, the SIP recommended the City move forward with the Plant Replacement CAS alternative (Alternative 2).

The City engaged CH_2M Hill (CH_2M) to conduct a peer review of the SIP. CH_2M confirmed that the SIP was well prepared, but offered a third alternative for rebuilding the plant:

5. **FGRs and Wetlands**. This alternative proposed using the existing FGRs as well as additional FGRs for secondary treatment. The ponds would be converted to wetlands and used as for effluent polishing (Figure 5). A benefit of this alternative is that it would make use of the existing pond space.



NOTE:
Year 2035 influent flows are also the estimated buildout influent flows.
For this reason the influent flow projection flattens out after the year 2035.

Figure 3
MM FLOWS RELATIVE TO NITROGEN EFFLUENT LIMITS
SECONDARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

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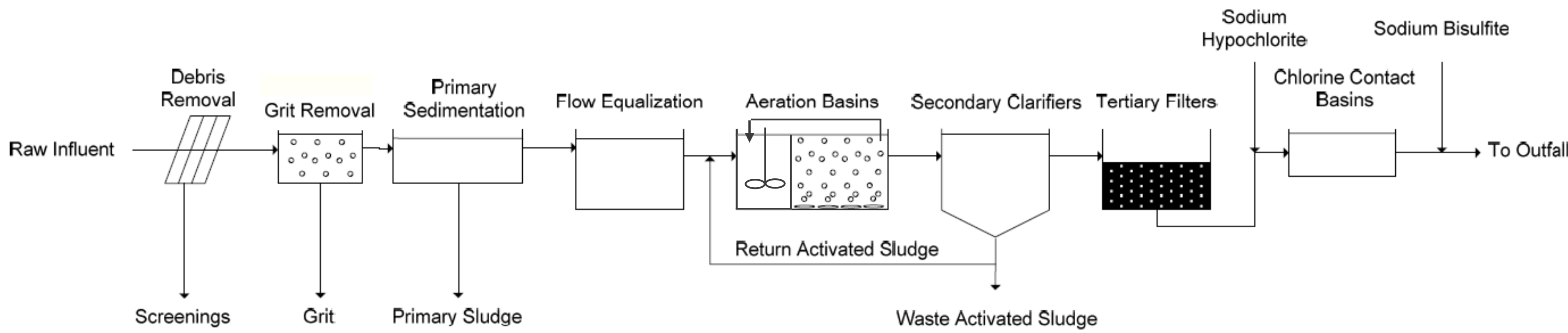

NOTE:
The Tertiary Filters and the Chlorine Contact Basins are existing unit processes. All other processes will be replaced as part of the Master Plan.

Figure 4
SIP RECOMMENDED PLANT REPLACEMENT AS ALTERNATIVE
SECONDARY TREATMENT
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CITY OF SUNNYVALE

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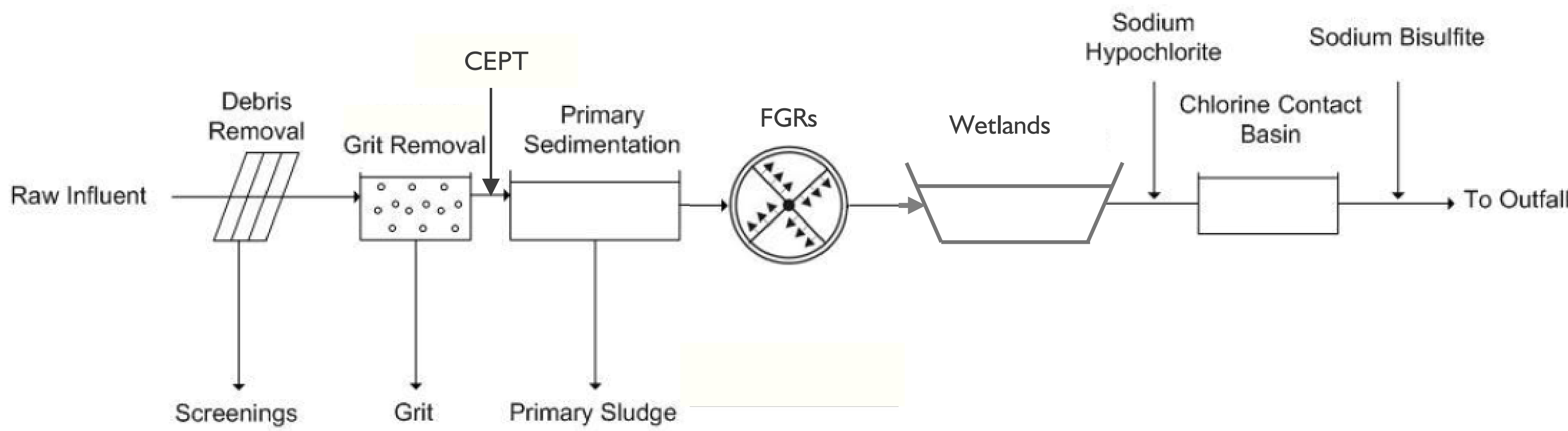

NOTE:
The FGRs, Tertiary Filters and the Chlorine Contact Basins are existing unit processes. All other processes will be replaced as part of the Master Plan. Additional FGRs are also planned as part of this alternative.

Figure 5
SIP PEER REVIEW FGR/WETLANDS ALTERNATIVE
SECONDARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

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The City decided to hold a workshop in December 2011 to allow a full vetting of all issues among both consulting firms and the City staff. The Plant Rehabilitation alternative (Alternative 1) was eliminated from consideration on the basis that it provided no advantage over the other alternatives, and is the least able to comply with more stringent anticipated future regulations. It was concluded the Plant Replacement CAS alternative (Alternative 2, Figure 4) and the FGR/wetlands alternative (Alternative 5, Figure 5) should be considered further.

3.3 Alternative Technologies

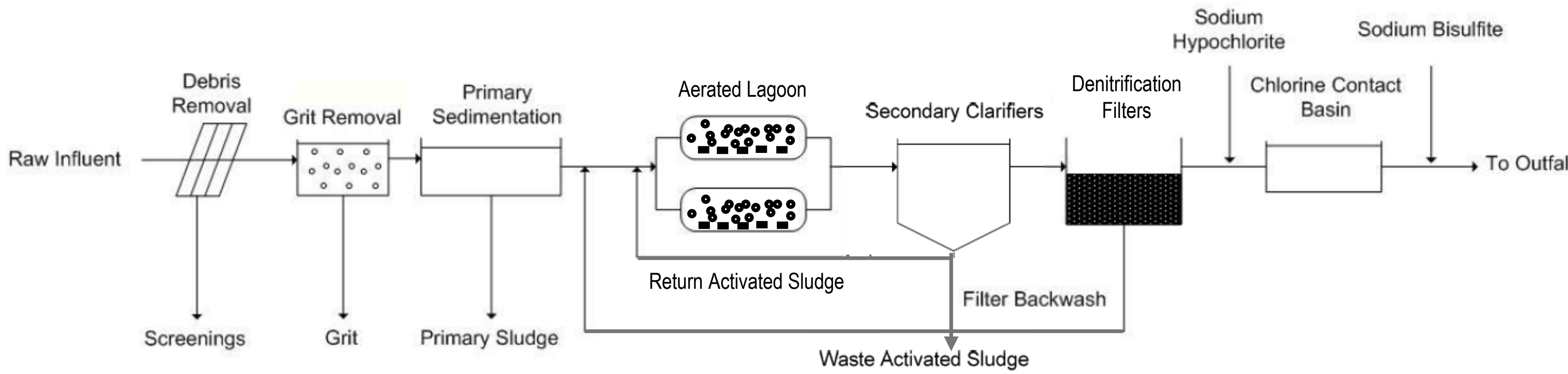
As a part of the one-week internal peer review *CAMP®* held on September 9th through 12th, 2013, the peer review committee reviewed the recommendations for the SIP and SIP peer review (Alternative 1 and 5). These alternatives were originally designed to meet ammonia limits. The Master Plan internal peer review *CAMP®* discussed the ability of these alternatives to meet a potential TN limit of 8 mg/L by the year 2035. During Master Plan internal peer review *CAMP®*, the City was not anticipating any future phosphorus limits and thus initial discussions for meeting a phosphorus limit were not part of this peer review workshop. The Master Plan internal peer review *CAMP®* recommended an additional alternative:

6. **Aerated Lagoons**. This alternative would convert a portion of the ponds to aerated lagoons (Figure 6). A benefit of this alternative is that it would make use of the existing pond space.

Other alternatives such as BAFs, IFAS, MBBR and MBRs (Alternative 3) were discussed at this workshop. The BAF, IFAS and MBBR alternatives were ultimately not carried forward since the peer review team felt that the advantages of the BAF, IFAS and MBBR were similar to the MBR alternative without all the same benefits. The MBR alternative had additional benefits due to its more compact footprint and superior effluent quality that would allow the District more flexibility in developing potential future effluent reuse options. The outcome of the Master Plan internal peer review *CAMP®* was to carry forward the initial recommendations of the SIP and SIP Peer Review (Plant Replacement CAS - Alternative 2 and FGR/Wetlands - Alternative 5) along with an Aerated Lagoon (Alternative 6). The Master Plan internal peer review *CAMP®* recommended that the Plant Replacement MBR alternative (Alternative 3) should be further evaluated if space or reuse opportunities became drivers.

4.0 FATAL FLAW SCREENING

An initial high level, fatal flaw screening was conducted of Alternatives 2, 5 and 6, with Alternatives 5 and 6 offering the benefit of continuing to use the existing pond space. This section describes the design criteria used in that initial analysis, and the results of the initial analysis.



NOTE:
The Tertiary Filters and the Chlorine Contact Basins are existing unit processes.
All other processes will be replaced as part of the Master Plan.

Figure 6
MASTER PLAN PEER REVIEW AERATED LAGOON ALTERNATIVE
SECONDARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

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4.1 Design Criteria

Table 3 summarizes the design criteria used in the fatal flaw screening. These design criteria were agreed to by the Master Plan internal peer review *CAMP*® held on September 9th through 12th, 2013. High-level process sizing is shown in Table 4.

Table 3 Design Criteria
Master Plan and Primary Treatment Design
City of Sunnyvale

Description	Alternative 2: Plant Replacement CAS(1)	Alternative 5: FGR/Wetland(1)	Alternative 6: Aerated Lagoon(1)
MM PC BOD Removal, %	31	70(2)	31
Aerobic/Total SRT, days	7/9	NA	7/14
MLSS, mg/L	2500	NA	1200
BOD loading, lb/cf-d	NA	15	0.015
Final Effluent TN, mg/L	8	8	8
Peak Flows Through Secondary Treatment, mgd	34.7(3)	34.7(3)	34.7(3)
SVI, mL/g	150	250	150

Notes:
(1) Based on the 2035 projected flows and loads for the design ammonia load scenario.
(2) With CEPT.
(3) 2035 equalized peak day flow based on an 8 MGal equalization basin volume.

Table 4 Process Sizing
Master Plan and Primary Treatment Design
City of Sunnyvale

Description	Alternative 2: Plant Replacement CAS(1)	Alternative 5: FGR/Wetland(1)	Alternative 6: Aerated Lagoon(1)
Aeration basin/aerated lagoon tank volume, MGal	10.5	NA	16
Secondary clarifier tank volume, MGal	4.6	NA	5.6
FGR volume, MGal			
Existing, MGal	NA	3	NA
New, MGal	NA	4	NA
Wetland Area, acre	NA	300	NA

Notes:
(1) Based on the 2035 projected flows and loads, design ammonia influent load scenario.

4.2 Screening Results

A high-level analysis was conducted of the three alternatives. The three alternatives were compared based on their reliability, ease of operation and maintenance (O&M), maximizing resources, power usage, flexibility to meet future permit, ease of implementation and site efficiency as summarized below and in Table 5. The screening criteria were reviewed with the City at the October 14th and 15th workshop.

- **Reliability**: The Plant Replacement CAS alternative (Alternative 2) was determined to be the most reliable process to meet effluent goals, followed by the Aerated Lagoon (Alternative 6) and FGR/wetlands (Alternative 5).
- **Ease of O&M**: All three alternatives were determined to have about the same ease of O&M.
- **Maximizing Resources**: The FGR/Wetlands Alternative 5 made the best use of the City's resources since both the FGRs and pond space would be used. The Aerated Lagoons Alternative 6 made use of the existing pond space and thus made the next best use of existing resources. The Plant Replacement CAS Alternative 2 utilized the least of the City's existing infrastructure.
- **Power Usage**: The FGR/Wetland Alternative 5 is anticipated to use the least amount of power. Both the Plant Replacement CAS Alternative 2 and Aerated Lagoons Alternative 6 are anticipated to use more power than the current natural system.
- **Flexibility to meet future permit**: The Plant Replacement CAS Alternative 2 provides the greatest flexibility to meet future permit. It is anticipated the effluent quality from the two natural system alternatives (Alternative 5 and 6) could potentially limit the City's future use of their effluent.
- **Ease of Implementation:** All three alternatives were determined to have about the same ease of implementation.
- **Site Efficiency:** The FGR/Wetlands Alternative 5 and the Aerated Lagoons Alterative 6 are both projected to be more space efficient than the Plant Replacement CAS Alternative 2.

The results of this screening are shown in Table 5 and were presented to the City at the two-day workshop on October 14th and 15th, 2013. Based on a comparison of the NPV of the three alternatives, the FGR/Wetland Alternative 5 was clearly the most expensive. Additionally, the ultimate performance of this alternative will be dependant of the performance of the wetland process, which is not as well established as the other processes. This high cost is due mostly to the cost of building an engineered berm around the entire pond system to protect against future sea level rise, which was estimated to cost approximately $9,500 per linear foot. The Aerated Lagoon Alternative 6 and Plant

Replacement CAS Alternative 2 were about the same cost. However, the Plant Replacement CAS Alternative 2 offered several non-cost advantages over the Aerated Lagoon Alternative 6 including a greater degree of reliability, and greater flexibility. For these reasons, the project team agreed to move forward with the Plant Replacement CAS Alternative 2.

Table 5 High Level Screening
Master Plan and Primary Treatment Design
City of Sunnyvale

Description	Alternative 2 Plant Replacement CAS	Alternative 5 FGR / Wetland	Alternative 6 Aerated Lagoon
Reliability	+	-	0
Ease of O&M	0	0	0
Maximize Resources	-	+	0
Power Usage	-	+	-
Flexibility to meet future permit	+	0	0
Ease of Implementation	0	0	0
Site Efficiency	-	+	+
NPV(3)	$246M±	$407M±	$247M±

Notes:
(1) + = Better, 0 = Neutral, - = Worse.
(2) Assumes 2035 flows and loads and an effluent TN limit of < 8 mg/L, design ammonia loads scenario.
(3) Costs are for comparison purposes only and do not include common elements.

5.0 COMPARISON OF CAS AND MBR

The City is in initial discussions with a local water agency on potential indirect potable reuse (IPR) options for their effluent. Based on these initial discussions with the water agency, the City was interested in understanding the cost and footprint implications of the Plant Replacement MBR Alternative (Alternative 3) which could produce a higher quality effluent that would be more amenable to IPR reuse.

MBRs are a combination of activated sludge reactors and membrane facilities (Figure 7). Membrane systems are pressure driven solids separation processes, which use membranes with extremely small pore spaces to remove particles. Typically, a vacuum is applied to a header pipe connected to the membranes, which draws the treated effluent through the membranes and into the pump. These systems can be used to replace clarifiers and filtration in the activated sludge process. Without the limitations set by solids flux in secondary clarification, the mixed liquor can be more concentrated (up to 10,000 mg/L) than with conventional activated sludge, which reduces the size of the activated sludge

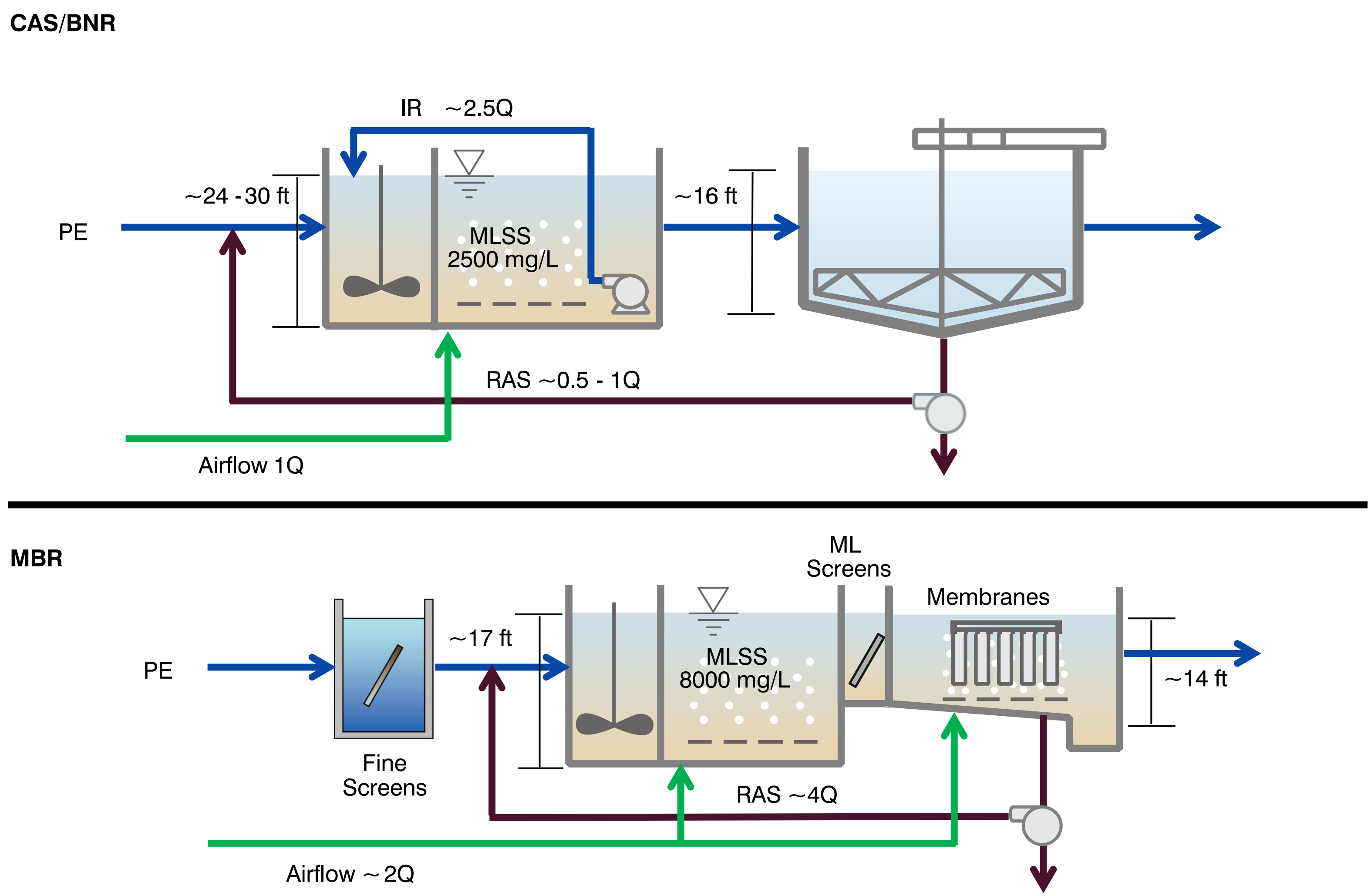

Figure 7
CAS AND MBR PROCESS CONFIGURATIONS
SECONDARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

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process. MBRs produce a high quality effluent that is superior to the effluent from both final clarification and tertiary filtration.

Due to the small pore size of the membrane, the primary effluent will need to pass through fine screens (one millimeter [mm] opening) prior to the aeration tanks. Membrane systems typically have a higher O&M cost than a traditional activated sludge system due to higher power requirements (from the higher aeration and pumping demands), the higher chemical costs (due to the need for periodic membrane cleanings), and the need for periodic membrane replacement (every six to ten years).

5.1 Design Criteria

An internal Master Plan peer review *CAMP*® was held on September 9th through 12th, 2013 to discuss design criteria for the alternatives considered. Based on the results of this workshop, the team decided to plan for a MLE configuration for both the Plant Replacement - CAS (Alternative 2) and Plant Replacement MBR (Alternative 3) alternatives. Additionally, the team decided to plan for a 7 day aerobic SRT. To address some of the uncertainties in influent characteristics and ammonia load, it was decided that a swing zone should be incorporated that could be either aerobic or anoxic. This would allow the basin to be operated with a larger anoxic zone at a shorter aerobic SRT of 6 days.

The remainder of this section summarizes the specific design criteria for the Plant Replacement CAS and Plant Replacement MBR alternatives.

5.1.1 Plant Replacement CAS

To minimize the site impacts and the impacts for the dewatering return stream, the team decided to incorporate sidestream treatment with a centrate and RAS re-aeration basin (CaRRB) into the plan for the CAS alternative. In this configuration, the RAS is combined with the centrate and aerated. This zone can efficiently nitrify the centrate's high ammonia concentration, provide aerobic inventory at a higher MLSS (thus saving site footprint) and can provide a seed of nitrifiers to the aeration basin.

A step feed configuration was considered for the CAS alterative as it offered the advantage of lower operating costs due to eliminating the need for MLR. This configuration was found to require more aeration basin volume to meet a TN limit of 8 mg/L. However, a basin capable of operating in both the MLE configuration and step feed configuration would be provided to offer the City greater operational flexibility should effluent limits be less strict than initially planned.

The Master Plan internal peer review team recommended setting the target MLSS concentration in the aeration basins to minimize site footprint between the aeration basins and secondary clarifiers. An initial analysis found that a MLSS concentration of 2500 mg/L minimized secondary site footprint.

5.1.2 Plant Replacement MBR

Due to the high MLSS concentration in the MBR aeration basin, an initial analysis found that CaRRB did not provide any benefit to the Pant Replacement - MBR alterative and therefore a conventional MLE configuration was planned for the Plant Replacement - MBR alterative.

Since any oxygen in the anoxic zone will consume soluble BOD and reduce the nitrogen removing capacity of the system, an unaerated RAS deoxygenation zone was included into the MBR configuration. This zone would essentially remove the high dissolved oxygen concentration in the RAS prior to the blending with the primary effluent.

5.1.3 Summary

Table 6 summarizes the key design criteria for the Plant Replacement CAS and Plant Replacement MBR alternatives.

**Table 6 Design Criteria for Plant Replacement CAS and MBR Alternatives
Master Plan and Primary Treatment Design
City of Sunnyvale**

Description	Plant Replacement CAS	Plant Replacement MBR
MM PC BOD Removal, %	31	31
Aeration Basin Configuration	MLE with CaRRB	MLE with Deox Zone
Aerobic/Total SRT, days	7/10	7/13
MLSS, mg/L	2500	8,000 (AB) / 10,000 (MBR)
Final Effluent TN, mg/L	8	8
Peak Flows Through Secondary Treatment, mgd	34.7(1)	34.7(1)
SVI, mL/g	150	NA
MBR Max Month Flux (gfd)	NA	16

Note:
(1) 2035 equalized peak day flow based on an 8 MGal equalization basin volume.

5.2 Analysis

Table 7 summarizes the key differences between the Plant Replacement CAS and Plant Replacement MBR processes at the WPCP. As shown in Table 7, the Plant Replacement CAS alternative uses approximately 3.5 times the volume as the Plant Replacement MBR alternative. Design criteria and model information for the Plant Replacement CAS and Plant Replacement MBR alternatives are presented in Appendix C.

Table 7	CAS and MBR Comparison Master Plan and Primary Treatment Design City of Sunnyvale	
Description	**Plant Replacement CAS (Alternative 2)**	**Plant Replacement MBR (Alternative 3)**
Aeration basin tank volume, MGal	10.5	3.7
Aeration basin side water depth, ft	30	17
Secondary clarifier tank volume, MGal	4.6	NA
MBR tank volume, MGal	NA	0.6 MG

Notes:
(1) Assume the design nitrogen scenario.
(2) Both CAS and MBR processes are approximately equal in their ability to meet future permit limits for phosphorus, nitrogen and ammonia.

Table 8 summarizes capital cost comparison of the Plant Replacement CAS and Plant Replacement MBR alternatives. The MBR process produces a higher quality effluent, which has added value to the water agency. However, since this has no added value to the City, the added benefit of the higher effluent quality is not captured in the cost comparison. As is shown in Table 8, the project costs of the Plant Replacement CAS alterative is about $44M less expensive than the Plant Replacement MBR alternative. Table 9 summarizes the annual costs for the Plant Replacement CAS and Plant Replacement MBR alternatives. As shown in Table 9, the annual costs of the Plant Replacement MBR alternative are about 60% more expensive than of the Plant Replacement CAS alterative due to the higher maintenance, power, equipment replacement and chemical costs. Details on the capital and operation costs for the Plant Replacement CAS and Plant Replacement MBR alternatives are summarized in Appendix B.

The Plant Replacement CAS and Plant Replacement MBR alternatives were evaluated based on their reliability, ease of O&M, maximizing resources, power usage, flexibility to meet future permit, ease of implementation and site efficiency as summarized below and in Table 10.

- **Reliability**: Both alternatives are equally reliable in terms operation and meeting the effluent quality goals.
- **Ease of O&M**: It is anticipated that a MBR will take more operator attention.
- **Maximizing Resources**: Neither alterative makes use of the plant's existing FGRs, ponds or AFTs.

Table 8	Capital Cost Comparison Master Plan and Primary Treatment Design City of Sunnyvale	
Description	**Plant Replacement CAS[(1)]**	**Plant Replacement MBR[(1)]**
Fine Screens	--	$11M
Aeration Basins	$55M	$30M
Secondary Clarifiers	$32M	--
MBR Tanks	--	$84M
Filter Improvements	$3M	--
Total Capital Cost	**$90M±**	**$125M±**
Project Costs[(2)]	$32M	$44M
Value of Land[(3)]	$8M	$5M
Total Project Cost	**$130M±**	**$174M±**

Notes:

(1) Costs for full treatment option with facilities needed for the year 2035 flows and loads. Costs based on AACE Class 4, Planning Level, estimated level of accuracy -30% to +50%. More detailed cost information for this table is included in Appendix B. Costs are for alternative comparison only and exclude common facilities. Common costs for diurnal equalization is assumed for both ($39M) and not included in this comparison.

(2) 35% added for project costs.

(3) Land valued at $3M/acre.

Table 9	O&M Cost Comparison Master Plan and Primary Treatment Design City of Sunnyvale	
Description	**Plant Replacement CAS[(1,2,3)]**	**Plant Replacement MBR[(1,2)]**
Operations Labor	$740,000	$730,000
Maintenance Labor	$530,000	$760,000
Power	$1,270,000	$1,710,000
Equipment Replacement	$580,000	$1,660,000
Chemicals	$20,000	$73,000
Annual Costs (2025)[(4)]	$3,100,000	$4,900,000
NPV[(5)]	**$44M±**	**$68M±**

Notes:

(1) Cost backup included in Appendix C.

(2) Includes O&M costs for tertiary filtration.

(3) Annual costs in year 2025 shown in current dollars.

(4) 20 year period, inflation = 3%, cost of money = 7%, real discount rate = 3.8%

Table 10 Evaluation of CAS and MBR Master Plan and Primary Treatment Design City of Sunnyvale		
Description	Plant Replacement CAS (Alternative 2)	Plant Replacement MBR (Alternative 3)
Reliability	+	+
Ease of O&M	+	0
Maximize Resources	-	-
Power Usage	-	-
Flexibility to meet future permit	0	+
Ease of Implementation	0	+
Site Efficiency	-	+
NPV(3)	$172M±	$242M±

Notes:
(1) + = Better, 0 = Neutral, - = Worse.
(2) Assumes 2035 flows and loads and an effluent TN limit of < 8 mg/L.
(3) Costs are for alternative comparison only and exclude common facilities.

- **Power Usage**: Both alternatives are anticipated to use more power than the current natural system. As shown in Table 9, it is anticipated that the Plant Replacement MBR alternative will use more power than the Plant Replacement CAS alternative due to the need to provide coarse bubble aeration of the membrane cassettes, the need for a high RAS rate and the inefficiencies of aerating the high mixed liquor concentration in the membrane tanks.
- **Flexibility to meet future permit**: The MBR produces a higher quality effluent which will allow the City more flexibility in reuse options and greater flexibility to meet tighter effluent limits.
- **Ease of Implementation:** The MBR system is more modular and can be more easily expanded to meet increasing flows.
- **Site Efficiency:** The MBR process is more compact than the CAS process and will be more site efficient.

The NPV of the Plant Replacement CAS alternative is $70M less expensive than the Plant Replacement MBR alterative. Additionally, it is expected that the Plant Replacement CAS alterative would be simpler to operate. The Plant Replacement MBR alternative provides a clear advantage from site footprint perspective. Additionally, the Plant Replacement MBR alternative offers more flexibility and ease of compliance. Since the Plant Replacement CAS alternative has the lowest NPV, requires less energy and is simpler to operate, the project team decided to move forward to develop the final site layouts based on the Plant Replacement CAS alternative. The main driver to implement an MBR facility would be the need to provide high quality effluent for IPR reuse.

6.0 ALTERNATIVE REFINEMENT

Based on the recommendations of the fatal flaw screening presented at the two-day workshop held on October 14th and 15th, 2013, the Plant Replacement CAS was carried forward for reasons stated earlier.

This section summarizes the more detailed analysis of the Plant Replacement CAS alternative including: (1) equalization; (2) implications of the high nitrogen load scenario; (3) alternatives to treat phosphorus to meet a total phosphorus limit of 1 mg/L by 2034; and (4) alternatives to meet a total nitrogen limit of 3 mg/L after 2034.

6.1 Diurnal Equalization

To provide secondary treatment to meet the 2035 peak hour flow of 58.5 mgd would require more secondary facilities than would likely fit on the limited site. Due to site limitations, 8 MGal of diurnal equalization located in the current site of the ponds is planned that would limit the peak flow to around 35 mgd as shown in Figure 8. The equalization volume was selected based on a high-level analysis comparing the cost of equalization with the cost of additional secondary treatment facilities. Figure 9 shows the proposed location of the equalization facility, which would include two 4-MG equalization (EQ) tanks and an EQ pump station. As shown in Figure 10, primary effluent would flow into the Primary Effluent Distribution Structure and flows in excess of 34.7 mgd would be routed to the EQ tanks. This could be achieved with an overflow weir. Once the primary effluent flow had decreased below 34.7 mgd, the EQ pump station would be used to return the equalized flow to the Primary Effluent Distribution Structure, where it would then flow to the aeration basins.

Construction of the equalization facilities at the pond site would include: removal of sludge from the ponds; and construction of the EQ tanks and pump station, an access road, and a primary effluent pipeline connecting the existing primary effluent pipeline to the EQ tanks. Table 11 summarizes the cost estimate for the 8 MGal equalization basins.

Table 11 Equalization Basin Cost Estimate
Master Plan and Primary Treatment Design
City of Sunnyvale

Description	Cost Estimate (1)
Road Construction	$15.6 +/-
Tank and EQ Pump Station Construction	$19.3 +/-
PE Pipeline Construction	$0.5 +/-
Sludge Removal	$3.8 +/-
Total	**$39.2** +/-

Note:
(1) Costs based on AACE Class 4, Planning Level, estimated level of accuracy -30% to +50%. More detailed cost information for this table is included in Appendix B.

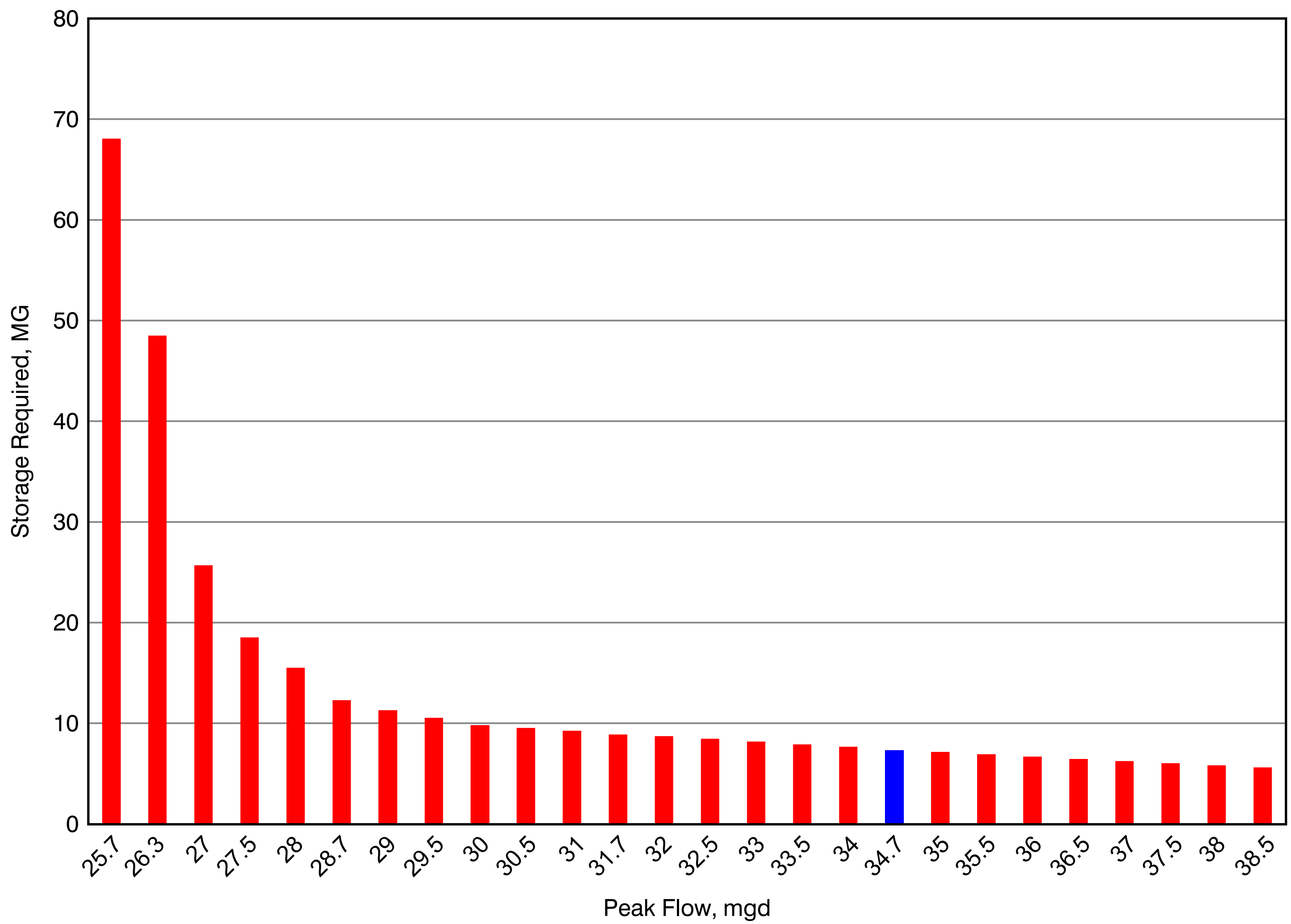

Figure 8
DIURNAL EQUALIZATION STORAGE VOLUME
SECONDARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

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Figure 9
PROPOSED EQUALIZATION LOCATION
SECONDARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

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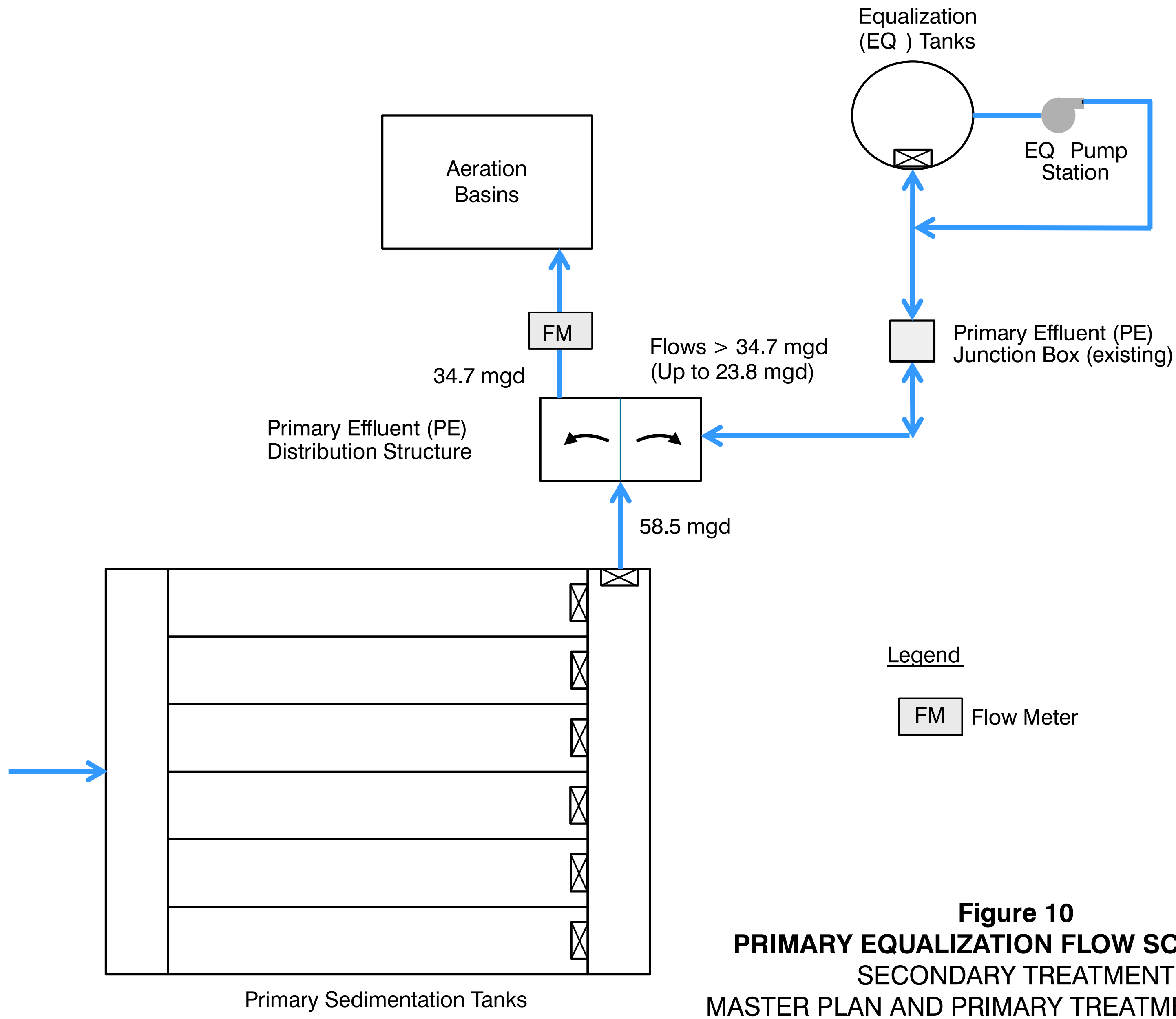

Figure 10
PRIMARY EQUALIZATION FLOW SCHEMATIC
SECONDARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

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6.2 Implications of the High Nitrogen Load Scenario

The *Flow and Load Evaluation: Master Plan* (October 2013) presented ammonia projections for both a high and design load scenario. The design maximum month ammonia load scenario used the maximum of the max month to average dry weather ammonia load peaking factor from the last three years of 1.28, which is consistent with the SIP Peer Review and the other local agencies. The high ammonia load scenario calculated the maximum month ammonia load assuming the maximum of the maximum month to average dry weather ammonia load peaking factors for the past twelve years of 1.64, which is higher than typically seen. It is assumed that BOD and TSS concentrations are the same between the design and high ammonia load scenarios.

The analysis thus far has focused on the design nitrogen load scenario since it is anticipated to be the most likely scenario. Table 12 summarizes the implication of the high nitrogen load scenario on the aeration basin sizing. If the City were to see nitrogen loads estimated for the high load scenario, an additional aeration basin would be required along with methanol addition. For planning purposes, the area of one additional aeration basin will be set aside to deal with the potential for future higher nitrogen loads.

Table 12 Implications of the High Nitrogen Load Scenario
Master Plan and Primary Treatment Design
City of Sunnyvale

Description	Design Nitrogen Load Scenario	High Nitrogen Load Scenario
2035 MM Influent TKN, ppd	7,600	9,800
2035 MM Primary Effluent TKN, ppd	7,000	9,100
2035 MM Primary Effluent BOD/TKN	4.7	3.8
Anoxic Volume, %	37(1)	48(2)
Aeration Basins, Number / MGal, each	4 / 2.6	5 / 2.6
MM Methanol Dose, ppd (as COD)	NA	2,200
MM IR flow, mgd	100	80

Notes:
(1) Operated in a MLE configuration.
(2) Operated in a 4-stage Bardenpho configuration.

6.3 Alternatives to Treat Phosphorus

By 2034, the City may need to meet a total phosphorus limit of 1 mg/L. Phosphorus limits can be met by either removing the phosphorus from the liquid stream biologically or chemically. Biological phosphorus removal (BPR) has the advantage of not requiring on-going chemical costs but requires more space since an anaerobic zone of approximately 10 to 20 percent of the basin volume is required. Additionally, the anaerobic zone will utilize the vast majority of the volatile fatty acids present in the primary effluent and therefore either the anoxic zones will need to increase in size or a supplemental carbon source will be required to denitrify. However, due to the limited site space, BPR would not fit on the site. Although BPR was initially ruled out due to site footprint considerations, footprint for an additional basin is being set aside should the influent ammonia loads be higher than planned. If this footprint is not needed for high influent ammonia loads, it could be used to provide the needed footprint for BPR and combined with phosphorus (i.e., struvite) harvesting, methanol and operation at an aerobic SRT of 5 days could be able to meet the projected effluent limits for nitrogen and phosphorus. To support BPR, the site layout includes space reserved for phosphorus harvesting.

Two options were considered for chemical phosphorus removal:

- **Actiflo™:** a ballasted flocculation system (Figure 11) that would require about 6 feet of head and would be placed between the secondary clarifiers and the filters. This process operates at a hydraulic loading rate of 25 gpm/sf and can meet the design total phosphorus limits 1 mg/L.
- **Chemically Enhanced Primary Clarification (CEPT):** by adding ferric and polymer, the primary clarifiers can reduce the phosphorus concentration sufficiently low to meet a total phosphorus limit of 1 mg/L. However since CEPT

Table 13 summarizes the capital and operating costs of the two chemical removal options: Actiflo™ and CEPT. The costs presented in Table 13 assume that phosphorus is removed with ferric chloride in both alternatives. If the City decides to switch to UV disinfection, the addition of ferric chloride will lead to lower UV transmittance. To avoid this interference, the City may need to switch from ferric chloride to alum. Additionally, since CEPT will also remove BOD that would be required by the denitrification process, methanol will be required in the aeration basin to meet a total nitrogen limit of 8 mg/L. Modeling suggests that no additional aeration basins will be required for this alternative.

The Actiflo™ alternative had the higher capital cost, and the NPV of the operating and maintenance cost for the CEPT alternative was slightly higher, such that the CEPT alternative had the lowest overall NPV. Additionally, the CEPT alternative had several non-cost benefits including a smaller footprint and hydraulic considerations. These cost and non-cost factors resulted in the selection of CEPT as the alternative to meet a total phosphorus limit of 1 mg/L by 2034. Also as the result of increased primary clarifier TSS removal, CEPT offers the additional benefit of increased methane production from the anaerobic digestion process, which can be used to generate electricity as part of a cogen facility. To support chemical phosphorus removal with CEPT, the site layout includes space reserved for chemical dosing at the primary clarifiers and the dual media filters.

6.4 Alternatives to Meet a Total Nitrogen Limit of 3 mg/L

As presented in Table 2, the WPCP may need to meet a TN of 3 mg/L beyond the planning period or sometime in the 2040 to 2050 timeframe. This level of effluent TN cannot be achieved in the aeration basins alone and thus it was assumed that denitrification filters would be required. Denitrification filters are a proven attached growth processes that has

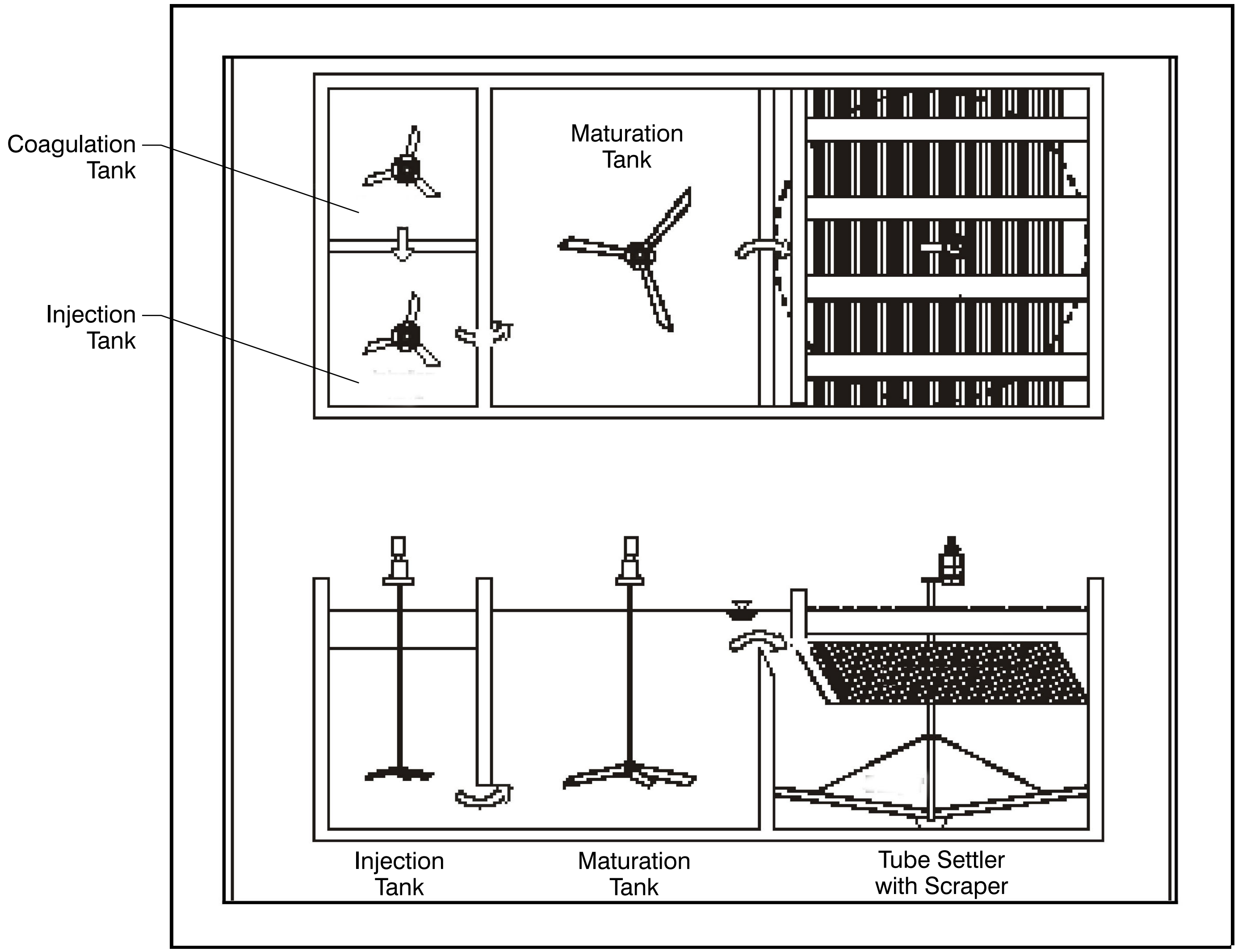

Figure 11
ACTIFLO™ SCHEMATIC
SECONDARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

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Table 13 Alternatives to Treat Phosphorus Master Plan and Primary Treatment Design City of Sunnyvale		
Description	**Actiflo™**	**CEPT**
Capital		
Actiflo	$8.9M± (2)	NA
Chemical dosing system	NA	$1M±(3)
Total	**$8.9M±**	**$1M±**
O&M(4)		
Ferric Chloride	$830,000/yr(5)	$975,000/yr(6)
Polymer	$41,000/yr(5)	$16,000/yr(6)
Methanol(7)	NA	$98,000/yr
Pumping	$123,000/yr(8)	NA
Total	**$994,000/yr**	**$1,089,000/yr**
Present Worth of O&M(9)	**$13.8M±**	**$15.1M±**
NPV	**$22.7M±**	**$16.1M±**

Notes:
(1) Costs based on AACE Class 5, Concept Screening, estimated level of accuracy -50% to +100%, year 2035 flows and loads with the design influent ammonia scenario. Costs are for alternative comparison only and exclude common facilities.
(2) Cost for a 30 mgd Actiflo™ system.
(3) Allowance.
(4) Costs shown in current dollars for year 2025 flows.
(5) Based on initial discussions with Kruger ($FeCl3$ = 56 mg/L). Planning value, actual dose target would need to be determined with Jar Testing.
(6) Assumed Fe/OP molar ratio of 2.
(7) Based on a methanol dose of 10 mg/L as COD.
(8) Based on power requirements for Actiflo™ at the Rock Creek AWWTF.
(9) Based on a 20-year payback, real discount rate of 3.8%.

been successfully used to achieve nitrogen removal to this level. The Dravo Corporation initially patented and marketed single media, downflow, deep bed denitrification filters. Since then, the product licenses have since been sold to Tetra Engineered Systems. These filters typically follow secondary clarification and combine tertiary filtration with secondary denitrification. This process requires that nitrification be provided upstream. They also require a source of carbon, usually methanol, be added. This process will provide nearly complete denitrification unless split treatment is practiced. Denitrification filters are unique in that they provide both suspended solids removal and nitrogen removal. For planning purposes, a 10,500 sf area on the WPCP site was set aside for future denitrification filters and methanol feed facilities.

7.0 IMPLEMENTATION CONSIDERATIONS

7.1 Options for Phasing

Due to uncertainties in growth and future regulations, the project team looked at the implications of phasing in the Plant Replacement CAS alternative to help manage cash flow expenditures. For this analysis, two phases were considered: Phase 1, which would be in service by approximately the year 2025 and would maximize total nitrogen removal and a Phase 2, which would be in service by approximately the year 2035 and would be designed to meet a total nitrogen limit of 8 mg/L. This analysis evaluated 2025 and 2035 flows and loads and did not look at flow and load conditions between these two years. The exact timing of facilities needed between 2025 and 2035 will be determined during the pre-design phase and will be based on flows, loads and regulatory drivers. Two alternatives were evaluated:

- **Full Treatment CAS**: For this alternative, the entire flow would be treated through CAS secondary treatment. For this analysis, only the facilities that would be needed for 2025 flows and loads would be built initially. The remainder of the facilities would be built and become operational by 2035. This alterative would be able to meet an effluent TN limit of 8 mg/L by 2025 and an effluent TP limit of 1 mg/L by 2035. Expected facilities needed at 2025 and 2035 are summarized in Table 14.

  Split Flow CAS: In 2025 a maximum base-loaded flow of 17.8 mgd would be treated through a new CAS secondary treatment process and the remainder of the flow would be treated through the WPCP's existing secondary treatment process (ponds/FGRs/ AFTs). In the split flow mode, the aeration basins would be operated at a lower aerobic SRT of 5 days. Additionally, the split flow mode would operate at a base-loaded condition, with all the peaks handled by the existing pond system. Figure 12 shows a schematic of the split flow treatment option. As shown in Figure 13, primary effluent would flow into the Primary Effluent Distribution Structure and flows in excess of 17.8 mgd would be routed to the pond system. This could be achieved with an overflow weir. Since the existing pond system needs to maintain a minimum flow of around 4 mgd (agreed to at the December 13, 2013 Split Flow Meeting), the overflow weir would be automated and could be lowered to ensure that the minimum flow is maintained through the existing pond system. By 2035, the entire flow would be treated through an expanded CAS process. Since this alternative relies on the City's current natural system (ponds/FGRs/AFTs) for treatment of a portion of the flow, it is not anticipated that it would be able to meet a TN limit of 8 mg/L by the year 2025. However, it is anticipated that this alternative would result in an improvement in winter nitrification (as shown in Table 15) and an improvement in effluent nitrogen loads (Figure 14). This alternative would be able to meet an effluent TN limit of 8 mg/L and TP limit of 1 mg/L by 2035. Based on initial conversations with the Regional Board, it appears that the Regional Board would be accepting of a split flow approach. Expected facilities needed at 2025 and 2035 are summarized in Table 14.

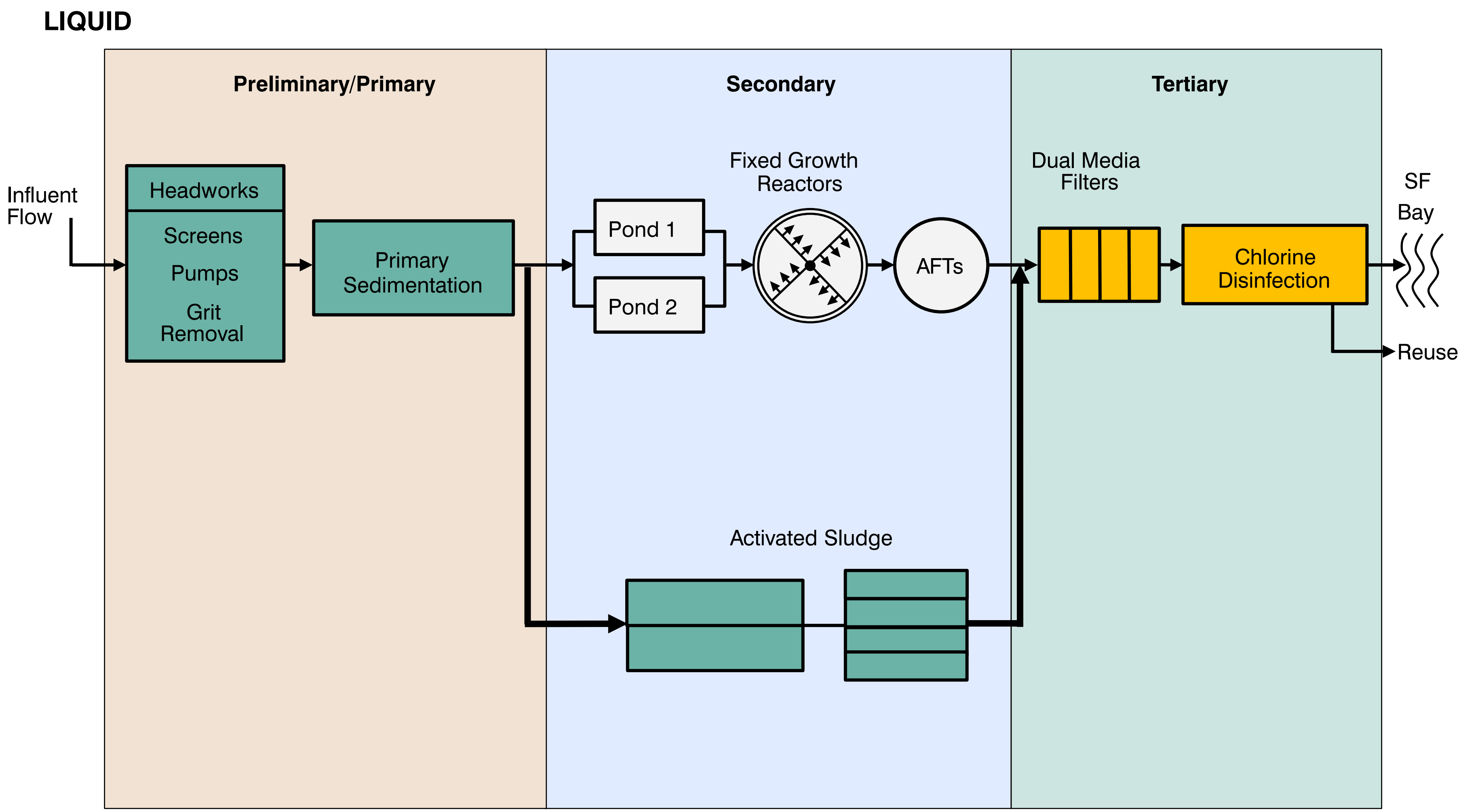

Figure 12
SPLIT TREATMENT CONCEPT
SECONDARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

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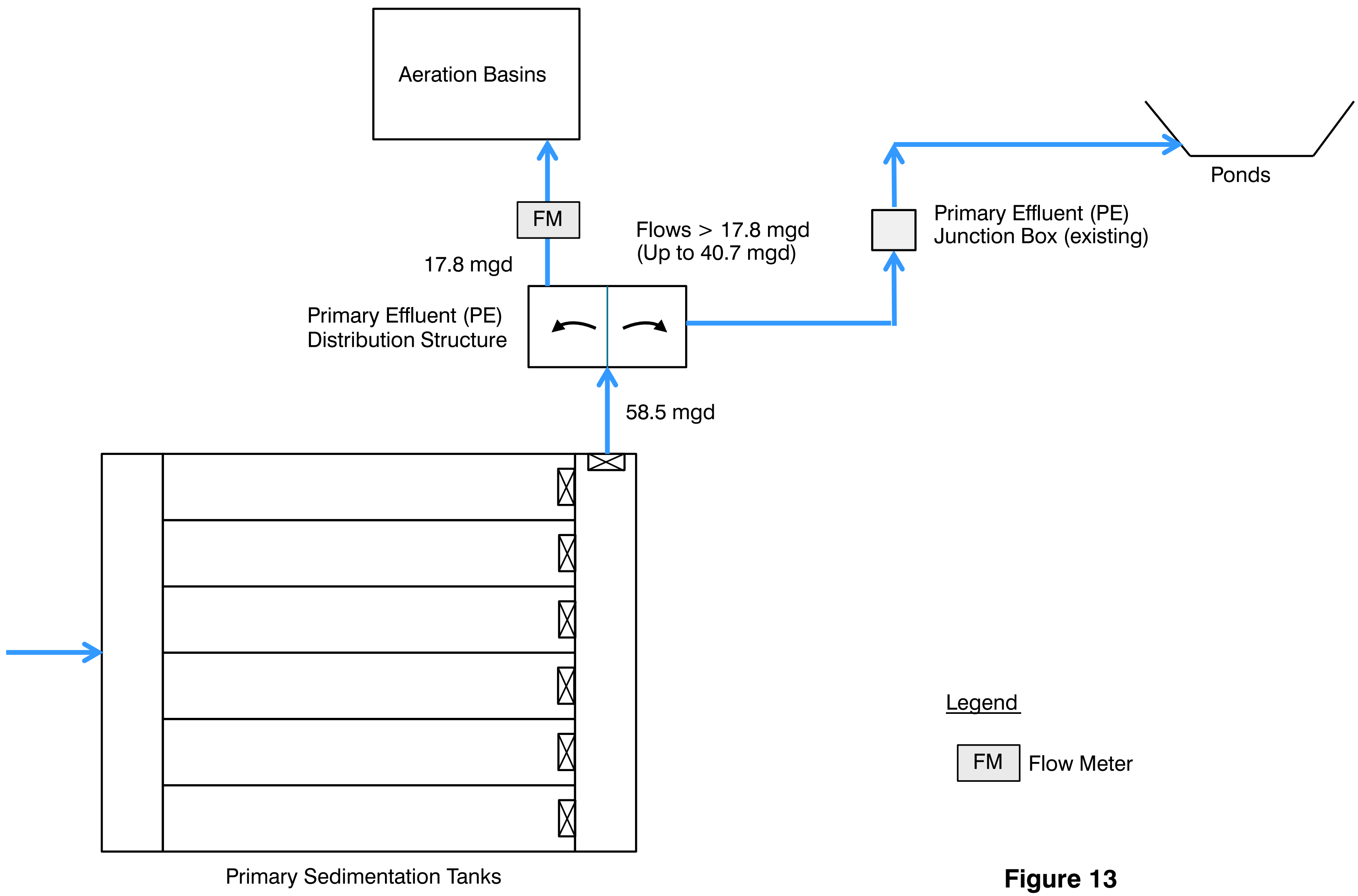

Figure 13
SPLIT FLOW TREATMENT FLOW SCHEMATIC
SECONDARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

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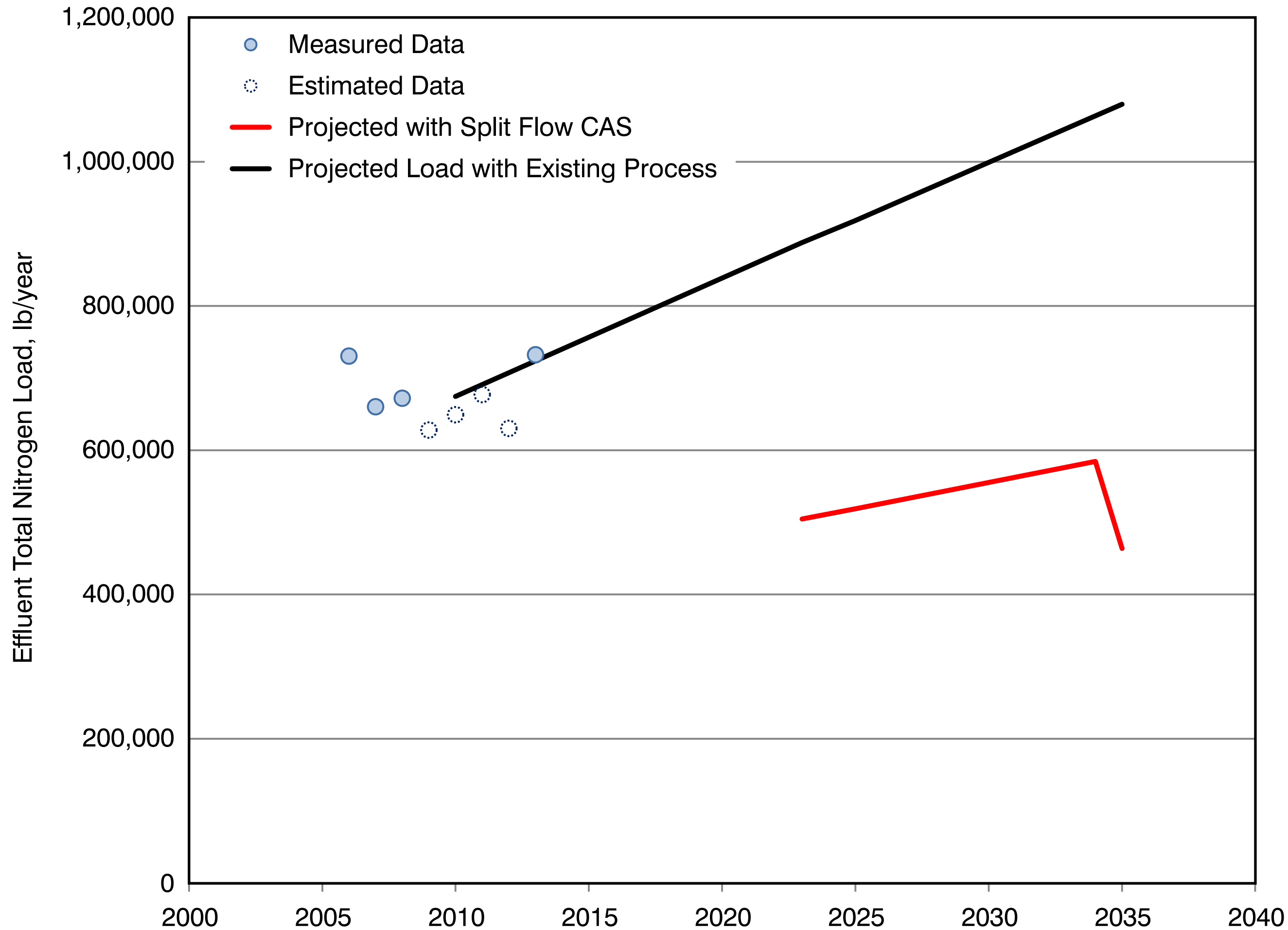

NOTE:
Data for the years 2006, 2007, 2008 and 2013 were measured by the City and represent the average effluent TN load over the course of these years. Data for the years 2009, 2010, 2011 and 2012 was estimated based on measured effluent flow for those years and the average TN concentration for the four years of measure. The projected red line abruptly drops in 2035 due to the projection that the full CAS plant would come online that year.

Figure 14
EXPECTED YEARLY TN LOAD WITH SPLIT TREATMENT
SECONDARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

Table 14 Phasing Comparison Master Plan and Primary Treatment Design City of Sunnyvale						
	Full Treatment CAS			Split Flow CAS		
Description	**2025**		**2035(1)**	**2025**		**2035(1)**
Aeration Tanks	3 tanks	+	1 tank	2 tanks(2)	+	2 tanks
Secondary Clarifiers	8 clarifiers	+	NA	4 clarifiers	+	4 clarifiers
Blower Bldg.	Bldg w/5 blowers	+	NA	Bldg w/4 blowers	+	1 blower
RAS/WAS PS	PS w/5 pumps	+	NA	PS w/3 pumps	+	2 pumps
Diurnal EQ	Full EQ	+	NA	NA	+	Full EQ
Emergency EQ	Full EQ	+	NA	NA	+	Full EQ

Notes:
(1) Additional units required.
(2) Base loaded aeration basins operated at a 5 day aerobic SRT.
Anticipated facilities needed for the design nitrogen load scenario.

Table 15 Expected Effluent Quality in 2025 with Split Flow AS Alternative Master Plan and Primary Treatment Design City of Sunnyvale			
	Existing System (ponds/FGRs/AFTs)	**CAS**	**Blend**
AAF Influent, mgd	4.0(1)	13.8	17.8
AAF Effluent, mgd	2.6(2)	12.4(3)	15.0
AAF NH3, mg/L	12.7	2.0	4.2
AAF TN, mg/L	21.7	9.0	11.3
Winter MMF Influent, mgd	5.1	17.8	22.9
Winter MMF Effluent, mgd	5.1(4)	17.4(3)	21.1
Winter MMF NH3, mg/L	18.0(5)	2.0	4.8
Winter MMF TN, mg/L	26.2(5)	9.0	12.0

Notes:
AAF = average annual flow, MMF = maximum month flow.
(1) The minimum flow to the natural system is 4 mgd as agreed on at the December 13, 2013 Split Flow meeting. This flow was based on a typical average annual evaporation rate of 1.4 mgd and a minimum pond flow of approximately 2.6 mgd.
(2) Difference between influent and effluent flow is estimated from the difference between pan evaporation and precipitation data.
(3) Difference between influent and effluent flow is from estimated recycled water use (assumed to equal current levels).
(4) Assumed that for the MMF, there would be no net loss of water from the natural system due to evaporation / precipitation.
(5) Assumed that the existing system (ponds/FGRs/AFTs) can at least meet current winter ammonia limits and current maximum month measured TN concentrations.

Table 14 summarizes the differences between the Full Treatment CAS and Split Flow CAS alternatives. Based on these differences, the capital, O&M and NPV costs of these two alternatives were compared in Table 16. More detailed cost information for this table is included in Appendix B. The Split Flow CAS alternative has a higher total capital cost due to required upgrades to the City's existing system to allow it to function until 2035. The assumed upgrades were discussed at the December 13, 2013 Split Flow Meeting and include: (1) flow split structure; (2) rehabilitation of the FGRs; (3) effluent monitoring stations upstream and downstream of the AFTs; (4) piping and valving provisions to the filter complex to allow for recycled water provisions; (5) pond effluent pump with VFD; and (6) two pond dredging events. It is not assumed that the ponds would be retrofitted to protect against sea-level rise. Although the Split Flow CAS alternative has a higher capital cost, this alternative's lower O&M costs and ability to delay significant capital investment result in a lower NPV cost.

Table 16 Present Worth Summary
Master Plan and Primary Treatment Design
City of Sunnyvale

Description	Conventional CAS (1) ($ in Millions)	Split Flow Conventional CAS (1) ($ in Millions)
Capital Costs through 2035(2)	$171M±	$186M±
O&M/year in 2025(3)	$1.5M±	$1.2M±
Present Worth – Capital(3)	$128M±	$116M±
Present Worth – O&M(3,4)	$16M±	$14M±
NPV	$146M±	$133M±

Notes:
(1) Costs based on AACE Class 4, Planning Level, estimated level of accuracy -30% to +50%. More detailed cost information for this table is included in Appendix B. Costs are for alternative comparison only and exclude common facilities.
(2) Includes aeration basins, secondary clarifiers, equalization, and project costs.
(3) Includes operations, maintenance, chemical and power costs.
(4) Inflation = 3%, Cost of money = 7%, Real discount rate = 3.8%, 20 year period.

Figure 15 compares the escalated cash flow of the two alternatives (assuming a 3 percent escalation rate) for the entire plant project. Table 17 summarizes the elements included in the first phase (through 2025). More detailed cost information for this table is included in Appendix B. For the Full Treatment CAS alternative, the first phase (through 2026) escalated project costs are $384M and the escalated costs through 2035 are $484M. For the Split Flow CAS alternative, the first phase escalated project costs are $293M and the escalated costs through 2035 are $546M.

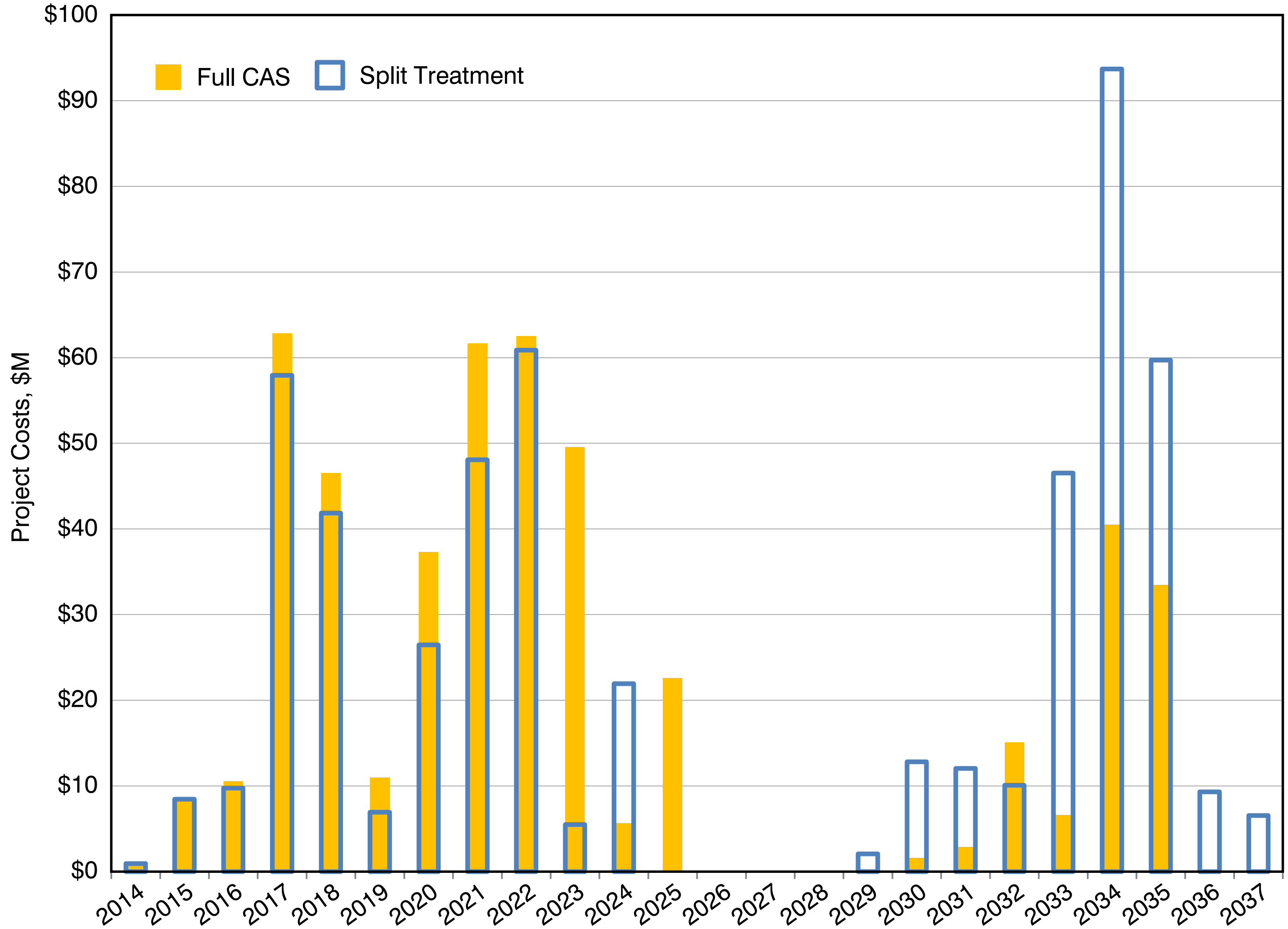

Figure 15
CASH FLOW SUMMARY FOR
FULL TREATMENT CAS AND SPLIT FLOW CAS
SECONDARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

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Table 17 Summary of Project Elements Through 2025 Master Plan and Primary Treatment Design City of Sunnyvale		
Project Elements	**Full Treatment CAS**	**Split Flow CAS**
Headworks / primary sedimentation	X	X
New administration and maintenance building	X	X
Aeration basins	3 of 4	2 of 4
Secondary clarifiers	8 of 8	4 of 8
Existing system upgrades	none	X
Diurnal equalization	X	none
Thickening / dewatering upgrades (Phase 1)	X	X
Existing digester feed upgrades	X	X
Cogeneration	X	X
New digesters	X	X
Total Phase 1 (through the year 2025) escalated cost(1)	$384M	$293M
Total Phase 1 + Phase 2 escalated costs (through the year 2035)(1)	$484M	$546M

Notes:
Costs based on AACE Class 4, Planning Level, estimated level of accuracy -30% to +50%. More detailed cost information for this table is included in Appendix B.
X = Same for both Full Treatment and Split Flow CAS scenarios.
(1) Escalated at a rate of 3% per year.

The Split Flow CAS alternative offers significant benefits in terms of flexibility and cash flow over the Full Treatment CAS alternative. Challenges of this alternative include siting considerations. Since this alternative continues to use existing facilities (the FGRs and AFTs), this footprint is not available for other processes such as UV or membranes for future reuse options such as indirect potable reuse (IPR). Due to uncertainties in flow and load projections as well as future regulations, the City may decide to phase in secondary treatment by utilizing a split-flow treatment approach to better manage cash flow.

7.2 Site Considerations

An initial site evaluation indicated that a conventional secondary process would require 30 feet deep aeration basins and rectangular secondary clarifiers to fit on the site. After conducting a review of the site layout for the entire plant, it was determined that circular clarifiers and 24 feet deep aeration basins could fit on the site.

Further detail on the configuration of the aeration basins and secondary clarifiers can be found in the Basis of Design Memorandum. Additionally, sufficient head will be provided in the secondary process to allow for operation in a MLE and step feed configuration but not for a small footprint process such as IFAS. Revised cost estimates for the secondary process will be developed as part of the CIP process and presented in the CIP Memorandum. The revised site layout will be presented in the Site Layout Memorandum. The site layout for the MBR facility is shown in Appendix D.

8.0 FINDINGS/RECOMMENDATIONS

Based on the analysis presented in this memorandum, CAS secondary process provides the process needs to accommodate future regulatory limits for nitrogen and phosphorus. In addition, the Plant Replacement CAS alternative has the lowest NPV when compared to the Plant Replacement MBR alternative. Due to cost and non-cost considerations, the Plant Replacement CAS alternative will be utilized for finalizing the site layout considerations. Future decisions made by the City such as a decision to partner with a water agency to do IPR could change the analysis and provide more of a driver for MBR treatment. Due to uncertainties in flow, load projections as well as future regulations, the City may decide to phase in secondary treatment by utilizing a split-flow treatment approach.

APPENDIX A – PROCESS ALTERNATIVES REVIEW WORKSHOP MINUTES AND SLIDES – OCTOBER 15TH, 2013

CONFERENCE MEMORANDUM

Project:	Master Plan and Primary Treatment Design	**Conf. Date:**	October 14, 2013
Client:	City of Sunnyvale	**Issue Date:**	December 3, 2013
Location:	Sunnyvale Community Center, 550 East Remington Drive, Neighborhood Room		
Attendees:	City: Bryan Berdeen Dan Hammons Alo Kauravlla Craig Mobeck Manuel Pineda Kent Steffens John Stufflebean Melody Tovar Bhavani Yerrapotu	Carollo/HDR/Subconsultants: Anne Conklin Jamel Demir Jim Hagstrom Katy Rogers Scott Parker Dana Hunt Hany Gerges Alex Ekster David Jenkins J.B. Neethling Boris Pastushenko Ray Goebel	
Purpose:	Process Alternatives Review Workshop (Workshop 2)		
Distribution:	Attendees, Jan Davel, Daniel Cheng	**File:**	9265A.00

Discussion:
The following is our understanding of the subject matter covered in this conference. If this differs with your understanding, please notify us.

1. **PRIMARY TREATMENT**
   a. **Discussion**
      1) "Primaries" vs. "No Primaries" evaluation
         a) An analysis was presented which compared the NPV of installing or not installing primary sed tanks (PSTs). Question raised as to whether adding CEPT would change the results of the analysis favoring installation of PSTs. Noted that CEPT should not have an impact on the relative costs of the alternatives. CEPT should be considered for use on a temporary basis to deal with interim operational issues, such as optimizing performance during peak flows or optimizing performance when taking basins out of service. It is not cost effective for regular operational needs. As a result, whether CEPT is included or not should not impact the size and overall cost of the PSTs.
         b) **It is recommended that PSTs be included in the proposed process train.**

2) Field Testing Results/ PST Rating

   a) Field testing was conducted to characterize the influent solids at the WPCP (e.g., settling velocity).

   b) Initial results indicate about 20% of the solids are un-settleable – they will not settle in the PSTs (which is considered a low fraction).

   c) Implementing CEPT did not change the fraction of un-settlable solids. This is typical, given the un-settlable fraction is already low at 20%. If the fraction were higher, around 40%, then implementing CEPT would more likely reduce the fraction of un-settable solids.

   d) Implementing CEPT did increase the settling velocity of the solids.

      (1) It was agreed, the solids are amenable to CEPT and CEPT is a tool that could be used on an interim basis to help with process transitions, taking tanks offline, etc. (at some facilities CEPT has no impact on solids).

      (2) It was noted, increasing the polymer dose did not significantly increase the settling velocity. Given polymer is expensive, it may be worth using polymer at lower doses. It was agreed that it would be good to optimize the CEPT system once the PSTs are online.

   e) Impacts of CEPT on other processes were discussed.

      (1) Question was raised regarding the impact of polymer for increasing the toxicity of the final effluent. Based on the location for polymer dosing, it should not increase the toxicity. The CEPT testing was done using the same polymer that is currently used at the plant and the polymer doses for CEPT would be much smaller than current polymer doses for filtration.

      (2) It was noted, that any residual polymer added for CEPT will likely end up in the digesters. It is likely to be negligible, especially given the fact CEPT would used on an interim basis.

      (3) **Action Item: Carollo/HDR to identify potential impacts of adding ferric for CEPT on downstream processes and the final discharge (e.g., UV disinfection, filtration,etc.).**

3) Discussed the proposed design overflow rate of 2,000 gpd/sf

   a) The overflow rate being recommended was similar to the overflow rate that was occurring at the plant during the field testing of the PSTs. The PSTs performed well at this overflow rate. The influent flow to the plant was low during the testing period. The testing period captured the daily peaks for each day of testing.

      (1) The PSTs will be stress tested at a higher overflow rate in the next month to determine if the design overflow rate of 2,000 gpd/sf is conservative enough. The stress testing results will also be used to confirm the shape of the performance curve that shows how removal efficiency varies as a function of overflow rate.

      (2) It was noted, there is not enough site space for the new PSTs to have the same detention time as the existing PSTs.

         (a) Five to six of the ten existing PSTs are typically in operation. The future PSTs will be larger than the existing six PSTs typically in operation.

(b) The existing PSTs remove a lot of solids. The smaller future PSTs will remove fewer solids, and the load to the secondary treatment process may increase. This may be an issue in the interim, because the loading to the ponds will increase. This is something to be considered; however, depending on how rapidly influent flows increase, this may not be a big issue.

(3) It was noted that the influent solids to the PSTs will likely be reduced in the future. This is because the existing grinders break up rags and large debris, which then flow to the aerated grit chambers and then the PSTs. The future facility will include screens that remove rags and large debris. It will also include a new grit removal system that is expected to remove more grit than the existing system. It was noted that it is difficult to speculate how much the solids will change and how the changes might impact PST performance.

4) Basis of Design/ PST Configuration

a) The proposed basins are about 20% larger than those proposed in the SIP because the design flows are higher and the surface overflow rates are lower than for the SIP (SIP is based on 2,200 gpd/SF, while the Master Plan is based on 2,000 gpd/SF). The SIP is based on a maximum month flow (MMF) of 22.4 mgd, while the Master Plan is based on a MMF of 26.2 mgd.

b) The PSTs could potentially be built in phases – Phase 1 would include five tanks to meet 2025 flows and Phase 2 would include one additional tank to meet 2035 flows.

c) During the internal peer review there was agreement that the cost premium to build one tank in the future is likely not worth the benefit of minimizing Phase 1 capital costs.

d) Agreed, the decision to phase the PSTs will largely be based on cost. It will also be based on the finalized size of primaries that will be needed to meet limits in the interim before secondary treatment is online. This decision should be made when the design criteria and costs are more finalized.

(1) **Action Item: Carollo/HDR to determine phasing of PSTs as part of the overall implementation plan.**

e) The number of tanks and level of redundancy still needs to be finalized. This should be done once the design criteria is finalized and as part of a separate meeting.

(1) **Action Item: Carollo/HDR to determine how the reliability/redundancy of the PSTs may impact downstream processes (e.g., how will filtration be impacted if a PST goes down).**

f) Question raised concerning the continued use of the existing PSTs versus replacement with new PSTs.

(1) The existing PSTs were noted as a high priority item in the 2009 Asset Management report (8 of the 10 tanks are over 50 years old – noted similar in age and condition to the West Primaries at San Jose). It is important to replace the existing PSTs because the piping that connects the grit basins with the primary tanks is vulnerable to failure during an earthquake. If these

pipes break, then there is no way of getting flow through the WPCP (very expensive to seismically retrofit these tanks).

(2) **Carollo/HDR recommended that the existing PSTs be replaced with new PSTs (with CEPT capabilities) designed for a 2000 gpd/sf overflow rate.**

5) Thin versus Thick Sludge Pumping in the PSTs

a) Thin sludge pumping was proposed in the SIP, which requires that the primary sludge be thickened in a separate process. With thin sludge pumping, a large hopper is utilized and the sludge is pumped more continuously.

b) Thick sludge pumping is currently practiced in the City's existing PSTs. With thick sludge pumping, a small hopper is utilized and sludge is pumped at an intermittent rate. Pumping at an intermittent rate allows you to build a sludge blanket, which compacts the solids and increases the thickness of the solids.

c) Sludge thickening options were discussed.

(1) One option is to build the co-thickening process in Phase 1 with the new PSTs and thicken only primary sludge until the secondary treatment process is implemented. This option was not preferred because it would increase the upfront capital cost of the Phase 1 project.

(2) A second option is to thicken primary sludge in the PSTs in the short term and then either thicken WAS separately or co-thicken primary sludge and WAS when the secondary treatment process is implemented.

b. **<u>Decisions</u>**

1) Proceed with the implementation of primary sedimentation basins using 2,000 gpd/sf overflow rate.

2) Implement new PSTs as part of the Phase 1 project, as opposed to using the existing PSTs.

3) Include CEPT facilities in the Phase 1 Project.

4) Thicken primary sludge in the primary sedimentation tanks.

c. **<u>Action Items</u>**

1) Carollo/HDR to determine how much adding ferric for CEPT will impact downstream processes and the final discharge (e.g., UV disinfection, filtration,etc.).

2) City/HDR to stress test PSTs before the wet weather season.

3) HDR to determine the optimum size of the CEPT facilities (to be completed as part of final design).

4) Carollo/HDR to determine number and phasing of PSTs required for adequate reliability/redundancy.

5) Carollo/HDR to determine how the realiability/redundancy of the PSTs may impact downstream processes.

6) If needed, during final design, visit primary sedimentation tanks with the features we are considering for the primary sedimentation tanks (e.g., covers).

2. **SECONDARY TREATMENT**

a. **Discussion**

1) Regulatory Considerations and Implications

a) There are two sets of discharge requirements to consider:

(1) Bay discharge requirements, which will drive major planning decisions.

(2) Title 22 reuse requirements, which will drive planning decisions related to providing recycled water.

b) Future regulations for nutrient removal are highly uncertain. Given the level of uncertainty with future regulations, it was agreed the Master Plan should be based on the regulation implementation summary presented at the Process Alternatives Review Workshop.

(1) Assume in the 2019 permit cycle, the ammonia limits will be more strict (to what level is unknown). Based on compliance schedule of ten years, improvements needed in-place by 2029 (may be able to phase improvements)

(2) Assume that TN compliance will be required no earlier than 2034.

c) Sunnyvale has less stringent limits for TSS and ammonia, than the other two lower South Bay plants. The less stringent limits are in recognition of the different (pond-based) secondary treatment system at the Sunnyvale WPCP. The limits are not "lagoon-based" in the sense of the alternative secondary treatment standards for pond systems provided for in 40CFR. Sunnyvale's BOD and TSS limits are well below those alternative standards. As the WPCP improves operational performance, then limits will become more stringent.

d) It was agreed that if the City implements a new secondary treatment process, permit limits will likely be modified. The performance-based ammonia limit in the permit could be modified to include a quality (WQ) based ammonia limit.

(1) If you have WQ-based ammonia limits they could be significantly lower than the current limits. Future performance-based limits would likely be similar to or lower than the current limits. As noted, the current limits are performance-based. Although such limits are based on actual plant performance in the years preceding the permit renewal, once established, it is unlikely that the Water Board would allow less stringent limits in any subsequent permit.

(2) It was agreed, the Master Plan should be based on a WQ-based ammonia limit to be conservative.

e) One element of the future permit will be an optimization study. The City is hoping the Master Plan can serve as the optimization study.

2) Alternatives Analysis

a) The SIP recommended activated sludge (AS) for the plant replacement project. The SIP peer review process included a FGR/wetlands process train. The Master Plan peer review team suggested looking at an aerated lagoon option. NPV costs and associated subjective analysis was presented for these three alternatives. Based on this analysis, **Carollo/HDR recommended that the FGR/wetland and aerated lagoon alternatives be eliminated from further consideration.**

b) Discussed costs of constructing berms in the existing lagoon area. Because of sea level rise considerations, improvements made to the existing ponds may trigger the need to meet dam safety requirements (SIP addressed similar issues). Discussed the proposed Army Corps improvements planned for SF Bay.

   (1) They are currently considering implementing concrete dams (i.e., a sea wall) as opposed to earthen dams. Some preliminary plans show the sea wall extending across a section of the plant area, but not spanning the entire plant area. The Corps is about seven years away from setting the location of the sea wall and about 15 years away from constructing it.

   (2) It was agreed there is sufficient uncertainty of when and what the Army Corps will build, therfore the Master Plan should be based on the City providing any necessary improvements to protect the plant against sea level rise.

c) Discussed the alternative analysis for the conventional vs MBR activated sludge options.

   (1) Clarified that the equalization costs for the activated sludge (AS) and MBR alternatives includes the cost for new berms. The new berms account for about half of the EQ basin cost. If the EQ basins can be located closer to the WPCP (i.e., Cargill site), costs for the new berms could be significantly reduced.

   (2) Clarified that there is not enough space on the site to accommodate the EQ basin for either the AS or MBR option.

d) Question was raised as to what size microfiltration facility (MF) would need to be added to the conventional AS process to produce the same quality effluent as the MBR system.

   (1) Clarified that membrane-quality effluent is not required for Title 22 recycled water needs (an AS and dual media filter process would be sufficient). MF quality water would be needed for an IPR use only.

   (2) An MF facility at the back end of the plant would be considered to remove color from the effluent. There is some question as to whether an MF and MBR processes effectively reduce color.

   (3) Based on implementing an IPR project (estimated to require 13 mgd of effluent), this size of MF is estimated to cost about $26M±.

   (4) Clarified more land will be required to fit a separate MF on the site as an add-on to the conventional AS plant.

   (5) **Action Item: Carollo to evaluate implementing an AS + small MF system versus an MBR system to meet recycled water requirements and remove color. Both capital and operating costs need to be considered.**

e) The cost analysis for AS versus MBR may look different in the future depending on changes to power, concrete, labor costs, etc.

   (1) **Action Item: Carollo to conduct a sensitivity analysis of the MBR and AS costs to changes in cost for power, labor, concrete, etc.**

3) Site Layouts

   a) Equalization (EQ)

(1) It was agreed, the proposed EQ basins are too large to fit on the WPCP site.

(2) There are two storage needs at the plant: diurnal EQ and emergency storage of primary effluent (PE). If we can use the Cargill site for EQ, then the A4 site might be a good option for PE storage. It was stated the City still needs to connect A4 to the Bay.

(3) Given the costs of the EQ basins, the idea of implementing more MBR trains to handle peak flows instead of implementing EQ was discussed. This option was dismissed because the City does not want to operate a diurnal MBR facility.

(4) **Action Item: Carollo to attempt to develop less expensive EQ alternatives.**

b) AS Layout

(1) Based on a high-level assessment, conventional activated sludge just fits on the site, but the site layout is constrained. The MBR layout is less constrained. Noted that there is some space south of the existing fenceline that could be utilized.

(2) Rectangular clarifiers are preferred over circular clarifiers for the conventional AS alternative because they provide a more efficient use of site space. Although rectangular clarifiers have greater potential for solids carryover, the filters downstream provide a buffer to handle solids carryover.

(3) **Action Item: City to confirm potential site space available, including the Cargill site and the area south of the plant between the plant and SMaRT station. This information is necessary to prepare for the January Workshops dedicated to the Site Plan.** ***<Subsequent to the workshop, a meeting was held and areas within the current WPCP site boundaries were identified.>***

c) Space for potential future RO

(1) Question was raised as to whether there would be enough space for RO in the future?

(2) Implementing an MF/RO facility (for IPR uses) reduces the need for filtration to SF Bay.

(3) Potential siting of an RO facility will be evaluated as part of a separate evaluation to be performed by SCVWD. SCVWD to assess this issue.

4) Alternate Project Phasing Considerations

a) An alternative phasing of the first phase of secondary treatment was presented which would be comprised of the existing pond/FGR/AFT system in combination with an AS or MBR system. Initially this split system would be designed to meet more restrictive winter ammonia requirements. When more restrictive TN limits are implemented, the City would then convert to a full AS or MBR system.

(1) For blending purposes, the AS portion of a split stream system would be expected to routinely achieve an ammonia limit of 0.5 mg/L.

(2) Implementing split stream treatment would reduce power costs for a number of years.

(3) The ponds could be used for EQ until the full secondary system is built.

(4) Implementing split stream treatment could be presented to the Regional Board as the City's initial effort to comply with more stringent ammonia and TN limits.

b) Split stream alternatives were discussed.

(1) Split Treatment Scenario 1: Implement per SIP Phasing

(a) Build the project with headworks and full primary in Phase 1.

(b) Build smaller phase of secondary in Phase 2. This will save on capital cost in the near-term, with the added benefit of O&M savings.

(c) City will be able to achieve a lower standard in the winter time with this system to satisfy the Regional Board's request to do what is reasonable in the short term.

(2) Split Treatment Scenario 2A: Implement AS facilities earlier in combination with using existing PSTs

(a) Build headworks and small secondary process in Phase 1. Hold off on primary facilities until Phase 2 (2022/2023).

(b) Using the existing PSTs will require pumping primary effluent to the secondary process.

(c) This is a low cost option, but high-risk given the existing primaries are vulnerable to catastrophic failure during an earthquake.

(3) Split Treatment Scenario 2B: Implement Earlier with New, Smaller PSTs

(a) Build the headworks, some of the PSTs, (e.g., build 4 out of 6), and a small secondary process in Phase 1. Build the rest of the primaries and secondary treatment process in Phase 2.

(b) Build smaller phase of secondary to take care of initial nutrient removal requirements.

(c) This is a higher capital cost upfront, but provides more reliability that Scenario 2A.

(d) Use of CEPT for reliable capacity could potentially be used to minimize the number of PSTs to be built initially.

(4) Agreed split stream treatment seems very reasonable, especially from the standpoint of spreading costs.

(5) Agreed split Stream Alternative 2A should not be evaluated further because the risk does not outweigh the cost. Split Stream Alternatives 1 and 2B should be considered further.

(6) Agreed both conventional activated sludge and MBR alternatives should be carried forward to evaluate the split stream treatment analysis.

(7) **It is recommended that spilt treatment options be further evaluated (impact on MP engineering budget to be determined). <Subsequent to the workshop, Carollo committed to an all day workshop and preparing cost estimates for each of the 4 options (to be done within the existing budget). >**

5) Cost Comparison with SIP

   a) The activated sludge costs are higher than those presented in the SIP. Some explanations for the discrepancy include: (1) the Master Plan is based on higher flows, (2) latest estimates considers premium costs for construction on a constrained site, (3) higher costs for berm improvements to accommodate sea level rise, and (4) current estimates includes costs for pile foundations. It was also noted that the nutrient removal goals may be different between the two plans as well, due to changes in anticipated regulations. More is known now about nutrient limits (timing and magnitude) than was known at the time of the SIP.

   b) The $318M SIP budget is the budget that was approved, not necessarily the total cost of all improvements recommended , since the SIP provided an overall 20 year estimate of improvements.

   c) If the recommended improvements included in the MP are more than $318M. City staff will need to provide justification for the increase. To do this, it is important that there is an understanding of what was included in the $318M budget.

b. **Decisions**

1) Giving the level of uncertainty with future regulations, it was agreed the Master Plan should be based on the regulatory implementation summary presented at the Process Alternatives Review Workshop.
2) The Master Plan will be based on a WQ-based ammonia limit.
3) For planning purposes, assume that if any improvements are made in the existing pond area, new berms will need to be constructed (need to determine whether compliance with dam design standards is required).
4) Eliminated Pond/FGR/AFT and aerated ponds as a viable long-term secondary process option, leaving conventional AS and MBR AS as the two viable options.
5) Split stream treatment is a viable approach and should be considered further as an alternative to implementing a full/partial primary treatment facility in Phase 1 and a full secondary treatment process in Phase 2. Both conventional activated sludge and MBR alternatives will be carried forward to evaluate the split stream treatment analysis. Split Stream Alternative 2A, should not be evaluated further because the risk does not outweigh the cost. Split Stream Alternatives 1 and 2B should be considered further.

c. **Action Items**

1) Carollo to evaluate implementing an AS + small MF system versus an MBR system to meet recycled water requirements and remove color. Both capital and operating costs need to be considered.
2) Carollo to attempt to develop less expensive EQ alternatives.
3) Carollo to conduct a sensitivity analysis of the MBR and AS costs with respect to changes in cost for power, labor, concrete, etc.

4) Carollo to evaluate the following secondary treatment alternatives as part of a separate one-day workshop:
   a) Full MBR
   b) Full AS
   c) Split Stream Treatment Alternative 1 – Building full Headworks/Primaries in Phase 1 and small AS in Phase 2
   d) Split Stream Treatment Alternative 2B – Building partial Headworks/Primaries and Small AS in Phase 1

   Based on the results of this analysis, Carollo to develop communication plan to the Regional Board that conveys the City's implementation approach for meeting nutrient removal requirements in SF Bay.
5) City to confirm potential site space availability, including the Cargill site and the area south of the plant between the plant and Pond A-4. This information is necessary to prepare for the January Workshops dedicated to the Site Plan.
6) As part of the CIP development, City and Carollo to decide what costs are included in the $318M capital improvement budget developed from the SIP.

Prepared By:

Katy Rogers

KR/JD:kr

This workshop module will be a success if …

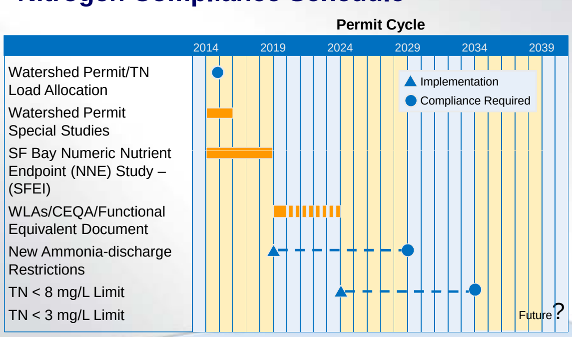
- Evaluate updates to SIP alternatives
- Establish secondary process alternative

Agenda

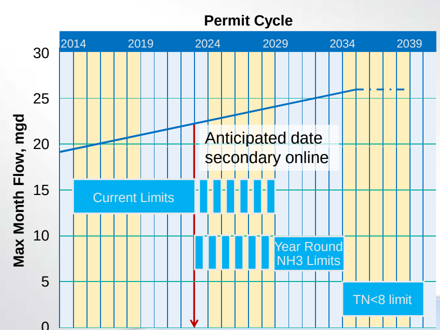
- ✓ Regulatory Considerations
- ✓ Regulatory Implications
- ✓ SIP Recommendations
- ✓ New Processes
- ✓ Alternatives Analysis
- ✓ Site Layouts
- ✓ Project Phasing Considerations
- ✓ Next Steps

Regulatory Considerations and Implications

Regulatory Considerations – Nitrogen Compliance Schedule



MM Flows Relative to Nitrogen Effluent Limits



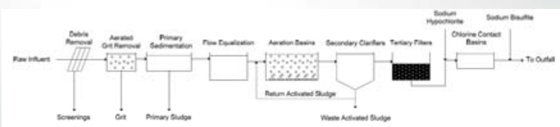
Regulatory Implications

- When secondary plant comes online, likely to either modify the performance-based ammonia limit, or be given a WQ - based limit

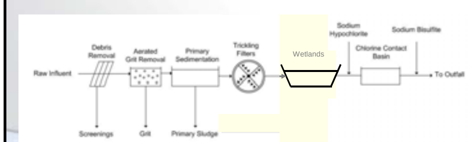
SIP Recommendations and New Processes

SIP/Peer Review Recommended Alternatives

- SIP Recommendation - New Plant AS

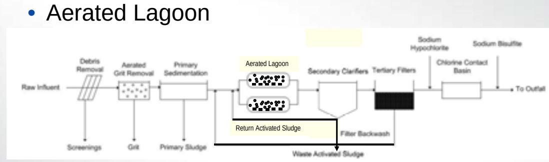


- SIP Peer Review Recommendation – FGR / Wetlands



Facility Plan Peer Review Alternative

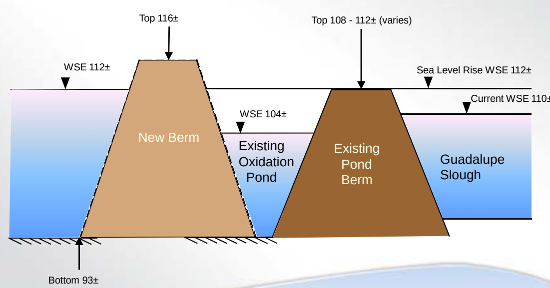
- Aerated Lagoon



SIP also identified potential issues associated with use of existing pond systems

- Existing pond levies are not engineered
- Future impacts from sea level rise

New Berm Constructed Against Sea Level Rise



Alternatives Analysis

Evaluation of Alternatives

	1: BNR	2: FGR + Wetland	3: Aerated Lagoon
Reliability	+	-	0
Ease of O&M	+	0	0
Maximize Resources	-	+	0
Power Usage	0	+	-
Flexibility	+	0	0
Ease of Implementation/ Compliance	0	0	0
Site Efficiency	-	+	+
Net Present Value (NPV)	$246M±	$407M±	$247M±

Notes:
Assumes 2035 flows and loads and an effluent limit of TN < 8 mg/L

+ Better	0 Neutral	- Worse

Evaluation of Alternatives

	1: BNR	2: FGR + Wetland	3: Aerated Lagoon
Reliability	+	-	0
Ease of O&M	+	0	0
Maximize Resources	-	+	0
Power Usage	0	+	-
Flexibility	+	0	0
Ease of Implementation/ Compliance	0	0	0
Site Efficiency	-	+	+
Net Present Value (NPV)	$246M±	$407M±	$247M±

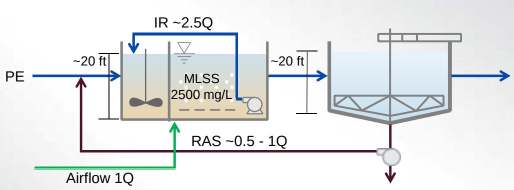
Notes:
Assumes 2035 flows and loads and an effluent limit of TN < 8 mg/L

+ Better	0 Neutral	- Worse

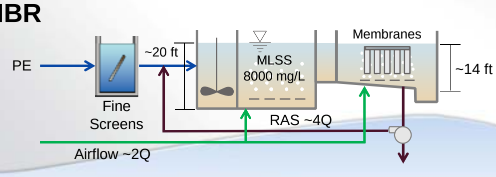
MBR was added back into secondary process alternatives

- FSRWE introduced MBRs as potential short-term alternative
- WPCP site limitations

NAS/BNR



MBR



AS vs MBR Comparison

	AS	MBR
Activated Sludge Tank Volume	8.9 MG	3.1 MG
Clarifier tank volume	4.4 MG	--
MBR tank volume	--	0.6 MG
Aeration power (AAF)	480 hp	1300 hp

Capital Cost Comparison

	1: AS	2: MBR
Equalization	$48M	$44M
Fine Screens	--	$16M
Aeration Basins	$51M	$29M
Secondary Clarifiers	$24M	--
MBR Tanks	--	$75M
Pile Support	$14M	$5M
Filter Improvements	$3M	--
Total Capital Cost	**$140M±**	**$169M±**
Project Costs	$49M	$60M
Constrained Site Adder	$4M	--
Value of Land	$8M	$2M
Total Project Cost	**$201M±**	**$231M±**

O&M Cost Comparison

	1: AS	2: MBR
Operations Labor	$690,000	$690,000
Maintenance Labor	$870,000	$780,000
Power	$950,00	$1,750,000
Equipment Replacement	$880,000	$1,650,000
Chemicals	$20,000	$140,000
Annual Costs (2025)	$3,410,000	$5,010,000
NPV	$49M±	$72M±

Evaluation of Alternatives

	1: AS	2: MBR
Reliability	+	+
Ease of O&M	+	0
Maximize Resources	-	-
Power Usage	0	-
Flexibility	0	+
Ease of Implementation/ Compliance	0	+
Site Efficiency	-	+
Net Present Value (NPV)	$250M±	$300M±

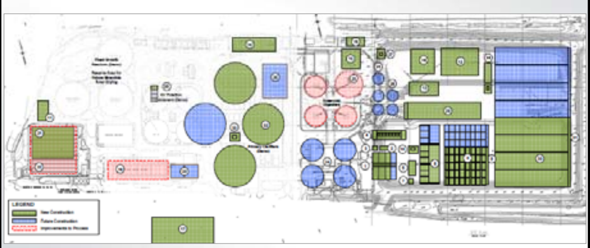
Notes:

Assumes 2035 flows and loads and an effluent limit of TN < 8 mg/L. Doesn't account for the high ammonia load scenario.

+ Better	0 Neutral	- Worse

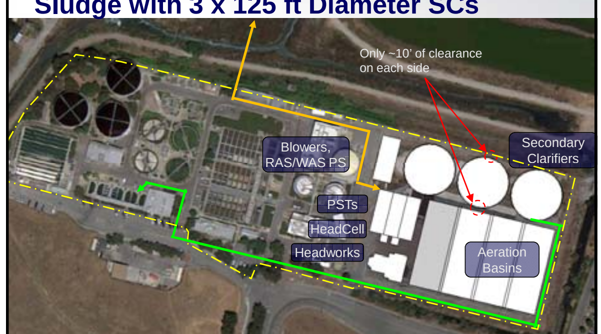
Site Layouts

SIP Layout



Green = 2035, MMF = 22.4 mgd
Blue = Build-out, MMF = 39.6 mgd

Site Layout – Conventional Activated Sludge with 3 x 125 ft Diameter SCs

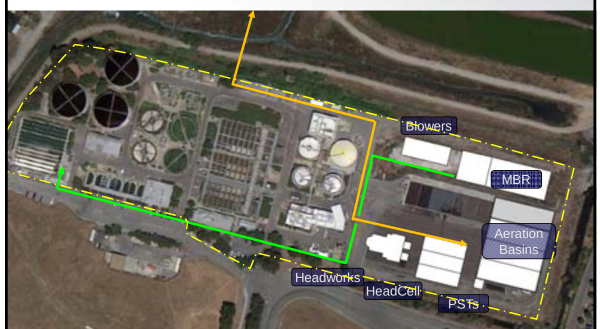


Site Layout – Conventional Activated Sludge with Rectangular Clarifiers

Site Layout – Conventional Activated Sludge with 3 x 125 ft Diameter SCs

Site Layout – Conventional Activated Sludge with West Rectangular Clarifiers

Site Layout – MBR Activated Sludge



Full Site Layout – Conventional Activated Sludge with West Rectangular Clarifiers

Full Site Layout – MBR Activated Sludge

Cost Comparison with SIP

SIP vs Master Plan Construction Cost Estimates (June 2014) - $Million

	SIP	Master Plan
Equalization	$26M±	$48M±
Activated Sludge	$46M±	$89M±
MBR	$92M±	$125M±

SIP vs MP – What's changed?

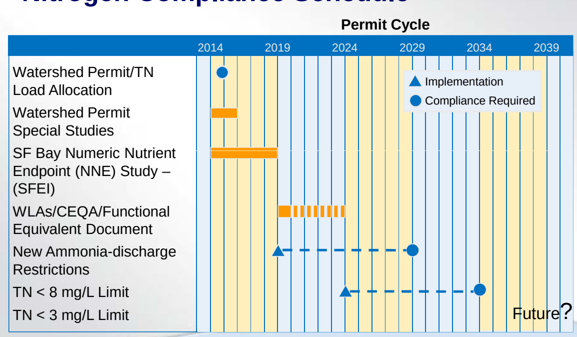
- Increased flows (22.4 mgd to 26.3 mgd)
- ID of specific site constraints issues
- Cost for sea level rise protection (berm construction)
  - Impacts costs of equalization
- Cost of piles?

Project Phasing Considerations

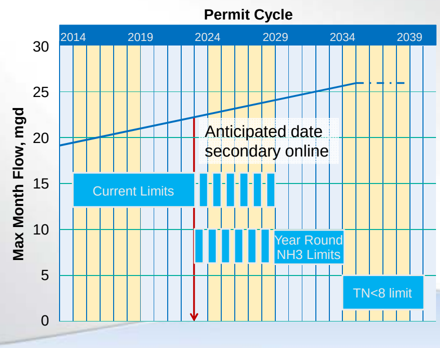
Phasing Considerations For Secondary Treatment

- Consistent with master planning efforts
  - Project Implementation Plan
- Flexibility to meet/address
  - Regulatory uncertainty
  - Growth variability
- Regulatory compliance strategy
- Cost of service
  - Capital
  - O&M

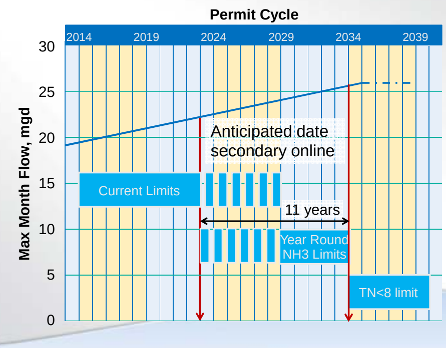
Regulatory Considerations – Nitrogen Compliance Schedule



MM Flows Relative to Nitrogen Effluent Limits



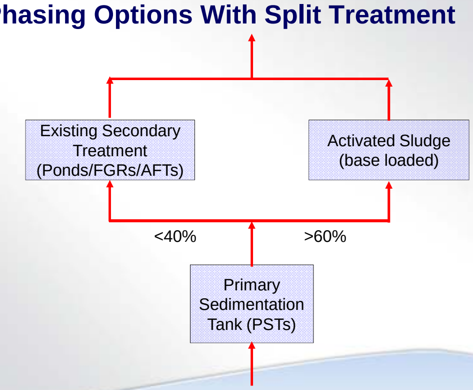
Anticipate 11 Years Before Needing To Meet TN Limits



Because of Cost Increase, Looked at Option of Split Treatment

- Utilization of existing infrastructure
  - Ponds/FGRs/AFTs
  - Lower loadings will minimize near-term upgrade costs
  - Reduce near-term O&M costs until full-activated sludge is required
- Lower loadings will minimize near-term upgrade costs: allows for the design of a base-loaded AS plant
  - Smaller secondary clarifiers
  - Smaller aeration basins/lower nitrification safety factor
  - More stable operations/less need for automation
- Can delay the need for equalization

Phasing Options With Split Treatment



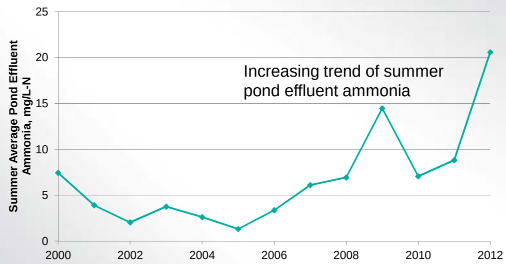
Impacts of Split Treatment

- Existing secondary treatment plant
  - Lower flow improves process reliability
  - Need to control ammonia loading to FGRs to achieve consistent nitrification
    - Divert centrate from new activated sludge system to FGRs
    - Only use 100 ac pond during the summer (BOD removal only)
    - Modify flow split seasonally
  - TAG identified option to phase out FGRs, i.e., AFT effluent to activated sludge (needs to be evaluated)

Split Treatment Scenarios

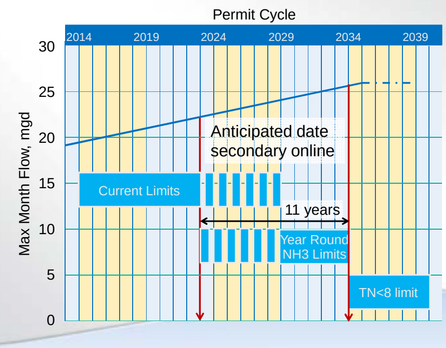
- Scenario 1: Implement per SIP phasing
  - Operational in 2022/2023
- Scenario 2: Implement earlier
  - Scenario 2A: Use existing PSTs
  - Scenario 2B: Build smaller new PSTs

Why should we consider an accelerated secondary project?

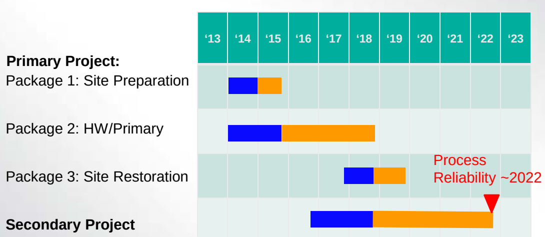


Which risk is greater, PST failure or pond failure?

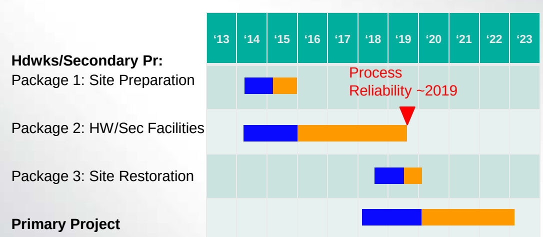
MM Flows Relative to Nitrogen Effluent Limits



Project Implementation Schedule – Scenario 1 (SIP)



Project Implementation Schedule – Scenario 2



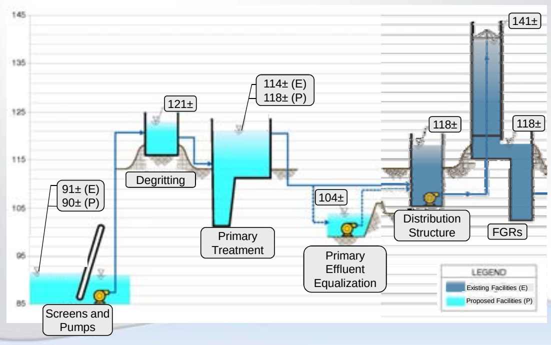
Potential Costs Savings With Scenario 1

	SIP	Master Plan	Split Treatment Scenario 1
Capital			
Equalization	$26M	$48M±	--
AS	$46M	$89M±	$62M±
O&M Annual	NA	$3.4M±	$2.7M±

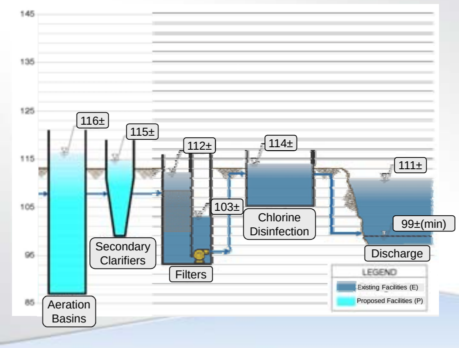
Impacts of Implementing Scenario 2A

- Assumes use of existing PSTs
  - Requires some investment for continued use (needs evaluation)
  - Requires pumping to activated sludge (~2-4 ft)

WPCP Hydraulic Profile



WPCP Hydraulic Profile
Continued



Potential Costs Savings with Scenario 2A

	SIP	Master Plan	Split Treatment Scenario 2A
Capital			
Equalization	$26M	$48M±	--
PST Imp. and PEPS	$16M	$18M±	$3M±
Activated Sludge	$46M	$89M±	$62M±
O&M Annual	NA	$3.4M±	$2.7M±

Impacts of Implementing Scenario 2B

- Construct new, smaller PSTs
  - Delays investment in full PST facility
  - Operates at higher surface overflow rates in the interim (2,500 gpd/sf?)

Potential Costs Savings with Scenario 2B

	SIP	Master Plan	Split-Treatment Scenario 2B
Capital			
Equalization	$21M	$48M±	--
PST Imp. and PEPS	$16M	$18M±	$14M±
Activated Sludge	$46M	$89M±	$62M±
O&M Annual	NA	$3.4M±	$2.7M±

Potential Costs Savings with Split-Flow Treatment

	Master Plan	Split-Treatment Scenario 1	Split-Treatment Scenario 2A	Split-Treatment Scenario 2B
Capital				
Equalization	$48M	--	--	--
PST Imp. + PEPS	$18M	$18M	$3M	$14M
Activated Sludge	$89M	$62M	$62M	$62M
Total	**$155M±**	**$80M±**	**$65M±**	**$76M±**
O&M Annual	$3.4M	$2.7M	$2.7M	$2.7M

What would drive you away from split treatment?

- Flows increase beyond manageable split
- Regulatory need to meet TN<8 mg/L

Conclusions / Recommendations

- Conventional AS has a lower NPV than the MBR
  - This gap could decrease if the EQ basin location cannot be optimized (i.e., located on Cargill site)
- Preliminary findings indicate that conventional AS and MBR will fit on the existing site (but conventional AS is more constrained)
- At this stage of the site layout evaluation, the MBR provides more flexibility for future process/support bldg. considerations
- Recommend that decision on conventional AS vs MBR be delayed until the site layouts & costs are more developed

Next Steps

Secondary Treatment Next Steps

- Further optimization of split-treatment approach
- Investigate alternate locations for equalization basin (i.e., Cargill)

This workshop module will be a success if …

- Evaluate updates to SIP alternatives
- Establish secondary process alternative

End

APPENDIX B – COST BACKUP INFORMATION

Table 16 Present Worth Summary
Master Plan and Primary Treatment Design
City of Sunnyvale

Description	Conventional AS ($ in Millions)	Split Flow Conventional AS ($ in Millions)
Capital(1)	$171M±	$186M±
O&M/year in 2025(2)	$1.5M±	$1.2M±
Present Worth – Capital(2)	$128M±	$116M±
Present Worth – O&M(2,3)	$16M±	$14M±
NPV	$146M±	$133M±

Notes:
Costs based on AACE Class 4, Planning Level, estimated level of accuracy -30% to +50%. More detailed cost information for this table is included in Appendix B.
(1) Includes aeration basins, secondary clarifiers, equalization, and project costs.
(2) Includes operations, maintenance, chemical and power costs.
(3) Inflation = 3%, Cost of money = 7%, Real discount rate = 3.8%, 20 year period.

PROJECT SUMMARY
PROJECT : Sunnyvalue Facility Plan
JOB # : 9265A.00 — 7/3/2014
LOCATION : Sunnyvale, CA — ASC
ELEMENT : PROJECT SUMMARY

Backup Info	DESIGN PERIOD			CONSTRUCTION PERIOD			DESCRIPTION	CURRENT CONSTRUCTION COST	CURRENT PROJECT COST	ESCALATED PROJECT COST	PRESENT WORTH OF PROJECT
Full Treatment AS											
A	Jan-16	-	Jun-18	Jul-18	-	Dec-23	Aeration Basin P1	$ 44,400,000	$ 59,940,000	$ 73,346,134	$ 46,304,251
B	Jan-16	-	Jun-18	Jul-18	-	Dec-23	Secondary Clarifiers	$ 32,300,000	$ 43,605,000	$ 53,357,661	$ 33,685,299
C	Jan-16	-	Jun-18	Jul-18	-	Dec-23	Equalization	$ 39,000,000	$ 52,650,000	$ 64,425,659	$ 40,672,653
D	Jan-32	-	Jun-33	Jul-33	-	Jun-35	Aeration Basin P2	$ 10,200,000	$ 13,770,000	$ 25,105,217	$ 6,351,944
Allowance	Jan-32	-	Jun-33	Jul-33	-	Jun-35	Chemical dosing	$ 1,000,000	$ 1,350,000	$ 2,461,296	$ 622,740
Split Treatment AS											
E	Jan-16	-	Jun-18	Jul-18	-	Dec-22	Aeration Basin P1	$ 33,200,000	$ 44,820,000	$ 54,120,222	$ 35,205,174
F	Jan-16	-	Jun-18	Jul-18	-	Dec-22	Secondary Clarifiers P1	$ 19,300,000	$ 26,055,000	$ 31,461,454	$ 20,465,659
G	Jan-16	-	Jun-18	Jul-18	-	Dec-22	Existing Facilities Upgrades	$ 11,000,000	$ 14,850,000	$ 17,931,399	$ 11,664,365
H	Jan-29	-	Jun-31	Jul-31	-	Jun-35	Aeration Basin P2	$ 21,400,000	$ 28,890,000	$ 50,900,218	$ 13,940,865
I	Jan-29	-	Jun-31	Jul-31	-	Jun-35	Secondary Clarifiers P2	$ 13,000,000	$ 17,550,000	$ 30,920,693	$ 8,468,750
C	Jan-29	-	Jun-31	Jul-31	-	Jun-35	Equalization	$ 39,000,000	$ 52,650,000	$ 92,762,079	$ 25,406,249
Allowance	Jan-29	-	Jun-31	Jul-31	-	Jun-35	Chemical dosing (SF)	$ 1,000,000	$ 1,350,000	$ 2,378,515	$ 651,442
							Total Cost Full AS (Secondary)	$ 126,900,000	$171,315,000	$ 218,695,967	$ 127,636,886
							Total Cost Split Treatment (Secondary)	$ 137,900,000	$186,165,000	$ 280,474,579	$ 115,802,505

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Full CAS AAF, mgd	17.0	17.3	17.5	17.8	18.1	18.3	18.6	18.8	19.1	19.4	19.6	19.9	20.1	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4
maitenance	$252,526	$252,526	$252,526	$252,526	$252,526	$252,526	$252,526	$252,526	$252,526	$252,526	$252,526	$252,526	$252,526	$281,887	$281,887	$281,887	$281,887	$281,887	$281,887	$281,887	$281,887
Power	$1,207,351	$1,218,459	$1,229,568	$1,240,676	$1,251,785	$1,262,893	$1,274,002	$1,285,110	$1,296,219	$1,307,327	$1,318,436	$1,329,544	$1,340,653	$1,351,761	$1,351,761	$1,351,761	$1,351,761	$1,351,761	$1,351,761	$1,351,761	$1,351,761
Total	$1,459,877	$1,470,985	$1,482,094	$1,493,202	$1,504,311	$1,515,419	$1,526,528	$1,537,636	$1,548,745	$1,559,853	$1,570,962	$1,582,070	$1,593,179	$1,633,648	$1,633,648	$1,633,648	$1,633,648	$1,633,648	$1,633,648	$1,633,648	$1,633,648
Present Worth Cost	$1,088,435	$1,057,196	$1,026,795	$997,212	$968,428	$940,423	$913,179	$886,677	$860,900	$835,829	$811,447	$787,736	$764,681	$755,849	$728,611	$702,355	$677,045	$652,647	$629,128	$606,457	$584,603
Total Present Worth	$16,187,198																				
Split Treatment																					
CAS AAF, mgd	13.0	13.3	13.5	13.8	14.1	14.3	14.6	14.8	15.1	15.4	15.6	15.9	16.1	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4
maintenance	$169,139	$169,139	$169,139	$169,139	$169,139	$169,139	$169,139	$169,139	$169,139	$169,139	$169,139	$169,139	$169,139	$281,887	$281,887	$281,887	$281,887	$281,887	$281,887	$281,887	$281,887
Chemical	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)	($100,000)
Power	$728,564	$776,502	$824,440	$872,379	$920,317	$968,255	$1,016,193	$1,064,132	$1,112,070	$1,160,008	$1,207,946	$1,255,885	$1,303,823	$1,351,761	$1,351,761	$1,351,761	$1,351,761	$1,351,761	$1,351,761	$1,351,761	$1,351,761
Natural System, AAF mgd	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Misc operations	$86,721	$86,721	$86,721	$86,721	$86,721	$86,721	$86,721	$86,721	$86,721	$86,721	$86,721	$86,721	$86,721								
maintenance	$84,778	$84,778	$84,778	$84,778	$84,778	$84,778	$84,778	$84,778	$84,778	$84,778	$84,778	$84,778	$84,778								
Chemical	$27,275	$27,275	$27,275	$27,275	$27,275	$27,275	$27,275	$27,275	$27,275	$27,275	$27,275	$27,275	$27,275								
Power	$46,152	$46,152	$46,152	$46,152	$46,152	$46,152	$46,152	$46,152	$46,152	$46,152	$46,152	$46,152	$46,152								
Total	$1,042,629	$1,090,567	$1,138,506	$1,186,444	$1,234,382	$1,282,320	$1,330,259	$1,378,197	$1,426,135	$1,474,073	$1,522,012	$1,569,950	$1,617,888	$1,533,648	$1,533,648	$1,533,648	$1,533,648	$1,533,648	$1,533,648	$1,533,648	$1,533,648
Present Worth Cost	$777,349	$783,790	$788,757	$792,348	$794,656	$795,769	$795,769	$794,737	$792,745	$789,865	$786,163	$781,702	$776,541	$709,582	$684,011	$659,362	$635,601	$612,697	$590,618	$569,334	$548,818
Total Present Worth	$14,482,863																				
15 yr present worth	$9,472,841																				

Project: **Sunnyvale Master Plan** **2025 Full Treatment** Sheet A
Subject: **BNR Tanks - 2025 Flow and Loadings (3 New Concrete Tanks)**
By : **ASC**
Date : **11-Mar-14**

Capital Cost Estimate

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
1	Tank Excavation	43,292	cy	$12	$523,163
2	ABC backfill	3,899	cy	$25	$98,151
3	Backfill	4,279	cy	$15	$65,662
4	Sheeting, shoring	29,997	sf	$35	$1,047,864
5	Dewatering	35,094	sf	$11	$386,029
6	Misc site work	8%	of subtotal		$2,438,975
7	Steel Pipe Piling	62,299	lf	$55	$0
	Subtotal site/civil				$4,559,844
8	Slab Concrete	4,219	cy	$327	$1,378,782
9	Wall Concrete	5,160	cy	$681	$3,512,234
10	Elevated slab concrete	604	cy	$487	$294,036
11	Miscellaneous Concrete	2345	cy	$382	$895,755
12	Handrail	4,080	lf	$88	$358,572
13	Miscellaneous metals	3%	of subtotal		$914,616
14	Odor Control Covers	46,791	sf	$109	$0
15	Blower Building	4,125	sf	$326	$1,343,774
16	Coatings	4,125	sf	$15	$63,499
	Subtotal Structural				$8,761,267
17	Blowers (300 hp)	5	ea	$265,373	$1,326,864
18	Aerators (hp)	0	ea	$0	$0
19	Mixers (25 hp)	9	ea	$44,052	$396,471
20	Internal Recirculation Pumps (50 hp)	4	ea	$85,012	$340,048
21	Odor Control Equipment	77,986	cfm	$4	$0
22	Diffusers	6,501	ea	$72	$468,847
	Subtotal Equipment				$2,532,230
23	Piping and Miscellaneous Mechanical	15%	of subtotal		$4,573,079
24	Electrical	21%	of subtotal		$6,402,311
25	Instrumentation and Control	7%	of subtotal		$2,134,104
	Subtotal Structural, Equip, Mech, Elect, I&C				$28,962,834
26	Yard piping	5%	of subtotal		$1,524,360
	Subtotal				$30,487,193
	Contingency	32%			$9,832,120
	Total Direct Costs				**$40,319,313**
	Contractor Overhead and Profit	10%			$4,031,931
	Total Current Estimated Construction Costs				$44,351,244
	Total Current Estimated Construction Costs				**$44,351,244**
	Engineering Design, Legal Fees, Administration	35%			$15,522,936
	Total Estimated Future Capital Cost				**$59,874,180**

Project: **Sunnyvale Master Plan** SHEET B
Subject: **BNR Secondary Sedimentation (8 New Tanks) - 2035 Flow and Loads**
By : **ASC**
Date : **11-Mar-14**

Capital Cost Estimate

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
1	Tank Excavation	29,862	cy	$12	$360,870
2	ABC backfill	4,260	cy	$25	$107,228
3	Backfill	7,142	cy	$15	$109,589
4	Sheeting, shoring	31,970	sf	$35	$1,116,758
5	Dewatering	38,339	sf	$11	$421,729
6	Site work (additional)	6%	of subtotal		$1,331,880
7	Steel Pipe Piling	67,955	lf	$55	$0
	subtotal site/civil				$3,448,053
8	Slab Concrete	4,260	cy	$327	$1,392,060
9	Wall Concrete	2,614	cy	$681	$1,779,221
10	Elevated Slab Concrete	734	cy	$487	$356,994
11	Miscellaneous Concrete	1719	cy	$382	$656,468
12	Handrail	6,563	lf	$88	$577,536
13	Miscellaneous Metal	3%	of subtotal		$665,940
14	Existing Clarifier Demo	0	ls	$200,000	$0
15	RAS/WAS Building	1,750	sf	$366	$639,683
16	Coatings	1,750	sf	$15	$26,939
	Subtotal Structural				$6,094,841
17	Drive Mechanism (240 ft length)	8	ea	$227,644	$1,821,150
18	RAS Pumps w/VFD (50. hp)	5	ea	$131,470	$657,351
19	WAS Pumps W/VFD (15. hp)	3	ea	$62,503	$187,509
	Subtotal Equipment				$2,666,010
20	Piping and Miscellaneous Mechanical	18%	of subtotal		$3,995,641
21	Electrical	15%	of subtotal		$3,329,701
22	Instrumentation and Control	7%	of subtotal		$1,553,860
	Subtotal Structural, Equip, Mech, Elect, I&C				$21,088,106
23	Yard piping	5%	of subtotal		$1,109,900
	Subtotal				$22,198,007
	Contingency	32%			$7,158,857
	Total Direct Costs				**$29,356,864**
	Contractor Overhead and Profit	10%			$2,935,686
	Total Current Estimated Construction Costs				$32,292,550
	Engineering Design, Legal Fees, Administration	35%			$11,302,393
	Total Estimated Future Capital Cost				**$43,594,943**

SHEET C

Equalization Cost Estimate

Project Element	Construction Cost	Backup Sheet
Road	$15,650,000	C1
DN Tanks	$19,310,000	C2
Sludge Removal	$470,000	C3
PE Pipe	$3,790,000	C4
Total	**$39,220,000**	

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SHEET C1

PROJECT ENR:	9542
PROJECT LOCATION FACTOR:	117.9
ESTIMATED MIDPOINT OF CONSTRUCTION :	
COST ESTIMATE ENR DATE :	6/15/2013
BY :	DC
REVIEWED BY:	

TITLE: SCVWD Berm Impacts Cost Estimate
PROJECT : Sunnyvale Master Plan and Primary Treatment Design
JOB # : 9265A00
LOCATION : Sunnyvale, CA

Leave blank if not used

DIVISION	DESCRIPTION	QUAN	UNIT	UNIT COST	SOURCE ENR CCI	SOURCE RS-MEANS LF	SUBTOTAL	TOTAL
2	SITEWORK							
	Sheet Piles for Road Construction	57,600	SF	$50	9,542	116.5	$2,914,609	
	22CY Scraper, Class Class A (Easy Dig), Grade, Fill & Compact, 5000' Haul	127,531	CY	$3.14	9,552		$472,295	
	Import fill	153,037	CY	$22.62		107.8	$3,786,040	
	4" AC PAVING ON 4" ABC	48,000	SF	$2.66	9,552		$150,377	
	22CY Scraper, Class B (Medium Dig), Grade, Fill & Compact, 3000' Haul	37,600	CY	$3.14	9,552		$139,247	
	20 CY Dump Truck, 20 Miles/Round Trip	45,120	CY	$9.67	9,552		$513,781	
	Loading Loose Materials, 8.25 Cy Bucket, 988-B Loader, All Classes	45,120	CY	$0.89	9,552		$47,072	
	Total, Div. 02000							$8,023,421
	SUBTOTAL							**$8,023,421**
	Demolition Contingency	5	%					$401,171
	Yard Piping, Shoring, Coatings Contingency	15	%					$1,203,513
	Electrical and Instrumentation Contingency	0	%					$0
	SUBTOTAL							**$9,628,106**
	Estimating Contingency	30	%					$2,888,432
	SUBTOTAL							**$12,516,537**
	Construction Contingency	25	%					$3,129,134
	SUBTOTAL							**$15,645,672**

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SHEET C2

PROJECT ENR:	9542
PROJECT LOCATION FACTOR:	117.9
ESTIMATED MIDPOINT OF CONSTRUCTION :	
COST ESTIMATE ENR DATE :	6/15/2013
BY :	DC
REVIEWED BY:	

TITLE: EQ Basin Cost Estimate (34.7 mgd Process Flow, 8 Mgal EQ Volume)
PROJECT : Sunnyvale Master Plan and Primary Treatment Design
JOB # : 9265A00
LOCATION : Sunnyvale, CA

Leave blank if not used

DIVISION	DESCRIPTION	QUAN	UNIT	UNIT COST	SOURCE ENR CCI	SOURCE RS-MEANS LF	SUBTOTAL	TOTAL
2	SITEWORK							
	18" Octagonal x 50' Long Precast Conc. Piling, in Class A,B,C, Mat'l	41,050	LF	$56	9,552		$2,691,493	
	Sheet Pile Cofferdam	10,500	SF	$50	9,542	116.5	$531,309	
	Import fill to finish grade around tanks	21,104	CY	$22.62		107.8	$522,103	
	22CY Scraper, Class B (Medium Dig), Grade, Fill & Compact, 3000' Haul	6,000	CY	$3.14			$22,243	
	20 CY Dump Truck, 20 Miles/Round Trip	7,200	CY	$9.67			$82,072	
	Loading Loose Materials, 8.25 Cy Bucket, 988-B Loader, All Classes	7,200	CY	$0.89			$7,519	
	Total, Div. 02000							$3,856,740
3	CONCRETE							
	Conc. Prestress Tank, 4 Mgal w/ Open Top, 25' SWD, 160' DIA	2	EA	$2,500,000	9,516	116.3	$5,082,637	
	Penetration Allowance (For Inlet and Outlets)	6	EA	$20,000	9,516	116.3	$121,983	
	Total, Div. 03000							$5,204,620
15	MECHANICAL							
	PE Return Pump Station and EQ Diversion Structure	1	LS	$500,000	8,921	117.9	$534,833	
	Total, Div 15000							$534,833
	SUBTOTAL							**$9,596,193**
	Demolition Contingency	5	%					$479,810
	Yard Piping, Shoring, Coatings Contingency	15	%					$1,439,429
	Electrical and Instrumentation Contingency	20	%					$1,919,239
	SUBTOTAL							**$13,434,671**
	Estimating Contingency	15	%					$2,015,201
	SUBTOTAL							**$15,449,871**
	Construction Contingency	25	%					$3,862,468
	SUBTOTAL							**$19,312,339**

SHEET C3

PROJECT ENR:	9542
PROJECT LOCATION FACTOR:	117.9
ESTIMATED MIDPOINT OF CONSTRUCTION :	
COST ESTIMATE ENR DATE :	6/15/2013
BY :	DC
REVIEWED BY:	

TITLE: EQ Basin Cost Estimate (34.7 mgd Process Flow, 8 Mgal EQ Volume)
PROJECT : Sunnyvale Master Plan and Primary Treatment Design
JOB # : 9265A00
LOCATION : Sunnyvale, CA

Leave blank if not used

DIVISION	DESCRIPTION	QUAN	UNIT	UNIT COST	SOURCE ENR CCI	SOURCE RS-MEANS LF	SUBTOTAL	TOTAL
2	SITEWORK							
	Sludge Removal	690	Ton	$471		117.9	$324,786	
	Total, Div. 02000							$324,786
	SUBTOTAL							**$324,786**
	Demolition Contingency	0	%					$0
	Yard Piping, Shoring, Coatings Contingency	0	%					$0
	Electrical and Instrumentation Contingency	0	%					$0
	SUBTOTAL							**$324,786**
	Estimating Contingency	15	%					$48,718
	SUBTOTAL							**$373,503**
	Construction Contingency	25	%					$93,376
	SUBTOTAL							**$466,879**

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SHEET C4

PROJECT ENR:	9542
PROJECT LOCATION FACTOR:	117.9
ESTIMATED MIDPOINT OF CONSTRUCTION :	
COST ESTIMATE ENR DATE :	6/15/2013
BY :	DC
REVIEWED BY:	

TITLE: SCVWD Berm Impacts Cost Estimate
PROJECT : Sunnyvale Master Plan and Primary Treatment Design
JOB # : 9265A00
LOCATION : Sunnyvale, CA

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DIVISION	DESCRIPTION	QUAN	UNIT	UNIT COST	SOURCE ENR CCI	SOURCE RS-MEANS LF	SUBTOTAL	TOTAL
15	MECHANICAL							
	60" PE Pipeline	3,300	LF	$574	9,437	116.3	$1,941,625	
	Total, Div 15000							$1,941,625
	SUBTOTAL							**$1,941,625**
	Demolition Contingency	5	%					$97,081
	Yard Piping, Shoring, Coatings Contingency	15	%					$291,244
	Electrical and Instrumentation Contingency	0	%					$0
	SUBTOTAL							**$2,329,950**
	Estimating Contingency	30	%					$698,985
	SUBTOTAL							**$3,028,935**
	Construction Contingency	25	%					$757,234
	SUBTOTAL							**$3,786,169**

Project:	**Sunnyvale Master Plan**	**2035 Full Treatment P2 Costs**		SHEET D
Subject:	**BNR Tanks 1 new concrete tank**			
By :	**ASC**			
Date :	**11-Mar-14**			

Capital Cost Estimate

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
1	Tank Excavation	13,671	cy	$12	$165,209
2	ABC backfill	1,300	cy	$25	$32,717
3	Backfill	755	cy	$15	$11,592
4	Sheeting, shoring	4,800	sf	$35	$167,658
5	Dewatering	11,698	sf	$11	$128,676
6	Misc site work	8%	of subtotal		$560,942
7	Steel Pipe Piling	20,096	lf	$55	$0
	Subtotal site/civil				$1,066,794
8	Slab Concrete	1,406	cy	$327	$459,594
9	Wall Concrete	1,557	cy	$681	$1,059,386
10	Elevated slab concrete	182	cy	$487	$88,643
11	Miscellaneous Concrete	741	cy	$382	$282,960
12	Handrail	1,230	lf	$88	$108,099
13	Miscellaneous metals	3%	of subtotal		$210,353
14	Odor Control Covers	46,791	sf	$109	$0
15	Blower Building	0	sf	$326	$0
16	Coatings	0	sf	$15	$0
	Subtotal Structural				$2,209,036
17	Blowers (300 hp)	0	ea	$265,373	$0
18	Aerators (hp)	0	ea	$0	$0
19	Mixers (25 hp)	3	ea	$44,052	$132,157
20	Internal Recirculation Pumps (50 hp)	1	ea	$85,012	$85,012
21	Odor Control Equipment	0	cfm	$4	$0
22	Diffusers	2,123	ea	$72	$153,127
	Subtotal Equipment				$370,296
23	Piping and Miscellaneous Mechanical	15%	of subtotal		$1,051,767
24	Electrical	21%	of subtotal		$1,472,474
25	Instrumentation and Control	7%	of subtotal		$490,825
	Subtotal Structural, Equip, Mech, Elect, I&C				$6,661,192
26	Yard piping	5%	of subtotal		$350,589
	Subtotal				$7,011,781
	Contingency	32%			$2,261,299
	Total Direct Costs				**$9,273,080**
	Contractor Overhead and Profit	10%			$927,308
	Total Current Estimated Construction Costs				**$10,200,388**
	Engineering Design, Legal Fees, Administration	35%			$3,570,136
	Total Present Value of Capital Cost				**$13,770,524**

Project: **Sunnyvale Master Plan** SHEET E
Subject: **BNR Tanks - 2025 Split Treatment Flow and Loadings (2 New Concrete Tanks)**
By : **ASC**
Date : **11-Mar-14**

Capital Cost Estimate

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
1	Tank Excavation	29,621	cy	$12	$357,954
2	ABC backfill	2,600	cy	$25	$65,434
3	Backfill	3,524	cy	$15	$54,070
4	Sheeting, shoring	25,198	sf	$35	$880,205
5	Dewatering	23,396	sf	$11	$257,353
6	Site work (additional, not constrained site adder)	8%	of subtotal		$1,827,567
7	Steel Pipe Piling	42,203	lf	$55	$0
	subtotal site/civil				$3,442,584
8	Slab Concrete	2,813	cy	$327	$919,188
9	Wall Concrete	3,604	cy	$681	$2,452,847
10	Elevated Slab Concrete	422	cy	$487	$205,393
11	Miscellaneous Concrete	1604	cy	$382	$612,795
12	Handrail	2,850	lf	$88	$250,473
13	Miscellaneous metals	3%	of subtotal		$685,338
14	Odor Control Covers	46,791	sf	$109	$0
15	Blower Building	4,125	sf	$326	$1,343,774
16	Coatings	4,125	sf	$15	$63,499
	Subtotal Structural				$6,533,307
17	Blowers (300 hp)	4	ea	$265,373	$1,061,491
18	Aerators (hp)	0	ea	$0	$0
19	Mixers (25 hp)	6	ea	$44,052	$264,314
20	Internal Recirculation Pumps (50 hp)	3	ea	$85,012	$255,036
21	Odor Control Equipment	77,986	cfm	$4	$0
22	Diffusers	4,471	ea	$72	$322,456
	Subtotal Equipment				$1,903,296
23	Piping and Miscellaneous Mechanical	15%	of subtotal		$3,426,688
24	Electrical	21%	of subtotal		$4,797,364
25	Instrumentation and Control	7%	of subtotal		$1,599,121
	Subtotal Structural, Equip, Mech, Elect, I&C				$21,702,360
26	Yard piping	5%	of subtotal		$1,142,229
	Subtotal				$22,844,590
	Contingency	32%			$7,367,380
	Total Direct Costs				**$30,211,970**
	Contractor Overhead and Profit	10%			$3,021,197
	Total Current Estimated Construction Costs				**$33,233,167**
	Engineering Design, Legal Fees, Administration	35%			$11,631,609
	Total Estimated Future Capital Cost				**$44,864,776**

Project:	**Sunnyvale Master Plan**	**2025 Split Stream SC Costs**		SHEET F
Subject:	**BNR Secondary Sedimentation (4 New Tanks) - 2025 Split Treatment Flow and Loads**			
By :	**ASC**			
Date :	**11-Mar-14**			

Capital Cost Estimate

Item	**Description**	**Quantity**	**Unit**	**Unit cost, $**	**Cost, $**
1	Tank Excavation	15,809	cy	$12	$191,049
2	ABC backfill	2,130	cy	$25	$53,614
3	Backfill	4,449	cy	$15	$68,270
4	Sheeting, shoring	25,570	sf	$35	$893,193
5	Dewatering	19,170	sf	$11	$210,865
6	Site work	6%	of subtotal		795731.4
7	Steel Pipe Piling	35,205	lf	$55	$0
	subtotal site/civil				$2,212,722
8	Slab Concrete	2,130	cy	$327	$696,030
9	Wall Concrete	1,434	cy	$681	$975,684
10	Elevated Slab Concrete	402	cy	$487	$195,767
11	Miscellaneous Concrete	891	cy	$382	$340,311
12	Handrail	3,599	lf	$88	$316,707
13	Miscellaneous Metal	3%	of subtotal		$397,866
14	Existing Clarifier Demo	0	ls	$200,000	$0
15	RAS/WAS Building	1,750	sf	$366	$639,683
16	Coatings	1,750	sf	$15	$26,939
	Subtotal Structural				$3,588,988
17	Drive Mechanism (240 ft length)	4	ea	$227,644	$910,575
18	RAS Pumps w/VFD (50. hp)	3	ea	$131,470	$394,410
19	WAS Pumps W/VFD (15. hp)	3	ea	$62,503	$187,509
	Subtotal Equipment				$1,492,494
20	Piping and Miscellaneous Mechanical	18%	of subtotal		$2,387,194
21	Electrical	15%	of subtotal		$1,989,328
22	Instrumentation and Control	7%	of subtotal		$928,353
	Subtotal Structural, Equip, Mech, Elect, I&C				$12,599,080
23	Yard piping	5%	of subtotal		$663,109
	Subtotal				$13,262,190
	Contingency	32%			$4,277,056
	Total Direct Costs				**$17,539,246**
	Contractor Overhead and Profit	10%			$1,753,925
	Total Current Estimated Construction Costs				$19,293,170
	Engineering Design, Legal Fees, Administration	35%			$6,752,610
	Total Estimated Future Capital Cost				**$26,045,780**

Existing Facility Upgrades

Improvements	Costs, $M
Flow split structure	$0.5M±
Rehab of FGRs (plenum/distributor/media	$6.0M±
Effluent monitoring stations (upstream & downstream of AFTs)	$0.5M±
Piping/valving upgrades to filter complex (recycled water provisions)	$2.0M±
Pond effluent pump VFD	$0.2M±
Pond dredging (assuming two events)	$1.8M±
Total	**$11.0M±**

Project: **Sunnyvale Master Plan** **2035 Split Stream Costs P2** SHEET H
Subject: **BNR Tanks 2 new concrete tanks**
By : **ASC**
Date : **11-Mar-14**

Capital Cost Estimate

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
1	Tank Excavation	27,342	cy	$12	$330,417
2	ABC backfill	2,600	cy	$25	$65,434
3	Backfill	1,511	cy	$15	$23,183
4	Sheeting, shoring	9,599	sf	$35	$335,316
5	Dewatering	23,396	sf	$11	$257,353
6	Site work (additional, not constrained site adder)	8%	of subtotal		$1,172,351
7	Steel Pipe Piling	40,193	lf	$55	$0
	subtotal site/civil				$2,184,054
8	Slab Concrete	2,813	cy	$327	$919,188
9	Wall Concrete	3,113	cy	$681	$2,118,773
10	Elevated Slab Concrete	364	cy	$487	$177,286
11	Miscellaneous Concrete	1481	cy	$382	$565,919
12	Handrail	2,460	lf	$88	$216,198
13	Miscellaneous metals	3%	of subtotal		$439,632
14	Odor Control Covers	0	sf	$109	$0
15	Blower Building	0	sf	$326	$0
16	Coatings	0	sf	$15	$0
	Subtotal Structural				$4,436,996
17	Blowers (300 hp)	1	ea	$265,373	$265,373
18	Aerators (hp)	0	ea	$265,373	$0
19	Mixers (25 hp)	6	ea	$44,052	$264,314
20	Internal Recirculation Pumps (50 hp)	2	ea	$85,012	$170,024
21	Odor Control Equipment	0	cfm	$4	$0
22	Diffusers	4,153	ea	$72	$299,518
	Subtotal Equipment				$999,229
23	Piping and Miscellaneous Mechanical	15%	of subtotal		$2,198,158
24	Electrical	21%	of subtotal		$3,077,421
25	Instrumentation and Control	7%	of subtotal		$1,025,807
	Subtotal Structural, Equip, Mech, Elect, I&C				$13,921,665
26	Yard piping	5%	of subtotal		$732,719
	Subtotal				$14,654,384
	Contingency	32%			$4,726,039
	Total Direct Costs				**$19,380,423**
	Contractor Overhead and Profit	10%			$1,938,042
	Total Current Estimated Construction Costs				$21,318,465
	Engineering Design, Legal Fees, Administration	35%			$7,461,463
	Total Estimated Future Capital Cost				**$28,779,928**

Project: **Sunnyvale Master Plan** **2035 Split Stream P2 SC Costs** SHEET I
Subject: **BNR Secondary Sedimentation Tanks (4 new tanks)**
By : **ASC**
Date : **11-Mar-14**

Capital Cost Estimate

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
1	Tank Excavation	14,053	cy	$12	$169,821
2	ABC backfill	2,130	cy	$25	$53,614
3	Backfill	2,693	cy	$15	$41,318
4	Sheeting, shoring	6,400	sf	$35	$223,565
5	Dewatering	19,170	sf	$11	$210,865
6	Site work	6%	of subtotal		$536,149
7	Steel Pipe Piling	32,749	lf	$55	$0
	subtotal site/civil				$1,235,331
8	Slab Concrete	2,130	cy	$327	$696,030
9	Wall Concrete	1,181	cy	$681	$803,537
10	Elevated Slab Concrete	331	cy	$487	$161,226
11	Miscellaneous Concrete	828	cy	$382	$316,157
12	Handrail	2,964	lf	$88	$260,828
13	Miscellaneous Metal	3%	of subtotal		$268,075
14	Existing Clarifier Demo	0	ls	$200,000	$0
15	RAS/WAS Building	0	sf	$366	$0
16	Coatings	0	sf	$15	$0
	Subtotal Structural				$2,505,853
17	Drive Mechanism (240 ft length)	4	ea	$227,644	$910,575
18	RAS Pumps w/VFD (50. hp)	2	ea	$131,470	$262,940
19	WAS Pumps W/VFD (15. hp)	0	ea	$62,503	$0
	Subtotal Equipment				$1,173,515
20	Piping and Miscellaneous Mechanical	18%	of subtotal		$1,608,447
21	Electrical	15%	of subtotal		$1,340,373
22	Instrumentation and Control	7%	of subtotal		$625,507
	Subtotal Structural, Equip, Mech, Elect, I&C				$8,489,026
23	Yard piping	5%	of subtotal		$446,791
	Subtotal				$8,935,817
	Contingency	32%			$2,881,801
	Total Direct Costs				**$11,817,618**
	Contractor Overhead and Profit	10%			$1,181,762
	Total Current Estimated Construction Costs				$12,999,380
	Engineering Design, Legal Fees, Administration	35%			$4,549,783
	Total Estimated Future Capital Cost				**$17,549,162**

Table 17 Summary of Project Elements Through 2025
Master Plan and Primary Treatment Design
City of Sunnyvale

Project Elements	Full Treatment AS	Split Flow AS
Headworks / primary sedimentation	X	X
New administration and maintenance building	X	X
Aeration basins	3 of 4	2 of 4
Secondary clarifiers	8 of 8	4 of 8
Existing system upgrades	none	X
Diurnal equalization	X	none
Thickening / dewatering upgrades (Phase 1)	X	X
Existing digester feed upgrades	X	X
Cogeneration	X	X
New digesters	X	X
Total Phase 1 (through the year 2025) escalated cost(1)	$384M	$293M
Total Phase 1 + Phase 2 escalated costs (through the year 2035)(1)	$484M	$546M

Notes:
Costs based on AACE Class 4, Planning Level, estimated level of accuracy -30% to +50%. More detailed cost information for this table is included in Appendix B.
X = Same for both Full Treatment and Split Flow AS scenarios.
(1) Escalated at a rate of 3% per year.

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PROJECT SUMMARY
PROJECT : Sunnyvalue Facility Plan
JOB # : 9265A.00 — 7/3/2014
LOCATION : Sunnyvale, CA — ASC
ELEMENT : PROJECT SUMMARY

DESIGN PERIOD	CONSTRUCTION PERIOD	DESCRIPTION	CURRENT CONSTRUCTION COST	CURRENT PROJECT COST	ESCALATED PROJECT COST
Full Treatment AS					
Oct-14 - Sep-15	Oct-15 - Oct-16	Filter Improvements	$ 3,000,000	$ 4,050,000	$ 4,319,057
Jan-16 - Jun-18	Jul-18 - Dec-23	Aeration Basin P1	$ 44,400,000	$ 59,940,000	$ 73,346,134
Jan-16 - Jun-18	Jul-18 - Dec-23	Secondary Clarifiers	$ 32,300,000	$ 43,605,000	$ 53,357,661
Jan-16 - Jun-18	Jul-18 - Dec-23	Equalization	$ 39,000,000	$ 52,650,000	$ 64,425,659
Jan-16 - Jun-18	Jul-18 - Dec-23	Thickening/Dewatering P1	$ 30,000,000	$ 40,500,000	$ 49,558,199
Jan-16 - Jun-18	Jul-18 - Dec-23	Existing Digester Feed Upgrades	$ 2,000,000	$ 2,700,000	$ 3,303,880
Jan-21 - Jun-22	Jul-22 - Dec-23	New Admin/Maint bldg P2	$ 2,000,000	$ 2,700,000	$ 3,532,129
Jan-22 - Dec-23	Jan-24 - Dec-25	Cogen	$ 11,000,000	$ 14,850,000	$ 20,427,984
Jan-22 - Dec-23	Jan-24 - Dec-25	Digestesr	$ 6,000,000	$ 8,100,000	$ 11,143,060
Jul-29 - Dec-30	Jan-31 - Dec-32	UV	$ 7,000,000	$ 9,450,000	$ 16,002,888
Jan-32 - Jun-33	Jul-33 - Jun-35	Emergency Storage	$ 20,000,000	$ 27,000,000	$ 49,225,916
Jan-32 - Jun-33	Jul-33 - Jun-35	Aeration Basin P2	$ 10,200,000	$ 13,770,000	$ 25,105,217
Jan-32 - Jun-33	Jul-33 - Jun-35	Chemical dosing	$ 1,000,000	$ 1,350,000	$ 2,461,296
Oct-33 - Jun-34	Jul-34 - Jun-35	Thickening/Dewatering P2	$ 3,000,000	$ 4,050,000	$ 7,514,669
Split Treatment AS					
Oct-14 - Sep-15	Oct-15 - Oct-16	Filter Improvements	$ 3,000,000	$ 4,050,000	$ 4,319,057
Jan-16 - Jun-18	Jul-18 - Dec-22	Aeration Basin P1	$ 33,200,000	$ 44,820,000	$ 54,120,222
Jan-16 - Jun-18	Jul-18 - Dec-22	Secondary Clarifiers P1	$ 19,300,000	$ 26,055,000	$ 31,461,454
Jan-16 - Jun-18	Jul-18 - Dec-22	Existing Facilities Upgrades	$ 11,000,000	$ 14,850,000	$ 17,931,399
Jan-16 - Jun-18	Jul-18 - Dec-22	Thickening/Dewatering P1 (SF)	$ 29,000,000	$ 39,150,000	$ 47,273,688
Jan-16 - Jun-18	Jul-18 - Dec-22	Existing Digester Feed Upgrades (SF)	$ 2,000,000	$ 2,700,000	$ 3,260,254
Jan-20 - Jun-21	Jul-21 - Dec-22	New Admin/Maint Bldg P2 (SF)	$ 2,000,000	$ 2,700,000	$ 3,429,237
Jan-21 - Dec-22	Jan-23 - Dec-24	Cogen (SF)	$ 11,000,000	$ 14,850,000	$ 19,832,994
Jan-21 - Dec-22	Jan-23 - Dec-24	Digester (SF)	$ 6,000,000	$ 8,100,000	$ 10,817,997
Jan-29 - Jun-31	Jul-31 - Jun-35	Aeration Basin P2	$ 21,400,000	$ 28,890,000	$ 50,900,218
Jan-29 - Jun-31	Jul-31 - Jun-35	Secondary Clarifiers P2	$ 13,000,000	$ 17,550,000	$ 30,920,693
Jan-29 - Jun-31	Jul-31 - Jun-35	Equalization	$ 39,000,000	$ 52,650,000	$ 92,762,079
Jan-29 - Jun-31	Jul-31 - Jun-35	Emergency Storage	$ 20,000,000	$ 27,000,000	$ 47,570,297
Jan-29 - Jun-31	Jul-31 - Jun-35	Chemical dosing (SF)	$ 1,000,000	$ 1,350,000	$ 2,378,515
Oct-33 - Jun-34	Jul-34 - Jun-35	Thickening/Dewatering P2 (SF)	$ 4,000,000	$ 5,400,000	$ 10,018,282
Jul-33 - Jun-35	Jul-35 - Jun-37	UV	$ 7,000,000	$ 9,450,000	$ 18,264,665
Common Projects					
Apr-14 - Dec-15	Jan-16 - Jun-18	Headworks/Primary Sed	$ 60,000,000	$ 81,000,000	$ 88,558,545
Jul-15 - Dec-16	Jan-17 - Jun-18	New Admin/Maint bldg P1	$ 8,000,000	$ 10,800,000	$ 12,007,561
		TOTAL COST FULL AS (THROUGH 2026)	$ 237,700,000	$320,895,000	$ 383,979,869
		TOTAL COST SPLIT TREATMENT (THROUGH 2026)	$ 184,500,000	$249,075,000	$ 293,012,408
		TOTAL COST FULL AS	$ 278,900,000	$ 376,515,000	$ 484,289,856
		TOTAL COST SPLIT TREATMENT	$ 289,900,000	$391,365,000	$ 545,827,157

Note: Current construction cost = construction cost in current days dollars
Escalated Project Costs are escallated to mid point of construction, and include ELA costs

Table 8	**Capital Cost Comparison Master Plan and Primary Treatment Design City of Sunnyvale**	
Description	**AS(1)**	**MBR(1)**
Fine Screens	--	$11M
Aeration Basins	$55M	$30M
Secondary Clarifiers	$32M	--
MBR Tanks	--	$84M
Filter Improvements	$3M	--
Total Capital Cost	**$90M±**	**$125M±**
Project Costs(2)	$32M	$44M
Value of Land(3)	$8M	$5M
Total Project Cost	**$130M±**	**$174M±**

Notes:

(1) Costs for full treatment option with facilities needed for the year 2035 flows and loads. Backup for these costs are included in Appendix B.

(2) 35% added for project costs.

(3) Land valued at $3M/acre.

Common costs for diurnal equalization is assumed for both ($39M) and not included in this comparison.

Project: **Sunnyvale Master Plan**
Subject: **BNR Tanks - Design Flow and Loadings (4 New Concrete Tanks)**
By : **ASC**
Date : **11-Mar-14**

Capital Cost Estimate

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
1	Tank Excavation	56,962	cy	$12	$688,371
2	ABC backfill	5,199	cy	$25	$130,868
3	Backfill	5,035	cy	$15	$77,253
4	Sheeting, shoring	34,797	sf	$35	$1,215,522
5	Dewatering	46,791	sf	$11	$514,706
6	Misc site work	8%	of subtotal		$2,778,538
7	Steel Pipe Piling	82,395	lf	$55	$0
	Subtotal site/civil				$5,405,259
8	Slab Concrete	5,626	cy	$327	$1,838,376
9	Wall Concrete	6,717	cy	$681	$4,571,620
10	Elevated Slab Concrete	787	cy	$487	$382,679
11	Miscellaneous Concrete	3086	cy	$382	$1,178,714
12	Handrail	5,310	lf	$88	$466,671
13	Miscellaneous metals	3%	of subtotal		$1,111,415
14	Odor Control Covers	46,791	sf	$109	$0
15	Blower Building	4,125	sf	$326	$1,343,774
16	Coatings	4,125	sf	$15	$63,499
	Subtotal Structural				$10,956,749
17	Blowers (300 hp)	5	ea	$265,373	$1,326,864
18	Aerators (hp)	0	ea	$0	$0
19	Mixers (25 hp)	12	ea	$44,052	$528,628
20	Internal Recirculation Pumps (50 hp)	5	ea	$85,012	$425,060
21	Odor Control Equipment	77,986	cfm	$4	$0
22	Diffusers	8,624	ea	$72	$621,974
	Subtotal Equipment				$2,902,525
23	Piping and Miscellaneous Mechanical	15%	of subtotal		$5,557,077
24	Electrical	21%	of subtotal		$7,779,908
25	Instrumentation and Control	7%	of subtotal		$2,593,303
	Subtotal Structural, Equip, Mech, Elect, I&C				$35,194,820
26	Yard piping	5%	of subtotal		$1,852,359
	Subtotal				$37,047,179
	Contingency	32%			$11,947,715
	Total Direct Costs				**$48,994,895**
	Contractor Overhead and Profit	10%			$4,899,489
	Total Current Estimated Construction Costs				**$53,894,384**
	Engineering Design, Legal Fees, Administration	35%			$18,863,034
	Total Estimated Future Capital Cost				**$72,757,418**
	Land	1.3	acre	$3,000,000	$3,857,306

Operations and Maintenance Cost Estimate

Item	Description	Quantity	Unit	Unit Cost	Annual Cost
1	Operations	3.2	FTE	$200,000	$636,295
	Maintenance	0.8	FTE	$200,000	$157,000
3	Power	6,203,382	kWh	$0.20	$1,240,676
4	Structural Maintenance	1%			$109,567
5	Equipment Maintenance	2%			$58,051
6	Chemicals			$0.00	$0
	Chlorine	0	lb	$0.62	$0
	Total Annual Cost				$2,201,589
	Present Worth Factor	13.9107			
	Present Worth Cost				$30,626,000

Project: **Sunnyvale Master Plan**
Subject: **BNR Secondary Sedimentation (8 New Tanks) - Design Flow and Loads**
By : **ASC**
Date : **11-Mar-14**

Capital Cost Estimate

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
1	Tank Excavation	29,862	cy	$12	$360,870
2	ABC backfill	4,260	cy	$25	$107,228
3	Backfill	7,142	cy	$15	$109,589
4	Sheeting, shoring	31,970	sf	$35	$1,116,758
5	Dewatering	38,339	sf	$11	$421,729
6	Site work (additional)	6%	of subtotal		$1,331,880
7	Steel Pipe Piling	67,955	lf	$55	$0
	subtotal site/civil				$3,448,053
8	Slab Concrete	4,260	cy	$327	$1,392,060
9	Wall Concrete	2,614	cy	$681	$1,779,221
10	Elevated Slab Concrete	734	cy	$487	$356,994
11	Miscellaneous Concrete	1719	cy	$382	$656,468
12	Handrail	6,563	lf	$88	$577,536
13	Miscellaneous Metal	3%	of subtotal		$665,940
14	Existing Clarifier Demo	0	ls	$200,000	$0
15	RAS/WAS Building	1,750	sf	$366	$639,683
16	Coatings	1,750	sf	$15	$26,939
	Subtotal Structural				$6,094,841
17	Drive Mechanism (240 ft length)	8	ea	$227,644	$1,821,150
18	RAS Pumps w/VFD (50. hp)	5	ea	$131,470	$657,351
19	WAS Pumps W/VFD (15. hp)	3	ea	$62,503	$187,509
	Subtotal Equipment				$2,666,010
20	Piping and Miscellaneous Mechanical	18%	of subtotal		$3,995,641
21	Electrical	15%	of subtotal		$3,329,701
22	Instrumentation and Control	7%	of subtotal		$1,553,860
	Subtotal Structural, Equip, Mech, Elect, I&C				$21,088,106
23	Yard piping	5%	of subtotal		$1,109,900
	Subtotal				$22,198,007
	Contingency	32%			$7,158,857
	Total Direct Costs				**$29,356,864**
	Contractor Overhead and Profit	10%			$2,935,686
	Total Current Estimated Construction Costs				$32,292,550
	Engineering Design, Legal Fees, Administration	35%			$11,302,393
	Total Estimated Future Capital Cost				**$43,594,943**
	Land	1.0	acre	$3,000,000	$3,037,045
	Land from filters	0.3	acre	$3,000,001	$950,758

Operations and Maintenance Cost Estimate

Item	Description	Quantity	Unit	Unit Cost	Annual Cost
1	Operations		hr	$200,000	$0
	Maintenance	0.9	hr	$200,000	$173,333
3	Power (Included in MLE Tank Cost)	0	kWh	$0.20	$0
4	Structural Maintenance	1%			$60,948
5	Equipment Maintenance	2%			$53,320
6	Chemicals			$0.00	$0
	Chlorine	0	lb	$0.62	$0
	Total Annual Cost				$287,602
	Present Worth Factor	13.9107			
	Present Worth Cost				$4,001,000

Project: **Sunnyvale Master Plan** Peak Flow 35 mgd
Subject: **Fine Screening at Design Loads**
By : **ASC**
Date : **11-Mar-14**

Capital Cost Estimate

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
1	Structure Excavation	502	cy	$12.08	$6,064
2	ABC Backfill	84	cy	$25.17	$2,105
3	Structure Backfill	418	cy	$15.34	$6,416
4	Sheeting,shoring	0	sf	$35	$0
5	Dewatering	0	sf	$11	$0
6	Misc. Site work	4.0%	of subtotal		$303,381
7	Pilings under new structure	0	sf	$55	$0
	Subtotal site/civil				$317,965
8	Slab Concrete	119	cy	$327	$38,730
9	Wall Concrete	148	cy	$681	$100,831
10	Elevated Slab Concrete	59	cy	$487	$28,830
11	Misc Concrete	160	cy	$382	$61,120
12	Handrail	160	lf	$88	$14,063
13	Grating	400	sf	$87	$34,946
14	Misc Metals	1.0%	of subtotal		$75,845
15	Building	1,600	sf	$325.76	$0
16	Coatings	1.0%	of subtotal		$75,845
	Subtotal Structural				$430,209
17	Rotating Fine Screen	4	ea	$825,000.00	$3,300,000
18	Screenings Compactor	0	ea	$145,699.80	$0
19	Shaftless Screw Conveyor	1	ea	$75,000.00	$75,000
20	Booster pumps and appurtenances	1	LS	$200,000.00	$200,000
	Subtotal Equipment				$3,575,000
21	Piping and Miscellaneous Mechanical	17%	of subtotal		$1,289,368
22	Electrical	15%	of subtotal		$1,137,678
23	Instrumentation and Control	7%	of subtotal		$530,916
	Subtotal Structural, Equip, Mech, Elect, I&C				$7,281,136
24	Yard piping	4%	of subtotal		$303,381
	Subtotal				$7,584,517
	Subtotal				$7,887,897
	Contingency	32%			$2,543,847
	Total Direct Costs				**$10,431,744**
	Contractor Overhead and Profit	10%			$1,043,174
	Total Current Estimated Construction Costs				$11,474,919
	Engineering Design	35%			$4,016,222
	Total Estimated Future Capital Cost				**$15,491,140**
	Land	0.0	acre	$3,000,000	$110,193

Operations and Maintenance Cost Estimate

Item	Description	Quantity	Unit	Unit Cost	Annual Cost
1	Operations	0.25	hr	$200,000	$50,000
	Maintenance	0.75		$200,000	$149,794
3	Power	19605	kWh	$0.20	$3,921
4	Structural Maintenance	1%			$4,474
5	Equipment replacement	2%			$179,709
6	Chemicals			$0.00	$0
	Chlorine	0	lb	$0.62	$0
	Total Annual Cost				$387,898
	Present Worth Factor	13.9107			
	Present Worth Cost				$5,396,000

Project: **Sunnyvale Master Plan**
Subject: **Membrane Bioreactors (4 New Concrete BNR Tanks at Design Flow and Loads)**
By : **ASC**
Date : **11-Mar-14**

Capital Cost Estimate

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
1	Tank Excavation	23,588	cy	$12	$285,047
	ABC Backfill	6,552	cy	$25	$164,926
2	Backfill	1,682	cy	$15	$25,805
	Sheeting, shoring	28,744	sf	$35	$1,004,090
	Dewatering	31,888	sf	$11	$350,771
	Site work for distribution box	3,715	cy	$34	$125,600
	Site work	0.5%	of subtotal		$101,848
7	Steel Pipe Piling	51,267	lf	$55	$0
	Subtotal Site/Civil				$2,058,086
3	Slab Concrete	3,543	cy	$327	$1,157,838
4	Wall Concrete	2,750	cy	$681	$1,871,939
	Elevated Slab Concrete	550	cy	$487	$267,613
5	Miscellaneous Concrete	200	cy	$382	$76,400
6	Handrail	3,713	lf	$88	$326,350
	Miscellaneous Metal	0.5%	of subtotal		$101,848
9	Odor Control Covers	26,797	sf	$109	$0
8	Blower Building	7,250	sf	$326	$2,361,785
	Coatings	7250	sf	$15	$108,750
	Concrete / metals for distribution box	683	cy	$1,034	$706,199
	Subtotal Structural				$6,978,721
10	Blowers (Aeration Only) - 300. hp	6	ea	$265,373	$1,592,236
11	Mixers (10 hp)	12	ea	$34,504	$414,043
12	Internal Recirculation Pumps	0	ea	$0	$0
13	Diffusers	6,342	ea	$76	$481,600
14	Odor Control Equipment	60,695	cfm	$4	$0
	Equipment/mechanical for distribution box	1		$321,041	$321,041
	Subtotal Non-MBR Equipment				$2,808,921
15	Piping and Miscellaneous Mechanical (Non MBR)	10%	of subtotal		$2,036,964
16	Electrical (Non MBR)	21%	of subtotal		$4,277,624
17	Instrumentation and Control (Non MBR)	7%	of subtotal		$1,425,875
	Subtotal Structural, Equip, Mech, Elect, I&C				$19,586,192
	Yard piping	4%			$783,448
	Subtotal				$20,369,640
	Contingency	32%			$6,569,209
	Total Direct Costs				**$26,938,849**
	Contractor Overhead and Profit	10%			$2,693,885
	Total current estimated construction costs				**$29,632,734**
	Engineering Design, Legal Fees, Administration	35%			$10,370,500
	Total Estimated Capital Cost				**$40,000,500**
	Total Present Value of Capital Cost				**$40,000,500**
	Land	0.9	acre	$3,000,000	$2,722,596

Operations and Maintenance Cost Estimate

Item	Description	Quantity	Unit	Unit Cost	Annual Cost
1	Operations	3.2	FTE	$200,000	$636,295
	Maintenance	0.8	FTE	$200,000	$157,000
3	Power	4,221,344	kWh	$0.20	$844,269
4	Structural Maintenance	1%			$69,787
5	Equipment Maintenance (other than Membranes)	2%			$56,178
6	Chemicals			$0.00	$0
	Chlorine	0	lb	$0.62	$0
	Citric Acid	0	lb	$0.50	$0
	Total Annual Cost				$1,763,529
	Present Worth Factor	13.9107			
	Present Worth Cost				$24,532,000

Project: **Sunnyvale Master Plan**
Subject: **Membrane Bioreactors (7 New Membrane Tanks) at Design Flow and Loads**
By : **ASC**
Date : **11-Mar-14**

Capital Cost Estimate

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
1	Tank Excavation	6,001	cy	$12	$72,519
2	ABC backfill	2,084	cy	$25	$52,448
3	Backfill	761	cy	$15	$11,681
4	Sheeting, shoring	16,693	sf	$35	$583,131
5	Dewatering	9,065	sf	$11	$99,715
6	Site work for ML screens	605	cy	$17	$10,291
7	Site work	2%	subtotal (exc membrane)		$703,419
8	Steel Pipe Piling	17,255	lf	$55	$0
	Subtotal Site/Civil				$1,533,204
9	Slab Concrete	1,271	cy	$327	$415,378
10	Wall Concrete	1,391	cy	$681	$946,620
11	Elevated wall concrete		cy	$487	$0
12	Miscellaneous Concrete	1491	cy	$720	$1,073,372
13	Handrail	1,157	lf	$92	$106,067
14	Miscellaneous Metal	3%	subtotal (exc membrane)		$1,055,129
15	Equipment Building	9,505	sf	$294	$2,792,544
16	RAS/WAS PS building	3,507	sf	$366	$1,281,926
17	Coatings	22,632	sf	$15	$339,482
18	Chemical Equipment Area	3,553	sf	$375	$1,333,243
19	Spent CIP storage area	3,939	sf	$286	$1,127,292
20	MBR Tank Odor Control Cover	9,620	sf	$0	$0
21	MBR Tank Roof	9,620	sf	$43	$413,660
22	Bridge Crane and structure	1	ea	$1,418,880	$1,418,880
23	Concrete/metals for ML screens	612	cy	$836	$511,702
	Subtotal Structural				$12,303,592
24	Membranes	1,927,413	sf	$3.44	$6,639,600
25	Other MBR Tanks and Equipment	1,927,413	sf	$8.37	$16,124,188
26	RAS Pumps W/VFD (200. hp)	6	ea	$250,838	$1,505,025
27	WAS Pumps W/VFD (15. hp)	3	ea	$62,503	$187,509
28	ML Screens (45. mgd/each)	4	ea	$315,745	$1,262,979
29	Misc equipment for ML screens	1	ea	$25,260	$25,260
	Subtotal Equipment				$24,456,322
30	Piping and Miscellaneous Mechanical (MBR)	30%	subtotal (exc membrane)		$10,551,287
31	Electrical (MBR)	15%	subtotal (exc membrane)		$5,275,644
32	Instrumentation and Control (MBR)	7%	subtotal (exc membrane)		$2,461,967
	Subtotal Structural, Equip, Mech, Elect, I&C				$56,582,016
33	Yard piping	4%	subtotal (exc membrane)		$1,352,729
	Subtotal				$57,934,745
	Contingency	32%			$18,683,955
	Total Direct Costs				**$76,618,700**
	Contractor Overhead and Profit	10%			$7,661,870
	Total current estimated construction costs				$84,280,570
	Engineering Design, Legal Fees, Administration	35%			$29,498,000
	Total Estimated Capital Cost				**$113,778,000**
	Land	0.7	acre	$3,000,000	$2,240,060

Operations and Maintenance Cost Estimate

Item	Description	Quantity	Unit	Unit Cost	Annual Cost
1	Operations	0.2	FTE	$200,000	$43,333
	Maintenance	2.3	FTE	$200,000	$452,793
3	Power	4,266,268	kWh	$0.20	$853,254
4	Structural Maintenance	1%			$123,036
5	Equipment Maintenance (other than Membranes)	2%			$382,099
6	Membrane Replacement	244,811	sf per year	$3.44	$843,329
6	Chemicals			$0.00	$0
	Chlorine	17,732	lb	$0.62	$10,994
	Citric Acid	123,100	lb	$0.50	$61,550
	Total Annual Cost				$2,770,388
	Present Worth Factor	13.9107			
	Present Worth Cost				$38,538,000

APPENDIX C – MODEL OUTPUT

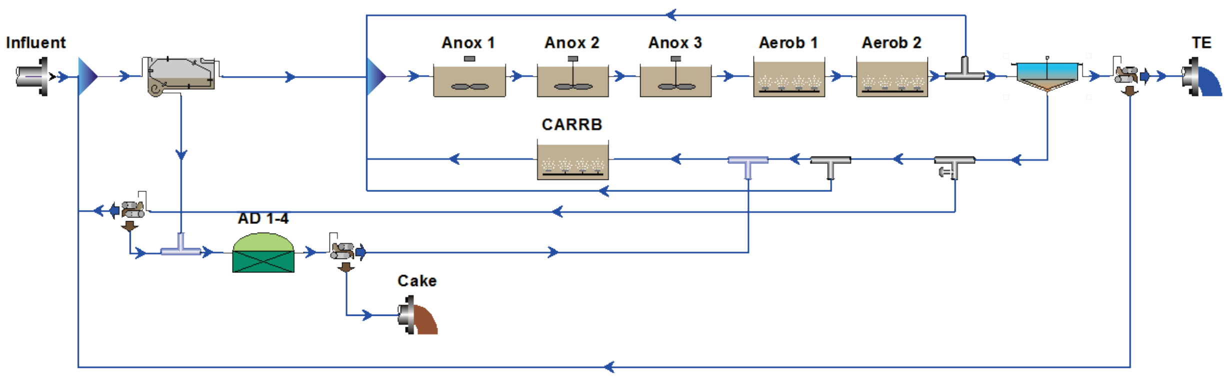
BioWin user and configuration data

Project details
Project name: Unknown Project ref.: BW1
Plant name: Unknown User name: AConklin

Created: 7/6/2013 Saved: 3/20/2014

Steady state solution
Target SRT: 7.00 days SRT #0: 6.97 days (aerobic SRT, including CaRRB)
Temperature: 16.5°C

Flowsheet



Configuration information for all Anaerobic Digester units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]	Head space volume
AD 1-4	4.3350	3.925E+4	14.764	0.5

Operating data Average (flow/time weighted as required)

Element name	Pressure [psi]	pH
AD 1-4	14.9	7.0

Element name	Average Temperature
AD 1-4	35.0

Configuration information for all Bioreactor units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]	# of diffusers
Anox 3	1.3500	6015.6253	30.000	Un-aerated
Aerob 1	3.0400	1.355E+4	30.000	3069
Aerob 2	3.0400	1.355E+4	30.000	3069
Anox 2	1.3500	6015.6253	30.000	Un-aerated
CARRB	0.3990	1777.9515	30.000	403
Anox 1	1.3500	6015.6253	30.000	Un-aerated

Operating data Average (flow/time weighted as required)

Element name	Average DO Setpoint [mg/L]
Anox 3	0
Aerob 1	2.0
Aerob 2	2.0
Anox 2	0
CARRB	1.0
Anox 1	0

Aeration equipment parameters

Element name	k1 in C = k1(PC)^0.25 + k2	k2 in C = k1(PC)^0.25 + k2	Y in Kla = C Usg ^ Y - Usg in [m3/(m2 d)]	Area of one diffuser	% of tank area covered by diffusers [%]
Anox 3	2.5656	0.0432	0.8200	0.4413	10.0000
Aerob 1	2.5656	0.0432	0.8200	0.4413	10.0000
Aerob 2	2.5656	0.0432	0.8200	0.4413	10.0000
Anox 2	2.5656	0.0432	0.8200	0.4413	10.0000
CARRB	2.5656	0.0432	0.8200	0.4413	10.0000
Anox 1	2.5656	0.0432	0.8200	0.4413	10.0000

Configuration information for all Model clarifier units

Physical data

Element name	Volume[Mil. Gal]	Area[ft2]	Depth[ft]	Number of layers	Top feed layer	Feed Layers
SC	4.9730	4.155E+4	16.000	10	6	1

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
SC	Flowrate [Under]	10

Element name	Average Temperature	Reactive
SC	Uses global setting	No

Local settling parameters

Element name	Maximum Vesilind settling velocity (Vo)	Vesilind hindered zone settling parameter (K) [L/g]	Clarification switching function [mg/L]	Specified TSS conc.for height calc. [mg/L]	Maximum compactability constant [mg/L]
SC	0.325	0.435	100.0000	2500.0000	1.500E+4

Configuration information for all Splitter units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
WAS	Flowrate [Side]	0.238991777800934
MLR splitter	Flowrate [Side]	101

RAS Splitter (for CaRRB)	Fraction	0.70

Configuration information for all COD Influent units

Operating data Average (flow/time weighted as required)

Element name	Influent
Time	0
Flow	26.3
Total COD mgCOD/L	474.00
Total Kjeldahl Nitrogen mgN/L	34.70
Total P mgP/L	5.30
Nitrate N mgN/L	0.30
pH	7.50
Alkalinity mmol/L	4.94
ISS Influent mgISS/L	21.60
Calcium mg/L	80.00
Magnesium mg/L	15.00
Dissolved oxygen mg/L	0

Element name	Influent
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.1813
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.6500
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable COD]	0.9006
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.0633
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.1472
Fna - Ammonia [gNH3-N/gTKN]	0.6364
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.4271
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.0200
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.0194
Fpo4 - Phosphate [gPO4-P/gTP]	0.5897
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.0110
FZbh - OHO COD fraction [gCOD/g of total COD]	0.0200
FZbm - Methylotroph COD fraction [gCOD/g of total COD]	1.000E-4
FZaob - AOB COD fraction [gCOD/g of total COD]	1.000E-4
FZnob - NOB COD fraction [gCOD/g of total COD]	1.000E-4
FZamob - ANAMMOX COD fraction [gCOD/g of total COD]	1.000E-4
FZbp - PAO COD fraction [gCOD/g of total COD]	1.000E-4
FZbpa - Propionic acetogens COD fraction [gCOD/g of total COD]	1.000E-4
FZbam - Acetoclastic methanogens COD fraction [gCOD/g of total COD]	1.000E-4
FZbhm - H2-utilizing methanogens COD fraction [gCOD/g of total COD]	1.000E-4
FZe - Endogenous products COD fraction [gCOD/g of total COD]	0

Configuration information for all Ideal primary settling tank units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]
PC	1.3209	1.346E+4	13.123

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
PC	Flowrate [Under]	0.1

Element name	Percent removal	Blanket fraction
PC	51.50	0.10

Configuration information for all Dewatering unit units

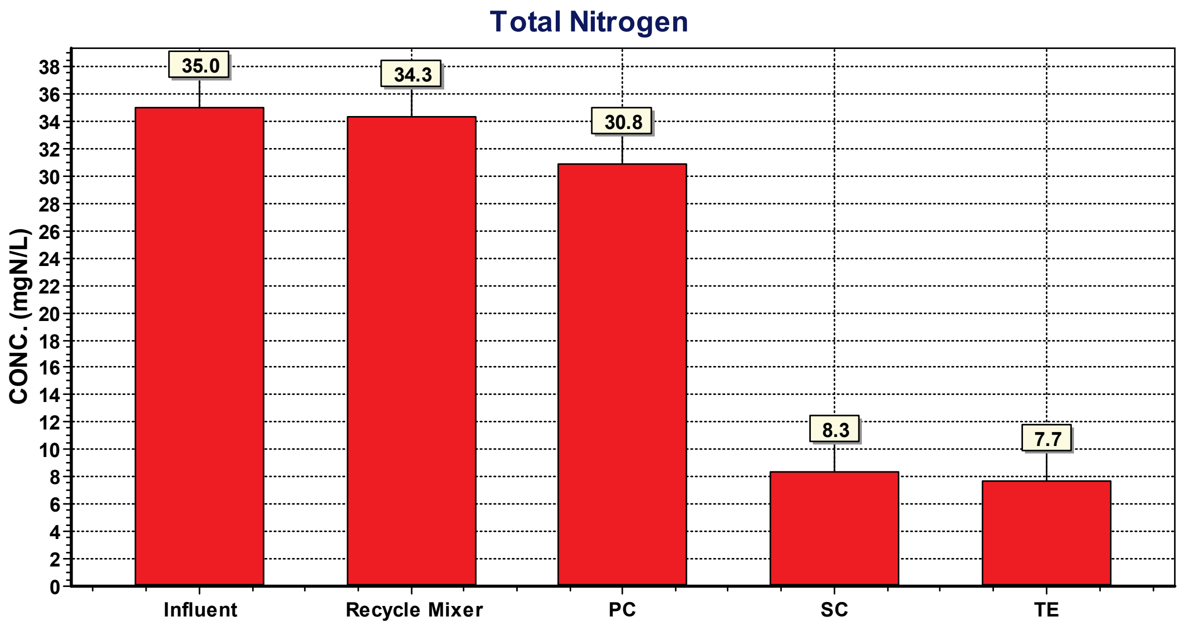
Operating data Average (flow/time weighted as required)

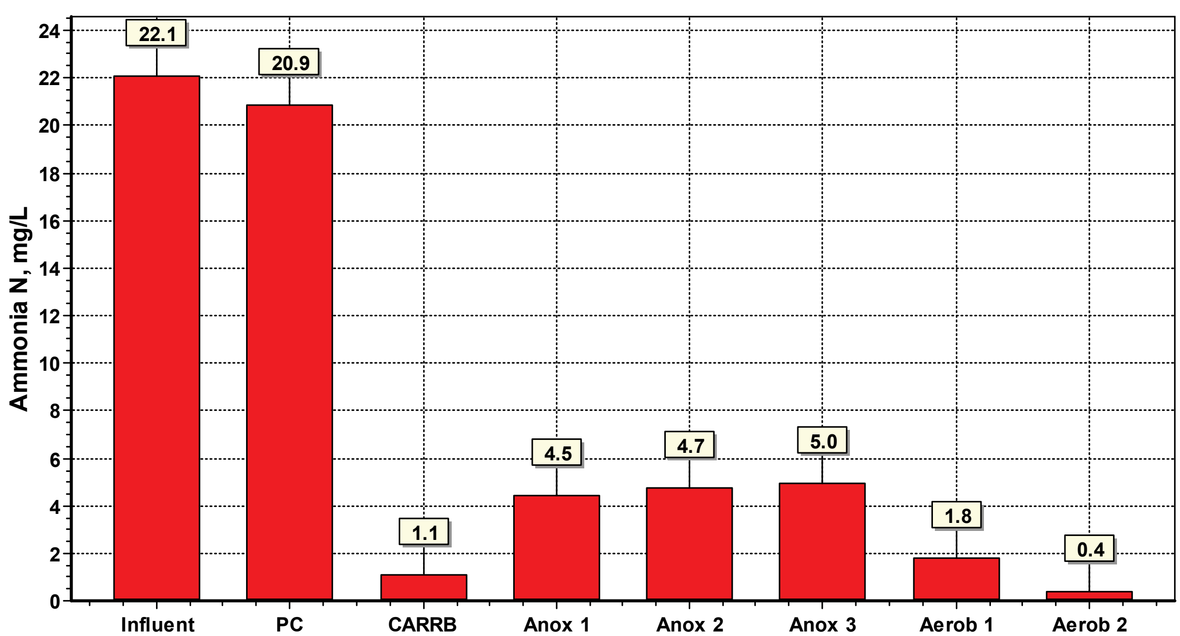
Element name	Split method	Average Split specification
Dewatering	Flowrate [Under]	0.013
WAS thickening	Flowrate [Under]	0.043
Filters	Fraction	0.05

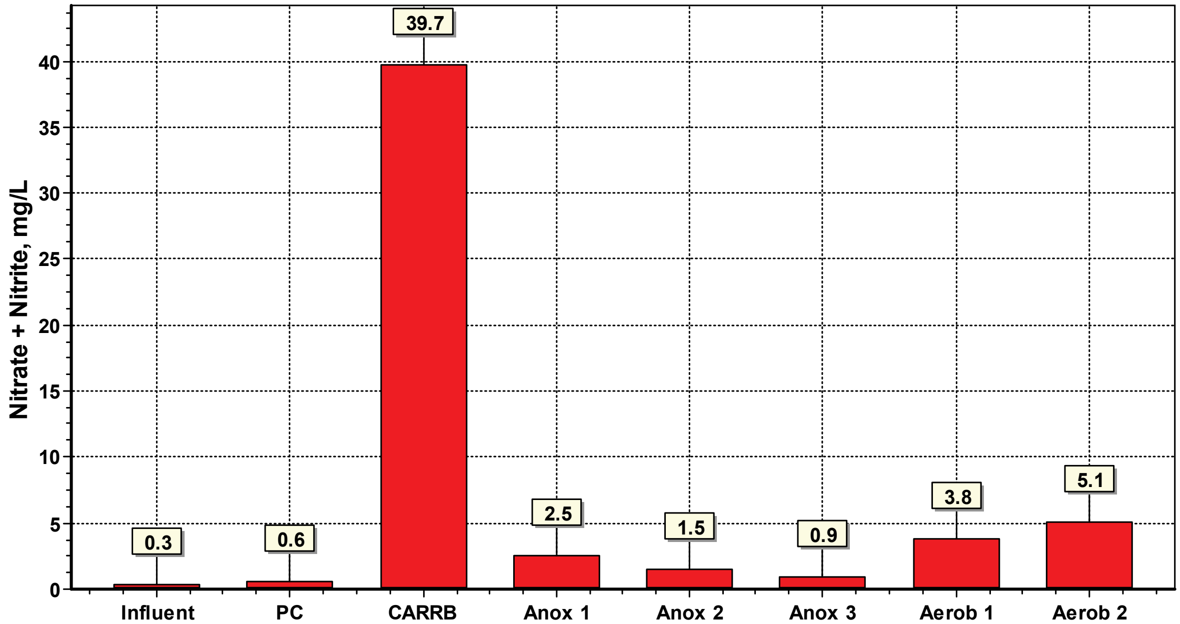
Element name	Percent removal
Dewatering	90.00

WAS thickening	95.00
Filters	60.00

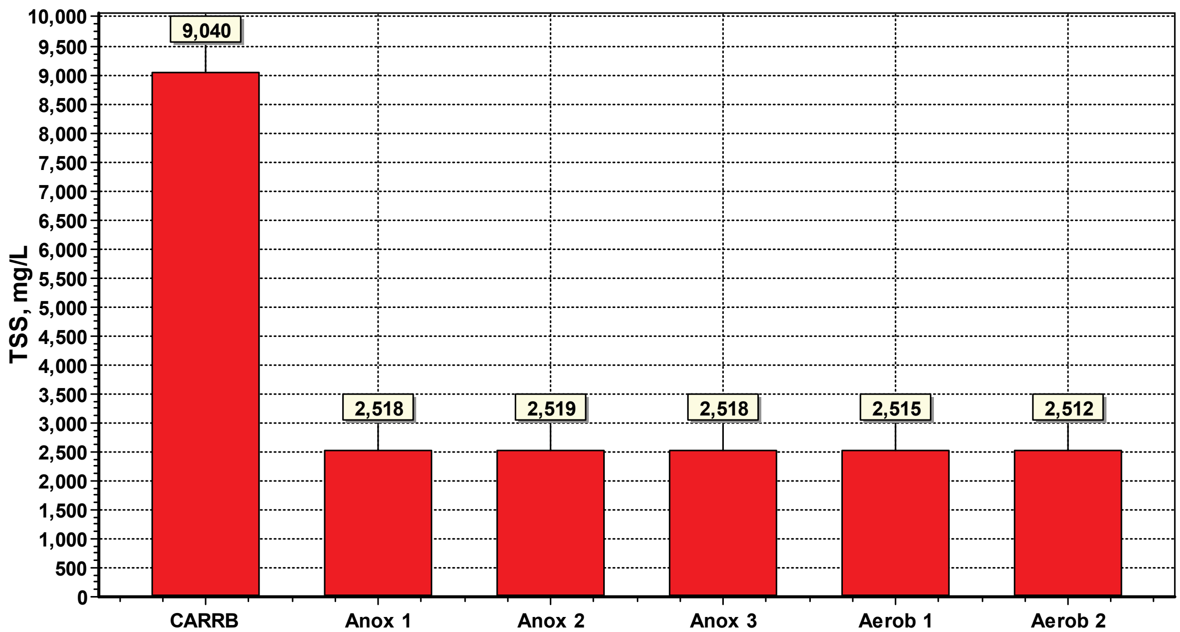
BioWin Album



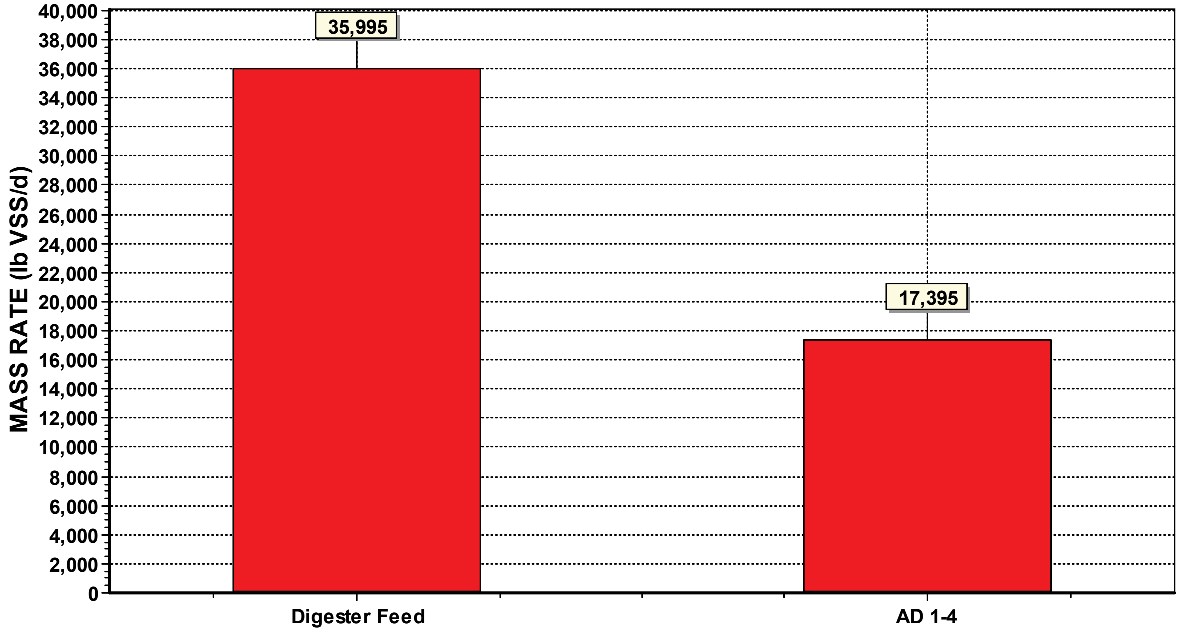




39.7
0.3
0.6
2.5
1.5
0.9
3.8
5.1
Nitrate + Nitrite, mg/L
0
5
10
15
20
25
30
35
40
Influent
PC
CARRB
Anox 1
Anox 2
Anox 3
Aerob 1
Aerob 2



9,040
2,518
2,519
2,518
2,515
2,512
TSS, mg/L
10,000
9,500
9,000
8,500
8,000
7,500
7,000
6,500
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
CARRB
Anox 1
Anox 2
Anox 3
Aerob 1
Aerob 2


MASS RATE (lb VSS/d)
40,000
38,000
36,000
34,000
32,000
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
35,995
17,395
Digester Feed
AD 1-4

Global Parameters

AOB

Name	Default	Value	
Max. spec. growth rate [1/d]	0.9000	0.9000	1.0720
Substrate (NH4) half sat. [mgN/L]	0.7000	0.7000	1.0000
Byproduct NH4 logistic slope [-]	50.0000	50.0000	1.0000
Byproduct NH4 inflection point [mgN/L]	1.4000	1.4000	1.0000
AOB denite DO half sat. [mg/L]	0.1000	0.1000	1.0000
AOB denite HNO2 half sat. [mgN/L]	5.000E-6	5.000E-6	1.0000
Aerobic decay rate [1/d]	0.1700	0.1700	1.0290
Anoxic/anaerobic decay rate [1/d]	0.0800	0.0800	1.0290
KiHNO2 [mmol/L]	0.0050	0.0050	1.0000

NOB

Name	Default	Value	
Max. spec. growth rate [1/d]	0.7000	0.7000	1.0600
Substrate (NO2) half sat. [mgN/L]	0.1000	0.1000	1.0000
Aerobic decay rate [1/d]	0.1700	0.1700	1.0290
Anoxic/anaerobic decay rate [1/d]	0.0800	0.0800	1.0290
KiNH3 [mmol/L]	0.0750	0.0750	1.0000

ANAMMOX

Name	Default	Value	
Max. spec. growth rate [1/d]	0.1000	0.1000	1.1000
Substrate (NH4) half sat. [mgN/L]	2.0000	2.0000	1.0000
Substrate (NO2) half sat. [mgN/L]	1.0000	1.0000	1.0000
Aerobic decay rate [1/d]	0.0190	0.0190	1.0290
Anoxic/anaerobic decay rate [1/d]	0.0095	0.0095	1.0290
Ki Nitrite [mgN/L]	1000.0000	1000.0000	1.0000
Nitrite sensitivity constant [L / (d mgN)]	0.0160	0.0160	1.0000

OHO

Name	Default	Value	
Max. spec. growth rate [1/d]	3.2000	3.2000	1.0290
Substrate half sat. [mgCOD/L]	5.0000	5.0000	1.0000
Anoxic growth factor [-]	0.5000	0.5000	1.0000
Denite N2 producers (NO3 or NO2) [-]	0.5000	0.5000	1.0000
Aerobic decay rate [1/d]	0.6200	0.6200	1.0290
Anoxic decay rate [1/d]	0.2330	0.2330	1.0290
Anaerobic decay rate [1/d]	0.1310	0.1310	1.0290
Hydrolysis rate [1/d]	2.1000	2.1000	1.0290
Hydrolysis half sat. [-]	0.0600	0.0600	1.0000
Anoxic hydrolysis factor [-]	0.2800	0.2800	1.0000
Anaerobic hydrolysis factor (AS) [-]	0.0400	0.0400	1.0000
Anaerobic hydrolysis factor (AD) [-]	0.2000	1.0000	1.0000
Adsorption rate of colloids [L/(mgCOD d)]	0.1500	0.1500	1.0290
Ammonification rate [L/(mgN d)]	0.0400	0.0400	1.0290
Assimilative nitrate/nitrite reduction rate [1/d]	0.5000	0.5000	1.0000
Fermentation rate [1/d]	1.6000	1.6000	1.0290
Fermentation half sat. [mgCOD/L]	5.0000	5.0000	1.0000
Fermentation growth factor (AS) [-]	0.2500	0.2500	1.0000
Endogenous products decay rate[1/d]	0	0	1.0000
Free nitrous acid inhibition [mmol/L]	1.000E-7	1.000E-7	1.0000

Methylotrophs

Name	Default	Value	
Max. spec. growth rate [1/d]	1.3000	1.3000	1.0720
Methanol half sat. [mgCOD/L]	0.5000	0.5000	1.0000
Denite N2 producers (NO3 or NO2) [-]	0.5000	0.5000	1.0000
Aerobic decay rate [1/d]	0.0400	0.0400	1.0290
Anoxic/anaerobic decay rate [1/d]	0.0300	0.0300	1.0290
Free nitrous acid inhibition [mmol/L]	1.000E-7	1.000E-7	1.0000

PAO

Name	Default	Value	
Max. spec. growth rate [1/d]	0.9500	0.9500	1.0000
Max. spec. growth rate, P-limited [1/d]	0.4200	0.4200	1.0000
Substrate half sat. [mgCOD(PHB)/mgCOD(Zbp)]	0.1000	0.1000	1.0000
Substrate half sat., P-limited [mgCOD(PHB)/mgCOD(Zbp)]	0.0500	0.0500	1.0000
Magnesium half sat. [mgMg/L]	0.1000	0.1000	1.0000
Cation half sat. [mmol/L]	0.1000	0.1000	1.0000
Calcium half sat. [mgCa/L]	0.1000	0.1000	1.0000
Aerobic/anoxic decay rate [1/d]	0.1000	0.1000	1.0000
Aerobic/anoxic maintenance rate [1/d]	0	0	1.0000
Anaerobic decay rate [1/d]	0.0400	0.0400	1.0000
Anaerobic maintenance rate [1/d]	0	0	1.0000
Sequestration rate [1/d]	4.5000	4.5000	1.0000
Anoxic growth factor [-]	0.3300	0.3300	1.0000

Acetogens

Name	Default	Value	
Max. spec. growth rate [1/d]	0.2500	0.2500	1.0290
Substrate half sat. [mgCOD/L]	10.0000	10.0000	1.0000
Acetate inhibition [mgCOD/L]	10000.0000	10000.0000	1.0000
Anaerobic decay rate [1/d]	0.0500	0.0500	1.0290
Aerobic/anoxic decay rate [1/d]	0.5200	0.5200	1.0290

Methanogens

Name	Default	Value	
Acetoclastic max. spec. growth rate [1/d]	0.3000	0.3000	1.0290
H2-utilizing max. spec. growth rate [1/d]	1.4000	1.4000	1.0290
Acetoclastic substrate half sat. [mgCOD/L]	100.0000	100.0000	1.0000
Acetoclastic methanol half sat. [mgCOD/L]	0.5000	0.5000	1.0000
H2-utilizing CO2 half sat. [mmol/L]	0.1000	0.1000	1.0000
H2-utilizing substrate half sat. [mgCOD/L]	0.1000	0.1000	1.0000
H2-utilizing methanol half sat. [mgCOD/L]	0.5000	0.5000	1.0000
Acetoclastic propionic inhibition [mgCOD/L]	10000.0000	10000.0000	1.0000
Acetoclastic anaerobic decay rate [1/d]	0.1300	0.1300	1.0290
Acetoclastic aerobic/anoxic decay rate [1/d]	0.6000	0.6000	1.0290
H2-utilizing anaerobic decay rate [1/d]	0.1300	0.1300	1.0290
H2-utilizing aerobic/anoxic decay rate [1/d]	2.8000	2.8000	1.0290

pH

Name	Default	Value
OHO low pH limit [-]	4.0000	4.0000
OHO high pH limit [-]	10.0000	10.0000
Methylotrophs low pH limit [-]	4.0000	4.0000
Methylotrophs high pH limit [-]	10.0000	10.0000
Autotrophs low pH limit [-]	5.5000	5.5000
Autotrophs high pH limit [-]	9.5000	9.5000
PAO low pH limit [-]	4.0000	4.0000
PAO high pH limit [-]	10.0000	10.0000
OHO low pH limit (anaerobic) [-]	5.5000	5.5000
OHO high pH limit (anaerobic) [-]	8.5000	8.5000
Propionic acetogens low pH limit [-]	4.0000	4.0000
Propionic acetogens high pH limit [-]	10.0000	10.0000
Acetoclastic methanogens low pH limit [-]	5.0000	5.0000
Acetoclastic methanogens high pH limit [-]	9.0000	9.0000
H2-utilizing methanogens low pH limit [-]	5.0000	5.0000
H2-utilizing methanogens high pH limit [-]	9.0000	9.0000

Switches

Name	Default	Value
Aerobic/anoxic DO half sat. [mgO2/L]	0.0500	0.0500
Anoxic/anaerobic NOx half sat. [mgN/L]	0.1500	0.1500
AOB DO half sat. [mgO2/L]	0.2500	0.2500
NOB DO half sat. [mgO2/L]	0.5000	0.5000
ANAMMOX DO half sat. [mgO2/L]	0.0100	0.0100
Anoxic NO3(->NO2) half sat. [mgN/L]	0.1000	0.1000
Anoxic NO3(->N2) half sat. [mgN/L]	0.0500	0.0500
Anoxic NO2(->N2) half sat. (mgN/L)	0.0100	0.0100
NH3 nutrient half sat. [mgN/L]	0.0050	0.0050
Poly P half sat. [mgP/mgCOD]	0.0100	0.0100
VFA sequestration half sat. [mgCOD/L]	5.0000	5.0000
P uptake half sat. [mgP/L]	0.1500	0.1500
P nutrient half sat. [mgP/L]	0.0010	0.0010
Autotroph CO2 half sat. [mmol/L]	0.1000	0.1000
H2 low/high half sat. [mgCOD/L]	1.0000	1.0000
Propionic acetogens H2 inhibition [mgCOD/L]	5.0000	5.0000
Synthesis anion/cation half sat. [meq/L]	0.0100	0.0100

Common

Name	Default	Value
Biomass volatile fraction (VSS/TSS)	0.9200	0.9200
Endogenous residue volatile fraction (VSS/TSS)	0.9200	0.9200
N in endogenous residue [mgN/mgCOD]	0.0700	0.0700
P in endogenous residue [mgP/mgCOD]	0.0220	0.0220
Endogenous residue COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200
Particulate substrate COD:VSS ratio [mgCOD/mgVSS]	1.6000	1.9840
Particulate inert COD:VSS ratio [mgCOD/mgVSS]	1.6000	1.6000

AOB

Name	Default	Value
Yield [mgCOD/mgN]	0.1500	0.1500
AOB denite NO2 fraction as TEA [-]	0.5000	0.5000
Byproduct NH4 fraction to N2O [-]	0.0025	0.0025
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous residue [-]	0.0800	0.0800
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200

NOB

Name	Default	Value
Yield [mgCOD/mgN]	0.0900	0.0900
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous residue [-]	0.0800	0.0800
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200

ANAMMOX

Name	Default	Value
Yield [mgCOD/mgN]	0.1140	0.1140
Nitrate production [mgN/mgBiomassCOD]	2.2800	2.2800
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous residue [-]	0.0800	0.0800
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200

OHO

Name	Default	Value
Yield (aerobic) [-]	0.6660	0.6660
Yield (fermentation, low H2) [-]	0.1000	0.1000
Yield (fermentation, high H2) [-]	0.1000	0.1000
H2 yield (fermentation low H2) [-]	0.3500	0.3500
H2 yield (fermentation high H2) [-]	0	0
Propionate yield (fermentation, low H2) [-]	0	0
Propionate yield (fermentation, high H2) [-]	0.7000	0.7000
CO2 yield (fermentation, low H2) [-]	0.7000	0.7000
CO2 yield (fermentation, high H2) [-]	0	0
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Endogenous fraction - aerobic [-]	0.0800	0.0800
Endogenous fraction - anoxic [-]	0.1030	0.1030
Endogenous fraction - anaerobic [-]	0.1840	0.1840
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200
Yield (anoxic) [-]	0.5400	0.5400
Yield propionic (aerobic) [-]	0.6400	0.6400
Yield propionic (anoxic) [-]	0.4600	0.4600
Yield acetic (aerobic) [-]	0.6000	0.6000
Yield acetic (anoxic) [-]	0.4300	0.4300
Yield methanol (aerobic) [-]	0.5000	0.5000
Adsorp. max. [-]	1.0000	1.0000
Max fraction to N2O at high FNA over nitrate [-]	0.0500	0.0500
Max fraction to N2O at high FNA over nitrite [-]	0.1000	0.1000

Methylotrophs

Name	Default	Value
Yield (anoxic) [-]	0.4000	0.4000
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous residue [-]	0.0800	0.0800
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200
Max fraction to N2O at high FNA over nitrate [-]	0.1000	0.1000
Max fraction to N2O at high FNA over nitrite [-]	0.1500	0.1500

PAO

Name	Default	Value
Yield (aerobic) [-]	0.6390	0.6390
Yield (anoxic) [-]	0.5200	0.5200
Aerobic P/PHA uptake [mgP/mgCOD]	0.9300	0.9500
Anoxic P/PHA uptake [mgP/mgCOD]	0.3500	0.3500
Yield of PHA on sequestration [-]	0.8890	0.8890
N in biomass [mgN/mgCOD]	0.0700	0.0700
N in sol. inert [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous part. [-]	0.2500	0.2500
Inert fraction of endogenous sol. [-]	0.2000	0.2000
P/Ac release ratio [mgP/mgCOD]	0.5100	0.4900
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200
Yield of low PP [-]	0.9400	0.9400

Acetogens

Name	Default	Value
Yield [-]	0.1000	0.1000
H2 yield [-]	0.4000	0.4000
CO2 yield [-]	1.0000	1.0000
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous residue [-]	0.0800	0.0800
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200

Methanogens

Name	Default	Value
Acetoclastic yield [-]	0.1000	0.1000
Methanol acetoclastic yield [-]	0.1000	0.1000
H2-utilizing yield [-]	0.1000	0.1000
Methanol H2-utilizing yield [-]	0.1000	0.1000
N in acetoclastic biomass [mgN/mgCOD]	0.0700	0.0700
N in H2-utilizing biomass [mgN/mgCOD]	0.0700	0.0700
P in acetoclastic biomass [mgP/mgCOD]	0.0220	0.0220
P in H2-utilizing biomass [mgP/mgCOD]	0.0220	0.0220
Acetoclastic fraction to endog. residue [-]	0.0800	0.0800
H2-utilizing fraction to endog. residue [-]	0.0800	0.0800
Acetoclastic COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200
H2-utilizing COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200

General

Name	Default	Value
Molecular weight of other anions [mg/mmol]	35.5000	35.5000
Molecular weight of other cations [mg/mmol]	39.1000	39.1000
Mg to P mole ratio in polyphosphate [mmolMg/mmolP]	0.3000	0.3000
Cation to P mole ratio in polyphosphate [meq/mmolP]	0.1500	0.3000
Ca to P mole ratio in polyphosphate [mmolCa/mmolP]	0.0500	0.0500
Cation to P mole ratio in organic phosphate [meq/mmolP]	0.0100	0.0100
Bubble rise velocity (anaerobic digester) [cm/s]	23.9000	23.9000
Bubble Sauter mean diameter (anaerobic digester) [cm]	0.3500	0.3500
Anaerobic digester gas hold-up factor []	1.0000	1.0000
Tank head loss per metre of length (from flow) [m/m]	0.0025	0.0025

Mass transfer

Name	Default	Value	
Kl for H2 [m/d]	17.0000	17.0000	1.0240
Kl for CO2 [m/d]	10.0000	10.0000	1.0240
Kl for NH3 [m/d]	1.0000	1.0000	1.0240
Kl for CH4 [m/d]	8.0000	8.0000	1.0240
Kl for N2 [m/d]	15.0000	15.0000	1.0240
Kl for N2O [m/d]	8.0000	8.0000	1.0240
Kl for O2 [m/d]	13.0000	13.0000	1.0240

Henry's law constants

Name	Default	Value	
CO2 [M/atm]	0.0340	0.0340	2400.0000
O2 [M/atm]	0.0013	0.0013	1500.0000
N2 [M/atm]	6.500E-4	6.500E-4	1300.0000
N2O [M/atm]	0.0250	0.0250	2600.0000
NH3 [M/atm]	58.0000	58.0000	4100.0000
CH4 [M/atm]	0.0014	0.0014	1600.0000
H2 [M/atm]	7.800E-4	7.800E-4	500.0000

Physico-chemical rates

Name	Default	Value	
Struvite precipitation rate [1/d]	3.000E+10	3.000E+10	1.0240
Struvite redissolution rate [1/d]	3.000E+11	3.000E+11	1.0240
Struvite half sat. [mgTSS/L]	1.0000	1.0000	1.0000
HDP precipitation rate [L/(molP d)]	1.000E+8	1.000E+8	1.0000
HDP redissolution rate [L/(mol P d)]	1.000E+8	1.000E+8	1.0000
HAP precipitation rate [molHDP/(L d)]	5.000E-4	5.000E-4	1.0000

Physico-chemical constants

Name	Default	Value
Struvite solubility constant [mol/L]	6.918E-14	6.918E-14
HDP solubility product [mol/L]	2.750E-22	2.750E-22
HDP half sat. [mgTSS/L]	1.0000	1.0000
Equilibrium soluble PO4 with Al dosing at pH 7 [mgP/L]	0.0100	0.0100
Al to P ratio [molAl/molP]	0.8000	0.8000
Al(OH)3 solubility product [mol/L]	1.259E+9	1.259E+9
AlHPO4+ dissociation constant [mol/L]	7.943E-13	7.943E-13
Equilibrium soluble PO4 with Fe dosing at pH 7 [mgP/L]	0.0100	0.0100
Fe to P ratio [molFe/molP]	1.6000	1.6000
Fe(OH)3 solubility product [mol/L]	0.0500	0.0500
FeH2PO4++ dissociation constant [mol/L]	5.012E-22	5.012E-22

Aeration

Name	Default	Value
Alpha (surf) OR Alpha F (diff) [-]	0.5000	0.5000
Beta [-]	0.9500	0.9500
Surface pressure [kPa]	101.3250	101.3250
Fractional effective saturation depth (Fed) [-]	0.3250	0.3250
Supply gas CO2 content [vol. %]	0.0350	0.0350
Supply gas O2 [vol. %]	20.9500	20.9500
Off-gas CO2 [vol. %]	2.0000	2.0000
Off-gas O2 [vol. %]	18.8000	18.8000
Off-gas H2 [vol. %]	0	0
Off-gas NH3 [vol. %]	0	0
Off-gas CH4 [vol. %]	0	0
Surface turbulence factor [-]	2.0000	2.0000
Set point controller gain []	1.0000	1.0000

Modified Vesilind

Name	Default	Value
Maximum Vesilind settling velocity (Vo) [ft/min]	0.387	0.387
Vesilind hindered zone settling parameter (K) [L/g]	0.370	0.370
Clarification switching function [mg/L]	100.000	100.000
Specified TSS conc.for height calc. [mg/L]	2500.000	2500.000
Maximum compactability constant [mg/L]	15000.000	15000.000

Double exponential

Name	Default	Value
Maximum Vesilind settling velocity (Vo) [ft/min]	0.934	0.934
Maximum (practical) settling velocity (Vo') [ft/min]	0.615	0.615
Hindered zone settling parameter (Kh) [L/g]	0.400	0.400
Flocculent zone settling parameter (Kf) [L/g]	2.500	2.500
Maximum non-settleable TSS [mg/L]	20.0000	20.0000
Non-settleable fraction [-]	0.0010	0.0010
Specified TSS conc. for height calc. [mg/L]	2500.0000	2500.0000

Emission factors

Name	Default	Value
Carbon dioxide equivalence of nitrous oxide	296.0000	296.0000
Carbon dioxide equivalence of methane	23.0000	23.0000

Biofilm general

Name	Default	Value	
Attachment rate [g / (m2 d)]	80.0000	80.0000	1.0000
Attachment TSS half sat. [mg/L]	100.0000	100.0000	1.0000
Detachment rate [g/(m3 d)]	8.000E+4	8.000E+4	1.0000
Solids movement factor []	10.0000	10.0000	1.0000
Diffusion neta []	0.8000	0.8000	1.0000
Thin film limit [mm]	0.5000	0.5000	1.0000
Thick film limit [mm]	3.0000	3.0000	1.0000
Assumed Film thickness for tank volume correction (temp independant) [mm]	0.7500	0.7500	1.0000
Film surface area to media area ratio - Max.[ ]	1.0000	1.0000	1.0000
Minimum biofilm conc. for streamer formation [gTSS/m2]	4.0000	4.0000	1.0000

Maximum biofilm concentrations [mg/L]

Name	Default	Value	
Ordinary heterotrophic organisms (OHO)	5.000E+4	5.000E+4	1.0000
Methylotrophs	5.000E+4	5.000E+4	1.0000
Ammonia oxidizing biomass (AOB)	1.000E+5	1.000E+5	1.0000
Nitrite oxidizing biomass (NOB)	1.000E+5	1.000E+5	1.0000
Anaerobic ammonia oxidizers (ANAMMOX)	5.000E+4	5.000E+4	1.0000
Polyphosphate accumulating organisms (PAO)	5.000E+4	5.000E+4	1.0000
Propionic acetogens	5.000E+4	5.000E+4	1.0000
Methanogens - acetoclastic	5.000E+4	5.000E+4	1.0000
Methanogens - hydrogenotrophic	5.000E+4	5.000E+4	1.0000
Endogenous products	3.000E+4	3.000E+4	1.0000
Slowly bio. COD (part.)	5000.0000	5000.0000	1.0000
Slowly bio. COD (colloid.)	4000.0000	4000.0000	1.0000
Part. inert. COD	5000.0000	5000.0000	1.0000
Part. bio. org. N	0	0	1.0000
Part. bio. org. P	0	0	1.0000
Part. inert N	0	0	1.0000
Part. inert P	0	0	1.0000
Stored PHA	5000.0000	5000.0000	1.0000
Releasable stored polyP	1.150E+6	1.150E+6	1.0000
Fixed stored polyP	1.150E+6	1.150E+6	1.0000
Readily bio. COD (complex)	0	0	1.0000
Acetate	0	0	1.0000
Propionate	0	0	1.0000
Methanol	0	0	1.0000
Dissolved H2	0	0	1.0000
Dissolved methane	0	0	1.0000
Ammonia N	0	0	1.0000
Sol. bio. org. N	0	0	1.0000
Nitrous Oxide N	0	0	1.0000
Nitrite N	0	0	1.0000
Nitrate N	0	0	1.0000
Dissolved nitrogen gas	0	0	1.0000
PO4-P (Sol. & Me Complexed)	1.000E+10	1.000E+10	1.0000
Sol. inert COD	0	0	1.0000
Sol. inert TKN	0	0	1.0000
ISS Influent	1.300E+6	1.300E+6	1.0000
Struvite	8.500E+5	8.500E+5	1.0000
Hydroxy-dicalcium-phosphate	1.150E+6	1.150E+6	1.0000
Hydroxy-apatite	1.600E+6	1.600E+6	1.0000
Magnesium	0	0	1.0000
Calcium	0	0	1.0000
Metal	1.000E+10	1.000E+10	1.0000
Other Cations (strong bases)	0	0	1.0000
Other Anions (strong acids)	0	0	1.0000
Total CO2	0	0	1.0000
User defined 1	0	0	1.0000
User defined 2	0	0	1.0000
User defined 3	5.000E+4	5.000E+4	1.0000
User defined 4	5.000E+4	5.000E+4	1.0000
Dissolved oxygen	0	0	1.0000

Effective diffusivities [m2/s]

Name	Default	Value	
Ordinary heterotrophic organisms (OHO)	5.000E-14	5.000E-14	1.0290
Methylotrophs	5.000E-14	5.000E-14	1.0290
Ammonia oxidizing biomass (AOB)	5.000E-14	5.000E-14	1.0290
Nitrite oxidizing biomass (NOB)	5.000E-14	5.000E-14	1.0290
Anaerobic ammonia oxidizers (ANAMMOX)	5.000E-14	5.000E-14	1.0290
Polyphosphate accumulating organisms (PAO)	5.000E-14	5.000E-14	1.0290
Propionic acetogens	5.000E-14	5.000E-14	1.0290
Methanogens - acetoclastic	5.000E-14	5.000E-14	1.0290
Methanogens - hydrogenotrophic	5.000E-14	5.000E-14	1.0290
Endogenous products	5.000E-14	5.000E-14	1.0290
Slowly bio. COD (part.)	5.000E-14	5.000E-14	1.0290
Slowly bio. COD (colloid.)	5.000E-12	5.000E-12	1.0290
Part. inert. COD	5.000E-14	5.000E-14	1.0290
Part. bio. org. N	5.000E-14	5.000E-14	1.0290
Part. bio. org. P	5.000E-14	5.000E-14	1.0290
Part. inert N	5.000E-14	5.000E-14	1.0290
Part. inert P	5.000E-14	5.000E-14	1.0290
Stored PHA	5.000E-14	5.000E-14	1.0290
Releasable stored polyP	5.000E-14	5.000E-14	1.0290
Fixed stored polyP	5.000E-14	5.000E-14	1.0290
Readily bio. COD (complex)	6.900E-10	6.900E-10	1.0290
Acetate	1.240E-9	1.240E-9	1.0290
Propionate	8.300E-10	8.300E-10	1.0290
Methanol	1.600E-9	1.600E-9	1.0290
Dissolved H2	5.850E-9	5.850E-9	1.0290
Dissolved methane	1.963E-9	1.963E-9	1.0290
Ammonia N	2.000E-9	2.000E-9	1.0290
Sol. bio. org. N	1.370E-9	1.370E-9	1.0290
Nitrous Oxide N	1.607E-9	1.607E-9	1.0290
Nitrite N	2.980E-9	2.980E-9	1.0290
Nitrate N	2.980E-9	2.980E-9	1.0290
Dissolved nitrogen gas	1.900E-9	1.900E-9	1.0290
PO4-P (Sol. & Me Complexed)	2.000E-9	2.000E-9	1.0290
Sol. inert COD	6.900E-10	6.900E-10	1.0290
Sol. inert TKN	6.850E-10	6.850E-10	1.0290
ISS Influent	5.000E-14	5.000E-14	1.0290
Struvite	5.000E-14	5.000E-14	1.0290
Hydroxy-dicalcium-phosphate	5.000E-14	5.000E-14	1.0290
Hydroxy-apatite	5.000E-14	5.000E-14	1.0290
Magnesium	7.200E-10	7.200E-10	1.0290
Calcium	7.200E-10	7.200E-10	1.0290
Metal	4.800E-10	4.800E-10	1.0290
Other Cations (strong bases)	1.440E-9	1.440E-9	1.0290
Other Anions (strong acids)	1.440E-9	1.440E-9	1.0290
Total CO2	1.960E-9	1.960E-9	1.0290
User defined 1	6.900E-10	6.900E-10	1.0290
User defined 2	6.900E-10	6.900E-10	1.0290
User defined 3	5.000E-14	5.000E-14	1.0290
User defined 4	5.000E-14	5.000E-14	1.0290
Dissolved oxygen	2.500E-9	2.500E-9	1.0290

EPS Strength coefficients [ ]

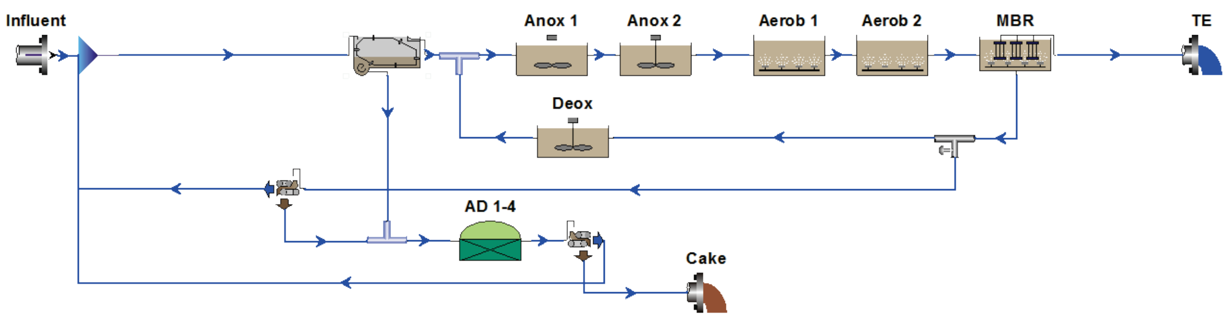
Name	Default	Value	
Ordinary heterotrophic organisms (OHO)	1.0000	1.0000	1.0000
Methylotrophs	1.0000	1.0000	1.0000
Ammonia oxidizing biomass (AOB)	5.0000	1.0000	1.0000
Nitrite oxidizing biomass (NOB)	25.0000	1.0000	1.0000
Anaerobic ammonia oxidizers (ANAMMOX)	10.0000	1.0000	1.0000
Polyphosphate accumulating organisms (PAO)	1.0000	1.0000	1.0000
Propionic acetogens	1.0000	1.0000	1.0000
Methanogens - acetoclastic	1.0000	1.0000	1.0000
Methanogens - hydrogenotrophic	1.0000	1.0000	1.0000
Endogenous products	1.0000	1.0000	1.0000
Slowly bio. COD (part.)	1.0000	1.0000	1.0000
Slowly bio. COD (colloid.)	1.0000	1.0000	1.0000
Part. inert. COD	1.0000	1.0000	1.0000
Part. bio. org. N	1.0000	1.0000	1.0000
Part. bio. org. P	1.0000	1.0000	1.0000
Part. inert N	1.0000	1.0000	1.0000
Part. inert P	1.0000	1.0000	1.0000
Stored PHA	1.0000	1.0000	1.0000
Releasable stored polyP	1.0000	1.0000	1.0000
Fixed stored polyP	1.0000	1.0000	1.0000
Readily bio. COD (complex)	0	0	1.0000
Acetate	0	0	1.0000
Propionate	0	0	1.0000
Methanol	0	0	1.0000
Dissolved H2	0	0	1.0000
Dissolved methane	0	0	1.0000
Ammonia N	0	0	1.0000
Sol. bio. org. N	0	0	1.0000
Nitrous Oxide N	0	0	1.0000
Nitrite N	0	0	1.0000
Nitrate N	0	0	1.0000
Dissolved nitrogen gas	0	0	1.0000
PO4-P (Sol. & Me Complexed)	1.0000	1.0000	1.0000
Sol. inert COD	0	0	1.0000
Sol. inert TKN	0	0	1.0000
ISS Influent	0.3300	0.3300	1.0000
Struvite	1.0000	1.0000	1.0000
Hydroxy-dicalcium-phosphate	1.0000	1.0000	1.0000
Hydroxy-apatite	1.0000	1.0000	1.0000
Magnesium	0	0	1.0000
Calcium	0	0	1.0000
Metal	1.0000	1.0000	1.0000
Other Cations (strong bases)	0	0	1.0000
Other Anions (strong acids)	0	0	1.0000
Total CO2	0	0	1.0000
User defined 1	0	0	1.0000
User defined 2	0	0	1.0000
User defined 3	1.0000	1.0000	1.0000
User defined 4	1.0000	1.0000	1.0000
Dissolved oxygen	0	0	1.0000

BioWin user and configuration data

Project details
Created: 7/6/2013 **Saved: 3/20/2014**

Steady state solution
Target SRT: 7.00 days **SRT #0: 7.00 days (aerobic SRT: Aerob 1, Aerob 2)**
Temperature: 16.5°C

Flowsheet



Configuration information for all Anaerobic Digester units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]	Head space volume
AD 1-4	4.3350	3.925E+4	14.764	0.5

Operating data Average (flow/time weighted as required)

Element name	Pressure [psi]	pH
AD 1-4	14.9	7.0

Element name	Average Temperature
AD 1-4	35.0

Configuration information for all Ideal primary settling tank units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]
PC	1.3209	1.346E+4	13.123

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
PC	Flowrate [Under]	0.09

Element name	Percent removal	Blanket fraction
PC	51.50	0.10

Configuration information for all Bioreactor units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]	# of diffusers
Anox 2	0.6240	5650.0048	14.764	Un-aerated
Aerob 1	1.0000	9054.4949	14.764	4104
Aerob 2	1.0000	9054.4949	14.764	2052
Anox 1	0.6240	5650.0048	14.764	Un-aerated
Deox	0.4000	3621.7980	14.764	Un-aerated

Operating data Average (flow/time weighted as required)

Element name	Average DO Setpoint [mg/L]
Anox 2	0
Aerob 1	2.0
Aerob 2	2.0
Anox 1	0
Deox	0

Aeration equipment parameters

Element name	k1 in C = k1(PC)^0.25 + k2	k2 in C = k1(PC)^0.25 + k2	Y in Kla = C Usg ^ Y - Usg in [m3/(m2 d)]	Area of one diffuser	% of tank area covered by diffusers [%]
Anox 2	2.5656	0.0432	0.8200	0.4413	10.0000
Aerob 1	2.5656	0.0432	0.8200	0.4413	20.0000
Aerob 2	2.5656	0.0432	0.8200	0.4413	10.0000
Anox 1	2.5656	0.0432	0.8200	0.4413	10.0000
Deox	2.5656	0.0432	0.8200	0.4413	10.0000

Element name	Alpha (surf) OR Alpha F (diff) [-]	Beta [-]	Surface pressure [kPa]	Fractional effective saturation depth (Fed) [-]
Aerob 1	0.5000	0.9500	101.3250	0.3250

Element name	Supply gas CO2 content [vol. %]	Supply gas O2 [vol. %]	Off-gas CO2 [vol. %]	Off-gas O2 [vol. %]	Off-gas H2 [vol. %]	Off-gas NH3 [vol. %]	Off-gas CH4 [vol. %]	Surface turbulence factor [-]
Aerob 1	0.0350	20.9500	2.0000	18.8000	0	0	0	2.0000

Configuration information for all Membrane bioreactor units

Physical data

Element name	Volume [Mil. Gal]	Area [ft2]	Depth [ft]	# of diffusers	# of cassettes	Displaced volume / cassette [ft3/cassette]	Membrane area / cassette [ft2/cassette]	Total displaced volume [Mil. Gal]	Membrane surface area [ft2]
MBR	0.5400	7734.6517	9.333	2156	96.00	60.160	17760.00	0.04	1704960.00

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
MBR	Flow paced	440.00 %

Element name	Average Air flow rate [ft3/min (20C, 1 atm)]
MBR	16320.0

Aeration equipment parameters

Element name	k1 in C = k1(PC)^0.25 + k2	k2 in C = k1(PC)^0.25 + k2	Y in Kla = C Usg ^ Y - Usg in [m3/(m2 d)]	Area of one diffuser	% of tank area covered by diffusers [%]
MBR	0.0500	0.3800	1.0500	0.5382	15.0000

Element name	Alpha (surf) OR Alpha F (diff) [-]	Beta [-]	Surface pressure [kPa]	Fractional effective saturation depth (Fed) [-]
MBR	0.7000	0.9500	101.3250	0.3000

Element name	Supply gas CO2 content [vol. %]	Supply gas O2 [vol. %]	Off-gas CO2 [vol. %]	Off-gas O2 [vol. %]	Off-gas H2 [vol. %]	Off-gas NH3 [vol. %]	Off-gas CH4 [vol. %]	Surface turbulence factor [-]
MBR	0.0350	20.9500	1.2000	19.9000	0	0	0	2.0000

Configuration information for all COD Influent units

Operating data Average (flow/time weighted as required)

Element name	Influent
Time	0
Flow	26.3
Total COD mgCOD/L	474.00
Total Kjeldahl Nitrogen mgN/L	34.70
Total P mgP/L	5.30
Nitrate N mgN/L	0.30
pH	7.50
Alkalinity mmol/L	4.94
ISS Influent mgISS/L	21.60
Calcium mg/L	80.00
Magnesium mg/L	15.00
Dissolved oxygen mg/L	0

Element name	Influent
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.1813
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.6500
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable COD]	0.9006
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.0633
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.1472
Fna - Ammonia [gNH3-N/gTKN]	0.6364
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.4271
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.0200
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.0194
Fpo4 - Phosphate [gPO4-P/gTP]	0.5897
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.0110
FZbh - OHO COD fraction [gCOD/g of total COD]	0.0200
FZbm - Methylotroph COD fraction [gCOD/g of total COD]	1.000E-4
FZaob - AOB COD fraction [gCOD/g of total COD]	1.000E-4
FZnob - NOB COD fraction [gCOD/g of total COD]	1.000E-4
FZamob - ANAMMOX COD fraction [gCOD/g of total COD]	1.000E-4
FZbp - PAO COD fraction [gCOD/g of total COD]	1.000E-4
FZbpa - Propionic acetogens COD fraction [gCOD/g of total COD]	1.000E-4
FZbam - Acetoclastic methanogens COD fraction [gCOD/g of total COD]	1.000E-4
FZbhm - H2-utilizing methanogens COD fraction [gCOD/g of total COD]	1.000E-4
FZe - Endogenous products COD fraction [gCOD/g of total COD]	0

Configuration information for all Dewatering unit units

Operating data Average (flow/time weighted as required)

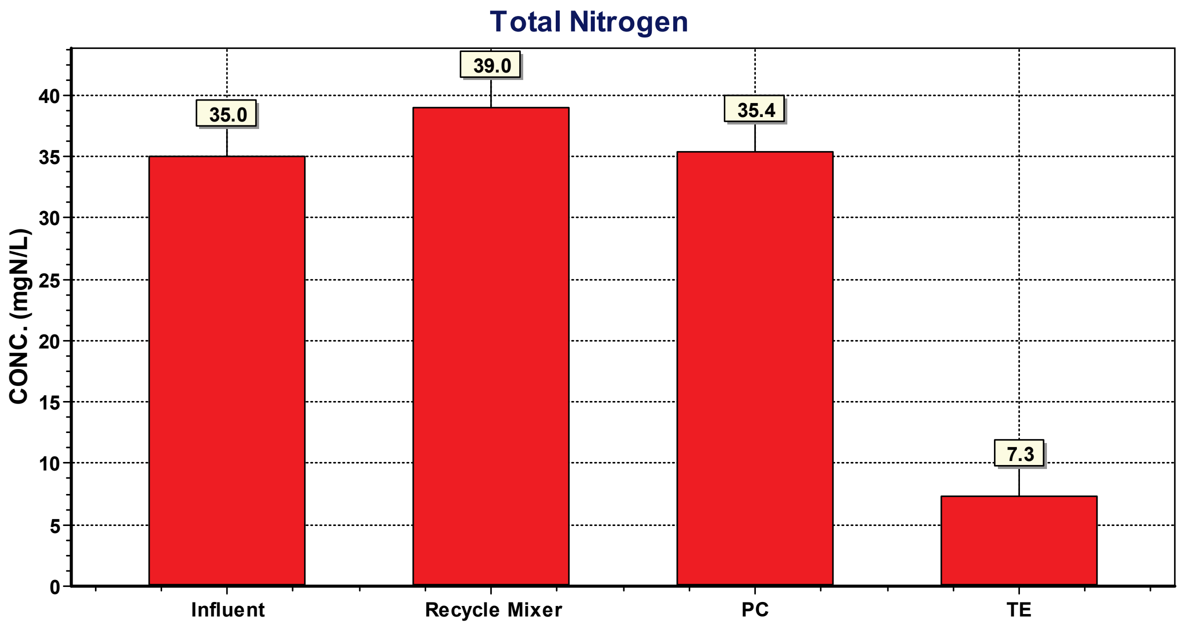
Element name	Split method	Average Split specification
Dewatering	Flowrate [Under]	0.012
WAS thickening	Flowrate [Under]	0.04

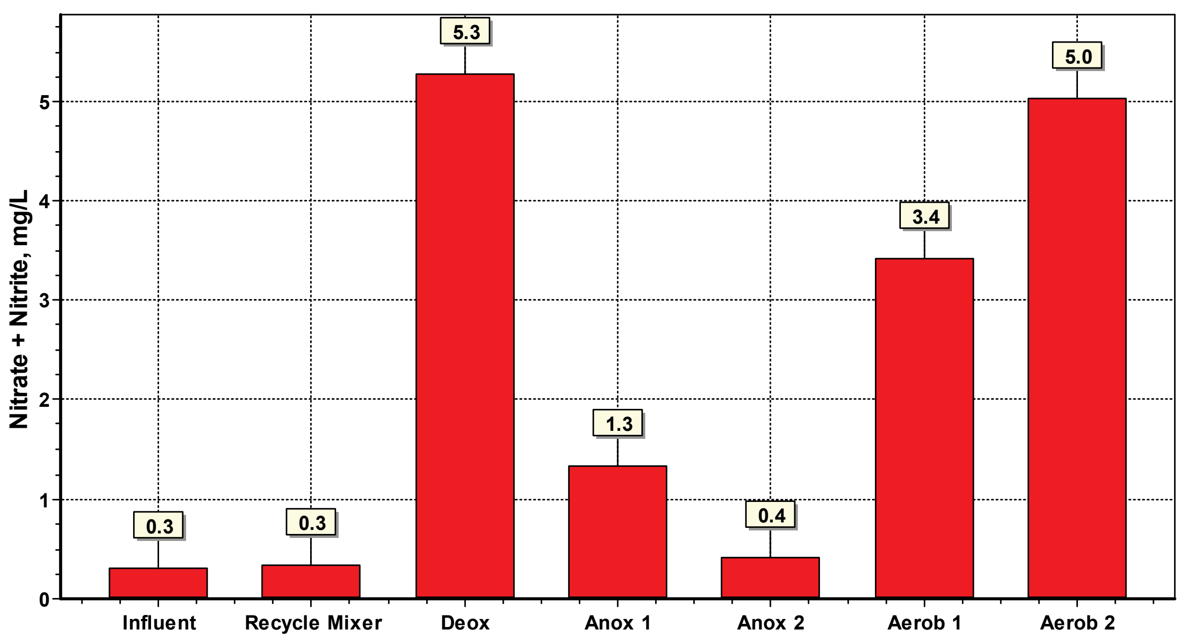
Element name	Percent removal
Dewatering	90.00
WAS thickening	95.00

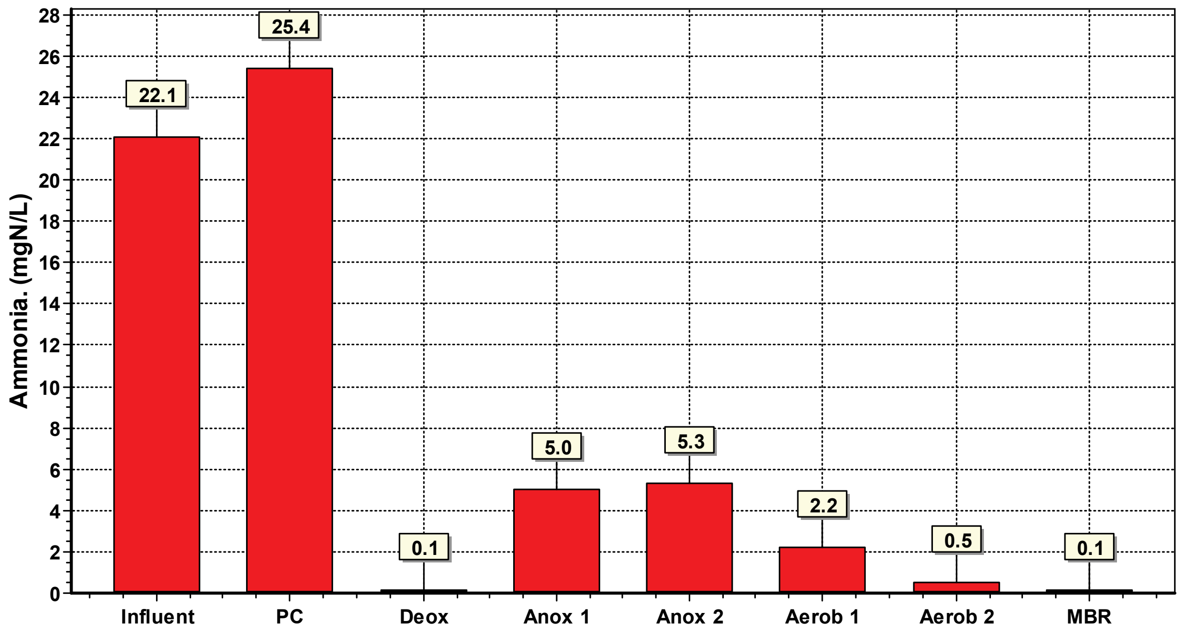
Configuration information for all Splitter units

Operating data Average (flow/time weighted as required)

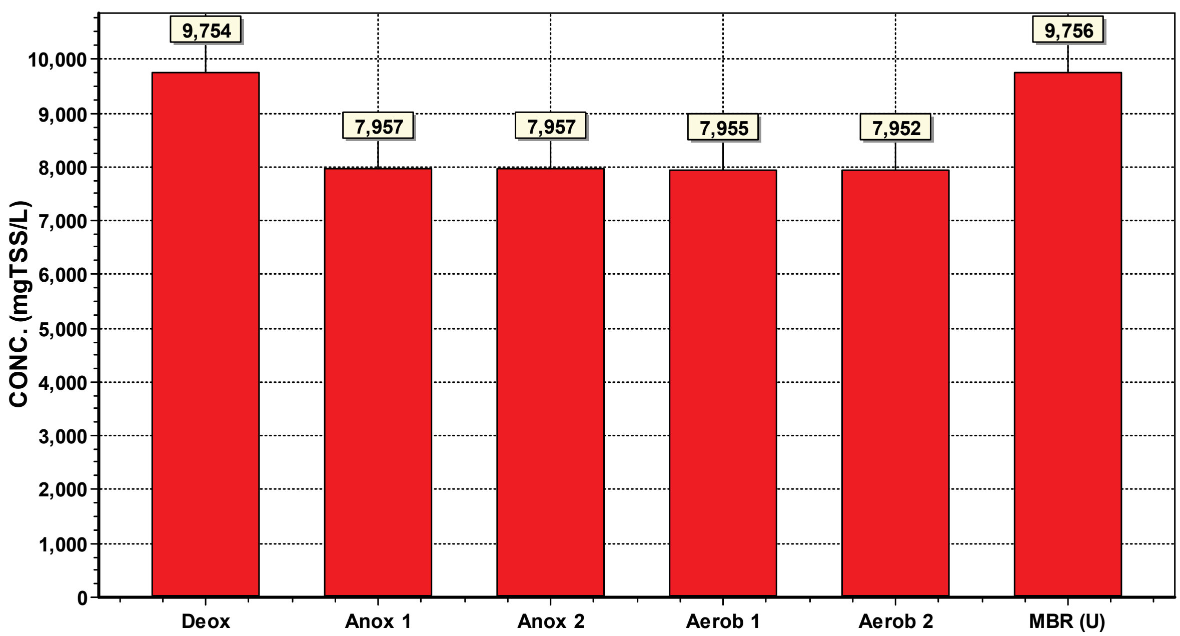
Element name	Split method	Average Split specification
WAS	Flowrate [Side]	0.232901932223214


Total Nitrogen
CONC. (mgN/L)
0
5
10
15
20
25
30
35
40
35.0
39.0
35.4
7.3
Influent
Recycle Mixer
PC
TE

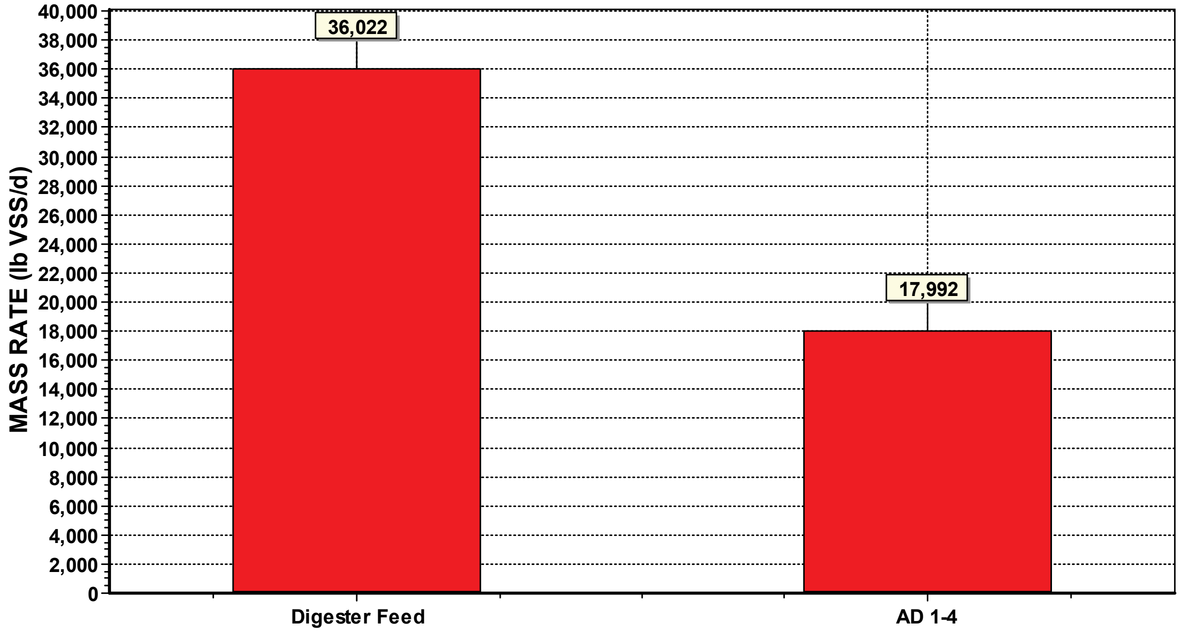

Nitrate + Nitrite, mg/L
0
1
2
3
4
5
0.3
0.3
5.3
1.3
0.4
3.4
5.0
Influent
Recycle Mixer
Deox
Anox 1
Anox 2
Aerob 1
Aerob 2



Ammonia. (mgN/L)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
22.1
25.4
0.1
5.0
5.3
2.2
0.5
0.1
Influent
PC
Deox
Anox 1
Anox 2
Aerob 1
Aerob 2
MBR



CONC. (mgTSS/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
9,754
7,957
7,957
7,955
7,952
9,756
Deox
Anox 1
Anox 2
Aerob 1
Aerob 2
MBR (U)



MASS RATE (lb VSS/d)
40,000
38,000
36,000
34,000
32,000
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
36,022
17,992
Digester Feed
AD 1-4

Global Parameters

AOB

Name	Default	Value	
Max. spec. growth rate [1/d]	0.9000	0.9000	1.0720
Substrate (NH4) half sat. [mgN/L]	0.7000	0.7000	1.0000
Byproduct NH4 logistic slope [-]	50.0000	50.0000	1.0000
Byproduct NH4 inflection point [mgN/L]	1.4000	1.4000	1.0000
AOB denite DO half sat. [mg/L]	0.1000	0.1000	1.0000
AOB denite HNO2 half sat. [mgN/L]	5.000E-6	5.000E-6	1.0000
Aerobic decay rate [1/d]	0.1700	0.1700	1.0290
Anoxic/anaerobic decay rate [1/d]	0.0800	0.0800	1.0290
KiHNO2 [mmol/L]	0.0050	0.0050	1.0000

NOB

Name	Default	Value	
Max. spec. growth rate [1/d]	0.7000	0.7000	1.0600
Substrate (NO2) half sat. [mgN/L]	0.1000	0.1000	1.0000
Aerobic decay rate [1/d]	0.1700	0.1700	1.0290
Anoxic/anaerobic decay rate [1/d]	0.0800	0.0800	1.0290
KiNH3 [mmol/L]	0.0750	0.0750	1.0000

ANAMMOX

Name	Default	Value	
Max. spec. growth rate [1/d]	0.1000	0.1000	1.1000
Substrate (NH4) half sat. [mgN/L]	2.0000	2.0000	1.0000
Substrate (NO2) half sat. [mgN/L]	1.0000	1.0000	1.0000
Aerobic decay rate [1/d]	0.0190	0.0190	1.0290
Anoxic/anaerobic decay rate [1/d]	0.0095	0.0095	1.0290
Ki Nitrite [mgN/L]	1000.0000	1000.0000	1.0000
Nitrite sensitivity constant [L / (d mgN)]	0.0160	0.0160	1.0000

OHO

Name	Default	Value	
Max. spec. growth rate [1/d]	3.2000	3.2000	1.0290
Substrate half sat. [mgCOD/L]	5.0000	5.0000	1.0000
Anoxic growth factor [-]	0.5000	0.5000	1.0000
Denite N2 producers (NO3 or NO2) [-]	0.5000	0.5000	1.0000
Aerobic decay rate [1/d]	0.6200	0.6200	1.0290
Anoxic decay rate [1/d]	0.2330	0.2330	1.0290
Anaerobic decay rate [1/d]	0.1310	0.1310	1.0290
Hydrolysis rate [1/d]	2.1000	2.1000	1.0290
Hydrolysis half sat. [-]	0.0600	0.0600	1.0000
Anoxic hydrolysis factor [-]	0.2800	0.2800	1.0000
Anaerobic hydrolysis factor (AS) [-]	0.0400	0.0400	1.0000
Anaerobic hydrolysis factor (AD) [-]	0.2000	1.0000	1.0000
Adsorption rate of colloids [L/(mgCOD d)]	0.1500	0.1500	1.0290
Ammonification rate [L/(mgN d)]	0.0400	0.0400	1.0290
Assimilative nitrate/nitrite reduction rate [1/d]	0.5000	0.5000	1.0000
Fermentation rate [1/d]	1.6000	1.6000	1.0290
Fermentation half sat. [mgCOD/L]	5.0000	5.0000	1.0000
Fermentation growth factor (AS) [-]	0.2500	0.2500	1.0000
Endogenous products decay rate[1/d]	0	0	1.0000
Free nitrous acid inhibition [mmol/L]	1.000E-7	1.000E-7	1.0000

Methylotrophs

Name	Default	Value	
Max. spec. growth rate [1/d]	1.3000	1.3000	1.0720
Methanol half sat. [mgCOD/L]	0.5000	0.5000	1.0000
Denite N2 producers (NO3 or NO2) [-]	0.5000	0.5000	1.0000
Aerobic decay rate [1/d]	0.0400	0.0400	1.0290
Anoxic/anaerobic decay rate [1/d]	0.0300	0.0300	1.0290
Free nitrous acid inhibition [mmol/L]	1.000E-7	1.000E-7	1.0000

PAO

Name	Default	Value	
Max. spec. growth rate [1/d]	0.9500	0.9500	1.0000
Max. spec. growth rate, P-limited [1/d]	0.4200	0.4200	1.0000
Substrate half sat. [mgCOD(PHB)/mgCOD(Zbp)]	0.1000	0.1000	1.0000
Substrate half sat., P-limited [mgCOD(PHB)/mgCOD(Zbp)]	0.0500	0.0500	1.0000
Magnesium half sat. [mgMg/L]	0.1000	0.1000	1.0000
Cation half sat. [mmol/L]	0.1000	0.1000	1.0000
Calcium half sat. [mgCa/L]	0.1000	0.1000	1.0000
Aerobic/anoxic decay rate [1/d]	0.1000	0.1000	1.0000
Aerobic/anoxic maintenance rate [1/d]	0	0	1.0000
Anaerobic decay rate [1/d]	0.0400	0.0400	1.0000
Anaerobic maintenance rate [1/d]	0	0	1.0000
Sequestration rate [1/d]	4.5000	4.5000	1.0000
Anoxic growth factor [-]	0.3300	0.3300	1.0000

Acetogens

Name	Default	Value	
Max. spec. growth rate [1/d]	0.2500	0.2500	1.0290
Substrate half sat. [mgCOD/L]	10.0000	10.0000	1.0000
Acetate inhibition [mgCOD/L]	10000.0000	10000.0000	1.0000
Anaerobic decay rate [1/d]	0.0500	0.0500	1.0290
Aerobic/anoxic decay rate [1/d]	0.5200	0.5200	1.0290

Methanogens

Name	Default	Value	
Acetoclastic max. spec. growth rate [1/d]	0.3000	0.3000	1.0290
H2-utilizing max. spec. growth rate [1/d]	1.4000	1.4000	1.0290
Acetoclastic substrate half sat. [mgCOD/L]	100.0000	100.0000	1.0000
Acetoclastic methanol half sat. [mgCOD/L]	0.5000	0.5000	1.0000
H2-utilizing CO2 half sat. [mmol/L]	0.1000	0.1000	1.0000
H2-utilizing substrate half sat. [mgCOD/L]	0.1000	0.1000	1.0000
H2-utilizing methanol half sat. [mgCOD/L]	0.5000	0.5000	1.0000
Acetoclastic propionic inhibition [mgCOD/L]	10000.0000	10000.0000	1.0000
Acetoclastic anaerobic decay rate [1/d]	0.1300	0.1300	1.0290
Acetoclastic aerobic/anoxic decay rate [1/d]	0.6000	0.6000	1.0290
H2-utilizing anaerobic decay rate [1/d]	0.1300	0.1300	1.0290
H2-utilizing aerobic/anoxic decay rate [1/d]	2.8000	2.8000	1.0290

pH

Name	Default	Value
OHO low pH limit [-]	4.0000	4.0000
OHO high pH limit [-]	10.0000	10.0000
Methylotrophs low pH limit [-]	4.0000	4.0000
Methylotrophs high pH limit [-]	10.0000	10.0000
Autotrophs low pH limit [-]	5.5000	5.5000
Autotrophs high pH limit [-]	9.5000	9.5000
PAO low pH limit [-]	4.0000	4.0000
PAO high pH limit [-]	10.0000	10.0000
OHO low pH limit (anaerobic) [-]	5.5000	5.5000
OHO high pH limit (anaerobic) [-]	8.5000	8.5000
Propionic acetogens low pH limit [-]	4.0000	4.0000
Propionic acetogens high pH limit [-]	10.0000	10.0000
Acetoclastic methanogens low pH limit [-]	5.0000	5.0000
Acetoclastic methanogens high pH limit [-]	9.0000	9.0000
H2-utilizing methanogens low pH limit [-]	5.0000	5.0000
H2-utilizing methanogens high pH limit [-]	9.0000	9.0000

Switches

Name	Default	Value
Aerobic/anoxic DO half sat. [mgO2/L]	0.0500	0.0500
Anoxic/anaerobic NOx half sat. [mgN/L]	0.1500	0.1500
AOB DO half sat. [mgO2/L]	0.2500	0.2500
NOB DO half sat. [mgO2/L]	0.5000	0.5000
ANAMMOX DO half sat. [mgO2/L]	0.0100	0.0100
Anoxic NO3(->NO2) half sat. [mgN/L]	0.1000	0.1000
Anoxic NO3(->N2) half sat. [mgN/L]	0.0500	0.0500
Anoxic NO2(->N2) half sat. (mgN/L)	0.0100	0.0100
NH3 nutrient half sat. [mgN/L]	0.0050	0.0050
Poly P half sat. [mgP/mgCOD]	0.0100	0.0100
VFA sequestration half sat. [mgCOD/L]	5.0000	5.0000
P uptake half sat. [mgP/L]	0.1500	0.1500
P nutrient half sat. [mgP/L]	0.0010	0.0010
Autotroph CO2 half sat. [mmol/L]	0.1000	0.1000
H2 low/high half sat. [mgCOD/L]	1.0000	1.0000
Propionic acetogens H2 inhibition [mgCOD/L]	5.0000	5.0000
Synthesis anion/cation half sat. [meq/L]	0.0100	0.0100

Common

Name	Default	Value
Biomass volatile fraction (VSS/TSS)	0.9200	0.9200
Endogenous residue volatile fraction (VSS/TSS)	0.9200	0.9200
N in endogenous residue [mgN/mgCOD]	0.0700	0.0700
P in endogenous residue [mgP/mgCOD]	0.0220	0.0220
Endogenous residue COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200
Particulate substrate COD:VSS ratio [mgCOD/mgVSS]	1.6000	1.9840
Particulate inert COD:VSS ratio [mgCOD/mgVSS]	1.6000	1.6000

AOB

Name	Default	Value
Yield [mgCOD/mgN]	0.1500	0.1500
AOB denite NO2 fraction as TEA [-]	0.5000	0.5000
Byproduct NH4 fraction to N2O [-]	0.0025	0.0025
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous residue [-]	0.0800	0.0800
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200

NOB

Name	Default	Value
Yield [mgCOD/mgN]	0.0900	0.0900
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous residue [-]	0.0800	0.0800
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200

ANAMMOX

Name	Default	Value
Yield [mgCOD/mgN]	0.1140	0.1140
Nitrate production [mgN/mgBiomassCOD]	2.2800	2.2800
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous residue [-]	0.0800	0.0800
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200

OHO

Name	Default	Value
Yield (aerobic) [-]	0.6660	0.6660
Yield (fermentation, low H2) [-]	0.1000	0.1000
Yield (fermentation, high H2) [-]	0.1000	0.1000
H2 yield (fermentation low H2) [-]	0.3500	0.3500
H2 yield (fermentation high H2) [-]	0	0
Propionate yield (fermentation, low H2) [-]	0	0
Propionate yield (fermentation, high H2) [-]	0.7000	0.7000
CO2 yield (fermentation, low H2) [-]	0.7000	0.7000
CO2 yield (fermentation, high H2) [-]	0	0
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Endogenous fraction - aerobic [-]	0.0800	0.0800
Endogenous fraction - anoxic [-]	0.1030	0.1030
Endogenous fraction - anaerobic [-]	0.1840	0.1840
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200
Yield (anoxic) [-]	0.5400	0.5400
Yield propionic (aerobic) [-]	0.6400	0.6400
Yield propionic (anoxic) [-]	0.4600	0.4600
Yield acetic (aerobic) [-]	0.6000	0.6000
Yield acetic (anoxic) [-]	0.4300	0.4300
Yield methanol (aerobic) [-]	0.5000	0.5000
Adsorp. max. [-]	1.0000	1.0000
Max fraction to N2O at high FNA over nitrate [-]	0.0500	0.0500
Max fraction to N2O at high FNA over nitrite [-]	0.1000	0.1000

Methylotrophs

Name	Default	Value
Yield (anoxic) [-]	0.4000	0.4000
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous residue [-]	0.0800	0.0800
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200
Max fraction to N2O at high FNA over nitrate [-]	0.1000	0.1000
Max fraction to N2O at high FNA over nitrite [-]	0.1500	0.1500

PAO

Name	Default	Value
Yield (aerobic) [-]	0.6390	0.6390
Yield (anoxic) [-]	0.5200	0.5200
Aerobic P/PHA uptake [mgP/mgCOD]	0.9300	0.9500
Anoxic P/PHA uptake [mgP/mgCOD]	0.3500	0.3500
Yield of PHA on sequestration [-]	0.8890	0.8890
N in biomass [mgN/mgCOD]	0.0700	0.0700
N in sol. inert [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous part. [-]	0.2500	0.2500
Inert fraction of endogenous sol. [-]	0.2000	0.2000
P/Ac release ratio [mgP/mgCOD]	0.5100	0.4900
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200
Yield of low PP [-]	0.9400	0.9400

Acetogens

Name	Default	Value
Yield [-]	0.1000	0.1000
H2 yield [-]	0.4000	0.4000
CO2 yield [-]	1.0000	1.0000
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous residue [-]	0.0800	0.0800
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200

Methanogens

Name	Default	Value
Acetoclastic yield [-]	0.1000	0.1000
Methanol acetoclastic yield [-]	0.1000	0.1000
H2-utilizing yield [-]	0.1000	0.1000
Methanol H2-utilizing yield [-]	0.1000	0.1000
N in acetoclastic biomass [mgN/mgCOD]	0.0700	0.0700
N in H2-utilizing biomass [mgN/mgCOD]	0.0700	0.0700
P in acetoclastic biomass [mgP/mgCOD]	0.0220	0.0220
P in H2-utilizing biomass [mgP/mgCOD]	0.0220	0.0220
Acetoclastic fraction to endog. residue [-]	0.0800	0.0800
H2-utilizing fraction to endog. residue [-]	0.0800	0.0800
Acetoclastic COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200
H2-utilizing COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200

General

Name	Default	Value
Molecular weight of other anions [mg/mmol]	35.5000	35.5000
Molecular weight of other cations [mg/mmol]	39.1000	39.1000
Mg to P mole ratio in polyphosphate [mmolMg/mmolP]	0.3000	0.3000
Cation to P mole ratio in polyphosphate [meq/mmolP]	0.1500	0.3000
Ca to P mole ratio in polyphosphate [mmolCa/mmolP]	0.0500	0.0500
Cation to P mole ratio in organic phosphate [meq/mmolP]	0.0100	0.0100
Bubble rise velocity (anaerobic digester) [cm/s]	23.9000	23.9000
Bubble Sauter mean diameter (anaerobic digester) [cm]	0.3500	0.3500
Anaerobic digester gas hold-up factor []	1.0000	1.0000
Tank head loss per metre of length (from flow) [m/m]	0.0025	0.0025

Mass transfer

Name	Default	Value	
Kl for H2 [m/d]	17.0000	17.0000	1.0240
Kl for CO2 [m/d]	10.0000	10.0000	1.0240
Kl for NH3 [m/d]	1.0000	1.0000	1.0240
Kl for CH4 [m/d]	8.0000	8.0000	1.0240
Kl for N2 [m/d]	15.0000	15.0000	1.0240
Kl for N2O [m/d]	8.0000	8.0000	1.0240
Kl for O2 [m/d]	13.0000	13.0000	1.0240

Henry's law constants

Name	Default	Value	
CO2 [M/atm]	0.0340	0.0340	2400.0000
O2 [M/atm]	0.0013	0.0013	1500.0000
N2 [M/atm]	6.500E-4	6.500E-4	1300.0000
N2O [M/atm]	0.0250	0.0250	2600.0000
NH3 [M/atm]	58.0000	58.0000	4100.0000
CH4 [M/atm]	0.0014	0.0014	1600.0000
H2 [M/atm]	7.800E-4	7.800E-4	500.0000

Physico-chemical rates

Name	Default	Value	
Struvite precipitation rate [1/d]	3.000E+10	3.000E+10	1.0240
Struvite redissolution rate [1/d]	3.000E+11	3.000E+11	1.0240
Struvite half sat. [mgTSS/L]	1.0000	1.0000	1.0000
HDP precipitation rate [L/(molP d)]	1.000E+8	1.000E+8	1.0000
HDP redissolution rate [L/(mol P d)]	1.000E+8	1.000E+8	1.0000
HAP precipitation rate [molHDP/(L d)]	5.000E-4	5.000E-4	1.0000

Physico-chemical constants

Name	Default	Value
Struvite solubility constant [mol/L]	6.918E-14	6.918E-14
HDP solubility product [mol/L]	2.750E-22	2.750E-22
HDP half sat. [mgTSS/L]	1.0000	1.0000
Equilibrium soluble PO4 with Al dosing at pH 7 [mgP/L]	0.0100	0.0100
Al to P ratio [molAl/molP]	0.8000	0.8000
Al(OH)3 solubility product [mol/L]	1.259E+9	1.259E+9
AlHPO4+ dissociation constant [mol/L]	7.943E-13	7.943E-13
Equilibrium soluble PO4 with Fe dosing at pH 7 [mgP/L]	0.0100	0.0100
Fe to P ratio [molFe/molP]	1.6000	1.6000
Fe(OH)3 solubility product [mol/L]	0.0500	0.0500
FeH2PO4++ dissociation constant [mol/L]	5.012E-22	5.012E-22

Aeration

Name	Default	Value
Alpha (surf) OR Alpha F (diff) [-]	0.5000	0.5000
Beta [-]	0.9500	0.9500
Surface pressure [kPa]	101.3250	101.3250
Fractional effective saturation depth (Fed) [-]	0.3250	0.3250
Supply gas CO2 content [vol. %]	0.0350	0.0350
Supply gas O2 [vol. %]	20.9500	20.9500
Off-gas CO2 [vol. %]	2.0000	2.0000
Off-gas O2 [vol. %]	18.8000	18.8000
Off-gas H2 [vol. %]	0	0
Off-gas NH3 [vol. %]	0	0
Off-gas CH4 [vol. %]	0	0
Surface turbulence factor [-]	2.0000	2.0000
Set point controller gain []	1.0000	1.0000

Modified Vesilind

Name	Default	Value
Maximum Vesilind settling velocity (Vo) [ft/min]	0.387	0.387
Vesilind hindered zone settling parameter (K) [L/g]	0.370	0.370
Clarification switching function [mg/L]	100.000	100.000
Specified TSS conc.for height calc. [mg/L]	2500.000	2500.000
Maximum compactability constant [mg/L]	15000.000	15000.000

Double exponential

Name	Default	Value
Maximum Vesilind settling velocity (Vo) [ft/min]	0.934	0.934
Maximum (practical) settling velocity (Vo') [ft/min]	0.615	0.615
Hindered zone settling parameter (Kh) [L/g]	0.400	0.400
Flocculent zone settling parameter (Kf) [L/g]	2.500	2.500
Maximum non-settleable TSS [mg/L]	20.0000	20.0000
Non-settleable fraction [-]	0.0010	0.0010
Specified TSS conc. for height calc. [mg/L]	2500.0000	2500.0000

Emission factors

Name	Default	Value
Carbon dioxide equivalence of nitrous oxide	296.0000	296.0000
Carbon dioxide equivalence of methane	23.0000	23.0000

Biofilm general

Name	Default	Value	
Attachment rate [g / (m2 d)]	80.0000	80.0000	1.0000
Attachment TSS half sat. [mg/L]	100.0000	100.0000	1.0000
Detachment rate [g/(m3 d)]	8.000E+4	8.000E+4	1.0000
Solids movement factor []	10.0000	10.0000	1.0000
Diffusion neta []	0.8000	0.8000	1.0000
Thin film limit [mm]	0.5000	0.5000	1.0000
Thick film limit [mm]	3.0000	3.0000	1.0000
Assumed Film thickness for tank volume correction (temp independant) [mm]	0.7500	0.7500	1.0000
Film surface area to media area ratio - Max.[ ]	1.0000	1.0000	1.0000
Minimum biofilm conc. for streamer formation [gTSS/m2]	4.0000	4.0000	1.0000

Maximum biofilm concentrations [mg/L]

Name	Default	Value	
Ordinary heterotrophic organisms (OHO)	5.000E+4	5.000E+4	1.0000
Methylotrophs	5.000E+4	5.000E+4	1.0000
Ammonia oxidizing biomass (AOB)	1.000E+5	1.000E+5	1.0000
Nitrite oxidizing biomass (NOB)	1.000E+5	1.000E+5	1.0000
Anaerobic ammonia oxidizers (ANAMMOX)	5.000E+4	5.000E+4	1.0000
Polyphosphate accumulating organisms (PAO)	5.000E+4	5.000E+4	1.0000
Propionic acetogens	5.000E+4	5.000E+4	1.0000
Methanogens - acetoclastic	5.000E+4	5.000E+4	1.0000
Methanogens - hydrogenotrophic	5.000E+4	5.000E+4	1.0000
Endogenous products	3.000E+4	3.000E+4	1.0000
Slowly bio. COD (part.)	5000.0000	5000.0000	1.0000
Slowly bio. COD (colloid.)	4000.0000	4000.0000	1.0000
Part. inert. COD	5000.0000	5000.0000	1.0000
Part. bio. org. N	0	0	1.0000
Part. bio. org. P	0	0	1.0000
Part. inert N	0	0	1.0000
Part. inert P	0	0	1.0000
Stored PHA	5000.0000	5000.0000	1.0000
Releasable stored polyP	1.150E+6	1.150E+6	1.0000
Fixed stored polyP	1.150E+6	1.150E+6	1.0000
Readily bio. COD (complex)	0	0	1.0000
Acetate	0	0	1.0000
Propionate	0	0	1.0000
Methanol	0	0	1.0000
Dissolved H2	0	0	1.0000
Dissolved methane	0	0	1.0000
Ammonia N	0	0	1.0000
Sol. bio. org. N	0	0	1.0000
Nitrous Oxide N	0	0	1.0000
Nitrite N	0	0	1.0000
Nitrate N	0	0	1.0000
Dissolved nitrogen gas	0	0	1.0000
PO4-P (Sol. & Me Complexed)	1.000E+10	1.000E+10	1.0000
Sol. inert COD	0	0	1.0000
Sol. inert TKN	0	0	1.0000
ISS Influent	1.300E+6	1.300E+6	1.0000
Struvite	8.500E+5	8.500E+5	1.0000
Hydroxy-dicalcium-phosphate	1.150E+6	1.150E+6	1.0000
Hydroxy-apatite	1.600E+6	1.600E+6	1.0000
Magnesium	0	0	1.0000
Calcium	0	0	1.0000
Metal	1.000E+10	1.000E+10	1.0000
Other Cations (strong bases)	0	0	1.0000
Other Anions (strong acids)	0	0	1.0000
Total CO2	0	0	1.0000
User defined 1	0	0	1.0000
User defined 2	0	0	1.0000
User defined 3	5.000E+4	5.000E+4	1.0000
User defined 4	5.000E+4	5.000E+4	1.0000
Dissolved oxygen	0	0	1.0000

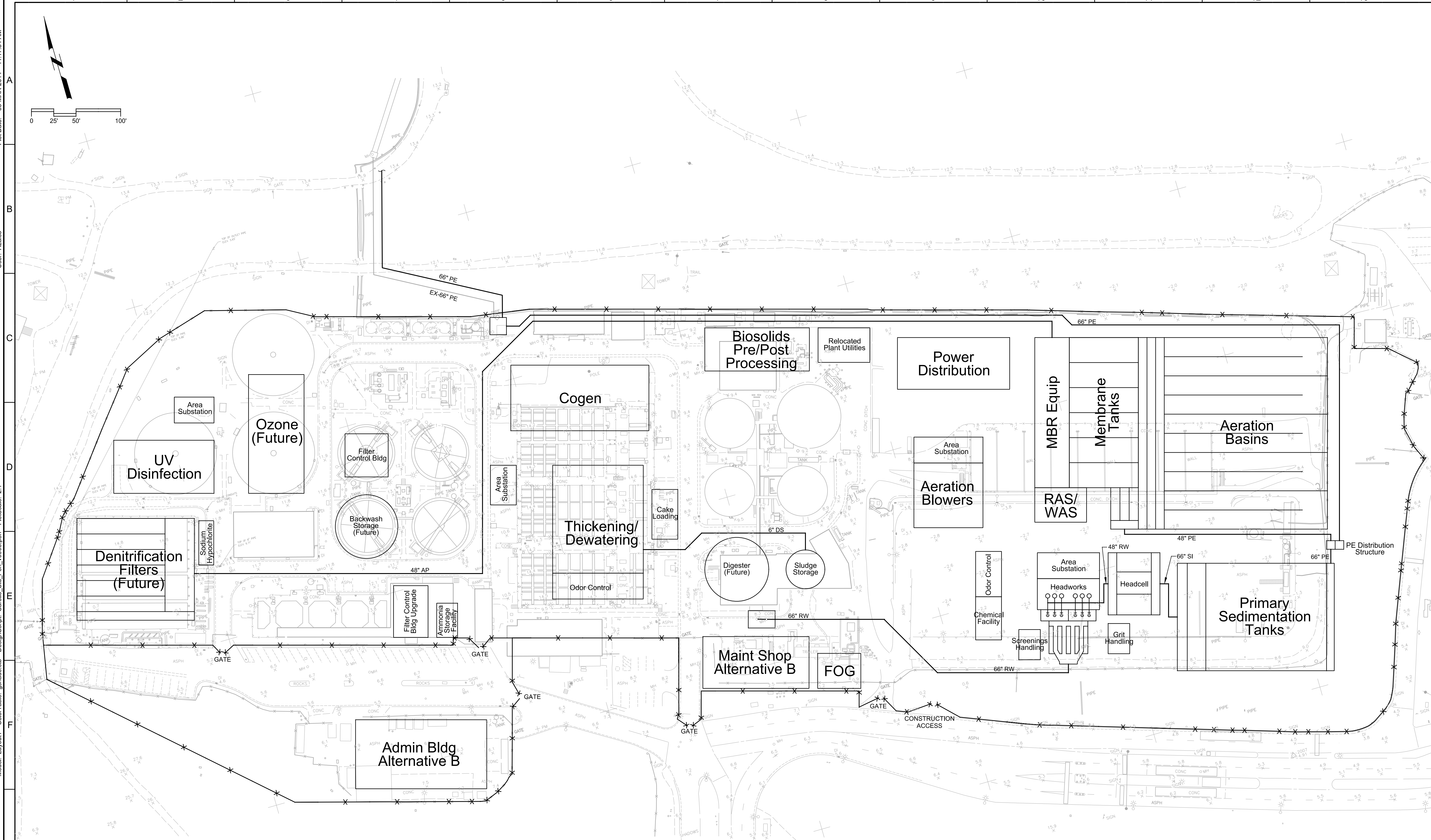
Effective diffusivities [m2/s]

Name	Default	Value	
Ordinary heterotrophic organisms (OHO)	5.000E-14	5.000E-14	1.0290
Methylotrophs	5.000E-14	5.000E-14	1.0290
Ammonia oxidizing biomass (AOB)	5.000E-14	5.000E-14	1.0290
Nitrite oxidizing biomass (NOB)	5.000E-14	5.000E-14	1.0290
Anaerobic ammonia oxidizers (ANAMMOX)	5.000E-14	5.000E-14	1.0290
Polyphosphate accumulating organisms (PAO)	5.000E-14	5.000E-14	1.0290
Propionic acetogens	5.000E-14	5.000E-14	1.0290
Methanogens - acetoclastic	5.000E-14	5.000E-14	1.0290
Methanogens - hydrogenotrophic	5.000E-14	5.000E-14	1.0290
Endogenous products	5.000E-14	5.000E-14	1.0290
Slowly bio. COD (part.)	5.000E-14	5.000E-14	1.0290
Slowly bio. COD (colloid.)	5.000E-12	5.000E-12	1.0290
Part. inert. COD	5.000E-14	5.000E-14	1.0290
Part. bio. org. N	5.000E-14	5.000E-14	1.0290
Part. bio. org. P	5.000E-14	5.000E-14	1.0290
Part. inert N	5.000E-14	5.000E-14	1.0290
Part. inert P	5.000E-14	5.000E-14	1.0290
Stored PHA	5.000E-14	5.000E-14	1.0290
Releasable stored polyP	5.000E-14	5.000E-14	1.0290
Fixed stored polyP	5.000E-14	5.000E-14	1.0290
Readily bio. COD (complex)	6.900E-10	6.900E-10	1.0290
Acetate	1.240E-9	1.240E-9	1.0290
Propionate	8.300E-10	8.300E-10	1.0290
Methanol	1.600E-9	1.600E-9	1.0290
Dissolved H2	5.850E-9	5.850E-9	1.0290
Dissolved methane	1.963E-9	1.963E-9	1.0290
Ammonia N	2.000E-9	2.000E-9	1.0290
Sol. bio. org. N	1.370E-9	1.370E-9	1.0290
Nitrous Oxide N	1.607E-9	1.607E-9	1.0290
Nitrite N	2.980E-9	2.980E-9	1.0290
Nitrate N	2.980E-9	2.980E-9	1.0290
Dissolved nitrogen gas	1.900E-9	1.900E-9	1.0290
PO4-P (Sol. & Me Complexed)	2.000E-9	2.000E-9	1.0290
Sol. inert COD	6.900E-10	6.900E-10	1.0290
Sol. inert TKN	6.850E-10	6.850E-10	1.0290
ISS Influent	5.000E-14	5.000E-14	1.0290
Struvite	5.000E-14	5.000E-14	1.0290
Hydroxy-dicalcium-phosphate	5.000E-14	5.000E-14	1.0290
Hydroxy-apatite	5.000E-14	5.000E-14	1.0290
Magnesium	7.200E-10	7.200E-10	1.0290
Calcium	7.200E-10	7.200E-10	1.0290
Metal	4.800E-10	4.800E-10	1.0290
Other Cations (strong bases)	1.440E-9	1.440E-9	1.0290
Other Anions (strong acids)	1.440E-9	1.440E-9	1.0290
Total CO2	1.960E-9	1.960E-9	1.0290
User defined 1	6.900E-10	6.900E-10	1.0290
User defined 2	6.900E-10	6.900E-10	1.0290
User defined 3	5.000E-14	5.000E-14	1.0290
User defined 4	5.000E-14	5.000E-14	1.0290
Dissolved oxygen	2.500E-9	2.500E-9	1.0290

EPS Strength coefficients [ ]

Name	Default	Value	
Ordinary heterotrophic organisms (OHO)	1.0000	1.0000	1.0000
Methylotrophs	1.0000	1.0000	1.0000
Ammonia oxidizing biomass (AOB)	5.0000	1.0000	1.0000
Nitrite oxidizing biomass (NOB)	25.0000	1.0000	1.0000
Anaerobic ammonia oxidizers (ANAMMOX)	10.0000	1.0000	1.0000
Polyphosphate accumulating organisms (PAO)	1.0000	1.0000	1.0000
Propionic acetogens	1.0000	1.0000	1.0000
Methanogens - acetoclastic	1.0000	1.0000	1.0000
Methanogens - hydrogenotrophic	1.0000	1.0000	1.0000
Endogenous products	1.0000	1.0000	1.0000
Slowly bio. COD (part.)	1.0000	1.0000	1.0000
Slowly bio. COD (colloid.)	1.0000	1.0000	1.0000
Part. inert. COD	1.0000	1.0000	1.0000
Part. bio. org. N	1.0000	1.0000	1.0000
Part. bio. org. P	1.0000	1.0000	1.0000
Part. inert N	1.0000	1.0000	1.0000
Part. inert P	1.0000	1.0000	1.0000
Stored PHA	1.0000	1.0000	1.0000
Releasable stored polyP	1.0000	1.0000	1.0000
Fixed stored polyP	1.0000	1.0000	1.0000
Readily bio. COD (complex)	0	0	1.0000
Acetate	0	0	1.0000
Propionate	0	0	1.0000
Methanol	0	0	1.0000
Dissolved H2	0	0	1.0000
Dissolved methane	0	0	1.0000
Ammonia N	0	0	1.0000
Sol. bio. org. N	0	0	1.0000
Nitrous Oxide N	0	0	1.0000
Nitrite N	0	0	1.0000
Nitrate N	0	0	1.0000
Dissolved nitrogen gas	0	0	1.0000
PO4-P (Sol. & Me Complexed)	1.0000	1.0000	1.0000
Sol. inert COD	0	0	1.0000
Sol. inert TKN	0	0	1.0000
ISS Influent	0.3300	0.3300	1.0000
Struvite	1.0000	1.0000	1.0000
Hydroxy-dicalcium-phosphate	1.0000	1.0000	1.0000
Hydroxy-apatite	1.0000	1.0000	1.0000
Magnesium	0	0	1.0000
Calcium	0	0	1.0000
Metal	1.0000	1.0000	1.0000
Other Cations (strong bases)	0	0	1.0000
Other Anions (strong acids)	0	0	1.0000
Total CO2	0	0	1.0000
User defined 1	0	0	1.0000
User defined 2	0	0	1.0000
User defined 3	1.0000	1.0000	1.0000
User defined 4	1.0000	1.0000	1.0000
Dissolved oxygen	0	0	1.0000

APPENDIX D – MBR SITE LAYOUT



REV	DATE	BY	DESCRIPTION

DESIGNED
DRAWN
CHECKED
DATE
FEBRUARY 2014

PROJECT ENGINEER
PROJECT MANAGER
PRINCIPAL

carollo®

CITY OF SUNNYVALE CALIFORNIA

CITY OF SUNNYVALE
MASTER PLAN
MBR
ALTERNATIVE B

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO.
9265A.00
DRAWING NO.
SHEET NO.
OF XX

Plot Date: 05-MAR-2014 11:17:54 AM User: ALaico PlotScale: 2:1 Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen
LAST SAVED BY: alaico

PROJECT NO. FILE NAME: 9265A0001C001.dgn