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CITY OF SUNNYVALE

MASTER PLAN AND PRIMARY TREATMENT DESIGN

TECHNICAL MEMORANDUM

PRIMARY TREATMENT:

MASTER PLAN

FINAL

March 2014

carollo in association with HDR

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CITY OF SUNNYVALE

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TECHNICAL MEMORANDUM

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MASTER PLAN

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PRIMARY TREATMENT: MASTER PLAN

1.0 INTRODUCTION

The City of Sunnyvale's (City) Water Pollution Control Plant (WPCP) has ten (10) primary sedimentation tanks (PSTs) which were constructed and/or modified in several stages from 1956 to 1983. PSTs No. 1 through 6, which were built in the mid 1950s and early 1960s, were identified for repair and replacement (R&R) in the 2006 Asset Condition Assessment (ACA).The City's WPCP Strategic Infrastructure Plan (SIP), which was prepared in 2009, recommended construction of new PSTs in the emergency sludge storage lagoon (southeastern) area of the WPCP.

This technical memorandum (TM) presents an analysis and evaluation of alternatives for primary treatment at the WPCP with recommendations of a preferred alternative. PST design criteria for the recommended alternative are also presented in this TM. The primary treatment process proposed for the WPCP are 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 SIP. The primary treatment analysis and recommendations included in this TM are based on full activated sludge secondary treatment coming online in year 2023.

The evaluation was completed in a two 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 and (2) a two-day workshop on October 14th and 15th, 2013, during which time the Carollo/HDR team presented the recommended treatment processes to the City staff. The key findings and recommendations developed for the primary 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 primary treatment process include:

- Primary treatment should be implemented because it is not cost effective to construct and operate a new secondary treatment system without primary clarifiers.

- It is recommended that construction of the PSTs not be phased. The recommended PSTs would be designed to accommodate the 2035 maximum month (MM) flow of 26.2 million gallons per day (mgd) and should be able to handle minimum and peak flow conditions.

- Primary Sedimentation Tanks:

- A surface overflow rate (OFR) of 2,000 gallons per day per square foot (gpd/sf), with all tanks in service at MM flow in 2035 was selected for design basis.
- Six (6) PSTs would be constructed to provide proper operation and sufficient flexibility and redundancy.

- Chemically Enhanced Primary Treatment (CEPT):
  - The primary treatment design would include provisions for a permanent CEPT facility. CEPT would only be used on an “as-needed” basis under high loading conditions (MM or higher) and when one PST is out of service. The facilities also provide additional flexibility and redundancy to the WPCP staff.
  - The CEPT facility would be designed for a dose of 20 mg /L of ferric chloride and 0.2 milligrams per liter (mg/L) of polymer. The chemical addition point would be further evaluated during preliminary design, however at this time chemical addition at the PST influent channel is envisioned.

- Primary Influent:
  - The PSTs would include an influent channel which will be designed to convey and distribute peak flows to the online PSTs. The channel would be aerated with coarse bubble aeration. Influent flow distribution will be further analyzed and developed in preliminary design.

- Primary Effluent:
  - The PSTs would include an effluent channel which would collect effluent from overflow weirs and launders within the tanks. The channel would be designed to convey peak flows. Effluent collection would be further analyzed and evaluated in preliminary design.
  - Primary effluent would be conveyed to the existing Oxidation Ponds by constructing a new primary effluent pipeline. Provisions for connection to future primary effluent equalization and the future secondary treatment system would be included.

- Primary Sludge:
  - Full length chain and flight sludge collector and cross collector would be provided in each PST. One (1) sludge hopper per tank would be provided for sludge collection.
  - The primary sludge hopper and pumps would be designed for thick sludge. No provisions for thin sludge pumping would be provided.
  - One (1) duty plus one standby sludge pump would serve two (2) PST sludge hoppers. A total of six (6) sludge pumps would be provided.

- Primary Scum:
  - Return flight skimming would be used for scum removal.
  - One scum box would collect scum from three (3) PSTs. A total of two scum boxes will be constructed.

- Scum pumping would include one (1) duty and one (1) standby pump for each scum box.

- Odor Control:
  - Provide a single, package-type bioscrubber system to treat odors collected from both the preliminary and primary treatment process areas.
  - Locate the odor control system near the preliminary and primary treatment processes to simplify the odor ducting design.
  - Include the following provisions to adequately contain and exhaust odors generated at the primary treatment facility:
    - ♦ Cover the PST influent/effluent channels and PST launder area (the area where primary effluent flows over weirs and is collected in troughs). Include provisions to cover the entire PSTs, should further odor mitigation be required in the future. Include provisions for corrosion protection for all covered areas (e.g., use of stainless steel and concrete coatings).
    - ♦ Install exhaust fans to extract air enough air from the covered and enclosed areas to prevent fugitive emissions and convey it to the odor control system.
    - ♦ Install a ventilation system for areas that will be accessed by personnel to provide proper ventilation required for worker safety.

3.0 BACKGROUND

The WPCP has ten (10) existing PSTs which were built and/or modified in stages from 1956 through 1983. The modular PST construction stages are as follows:

- PSTs No. 1 through 6 were constructed in mid 1950s to early 1960s.
- PSTs No. 7 through 9 were constructed in 1970s.
- PST No. 10 was constructed in 1983.

In 2003, a structural evaluation performed by Kennedy/Jenks Consultants identified a number of structural deficiencies and many areas of deterioration in the PST and noted that in the event of an earthquake, the structure may fail. Further, the pre-aeration tanks and PSTs are structurally separated by a primary sedimentation gallery with fiberglass pipes which span between the tanks and across the gallery. This creates additional seismic vulnerability. These two structures will independently oscillate in a seismic event, and may fail and cause catastrophic damage by colliding with each other. The damage would result in reduced or entirely stopped wastewater conveyance through the WPCP and impede plant operations. Ultimately, such an event could result in overflows within the sewer collection system. Using that work, an Asset Condition Assessment (ACA) conducted in 2006 identified that PSTs No. 1 through 6 have a remaining useful life of 4 years and did not meet current structural/seismic code requirements. The ACA recommended that the City prepare a facilities master plan and identified replacement of the PSTs as the highest and/or first priority for project implementation.

The SIP prepared by Brown and Caldwell in 2009 was developed using the ACA recommendations. The SIP evaluated two approaches to address the PST issues:

- Renew primary treatment processes in their current location by either constructing new structures or completely rehabilitating the existing structures along with providing new mechanical equipment, piping, electric power supply and controls as needed.
- Construct new structures at a new location on the existing WPCP site along with providing new equipment, piping, electric power supply and controls as needed.

The latter approach was recommended since 1) it may save significant capital costs compared with rehabilitation of the PSTs, 2) results in less interference with plant operations during construction, and 3) commissioning of new facilities is simplified. It was also noted that the proposed location for the new PSTs reserves land at the WPCP for future tertiary treatment and recycled water facilities.

Both the ACA and SIP emphasized replacement of the PSTs at the earliest possible opportunity.

3.1 Existing PSTs

3.1.1 <u>Design Features</u>

There are ten (10) pre-aeration grit removal basins and PSTs at the WPCP. Each pre-aeration basin is dedicated to one PST. Table 1 provides existing PST design criteria.

Table 1 Existing Primary Sedimentation Tank Design Criteria
Master Plan and Primary Treatment Design
City of Sunnyvale

Description	Value
Primary Sedimentation Tanks	
No. of Units	10
Length, ft, each	110
Width, ft, each	19
Sludge Pumps	
Type	Progressive cavity
No. of Units	10
Capacity, gpm	75
Horsepower, HP	10

The flow from pre-aeration tanks is distributed to the PSTs through three (3), 30-inch inlet pipes provided for each PST. Submerged, finger type baffles are arranged to full width to evenly distribute the flow across the tank. Four (4) 41-ft long effluent weir troughs collect primary effluent from each tank and send it to a common effluent channel which combines the flow from all PSTs. The primary effluent is then discharged to the Oxidation Ponds via a 48-inch diameter pipe.

Each PST is equipped with a full length chain and flight sludge collector which collects settled solids at the bottom to sludge hopper located at inlet end of the tank. A cross collector which runs the width of the tank, collects sludge brought by the longitudinal sludge collector into a sludge hopper for removal. Each PST has its own dedicated sludge pump which pumps primary sludge from the hopper to the downstream process. PSTs No. 1 through 6 contain continuous chain and flight cross collectors and PSTs No. 7 through 10 contain helical screw type cross collectors.

The existing scum collection system consists of an air nozzle skimming system. Approximately five (5) air lateral headers were provided to each PST at nearly equal distance from the head of the tank. Once the scum is concentrated, it is removed by a two bladed helical scum remover and directed into a scum trough which is directly connected to the suction pipe of the scum ejectors.

3.1.2 Existing PSTs Performance

The SIP reported that the PSTs total suspended solids (TSS) annual average removal efficiency ranged from 41 to 54 percent, with an average (from 2004 through 2007) of approximately 46 percent (see Table 2, annual average PSTs TSS removal efficiency presented in SIP). Biochemical oxygen demand (BOD) removal efficiency of PSTs reported in the SIP averaged 23 percent. The TSS removal efficiency of the PSTs is lower than the industry standard. The SIP and Peer Review (CH2M Hill) attributed the low removal efficiencies to erroneous plant influent data. The SIP concurred that the actual removal efficiency of the PSTs is greater based on a review of digester loading data.

Table 2 Annual Average PSTs TSS Removal Efficiency presented in SIP
Master Plan and Primary Treatment Design
City of Sunnyvale

Year	TSS Removal Efficiency (%)[(1)]
2004	45
2005	41
2006	47
2007	54

Note:
(1) The removal efficiency was a bit skewed because the influent data is erroneous due to sampling issues (location of influent sampler was questionable)

Five to six out of ten existing PSTs are typically in service for normal operation. Current practice at WPCP is to thicken primary sludge in the tanks and then pump it to the digesters.

3.1.3 Existing PSTs Condition

Most of the Repair and Replacement (R&R) projects listed in ACA report were related to the primary sedimentation facilities. Apart from the structures not meeting current structural/seismic code requirements, concrete and metallic components of primary facilities were noted to be in poor condition based on the Primary Sedimentation Tank Evaluation performed by Kennedy/Jenks Consultants in 2003. Along with structural deficiencies, equipment recommended for R&R included slide gates, raw sludge pumps, sludge collector drives, scum collectors, electric power supply and control, and piping. Due to the significance of damage that may be caused by a seismic event and relatively short remaining useful life identified for the existing PSTs, replacing the PSTs was recommended as a high priority project.

3.2 SIP Recommendations

The SIP included the recommendation to replace the existing primary treatment process with a new primary treatment process at a new location on the existing WPCP site. The SIP recommendations for the new primary treatment process are summarized in Table 3 and described in greater detail in the Headworks and Primary Sedimentation Upgrades Alternatives Evaluation and Plant Replacement Alternatives Summary TMs of the SIP.

Table 3 summarizes how the SIP and Master Plan recommendations compare.

Table 3 Comparison of Master Plan and SIP Recommendations
Master Plan and Primary Treatment Design
City of Sunnyvale

Process/ Technology	Strategic Infrastructure Plan (2011)	Master Plan (2014)
Primary Clarifiers – number/over flow rate/MM flow/# tanks in service/dimensions	• Construct five new conventional PSTs with OFR of 2,700 gpd/sf for MM flow of 22.4 mgd in 2035, one PST out of service during MM flow and all in service during peak day or hour flow. Each PST will be 105 ft long, 20 ft wide and 10 ft deep. • At ADWF, SOR = 2000 gpd/sq ft. (ADWF = 16.7 (2035)) • At Peak Day flow, SOR = 4000 gpd/ sq ft. (Peak Day flow = 32.0 (2035))	• Construct six new conventional PSTs with OFR of 2,000 gpd/sf for MM flow of 26.2 mgd in 2035. The design allows for one PST to be out of service for all flow conditions. When a PST tank is out of service during MM, MW, PD or PH flow conditions, CEPT will be used. CEPT is not required for use when one tank is out of service during ADWF or AA flow conditions. Permanent CEPT facilities will be provided. Each PST will be 115 ft long, 19 ft wide and 14 ft deep (side water depth). • At ADWF, SOR = 1487

Table 3 Comparison of Master Plan and SIP Recommendations Master Plan and Primary Treatment Design City of Sunnyvale		
Process/ Technology	**Strategic Infrastructure Plan (2011)**	**Master Plan (2014)**
		gpd/sq ft. (ADWF = 19.5 (2035)) • At Peak Day flow, SOR = 3051 gpd/ sq ft. (Peak Day flow = 40.0 (2035))
Primary Clarifiers – location	• Construct new primary treatment facilities at new location in the existing digested sludge dewatering and drying area.	• Construct new primary treatment facilities at new location in the existing digested sludge dewatering and drying area.
Primary Clarifiers – elevation	• Elevate new PST structures to withstand inundation and damage during the 100 year flood event.	• Elevate new PST structures to withstand inundation and damage during the 100 year flood event.
Primary Clarifiers – influent distribution channel	• Provide integral primary influent distribution channel that evenly distribute flows to operating tankage and keeps organic solids in suspension.	• Provide integral primary influent distribution channel that evenly distribute flows to operating tankage, keeps organic solids in suspension, and provides partial flocculation of suspended matter.
Primary Clarifiers – effluent channel and primary effluent pipeline	• Provide integral primary effluent channel and new primary effluent pipeline to existing Oxidation Ponds with the potential to route to new secondary treatment process.	• Provide integral primary effluent channel and new primary effluent pipeline (existing primary effluent pipeline may be studied by the City as part of a separate project and reused where feasible) to existing Oxidation Ponds with the provisions to route to new secondary treatment process.
Primary Clarifiers – operation	• Overflow launders and sludge collectors that accommodate overflow liquid solids separation and intra-tank transport of settles primary sludge.	• Overflow launders and sludge collectors that accommodate overflow liquid solids separation and intra-tank transport of settles primary sludge. Flocculation, mid-tank baffles will be provided to

Table 3 Comparison of Master Plan and SIP Recommendations Master Plan and Primary Treatment Design City of Sunnyvale		
Process/ Technology	**Strategic Infrastructure Plan (2011)**	**Master Plan (2014)**
		enhance solids and biochemical oxygen demand capture.
Primary Clarifiers – sludge and scum collectors	• Provide new PSTs with simple full length chain and flight collectors, gravity sludge hopper, and return flight scum skimming features for scum removal.	• Provide new PSTs with simple full length chain and flight collectors and return flight scum skimming features for scum removal. Each tank will be provided with a cross collector to concentrate the sludge to the hopper. Sludge protector system (sludge canopy) will be provided.
Primary Clarifiers – isolation	• Provide sluice gates for tank isolation on entrance and exit of each tank.	• Provide slide gates for tank isolation on entrance and exit of each tank.
Primary Clarifiers – gallery structure	• Below grade structure adjacent to all primary sedimentation tanks to house pumping equipment to primary sludge, primary scum, and thickened primary sludge.	• Below grade gallery beneath the influent distribution channel to house primary sludge pumps. Scum pumps will be located in scum boxes.
Primary Clarifiers – scum pumps	• Provided 5 duty and 3 standby screw centrifugal pumps	• Provided 2 duty and 2 standby positive displacement pumps. (1 duty and one standby per scum box) Each scum box serves 3 PSTs.
Primary Clarifiers – sludge pumps	• Provided 5 duty and 3 standby positive displacement rotary lobe pumps for thin sludge pumping	• Provided 3 duty and 3 standby positive displacement pumps for thick sludge pumping. (1 duty and 1 standby pump for 2 PSTs)
Primary Clarifiers – primary sludge thickening	• Provide thin sludge pumping and separate thickening which may be delayed until secondary treatment processes. Remain flexible on inclusion of primary sludge thickening process	• Provide thick sludge pumping. Primary sludge will be thickened in the PSTs. Sludge canopy will be provided to protect hoppers and provide thickened sludge.
Odor Control	• Provide cost allowance (based on cost model) for odor control measures at primary treatment process	• Contain and treat odors generated at the preliminary and primary treatment facilities with one common,

Table 3 Comparison of Master Plan and SIP Recommendations Master Plan and Primary Treatment Design City of Sunnyvale		
Process/ Technology	**Strategic Infrastructure Plan (2011)**	**Master Plan (2014)**
	including covering and ventilating a portion of the PSTs and treating odorous air from the PSTs.	package-type bioscrubber system.

4.0 FLOWS AND LOADS FOR DESIGN BASIS

Historical plant influent data from 2004 to 2007 was analyzed in the SIP to determine future flows and loads. The SIP projected maximum month flow of 22.4 mgd in 2035. The OFR selected and the primary treatment process evaluated in the SIP were based on maximum month flow of 22.4 mgd in 2035.

A flow and load analysis using recent historical data (2000 through 2012) and growth projections was prepared by Carollo Engineers under the Master Plan and Primary Treatment Design Project and details are provided in Flows and Loads Evaluation TM. Table 4 provides a summary of the projected flows and loads by year. The PST alternative evaluation included herein is based on a maximum month flow of 26.2 mgd in 2035.

Table 4 Projected Flows
Master Plan and Primary Treatment Design
City of Sunnyvale

Flow, mgd	2010	2015	2025	2035
Average Dry Weather Flow (ADW)	13.2	14.46	16.98	19.5
Annual Average Flow (AA)	13.8	15.2	17.8	20.4
Maximum Month Flow (MM)	17.8	19.5	22.9	26.2
Maximum Week Flow (MW)	21.3	23.4	27.4	31.5
Peak Day Flow (PD)	27.1	29.7	34.8	40.0
Peak Hour Flow (PH)	39.6	43.4	50.9	58.5
TSS Load, ppd	**2010**	**2015**	**2025**	**2035**
ADW	27,000	28,000	31,000	34,000
AA	29,000	31,000	33,000	36,000
MM	35,000	37,000	40,000	44,000
MW	41,000	43,000	47,000	51,000
PD	76,000	80,000	87,000	95,000

5.0 ALTERNATIVES ANALYSIS

This section presents two alternatives that were developed and evaluated as follows:

- Alternative 1: No Primary Sedimentation Tanks
- Alternative 2: With Primary Sedimentation Tanks

The two alternatives are described and evaluated below.

5.1 Alternative 1: Without PSTs

Primary sedimentation treatment is the process to separate and remove suspended solids and floatables including grease and oils from incoming wastewater by physical –chemical methods. The influent wastewater velocity is reduced at the PST inlet to provide quiescent conditions and promote settling of suspended settleable solids. BOD associated with settled solids is also removed in this process. Removal of TSS and BOD reduces loading to downstream biological process thereby reducing the size of the biological processes, oxygen demand/air requirements, and waste activated sludge generation. When BOD is removed from primaries, anaerobically digested biogas and energy is produced rather than consumed in the secondary treatment process. This is an important factor in determining whether primary treatment is recommended.

In the existing WPCP, primary effluent is currently sent to two (2) oxidation ponds. If PSTs are eliminated the organic and solids loading to the oxidation ponds would increase. Additionally, the new secondary treatment facilities would need to be designed for higher loading if primary treatment is not provided, which would increase the capital cost and energy demands of the facility and would potentially reduce organic loading to the digesters (reducing digester gas production). A planning level net present value (NPV) analysis was performed comparing the NPV of not constructing PSTs versus constructing PSTs and presented to the City at the Workshop No. 2 on October 14, 2013. The NPV takes into consideration construction and operation and maintenance (O&M) costs of new PSTs and a new secondary treatment system.

Table 5 provides the NPV analysis for constructing PSTs versus not constructing PSTs ("No PST alternative"). Three different OFRs were included in the evaluation for PSTs. When comparing construction cost and present worth (PW) cost for new secondary treatment with PSTs alternatives, none of the PST alternatives have higher present worth cost. The "No PST" alternative assumes less biogas is produced which reduces the energy savings for the alternative. These factors, along with the fact that no new digesters to be constructed contribute to the "No PST" alternative having a higher NPV.

Another major concern with the "No PST" alternative is the ability of the oxidation ponds to handle the higher loads until the new secondary system becomes operational. Considering the impact on downstream processes and the NPV results, Carollo/HDR recommend proceeding with constructing new PSTs at the WPCP (see meeting minutes from Workshop No. 2 on October 14, 2013 in Appendix A).

Table 5	**NPV Analysis for PSTs vs. No PSTs Master Plan and Primary Treatment Design City of Sunnyvale**			
		With PSTs		
Project Element	**No PSTs**	**2,400 gpd/sf(1)**	**1,700 gpd/sf(1)**	**1,200 gpd/sf(1)**
Aeration Basin (AB) Project Cost	$78M	$58M	$56M	$55M
PST Project Cost	--	$16M	$17M	$24M
Aeration Present Worth (PW) Costs	$21M	$16M	$16M	$15M
Cogeneration PW Savings	-$9M	-$14M	-$15M	-$16M
Net Present Value (NPV)	**$90M±**	**$76M±**	**$74M±**	**$78M±**

Notes:
(1) OFR.
(2) Costs for comparison purposes only. Cost estimates exclude common facilities (e.g., common yard piping, odor control facilities, etc.).
(3) Power costs are based on an electricity cost of $0.20/kWh.
(4) Net present value based on a 20-year life cycle.

5.2 Alternative 2: With PSTs.

As mentioned previously, the removal of TSS and BOD accomplished in the PSTs greatly impacts the performance of the downstream oxidation ponds and/or proposed activated sludge process. The TSS and BOD removal efficiencies depend on the type of primary treatment provided and the size of the PSTs. In this study, two types of treatment were evaluated; conventional and chemically enhanced primary treatment (CEPT).

Conventional treatment is the most commonly used type of primary treatment which involves providing physical quiescent settling of suspended matter. Flocculation caused by air supply in the primary influent channel or pre-aeration tanks and/or hydraulic turbulence in the flocculation zone at the front end of the PST could significantly improve TSS and BOD removal efficiency.

CEPT is usually accomplished by adding a coagulant and a flocculate to the primary influent solids. The objectives of adding these chemicals are to:

- Reduce the level of non-settleable solids.
- Increase the settling velocities of the settleable solids.

For both types of treatment, it is essential to determine the optimal size of the new PSTs. The larger the PSTs, the lower the loading on the downstream processes but the higher the construction cost. Therefore, the project team combined field testing with computational fluid dynamic (CFD) analysis to ensure that the new PSTs are optimally sized and designed to provide the best performance at the lowest possible cost. Field testing was used to determine the settling characteristics of the incoming solids with and without chemicals.

5.2.1 Field Testing

Field tests were conducted over a period of two weeks. The first set of testing lasted three days and it covered conventional treatment (details of testing are included in Appendix B). The objectives of the conventional treatment testing were to:

- Determine the settling velocity distribution (SVD) of the incoming solids without chemicals.
- Estimate the removal efficiency of the existing PSTs during the sampling period.

The second set of testing lasted four days and it covered CEPT testing (details of testing are included in Appendix B). The objectives of the CEPT testing were to:

- Determine the optimal dosages of chemicals.
- Determine the settling velocity distribution of the solids after adding chemicals.

Jar testing indicated that three dosages of chemicals could be beneficial and further testing was needed to determine the SVDs of the incoming solids when subject to these dosages. Figure 1 and Figure 2 show the SVD for conventional treatment and one of the CEPT SVDs, respectively. Table 6 also provides average settling velocity from the various tests. The average settling velocity for conventional primary treatment was 1.46 in/min (2.1 m/hr), which falls within the typical range of 0.5 to 2.7 in/min (0.7 to 4.0 m/hr). Further, the results showed that the CEPT process increases the average settling velocity of the solids compared to conventional treatment. The resulting average settling velocity with a CEPT dose of 20 mg/L of Ferric Chloride and 0.2 mg/L of polymer is 2.54 in/min which is the highest velocity measured during the testing. It is also considered a good settling velocity and falls within the typical range of 1.5 in/min to 3.5 in/min. Therefore, the optimal chemical dosages are 20 mg/L of Ferric chloride and 0.2 mg/L of polymer.

As can been seen from Figures 1 and 2 and Table 6, CEPT did not significantly decrease the level of nonsettleable solids (solids with near zero settling velocity). Also, adding polymer did not improve the solids settling velocity of the solids. It was concluded from the CEPT testing that the optimal chemical dosage would be 20 mg/L of Ferric Chloride and 0.2 mg/L of polymer. This is considered a high dosage of chemicals when compared to the more commonly used dosage of 10 mg/L of Ferric and 0,1 mg/L of polymer. The annual cost of adding chemicals at these high dosage rates will be in excess of $1.5 million (based on 2013 chemical prices).

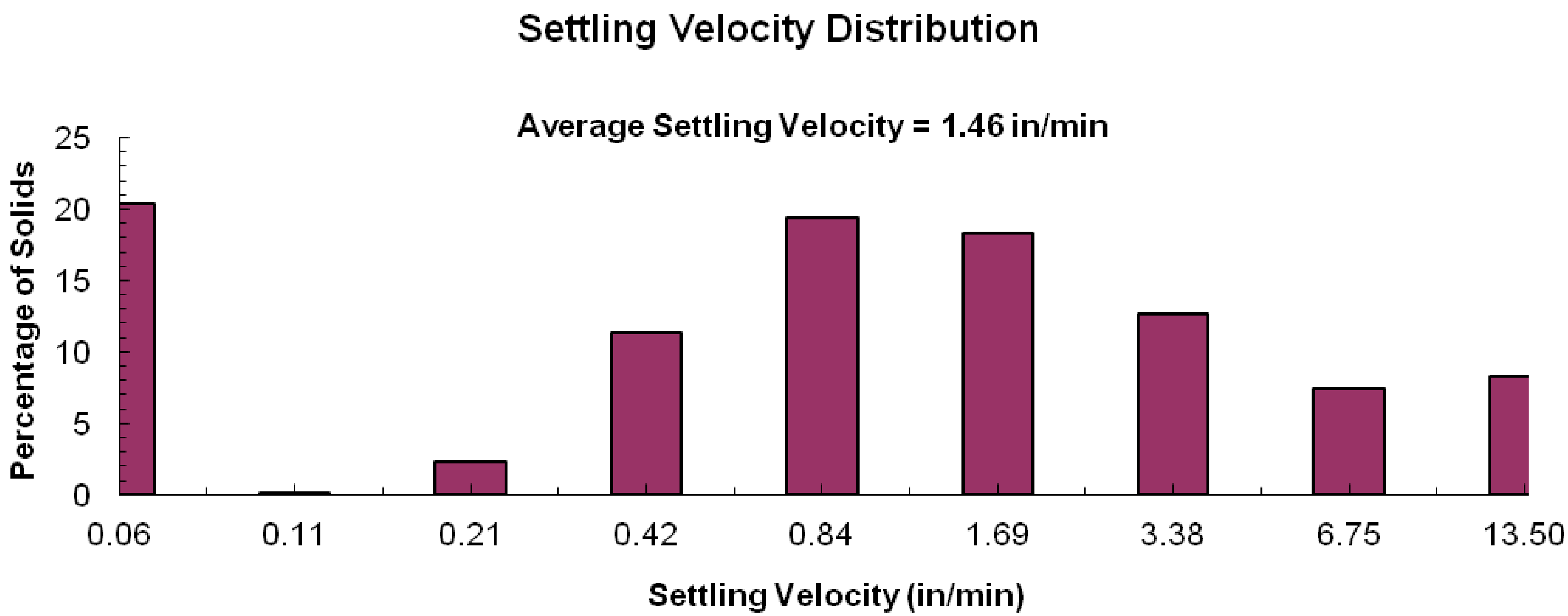


Figure 1
SETTLING VELOCITY DISTRIBUTION OF SUSPENDED SOLIDS
(CONVENTIONAL TREATMENT)
PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

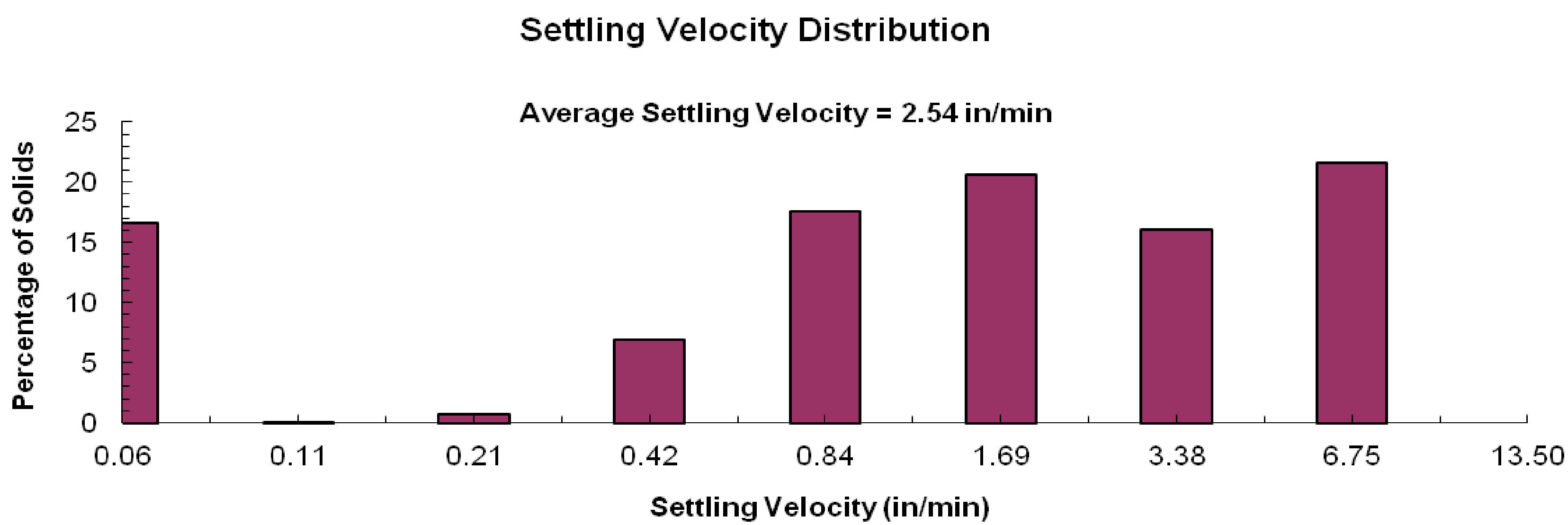


Figure 2
SETTLING VELOCITY DISTRIBUTION OF SUSPENDED SOLIDS (CEPT – 20 MG/L FERRIC CHLORIDE, 0.2 MG/L POLYMER)
PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

Table 6	**Average Settling Velocity from SVD Master Plan and Primary Treatment Design City of Sunnyvale**
Description	**Average settling velocity, in/min**
No Chemical Addition (Conventional Treatment)	1.46
CEPT	
Ferric Chloride = 10 mg/L, Polymer = 0.1 mg/L	1.60
Ferric Chloride = 20 mg/L, Polymer = 0.2 mg/L	2.54

5.2.2 Preliminary CFD Analysis

Computational fluid dynamic (CFD) analysis was used to develop the relationship between OFR and TSS removal efficiency for conventional and chemically enhanced primary treatment. The high accuracy clarifier model (HACM©) was utilized in the analysis. The SVDs obtained from field testing were used as input to the model.

Also, plant future flows were analyzed to determine the design flow rate to use as input to the model. It was assumed that year 2035 would be the design year and would correspond to a maximum month flow rate of 26.2 mgd. It was also assumed that the PST complex will be similar to the one outlined in the SIP. The SIP recommended building five PSTs. Using five PSTs and a MM flow rate of 26.2 mgd, each PST would be 120-foot long, 20-foot wide and 12-foot deep. A model of the PST was built. The performance of the PSTs was evaluated under different OFRs ranging from 600 to 4000 gpd/ft2. The TSS removal efficiency was estimated under different OFRs for conventional treatment and chemically enhanced primary treatment (CEPT). Figures 3 and 4 show the removal efficiency for the conventional and CEPT cases, respectively.

For comparison purposes, TSS removal efficiency of conventional treatment and CEPT at a OFR of 2,500 gpd/sf are approximately 53 percent and 70 percent, respectively. Although the figures show an improvement in removal efficiency as a result of adding chemicals, the high annual cost for adding chemicals are not be justified considering the addition of the new activated sludge process. In other words, it will be more cost effective to treat the higher BOD loading, realized from not using CEPT, in the activated sludge process. Therefore, the decision was made to operate CEPT on an “as-needed” basis under high loading conditions (MM or higher) and when one PST is offline.

CEPT has both positive and negative impacts on treatment processes. Advantages include reduced odor emissions in the PSTs and increased biogas production as a result of increased sludge volume due to higher TSS removal efficiency. CEPT would have minimal impact on sand filters.

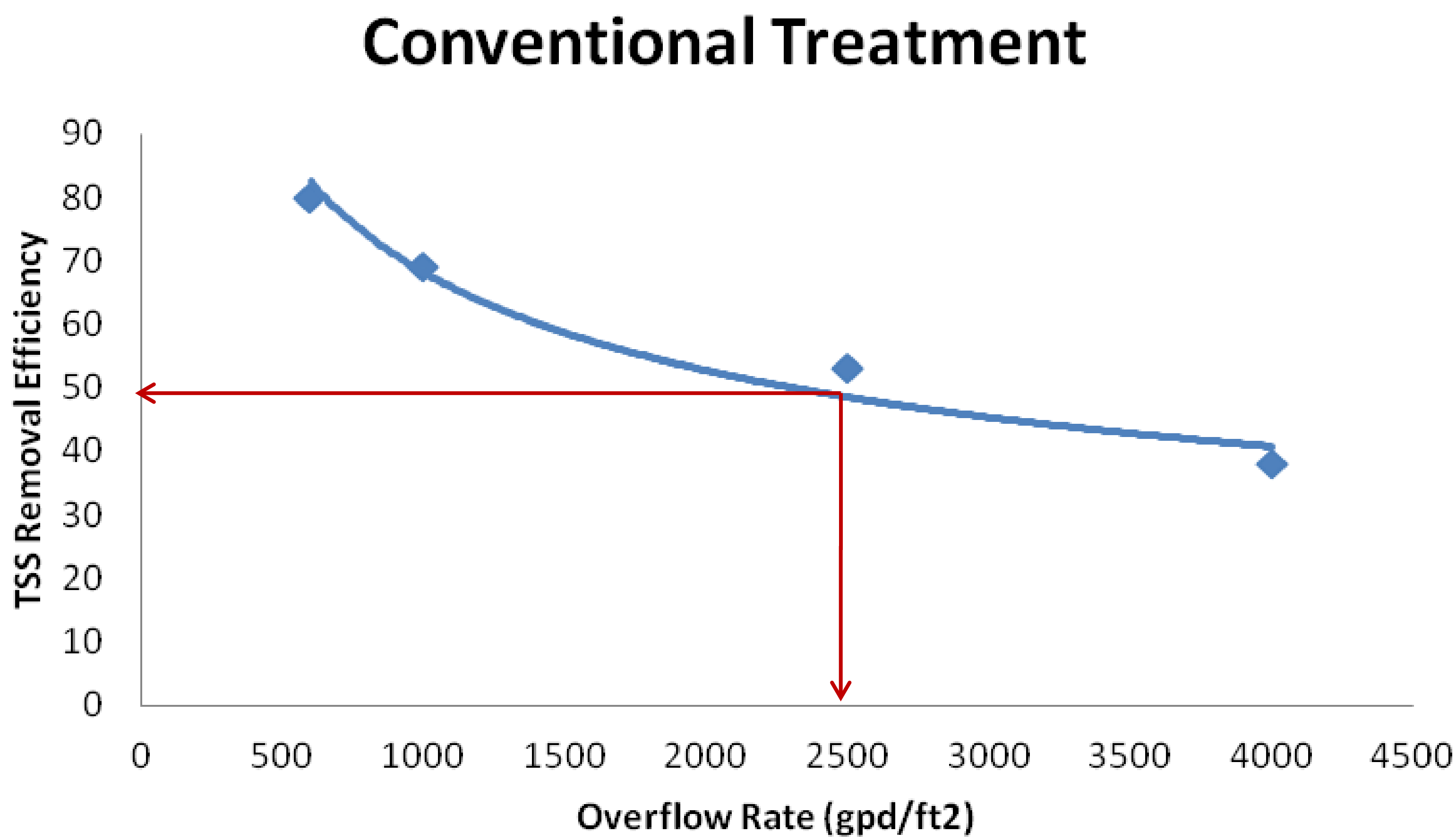


Figure 3
TSS REMOVAL EFFICIENCY OF CONVENTIONAL TREATMENT
PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

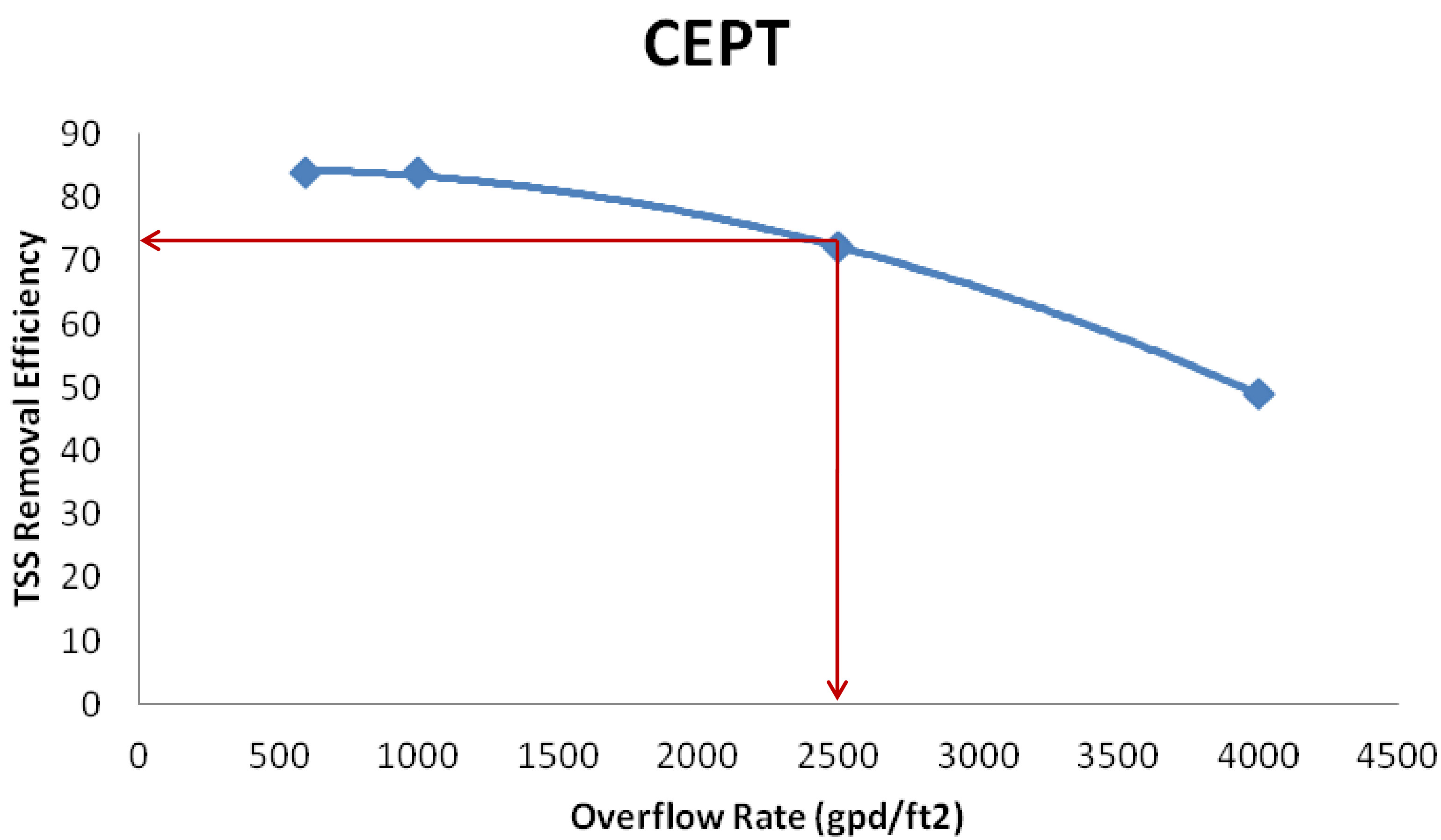


Figure 4
TSS Removal Efficiency of CEPT (Ferric Chloride = 20 mg/L and Polymer – 0.2 mg/L)
PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

Disadvantages include increased corrosion potentials in downstream processes, carbon source deficiency if denitrification is required in future due to higher BOD removal and primary sludge thickening and dewatering would be more difficult. In addition, Polymer addition in CEPT may contribute to disinfection byproducts in chlorination. If UV disinfection is used in downstream processes, it is recommended that additional analysis such as UV transmittance monitoring and water quality (iron content testing) be performed if iron based salt such as ferric chlorine is used for CEPT. This is recommended since iron interferences may occur with UV disinfection from iron based coagulant. Since CEPT is only recommended for use on a very limited “as-needed” basis at the WPCP, the above mentioned impacts would be very minimal.

The conventional treatment removal efficiency shown in Figure 3 was based on the influent suspended solids measured in the field (310 mg/L). In order to use this relationship in sizing the activated sludge process, the influent suspended solids estimated from the data analysis (210 mg/L) and utilized for future planning, was used. Figure 5 shows the removal efficiency realized from using the lower influent suspended solids concentrations. The removal efficiency based on influent TSS of 210 mg/L is slightly lower than the removal efficiency based on an influent TSS of 310 mg/L.

5.3 Recommended Alternative

Based on the evaluation of the two alternatives, conventional primary treatment would be the recommended alternative. It is also recommended to use CEPT on an “as-needed” basis under high loading conditions (MM or higher) and when one PST is offline. It was noted at Workshop No. 2 that the sizing of PSTs will not be based on year-round CEPT, but the ability to add chemicals to the PSTs would be provided for high flow even when a tank is offline. It also provides plant staff with additional flexibility and redundancy.

It was recommended that the CEPT facility would be designed to provide a ferric chloride dose of 20 mg-Fe/L and a polymer dose of 0.2 mg/L.

The subsequent sections further develop design features and criteria for conventional PSTs.

6.0 ALTERNATIVE DEVELOPMENT

6.1 OFR Selection

OFR is a key criteria for primary treatment design. Selection of a suitable OFR depends on the type of suspended solids to be removed, the settlable solids fraction, and influent solids concentration. At higher OFRs, the TSS and BOD removal efficiencies decreases. As a result, as the OFR increases and primary effluent quality degrades, the size of downstream processes increase to handle higher loadings. Table 7 shows the impact of PST size and how the secondary treatment process can compensate for increased loads. Selection of the appropriate OFR is important for cost effective plant construction and operation.

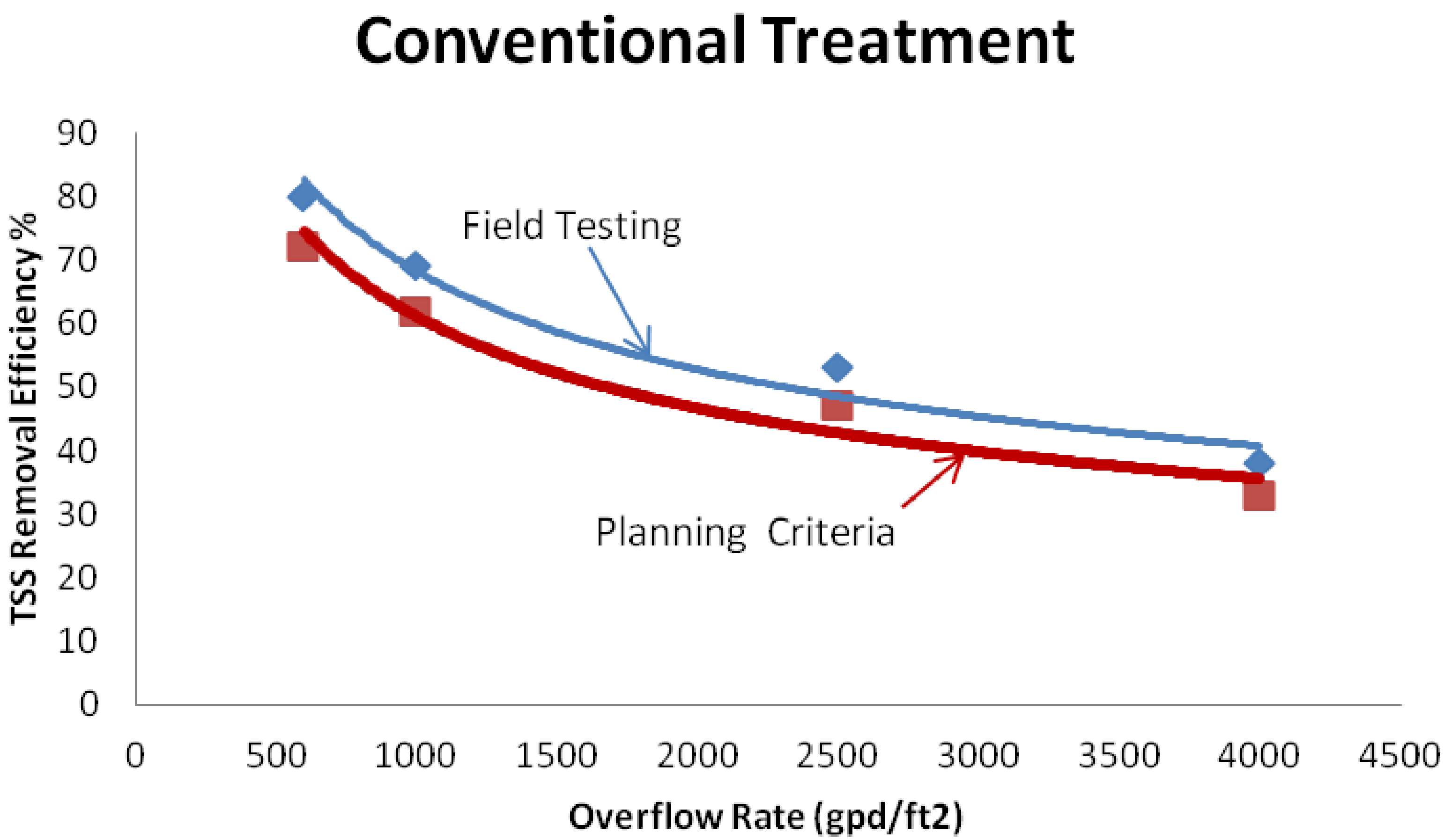


Figure 5
CORRECTION OF FIELD TESTING TO PROPOSED PLANNING CRITERIA
PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

Table 7	**Impact of PSTs Size on Downstream Processes Master Plan and Primary Treatment Design City of Sunnyvale**		
Element	**Smaller PSTs**	**Impact**	**Larger PSTs**
Capital Costs:		→	
PSTs	$	SOR decreases ←	$$$
Aeration Basins	$$$	BOD load increases	$
Operation and Maintenance (O&M) Costs:		←	
Aeration	$$$	BOD load increases →	$
Cogeneration	-$	More digester gas	-$$$

Table 7 and Figure 6 present the planning level economics of different OFRs associated with PST sizes and impact on downstream processes. An OFR of 2,000 gpd/sf at year 2035 MM influent flows was recommended and presented to the City at the October 2013 Workshop. At MM conditions, all tanks are assumed to be in service. If a PST needs to be taken offline during MM conditions, CEPT would be available to maintain primary effluent quality. The proposed OFR is similar to the PST overflow rate that was observed during the field testing described in Section 5.2. The existing PSTs performed well during the field testing (see Figure 3). The existing PSTs were stress tested by the City to confirm the recommended OFR of 2,000 gpd/sf and the removal efficiency as a function of OFR. Testing indicated that an OFR of 2000 gpd/sf will not cause deterioration of the PST effluent. The results of the stress testing effort and confirmation for increasing the OFR to 2000 gpd/sf are included Appendix C – Results of Primary Clarifiers Stress Testing at the Sunnyvale WPCP.

6.2 Number of PSTs

Various alternatives for the number of PSTs to be provided were considered. At the October 2013 workshop, a PST configuration was presented which included three larger tanks (115 feet by 38 feet by 14 feet) with two basins per tank separated by internal walls. Based on redundancy concerns by City staff, it was recommended that the three tank configuration be modified to provide six separate tanks (115 feet by 19 feet by 14 feet). For last consideration, the City staff requested a four tank configuration be evaluated as well (each 165 feet by 20 feet by 14 feet). Based on the OFR details provided in Section 6.1, these three options were further analyzed based on an OFR of 2,000 gpd/sf at year 2035 MM conditions.

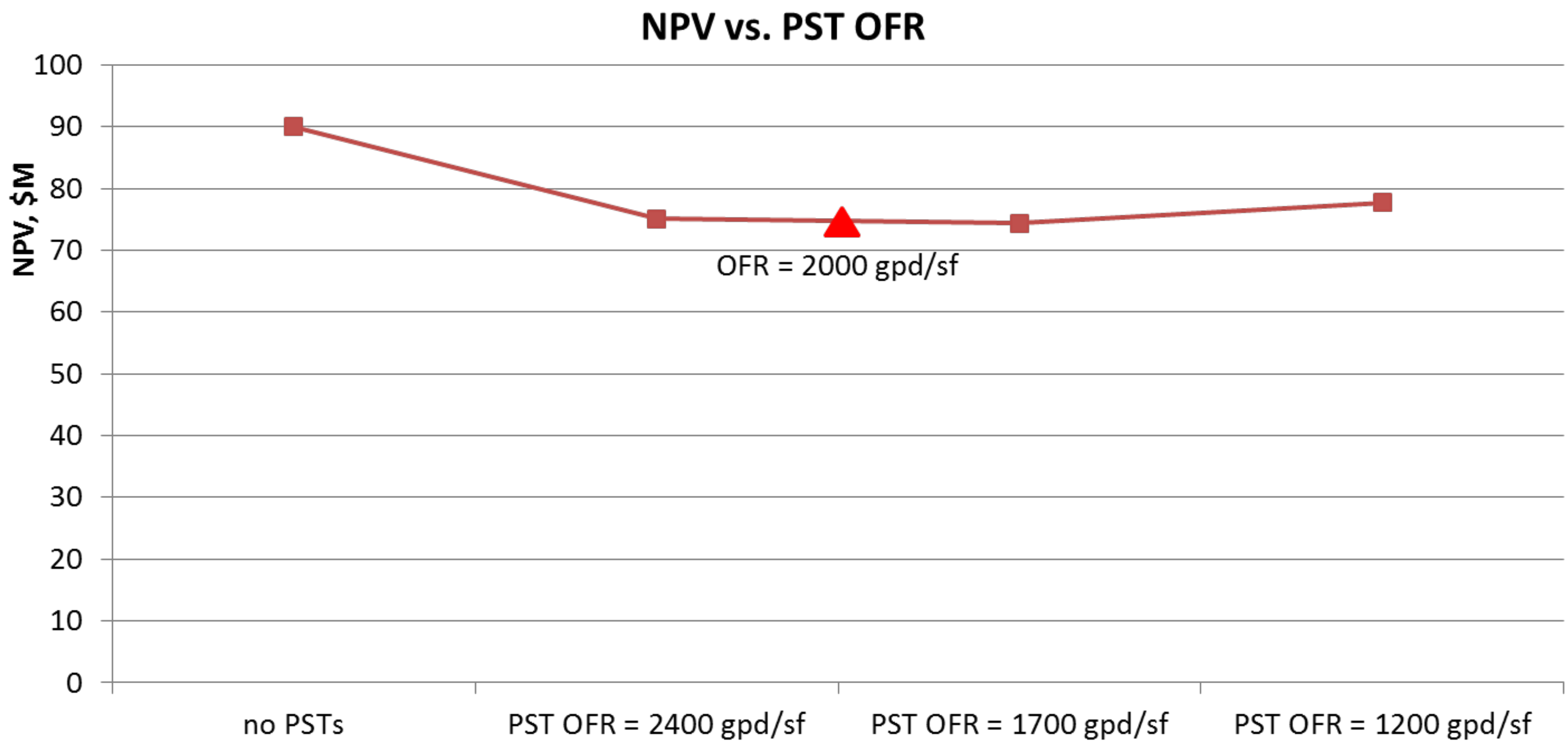


Figure 6
NPV FOR DIFFERENT OFR OF PSTS
PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

Based on redundancy and cost considerations under the three or four tank configuration, the level of redundancy is reduced because when a tank is taken out of service, more flow (33 percent more and 25 percent more respectively) is distributed to the in-service tanks. Under a six tanks configuration, if a basin is taken out of service, only 17 percent of influent flow is distributed to the in-service basins. Thus, the six tank option provides more redundancy and operational flexibility. Additionally, from a layout prospective, it has been our experience that PST length should not exceed 150 feet if equipped with a single sludge hopper at the front end of the tank. PSTs longer then 150 feet should be equipped with multiple hoppers to avoid over stressing the chain and flight mechanisms. Therefore, the four tank option would be more expensive to construct than the other options. Therefore it is recommended that the six (6) PST configuration to be constructed. Each PST would have a surface area of 2,185 sf (115 feet long by 19 feet wide) and a 14-foot side water depth. Each new PST would be 4.5 percent larger than the existing PSTs and would be approximately 20 percent larger than what was recommended in SIP which used a lower MM flow to year 2035.

As indicated in the discussion above, the settling characteristics of primary influent, level of non-settleable solids, and field verification indicated that higher than typical OFR could be used to design the PSTs, reducing the number of new PSTs and saving the City millions in capital expenditures. The selected OFR was further verified using computational fluid dynamics (CDF) to provide optimal design on internal arrangements.

Screenings and solids loading to future PSTs would likely be reduced since screenings removal and improved grit removal are being implemented at the WPCP. The existing headworks facility has grinders that break up rags and larger debris that gets diverted to the aerated grit and PSTs. The future headworks facility would utilize fine screens and grit removal that will improve rag, debris and grit removal upstream of the PSTs. At current and future flows and loads, the new PSTs would be expected to perform better than the existing PSTs due to the size, depth and improved headworks facilities.

6.3 Computational Fluid Dynamics (CFD) Modeling

The high accuracy clarifier model was used to identify and determine the size of the performance enhancement features for the proposed PSTs. Performance enhancement features are defined as the internal arrangements including baffles and effluent launders needed to achieve the best performance of a PST with a specific cross sectional area and volume. The performance enhancement features evaluated in this analysis included:

- Four transversal launders.
- Inlet flocculating perforated baffles (wood and fiberglass)
- First set of mid-tank perforated baffles (wood and fiberglass)
- Second set of mid tank baffles (wood and fiberglass).
- Sludge protector canopy system (fiberglass)

- It was assumed in the analysis that the PST complex consists of six separate tanks. Each PST has a length of 115 feet, a width of 19 feet and a side water depth of 14 feet. The flow would be evenly split between the six tanks by means of inlet gates and/or ports directing the flow from the primary influent channel into the PSTs. A flow rate of 4.37 mgd per PST and influent suspended solids concentrations of 210 mg/L were assumed. Details of CFD modeling is provided in CFD Modeling TM in Appendix C. Figure 7 shows the output of the HACM for the case with all performance enhancement features included. Table 8 shows the improved effluent TSS quality of the different performance features on PST performance that are recommended for the new PSTs. The enhancement features will be further evaluated during preliminary design.

Table 8 Effect of Performance Enhancement Features
Master Plan and Primary Treatment Design
City of Sunnyvale

Modification	Predicted Effluent TSS (mg/L) (1)	Projected Improvement (% Effluent TSS Removal) (1)
PST with four transversal launders	134	N/A
Inlet flocculating baffles	127	5
1st Set of mid-tank baffles	119	11
2st Set of mid-tank baffles	115	14
Sludge protector system	109	18

Note:

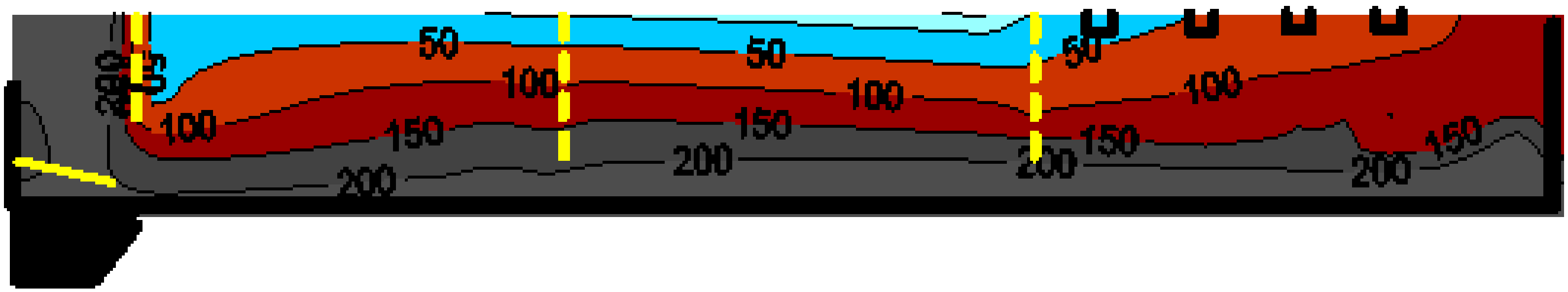
(1) The effluent TSS removal shown includes all performance enhancement features preceding the item listed.

6.4 Primary Sedimentation Tanks

6.4.1 Influent Distribution

A distribution channel adjoined to the PSTs would convey the influent flow from proposed grit removal system to the PSTs. The influent channel would be designed with provisions for sufficient pre-aeration to promote flocculation, keep solids in suspension, scrub odors, add dissolved oxygen, reduce septicity in the PSTs and promote floatable materials. It will be constructed for the entire width of PSTs.

Flow distribution to the PSTs would be designed to distribute flow and solids evenly among the tanks. Flow to the PSTs would be distributed from the influent channel to the PSTs by using submerged ports, orifices or gates. Wide opening slide gates would also be provided to enable basin isolation. Also, as mentioned in section 6.3, each PST would be equipped with inlet flocculating baffles, mid tank baffles and a sludge protector system.



Effluent Flow Rate = 4.37 mgd   ***Influent TSS = 210 mg/L***   ***Effluent TSS = 109 mg/L***

Figure 7
OUTPUT OF THE HACM
PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

6.4.2 Effluent Collection and Discharge

Primary effluent would be collected by overflow weirs and four transversal launders and discharged into a common effluent channel at the end of the PSTs. The last launder will be located 14 feet from the end wall. The launders would be placed 7 feet apart. The weirs would evenly withdraw flow, reduce high velocity gradients, reduce short circuiting and also act as the level control for the water surface elevation in the PSTs. A new primary effluent pipeline will be constructed from the primary effluent channel to the Oxidation Ponds. The existing primary effluent pipeline currently being rehabilitated will be used where feasible. Provisions would be made to accommodate future flows to primary equalization storage and the new secondary treatment system.

6.4.3 Sludge and Scum Collection and Handling

A full length chain and flight sludge collector (Figure 8) would be provided to each PST to scrape settled solids at bottom of each tank. The tank bottom would be sloped towards the sludge channel to direct sludge into channel which will be located at the front end of PSTs. The sludge collector would be guided to water surface on its return trip and will push scum to a trough which would be located approximately 45 feet from end wall. The scum trough would collect scum from three PSTs and discharge into a scum box at one side of the PSTs. The scum from other three PSTs will flow into the scum box located other side of the PSTs. Two scum pumps, one duty and one standby would be installed for each scum box. Sludge and scum pumps will be positive displacement type. Each PST would be equipped with a cross collector to concentrate the sludge to the hopper, one per tank.

Two sludge thickening alternatives were considered:

- Alternative 1: Construct co-thickening facility under the Primary Treatment project, and thicken only primary sludge until the secondary processes come online.
- Alternative 2: Thicken primary sludge in the PSTs and construct co-thickening facility with secondary treatment to thicken WAS or co-thicken with primary sludge.

The first alternative was not preferred as it increases capital cost of Phase I construction and it is not consistent with future secondary treatment considerations (i.e. future carbon needs for full BNR). Therefore it is recommended to thicken primary sludge in the PSTs and not provide provisions for thin sludge pumping. Two sludge pumps, one duty and one standby would be provided for two tanks.

This is consistent with the current practice at WPCP is to thicken sludge in the PSTs. A sludge blanket would be allowed to build in the PSTs. A single hopper per PST will be provided and the sludge would be intermittently pumped out by positive displacement pumps. The hopper and sludge removal system would be designed with provisions to allow adequate transport of sludge into the hopper and avoid forming a high sludge blanket on the bottom of the PSTs.

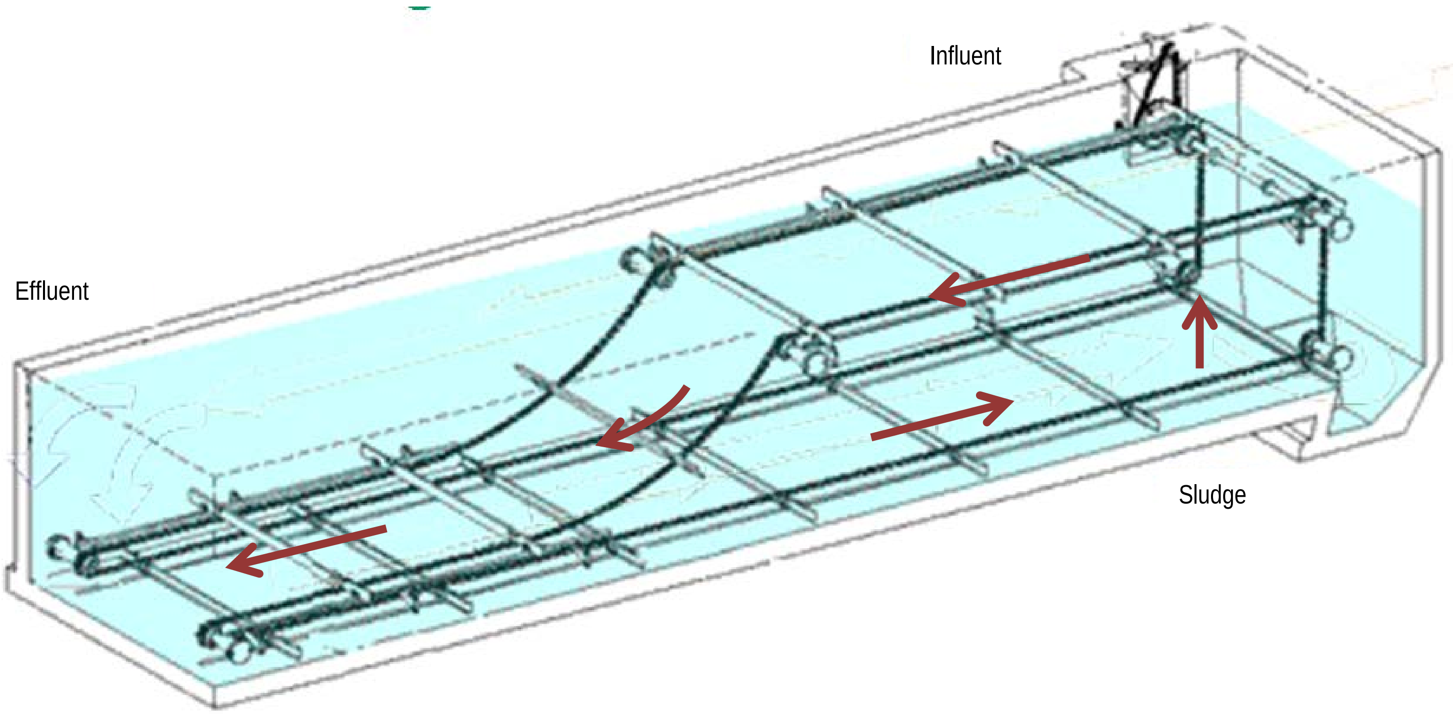


Figure 8
FULL LENGTH CHAIN AND FLIGHT (4-SHAFTED) SLUDGE COLLECTOR
PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

Also, the sludge protector system would be designed to provide enough volume to achieve a high concentration of primary sludge (while preventing re-suspension of solids due high flows and/or septicity conditions).

6.4.4 Odor Control

Primary treatment processes typically generate odors. As a result, many primary treatment facilities require some level of odor control to reduce odors onsite and prevent noticeable odors from spreading beyond the plant boundaries and affecting the area surrounding the WPCP.

This section summarizes odor regulations, odor testing that was conducted at the WPCP, an evaluation of odor control technologies, and recommendations for odor control at the primary treatment facilities.

6.4.4.1 Regulations

In the State of California, odors are regulated by CH&S code Section 41700 which states, “A person shall not discharge from any source whatsoever such quantities of air contaminants or other material which cause injury, detriment, nuisance or annoyance to any considerable number of people.” There is no regulation on how odor violations are determined.

The Bay Area Air Quality Management District (BAAQMD) has regulations to address certain odorous substances (e.g., hydrogen sulfide, sulfur dioxide). The limits are not applicable, however, unless a sufficient number of odor complaints are received.

The City has not received odor complaints for the current wastewater operations at the WPCP. Although the City has not received odor complaints, the City would like to develop a proactive approach in addressing odors as part of the long-term planning for the WPCP.

6.4.4.2 Onsite Odor Testing

In order to evaluate the odor generation potential at the WPCP, odor testing was performed at the WPCP on September 9 through 11, 2013. The odor testing identified which odorous compounds are being emitted from each source and in what concentrations. This information was used to evaluate where odor control should be implemented as well as the use of potential odor technologies.

The methodology and results of the study are summarized in the Odor Testing Report TM. The key findings and recommendations of the study, as they relate to the preliminary treatment process include:

- The headworks and primary facilities have relatively high H_2S concentrations.

- The headworks and primary clarifier odors were not overpowering during the testing, but they were certainly noticeable and capable of being detected off-site depending on the wind direction. The odors associated with the primary clarifiers were predominantly from the launder areas.

- Given the new processes will be similar to the current processes, it is highly probable the new processes will have similar odor generation potential. Therefore, provisions for odor containment and treatment should be provided. Specific areas to be addressed include the following: (1) screening and screenings handling areas; (2) influent wetwell; (3) grit removal and grit handling areas; (4) primary sedimentation tank (PST) influent/effluent channels and (5) PST launder area. Further details will be developed during the preliminary design phase.

- Given odors generated at the headworks and PSTs are similar, it is recommended that a common odor control system be provided for the headworks and primary clarifiers. This will reduce site space required for odor control and the overall cost of the odor control system.

6.4.4.3 Technologies Considered

The following odor control technologies are commonly used for odor control at WWTPs and were evaluated for treating odors generated by the preliminary and primary treatment processes:

- Activated sludge diffusion – diffusion of the odors into the aeration basins where they are oxidized

- Bioscrubber – a biological treatment process in which synthetic media is placed inside a vertical tower and odors are removed biologically

- Biofilter – a biological treatment process in which odors are removed biologically using organic or inorganic media, typically inside a custom built structure

All three technologies have been utilized successfully for many years and provide adequate odor control. However, since the secondary process will not be in operation until 2023 and due to some recent process control issues associated with activated sludge diffusion, activated sludge diffusion is not considered a viable alternative. Biofilters are a cost effective alternative, but typically require a significantly larger footprint than bioscrubbers. Based on a preliminary sizing analysis, use of biofilters is not practical due to the space limitations at the WPCP. Like biofilters, bioscrubbers require no chemical usage (if non-chlorinated plant effluent water is used in the system), utilize less site space and can be expanded to provide two-stage treatment of odors should more stringent odor control be necessary in the future. Given these advantages, package-type bioscrubber systems are recommended for scrubbing odors generated at the primary process. Further details will be provided during primary design.

6.4.4.4 Recommendations and Site Considerations

Odor control is an important design consideration in primary treatment. Hydrogen sulfide and other odorous components present in the raw wastewater will be released to atmosphere at places where high turbulence occurs such as conveyance channel, tank inlet, effluent launders, weir and scum troughs. The odor can be contained by providing covers to places where high turbulence is observed. The covers typically used in primary clarifiers are flat covers (see Figure 9) and barrel-arch cover with air vents (see Figure 10). These covers are very lightweight and easy to remove to access the tanks below. The main advantage of the barrel arch covers is that each panel can slide underneath the adjacent panel and does not have to be lifted and stored next to the PSTs to allow access.

The findings and recommendations for odor control include:

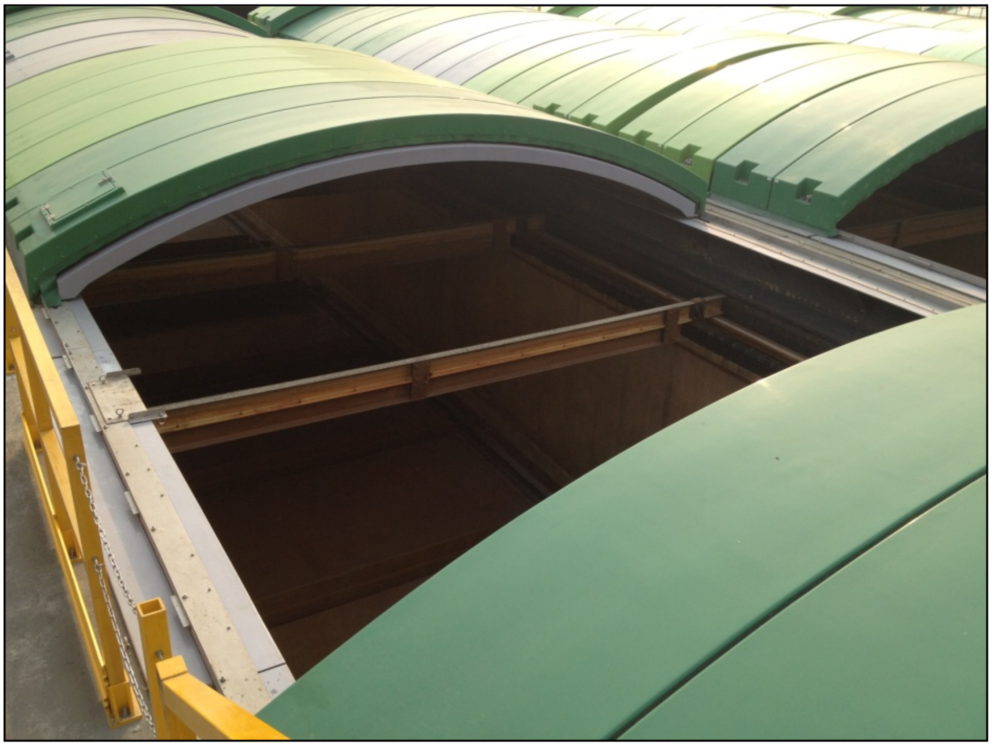
- Provide a single, package-type bioscrubber system to treat odors collected from both the preliminary and primary treatment process areas.
- Locate the odor control system near the preliminary and primary treatment processes to simplify the odor ducting design.
- Include the following provisions to adequately contain and exhaust odors generated at the primary treatment facility:
  - Cover the PST influent/effluent channels and PST launder area. Include provisions to cover the entire PSTs, should further odor mitigation be required in the future. Include provisions for corrosion protection for all covered areas (e.g., use of stainless steel and concrete coatings).
  - Install exhaust fans to extract enough air from the covered and enclosed areas to prevent fugitive emissions and convey it to the odor control system.
  - Install a ventilation system for areas that will be accessed by personnel to provide proper ventilation required for worker safety.

Further details for the containment, ventilation, and treatment of odors, will be provided as part of the preliminary design effort for the Primary Treatment Facility.

6.4.5 PST Basis of Design

Table 9 provides the PST Basis of Design.

Figure 9
FLAT ALUMINUM COVERS WITH AIR VENTS FOR ODOR
PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE



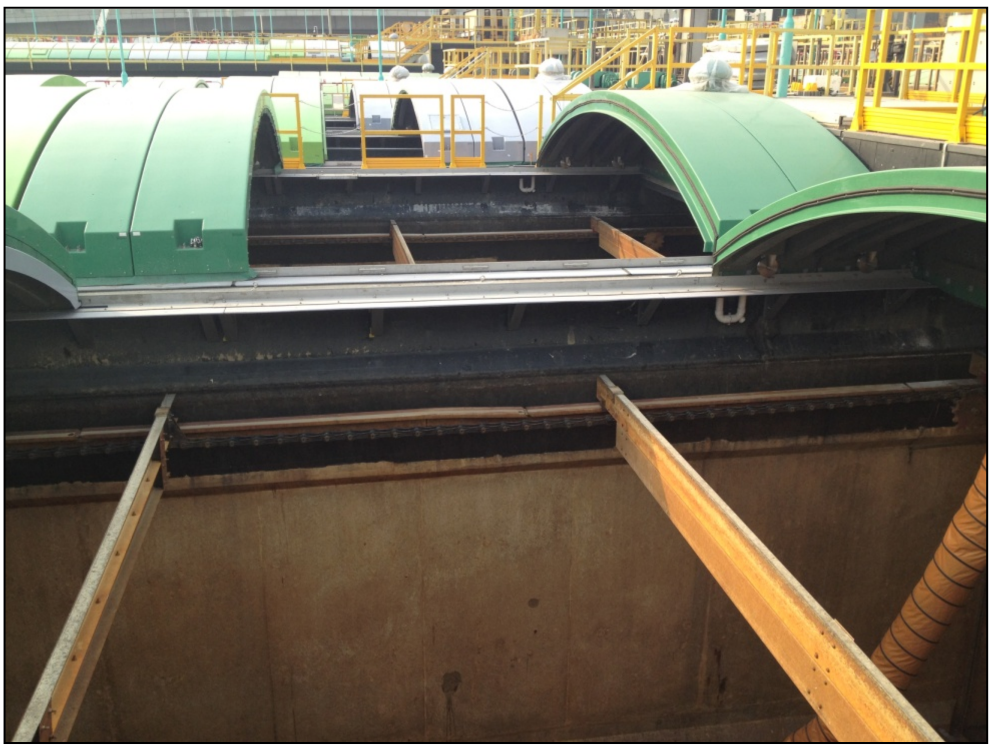


Figure 10
BARREL ARCH REMOVABLE COVER WITH AIR VENTS FOR ODOR CONTROL
PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

Table 9	PST Basis of Design Master Plan and Primary Treatment Design City of Sunnyvale
Description	
SOR, all tanks in service at MM flow in 2035, gpd/sf	2,000
No of PSTs	6
Length, ft	115
Width, ft	19
Depth (nominal side water), ft	14
Sludge collector per tank	1, full length
Cross collector per tank	1
Sludge hopper per tank	1
No. of scum boxes	2, total
No. of sludge pumps	2 (1 duty + 1 standby) for two tanks, 40 gpm capacity positive displacement
No. of scum pumps	2 (1 duty + 1 standby) per scum box, 15 gpm capacity positive displacement
Provision for CEPT	Yes, Ferric Chloride = 20 mg/L and polymer = 0.2 mg/L
Provisions for thin sludge pumping	No
Provisions for cover to mitigate odors	Yes

The PSTs would be arranged next to each other, side by side and to share wall between tanks. A common influent channel would distribute the flow to PSTs and a common effluent channel will collect primary effluent from all PSTs and send it to downstream processes. The influent and effluent channels would be located at the head and end of PSTs and will extend the entire width, respectively. The sludge pumps would be located in a gallery below the influent channel. The gallery would be designed to provide access to equipment for operations and maintenance. Scum boxes with pump stations would be located on either side of the PSTs. Figures 11, 12, 13, 14 present the PST layout in plan view and section. Figure 15 presents the chemical facility plan for CEPT operation.

- Drives of sludge collector, cross collector and scum troughs (baffle), gate actuators and controls would be installed above water surface level, near the top of the PSTs. This equipment and instruments require frequent access for operation and maintenance. Walkway with guardrails for fall protection, all around the PSTs and between the PSTs would be provided to access equipment and instruments, and for visual inspection of PST performance.

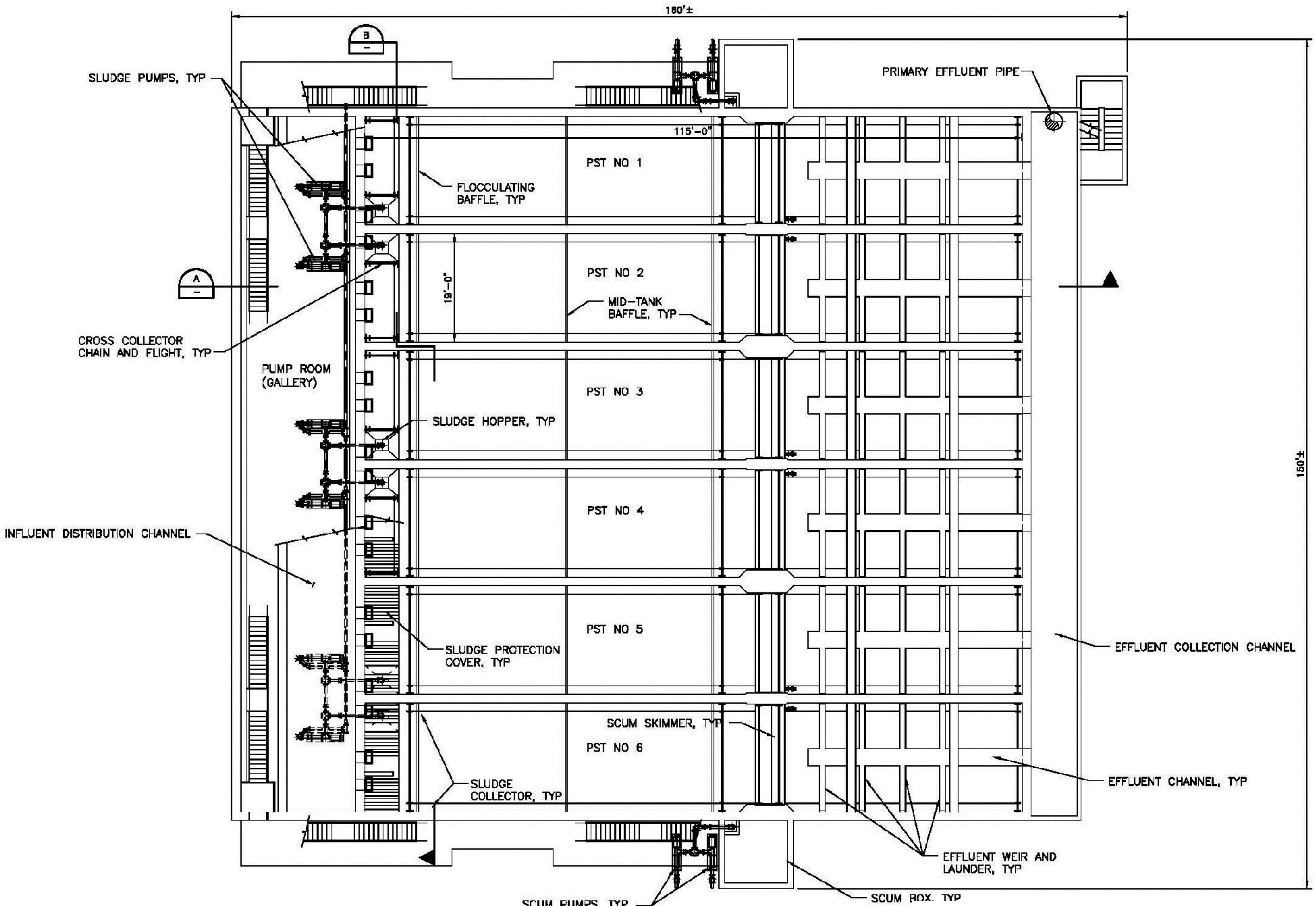


Figure 11
PRIMARY SEDIMENTATION TANKS – PLAN VIEW
PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

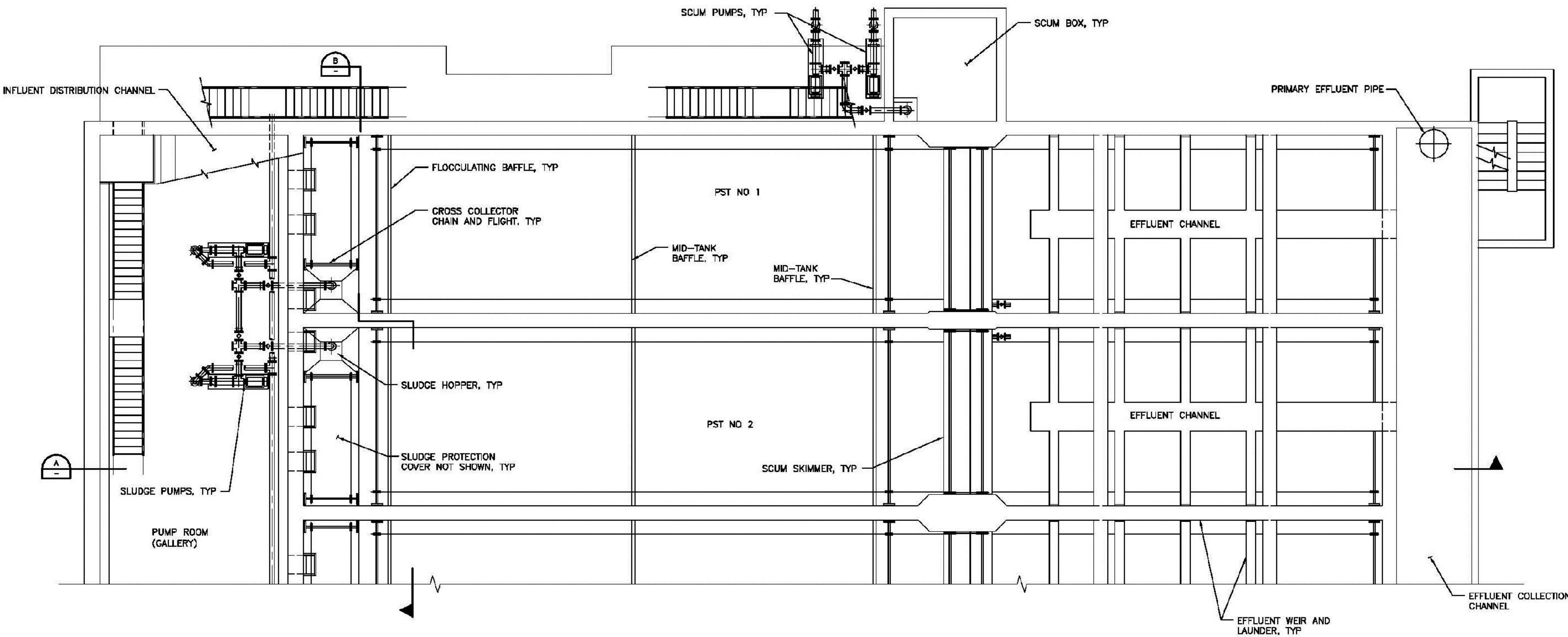


Figure 12
PRIMARY SEDIMENTATION TANKS – ENLARGED PLAN
PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

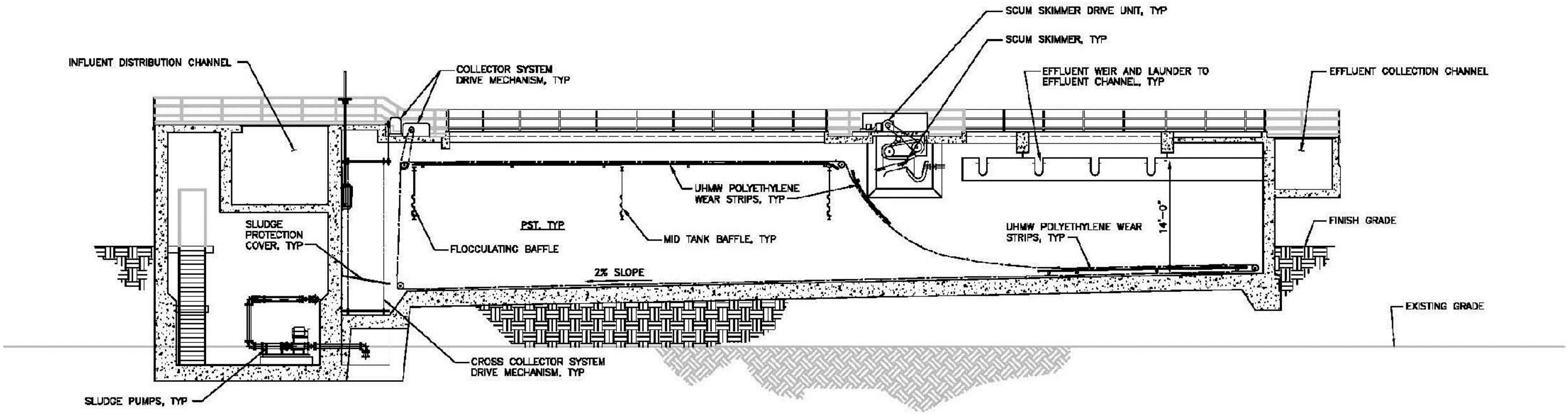


Figure 13
SECTIONAL VIEW A-A
PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

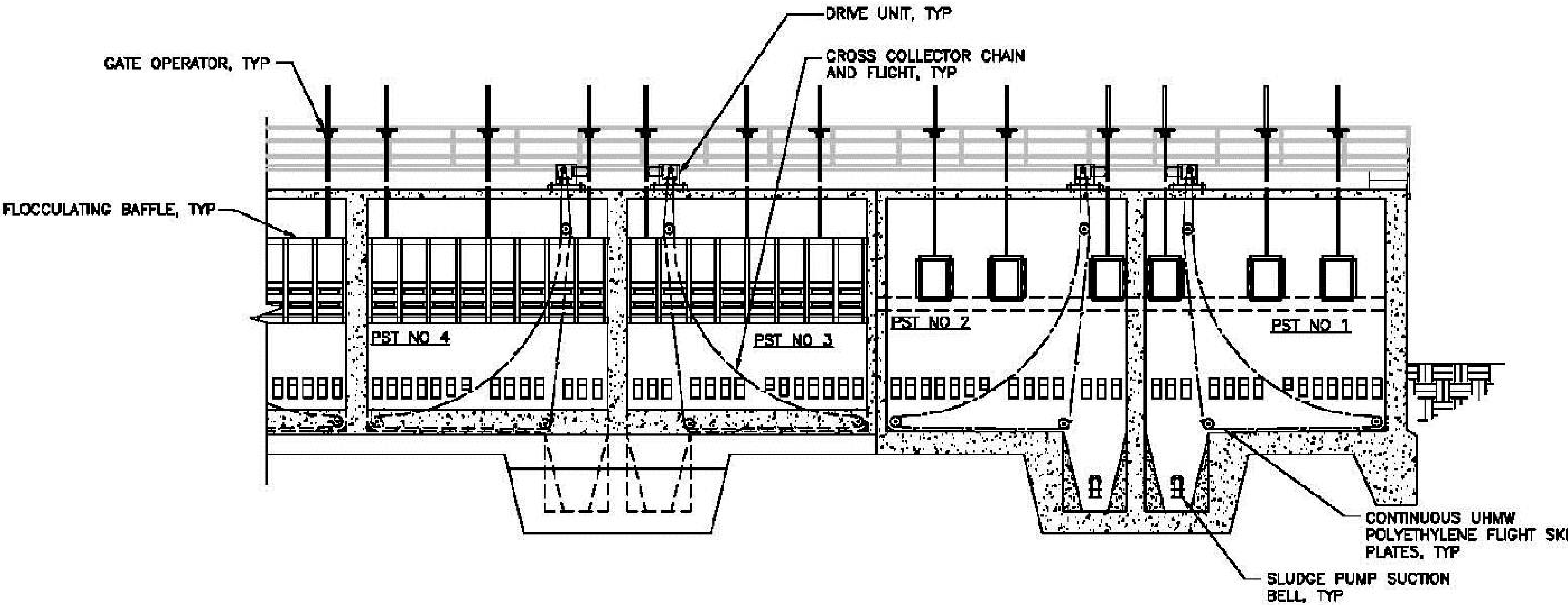


Figure 14
SECTIONAL VIEW B-B
PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

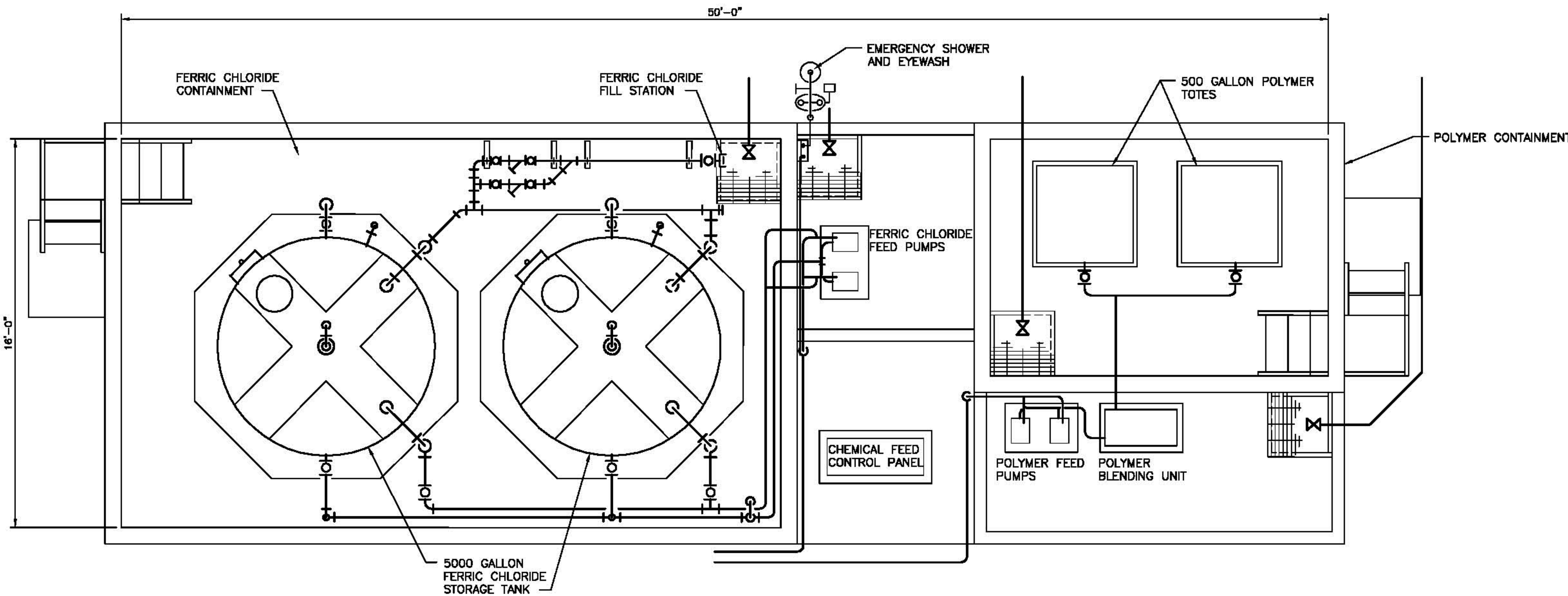


Figure 15
CHEMICAL FACILITY PLAN FOR CEPT
PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

6.5 Short Term and Long Term Considerations

The PSTs would be designed for OFR of 2,000 gpd/sf at MM flow in 2035. The design features and internal arrangements of PSTs stay the same for short-term and long-term operation. However, the PSTs should have provisions for operational compatibility with future upstream and downstream processes.

6.5.1 **<u>Short-Term</u>**

As mentioned previously the City anticipates new secondary treatment, conventional activated sludge or MBR will be online in 2023. Until then, the existing oxidation ponds would remain in-service and primary effluent from the new PSTs would be conveyed to the oxidation ponds. A new primary effluent pipeline would be constructed to convey primary effluent from the new PSTs to the oxidation ponds. The existing primary effluent pipeline being rehabilitated will be used where feasible.

The updated hydraulic profile would allow the new facilities to convey primary effluent from the new PSTs by gravity to the existing oxidation ponds via a new or rehabilitated existing primary effluent pipeline. In addition, provisions would be provided to convey flow in the future by gravity to the new primary effluent equalization storage and the new secondary treatment system.

- **<u>Long-Term</u>**

As part of constructing the new secondary treatment facilities (scheduled to be operational in 2023), the primary effluent pipeline (to the oxidation ponds) would be modified to convey flow to primary effluent equalization storage and the secondary treatment system.

7.0 IMPLEMENTATION CONSIDERATIONS (PHASING)

The PSTs could be potentially constructed in two phases: Phase 1 – construct five PSTs for 2025 flows and Phase 2 – Construct the sixth PST to meet 2035 flows. Construction of the sixth PST would need to occur prior to 2025 to accommodate the projected flow and loads. As provided in Table 10, the OFR is less than 4,000 gpd/sf for all flow conditions except peak hour. It is feasible to construct the PSTs in phases to meet 2025 and 2035 flows.

Considering the additional construction cost of approximately $2.5M to the City to construct the PSTs in two phases (five PSTs now and 1 PST at a later time) rather than constructing all six PSTs now under one construction project, as well as the added benefit of reliability and flexibility of having the sixth tank now, it is recommended to not phase the PST construction and construct all six new PSTs at this time.

Table 10 SOR for Phasing PSTs Construction Master Plan and Primary Treatment Design City of Sunnyvale						
Flow Condition	**ADWF**	**AA**	**MM**	**MW**	**PD**	**PH**
Phase 1 for 2025 flows, 5 PSTs						
Flow	16.98	17.8	22.9	27.4	34.8	50.9
OFR, all PSTs in service, gpd/sf	1,554	1,629	2,096	2,508	3,185	4,659
OFR, one PST out of service, gpd/sf	1,943	2,037	CEPT	CEPT	CEPT	CEPT
Phase 2 for 2035 flows, 6 PSTs						
Flow	19.5	20.4	26.2	31.5	40.0	58.5
OFR, all PSTs in service, gpd/sf	1,487	1,556	1,998	2,403	3,051	4,462
OFR, one PST out of service, gpd/sf	1,785	1,867	CEPT	CEPT	CEPT	CEPT

8.0 SITE CONSIDERATIONS

Based on preliminary site evaluations, the PSTs would be located in the area currently used for sludge drying and stockpiling. The structures of PST would be elevated to withstand inundation and damage during the 100 year flood event and provide sufficient hydraulic gradeline for the new treatment facilities downstream.

The new PSTs would occupy approximately 160 feet by 150 feet space in plan to construct influent channel, sludge pump station, sedimentation tanks, effluent channel and scum boxes with pumps. All the components will be integrated to minimize the required space. The CEPT facility would occupy 50 feet by 20 feet space in plan. Constructing the CEPT facility adjacent to the PSTs would provide advantages in terms of running shorter chemical piping to application points and ease of operation and maintenance.

Utilities such as potable water, service water, electricity, service air, sewer/drain, and storm water drains would be extended to new PSTs area proximity.

Access roads to the PSTs and around the PSTs would be provided and designed appropriately. Chemical delivery trucks must be able to access the CEPT facility to unload chemicals. The covers for any at grade or below grade structures in vehicular traffic area must be rated accordingly.

As a planning level effort, the PST major equipment would utilize approximately 196 HP of connected electrical load. This estimate does not include power required for instrumentation and controls. Since primary treatment is one of the critical processes in wastewater treatment, the entire processes would be connected to standby power.

9.0 FINDINGS AND RECOMMENDATIONS

Constructing and operating secondary treatment without PSTs would be expensive and troublesome in terms of issues associated with increased loading, less energy savings and O&M cost. Therefore it is recommended that PST be included as part of the proposed WPCP process facilities.

As recommended in the SIP, new primaries would be constructed in the sludge dewatering and drying area at the WPCP. Based on previous discussions, the following are recommended for the new PST facility design:

1. All structures required for primary treatment would be designed to accommodate the 2035 maximum month (MM) flow of 26.2 mgd and would be designed to be flexible enough to meet low and peak flow conditions.
2. Six (6) PSTs will be designed at OFR of 2,000 gpd/sf for MM flow in 2035. Each PST will be 115 feet long, 19 feet wide and 14 feet deep. It is recommended that all PSTs be constructed at the same time.
3. The primary treatment design would include provisions for a CEPT facility which would be sized for a dose of 20 mg/L of Ferric Chloride and 0.2 mg/L of polymer.
4. The PSTs would include integral influent channel which would be designed to handle peak flows and have pre-aeration provision. Influent flow distribution would be further analyzed and evaluated during the preliminary design.
5. The PSTs would include integral effluent channel which will be designed to collect effluent from overflow weirs and launders in the tanks and to handle peak flows. Effluent collection would be further analyzed and evaluated during the preliminary design.
6. Primary effluent would be discharged to existing oxidation ponds by constructing a new (or re-use of the existing rehabilitated) primary effluent pipe. Provisions will be provided to accommodate future conveyance of primary effluent to primary effluent equalization storage and the new secondary treatment facilities.
7. The PSTs would be equipped with flight and chain sludge collectors, cross collectors, sludge hopper, scum troughs and sludge and scum pumps. The sludge would be allowed to thicken in the PSTs and no provisions for thin sludge pumping will be provided. Two sludge pumps, one duty and one standby would be provided for two PSTs and two scum pumps, one duty and one standby would be provided for each scum box.
8. The PSTs would be equipped with performance enhancement features including transversal launders, influent flocculation baffles, mid tanks baffles and a sludge protector baffle systems.
9. The PSTs design would have provision to mitigate odor issues. This would be further analyzed and evaluated during the preliminary design.

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APPENDIX A – PROCESS ALTERNATIVES REVIEW WORKSHOP MINUTES AND SLIDES – OCTOBER 14TH, 2013

Engineers...Working Wonders With Water™

CONFERENCE MEMORANDUM

Project:	Master Plan and Primary Treatment Design	**Conf. Date:**	October 14, 2013
Client:	City of Sunnyvale	**Issue Date:**	October 31, 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:

K. Rogers

KR:JD:kr

This workshop module will be a success if …

- ✓ Establish the need for PSTs
- ✓ Establish the need for CEPT
- ✓ Establish the design criteria and preliminary sizing for PSTs (if needed)
  - ✓ Thick vs thin sludge pumping
  - ✓ Level of redundancy
  - ✓ Loading rates

Agenda

- Primaries vs. No Primaries
- SIP and other recommendations
- Key planning considerations
- Field testing results/ PST Rating
- Basis of design/ tank configuration
- Recommendations
- Next steps

Primaries vs. No Primaries

Cost Impact of PST Size

Element	Smaller PSTs	Impact	Larger PSTs
Capital Costs:			
PSTs	$	SOR decreases →	$$$
Aeration Basins	$$$	BOD load increases ←	$
O&M Costs:			
Aeration	$$$	BOD load increases ←	$
Cogen	-$	More digester gas →	-$$$

NPV Analysis

	No PSTs	With PSTs		
		2400 gpd/sf	1700 gpd/sf	1200 gpd/sf
AB Project Cost	$78M	$58M	$56M	$55M
PST Project Cost	--	$16M	$17M	$24M
Aeration PW Costs	$21M	$16M	$16M	$15M
Cogen PW Savings	-$9M	-$14M	-$15M	-$16M
NPV	**$90M±**	**$76M±**	**$74M±**	**$78M±**

Notes:
(1) Costs for comparison purposes only. Do not include common elements.

NPV Analysis

	No PSTs	With PSTs		
		2400 gpd/sf	1700 gpd/sf	1200 gpd/sf
AB Project Cost	$78M	$58M	$56M	$55M
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Cogen PW Savings	-$9M	-$14M	-$15M	-$16M
NPV	**$90M±**	**$76M±**	**$74M±**	**$78M±**

Notes:
(1) Costs for comparison purposes only. Do not include common elements.

Summary of SIP Recommendations

Summary of SIP PST Assumptions

- Five PSTs (no standby during maximum month)
- Each = 105 x 20 x 10
- MM flow = 22.4 mgd in 2035
- SOR = 2200 gpd/ft2 (conventional treatment)
- No CEPT was considered

Key Planning Considerations

PSTs - Key Planning Decisions

- Size and layout configuration for tanks
- Provisions for thick sludge/ thin sludge
- Provisions for CEPT
- Provisions for future primary sludge screening
- Basin top access/ odor control and cover provisions

Field Testing Results

Field Testing of PSTs

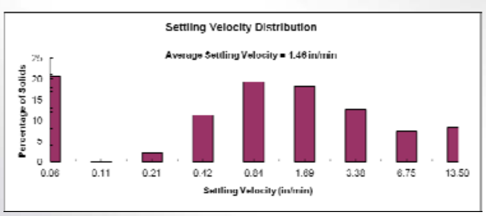
- Conventional Treatment
  - Three days of testing.
  - Settling tests to develop settling velocity distribution (SVD).
  - PST influent and effluent sampling.
- Jar testing
  - Determine the best three chemical dosages.

Field Testing PSTs

- Chemically Enhanced Primary Treatment
  - Three days of testing
    - Ferric Chloride = 10 mg/L, Polymer = 0.1 mg/L
    - Ferric Chloride = 20 mg/L, Polymer = 0.2 mg/L
    - Ferric Chloride = 20 mg/L, no Polymer
  - Settling Velocity tests to develop SVDs for CEPT

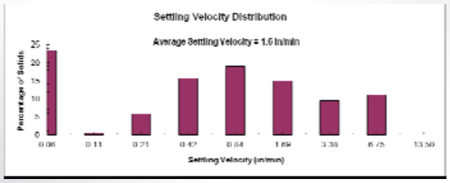
Data Analysis

- Conventional Treatment



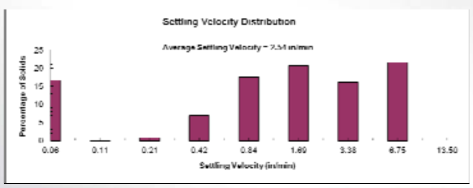
Data Analysis

- CEPT (Ferric Chloride 10 mg/L, Polymer = 0.1 mg/L)



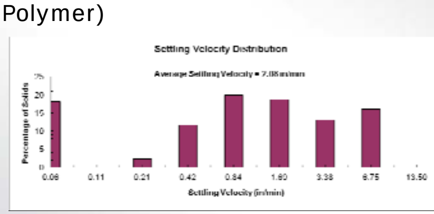
Data Analysis

- CEPT (Ferric Chloride 20 mg/L, Polymer = 0.2 mg/L)



Data Analysis

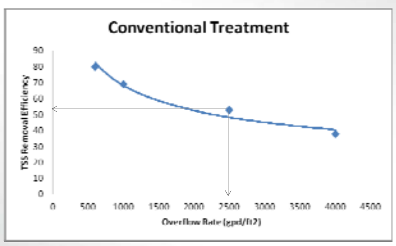
- CEPT (Ferric Chloride 20 mg/L, No Polymer)



Summary of Data Analysis

- Conventional treatment
  - Non-settleable solids = 21 %, similar to San Jose
  - Average Vs = 1.4 in/min = 2.1 m/hr (typical range 0.7 – 4.0 m/hr)
- CEPT
  - Didn't change level of nonsettleable solids.
  - Increased settling velocity
    - Average Vs = 1.5 in/min ($FeCl_3$=10 mg/L, p=0.1 mg/L).
    - Average Vs = 2.6 in/min ($FeCl_3$=20 mg/L, p=0.2 mg/L)
    - Average Vs = 2.1 in/min ($FeCl_3$=10 mg/L, p=0.1 mg/L)
  - <u>Recommendation</u>: Provide the capability for using CEPT ($FeCl_3$=20 mg/L, p=0.2 mg/L)

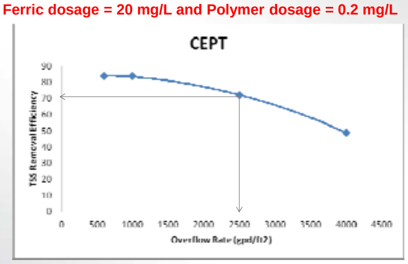
PST – Conventional treatment rating



SOR = 2500 gpd/ft2 - TSS Removal efficiency ~53 %

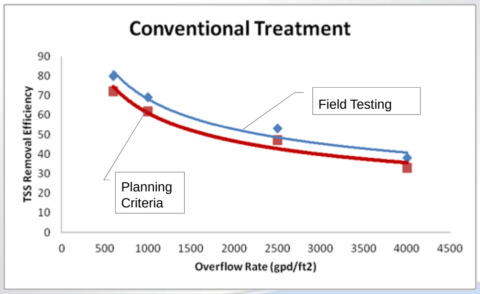
PST – CEPT Rating

Ferric dosage = 20 mg/L and Polymer dosage = 0.2 mg/L

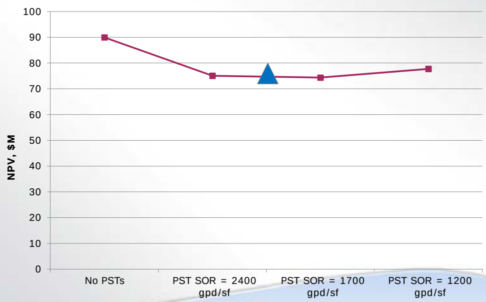


SOR = 2500 gpd/ft2 - TSS Removal efficiency ~70 %

Correction of Field Testing to Proposed Planning Criteria



Selected SOR of 2000 gpd/sf based on costs/performance



Basis of Design / Tank Configuration

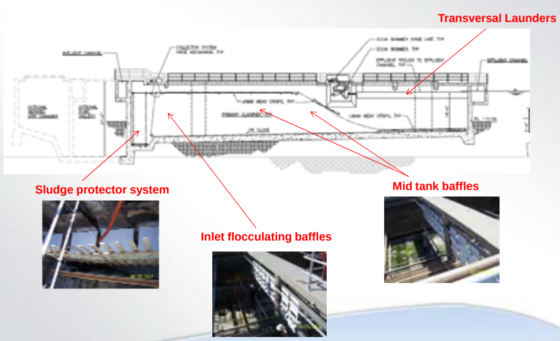
Basis of Design – Flow and Loads

	ADWF	AA	MM	MW	PD	PH
2010	13.2	13.8	17.8	21.3	27.1	39.6
2015	14.46	15.2	19.5	23.4	29.7	43.4
2025	16.98	17.8	22.9	27.4	34.8	50.9
2035	19.5	20.4	26.2	31.5	40.0	58.5

PSTs Basis of Design

- MM flow = 26.2 mgd (year 2035) vs 22.4 mgd from SIP
- SOR = 2000 gpd/sf (all in service)
- Three PSTs (all online and CEPT when one taken offline)
  - 2 flight mechanisms per PST
  - One hopper per PST
- Recommendation:
  - 3 PSTs (two flights per tank)
  - 115 ft x 38 ft x 14 ft (183,500 cf)
- SIP:
  - 5 PSTs
  - 105 ft x 20 ft x 10 ft (105,000 cf)

PSTs Internal Arrangements



Primary Sludge Management

- Why consider thin sludge pumping?
  - Minimizes re-solubilization of BOD
  - Requires thickening (dedicated or co-thickening with WAS) to minimize cost
  - Initially no WAS to co-thicken

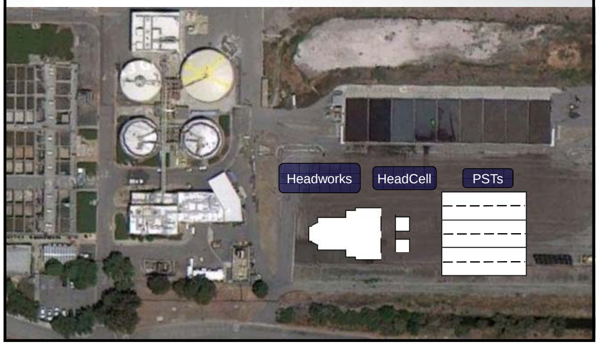
PS Management - Thin vs. Thick Sludge Pumping

- Thin Sludge:
  - Large hoppers
  - Continuous pumping
  - Centrifugal pumps
  - Design provisions to allow some thickening
- Thick Sludge:
  - Small hoppers
  - Intermittent pumping
  - Positive displacement pumps
  - Design provisions to allow thin sludge

Recommendation - Thin vs. Thick Sludge Pumping

- Thickening in the PSTs
- Available BOD will likely be required to meet future nitrogen standards (provides a carbon source for denitrification)

Headworks and PSTs Layout with HeadCell



Headworks and PSTs Layout with Aerated Grit Tanks

PSTs will have provisions to accommodate odor control

Very light weight
Sliding door design – ease of operation
Good air circulation

Recommendations & Next Steps

Recommendations

- Include PSTs in the treatment process
- SOR = 2000 gpd/sf (all in service)
- Three PSTs (all online and CEPT when one taken offline – CEPT 20/0.2)
- Dimensions: 115 ft x 38 ft x 14 ft
- Design for thickening in the PSTs
- Provisions for covers to mitigate odors

Next Steps

- Field testing to confirm design SOR
- Discuss redundancy of three tanks (with two flights each) vs. six separate tanks

This Meeting will be a Success if …

- Establish the need for PSTs
- Establish the need for CEPT
- Establish the design criteria for PSTs (if needed)
  - Thick vs thin sludge pumping
  - Level of redundancy
  - Loading rates

End

APPENDIX B – CHEMICALLY ENHANCED PRIMARY TREATMENT TM

Prepared By: Hany Gerges

Reviewed By: Dana Hunt

CITY OF SUNNYVALE

MASTER PLAN AND PRIMARY TREATMENT DESIGN

TECHNICAL MEMORANDUM

CHEMICALLY ENHANCED PRIMARY TREATMENT: MASTER PLAN

FINAL

November 2013

carollo in association with HDR

CITY OF SUNNYVALE

MASTER PLAN AND PRIMARY TREATMENT DESIGN

TECHNICAL MEMORANDUM
CHEMICALLY ENHANCED PRIMARY TREATMENT
MASTER PLAN

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Appendix C Testing Results
Appendix D Primary Sedimentation Tank Modeling

CHEMICALLY ENHANCED PRIMARY TREATMENT: MASTER PLAN

1.0 BACKGROUND

Chemically enhanced primary treatment (CEPT) is usually accomplished by adding a coagulant and a flocculate to the primary influent solids. The objectives of adding these chemicals are to:

- Reduce the level of non-settleable solids.
- Increase the settling velocities of the settleable solids.

By using CEPT, the size of the Primary Sedimentation Tanks (PSTs) could be reduced without adversely affecting the biological process. However, the annual cost of adding chemicals needs to be evaluated against the savings realized from building smaller PSTs. In general, CEPT could be cost effective alternative if the chemical dosages are low. On the other hand, CEPT could have some side effects that need to be evaluated. Some of these side effects include but not limited to:

1. Larger quantity of primary sludge to be processed. Potential of corrosion of some equipment and structures.
2. Need to add methanol in the future if denitrification is required due to low BOD (carbon source) in the primary effluent.

The purpose of this technical memorandum is to summarize the results, findings and conclusions of the chemically enhanced primary treatment (CEPT) testing performed at the City's Water Pollution Control Plant (WPCP). The objectives of the CEPT testing were to:

1. Determine the optimal dosages of Ferric Chloride and Polymer.
2. Determine the settling velocity distribution (SVD) with chemicals.

Jar testing was used to determine the best three possible dosages of chemicals. These dosages were then applied to the PST influent solids and settling velocity tests were performed. The results of the settling velocity tests were used to determine the settling velocity distribution (SVD) which was used later as an input to the high accuracy clarifier model to determine the PST removal efficiency. Details for CFD analysis are presented in another TM.

2.0 FIELD TESTING

Ferric Chloride and Cationic Polymer were used in the testing. The field testing and laboratory analyses were conducted by the WPCP staff according to the testing protocol prepared by HDR/Carollo and reviewed by the city staff. (Appendix A and B).

As mentioned previously, the objectives of the CEPT testing were to:

1. Determine the optimal dosages of Ferric Chloride and Polymer.
2. Determine the settling velocity distribution (SVD) with chemicals.

2.1 Jar Testing

A testing protocol was prepared by HDR/Carollo team and provided to City staff for review and approval before implementation (see Appendix A). According to the protocol, City staff was responsible for performing the field tests. A series of jar tests were performed to determine the optimal dosages of Ferric Chloride and Polymer. A six-paddle tester was used. Different combinations of chemical concentrations were considered. These concentrations were based on HDR/Carollo team experience at other plants as outlined below in samples 2 through 6. However, the proper amount of raw chemicals needed to achieve the recommended concentrations in the laboratory tests was determined by the City staff. Jar testing was conducted over two days. Six different samples were prepared during each day of testing. These samples included:

Sample 1 – A control sample (sample of the primary influent with no chemicals),

Sample 2 – A sample with 10 mg/L Ferric Chloride and subject to rapid mixing (300 rpm for 30 seconds) followed by gentle mixing (50 rpm) for 15 minutes.

Sample 3 – A sample with 15 mg/L Ferric Chloride and subject to rapid mixing (300 rpm for 30 seconds) followed by gentle mixing (50 rpm) for 15 minutes.

Sample 4 – A sample with 20 mg/L Ferric Chloride and subject to rapid mixing (300 rpm for 30 seconds) followed by gentle mixing (50 rpm) for 15 minutes.

Sample 5 – A sample with 10 mg/L Ferric Chloride and 0.1 mg/L of Cationic Polymer and subject to rapid mixing (300 rpm for 30 seconds) followed by gentle mixing (50 rpm) for 15 minutes.

Sample 6 – A sample with 20 mg/L Ferric Chloride and 0.2 mg/L of Cationic Polymer and subject to rapid mixing (300 rpm for 30 seconds) followed by gentle mixing (50 rpm) for 15 minutes.

The supernatant from each sample was analyzed by the City for total suspended solids (TSS), total biochemical oxygen demand (tBOD) and soluble biochemical oxygen demand (sBOD) (see Appendix C). No adverse effects of adding chemicals, such as an increase in levels of small particles, were observed in any of the samples. Data obtained from field testing was submitted to HDR/Carollo team who analyzed the data and selected the three optimal dosages to be used in the settling velocity distribution testing. The three dosages that yielded the lowest sBOD concentration in the supernatant were selected and applied when conducting settling velocity distribution testing. These dosages were; 10 mg/L of Ferric Chloride with 0.1 mg/L of polymer, 20 mg/L of Ferric Chloride with 0.2 mg/L of polymer, and 20 mg/L of Ferric chloride with no polymer.

2.2 Settling Velocity Distribution (SVD) Testing

According to the testing protocol, City staff performed the settling velocity Distribution (SVD) Testing. The three optimal dosages determined during jar testing were applied to samples of the primary clarifier influent. Then, the samples were poured into HDR's 4.2-L Kemmerer samplers (settling column shown in Figure 1) and samples of supernatant were collected after settling times had elapsed. The procedures for performing the tests, including the settling times tested, are included in Appendix B.

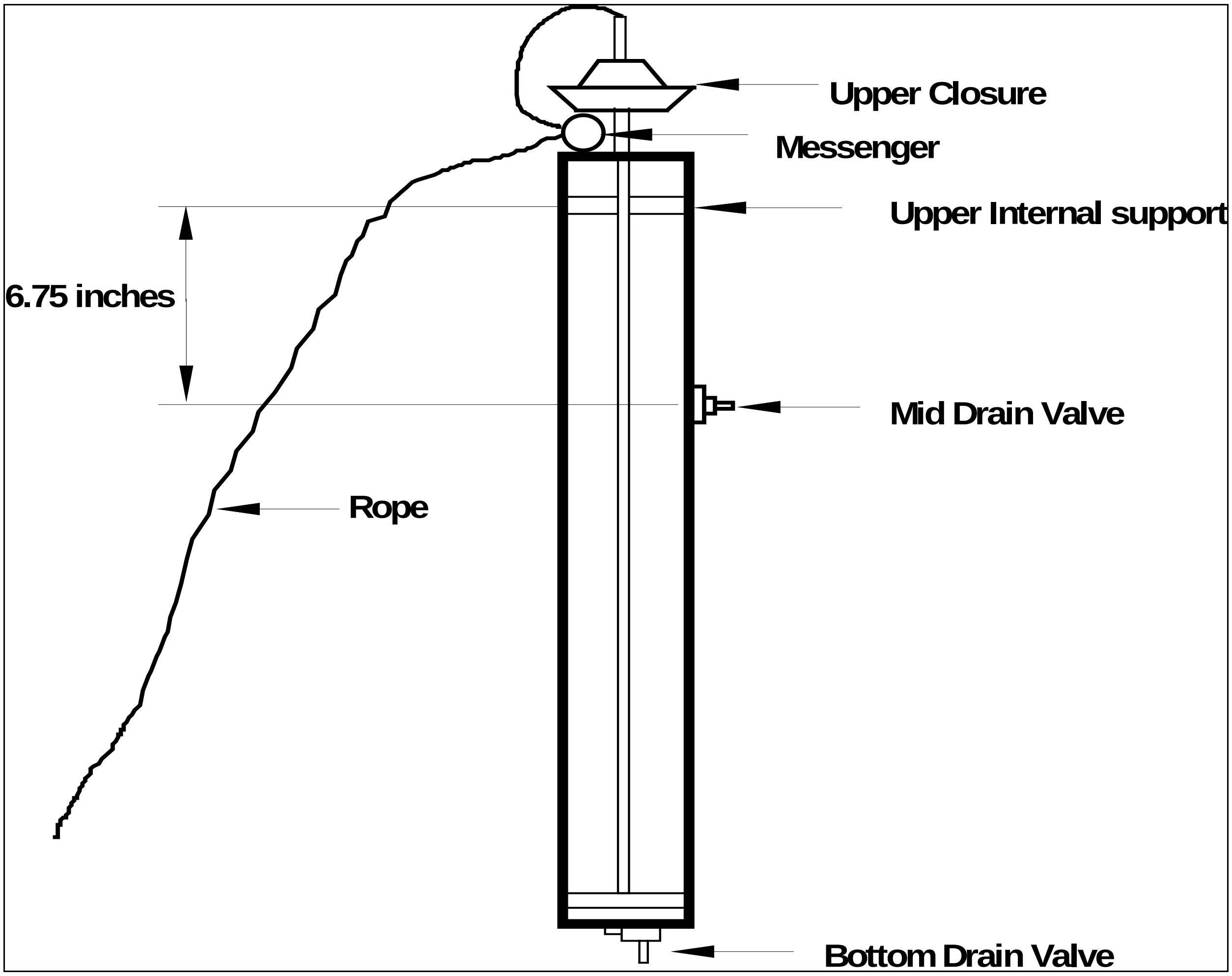

Figure 1
4.2 L KEMMERER SAMPLER
CHEMICALLY ENHANCED PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

Figures 2 through 4 show the relationship between settling times and TSS concentrations of the supernatant for the three dosages.

The solid curve presented in Figures 2 through 4 is represented by the following equation.

$$TSS_{sup} = TSS_{non} + (TSS_{in} - TSS_{non})\, e^{(-\lambda t)}$$

Where

TSS_{sup} = supernatant TSS concentration (mg/L)

TSS_{non} = Non-settleable concentration (mg/L)

TSS_{in} = initial concentration (mg/L)

λ = Settling parameter – curve fitting parameter (min-1)

t = settling time (min)

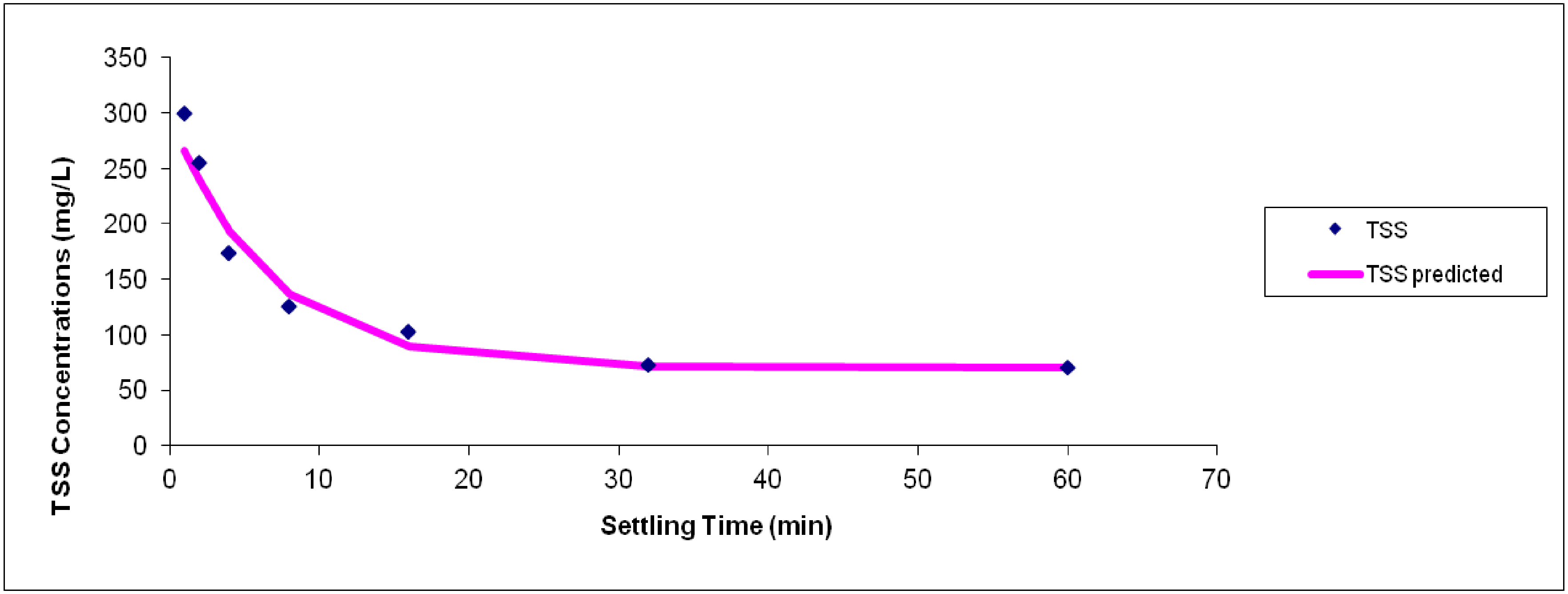

Figure 2
RELATIONSHIP BETWEEN SETTLING TIME AND SUPERNATANT CONCENTRATION – FERRIC CHLORIDE OF 10 MG/L AND POLYMER OF 0.1 MG/L
CHEMICALLY ENHANCED PRIMARY TREATMENT
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CITY OF SUNNYVALE

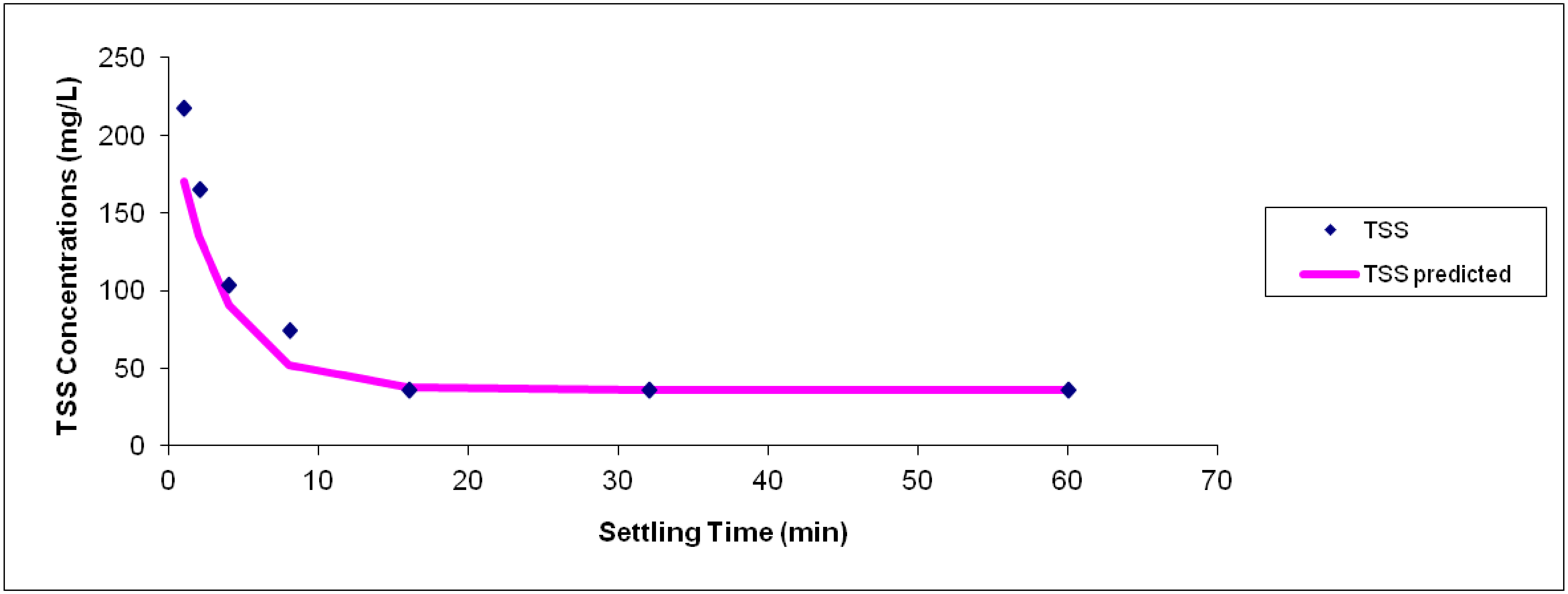

Figure 3
RELATIONSHIP BETWEEN SETTLING TIME AND SUPERNATANT CONCENTRATION – FERRIC CHLORIDE OF 20 MG/L AND POLYMER OF 0.2 MG/L
CHEMICALLY ENHANCED PRIMARY TREATMENT MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

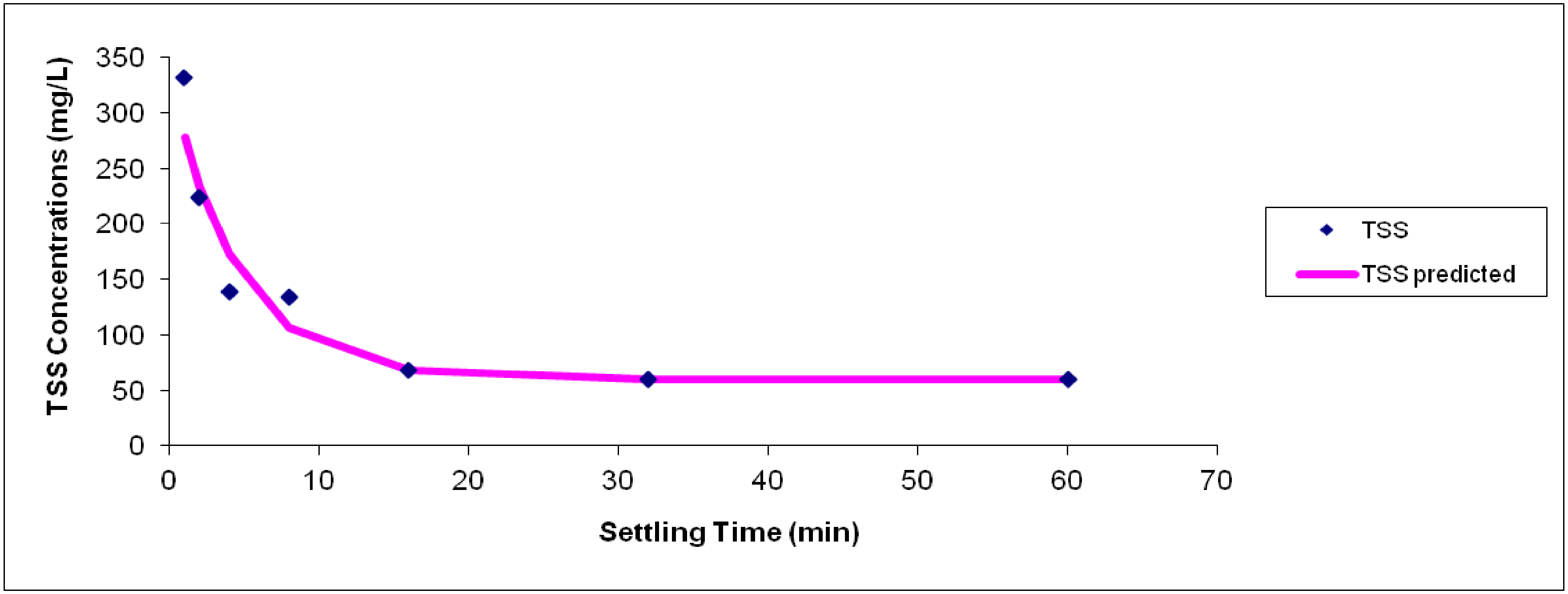

Figure 4
RELATIONSHIP BETWEEN SETTLING TIME AND SUPERNATANT CONCENTRATION – FERRIC CHLORIDE OF 20 MG/L WITH NO POLYMER
CHEMICALLY ENHANCED PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

3.0 DEVELOPMENT OF SETTLING VELOCITY DISTRIBUTIONS

The relationships between settling time and TSS concentrations were used to develop the settling velocity distributions. The settling time was converted to settling velocity by knowing the settling distance in the Kemmerer sampler (6.75 inches). Also, the removal efficiency at a specific settling velocity is the fraction of solids that has a settling velocity greater than or equal to that specific velocity. The relationship between the settling velocity and fraction of solids are shown in Figures 5 through 7. These figures also show the level of non-settleable solids for the three dosages. The results showed the average settling velocity with CEPT is ranges from 1.6 in/min to 2.54 in/min, depending on the dose, which falls within the typical range of 1.5 in/min to 3.5 in/min. It is also clear from the figures that adding more chemicals will increase settling velocity. In general these results from the three tests are consistent with tests previously performed at other facilities by HDR/Carollo team.

However, CEPT didn't decrease the level of non-settleable solids (solids with near zero settling velocity) significantly. This could be due to the fact the incoming influent suspended solids have a low level of non-settleable solids. The low level of non-settleable solids could be the result of high salinity levels in the incoming wastewater or good flocculation in the aerated grit chambers. .Also, adding polymer did not improve the solids settling velocity of the solids.

It was concluded from the CEPT testing that the optimal dosage would be 20 mg/L of Ferric Chloride and 0.2 mg/L of polymer because it provided the largest settling velocity with low non-settleable solids. This dose correlated to an average settling velocity of 2.54 in/min which is considered a good settling velocity and falls within the typical range of 1.5 in/min to 3.5 in/min. This is considered a high dosage of chemicals when compared to the more commonly used dosage of 10 mg/L of Ferric and 0,1 mg/L of polymer. The annual cost of adding chemicals at these high dosage rates will be in excess of $1.5 million.

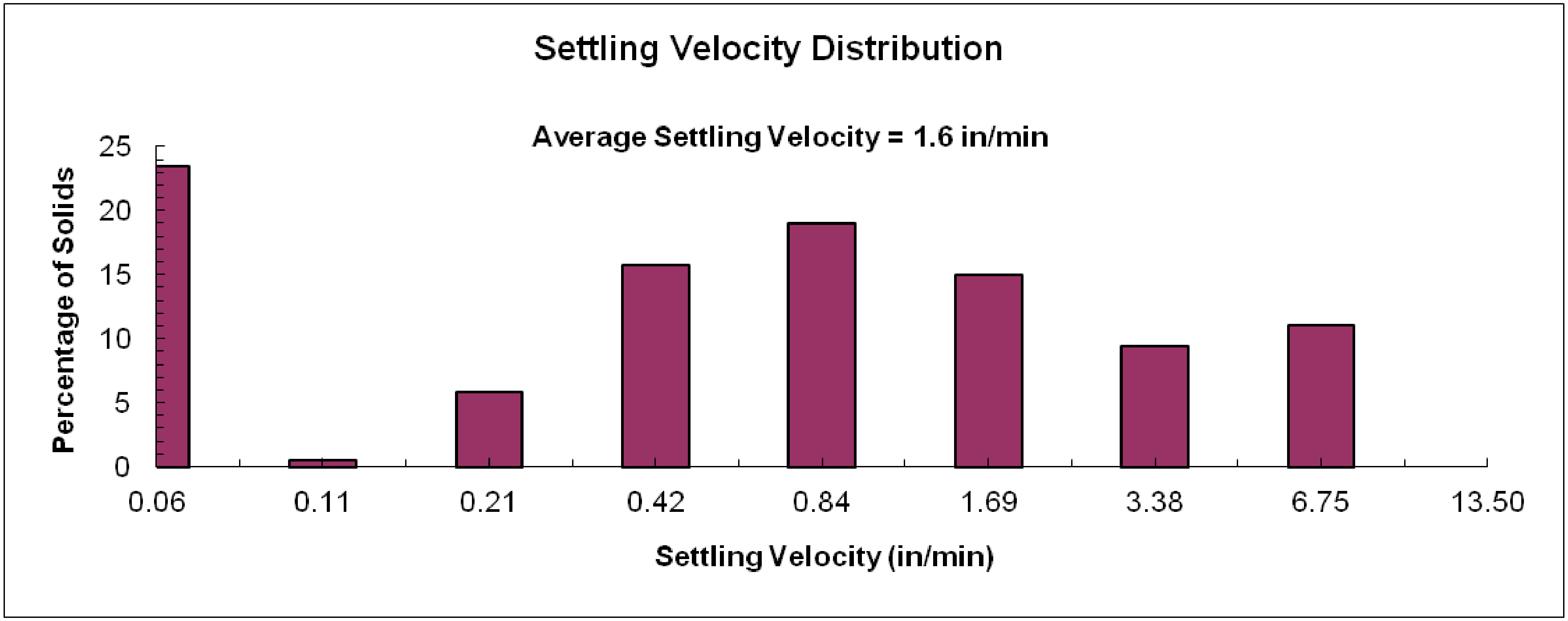

Figure 5
SETTLING VELOCITY DISTRIBUTION – FERRIC CHLORIDE OF 10 MG/L AND POLYMER OF 0.1 MG/L
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MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

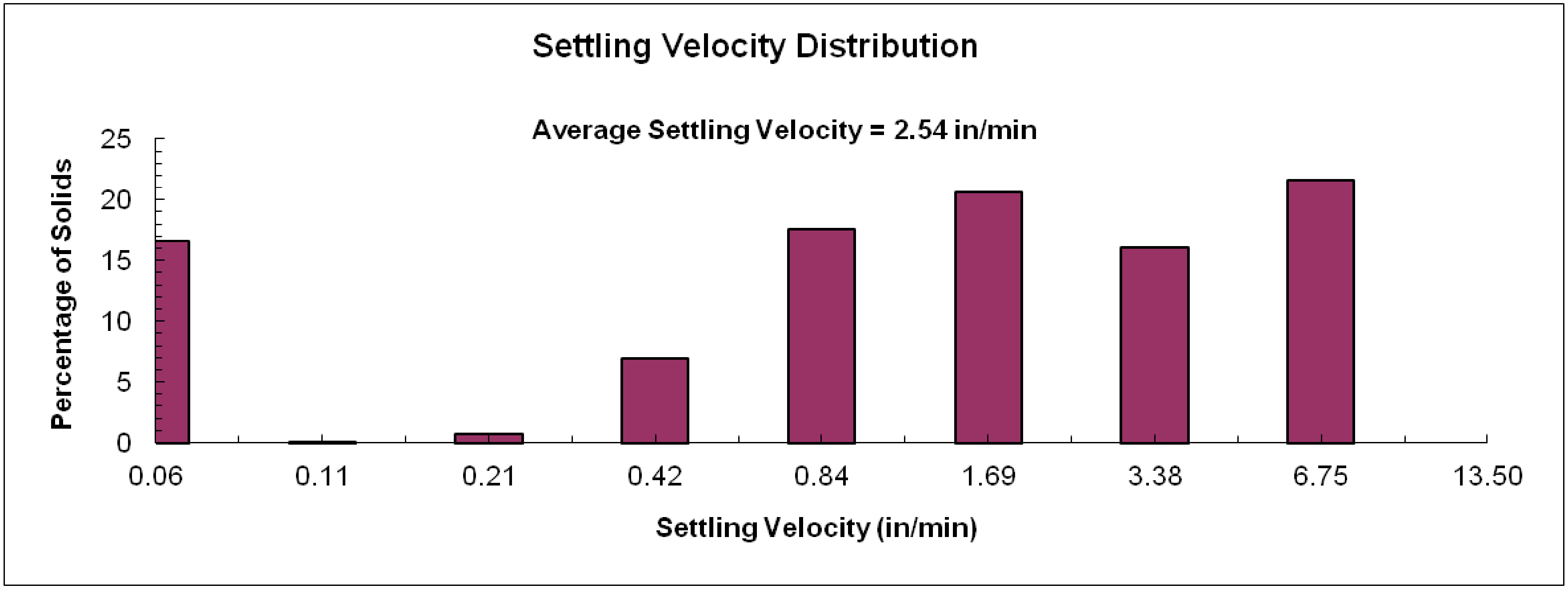


Figure 6
SETTLING VELOCITY DISTRIBUTION – FERRIC CHLORIDE OF 20 MG/L AND POLYMER OF 0.2 MG/L
CHEMICALLY ENHANCED PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

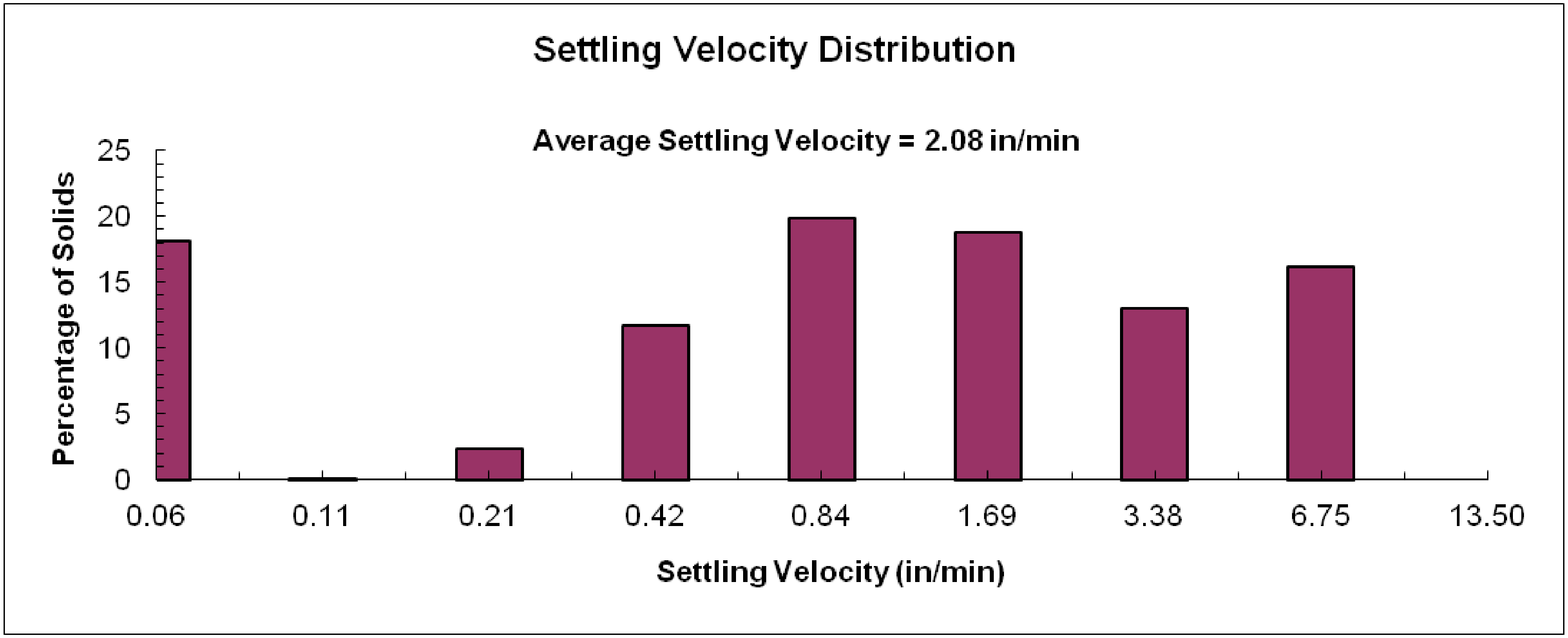


Figure 7
SETTLING VELOCITY DISTRIBUTION – FERRIC CHLORIDE 20 MG/L WITH NO POLYMER
CHEMICALLY ENHANCED PRIMARY TREATMENT
MASTER PLAN AND PRIMARY TREATMENT DESIGN
CITY OF SUNNYVALE

4.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the data collected and analyzed, the following conclusions were made:

1. The optimal dosages would be 20 mg/L of Ferric Chloride and 0.2 mg/L for polymer.
2. The resulting average settling velocity is 2.54 in/min which is considered a good settling velocity for CEPT application and falls within the typical range of 1.5 in/min to 3.5 in/min.

It is recommended to use the optimal dosage obtained from CEPT testing as an input to the clarifier modeling efforts to determine the expected removal efficiency of the proposed tanks under different loading conditions. The results of the modeling efforts are presented in Primary Sedimentation Tank and Secondary Treatment Technical Memoranda.

APPENDIX A – JAR TESTING

APPENDIX A: JAR TESTING

A series of jar tests will be performed by City staff to determine the optimal dosages of Ferric Chloride and polymer. A six-paddle tester will be used. It is recommended to test Ferric dosages of 10, 15 and 20 mg/L and polymer dosages of 0.1, 0.15 and 0.2 mg/L. City staff had expressed interest in testing two types of polymer. At the time of preparation of this testing protocol, only one type polymer was selected for testing. Each test will include a series of samples as follows:

Sample 1 – A control sample (sample of the primary influent with no chemicals),

Sample 2 – A sample with 10 mg/L Ferric and subject to rapid mixing (300 rpm for 30 seconds) followed by gentle mixing (50 rpm) for 15 minutes.

Sample 3 – A sample with 15 mg/L Ferric Chloride and subject to rapid mixing (300 rpm for 30 seconds) followed by gentle mixing (50 rpm) for 15 minutes.

Sample 4 – A sample with 20 mg/L Ferric Chloride and subject to rapid mixing (300 rpm for 30 seconds) followed by gentle mixing (50 rpm) for 15 minutes.

Sample 5 – A sample with 10 mg/L Ferric Chloride and 0.1 mg/L of anionic polymer and subject to rapid mixing (300 rpm for 30 seconds) followed by gentle mixing (50 rpm) for 15 minutes.

Sample 6 – A sample with 20 mg/L Ferric Chloride and 0.2 mg/L of anionic polymer and subject to rapid mixing (300 rpm for 30 seconds) followed by gentle mixing (50 rpm) for 15 minutes.

Table A-1 shows the testing schedule and the required laboratory analyses. Based on the results of the first day, chemicals dosages could be modified on the second day of testing.

Table A-1 CEPT Testing

Sample	Number of Samples	TSS	tBOD/sBOD
Jar Test (day one)	6	Yes	Yes/yes
Jar Test (day two)	6	Yes	Yes/yes

CONSULTANT Responsibilities:

- Provide the Jar tester.
- Supervise the testing on the first day.
- Select the optimal dosage based on data provided by City staff

City Responsibilities:

- Provide the chemicals.
- Perform Jar testing.
- Perform laboratory tests and provide the data to Consultant.

APPENDIX B – CHEMICALLY ENHANCED PRIMARY TREATMENT TESTING

APPENDIX B: CHEMICALLY ENHANCED PRIMARY TREATMENT TESTING

The optimal dosages determined during jar testing (Appendix B) will be applied to samples of the primary clarifier influent. Then, the samples will be poured into Kemmerer 4.2-L samplers (settling columns shown in Figure B-1) and samples of supernatant will be collected. Following are the procedures for performing the settling tests:

1. A sampling location at the front end of one of the primary clarifiers will identified and used to collect samples of the primary influent.
2. Kemmerer sampler or (a similar sampler) will be lowered below the water surface, and closed using the messenger. The water surface in the sampler will be lowered to mid point of the upper support by opening the bottom valve. The drained water will be collected in a 5-gallon bucket.
3. The sample will be poured into another 5-gallon bucket and gently mixed to ensure no settling in the bucket. Then the samples will be poured into the 2-L jars of the jar tester. A minimum of three jars will be used. The optimal dosages of chemicals will be applied to the jars. Samples will be subject to rapid mixing (300 rpm for 30 seconds) and gentle mixing (50 rpm for 15 minutes).
4. The contents of the 2-L jars will then be poured into a vertically secured Kemmerer sampler.
5. The sampler will be allowed to settle for a predefined settling time.
6. After the settling time elapse, a 1-liter sample will be collected through the sampling port located at 6.75 inches from mid point of the sampler upper support.
7. The sample will be then delivered to the laboratory to be analyzed for total suspended solids (TSS) and BOD as indicated in Table 2.
8. 8. Steps 2 through 6 will be repeated using different settling times. Settling times of 0.5, 1.0, 2.0, 4.0, 8.0, 16.0, and 32 minutes are to be used.
9. Steps 2 through 6 will be repeated and the sample will be allowed to settle for 60 minutes. The concentration of the supernatant is known as the non-settleable solids concentration.
10. The contents of the 5-gallon bucket should be mixed and a sample of the influent TSS to be collected. This sample is considered a composite sample of the influent suspended solids.

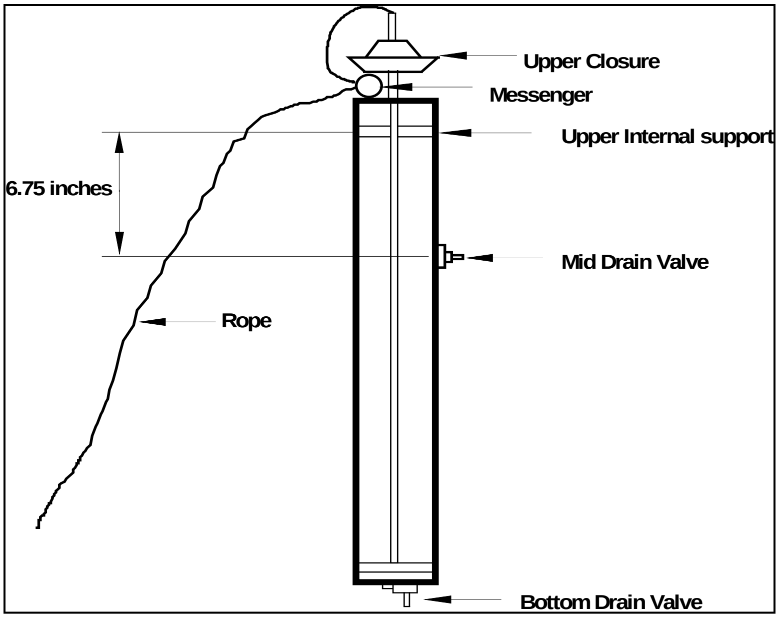


Figure B-1 A schematic of the 4.2-liter Kemmerer sampler

Table B-1 CEPT Settling Velocity Distribution Testing			
Sample	**Number of Samples**	**TSS**	**tBOD/sBOD**
SVD (day three)	10	Yes	Yes/No
SVD (day four)	10	Yes	Yes/No

CONSULTANT Responsibilities:

- Provide the Kemmerer samplers.
- Provide supervision on the one of the testing days.

City Responsibilities:

- Perform the settling velocity tests.
- Perform laboratory tests.

APPENDIX C – TESTING RESULTS

APPENDIX C: TESTING RESULTS

City of Sunny Vale
Field Testing
July 16 through July 29

Sample ID	Key	Chemical	Laboratory Analyses	TSS	TSS Dup	TSS avg	BOD (mg/L)
CEPT 1 -1	CEPT - first day of testing - one minute of settling time	10 mg/l Ferric + 0.1 poly	TSS/total BOD	297	300	299	206
CEPT 1 - 2	CEPT - first day of testing - 2 minutes of settling time	10 mg/l Ferric + 0.1 poly	TSS/total BOD	257	252	255	204
CEPT 1 -4	CEPT - first day of testing - 4 minutes of settling time	10 mg/l Ferric + 0.1 poly	TSS/total BOD	163	185	174	162
CEPT 1 - 8	CEPT - first day of testing - 8 minutes of settling time	10 mg/l Ferric + 0.1 poly	TSS/total BOD	125	127	126	141
CEPT 1 -16	CEPT - first day of testing - 16 minutes of settling time	10 mg/l Ferric + 0.1 poly	TSS/total BOD	103	103	103	68
CEPT 1 -32	CEPT - first day of testing - 32 minutes of settling time	10 mg/l Ferric + 0.1 poly	TSS/total BOD	73	72	73	79
CEPT 1 - 60	CEPT - first day of testing - 60 minutes of settling time	10 mg/l Ferric + 0.1 poly	TSS/total BOD	70	72	71	107
~~CEPT 1 - INF~~	~~CEPT - first day of testing - Influent TSS composite~~		~~TSS/total BOD~~				
~~CEPT 1 - EFF~~	~~CEPT - first day of testing - Effluent TSS grab~~		~~TSS/total BOD~~				
SECOND	**DAY OF TESTING**						
CEPT 2 -1	CEPT - second day of testing - one minute of settling time	20 mg/l Ferric + 0.2 poly	TSS/total BOD	213	220	217	130
CEPT 2 - 2	CEPT - second day of testing - 2 minutes of settling time	20 mg/l Ferric + 0.2 poly	TSS/total BOD	165	165	165	102
CEPT 2 -4	CEPT - second day of testing - 4 minutes of settling time	20 mg/l Ferric + 0.2 poly	TSS/total BOD	103	103	103	52
CEPT 2 - 8	CEPT - second day of testing - 8 minutes of settling time	20 mg/l Ferric + 0.2 poly	TSS/total BOD	78	90	84	56
CEPT 2 -16	CEPT - second day of testing - 16 minutes of settling time	20 mg/l Ferric + 0.2 poly	TSS/total BOD	33	39	36	25
CEPT 2 -32	CEPT - second day of testing - 32 minutes of settling time	20 mg/l Ferric + 0.2 poly	TSS/total BOD	36	36	36	37
CEPT 2 - 60	CEPT - second day of testing - 60 minutes of settling time	20 mg/l Ferric + 0.2 poly	TSS/total BOD	42	45	44	80
~~CEPT 2 - INF~~	~~CEPT - second day of testing - Influent TSS composite~~		~~TSS/total BOD~~				
~~CEPT 2 - EFF~~	~~CEPT - second day of testing - Effluent TSS grab~~		~~TSS/total BOD~~				

Third	DAY OF TESTING						
CEPT 3 -1	CEPT - first day of testing - one minute of settling time	20 mg/l Ferric only	TSS/total BOD	325	338	332	226
CEPT 3 - 2	CEPT - first day of testing - 2 minutes of settling time	20 mg/l Ferric only	TSS/total BOD	233	215	224	162
CEPT 3 -4	CEPT - first day of testing - 4 minutes of settling time	20 mg/l Ferric only	TSS/total BOD	135	143	139	104
CEPT 3 - 8	CEPT - first day of testing - 8 minutes of settling time	20 mg/l Ferric only	TSS/total BOD	132	135	134	133
CEPT 3 -16	CEPT - first day of testing - 16 minutes of settling time	20 mg/l Ferric only	TSS/total BOD	70	66	68	63
CEPT 3 -32	CEPT - first day of testing - 32 minutes of settling time	20 mg/l Ferric only	TSS/total BOD	62	58	60	74
CEPT 3 - 60	CEPT - first day of testing - 60 minutes of settling time	20 mg/l Ferric only	TSS/total BOD	62	60	61	108
~~CEPT 3 - INF~~	~~CEPT - first day of testing - Influent TSS composite~~		~~TSS/total BOD~~				
~~CEPT 3 - EFF~~	~~CEPT - first day of testing - Effluent TSS grab~~		~~TSS/total BOD~~				

APPENDIX D – PRIMARY SEDIMENTATION TANK MODELING

APPENDIX D: PRIMARY SEDIMENTATION TANK MODELING

This technical memorandum discusses the computational fluid dynamic (CFD) analysis of the new primary sedimentation tanks and field testing on the existing PSTs. Field testing was performed to determine the settling velocity distribution (SVD) of the incoming suspended solids. CFD analysis was performed to determine the size of the PSTs and the optimal internal arrangements needed to achieve the best performance.

1.0 BACKGROUND

PSTs are the workhorse at the City's water pollution control plant. They remove total suspended solids (TSS) and the particulate biochemical oxygen demand (pBOD) associated with the TSS. Currently, the plant has ten rectangular PSTs. Each PST is approximately 110-foot long, 19-foot wide and 9-foot deep. It had been recommended in the Strategic Infrastructure Plan (SIP) that existing PSTs be replaced with newer units. The performance of the new PSTs will greatly affect the performance of the downstream proposed activated sludge process. The larger the new PSTs, the higher the construction cost and the lower the biological loading on the downstream processes will be. Therefore, the project team decided to use CFD analysis to ensure that new PSTs are optimally sized and designed to provide best performance at the lowest possible cost.

The purpose of the CFD analysis was twofold:

1. Determine the optimal size of the new PSTs.
2. Determine the most cost effective internal arrangements.

HDR used its computer model the High Accuracy Clarifier Model (HACM©) to perform the CFD analysis.

1.1 Field Testing

A series of settling tests were performed on 16, 17 and 19 July 2013 at the Plant to determine the SVD of the primary influent suspended solids. The SVD was then used as an input to HDR's HACM© to determine the suspended solids removal efficiency of the new PSTs.

A 4.2 liter Kemmerer sampler (as shown in Figure 1) was used to determine the settling characteristics of the influent suspended solids. The following steps were used in conducting the settling tests as outlined in the field testing protocol:

1. A sampling location at the end of one of the pre-aeration tanks was used to collect samples of the primary influent.
2. The Kemmerer sampler was lowered below the water surface, and was then closed using the messenger.

3. The sampler was brought to the surface. The water surface in the sampler was lowered to mid point of the upper support by opening the bottom valve. The drained water collected in a 5-gallon bucket.
4. The sample was allowed to settle for a predefined settling time.
5. After the settling time had elapsed, a 1-liter sample was collected through the sampling port located at 6.75 inches from mid point of the sampler upper support.
6. The sample was then delivered to the Plant's laboratory to be analyzed for total suspended solids (TSS), and pBOD.
7. Steps 2 through 6 were repeated using different settling times. Settling times of 0.5, 1.0, 2.0, 4.0, 8.0, 16.0, and 32 minutes were used.
8. Steps 2 through 6 were repeated and the sample was allowed to settle for 60 minutes. The concentration of the supernatant is known as the non-settleable solids concentration (NSS).
9. The contents of the 5-gallon bucket were mixed and a sample of the influent TSS was collected. This sample was considered a composite sample of the influent suspended solids.

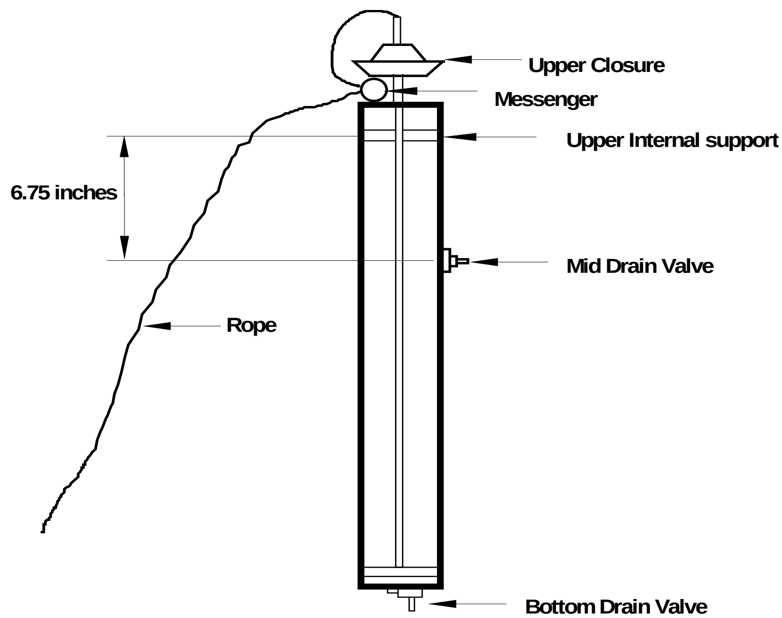


FIGURE 1. A SCHEMATIC OF THE 4.2-LITER KEMMERER SAMPLER

Figure 2 shows the relationship between the settling time and the supernatant concentration. The field testing indicated:

- The level of non-settleable solids in the PST influent = 63 mg/L
- The PST influent suspended solids concentration = 310 mg/L
- The percentage of non-settleable solids in the PST influent = 20 percent

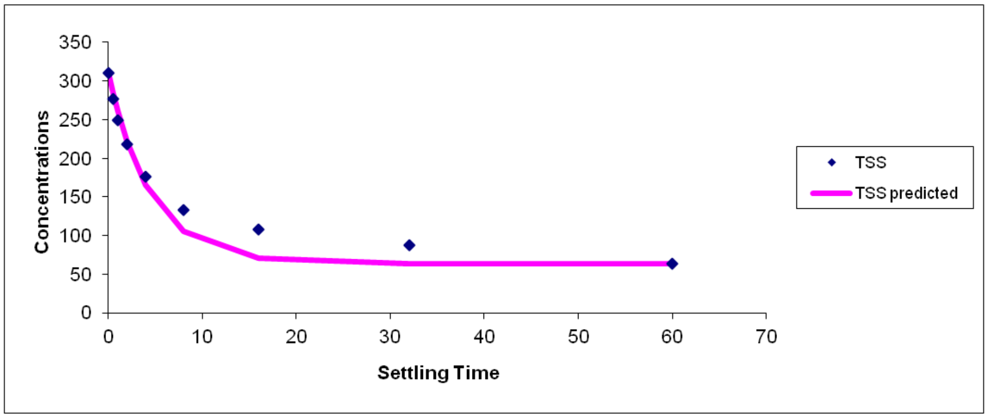


FIGURE 2. THE RELATIONSHIP BETWEEN SETTLING TIME AND SUPERNATANT CONCENTRATION

Knowing the settling distance in the Kemmerer sampler, the settling time was converted to settling velocity. Figure 3 shows the average SVD of the all the samples of influent suspended solids collected during the three day period. The average settling velocity was approximately 1.46 in/min which is considered good settling velocity and partially explains the good performance of the existing PSTs. Also, it should be noted that the non-settleable solids level of 20 percent is low which leads to better than average solids removal at the existing PSTs. This low level of nonsettleable solids could be due to adequate flocculation provided by the pre-aeration tanks and/or high level of salinity in the incoming wastewater.

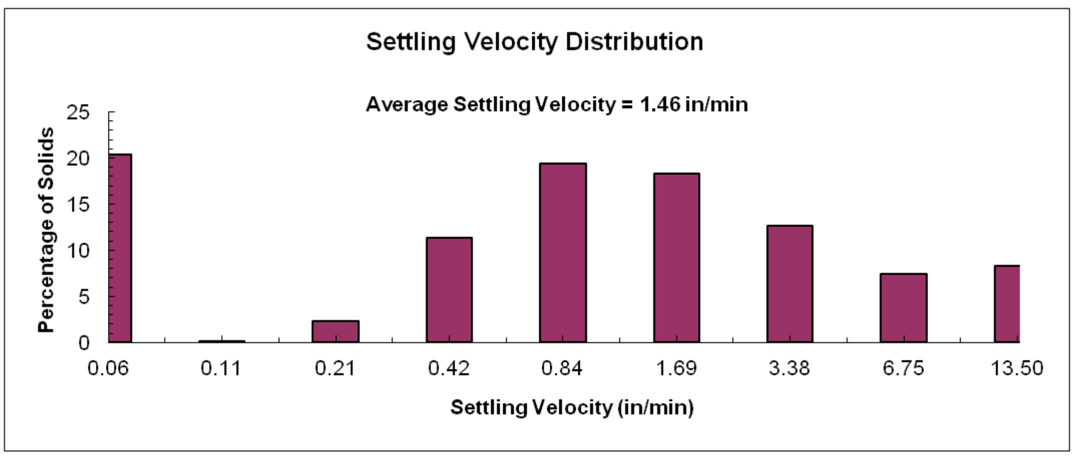


FIGURE 3. SETTLING VELOCITY DISTRIBUTION (SVD) OF THE INFLUENT SUSPENDED SOLIDS (JULY 2013)

1.1.1 Computational Fluid Dynamic Modeling

CFD was used to determine the cost effective size of the new PSTs and select the optimal internal arrangements. The following subsection describe the procedures and presents results of the CFD modeling

1.2 Sizing of Primary Sedimentation Tanks

The plant future flows were analyzed to determine design flow rate. In the CFD analysis, it was assumed that year 2035 would be the design year. In 2035, the maximum month flow rate will be 26.2 mgd. In order to determine the most cost effective size of the new PSTs, two possible configurations were analyzed using CFD. The first configuration was based on the SIP recommendation of building five PSTs. Each PST would be 105-foot long, 20-foot wide and 12-foot deep. The performance of the PSTs was evaluated under different over flow rates (OFRs) ranging from 600 to 4000 gpd/ft2. An influent suspended solids concentration of 310 mg/L was used. The total suspended solids removal efficiency was estimated under different OFRs for conventional treatment and chemically enhanced primary treatment (CEPT). The SVD for CEPT was determined based on field testing performed by City staff as documented in the *Chemically Enhanced Primary Treatment* technical memorandum. Figures 4 and 5 show the removal efficiency for conventional and CEPT cases, respectively.

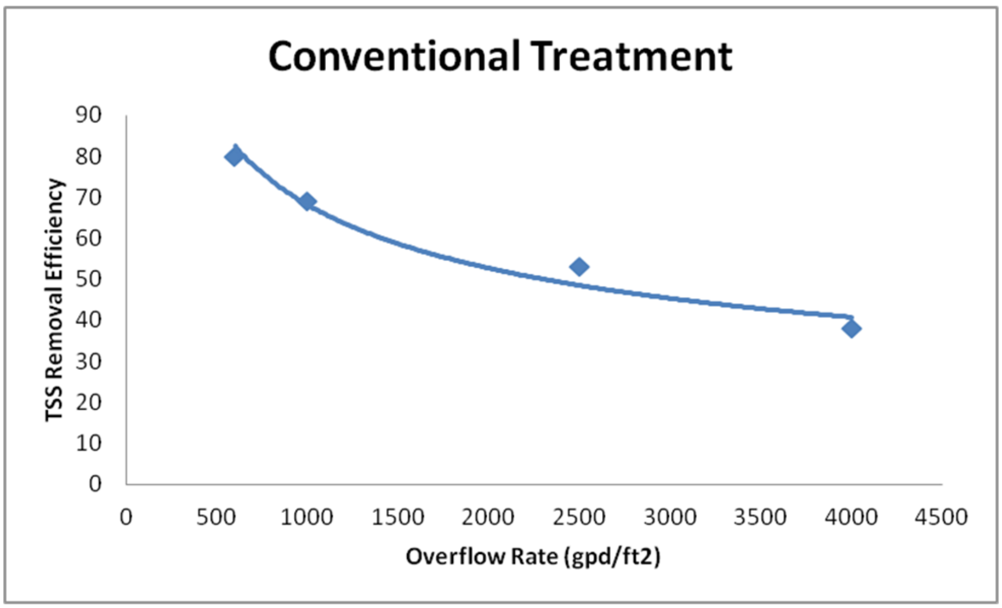


FIGURE 4. SUSPENDED SOLIDS REMOVAL EFFICIENCY FOR CONVENTIONAL TREATMENT (FIVE PSTS – 105' X 20' X 12')

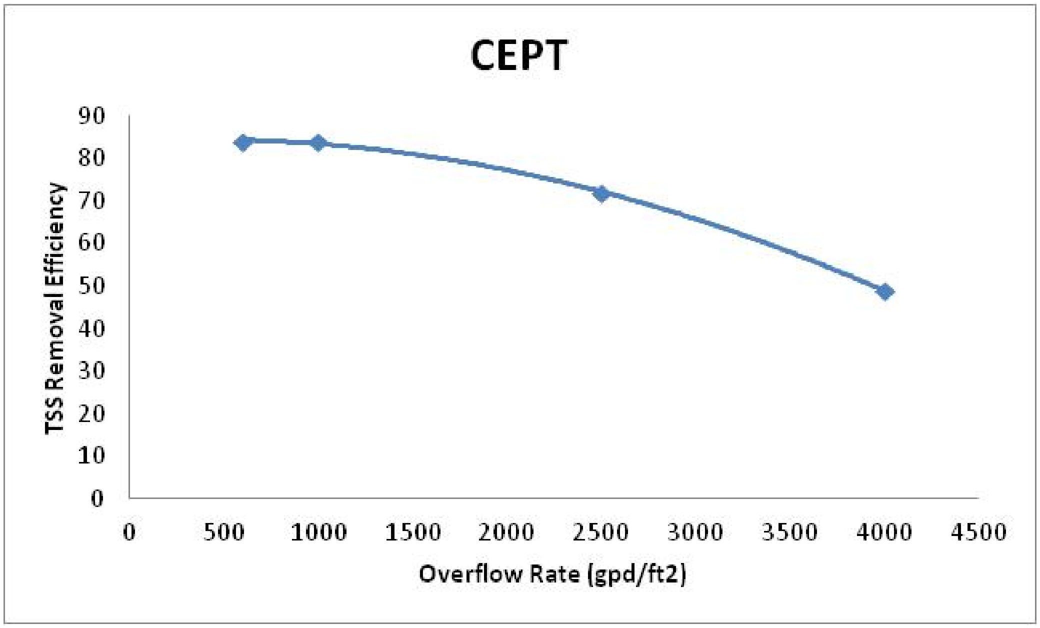


FIGURE 5. SUSPENDED SOLIDS REMOVAL EFFICIENCY FOR CEPT (FERRIC CHLORIDE = 20 MG/L AND POLYMER = 0.2 MG/L, FIVE PSTS – 105' X 20' X 12')

Figure 4 shows that PSTs can achieve TSS removal efficiency of approximately 47 percent at OFR of 2500 gpd/ft2. Figure 5 shows that at the same OFR (2500 pgd/ft2), PSTs can achieve 70 percent of TSS removal when chemicals are used. However, the cost of adding chemicals will be high and may not justify the improvement of performance. Therefore, the decision was made to use CEPT under wet weather conditions and when one of the PSTs is offline.

As mentioned previously, the conventional treatment removal efficiency curve was developed using influent suspended solids concentration of 310 mg/L which was measured during field testing. However, analysis of flows and loadings indicated that future influent suspended solids during maximum month would be 210 mg/L. Therefore, the CFD analysis was repeated using influent TSS concentration of 210 mg/L. Figure 6 shows the field testing and planning curves.

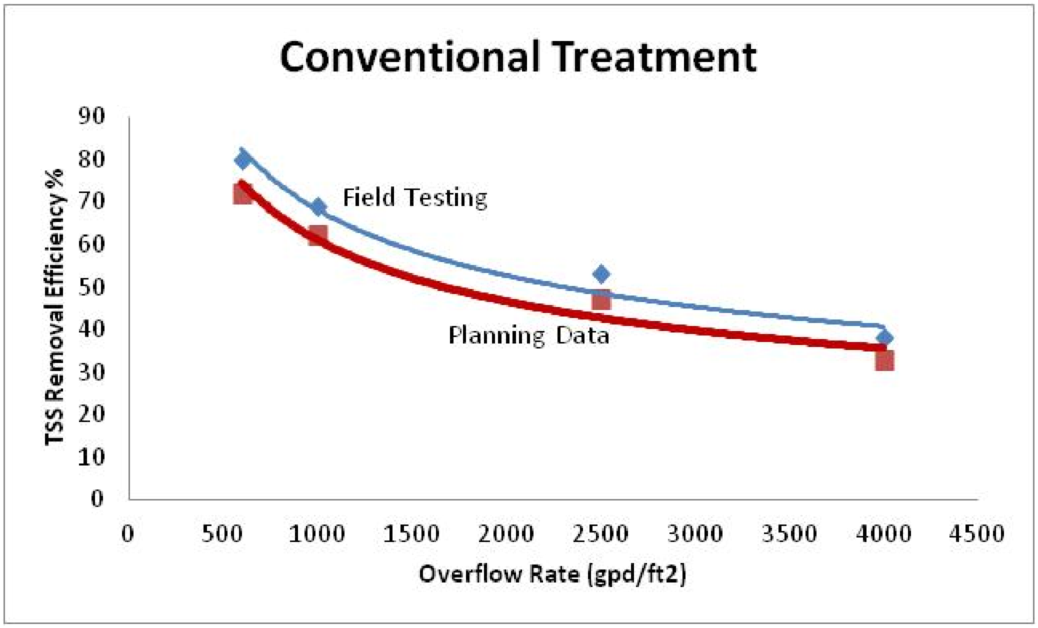


FIGURE 6. SUSPENDED SOLIDS REMOVAL EFFICIENCY FOR FIELD TESTING (INFLUENT TSS = 310 MG/L) AND PLANNING DATA (INFLUENT TSS = 210 MG/L

The results obtained from the analysis was then used an input to the activated biological model. By integrating the PSTs model with the biological model, project team was able to select the most cost effective OFR for the new PST

1.3 Design of New PSTs

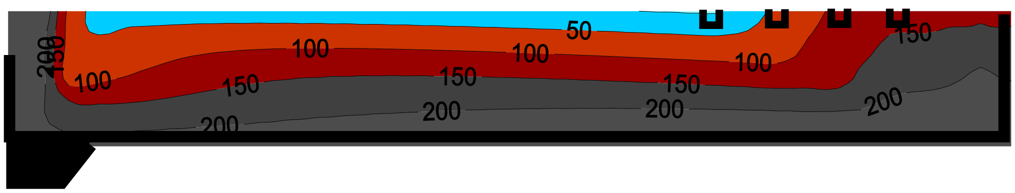
The integration of removal efficiency curves with biological modeling indicated that the optimal OFR for the new PSTs would be 2000 gpd/ft2. Different alternatives for the number of PSTs to be provided were considered: (a) three larger tanks (115' x 38' x 14') with two basins per tank separated by an internal wall, (b) four separate long tanks (165' x 20' x 14') and (c) six separate tanks (115' x 19' x 14'). If three or four tanks are constructed, the level of redundancy is reduced because when a tank is taken out of service, more flow (33 percent more and 25 percent more respectively) is distributed to the in-service tanks. If six tanks are constructed and a basin is taken out of service, only 17 percent of influent flow is distributed to the in-service basins. Thus, the six tank option provides more redundancy and operational flexibility. It also should be noted that it has been our experience that PST length not to exceed 150 feet if equipped with single hopper at the front end of the tank. PSTs longer then 150 foot long should be equipped with multiple hoppers to avoid over stressing chain and flight mechanisms. Therefore, the four tank option would be more expensive to construct than other options. It was decided by the project team to select the six tank option.

High accuracy clarifier model was used to build a model of one of the PSTs. It was assumed that the flow would be equally split between the PSTs and each PST would receive 4.37 mgd under maximum month conditions in year 2035. It was assumed that new PST would be equipped with state-of-the-art performance enhancement features. The performance enhancement feature evaluated in this analysis included:

1. Four transversal launders.
2. Inlet flocculating perforated baffles (wood and fiberglass)
3. Fist set of mid-tank perforated baffles (wood and fiberglass)
4. Second set of mid tank baffles (wood and fiberglass).
5. Sludge protector canopy system (fiberglass)

1.4 Transversal Launders

The use of transversal launders to collect effluent from rectangular PST is preferred due its favorable effect of density currents inside the tank leading to lower effluent suspended solids. In this analysis, it was assumed that PST would be equipped with four transversal launders. The last launder would be located 14 feet from the end wall. The launders would be placed 7 foot apart. Figure 7 shows the model output. The iso-concentration lines show the suspended solids concentration for this case. Model predicted that effluent suspended solids would be 134 mg/L with removal efficiency of 36 percent.



Effluent Flow Rate = 4.37 mgd ***Influent TSS = 210 mg/L*** ***Effluent TSS = 134 mg/L***

FIGURE 7. MODEL OUTPUT FOR THE BASE CASE – PST WITH TRANSVERSAL LAUNDERS

1.5 Influent Flocculation Baffles

The use of inlet perforated baffles in rectangular PSTs has been a standard design practice for many years. The main purpose of the perforated baffles is to distribute the incoming flow uniformly across the width of the PST. For the City's PSTs , the inlet baffles must serve two functions; distribute the flow across the width of the PST and form a flocculation chamber at the front end of the tank. The effect of installing an influent flocculation baffle system was evaluated using HACM. Two baffle systems were evaluated; fiberglass and wood.

1.5.1 <u>Fiberglass Baffle System</u>

The use of fiberglass baffles in clarifiers has increased over the last two decades. Fiberglass baffles provide high durability, light weight and ease of installation and maintenance features, all of which are attractive for PST applications. Figure 8 shows a front view and a cross section of a perforated fiberglass baffle system known as FLOCLIP (Integrated perforated flocculating baffle system -US patent 7,717,275). The system is patented by Dr. Hany Gerges. No patent royalty fees will be collected for the application of the system at the City's plant. The system is not proprietary to a specific manufacture or vendor and has been successfully implemented at many treatment plants.

The panels are 2-foot wide and 6-foot deep. The top three (3) feet of each panel is solid and the bottom three (3) feet is perforated. The panels are hooked together by clamps with 4 to 6 inch gaps between the panels. The baffle system would be located 9 feet from the inlet wall.

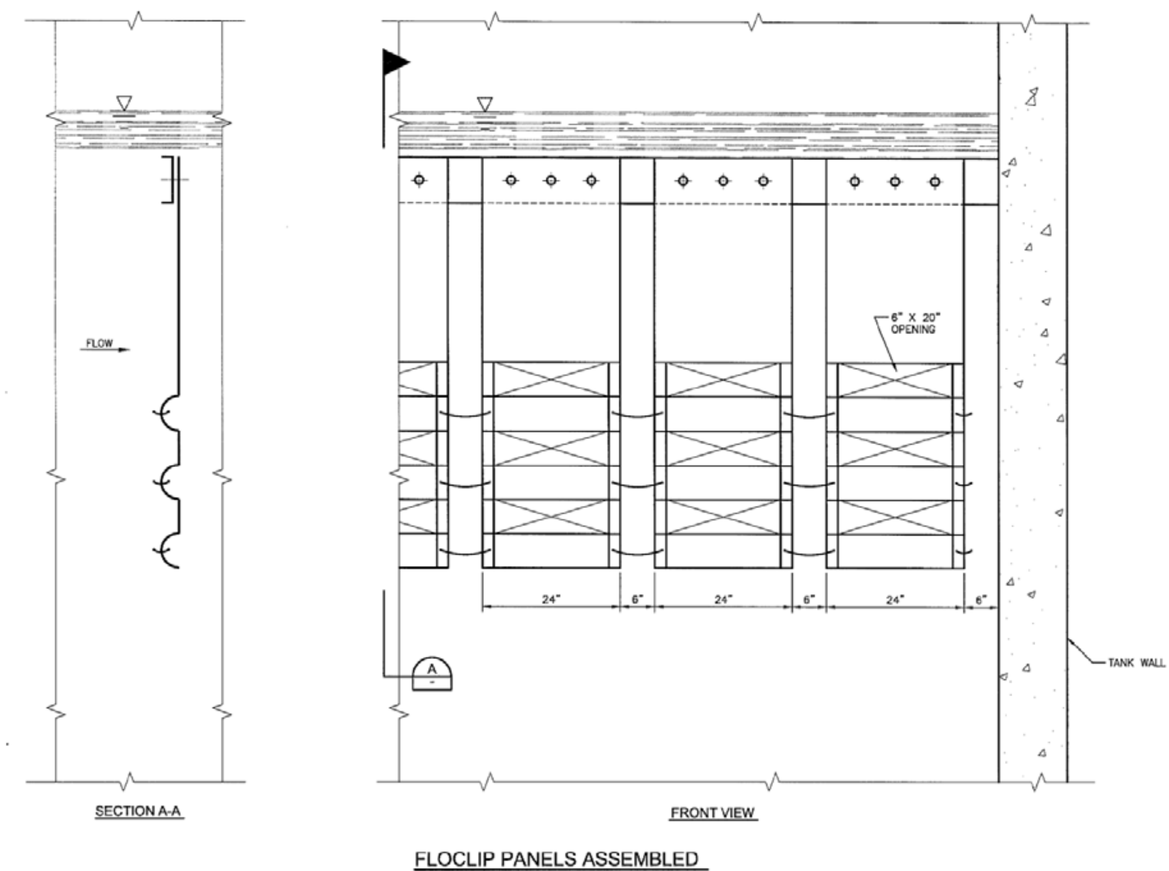


FIGURE 8. FRONT VIEWS AND CROSS SECTION OF FLOCLIP BAFFLE SYSTEM

1.5.2 Wood Baffle System

The effect of installing a wood finger baffle system was also investigated using HACM. Figure 9 shows a cross section of the proposed finger baffle system. The top five (5) feet of the baffle is solid to promote flocculation and the bottom three (3) feet are perforated to distribute the flow across the width. The effect of installing the finger wood baffle was investigated by using HACM©. The finger wood baffle would be located 9 feet from the PSTs inlet gates.

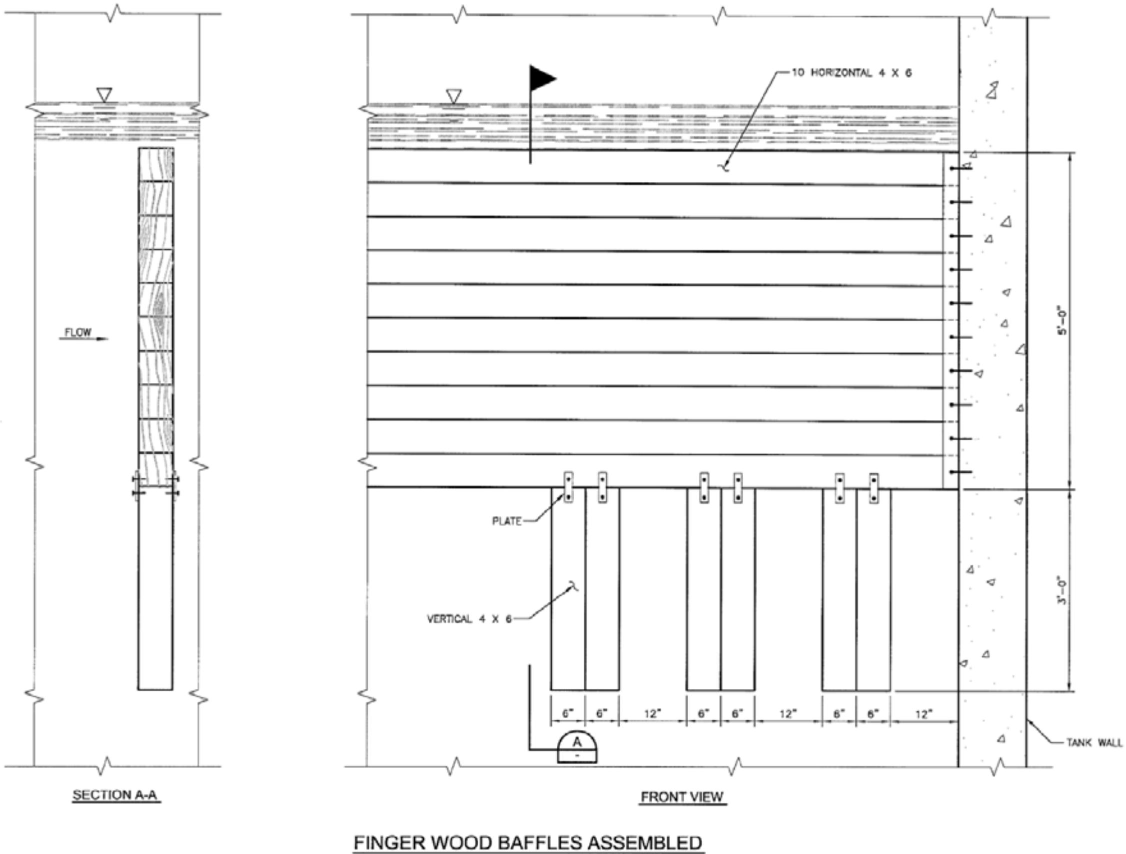


FIGURE .9 FRONT VIEW AND CROSS SECTION OF THE INLET FINGER WOOD BAFFLES

Modeling indicated that installation of influent baffle system would lower PST effluent suspended solids from 134 mg/L to about 127 mg/L, i.e., about increasing removal efficiency from 36 to 39.5 percent. . Both FLOCLIP and finger wood baffles result in similar effluent suspended solids concentration.

1.6 One Mid-tank Baffle System

The effect of installing one mid-tank baffle system was also investigated. Both fiberglass and wood baffle systems were considered. Figure 10 shows a front view and cross section of the fiberglass system. Figure 11 shows a front view and cross section of the wood baffle system. The mid-tank baffle system would be located 35 feet from the inlet wall.

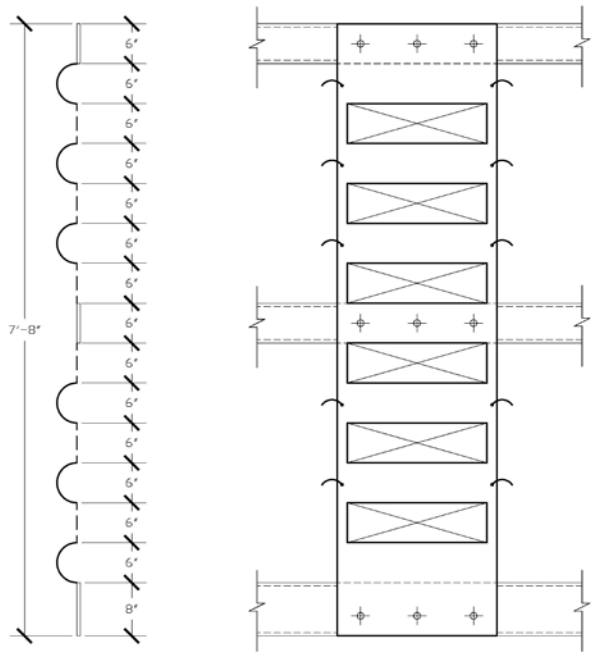


FIGURE 10. FRONT VIEW AND CROSS SECTION OF THE FIBERGLASS MID-TANK BAFFLE PANEL

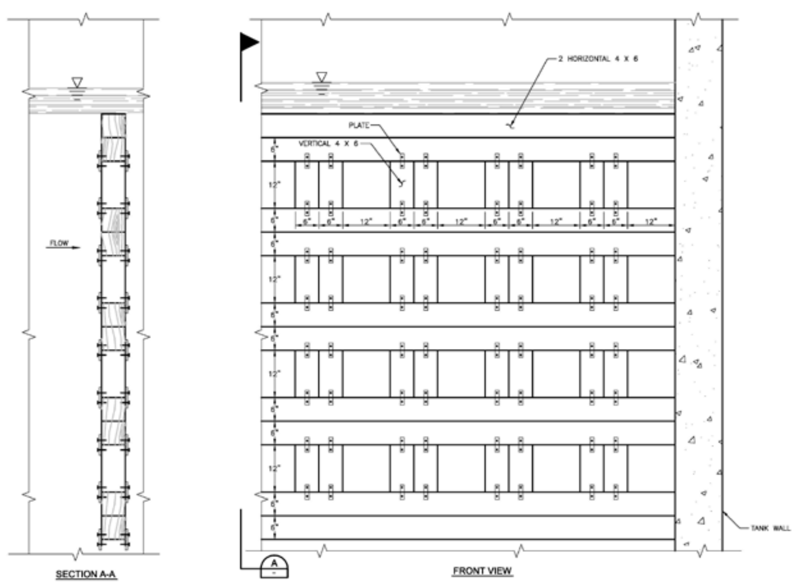


FIGURE 11. FRONT VIEW AND CROSS SECTION OF THE WOOD MID-TANK BAFFLE SYSTEM

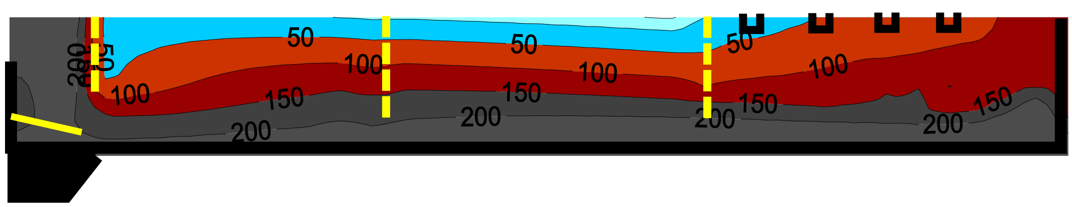
The model indicated that the installation of influent flocculation baffle and mid tank baffle systems would lower PST influent effluent suspended solids to about 119 mg/L with removal efficiency of 43 percent.

1.7 Two Mid-tank Baffle Systems

The effect of installing two mid-tank baffle systems was also investigated. Both fiberglass and wood baffle systems were considered. The first mid-tank baffle system would be located 35 feet from the inlet wall while the second system would be located 65 feet from the inlet wall. The model predicted that the two baffle systems would lower effluent suspended solids to about 115 mg/L with removal efficiency of 45 percent.

1.8 Sludge Protector Canopy System

A sludge protector canopy system is a system on panels installed above the sludge hopper at the front end of the PST. The purpose of the sludge canopy is to direct the flow above the blanket and prevent scouring of the sludge hopper. The system would be installed two feet above the sludge hopper to allow the transport of settled sludge into the hopper. Modeling indicated that installing the canopy in addition to the influent flocculating baffle and mid tank baffles would lower effluent suspended solids to 109 mg/L with removal efficiency of 48 percent. Figure 12 shows a cross section of the PST when equipped with all performance enhancement features.



Effluent Flow Rate = 4.37 mgd ***Influent TSS = 210 mg/L*** ***Effluent TSS = 109 mg/L***

FIGURE 12. PST EQUIPPED WITH PERFORMANCE ENHANCEMENT FEATURES

2.0 COST ESTIMATE

A preliminary cost estimate of the different baffle systems was developed. Table 1 shows a breakdown of the costs.

Table 1 Performance enhancement features cost (per PST)

Type of Baffle		Fiberglass	Wood
Flocculation Baffles	Materials	$ 17,000	$ 23,000
	Installation	$ 4,000	$ 10,000
1st Mid-Tank Baffle	Materials	$ 10,000	$ 10,000
	Installation	$ 4,000	$ 10,000

2nd Mid-Tank Baffle	**Materials**	**$ 10,000**	**$ 10,000**
	Installation	**$ 4,000**	**$ 10,000**
Sludge Protector System	**Materials**	**$ 10,000**	**$10,000**
	Installation	**$ 5,000**	**$ 5,000**
Total		**$ 64,000**	**$ 88,000**

Table 1 shows the fiberglass baffle system has a lower cost than wood baffle. This is mainly due to the fact that installation of fiberglass system is easier and is not labor intensive.

APPENDIX C – RESULTS OF PRIMARY CLARIFIERS STRESS TESTING AT THE SUNNYVALE WPCP

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TECHNICAL MEMORANDUM

Prepared for: City of Sunnyvale

Project title: Master Planning

Technical memorandum

Subject: Results of primary clarifiers stress testing at the Sunnyvale WPCP

Date: 12/5/2013

To: Jim Hagstrom,P.E.

From: Alex Ekster,Ph.D.,P.E.,B.C.E.E

Copy to: Jamel Demir,P.E., Anne Conklin P.E.

Reviewed by: Anne Conklin & Jamel Demir

Background

The Carollo/HDR master plan team is developing design criteria for the new primary sedimentation tanks (PSTs), at the City of Sunnyvale's WPCP. Based on the results of computational fluid dynamic (CFD) modeling, a hydraulic loading rate equal to 2000 gpd/sq.ft was proposed for sizing the PSTs. This loading is 1.5-2 times larger than the City's hydraulic loading rates for the existing PSTs.

Objective

The main objective of the PST field testing was to confirm that increasing the hydraulic loading rate to 2000 gpd/sq.ft would not cause a significant deterioration of primary effluent quality. The secondary objective was to determine the effect of higher than 2000 gpd/sq.ft clarifier loading rate on TSS and BOD removal rates.

Methods and Materials

A series of settling tests were performed by Plant staff in accordance with Ekster and Associates' testing protocol on three different dry weather days in late October/early November 2013. The number of existing PSTs in service on each day is provided in Table 1. Each PST is 110 ft long, 19 ft wide and 10ft deep. Daily average PST hydraulic loading rates were calculated by dividing, the recorded average daily flow by the total surface area of the primary clarifiers in service. Instantaneous primary clarifier hydraulic loading rates were also calculated throughout each day using the same formula. Instantaneous flows were averaged over the calculated clarifiers retention time of each test.

Table 1. Number of clarifiers in service and hydraulic loadings.

Day of the week	Number of PSTs in service	PSTs In Service	Daily Average Loading, gpd/sq.ft	Minimum Instantaneous loading, gpd/sq.ft	Maximum Instantaneous loading, gpd/sq.ft
Wednesday the 30th	2	Tanks 2 & 3	3100	4700	1450
Thursday the 31st	4	Tanks 2,3,6,7	1500	2300	700
Friday the 1st	3	Tanks 2,3 & 6	2000	2900	1000

A 3-gallon bucket was used for the influent grab-composite sample collection. Two buckets were used for effluent collection: one 3-gallon bucket for the mixed grab collection and one 5-gallon bucket for the non-settling test. The sample collection and analysis procedures are described below:

- Routine 24 hr. composite samples of primary influent and effluent were collected by plant staff.
- Influent grab samples were collected in the aerated grit chamber at four separate times each day: 4 am, 10 am, 4 pm, and 10 pm. Then, these samples were mixed with all samples collected at that same time (all the 4 am samples were mixed together and so on). These four specific sample collection times were selected based on an analysis of a typical diurnal flow pattern. This diurnal analysis revealed that the flow change was minimal for the one to two hours surrounding these times of the day and hence would give a relatively steady influent quality to analyze. All influent grab samples were analyzed for COD and in duplicate for TSS.
- Primary effluent grab-samples were collected at the primary effluent composite sampler location. The primary effluent sample collection time was calculated to be one hydraulic residence time from when the primary influent grab sample was taken.

  Portions of each effluent sample were used for analyzing non-settling fractions. Non-settling TSS, BOD and COD concentrations were determined by letting the primary effluent solids settle for one hour in a 5 gallon bucket and then siphoning water 2-3 inches below the surface. Then the non-settleable (colloidal) TSS, non-settleable (soluble and colloidal) BOD and COD concentrations were measured in the siphoned aliquot. The non-settling fraction is determined in the effluent rather than in the influent because full-scale clarifiers better reflect flocculation/deflocculation dynamics than a Kemmerer sampler (which is traditionally used for simulating this dynamic in the clarifiers).

Total TSS removal rate was calculated using the following formulas:

Removal of total TSS$=1-TSS_{effuent}/TSS_{influent}$

While total TSS removal rate is traditionally used to describe primary clarifier performance, removal rate of settleable TSS is a much more accurate clarifier performance indicator. This is because unlike total TSS removal rate, settable TSS is not affected by solids that cannot be settled even under ideal circumstances. Removal rate of settleable TSS was calculated using the following formula:

Removal of settleable TSS $=1-(TSS_{effluent}-TSS_{non\text{-}settleable})/(TSS_{influent}-TSS_{non\text{-}settleable})$.

Removals of BOD and COD were calculated using similar equations.

Results

Charts of influent flows on each of these days are presented in Appendix 1. Tables reflecting influent and effluent water qualities are presented in Appendices 2 and 3.

Grab Sampling

COD

COD values in the effluent grab samples presented some puzzling findings. While the ratio of non-settleable to total effluent COD ranged from 0.85 to 1.0 for the grab samples, the same ratio ranged from 0.6 to 0.85 for composite samples. Some of the influent COD data was determined to be erroneous as well. The WPCP staff recently started to perform COD data on a pilot basis to evaluate opportunities to replace BOD testing with COD testing. If the staff chooses to continue performing COD tests, sample pre-processing and QA/QC procedures may need to be re-evaluated based on the variation of the ratios described earlier. As a result of COD data uncertainty, COD removals will not be discussed further in this memorandum.

TSS

Based on grab sampling results, 34% of influent TSS on average was non-settleable. Based on composite sample results, this fraction was 32%. Figures 1 and 2 show the removal rates for total and settleable solids (calculated based on grab sampling results) as a function of the primary clarifier instantaneous hydraulic loading rate. Figure 1 shows that the removal rates of total TSS was fairly constant at 60% for hydraulic loading rates up to 3000 gpd/sq.ft. These removal rates decreased from 60% to about 30% for hydraulic loading rates between 3000 gpd/sq.ft and 4500 gpd/sq.ft. Figure 2 shows a similar trend for the settleable solids. The removal rate of settleable solids was fairly constant at around 90% for hydraulic loading rates up to 3000 gpd/sq.ft and decreased to a removal rate of around 50% at a hydraulic loading rate of 4500 gpd/sq.ft.

Figure 1. Removal rate of total suspended solids

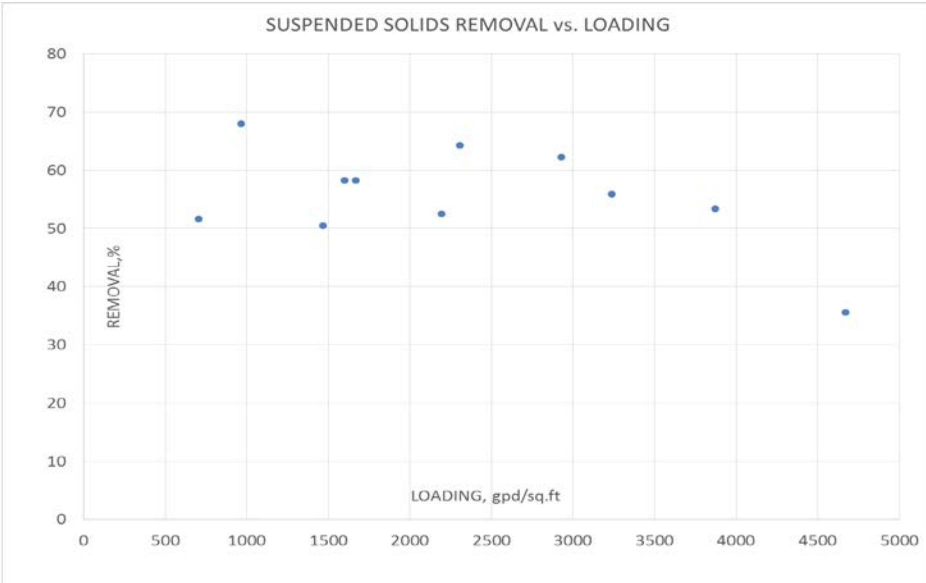
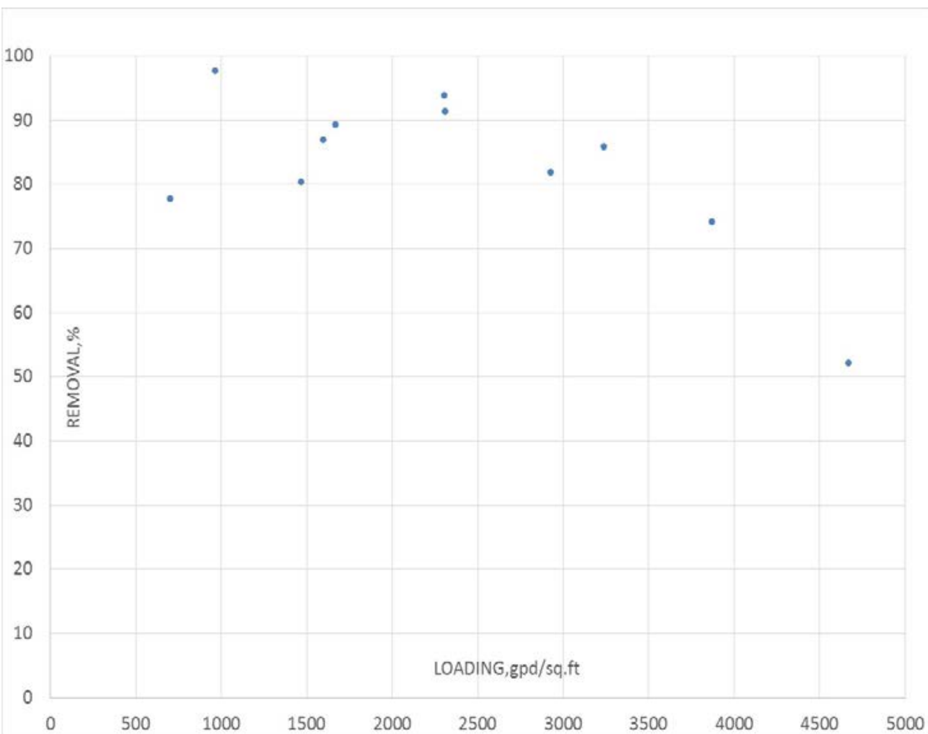


Figure 2. Removal rate of settleable suspended solids



Composite Sampling

The calculated removal rate of total and settleable TSS and BOD based on the composite samples and recorded daily average flow is presented in Table 2.

Table 2. Removal of TSS and BOD based on composite sampling

Average Daily Loading, gpd/sq.ft	TSS removal,%	Settleable TSS removal,%	BOD removal,%	Settleable BOD removal,%
3130	43	N/A	24	73
2014	58	86	23	65
1517	66	94	22	48

Composite sample results for BOD shows that on average 62% of influent BOD was non-settleable, with some days showing a removal rate as high as 67%. Based on a series of assumed conversion factors[1], the non-settleable TSS correlates to about a 20% non-settleable (colloidal) BOD fraction (equivalent to a soluble BOD fraction of 36%). Total non-settleable BOD, calculated as sum of soluble and colloidal fractions, would be 56%. The measured non-settleable BOD is approximately 62%, which is within about 10% of the calculated value.

Discussion of Findings

TSS removal

Figures 1 and 2 show that hydraulic loading rate had minimum impact on TSS removal efficiency at an instantaneous hydraulic loading below 2500 gpd/sq.ft. The removal rate of settleable solids at this hydraulic loading rate was 90% (±10%), while the average rate of TSS removal was around 59%. As the hydraulic loading rate starts to increase above 3000 gpd/sq.ft removal efficiency starts to decrease precipitously.

[1] Assumes the WPCP's recent measured VSS/TSS ratio of 0.89, a calculated sBOD fraction of 36% (calibrated to match the plant sCOD values), a calculated unbiodegradable fraction of the influent VSS of 0.27 (calibrated to match the plants measured BOD and COD), a typical COD/VSS fraction of 1.76 and a typical COD/BOD fraction of 1.89.

At a daily average hydraulic loading rate of 2000 gpd/sq.ft., the settleable solids removal rates are still was very good (around 86%) and similar to the removal rate at the 2000 gpd/sq.ft instantaneous loading. The TSS removal rate was 1.4 times higher at an instantaneous hydraulic loading rate of 3100 gpd/sq.ft than at daily average loading of the same value (58% vs. 43%). This difference can be explained by the fact that on the day when the average hydraulic loading rate was 3100 gpd/sq.ft., the TSS removal rate ranged from 35% to 58% due to a swing in instantaneous hydraulic loading rates of 1450 to 4700 gpd/sq.ft caused by diurnal flow variations.

Removals calculated using composite sample data at an average hydraulic loading rate of 1500 gpd/sq.ft. were about 8% higher than at 2000 gpd/sq.ft. and about 23% higher than at 3100 gpd/sq.ft. As a result, at a hydraulic loading of 2000 gpd/sq.ft. the primary effluent TSS should not increase by more than 10%-12% compared with current effluent TSS. Such minor increase in effluent TSS should not cause deterioration of any downstream treatment processes.

The non-settleable portion of TSS on the sampling dates was somewhat higher than observed at other plants. It is unknown how typical these values were during the stress testing period because no historical data of non-settleable portions of TSS exist. However, historical performance of the plant primary clarifiers may provide some indications of regularly observed values of non-settleable portions of TSS. Based on the fact that for the last several years median TSS removal rate was around 72%, we can estimate that median historical settleable TSS was at least 72%. This is a larger value than the 66% settleable TSS observed on the sampling days. As a result, TSS removal rates depicted in the Table 2 and Figure 1 are probably conservative.

BOD removal

BOD removal remained practically the same (around 22-24%) within the entire range of flow loadings. Based on this information, it is reasonable to assume that designing PSTs for an average day maximum month hydraulic loading rate of 2000 gpd/sq.ft. will not cause a reduction in BOD removal.

Low BOD removal rate is typically caused by a high fraction of non-settleable BOD. For unknown reasons, removal of settleable BOD improved with an increase in hydraulic loading rates, which is probably an artifact of specific plant influent issues.

Similarly to TSS, the non-settleable portion of BOD on the sampling dates was higher than observed at other plants. For the last several years median BOD removal rate was 41%. That means than the settleable BOD portion was larger than 41% of total BOD. On days of sampling this fraction was 38%. So, it is reasonable to assume that the median BOD removal rate will be higher than the 22%-24% removal rates observed on the days of sampling.

However, it is very plausible that from time to time influent settleable BOD will be significantly smaller than the median value (as was observed during the stress testing). As a result, most of primary effluent (i.e. activated sludge influent) BOD will consist of non-settleable (i.e. soluble and colloidal) BOD. A high fraction of secondary influent non-settleable BOD, if not removed in an anoxic compartment (selector), may cause filamentous bulking of an activated sludge. Following the PST stress testing experiments, BIOWIN modeling of the BNR aeration tanks (AT) has been performed. For modeling purposes it was assumed that primary effluent non-settleable BOD was greater than 90% of total BOD. Modeling results showed that when the ratio between anoxic and aerobic compartments in the AT was larger than 35% (as proposed by the Master Plan), only minimal bleed of non-settleable BOD from anoxic compartment was observed. Therefore, settleability of the activated sludge will remain good even on the days when the non-settleable BOD fraction is greater than 90% of the total BOD.

Conclusions

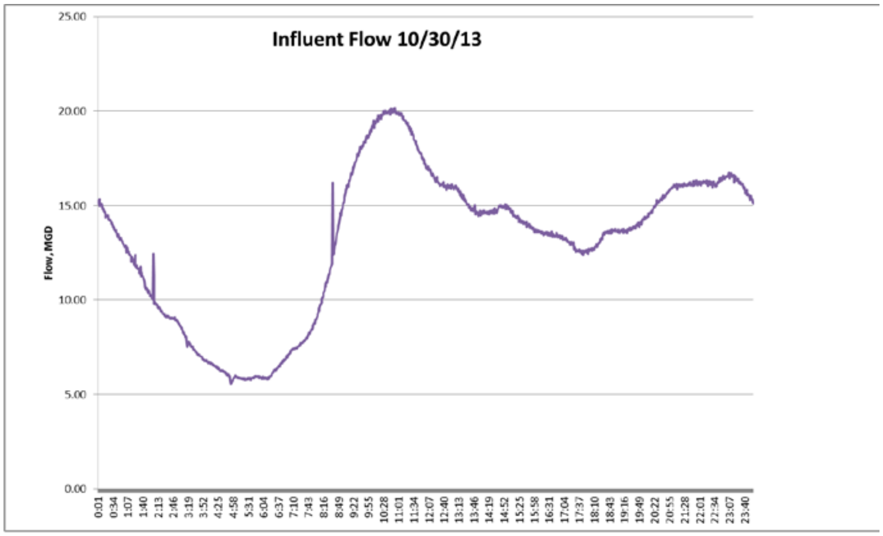
1. Increasing the daily average hydraulic loading rate to 2000 gpd/sq.ft should not significantly increase (less than by 10%-12%) the primary effluent TSS concentration and will not increase effluent BOD concentration. As a result, an increase of daily average hydraulic loading rate to 2000 gpd/sq ft from the currently observed 1000 gpd/sq.ft will not cause performance deterioration of any downstream processes.

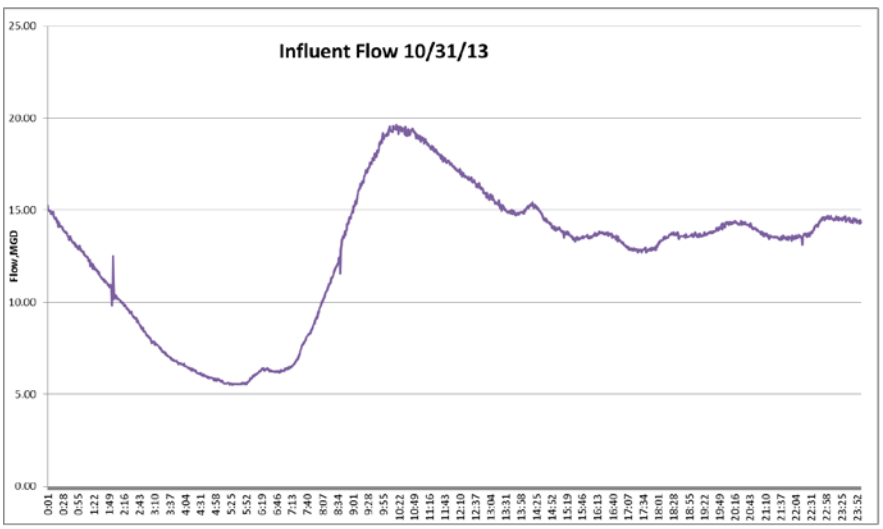
2. Increasing the daily average hydraulic loading rate to 3000 gpd/sq.ft. (to be observed during storm wet weather) may cause a larger increase in TSS effluent concentration (approximately by 30%) compared with values currently detected during wet weather.

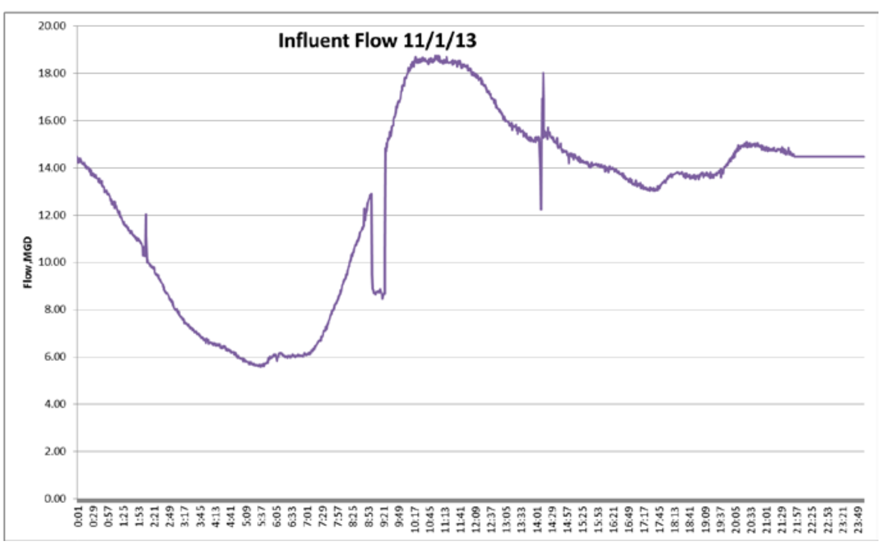
3. Increasing the average hydraulic loading rate to as much as 3000 gpd/sq.ft. will not cause a significant increase in effluent BOD concentration, although additional tests may be needed to confirm this hypothesis.

Acknowledgment. Plant operation and laboratory staff is acknowledged for samples collection and performing all tests.

Appendix 1. Diurnal flow variation







Appendix 2. Influent water quality

Date	Time	Sample type	TCOD mg/L	TSS mg/L	NH4 mgN/L	TKN mgN/L	BOD mg/L
10/30/2013	4:00	Grab mixed	272	113	21.6		*NR
	10:00	Grab mixed	560	303	42.2		NR
	16:00	Grab mixed	556	195	27		NR
	22:00	Grab mixed	524	253	27.0		NR
	23:59	Composite	532	198	25.6		199.0
10/31/2013	4:00	Grab mixed	300	122	25.8		115.0
	10:00	Grab mixed	658	305	46.6		267.0
	16:00	Grab mixed	570	218	30.4		NR
	22:00	Grab mixed	528	199	28.0		NR
	23:59	Composite	250	256	33.6		212.0
11/1/2013	4:00	Grab mixed	281	122	26		NR
	10:00	Grab mixed	598	262	48.4		NR
	16:00	Grab mixed	516	160	28.4		NR
	22:00	Grab mixed	401	184	27.0		NR
	23:59	Composite	210	214	32.6		211.0

Appendix 3. Effluent water quality

Date	Time	Sample Type	TCOD, mg/L	TSS, mg/L	NH4, mgN/L	TKN, mgN/L	BOD mg/L
10/30/2013	5:30	Grab mixed	168	56	22.2		*NR
	5:30	Grab non-setting	156	42	23		NR
	10:30	Grab mixed	244	195	44		NR
	10:30	Grab non-setting	246	96	44.8		NR
	16:40	Grab mixed	420	86	29		NR
	16:40	Grab non-setting	406	68	30.8		NR
	22:30	Grab mixed	450	118	26.6		NR
	22:30	Grab non-setting	418	71	28.4		NR
	23:59	Composite mixed	380	112	29.2		151.0
	23:59	Composite non-setting	328	**69	28.4		134.0
10/31/2013	6:00	Grab mixed	230	59	25.4		54.0
	6:00	Grab non-setting	222	41	25.8		50.0
	11:00	Grab mixed	358	109	42		154.0
	11:00	Grab non-setting	360	96	43		104.0
	17:30	Grab mixed	422	91	29.8		NR
	17:30	Grab non-setting	422	72	29.6		NR
	23:00	Grab mixed	388	83	28.4		NR
	23:00	Grab non-setting	364	69	30.2		NR
	23:59	Composite mixed	444	86	31		165.0
	23:59	Composite non-setting	270	76	32		115.0
	6:00	Grab non-setting	183	37	24		NR

Date	Time	Sample Type	TCOD, mg/L	TSS, mg/L	NH4, mgN/L	TKN, mgN/L	BOD mg/L
11/1/2013	10:45	Grab mixed	396	99	43.8		NR
	10:45	Grab non-setting	357	63	41.8		NR
	17:00	Grab mixed	425	76	27.4		NR
	17:00	Grab non-setting	402	78	26		NR
	22:45	Grab mixed	405	78	26.2		NR
	22:45	Grab non-setting	390	68	24		NR
	23:59	Composite mixed	370	91	28.6		163.0
	23:59	Composite non-setting	309	72	27.8		140.0