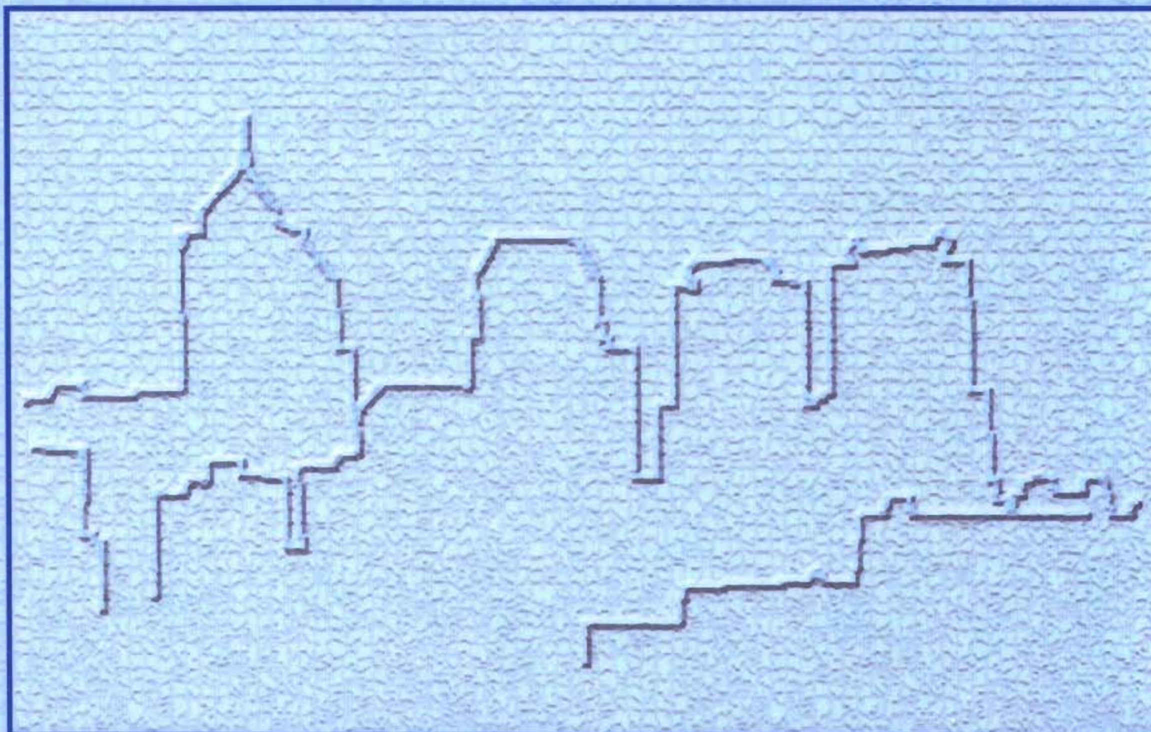
Supplemental Documentation Volume 7

Stress Testing of the Southeast WPCP

Updated: September 1, 2009

FINAL REPORT



Stress Testing of the Southeast WPCP

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Prepared for

Philadelphia Water Department

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December 2001

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SECTION 1
INTRODUCTION

1. Introduction

1.1 Project Objectives and Methodology

As part of its obligations under the Federal Clean Water Act and the Pennsylvania Clean Streams Law, the City of Philadelphia Water Department (PWD) has initiated a program with an objective to minimize the impact of Combined Sewer Overflows (CSO) on local receiving waters. One of the proposed strategies for reducing the CSO volume is to maximize flow to be treated by the water pollution control plants (WPCP) during periods of wet weather. To implement this strategy effectively, the PWD needs to have a clear understanding of the factors that affect how much flow each of the three WPCPs can effectively treat. With this knowledge, the PWD will be able to identify and prioritize plant upgrades and other system modifications that will allow it to meet the CSO minimization objectives in the most environmentally sound and cost-effective manner.

The PWD contracted CH2M HILL to conduct stress testing at the three wastewater treatment plants that are owned and operated by the City. The objective of the stress testing was to determine the reliable maximum capacity of the existing facilities and identify cost-effective methods of increasing the ability of these facilities to treat peak hydraulic flows associated with wet weather conditions. The major tasks performed during the project are briefly described below.

Historical Data and Operations Review. The objective of the historical data and operations review was to evaluate the physical condition, current loading, and treatment efficiency provided by the existing unit processes. A tour of the plant was conducted, and the process equipment and facilities were examined. Operating records, design information, and engineering drawings were studied to develop a strong understanding of the operations and constraints. Technical Memorandum 1 – Historical Data Review was produced to summarize the results of the site visit and historical data analysis.

Short-Term Stress Test. CH2M HILL performed a series of capacity and diagnostic tests to determine the loading versus performance characteristics of specific unit processes at each facility. The short-term stress testing focused on determining the response of the primary and secondary clarifiers to increased hydraulic loading under different operating conditions. The short-term stress testing at the Southeast WPCP (SEWPCP) included primary clarifier stress tests, secondary clarifier stress tests, secondary clarifier dye tests, and flow meter calibration. The results of each test are summarized in a test description report in Technical Memorandum 2 – Short-Term Test Results.

Long-Term Stress Test (Online Monitoring). Online monitoring equipment was installed to quantify the dynamic load/response characteristics of the secondary treatment system to naturally-occurring storm events. The equipment was also used to monitor the effect increased flows had on the solids inventory in the system and secondary effluent quality. Online monitoring included total plant flow, return activated sludge (RAS) flow, mixed liquor suspended solids (MLSS) concentration, sludge blanket levels, and secondary effluent total suspended solids (TSS) concentration. The equipment was in place from March 1 to June 30, 1999 and recorded data on a 10-minute interval. The results of the long-term stress test are summarized in Technical Memorandum 3 – Long-Term Online Monitoring Results. The detailed online monitoring data and instrument calibration records are provided under separate cover.

Hydraulic Throughput Capacity Assessment. WinHYDRO, a computer model that facilitates complex analysis of plant hydraulics, was used to evaluate the hydraulic throughput capacity of the SEWPCP. Hydraulic and energy grade lines from the headworks to the plant outfall were developed for the average and peak flow conditions. Hydraulic bottlenecks, which limit the hydraulic throughput capacity of the existing facilities, and flow distribution problems were identified and evaluated. The hydraulic throughput capacity of each unit process was determined. The results of the hydraulic modelling performed are summarized in Technical Memorandum 4 – Hydraulic Throughput Capacity of Existing Facilities.

Evaluation of Potential Improvements. Based upon stress testing and hydraulic modeling results, major bottlenecks that limit plant capacity were identified and potential solutions were developed to increase peak instantaneous capacity. Budgetary cost estimates were developed for each potential solution. The results of this analysis are summarized in Technical Memorandum 5 – Budgetary Cost Estimates for Potential Plant Improvements.

1.2 Report Organization

The project notebook consists of a final report and a series of attachments. The main body of the report contains a summary of the results from the stress testing, plant data analysis, and the evaluation of process improvements and upgrade options. The detailed results from the historical data review, short-term testing (stress tests, dye tests, and flow meter calibration), online monitoring, and hydraulic throughput capacity assessment are included in the project notebook as attachments. Tables describing the design criteria, scope of work, estimated capital costs for the potential process modifications and capital upgrades, and the current National Pollution Control Discharge Elimination System (NPDES) discharge permit for the site are also included as attachments.

SECTION 2

CURRENT PERFORMANCE

2. Current Performance

2.1 Description of Facilities

Figure 2-1 presents a site plan and Table 2.1 summarizes the existing unit processes at the SEWPCP.

TABLE 2.1
SOUTHEAST WPCP – SUMMARY OF UNIT PROCESSES

Unit Process	Number	Description
Coarse Screens	2	Width = 6.5 ft, single-rake front cleaned
Low-Level Pumps	6	Centrifugal pumps; 3 VSD, 3 constant speed Design Q = 70 mgd, at 45-ft head
Bar Screens	6	Width = 6.5 ft, 75 percent inclined, 1-inch opening
Grit Removal	6	Grit channels Length = 140 ft, width = 10 ft, SWD = 10 ft, volume = 14,000 ft^3 (each)
Flocculation Pre-aeration	2	Aerated channel Length = 225 ft, width = 28 ft, SWD = 13 ft, volume = 81,900 ft^3 (each)
Primary Clarifiers	4	Length = 250 ft, width = 125 ft, SWD = 12 ft Surface area = 31,250 ft^2, weir length = 635 ft (each) C&F sludge mechanism, influent end hopper
Flow Spit Chamber	24	Gates at 60-inch weir length 6 gates for 2 aeration basins
Aeration Basin	8	Four-pass – through flow only Length = 210 ft, width = 52.5 ft, SWD = 14.3 ft, volume = 1.18 mg (each) Operate with first pass as selector
Aeration System	4	1@ 40 Hp , 3@ 30 Hp (per basin)
Secondary Settling Tanks	12	Length = 214 ft, width = 68 ft, SWD = 11 ft Surface area = 14,552 ft^2 Weir length = 784 ft (each) Gould-type central hopper, C&F mechanism
Effluent Pumps	5	Q = 70 mgd at 11 head, VSD 3 units

2.1.1 Preliminary Treatment

The SEWPCP receives wastewater from the Lower Delaware low-level interceptor through an 11-foot-diameter gravity sewer. Mechanically-cleaned bar racks provide coarse screening before the raw sewage pump station. The pump station wet well is separated into two hydraulically-isolated chambers, each of which is serviced by three raw sewage pumps with a rated capacity of 70 mgd each. The pump station operation is controlled manually based on the level in the wet well. Under high flow conditions the pumps are susceptible to

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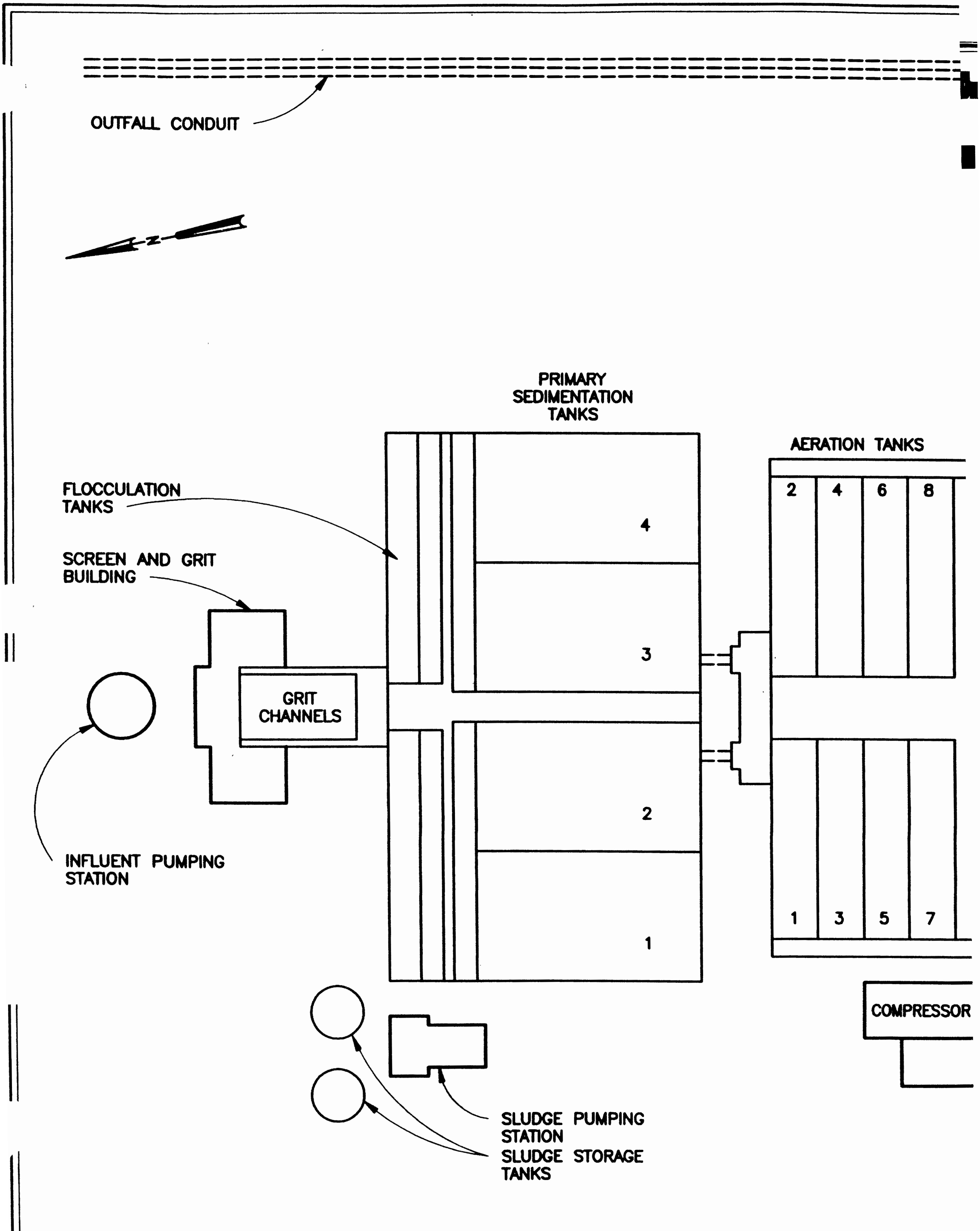

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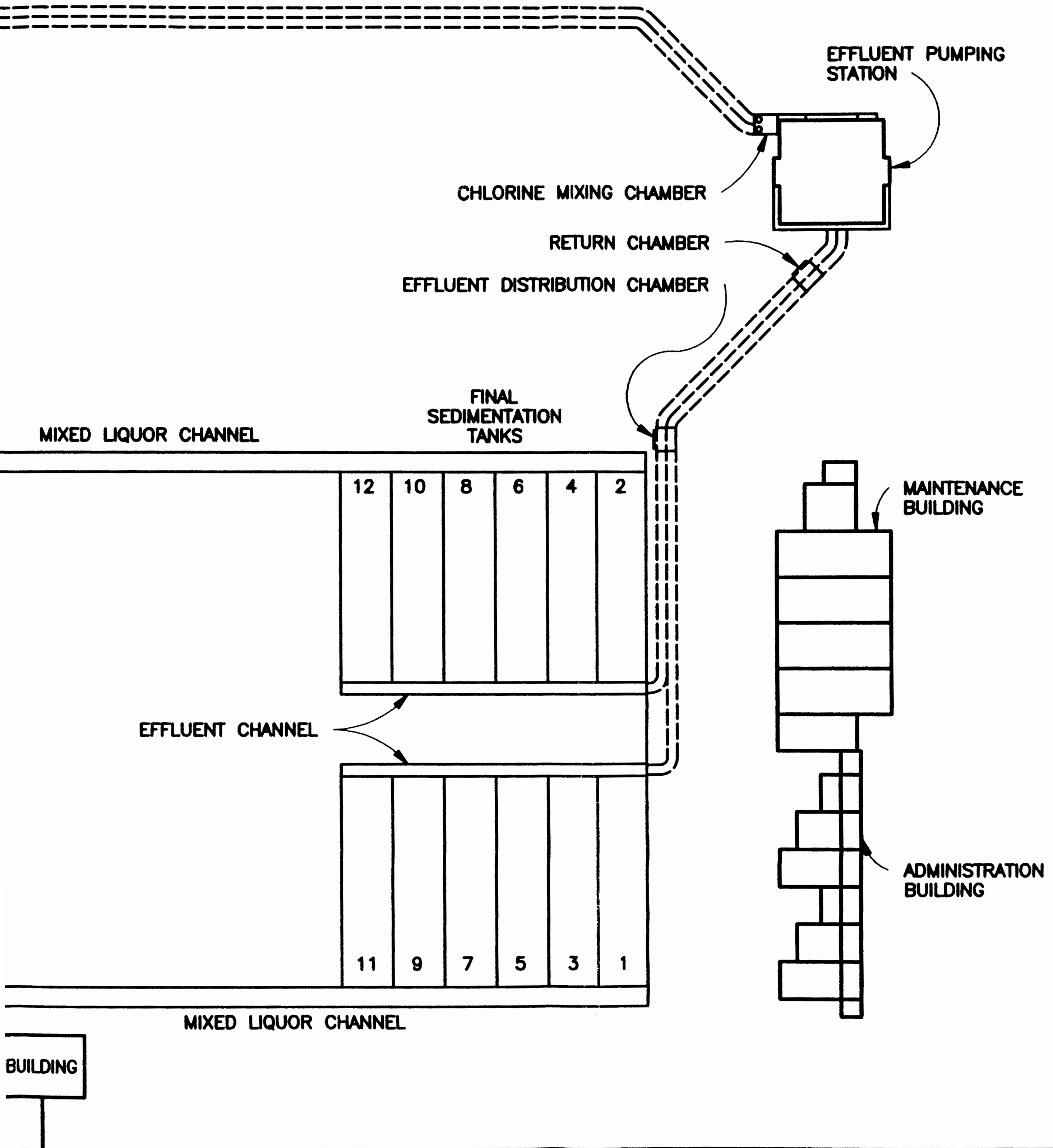

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FIGURE 2-1
SITE PLAN
SOUTHEAST WATER POLLUTION
CONTROL PLANT
CITY OF PHILADELPHIA WATER DEPARTMENT

vortexing, resulting in a sudden deterioration in the measured pump output (flow). Pump capacity is restored by temporarily shutting down the pump and allowing the wet well levels to rise. The maximum flow measured at the raw sewage pump station is approximately 286 mgd with both wet wells in service and 200 mgd with only one wet well in service.

The pump risers discharge into a common channel that leads to six mechanically-cleaned bar screens. The bar screens are located in the influent channel to the grit chambers with one bar screen per grit chamber. The grit chambers consist of six 10 by 140 feet channels with chain and flight collection mechanisms and screw conveyors to remove the grit. Under normal flow conditions, two out of six grit tanks are in service. The accumulated grit is pumped from the grit tanks, washed, and hauled offsite for disposal. The wastewater from the grit tanks flows into a common channel that leads to two flocculation tanks. The flocculation tanks are two-pass aerated tanks, which provide a total flow path length of 450 feet. The flocculation tanks discharge into a common primary influent channel.

Under high flow conditions, the grit chambers flood into the lower basement area through the grit conveyor wall notch. The hydraulic restriction is associated with the primary clarifier launders and the piping between the primary tanks and aeration basins. This issue is discussed in greater detail in Section 3.2.

2.1.2 Primary Treatment

The SEWPCP has four 250 by 125 feet rectangular primary clarifiers with a side wall depth of 12 feet. Each tank has seven chain and flight mechanisms that move the sludge to the influent end of the basin. The flow from the flocculation tanks enters the common influent channel between Primary Clarifiers 2 and 3. Each clarifier has 14 inlet weirs from the common influent channel. The primary sludge is pumped from two tanks every other day. The primary sludge is pumped to the sludge holding tank and then is pumped directly to the SWWPCP for treatment. There are no recycle streams returning to the SEWPCP headworks associated with this process. The primary effluent discharges into a common effluent channel that leads to two flow splitter boxes that control the flow distribution to the aeration basins.

The SEWPCP receives a significant quantity of ferric sludge from the Queen's Lane Water Treatment Plant. The water treatment plant sludge has very good settling characteristics and therefore enhances the performance of the primary treatment system.

However, in 1998, Queen's Lane Water Treatment Plant changed the coagulation procedures used at the facility. The chemical characteristics of the water treatment plant sludge changed, increasing the impact of the Queen's Lane sludge on the treatment processes at the SEWPCP.

The Queen's Lane sludge has exhibited the ability to remove phosphate from the wastewater stream, resulting in periodic incidences of severe nutrient deficiency in the secondary treatment process. Periods of nutrient deficiency encourage the growth of filamentous microorganisms in the activated sludge system, causing bulking sludge and premature failure of the secondary clarifiers.

2.1.3 Secondary Treatment

The SEWPCP has eight 4-pass aeration basins. The basins were originally designed as UNOX pure oxygen. They are currently operating with air. Under current loading conditions, six of the eight aeration basins are in service. Each basin is 52.5 by 210 feet, with a side wall depth of 14.3 feet. The aeration basin consists of four cells operating in series; the primary effluent follows a serpentine flow pattern through the basin, and the RAS is pumped to the upstream end of Cell A. There are no structures to allow step-feed in the basin. The water surface level (WSL) in the basin is controlled by the basin effluent weir structure.

Each cell has a single-paddle, submerged aerator/mixer located in the center of the tank. The SEWPCP operates the first cell as an anoxic selector in the summer months to improve the settling characteristics of the mixed liquor by turning off the first aerator/mixer. During high flow conditions, operations staff also turn off the aerators/mixers in the first and fourth cells to reduce the energy demand. This retains more solids in the aeration basin through settling, which reduces the solids loading on the secondary clarifiers.

The east and west secondary treatment processes are operated as separate systems. The mixed liquor from the east aeration basins flows to the east secondary clarifiers, and the RAS from the east secondary clarifiers is pumped to the east aeration basins. The RAS is flow-paced at approximately 30 percent of the flow through the plant. The mixed liquor from each set of aeration basins flows through a common mixed liquor channel to a set of six secondary clarifiers.

There are twelve 68 by 214 feet rectangular secondary clarifiers with a sidewall depth of 11 feet. Each clarifier has four chain and flight mechanisms that transport the sludge to a central hopper located at approximately the mid-length of the clarifier. The waste activated sludge (WAS) is pumped from the RAS system 24 hours per day. The target WAS flow rate is established based on a target solids retention time of 1.5 days and current mixed liquor concentration in the aeration basins.

2.1.4 Effluent Pumping and Disinfection

The secondary effluent flow from the east and west secondary treatment processes flows through a common conduit to the effluent pump station wet well and chlorine contact chamber. Under dry weather flow conditions, the secondary effluent flows by gravity through the outfall to the Delaware River. The outfall conduit provides contact time for disinfection.

The SEWPCP has five effluent pumps, each with a rated capacity of 70 mgd. The effluent pumps are operated based on the WSL in the effluent pump station wet well and, under wet weather flow and/or high tide conditions, will operate automatically. Three 24-hour composite samples are collected at the end of the facility outfall.

2.2 Regulatory Requirements

The SEWPCP NPDES permit limits include effluent BOD_5 and TSS concentrations; mass discharges; and percent removal for daily, weekly (calendar), and monthly averages. Table

2.2 summarizes the NPDES permit criteria for the facility in effect during testing. Compliance is based on the flow measured by the raw sewage flow meters located in the influent pump station and two 24-hour composite samples collected daily at the facility outfall.

PWD has negotiated a new NPDES permit for this facility effective August 1st, 2000. The modifications to the NPDES permit are summarized below.

As part of PWD's long-term combined sewer overflow (CSO) control program, PWD will be reducing the frequency and volume of untreated sewage discharges through the CSOs; in order to account for the increased loading due to the combined sewage flows that exceed the treatment plant's rated hydraulic capacity, the following methods may be used for calculating and reporting mass loadings and effluent concentrations on the monthly discharge monitoring reports:

- If a calendar month includes one or more days where flows exceed 168 mgd, a value of 85 percent may be used for those days for the purpose of calculating average monthly TSS percent removal. The actual TSS percent removal associated with those days shall be reported on the appropriate space provided on the DMR.
- If a calendar month includes one or more days where flow exceed 168 mgd, a value of 86 percent may be used for those days for the purpose of calculating average monthly BOD_5 percent removal. The actual BOD_5 percent removal associated with those days shall be reported on the appropriate space provided on the DMR.
- When daily flows exceed 168 mgd, the TSS and BOD_5 mass loadings for those days may be omitted from the average monthly and average weekly mass loading calculations, in accordance with the requirements of the Delaware River Basin Commission for Zone 3 of the Delaware Estuary. The actual TSS and BOD_5 loadings associated with those days shall be reported on the appropriate space provided on the DMR.

The BOD_5 in the raw wastewater shall be reduced by at least 86 percent as a monthly average. The percent removal shall be calculated from daily 24-hour composite samples of the influent and effluent. The BOD_5 percent removal requirement may be relaxed to 85 percent when the influent BOD_5 concentration is less than 75 mg/L on a monthly average basis, as long as the $CBOD_{20}$ allocation, equivalent mass BOD_5 limitation, and effluent BOD_5 concentration of 15 mg/L are not exceeded on a monthly average basis. At all other times, the 86 percent removal equipment would apply.

A copy of the new NPDES permit is located in the project notebook.

TABLE 2.2
SOUTHEAST WPCP – NPDES PERMIT REQUIREMENTS

Parameter	Units	Monthly Average	Weekly Average	Maximum Day	Peak Instantaneous
BOD_5					
Concentration	mg/L	30	45	–	60
Mass loading	lbs/day	19,650	29,475		
Percent removal	%	86			
TSS					
Concentration	mg/L	30	45	–	60
Mass loading	lbs/day	28,025	42,035		
Percent removal	%	85			
Flow	mgd	112		168	224

2.3 Current Loading And Performance Achieved

2.3.1 Unit Process Loading

Table 2.3 presents a summary of the current unit process loading over a three-year period from July 1995 to July 1998. The average and maximum daily flows were 106 mgd and 212 mgd, respectively. The maximum instantaneous flow was 286 mgd.

On September 16, 1999, during Hurricane Floyd, the maximum instantaneous flow was 274 mgd. The flow remained above 200 mgd for over 14 hours. During that period, the maximum WSL in the raw sewage wet well was 19.5 feet. During the five years from July 1995 to present, SEWPCP has not exceeded the CSO action level established for the facility.

The average raw sewage TSS and BOD_5 concentrations were 143 mg/L and 87 mg/L, respectively. The average organic loadings to the treatment plant, calculated based on the raw sewage TSS and BOD_5 concentration and the average flow for each day, were 126,281 lbs/day and 75,834 lbs/day, respectively.

TABLE 2.3
SOUTHEAST WPCP - SUMMARY OF CURRENT UNIT PROCESS LOADINGS (JULY 1995- JULY 1998)

Unit Process	Units	Current Loadings		Typical Values	Notes
		Average	Maximum		
Loading					
Hydraulic	Mgd	106	286		1
Organic					
BOD	lb/d	75,834	111,743		2
TSS	lb/d	126,281	222,378		2
Grit Tanks					
Volume (total)	ft^3	84,000			
Area (total)	ft^2	8,400			
HRT	Minutes	8.5	3.2	3 – 5	3
Primary Clarifiers					
Area (total)	ft^2	125,000			
Weir Length (total)	Ft	2,540			
Surface Overflow Rate	gpd/ft^2	848	2,288	1,000 – 3,000	3
Removal Efficiency					

TABLE 2.3
SOUTHEAST WPCP - SUMMARY OF CURRENT UNIT PROCESS LOADINGS (JULY 1995- JULY 1998)

Unit Process	Units	Current Loadings		Typical Values	Notes
		Average	Maximum		
BOD	%	49		35	
TSS	%	73		60	
Aeration Basins					
Volume (total)	Mg	7.08			4
BOD Loading	lbs/d/1,000 ft^3	29.6	48.9	20 – 40	4,2
HRT	Hours	2.6	0.8		4
MLSS	mg/L	1,357			
SVI	mL/g	144		100 – 150	
ISV	ft/hr	11			
SRT	Day	0.7			4
F/M	1/day	East 0.47 West 0.48			4
Secondary clarifiers					
Area (total)	ft^2	174,624			
Weir length	Ft	9,408			
Surface overflow rate	gpd/ft^2	607	1,638	600 – 1,500	3
Solids loading rate	lb/ft^2 per day	9.05	20	20 – 40	3

Notes: [1]Maximum hydraulic loading based on instantaneous flows
[2]Maximum loading based on 95th percentile
[3]Based on all units in service
[4]Based on six aeration basins in service

2.3.2 Primary Treatment Performance

The average and peak surface overflow rates (SOR) for the primary clarifiers were approximately 850 gpd/ft^2 and 2,286 gpd/ft^2, respectively. Typical overflow rates for rectangular clarifiers are between 1,000 gpd/ft^2 and 3,000 gpd/ft^2. The primary clarifiers at the SEWPCP are operating slightly below their expected capacity based on typical SORs.

The removal efficiencies achieved in the primary clarifiers are very good. This is due to the low hydraulic loading rate and the relatively high proportion of ferric solids from Queen's Lane Water Treatment Plant. The average TSS and BOD_5 removal efficiencies in the primary clarifiers were 73 percent and 49 percent, respectively.

2.3.3 Secondary Treatment Performance

The average primary effluent TSS and BOD_5 concentrations were 34 mg/L and 43 mg/L, respectively. The average and 95^{th} percentile total BOD_5 loadings to the secondary treatment system, calculated based on the primary effluent BOD_5 concentration and the average flow for each day, were 37,293 lbs/day and 61,629 lbs/day, respectively.

The aeration basins are currently operating with a solids residence time (SRT) of 0.7 days. The food to microorganisms (F:M) ratio in the aeration basins averaged 0.5 day^{-1}. The F:M ratio generally peaked in March each year, mainly due to an increase in food (BOD_5 loading) during the early spring periods. The average sludge volume index (SVI) between

July 1995 and December 1998 was 144 mL/g. The SVI was more than 200 mL/g approximately 5 percent of the time, indicating that the facility experiences occasional bulking incidents.

During January through March of 1999, the SEWPCP experienced a major sludge bulking incident. A microscopic examination of the mixed liquor indicated severe nutrient (phosphorus) deficiency in the biomass. Phosphoric acid was added to the return sludge, and the SVI dropped to levels typical for the facility.

The average and peak SORs for the secondary clarifiers were approximately 800 gpd/ft^2 and 1,640 gpd/ft^2, respectively. Typical SORs for rectangular Gould-type clarifiers are between 800 gpd/ft^2 and 1,500 gpd/ft^2. The secondary clarifiers at the SEWPCP are operating at their expected maximum hydraulic capacity based on typical SORs.

The average and peak solids loading rates (SLRs) for the secondary clarifiers were approximately 9 lbs/day/ft^2 and 20 lbs/ft^2 per day based on RAS flows of 30 percent. Typical peak SLRs for rectangular Gould-type clarifiers are between 20 lbs/day/ft^2 and 40 lbs/ft^2 per day. The secondary clarifiers at the SEWPCP are operating below the expected maximum hydraulic capacity based on typical SLRs.

The secondary clarifiers at the SEWPCP achieve a very good quality final effluent. The daily TSS and BOD_5 concentrations were consistently below the NPDES criteria of 60 mg/L. The average effluent TSS and BOD concentrations were 5.7 and 7.5 mg/L, respectively.

SECTION 3
CURRENT CAPACITY

3. Maximum Instantaneous Capacity

3.1 Maximum Treatment Capacity

The current maximum instantaneous treatment capacity of the unit processes at the SEWPCP was estimated using a combination of manufacturers information, standard engineering design loading and performance criteria, operations staff observations of previous performance, and field testing of specific unit processes.

The field testing conducted at the SEWPCP included the following:

Online Monitoring Data

- Secondary Clarifier 12
- Plant flow, RAS flow, mixed liquor TSS, sludge blanket level, and effluent TSS from March 1 to June 30, 1999

Primary Clarifier Stress Tests

- Primary Clarifier 4

Secondary Clarifier Stress Tests

- Secondary Clarifier 1 – gradual increase in hydraulic loading
- Secondary Clarifier 1 – sudden increase in hydraulic loading (spike loading)

Secondary Clarifier Dye Tests

- Secondary Clarifier 11

Table 3.1 summarizes the estimated treatment capacity for each unit. The basis of the estimated capacity is discussed below. The detailed field test results are presented in Technical Memorandum 2 – Short-Term Test Results and Technical Memorandum 3 – Long-Term Online Monitoring Results.

3.1.2 Preliminary Treatment

The estimated treatment capacity of the preliminary treatment system is 200 mgd. This is based on operators' observations for the maximum pumping capacity of the raw sewage pump station with one side of the wet well out of service because of partial blockage or failure of the coarse bar screens. The bar screen can be put back into service quickly. However the potential of permanently damaging the screen and pumps increases at flow rates greater than 240 mgd. With both sides of the raw sewage pump station wet well in service, the maximum capacity of the raw sewage pump station is 286 mgd. Maintaining the maximum flow rate requires manual control of the pumps, with four of the six pumps in operation at one time. The pumps are rotated into service as the pump output is reduced due to vortexing/cavitation. The capacity is limited by the wet well configuration.

TABLE 3.1
SOUTHEAST WWTP TREATMENT CAPACITY ASSESSMENT

Unit Process	Estimated Capacity (mgd)	Criteria
Pumping and Screening	286 240[1] – 1 coarse screen partialy blocked 200[2] – 1 wet well out of service	Observed maximum flow Observed maximum flow Observed maximum flow
Grit Removal	350[3] – 1 channel out of service	
Primary Treatment	225 mgd[4] – existing condition (hydraulic limitations) 260 mgd[4] – new launders 330 mgd[4] – improved sludge pumping	2,400 gpd/ft^2 – test results 2,800 gpd/ft^2 – SW test results 3,500 gpd/ft^2 – potential
Aeration Basins	N/A No change in organic loading pattern	
Secondary Clarifiers	200 mgd[4] – existing (sludge bulking incidence) 330 mgd[4] – current mixed liquor concentration	Long-term monitoring results Based on allowable SOR of 1,800 gpd/ft^2
	236 mgd[4] – mixed liquor concentration 2,000 mg/L	Based on allowable SLR of 30 lbs/day
Effluent Pump Station	280 mgd[5] (1 pump out of service)	70 mgd per pump
Disinfection	395 mgd – volume of plant outfall	HRT – 15 minutes

[1]Based on one screen partially blocked
[2]Based on one screen (1/2 of the wet well) out of service
[3]Based on removal of 60 mesh (0.25mm) particles
[4]Based on one clarifier out of service
[5]Based on 1 pump out of service rated capacity of pumps 70 mgd

The estimated treatment capacity of the bar screens and grit removal tanks is 350 mgd. This is based on five of the six channels in service, with an allowable average velocity in the grit channel of 1 ft/sec. The theoretical removal efficiency of the grit removal system is 90 percent of particles greater than 60 mesh (25 mm) under peak flow conditions.

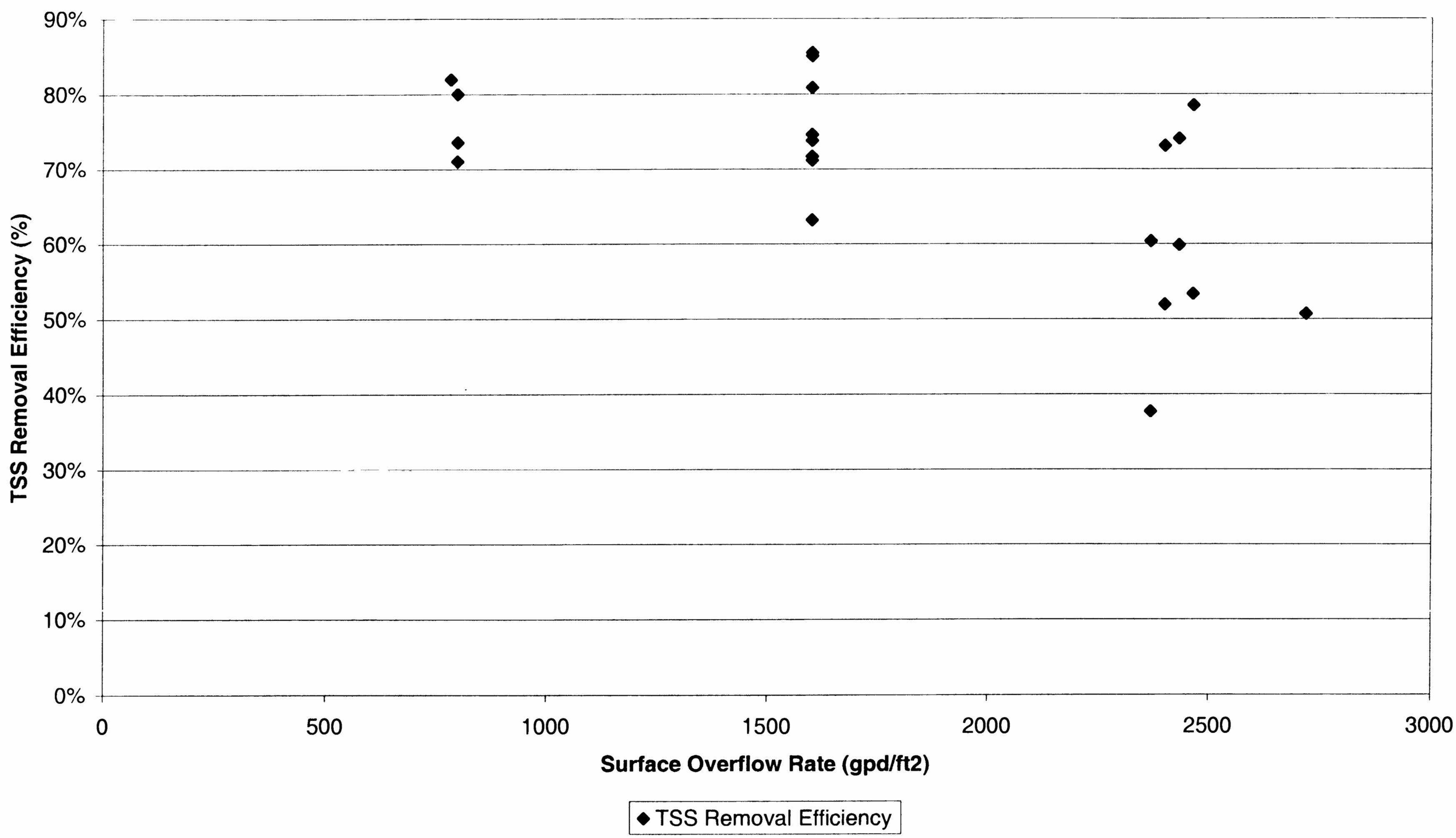
3.1.3 Primary Treatment

Six primary stress tests were conducted at the three wastewater treatment plants owned and operated by the PWD. Table 3.2 summarizes the physical characteristics of the clarifiers at each site and the stress tests performed. The primary clarifiers at all three plants are hydraulically similar. Differences in behaviour are the result of differences in influent characteristics and minor differences in influent and effluent structures.

One stress test was performed on the primary clarifiers at the SEWPCP. Figure 3.1 presents the measured TSS removal efficiency as a function of SOR observed during the test. The test procedures and detailed results are described in Technical Memorandum 2.

The performance of the primary clarifier at SEWPCP deteriorated at a SOR of 2,400 gpd/ft^2. Clarifier deterioration was due to hydraulic throughput failure of the launders, resulting in unbalanced flow distribution over the length of the effluent weir. At 75 mgd, the center half of the launder was submerged. The velocity at the outside ends of the weirs increased, resulting in increased upward velocities in these locations. Throughout the test, the clarifier

Figure 3-1
SEWPCP Primary Clarifier Stress Test
TSS Removal Efficiency versus Surface Overflow Rate (SOR)



launders had a free discharge into the clarifier collection channel (the WSL in the collection channel was not impacting the hydraulic throughput capacity of the launders). The estimated treatment capacity of the primary clarifiers is 225 mgd with three clarifiers in service. The capacity-limiting factor was the hydraulic throughput capacity of the clarifier launders. The primary clarifiers at the SEWPCP are virtually identical to the primary clarifiers at the SWWPCP, except for the configuration of the effluent launders. If the effluent launders on the SEWPCP primary clarfiers were replaced, the expected performance of these clarifiers would be similar to the measured performance of the SWWPCP primary clarifiers (allowable SOR of 2,800 gpd/ft^2). The estimated capacity of the primary clarifiers would increase to 260 mgd with three clarifiers in service or 350 mgd with all four clarifiers is service.

TABLE 3.2
PRIMARY CLARIFIERS STRESS TEST PERFORMED

Site	SEWPCP	SWWPCP	NEWPCP	
Clarifier dimension			**Set 1**	**Set 2**
# of clarifiers	4	5	8	4
Type	Rectangular	Rectangular	Rectangular	Rectangular
Length (ft)	250	250	240	250
Width (ft)	125	125	65	125
SWD (ft)	12	12	10	10
Sludge Removal				
Hopper location	Influent end	Influent end	Influent end	
Sludge collection	Chain & flight	Chain & flight	Chain & flight	
Pumping freq.	Once every two days	Once per day	Three times per day	
Influent structure				
Channel	Common	Common	Common	Common
Clarifier openings	Orifice and weirs	Orifice	Orifice	Orifice
Openings/clarifier	8 Orifices and 14 weirs	8	4	12
Location	Surface and mid-level	mid SWD	Bottom SWD	Surface and Bottom SWD
Baffling	Yes	Yes	yes	Yes
Effluent structure				
Type	Lateral launders	Finger launders	Finger launders	Finger launders
Orientation	Cross flow	Longitudinal	Longitudinal	Longitudinal
Weir length (ft)	193	307	137	274
Launders	3	21	12	24
Test performed	1	2	2	1
Target SOR (range) gpd/ft^2	1,000-2,400	1,000-3,500	1,000-3,000	750-2,800

The capacity of the primary clarifiers at the SEWPCP could be further increased by improving the sludge removal procedures for the primary clarifiers. This modification would require removing the primary sludge from the clarifiers more frequently. Allowable surface overflow rates of up to 3,500 gpd/ft^2 were observed at the SWWPCP for the test conducted on Primary Clarifier 4. The test was conducted without BRC solids and with no sludge blanket in the clarifier.

Based on an allowable SOR of 3,500 gpd/ft^2, the theoretical maximum treatment capacity of the existing primary clarifiers is 330 mgd with three clarifiers in service or 440 mgd with all four clarifiers in service.

3.1.4 Secondary Treatment

Six secondary clarifier stress tests were conducted at the three wastewater treatment plants owned and operated by the PWD. Table 3.3 summarizes the physical characteristics of the clarifiers at each site and the secondary clarifier stress tests performed. The secondary clarifiers at all three plants are very similar and performed similarly. Differences in performance were largely the result of differences in mixed liquor settling characteristics and solids loading during the tests.

TABLE 3.3
PHYSICAL CHARACTERISTICS OF THE SECONDARY CLARIFIERS TESTED

Site	SEWPCP	SWWPCP	NEWPCP	
Clarifier dimension			**Set 1**	**Set 2**
# of clarifiers	12	20	8	8
Type	Gould	Gould	Gould	Gould
Length (ft)	214	260	214	231
Width (ft)	68	75	75	70
SWD (ft)	11	11	11	13
Sludge Removal				
Hopper location	mid length	mid length	mid length	
Sludge collection	Chain & flight	Chain & flight	Chain & flight	
RAS removal	Gravity to sump	Pump per clarifier	Common pump	
RAS rate	30%	35%	15-30%	
MLSS	1,300	2,100	1,100	
Influent structure				
Channel	Common to 6	Common to 10	Common to 8	Common to 4
Clarifier openings	Adjustable weir	Orifice	Overflow Weir	Overflow Weir
Number per clarifier	4	4	4	4
Location	Top	Surface	Surface	Surface
Baffling	Yes	Yes	No	Yes

TABLE 3.3
PHYSICAL CHARACTERISTICS OF THE SECONDARY CLARIFIERS TESTED

Site	SEWPCP	SWWPCP	NEWPCP	
Effluent structure				
Type	Finger launders	Finger launders	Finger launders	Finger launders
Orientation	Longitudinal	Longitudinal	Longitudinal	Longitudinal
Weir length (m)	784	816	850	850
Number of Launders/	24	12	24	24
Test performed				
Stress test	2	1	0	3
Target SOR (range) gpd/ft^2	860-2,000	600-2,100		1,000-2,100
Dye tests	1	0	3	1

Two stress tests and one dye test were performed on the SEWPCP secondary clarifiers. The test procedures and results are described in Technical Memorandum 2; the main findings are summarized below.

Two stress tests were conducted on Secondary Clarifier 11 at the SEWPCP. Figures 3-2a and 3-2b present the flow and effluent TSS concentration as a function of time for each test. Figure 3-3 presents the effluent TSS concentration as a function of SOR for both tests. The first test was conducted by increasing the hydraulic loading on the clarifier gradually, in incremental steps. The second test was conducted by increasing the hydraulic loading suddenly from normal dry weather flow to peak flow within approximately five minutes. In both tests, the effluent TSS concentration remained well below 60 mg/L. The maximum SOR achieved during the tests was 2,100 gpd/ft^2.

Dye tests are used to evaluate the hydraulic efficiency of the secondary clarifiers. A clarifier dye test was performed on Secondary Clarifier 1. The test results indicated that there is relatively even flow distribution throughout the clarifier body, with only small areas of the tank not utilized for clarification. The slight short-circuiting observed is considered normal for a clarifier of this design.

Figure 3-2a
SEWPCP Secondary Clarifier Stress Test - Gradual Increase in Flow
Effluent TSS Concentration versus Time

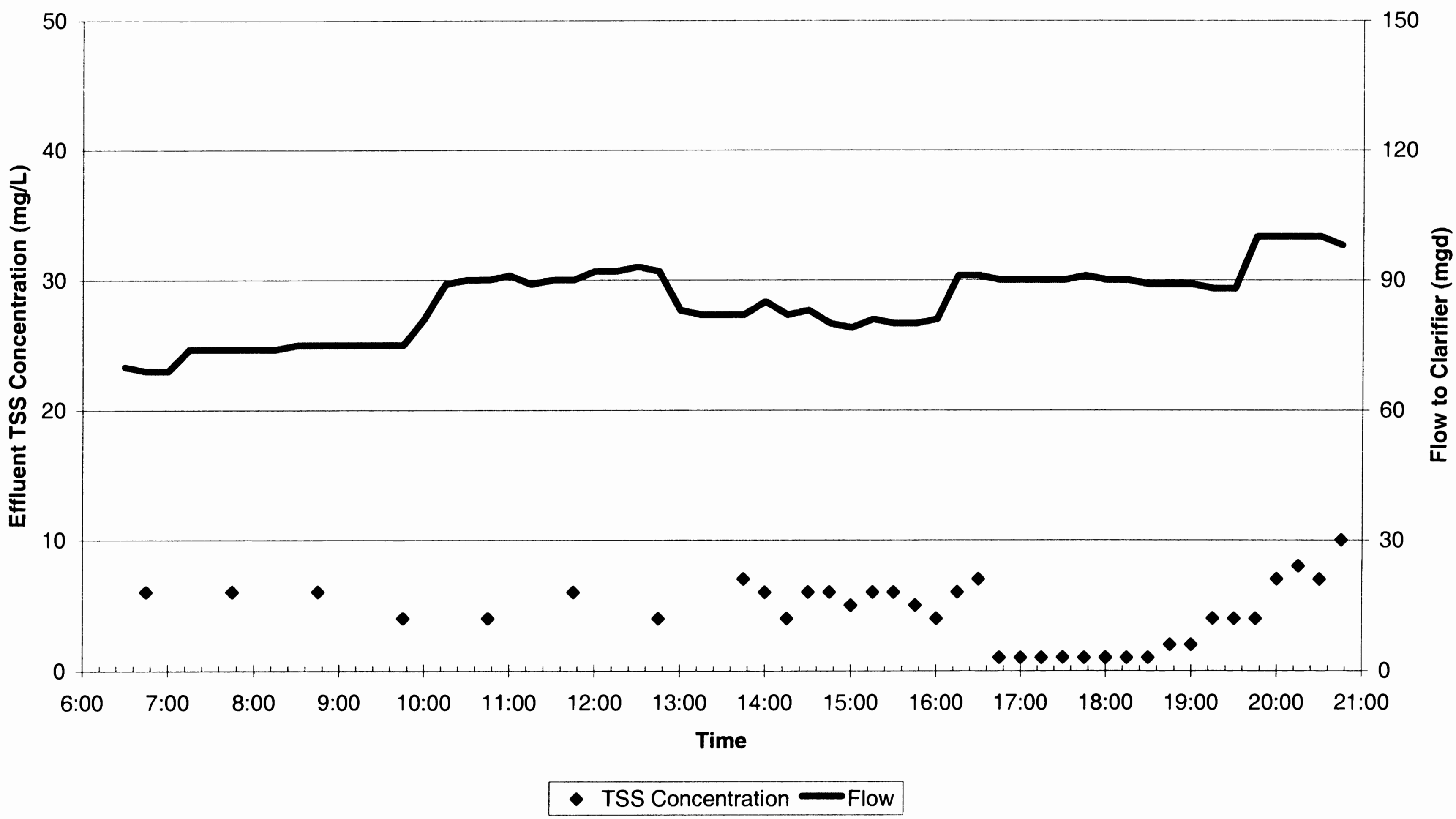


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Figure 3-2b
SEWPCP Secondary Clarifier 11 Stress Test - Sudden Increase in Flow
Effluent TSS Concentration versus Time

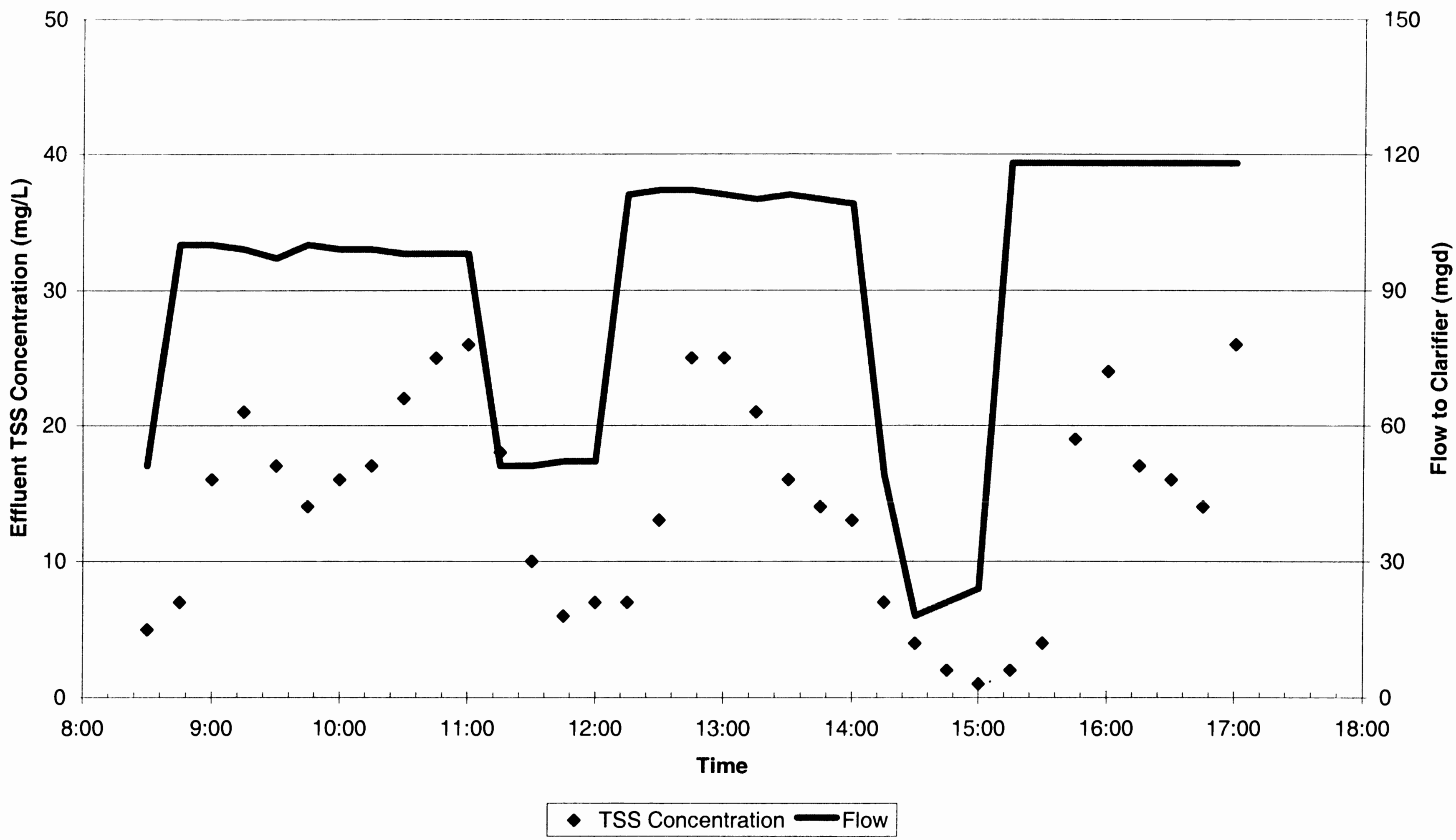
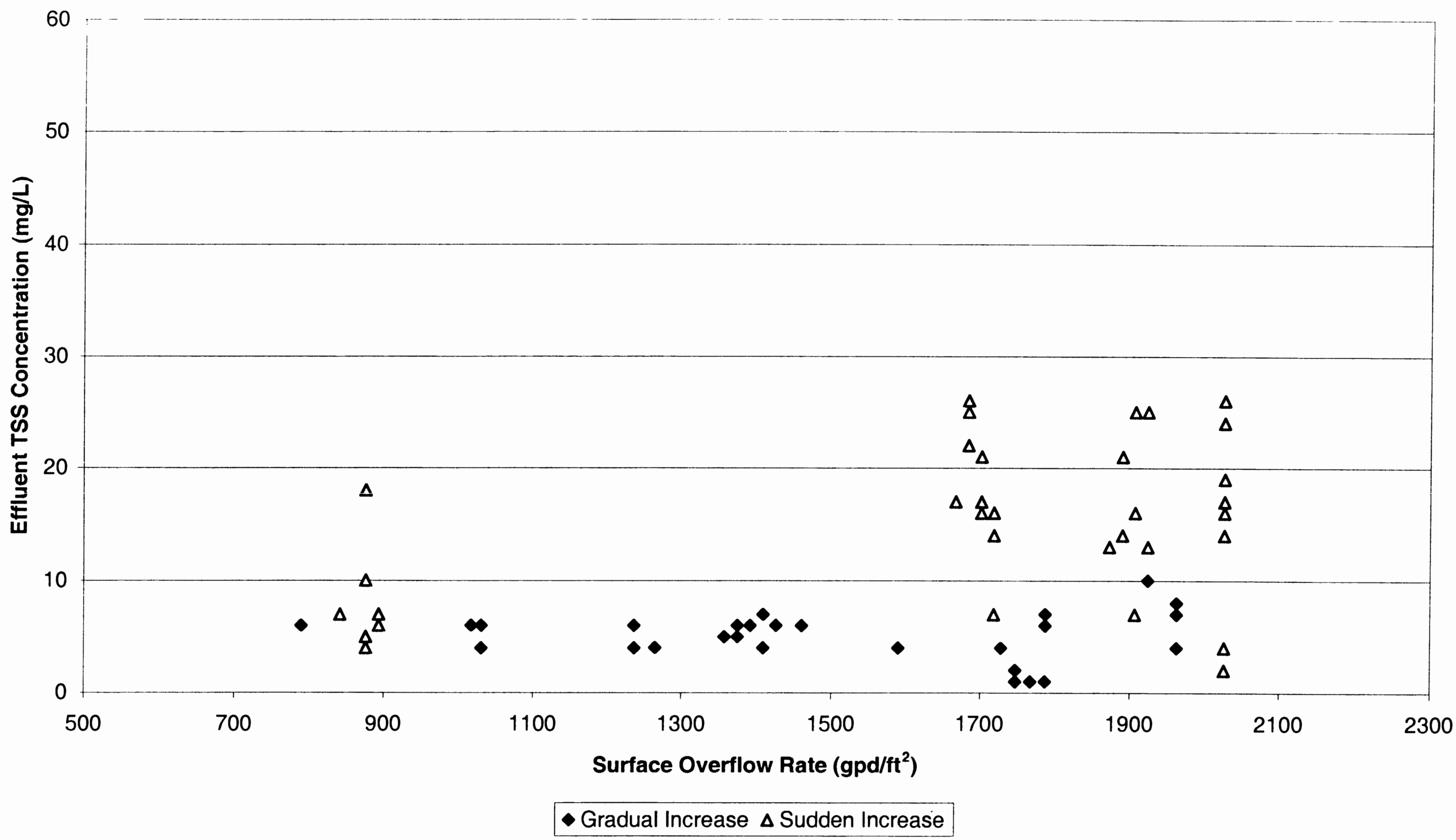


Figure 3-3
SEWPCP Secondary Clarifier Stress Test
Effluent TSS Concentration versus Surface Overflow Rate (SOR)



The performance of Secondary Clarifier 2 was monitored over a four-month period using online instrumentation to quantify the dynamic performance of the clarifiers to naturally-occurring storm events. The online instrumentation recorded total plant flow, RAS flow, mixed liquor TSS concentration, sludge blanket levels, and effluent TSS concentration. The online monitoring recorded the response of Secondary Clarifier 2 to seven storm events. Table 3.4 summarizes results of the online monitoring program; more detailed results are presented in Technical Memorandum 3.

The secondary clarifier TSS concentration exceeded 60 mg/L for short periods of time during the first three storms. The effluent TSS concentration rose significantly at plant flow rates between 120 to 220 mgd. The maximum SOR based on total plant flow and number of clarifiers in service during the storm events ranged from 1,250 to 1,300 gpd/ft^2. This is significantly lower than the maximum allowable SOR observed during the secondary clarifier stress test.

TABLE 3.4
RESULTS OF THE ONLINE MONITORING PROGRAM

Date	SVI	MLSS	TSS >60 mg/L		Peak Achieved	
	ml/g	mg/L	Q mgd	SOR gpd/ft^2	Q mgd	SOR gpd/ft^2
March 14	217	1,357	220	1,260	220	1,260
March 21	383	1,340	116	660	227	1,300
April 9	214	967	190	1,088	218	1,250
April 11	186	1,203	~	~	220	1,230
April 23	190	1,077	~	~	214	1,230
May 19	155	683	~	~	230	1,580
May 24	141	1,067	~	~	226	1,290

The secondary clarifier effluent TSS concentration did not exceed 60 mg/L for the remaining four storms, even though the maximum flow rate was similar to the first three storms. The main reason for the difference in performance between the first month of the online monitoring period and the remaining three months was the settling characteristics of the mixed liquor.

During February and March 1999, the SEWPCP experienced a severe sludge bulking incident. Samples of the mixed liquor were sent to Dr. David Jenkins at the University of California for microbial species identification. The results indicated that the overabundance of filamentous organisms that were causing the bulking incidence were associated with nutrient deficiency in the activated sludge system.

A sampling program was initiated to track the ortho-phosphate concentration at various points in the collection system and WPCP to identify the cause of the deficiency, and a temporary chemical feed system was installed to add phosphoric acid upstream of the aeration basin. It was determined that the ferric sludge from Queen's Lane Water Treatment Plant was absorbing the ortho-phosphate in the raw sewage before it arrived at the SEWPCP. The ortho-phosphate in the plant influent was less than the detection limit for most of the samples collected. The settling characteristics of the activated sludge improved after the nutrient deficiency was corrected.

The estimated capacity of the secondary clarifiers is 330 mgd with one clarifier out of service. This is based on the observed performance of the secondary clarifiers during the stress tests and on allowable SOR of 1,800 gpd.ft^2. Under bulking sludge conditions, the estimated capacity is less than 200 mgd. The secondary clarifiers at the three facilities are very similar, and therefore the results from stress testing at the other facilities can be used to predict the performance of the secondary clarifiers at the SEWPCP. The secondary clarifier stress test at the NEWPCP indicated that the clarifiers were susceptible to solids flux failure at solids loading rates of approximately 30 lbs/day. The solids flux failure was due to inefficiencies in the solids removal systems. Based on the stress test results from NEWPCP, the estimated capacity of the secondary clarifiers will be reduced if the mixed liquor concentration is increased.

At a mixed liquor concentration of 2,000 mg/L, the capacity of the secondary clarifiers would be reduced to 236 mgd. Modifications to the solids removal systems will be required to maintain current treatment capacity if higher mixed liquor concentrations are required in the future. Higher mixed liquor concentrations would be required if there were a significant change in the raw sewage quality due to changes in the industrial contributions or reduction in the ferric sludge.

3.1.5 Disinfection and Effluent Pump Station

The estimated capacity of the SEWPCP effluent pump station is 280 mgd. This is based on the rated capacity of the existing pumps with one pump out of service. The rated capacity of the disinfection is 395 mgd. This is based on 15 minute HRT in the existing outfall under peak flow conditions.

3.2 Hydraulic Throughput Capacity

The hydraulic throughput capacity of the unit processes at the SEWPCP was estimated using WinHYDRO, a computer model that facilitates complex analysis of plant hydraulics.

Hydraulic and energy gradelines from the headworks to the plant outfall were developed for a number of flow rates. The hydraulic throughput capacity of each unit process was developed based on the assumption that the downstream hydraulic bottlenecks had been resolved. Table 3.5 summarizes the estimated hydraulic throughput capacity for each unit process. The detailed hydraulic modeling results are presented in Technical Memorandum 4 – Hydraulic Throughput Capacity of Existing Facilities.

TABLE 3.5
SOUTHEAST WWTP CURRENT HYDRAULIC THROUGHPUT CAPACITY

Unit Process	Estimated Capacity (mgd)	Basis of Capacity Estimate
Outfall	450	• Flow path – Delaware River to the effluent pump station • Hydraulic control section – mean high tide 97.75 feet • Two outfall channels in service • Hydraulic exceedance – pump station discharge weir
Secondary effluent channel	Version A – 250 Version B >330	• Flow path – effluent PS wet well to secondary clarifier overflow weir • Hydraulic control section – wet well water surface level Version A – wet well level at maximum WSL 100.75 feet Version B – wet well level at WSL 97 feet • Ten secondary clarifiers in service • Hydraulic exceedance – clarifier overflow weir elevation
Mixed liquor channel	Version B > 330	• Flow path – effluent PS wet well to aeration basin overflow weir • Hydraulic control section – secondary clarifier weir The secondary clarifier weir has a free discharge • Hydraulic exceedance – aeration basin overflow weir
Aeration basin and primary flow split box	Capacity 1 – 235 Capacity 2 – 250 Capacity 3 – 330	• Flow path – aeration basin overflow weir to the primary clarifier overflow weir • Hydraulic control section – aeration basin overflow weir • 50/50 flow split between east and west side, six aeration basins in service • Hydraulic exceedance 1 – flow split weir elevation Hydraulic exceedance 2 – primary clarifier overflow weir Hydraulic exceedance 3 – top of concrete
Preliminary treatment	>330	• Flow path – primary clarifier overflow weir to the common influent channel downstream of the raw sewage pump station • Hydraulic control section – primary clarifier overflow weir • Four primary clarifiers and five grit channels and bar screens in service • Hydraulic exceedance – raw sewage pump station discharge weir

The hydraulic throughput capacity of the SEWPCP is greater than 330 mgd, except for the following locations:

- **Primary Clarifier Launders** - The primary clarifier launder capacity is exceeded at less than 75 mgd per clarifier. The launder becomes flooded and the water surface in the clarifier increases and backs up into the flocculation basins and grit tanks. This hydraulic limitation is the result of the small collection channel into which the launders discharge prior to discharging into the main primary effluent channels.

- **Aeration Basin Overflow Weir** - Under high flow conditions, the WSL in the aeration basin increases and submerges the primary effluent flow split weirs. The primary effluent flow split weirs become submerged at approximately 235 mgd. The primary clarifier effluent weirs become submerged at approximately 250 mgd. The WSL in the flocculation tanks and grit chambers is impacted by the increase in the WSL in the primary clarifiers. The hydraulic limitation is the aeration basin outfall weirs. The weir discharge is restricted to keep oxygen in the enclosed aeration tanks.

3.3 Capacity Limiting Factors

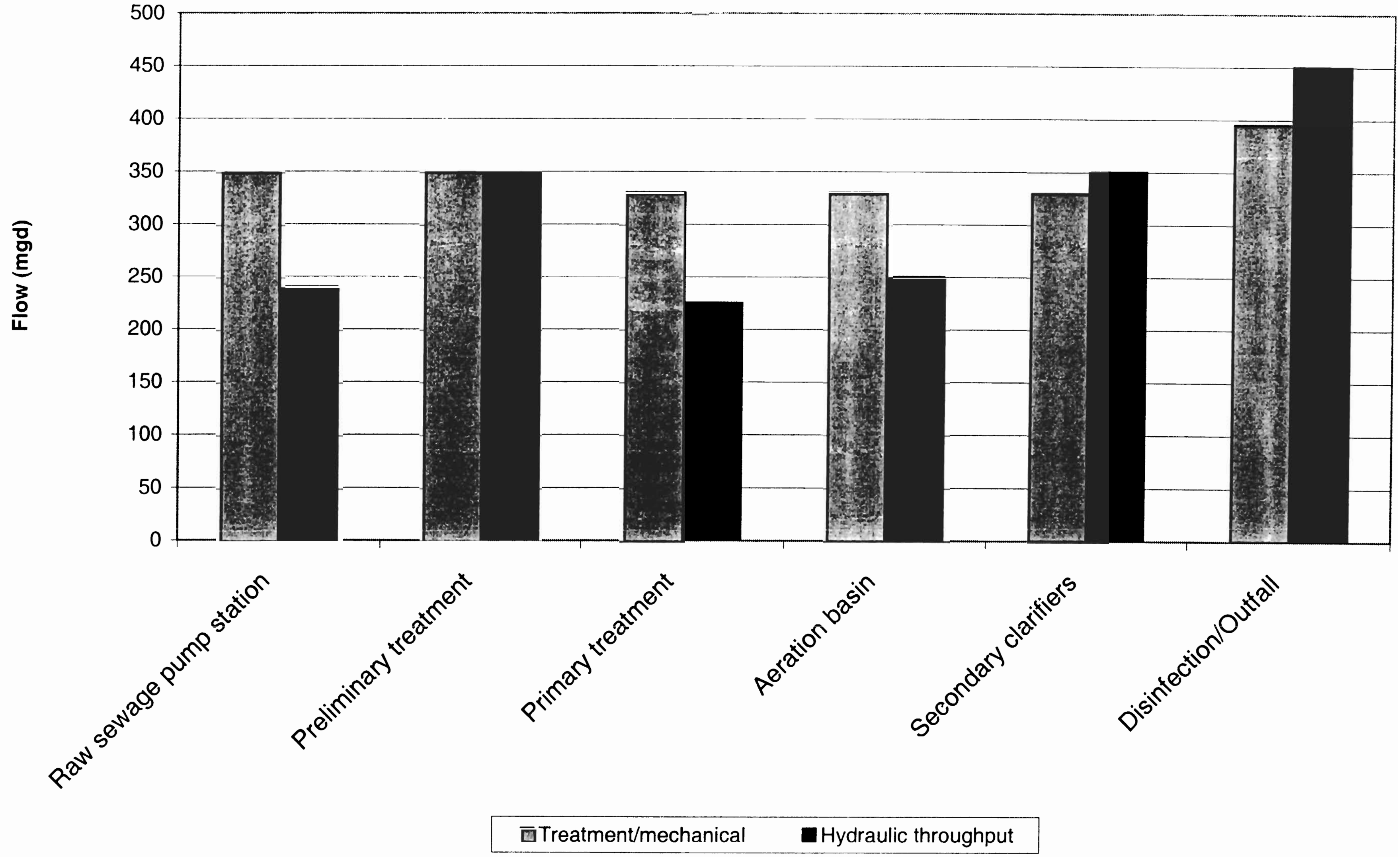
Figure 3-4 presents a summary of the estimated current peak instantaneous capacity on a unit process basis for the SEWPCP. The major capacity bottlenecks for the facility follow:

- **Raw Sewage Pump Station** - Estimated capacity of 200 mgd with one bar rack out of service. The bar rack can be put back into service quickly. However, the potential of permanently damaging the screens and pumps increases. The maximum capacity of the raw sewage pump station with both sides of the wet well in service is 286 mgd. Modifications to the pump station wet well and inlet structure are required to resolve this bottleneck.

- **Primary Clarifier Launders** - Estimated hydraulic throughput capacity of the primary clarifier launders is 225 mgd with three clarifiers in service. Replacing the clarifier launders would increase the primary treatment capacity to 260 mgd. Improved primary sludge pumping would increase the capacity to 300 mgd.

- **Aeration Basin Influent** - Estimated hydraulic throughput capacity of the aeration basin and primary effluent channels is 235 mgd before submerging the aeration basin influent weir. The facility will continue to operate but there will be deterioration in process control under these circumstances. The estimated hydraulic throughput capacity of the aeration basin and primary effluent channels is 250 mgd before flooding occur of the primary clarifier effluent weir. Secondary effluent pumping or aeration basin by-pass (extreme step feed) is required to resolve this bottleneck.

Figure 3-4
Southeast WPCP - Estimated Current Capacity



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SECTION 4

CURRENT SUSTAINABLE TREATMENT CAPACITY

4. Current Sustainable Treatment Capacity

4.1 Sustainable Treatment

The estimated treatment capacities summarized in section 3 of this report utilize maximum instantaneous limits currently in PWD's NPDES permits as the goal for the effluent quality. Since the maximum instantaneous and maximum daily limits are the same values, a process operation whose final effluent quality will meet the instantaneous maximum limits will also meet the daily maximum limits. However, the current NPDES permits, based on expected performance for plants that intake substantial quantities of stormwater, include maximum weekly and monthly limits that are significantly more stringent than the daily/ instantaneous limits. Furthermore, strict compliance with maximum monthly concentration limits will not guarantee monthly compliance with other quality limits in the permit, such as average monthly and weekly loading limits and percent removal requirements.

An important but difficult question remains regarding how long a facility (or process) can sustain high flows that allow effluent quality to meet all the permit effluent quality requirements.

The performance of the secondary clarifiers determines the final effluent quality from the SEWPCP. The data collected during the field-testing was used to predict final effluent quality as a function of flow rate. The predicted final effluent TSS and BOD_5 concentration for a given flow rate was used to determine the maximum flow that could be maintained for an infinite period of time with effluent quality meeting the monthly and weekly loading and percent removal requirements in the NPDES permit.

Secondary clarifier capacity is defined by either the clarification capacity, which is a function of SOR, or the solids flux capacity, which is a function of solids loading rate (SLR). Clarifier performance as a function of both SOR and SLR was collected during the testing for a range of operating conditions. Data from the six secondary clarifier stress test was used to quantify the secondary clarifier performance as a function of hydraulic loading and to identify the maximum allowable solids loading rate for the clarifiers.

The historical data was used to determine the yield and mixed liquor concentrations required as a function of primary effluent quality. The data from the primary clarifier stress tests was used to determine the expected primary effluent quality as a function of flow rate. The mixer liquor required for the expected primary effluent quality determines the solids loading rate for the secondary clarifier.

4.2 Analysis Methodology

4.2.1 Predicting Secondary Effluent Quality as a Function of the SOR

In the stress tests of the secondary clarifiers, the TSS and BOD_5 concentrations in the secondary effluent were measured as a function of the surface overflow rate applied to the clarifiers. A linear regression was performed on the field testing data to establish the relationship between SOR and TSS and BOD_5 concentrations in the effluent. The intercept and slope values obtained for the regression were statistically analyzed to find the 95% confidence level associated with these two coefficients. Using the upper 95% confidence level interval provides a conservative description of the relationship between the SOR and effluent quality. The model is used to predict TSS or BOD_5 for a given SOR; the value generated using the linear regression will be lower than the actual value observed 95 out of 100 times.

The estimated effluent concentrations and discharge loads (which are equal to the effluent flow rate multiplied by the effluent concentration) can then be compared to permit levels to determine the sustainable treatment capacity of the facility on a SOR basis.

4.2.2 Effect of the SLR on Secondary Clarifier Performance

Failure of the secondary clarifiers may occur due either to clarification or thickening. An increase in the hydraulic loading to the primary clarifiers will result in an increase in organic loading to the aeration basin due to an increase in the amount of organic material entering the plant and deterioration in the primary clarifier performance. An increase in the organic loading to the aeration tanks results in an increase in the mixed liquor concentrations and therefore an increase in he solids loading for a given flow. Therefore the analysis done in terms of the SOR must be complemented with an analysis of the effect of influent flow rate versus SLR.

Stress tests were performed on the primary clarifiers, and removal efficiencies as a function of the surface overflow rate in the primary clarifiers were documented. The data was used to predict the quality of the primary effluent as a function of the influent flow rate. This analysis, combined with analysis of historical data on solids production, was used to estimate the SLR as a function of flow, taking into account both the performance of the primary clarifiers and the increase in the organic loading associated with augmented flows.

The stress tests on the secondary clarifiers indicated that the maximum SLR that could be maintained before thickening failure occurs is 35 lb/(ft^2.day). The flow at which these solids loading rates are achieved is the maximum sustained flow that can be maintained in the plant before thickening failure occurs.

4.3 Analysis Results

4.3.1 Predicting Maximum Flows as a Function of the SOR

Figure 4.1 is a plot of the TSS in the secondary effluent and the SOR applied in the secondary clarifier from the six secondary clarifier stress tests conducted at the facilities owned and operated by PWD. The data from all six secondary clarifier stress tests were used in the preparation of this plot. Figure 4.2 presents the same analysis was done for the BOD_5 concentration in the secondary effluent.

Figure 4-1
Secondary Clarifier Stress Test - Effluent TSS Concentration as a Function of SOR

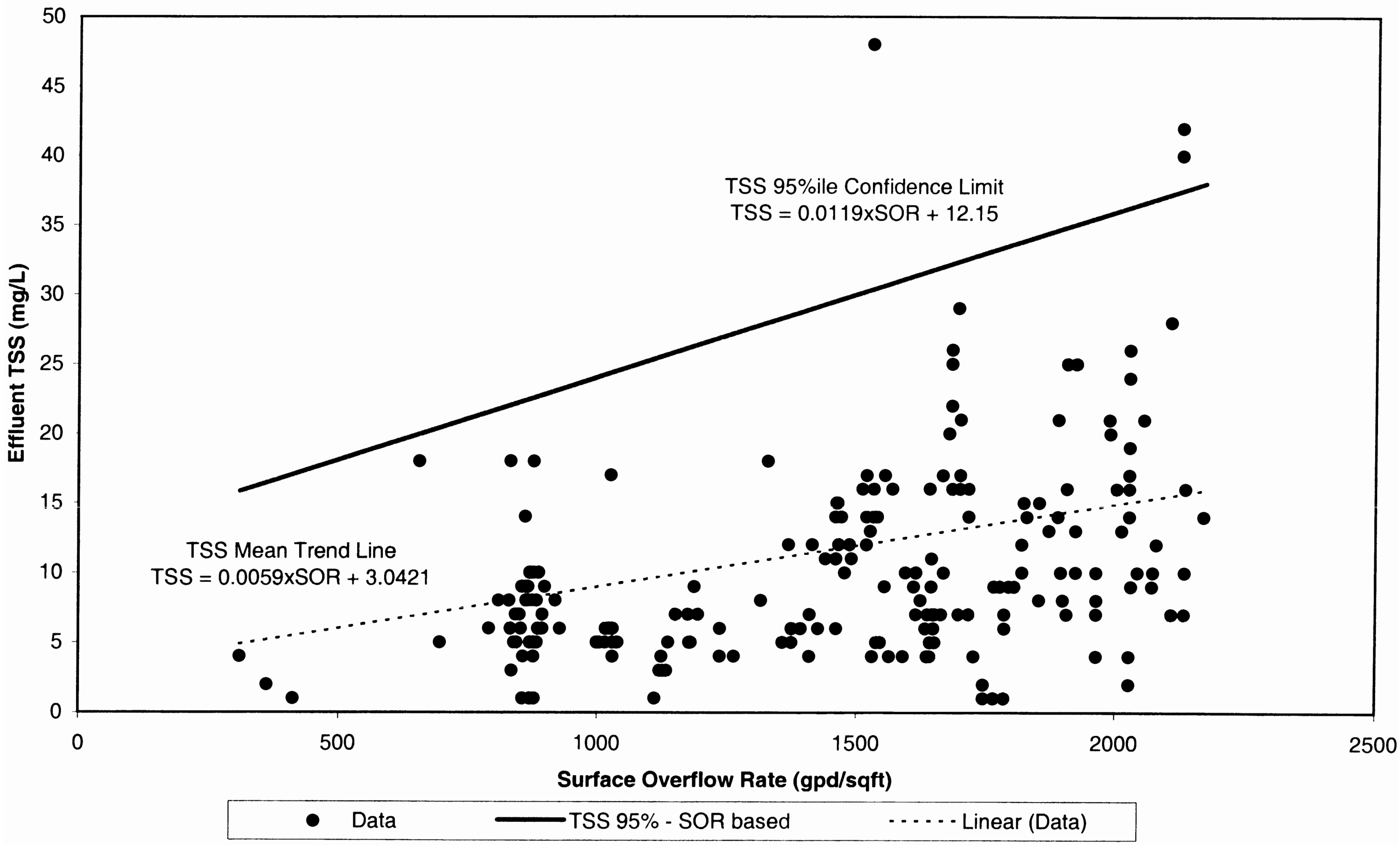
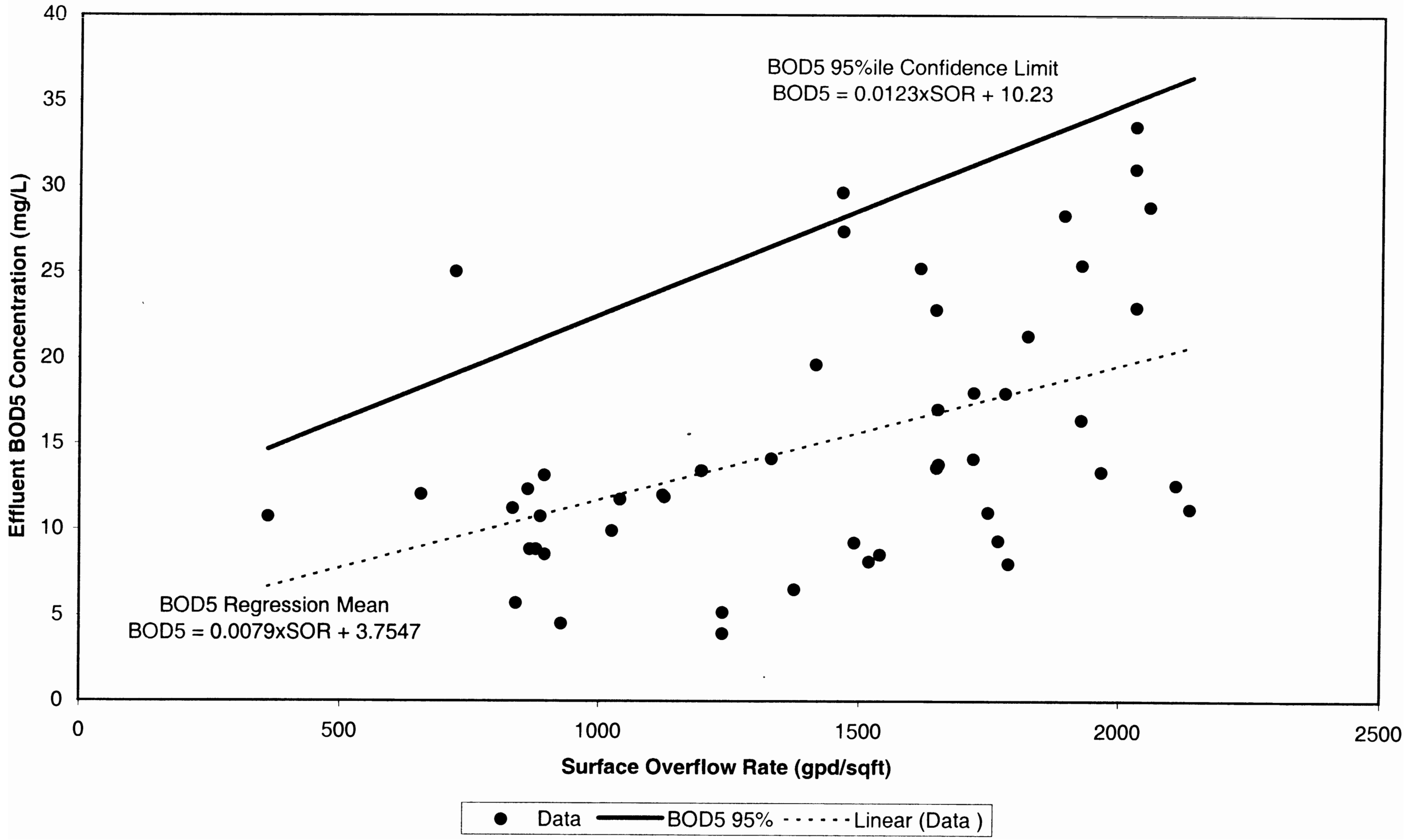


Figure 4-2
Secondary Clarifier Stress Test - Effluent BOD5 Concentration as a Function of SOR



The amount of TSS and BOD_5 discharged results from the product of the flow rate and the concentrations predicted by the 95% confidence level regressions. The discharge values were then compared to the NPDES Permit values for the SEWPCP. The results of this analysis are presented in Table 4.1.

TABLE 4.1 SOUTHEAST WPCP – NPDES PERMIT REQUIREMENTS AND RESULTS OF THE SUSTAINABLE FLOW ANALYSIS

Parameter	Units	NPDES Limit	Maximum Sustainable Flow based on SOR		Maximum Sustainable Flow based on SLR
			TSS Limit	BOD_5 Limit	
Maximum Day Limits	mgd	168			190
Maximum Week Limits	mgd		195	165	
BOD_5 Concentration	mg/L	45			
BOD5 Mass Loading	lbs/day	29,475			
TSS Concentration	mg/L	45			
TSS Mass Loading	lbs/day	42,035			
Maximum Monthly Limits	mgd	112	150	125	
BOD_5 Concentration	mg/L	30			
BOD_5 Mass Loading	lbs/day	19,650			
BOD $_5$ Percent Removal	%	86			
TSS Concentration	mg/L	30			
TSS Mass Loading	lbs/day	28,025			
TSS Percent Removal	%	85			

The maximum sustainable flows at which the SEWPCP can meet the weekly NPDES TSS and BOD_5 effluent mass loading requirements are 195 and 165 mgd, respectively. The BOD_5 weekly mass loading is the limiting criteria because the allowable effluent BOD_5 mass loading is significantly lower. The maximum daily flow in the NPDES permit is 168 mgd. This is very similar to the predicted maximum sustainable flow at which the facility can meet the weekly mass loading limits.

The maximum sustainable flows at which the SEWPCP can meet the monthly NPDES TSS and BOD_5 effluent mass loading requirements are 150 and 125 mgd, respectively. The maximum month sustainable capacity is slightly higher than the average design capacity of the facility.

4.3.2 Predicting Maximum Flows as a Function of SLR

The stress tests of the secondary clarifiers indicated that the maximum solids loading rate that could be sustained by the secondary clarifiers was 35 lb/(ft^2.day). The solids loading rate is a function of the MLSS concentration in the aeration basin and the influent and RAS flow rates. The MLSS concentration is dependent on the loading to the aeration basins, which in turn is dependent on the performance of the primary clarifiers as a function of the flow. The objective is to develop an overall correlation between the flow coming into the plant and the resulting solids loading rate into the secondary clarifiers.

The primary clarifier stress test results were used to determine the TSS percent removal in the primary clarifiers as a function of influent flow rate. A regression analysis of all stress test results performed in the primary clarifiers (except the test performed at the Southeast Plant where the clarifier failed prematurely due to the hydraulic limitations of the launders) was performed, and the lower 95% confidence levels associated with the regression parameters were calculated. Figure 4.3 presents the results of this analysis.

The yield for the SEWPCP was estimated based on the historical tonnage of waste activated sludge pumped to the SWWPCP and the TSS and BOD_5 concentrations in the primary effluent. The SEWPCP is operated at an SRT of 1.9 days, the RAS flow rate is about 30% of the influent flow rate, and the raw wastewater has an average TSS concentration of 142 mg/L. For the determination of the SLR limiting flow, it was assumed that all of the primary and secondary clarifiers are online, but that only six out of the eight aeration basins are in use. This corresponds to current operating practice at the site.

The SLR becomes 35 lb (ft^2.day) at the SEWPCP when the sustained flow is equal to 190 mgd. At flow rates greater than 190 mgd, thickening failure will occur unless measures are taken to reduce the solids loading rate to the secondary clarifiers. Preventative measures that are currently implemented at the SEWPCP include reducing the mixing in the aeration basin to allow solids to settle in Cells 1 and 4 and using the two aeration basins that are out of service as RAS storage for the duration of the storm.

Alternatively, step feed could be implemented at the SEWPCP by constructing an "in basin" primary effluent conduit along the length of the basin. The conduit would operate as a submerged diffusor and would require structural modifications to existing tanks. Improving the primary clarifier performance by providing "out of clarifier" primary sludge thickening or enhanced primary clarifier performance through chemical addition would also reduce the solids loading to the secondary clarifiers. However, these alternatives would require capital expenditure for additional facilities. Improving the solids removal efficiency of the clarifiers would effectively increase the allowable solids loading rate to the clarifier. This would require modifications to the existing RAS system.

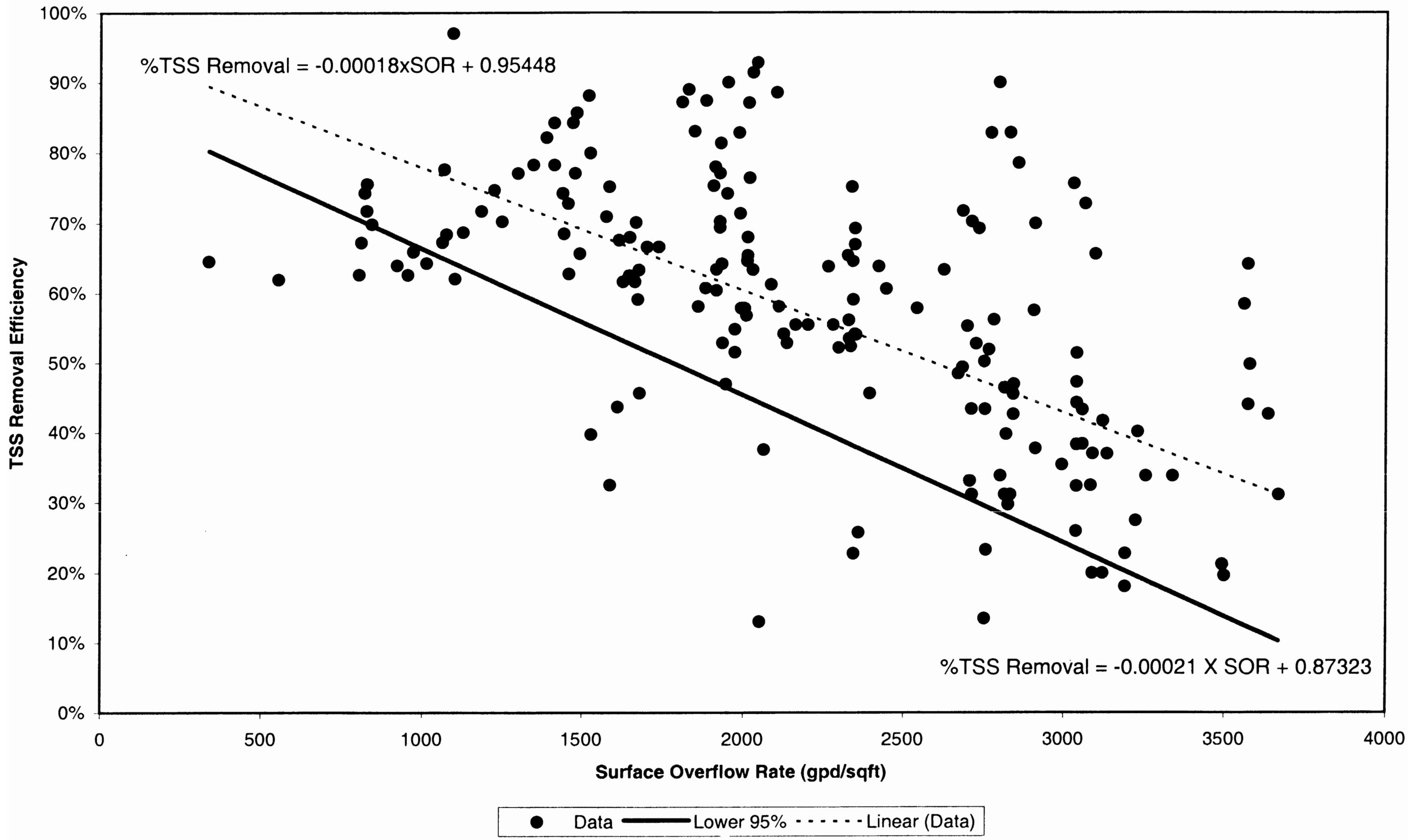
4.4 Control of High Flow Duration

Discussions with PWD managers directing PWD 's CSO program indicated that current CSO inline storage and draw-down plans expect that stored combined sewerage would be released to the plant over a 12-hour period following a storm event. This is a volume of combined sewerage that PWD's plants have not received in the past. Furthermore, there is flexibility in the draw-down strategy since the primary objective of the effort would be to return the storing sewer back to its original condition prior to the next storm event. It was clear that this is only a current plan and it would change should PWD be required in the future to provide additional combined sewerage storage to meet receiving water quality objectives.

From the wastewater treatment plant perspective, a number of factors can influence the ability of a plant to achieve weekly or monthly limits whenever the plant is being stressed by storm-induced, high influent flows. The number and distribution of rain events during the week/month, together with plant effluent quality during non-rain event periods, rank high on the list of influences. PWD's revised permit language provides effluent quality relief, but only when the daily plant flow exceeds the permitted maximum daily flows currently stated in the permits. No such relief occurs for flows below the maximum daily flow limits.

Since the impact of stored combined sewerage on the SEWPCP performance is an unchartered experience, it is recommended that the duration of storage be no greater than a 24-hour period for each storm event. Should the CSO program's strategy for stored combined sewerage change beyond this 24-hour period, the issue of plant compliance for all monthly and weekly effluent quality requirements should be reviewed.

Figure 4-3
Primary Clarifier Stress Test – Percent TSS Removal Efficiency as a Function of SOR



SECTION 5

POTENTIAL UPGRADES

5. Potential Upgrades

A list of potential improvements was developed to increase the capacity or improve the performance of the SEWPCP; the potential improvements are based on the results of stress tests on unit processes, long-term monitoring of the plant, and hydraulic modelling

Each upgrade option has been prioritized based upon the following criteria:

- **Priority A – Existing Facilities Optimization.** Improvements that are easily implemented, low cost, high benefit, and will have an immediate positive impact upon normal operations. These are options that can be included in short-term capital budgets.
- **Priority B – Proactive Improvements.** Improvements that are moderate in cost and will have a positive impact on plant capacity. This category also includes improvements that are necessary to maintain existing capacity for increased mixed liquor suspended solids in the aeration tanks. These are options that should be included in a long-term improvement plan.
- **Priority C - Capacity De-bottlenecking.** Improvements that have large costs associated with them and will greatly increase capacity above the current permitted peak flow. These options should be considered in an overall long-term, wet-weather flow control program and in the long-term improvement plan if significantly more treatment capacity is required at the facility.

The list of potential upgrades, budgetary cost estimates, and their associated prioritization is summarized below. The detailed descriptions of each upgrade are presented in Technical Memorandum 5 - Budgetary Cost Estimates for Potential Plant Improvements.

The cost estimates are based on preliminary costs and are for use as "budgetary" values only. The cost estimates are Class "C" cost estimates (order-of-magnitude costs) as defined by the American Association of Cost Engineers. The level of accuracy of the Class "C" cost estimates is +50 percent to –30 percent of the actual cost of construction. These costs can be used for decisionmaking to select options for more detailed analysis that are most feasible from both a design and cost perspective.

Table 5.1 includes the final estimated cost for each improvement. Table 5.2 presents a summary of the overall cost for improvements at the SEWPCP, which are broken down into alternatives that are dependant upon one another for an increase in capacity at the plant.

TABLE 5.1
POTENTIAL UPGRADE OPTIONS AT SOUTHEAST WPCP

Option No.	Description	Priority Classification	Estimated Conceptual Cost
1	Provide permanent facilities for phosphorous addition if influent phosphorous deficiency remains	A	$200,000
2	Resolve capacity limitation in existing pump station by adding a new bar rack	C	$8-10M, if feasible
3	New influent pump station (Includes adding new bar rack)	C	$24,140,000
4	Replace existing primary clarifier effluent launders with new launders running parallel to flow to increase hydraulic capacity	C	$1,265,000
5	Provide separate primary sludge thickening	C	$3,645,000
6	Provide an additional effluent pump at the effluent pumping station	C	$319,000
7	Provide primary effluent bypass to secondary clarifiers	C	$644,000
8	Resolve hydraulic limitation between primary clarifiers and aeration basin	C	$3,600,000

TABLE 5.2
SUMMARY OF BUDGETARY COSTS FOR POTENTIAL IMPROVEMENTS AT SOUTHEAST WPCP

Improvement Alternatives	Total Costs for Improvements (Million $)	Cumulative Costs for Improvements (Million $)	Peak Treatment Capacity (MGD)			
			Plant	Preliminary	Primary	Secondary
All process improvements (Option 1)	0.2	0.2	240	240	240	240
Increase in raw pumping capacity (Option 2/3)	24.14	24.34	240	330	240	240
Increase primary capacity, bypass aeration basins (Options 4, 5, 6, 7)	5.87	30.21	330	330	330	240
Increase primary and secondary treatment capacity (Options 4, 6, 8)	5.18	33.81	330	330	330	330

Process Improvements. The capacity of the SEWPCP is determined by the solids settling characteristics of the mixed liquor TSS. As discussed in Section 3.1.4, the solids received from Queen's Lane WTP cause a nutrient imbalance in the aeration basin, and phosphorus addition is required to correct this imbalance. Permanent facilities for phosphorus addition address the nutrient deficiency and are currently in use at the plant.

Increase in Raw Pumping Capacity. The capacity of the raw sewage pumping station limits the capacity of the SEWPCP. The objective of Improvement Alternative 2 is to increase the raw sewage pumping capacity. This is required before any other alternatives can be considered for increasing plant flow. The current raw water pumping station is limited to a flow of 200 mgd with one bar rack out of service because of hydraulic limitations in the raw water pump station wet well area.

The facility can operate up to a maximum capacity of 240 mgd with one bar rack partially obstructed. However, there is a greater potential for causing permanent damage to the bar rack or raw sewage pumps operating in this fashion. In the past ten years, a bar rack has been taken out of service for maintenance only once. In the past five years, the hydraulic throughput capacity has never been less than required as a result of maintenance activities. If more CSO flow is brought to the facility, the frequency of the hydraulic throughput being limited by a bar rack out of service will increase.

The hydraulic limitation of the raw sewage pump station is a result of the configuration of the inlet structures. The estimated capital cost of providing a new influent pump station is $24,140,000. A detailed hydraulic evaluation of the pump station inlet structure may identify a more cost-effective method of increasing the hydraulic throughput capacity. Potential retrofits include installing an additional bar rack, additional or larger inlet conduit and/or sluice gates, and modifications to the pump suction channels. However, due to the depth of the pump suction, any modification that requires changes to the inlet structure footprint will be expensive. A new influent pump station may be the preferred alternative.

Increase Primary Treatment Capacity with Aeration Bypass. The estimated primary treatment capacity is 225 mgd with three primary tanks in service. The capacity is limited by the hydraulic capacity of the effluent launders. Replacing the effluent launders will increase the primary treatment capacity to 260 mgd with three tanks in service. The estimated capital cost to replace the clarifier launders is $1,265,000.

The potential primary treatment capacity of the SEWPCP is 330 mgd. Increased primary sludge pumping would be required to achieve the additional primary treatment capacity. The estimated cost of providing a gravity sludge thickening facility at the SEWPCP is $3,645,000.

A bypass between the primary clarifier effluent channel and the mixed liquor channel/secondary clarifier influent will be required to circumvent the hydraulic bottleneck between the primary clarifiers and the aeration basins. One aproach would be to construct the primary effluent channel to the mixed liquor channel. The estimated cost for this potential upgrade is $644,000. The primary effluent would be added to the upstream end of the mixed liquor channel and pass through the secondary clarifiers before discharge. The estimated peak hydraulic capacity of the secondary clarifiers is 330 mgd at current mixed liquor concentrations. The primary effluent will increase the hydraulic loading on the secondary clarifiers without increasing the solids loading. Therefore, the secondary clarifiers have sufficient hydraulic capacity to treat the additional load.

The advantage of this approach is that the primary effluent will receive some additional treatment due to contact with the mixed liquor and the "sweeping" action of the activated sludge in the secondary clarifiers. The final effluent will be of higher quality than the blended effluent from the secondary clarifier and bypass stream combined after the secondary clarifier. However, the contact time between the activated sludge and primary effluent bypass will be very small and therefore BOD_5 removal from the primary effluent will be minimal. A relaxation in the permit requirements on days when aeration tank bypassing occurs is recommended. Additionally, to get the flow out of the plant, a new effluent pump would need to be added at a cost of $319,000.

Increase Primary and Secondary Treatment Capacity. The objective of this plan is to increase the secondary treatment capacity by eliminating the hydraulic bottlenecks at the influent end of the aeration basins. Offline sludge thickening would not be required because the primary effluent would receive full secondary treatment and no bypass arrangement of the aeration basins would be used. The estimated capital cost to provide intermittent pumping between the primary clarifiers and the aeration basin is $3,600,000. Additionally, a new effluent pump would need to be added to increase the capacity of the effluent pumping station from 280 mgd to 350 mgd. The capital cost would be $319,000 for the new pump. The hydraulic residence time of the outfall is greater than 15 minutes at this flowrate, therefore no additional chlorine contact time would be required.