Appendix H
Coastal Collection System Assessment Technical Memorandum

Santa Monica Bay Beaches Wet Weather Bacteria TMDL Implementation Plan

Technical Memorandum Task 7: Coastal Collection System Assessment

To: *Morad Sedrak, City of Los Angeles Watershed Protection Division*
Representing Jurisdiction 2 and 3 Agencies

From: *Jeff Friesen, CH:CDM*
Hampik Dekermenjian, CH:CDM
Dave Jones, CH:CDM

Date: *June 11, 2004*

Abstract:

This Technical Memorandum summarizes the coastal wastewater collection system (Coastal Interceptor sewer – CIS) capacity for the purpose of temporarily storing and then releasing post-storm-peak (off-peak) stormwater to the Hyperion Treatment Plant (Hyperion) for treatment. Capacities are assessed both in the collection system along the Santa Monica Bay coast and at Hyperion. The Memorandum considers how much stormwater flow can be diverted to the wastewater collection system, and when these diversions are possible.

1.0 Introduction

1.1 Background

The CH:CDM team is assisting Jurisdiction Groups 2 and 3 (which consist of the Cities of Los Angeles, Santa Monica, and El Segundo, the County of Los Angeles, and Caltrans) in developing an implementation plan that addresses the requirements of the Santa Monica Bay (SMB) Beaches Wet Weather Bacteria Total Maximum Daily Load (TMDL). The Implementation Plan is being developed to incorporate the input of multiple cities and agencies, their departments, as well as other affected stakeholders, and will build on other planning efforts that are currently in progress, such as the City of Los Angeles' Integrated Resources Plan (IRP). The Implementation Plan will use an integrated water resources management approach, which will address multiple pollutants, identify beneficial use opportunities, and integrate multiple agencies in its overall solution.

There are seven jurisdictions, organized by watersheds, which are impacted by this TMDL. Of these seven jurisdictions, the City of Los Angeles is the lead agency for Jurisdiction 2 and is a significant participant in three other Jurisdictions (1, 3 and 7). The City of Santa Monica is the lead in Jurisdiction 3 and is a participant in Jurisdiction 2. The first two jurisdictions for which action will be implemented are Jurisdictions 2 and 3. This technical memorandum pertains to the joint implementation planning effort for Jurisdictions 2 and 3 (see Figure 1).

In support of the City's efforts to prepare the Implementation Plan, the CH:CDM team is assisting the City with the following 11 specific tasks:

Task 1: Assist with TMDL Development Planning
Task 2: Provide Staff Support for the Development of an Integrated Implementation Plan
Task 3: Regulatory Requirements
Task 4: Detailed Hydrologic Study
Task 5: Beneficial Use Evaluation
Task 6: Treatment and Management Options Evaluation
Task 7: Coastal Collection System Evaluation
Task 8: Research Potential Sites for Collection, Treatment and Diversion Facilities
Task 9: Analysis of Implementation Alternatives
Task 10: Prepare TMDL Implementation Plan
Task 11: Task Management

As part of the IRP, the CH:CDM team and the City of Los Angeles developed draft volumes for the Facilities Plan. This Technical Memorandum builds upon two volumes of the Draft Facilities Plan: Volume 3, Runoff Management, and Section 5, Existing Collection System, of Volume 1, Wastewater Management. Both volumes were prepared by the CH:CDM Team and the City of Los Angeles and released in August 2003.

1.2 Purpose

Several stormwater runoff management options are possible for the purpose of reducing surface runoff from Jurisdiction 2 and 3 watersheds, and thereby reducing the potential for wet weather bacteria TMDL exceedances in Santa Monica Bay. The alternative examined in this Technical Memorandum considers introducing some or all of a stored volume of runoff into the wastewater collection system for treatment at the Hyperion Treatment Plant (Hyperion). Different target volumes have been estimated for different portions of the Jurisdiction 2 and 3 study area. These volumes would be released to the wastewater collection system at various locations along the Santa Monica Bay coast. Depending on the volume of runoff captured and the available collection system capacity, not all of each stored volume may be handled by the wastewater collection system. This diversion and treatment option is one of several alternatives[1] that are possible, and it is probable that one or more of a combination of options will be applied across the study area. The objective of the options, including this divert-and-treat option, is to prevent untreated stormwater from reaching Santa Monica Bay and thereby contributing to TMDL exceedances.

The purpose of this analysis is to satisfy the requirements of Task 7, the Coastal Collection System Evaluation. More specifically, the purpose is to assess the capacity of the collection

[1] See the Technical Memorandum titled, "*Treatment and Management Options – Task 6*"

and treatment systems to receive diverted off-peak stormwater runoff to help meet new wet weather bacteria TMDL requirements in the Santa Monica Bay receiving waters.

1.3 Scope

The scope includes hydrodynamic modeling and capacity assessment of the CIS, and development of model inputs including a rainfall event and the resulting inflow and infiltration into the collection system. These analyses determine how much of the stored stormwater runoff identified in a previous task can be diverted to Hyperion during off-peak times. A conceptual-level cost is also presented as a means of comparing this alternative with others presented in other Technical Memoranda.

These evaluations are specific to Jurisdictions 2 and 3. This task builds on the work previously performed by the CH:CDM Team, the City of Los Angeles and other agencies on the IRP project.

2.0 Methodology

2.1 Approach

Jurisdictions 2 and 3 comprise the Coastal Sewershed (indicated in Figure 1), which contributes wastewater to the CIS. In Task 4[2] of this study the Coastal Sewershed was divided into seven runoff subsheds (subsheds) which are outlined in Figure 1. Runoff subsheds are delineated based on surface topology, and therefore represent stormwater runoff watersheds. The Coastal Sewershed is defined by the wastewater collection system, and therefore has different boundaries than the runoff subsheds. A Task 4 hydrologic model estimated rainfall runoff volumes for each subshed. The subsheds, their characteristics, and the estimated runoff volumes are listed in Table 1.

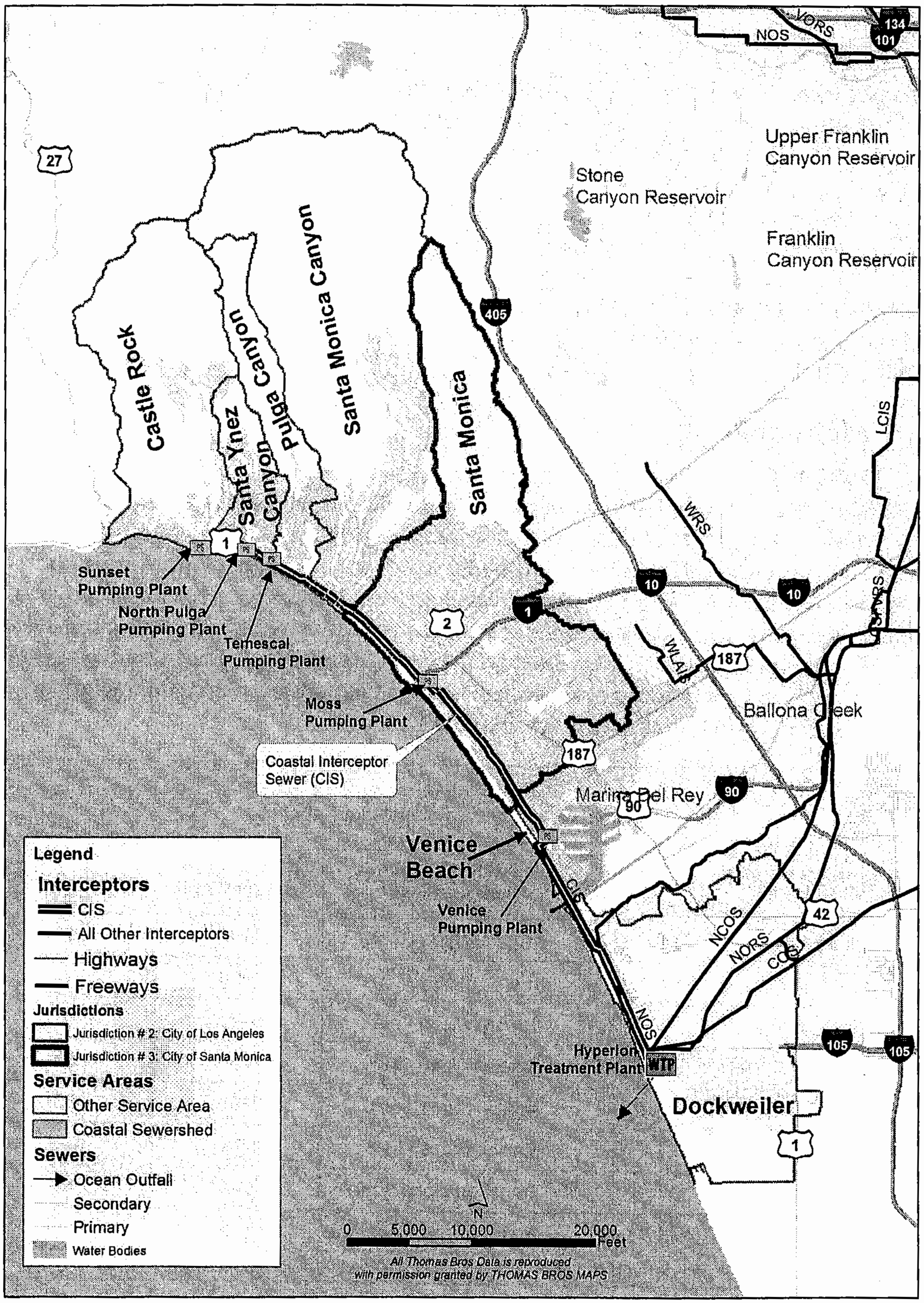
TABLE 1
Jurisdiction 2 and 3 Stormwater Subsheds

Subwatershed Name	Area (Acres)	Predominant Land Use/Percentage	% Impervious Ground Cover	Estimated Runoff Volume[1] (MG)
Castle Rock	4,982	Natural Open / 82%	9%	16
Santa Ynez Canyon	1,226	Single Family / 45%	26%	6
Pulga Canyon	1,984	Natural Open / 74%	13%	7
Santa Monica Canyon	10,125	Natural Open / 77%	8%	33
Santa Monica	9,152	Single Family / 40%	53%	63
Venice Beach	109	Beach Parks / 91%	16%	0.3
Dockweiler	6,879	Transportation / 30%	65%	49
Total:	34,457	Area-Weighted Average:	32%	

[1] Volumes and land use derived in Task 4 memorandum: *Detailed Hydrologic Study – Task 4.*

[2] See the Technical Memorandum titled, "*Detailed Hydrologic Study – Task 4*"

Figure 1. Study Area and Coastal Wastewater Collection System



Under most conditions storm water runoff will typically exceed bacteria criteria and cause exceedances of water quality objectives in Santa Monica Bay. The analysis that was done in Task 4 focused on the determination of runoff capture volumes, or operational storage volumes, as a method of limiting the number of days water quality objectives would be exceeded.

In this task, input from several sources was combined to produce an estimate of wastewater flows in the CIS, and treatment capacities in Hyperion, during and shortly after a rainfall event of specified intensity and duration.

The basis for the collection system capacity analysis is a modified hydraulic model of the City of Los Angeles outfall and interceptor wastewater collection system[3]. Developed in MOUSE (version 2003), a dynamic hydraulic modeling system from DHI Software, the model encompasses all interceptor and outfall sewers which discharge into Hyperion.

The approach to this evaluation involved the following:

- Extend the CIS portion of the City's MOUSE model to include approximately 13,500 feet of additional collection system piping and three additional pumping plants (in the Castle Rock, Santa Ynez Canyon, and Pulga Canyon subcatchment areas).
- Derive an appropriate rainfall event duration, hyetograph shape and related intensities for each of the subcatchment areas for the purpose of generating rainfall-dependent inflow and infiltration (RDI/I) hydrographs for the study area and the entire City.
- Generate estimated RDI/I flows using the derived rainfall events, a new model developed by the City, and existing I/I hydrographs from previous City modeling exercises.
- Establish the base condition modeling scenario that corresponds to approximately the 2020 conditions for the CIS and Hyperion.
- Run the CIS portion of the model with the derived rainfall events (calibration and verification for the majority of the model were done as part of the IRP study).
- Run the MOUSE model for the rest of the City to simulate flows into Hyperion, and add in the results from the CIS model run to get a complete picture of flows into Hyperion.
- Identify flow constraints in the CIS and excess capacities in the system for the purposes of diverting stored stormwater from each subcatchment (derived in Task 4) after the CIS flow peak has passed. Also assess the capacity for Hyperion to treat the diverted stormwater volume and identify any constraints.
- Provide a conceptual level cost estimate for comparison with other options.

[3] The outfall and interceptor sewers are those that collect sewage from sewer subsheds and convey it to a wastewater treatment facility.

3.0 Model Development and Analysis

Wastewater conveyance and treatment capacities were assessed for the year 2020 using the predicted wastewater flows from the 'Baseline Scenario' of the IRP. The dry weather model was first run to establish antecedent conditions, followed by a wet weather run from which capacity was assessed. The modifications made to the model and the development of model inputs are described below.

3.1 Hyperion Service Area (HSA) and the Coastal Interceptor Sewer (CIS) Model

Hyperion treats wastewater from a significant portion of the City of Los Angeles and from several contributing agencies. The area that Hyperion serves is known as the Hyperion Service Area (HSA). The CIS is one of many major sewers within the HSA; it conveys the wastewater from the Coastal Sewershed to Hyperion for treatment and ultimate discharge into Santa Monica Bay.

The CIS is a complex series of gravity and force-main pipe reaches ranging in diameter from 18 to 72 inches, with five integral pumping plants and numerous parallel segments. Built from the 1950s to the 1970s, a series of significant pumping plant and other upgrades were completed from 1994 through 2001. The originally-modeled 9.5 miles of CIS length were extended approximately two miles to allow conveyance capacity assessment for Castle Rock, Santa Ynez Canyon and Pulga Canyon subsheds. In addition to the two pumping plants in the original model, three additional significant pumping plants were added in the new model extension. Characteristics of the five pumping plants included in the model are listed in Table 2. Other minor pumping plants which contribute flows along the CIS were not modeled explicitly, but their contributions are captured in the model at wastewater contribution points. Other modifications were made to the model based on updated City of Los Angeles information that was not yet reflected in the City's pipe database.

Table 2
Primary CIS Pumping Plants

No.	Name	Estimated Maximum Pumping Rate (gpm)
646	Venice	48,000
632	Sunset	3,200
639	North Pulga	1,200
634	Temescal	3,500
N/A	Moss[1]	18,056

[1] Owned by the City of Santa Monica. All others owned by the City of Los Angeles

While this task focused primarily on the CIS, the rest of the HSA model was also important for the modeling effort because it generated both dry and wet weather flows into Hyperion that allowed the assessment of Hyperion capacity[4].

3.2 Low Flow (Dry Weather) Diversions

Dry weather urban runoff from the Coastal Sewershed is (or will be) diverted through low flow diversions to the CIS for treatment at Hyperion. A summary of existing and planned low flow diversions within the City is shown in Table 3. The total flow planned for dry weather diversion to Hyperion via the CIS by the end of 2005 is 3,840 gpm. This flow capacity is so small compared to the flow incurred during wet weather that the benefit of using the low flow diversions during wet weather is insignificant. Therefore, the low flow diversions are (and will be) temporarily closed during wet weather conditions and will therefore not contribute to Hyperion flows during wet weather. For this reason, the low flow diversions have been excluded from this analysis.

Table 3
Low Flow Stormdrain Diversions to CIS in the Coastal Sewershed

No.	Drain	Average Flow (gpm)	Drain Owner[1]	Lead Agency[1]	Construction Completion Date
Completed Projects					
1	Playa del Rey	104	LAC	LAC	15-Apr-2001
2	Thornton Avenue	60	CLA	CLA	22-Jun-1999
3	Bay Club Drive	60	CLA	CLA	24-Jan-2001
4	Palisades Park	278	CLA	CLA	28-Nov-2000
5	Santa Monica Canyon	1,215	LAC	CLA	10-Jun-2003
6	Venice Pavilion (Windward Ave Pump Station)	35	LAC	CLA	10-Jun-2003
7	Temescal Canyon	350	LAC	CLA	23-Jun-2003
8	Imperial Highway	21	LAC	CLA	29-Jun-2003
Under Construction					
1	Pulga Canyon	130	LAC	LAC[2]	31-Dec-2003
Under Design					
1	Castle Rock/Parker Canyon	75	LAC	LAC[2]	1-Sep-2004

[4] A more detailed summary of the existing collection system can be obtained from, *Integrated Resources Plan Interim Deliverable: Facilities Plan, Wastewater Management Volume, Section 5* (CH:CDM for the City of Los Angeles, 2003).

Table 3 Low Flow Stormdrain Diversions to CIS in the Coastal Sewershed					
2	North Westchester	130	LAC	LAC[2]	1-Sep-2004
3	Santa Ynez Canyon	826	LAC	LAC[2]	1-Dec-2004
4	Ashland Avenue	45	LAC	LAC[2]	31-Dec-2004
5	Rose Avenue	130	LAC	LAC[2]	31-Dec-2004
6	Brooks Avenue	130	LAC	LAC[2]	31-Dec-2004
7	Marquez Avenue	130	CLA	CLA	31-Dec-2004
Future Projects					
1	Montana Avenue[4]	45	LAC	SM[3]	1-Oct-2005
2	Wilshire Boulevard[4]	76	LAC	SM[3]	1-Oct-2005
Total dry weather flow diverted to CIS		**3,840 gpm**			

Notes:
1. CLA = City of Los Angeles; LAC = Los Angeles County; SM = City of Santa Monica
2. CLA will coordinate the implementation of the project(s) with LAC.
3. 100% of the drainage areas are within SM.
4. Average flow shown is estimated.

3.3 Rainfall Event Derivation

The average ~~critical~~ rainfall depth for this study was established in the IRP (and confirmed in Task 4) to be 0.45 inches. Because this depth needed to be translated into a rainfall event (with time and intensity) for the MOUSE model, an analysis of historical rainfall events was done. A series of events was collected, normalized, averaged, and the resulting shape and duration were scaled for each subshed, and for the rest of the HSA model area.

To determine a reasonable shape and duration for the rainfall event, historical hourly rainfall data from the Los Angeles International Airport (LAX) rain gauge[5] were examined for events that ranged from 0.40 to 0.50 inches in depth and that had had no rain for 24 hours either before or after the event. Eleven such events were found and are listed in Table 4. The average duration of these events was 6.3 hours, so a six-hour event duration was selected.

To determine the distribution of rainfall over the six-hour period, the 11 events were plotted as hourly rainfall depths and were superimposed such that the event peaks were aligned. This information, presented in Figure 2, also indicates the six-hour duration envelope from which the 'average' event shape was derived.

[5] The LAX gauge (No. 045114, *Los Angeles WSO ARPT*) was selected because of its 60-year historical record (August 1, 1944 to current), and because it lies within the study area.

Table 4 Extracted Historic Rainfall Events		
Date	Rainfall Depth (inches)	Event Duration (hours)
Jan 16, 1951	0.41	5
Feb 23, 1951	0.48	10
Jan 13, 1953	0.42	9
Nov 21, 1955	0.43	7
Apr 14, 1963	0.41	7
Oct 16, 1963	0.42	5
Dec 9, 1970	0.45	5
Mar 21, 1987	0.40	5
Jan 2, 1993	0.44	8
Jan 30, 1993	0.41	4
Dec 12, 1994	0.46	4
Average	0.43	6.3

Figure 2. Eleven Rainfall Events with Aligned Peak Intensities

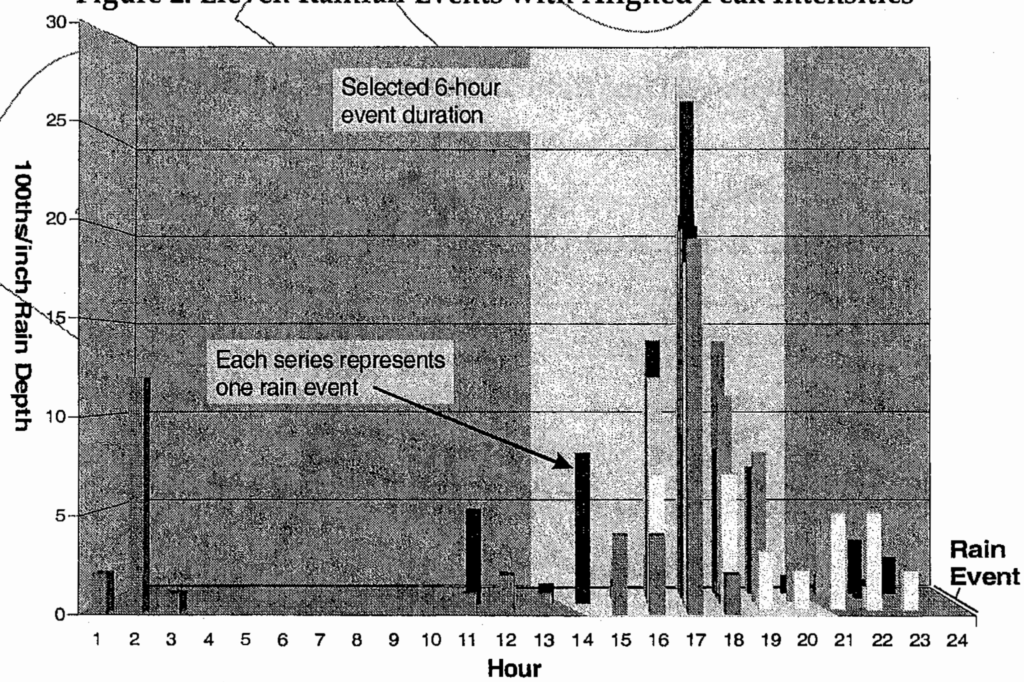


Figure 3 shows how the 11 independent events were normalized to develop an averaged hyetograph shape for the six-hour event. This shape was adjusted slightly: the first two hours' rainfall intensities were swapped to ensure that the model did not treat the first hour's peak as a separate event. The results are shown in Figure 4.

Figure 3. Averaged Hyetograph Shape from Eleven Independent Rainfall Event Shapes

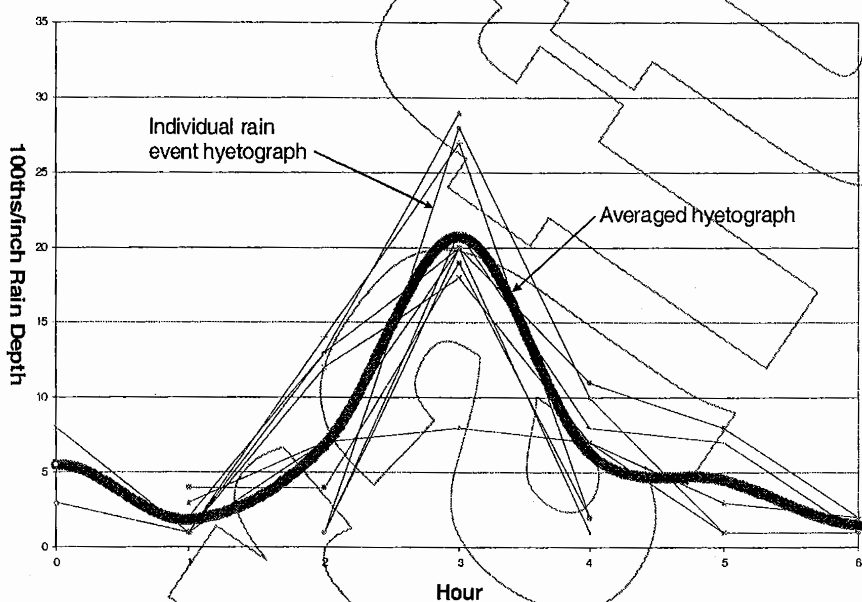
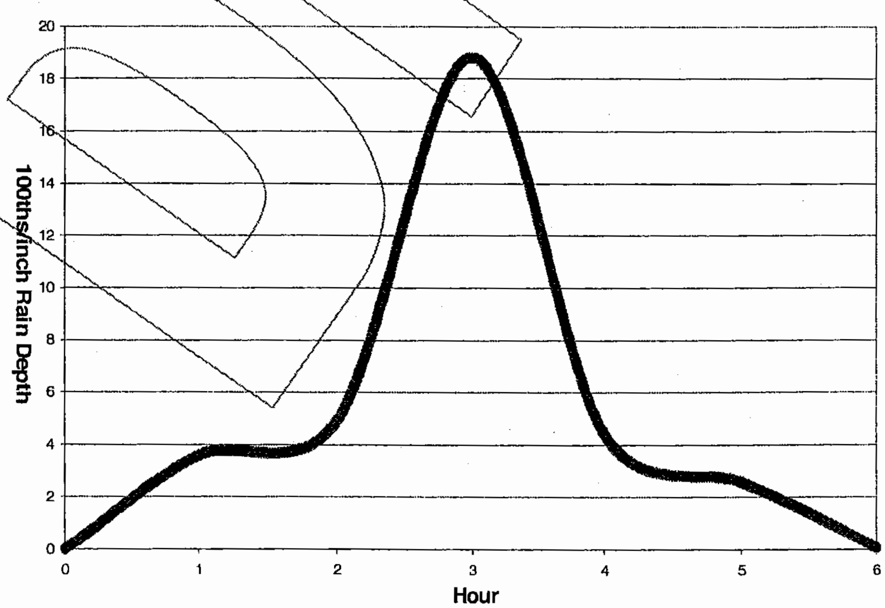
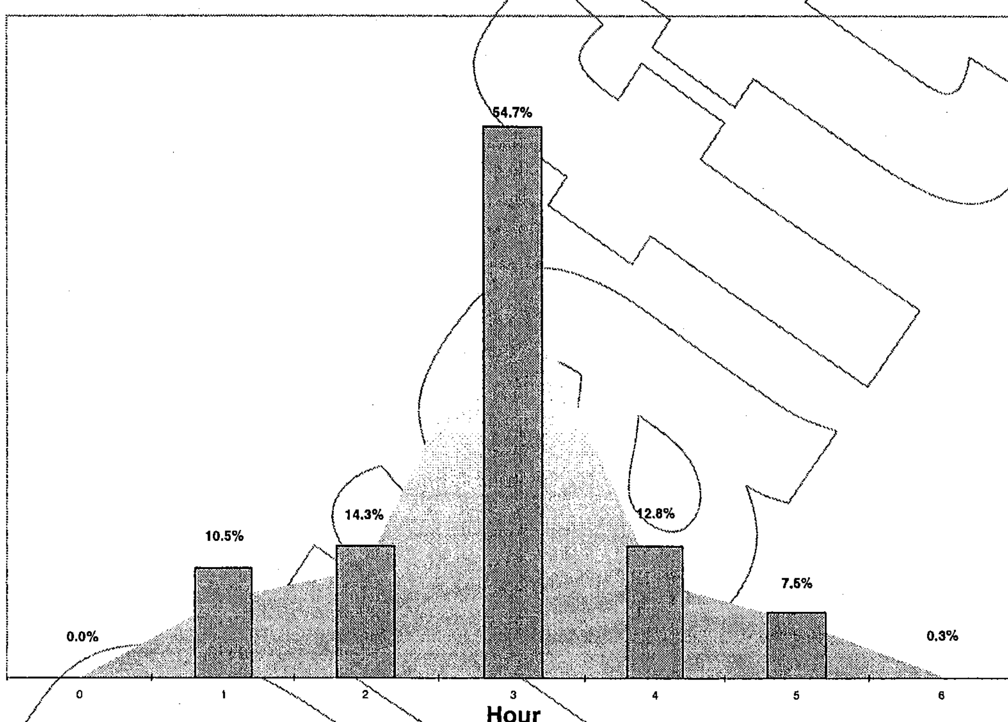


Figure 4. Final Rainfall Event Shape and Duration



Finally, Figure 5 shows the averaged hyetograph shape in Figure 4 that has been translated into the percentage of the total rainfall volume for any given event and allocated to each event hour.

Figure 5. Percentage of Rainfall Event Volume Allocated to Each Event Hour



In Task 4 of this study it was determined that due to significantly differing elevations of the centroid of each subshed, adjusted total rainfall event depths were required for each subshed. The derivation of these rainfall depths is explained in the Technical Memorandum titled *"Hydrologic Analysis – Task 4"*. Table 5 shows the event rainfall volumes and hourly depths for each of the six hours for each of the seven subsheds of the study area. Application of these hyetographs is discussed in the next section.

Table 5 Derivation of Hourly Hyetographs for Seven CIS Subsheds							
Subshed	Event Rainfall Depth[1] (inches)	Percent of Event Rainfall Volume for Each Hour[2]					
		10.5%	14.3%	54.7%	12.8%	7.5%	0.3%
		Hourly Rainfall Depths (inches)					
Castle Rock	0.75	0.078	0.107	0.410	0.096	0.057	0.002
Santa Ynez Canyon	0.65	0.068	0.093	0.355	0.083	0.049	0.002
Pulga Canyon	0.75	0.078	0.107	0.410	0.096	0.057	0.002
Santa Monica Canyon	0.77	0.080	0.109	0.418	0.098	0.058	0.002
Santa Monica	0.61	0.064	0.087	0.333	0.078	0.046	0.002
Venice Beach	0.42	0.044	0.060	0.230	0.054	0.032	0.001
Dockweiler	0.44	0.045	0.062	0.238	0.056	0.033	0.001
Remaining HSA	0.45	0.047	0.064	0.246	0.057	0.034	0.001
EVENT HOUR:		1	2	3	4	5	6

Notes:
[1] Derivation of these rainfall depths is explained in the Task 4 technical memorandum, *Hydrologic Analysis*.
[2] Corresponds to hourly event depth percentages derived in Figure 5.

3.4 Inflow and Infiltration (I/I)

To clarify the discussion on the generation of the I/I flows for this modeling task, definitions of the various components of I/I are first introduced. Following this, the derivation of the I/I flows for the model is discussed.

3.4.1 Definitions and Background

Inflow and infiltration (I/I) result from subsurface and surface water (stormwater runoff) entering a wastewater collection system through openings, leaks and illicit connections.

The *inflow* component originates from surface water that enters the collection system through connected building downspouts, catch basins, area or yard drains, and openings or leaks in maintenance hole covers and collars.

The *infiltration* portion of flow originates from subsurface water that enters the pipeline through open or cracked pipe joints, and deteriorated maintenance hole walls. I/I flow reduces the available wastewater conveyance capacity of the wastewater collection system. I/I varies depending on location, system age, structural integrity, intensity of rainfall, groundwater level, and soil type.

I/I = GWI + RDI/I

where: GWI = Groundwater infiltration

RDI/I = Rainfall-dependent inflow and infiltration

GWI is the relatively constant (independent of rainfall) component of I/I which enters the collection system through pipe and joint openings or cracks located below the groundwater table. GWI can vary seasonally depending on changes in the level of the groundwater table. Estimates of GWI are used to estimate the projected Average Dry Weather Flow (ADWF) and Peak Dry Weather Flow (PDWF) of a collection system.

RDI/I is the part of I/I that varies with rainfall. RDI/I consists of two components: rainfall-dependent infiltration (RDI), and stormwater inflow (SWI).

RDI/I = RDI + SWI

RDI enters the collection system through defects above the normal groundwater table, but still below the ground surface. SWI enters the collection system through direct connections (catch basins, private property leaks, maintenance/hole covers, area drains, open plumbing, defective cleanouts). Both RDI and SWI affect the system by contributing to peak wet-weather flows.

RDI/I flows were developed and incorporated into the model, as they can significantly reduce the conveyance capacity of the collection system.

3.4.2 Development of I/I Flows

I/I flows for this analysis were generated in two ways:

1. For the CIS portion of the model, I/I flows were automatically generated from a rainfall hyetograph input into the MOUSE model. The City is adding a city-wide calibrated I/I component to the existing MOUSE model, and it has completed calibration and verification for the CIS portion.

2. For the remainder of the City, existing I/I flow hydrographs used in the IRP were modified and imported into the MØUSE model at many nodes along the various interceptor and outfall sewers.

   The existing I/I hydrographs were scaled appropriately for use in this task. The rainfall event for the IRP was, by definition, a 10-year return period event and was determined to total 4.45 inches of rain over a 24-hour period. It was assumed that because the average rainfall depth for the current task was 0.45 inches, or one-tenth that of the IRP rainfall, scaling the IRP I/I hydrographs by one-tenth was appropriate.

It was acknowledged that the surface runoff response and infiltration conditions would not be the same for both events, and they would also be particularly dependent upon antecedent rainfall conditions (given the small relative size of the 0.45-inch event). Scaling the hydrographs implicitly assumed that the ground would be saturated, or close to saturated, and that all initial abstractions would have been removed (as would be the case with the 4.45-inch rainfall event). The resulting I/I flows were therefore considered to be conservative (marginally greater than expected).

3.5 Model Calibration

Because model calibration was completed as part of the IRP, no additional dry-weather calibration was required. Wet weather calibration has improved for the CIS sewershed since the IRP modeling was done, as the City has progressed with development of the MOUSE-based I/I model (as discussed earlier). For the rest of the HSA, the IRP wet weather event was ten-times as large as the event examined in this exercise, and it was assumed that the calibration done for the IRP was adequate. No additional wet weather calibration was therefore required for this exercise.

Descriptions of the calibration procedures used for both the dry weather IRP model and the (new) wet weather I/I model enhancement were provided by the City and have been included as an attachment for reference.

3.6 Capacity Assessment

Modeling results were assessed by considering the incremental flows that each subshed contributed along the CIS. The model generated a total of four days of flows. The rainfall events were added in on the second day, allowing an initial 24 hours for the dry weather response to be fully established before introducing the wet weather flows. This established the antecedent conditions in the model in preparation for the wet weather event. This is also in keeping with the minimum 24-hour dry periods both before and after the historical events used to derive the shape and duration of the introduced rainfall.

By comparing the modeled peaks to the model's estimation of full-flow pipe capacity, it was possible to assess how much capacity existed for releasing stored runoff. The limiting sewer pipe in each segment was identified by assessing the hydraulic capacity of a series of pipes and by isolating the pipe with the lowest capacity (or a low capacity) as well as the pipe with the greatest potential for a spill (i.e., the smallest distance between maintenance hole invert and ground elevation). In some cases, an existing pumping plant limited the conveyance capacity of the system.

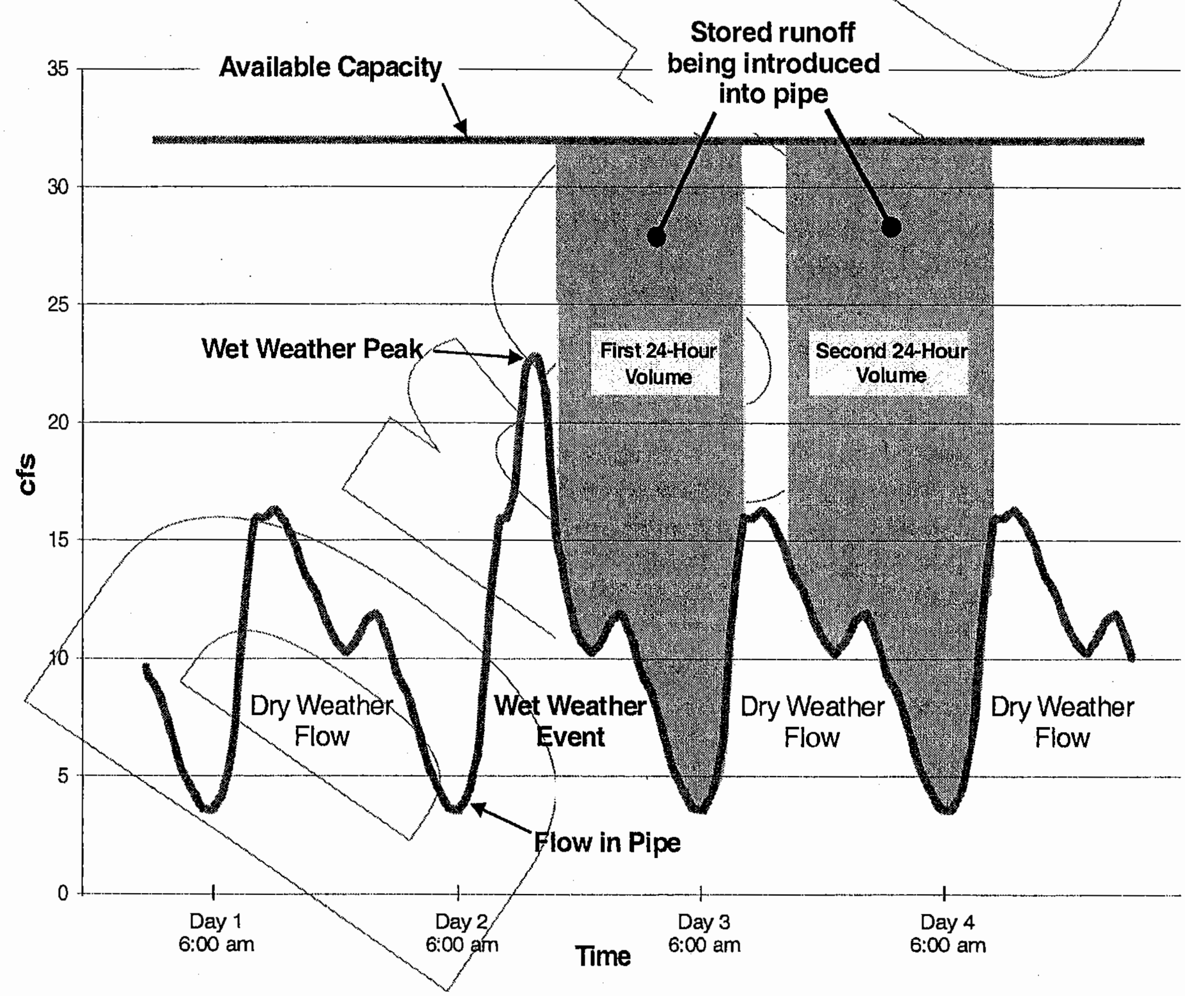
As an example, Figure 6 shows the modeled response of the City of Santa Monica subshed, the remaining capacity in the system, and the maximum 24-hour and 48-hour[6] volumes that could be conveyed downstream by the CIS. The first 24-hour volume represents the stored

[6] 48 hours is chosen as the maximum time for which stormwater can be held to ensure that the standing water does not breed mosquitoes, which can take as little as 72 hours. See, for example, Metzger, 2004.

runoff that would be released into the wastewater system starting approximately one hour after the wet weather peak flow occurs. Release would continue until approximately one hour before the next day's peak occurs. No release would be allowed until approximately one hour after the peak flow occurs on the second day, after which stored runoff would be released again until the following day's peak. This gap in released flow would provide a safety factor, and allow for unpredictable peak daily flows.

This approach was used to assess all subsheds.

Figure 6. Stored Stormwater Release to Collection System



The definition of 'capacity' was discussed with WESD and WCSD staff. It was agreed that a pipe would be considered to be at capacity if it was at full flow with no surcharge during a wet weather event. If the pipe was outlet controlled (particularly if downstream backwatering floods the pipe outlet), this definition of capacity would produce a significantly lower maximum flow limit compared with the traditional Manning's equation approach. While it is recognized that the existing system would operate under surcharged conditions during wet weather in some locations, this definition of capacity was considered to offer a more conservative (i.e., lower available capacity) assessment, particularly given that diverted stormwater runoff must not ultimately contribute to a wastewater spill.

4.0 Results

The capacity analyses considered each subshed in isolation: that is, only one subshed will contribute stored stormwater at a time. If subsheds would actually contribute simultaneously, only a small fraction of the total amount of stored stormwater from each subshed would be able to be introduced into the CIS within the 48-hour retention time limit because flows are cumulative. This does not rule out multiple subsheds contributing simultaneously, but such a configuration would be the subject of further study.

The most significant limitation to additional future peak wet weather flows in the CIS is acknowledged by the City of Los Angeles Bureau of Sanitation to be the Venice Pumping Plant[7] through which most CIS flows must pass to reach Hyperion. While the Venice Pumping Plant may currently limit the larger peak wet weather flows, this study is considering significantly lower flows, and it has used a definition of pipe capacity that does not allow for pipe surcharging. With these assumptions, the Venice Pumping Plant is not the limiting factor; rather, localized limitations in either pumping capacity of smaller upstream pumping plants, or flow capacity in pipe segments, govern depending on where flows are being added into the CIS.

Dockweiler is a special case because it discharges very little wastewater to the CIS. Instead, it discharges most of its wastewater flows into two of the large outfall sewers passing through the subshed. Dockweiler would not contribute stored runoff to the CIS, but would release stormwater into the outfall sewers. Dockweiler could therefore release stored runoff to the collection system simultaneously with one or more other subsheds without affecting the capacity of the CIS.

4.1 Capacity by Subshed

Table 7 summarizes the results of the modeling analyses by subshed. Following Table 7, the results for each subshed are discussed. At the end of this section, capacity at Hyperion is briefly discussed.

[7] A June 12, 1996 inter-departmental City report titled, "Venice Capacity Study" (W.O. E2000830) summarized the inadequacy of the Venice Pumping Plant to keep up with wet weather flows on January 4 and January 10, 1995. All five pumps at this facility were operating with a recorded discharge of 47,980 gpm while the water level in the wetwell continued to rise[1]. Design of the parallel force main is ongoing at the time of this writing. When completed, the Venice Pumping Plant is expected to have a maximum pumping capacity of approximately 70,000 gpm.

Table 7
Summary of Subshed Stormwater Diversion Analysis

Subshed	Maximum Local Conveyance Capacity	2020 Modeled Flows			RDI/I		Stored	Off-Peak Diversion Capacity[2]			
		ADWF	PDWF	PWWF	Volume Entering Collection System	24-Hour Averaged RDI/I	Rainfall Event Runoff Volume	Average Post Wet-Peak Flow Capacity	Total 48-Hour Divertable Volume	First 24-Hour Divertable Volume	Conveyance Capacity Relative to 48-Hour Stored Volume[3]
	(gpm)	(gpm)	(gpm)	(gpm)	(gal)	(gpm)	(MG)[1]	(gpm)	(MG)	(MG)	
Castle Rock	3,000	653	1,186	1,248	14,945	10	16	2,195	6.3	3.1	40%
Santa Ynez Canyon	4,700	288	528	597	14,839	10	6	4,041	11.6	5.8	194%
Pulga Canyon[4]	8,932	62	117	139	3,134	2	7	7,420	21.4	11.8	305%
Santa Monica Canyon[4]	13,061	304	485	2,280	348,435	242	33	7,740	22.3	10.7	68%
Santa Monica[4]	14,452	4,728	7,659	10,839	732,526	509	63	7,740	22.3	10.7	35%
Venice Beach[4]	21,993	676	1,122	2,989	326,878	227	0.3	13,146	37.9	17.3	12,620%
Dockweiler[4,5]	198,383	N/A[6]	N/A[6]	N/A[6]	N/A[6]	N/A[6]	49	31,546	90.9	60.4	185%

Notes:

N/A – Not Available

1 Stored stormwater runoff volumes for each subshed are taken from the Task 4 Technical Memorandum.

2 It is assumed that stored stormwater can be released into the CIS from one hour after the peak 15 minutes of wet weather flow up to approximately one hour before the peak 15 minutes of the next day's dry weather flow. Refer to the gap between diversion volumes in Figure 6.

3 Percentage of the estimated stored runoff volume that can be diverted and treated in the 48-hour post-peak period.

4 The collection system capacity for this subshed is dependent upon upstream flows.

5 The Dockweiler area contributes wastewater to the Central Outfall Sewer (COS) and the North Outfall Sewer (NOS), and not to the CIS.

6 The MOUSE model did not allow Dockweiler flows to be isolated from the model results. Values presented assume that stored runoff in Dockweiler would discharge to COS and NCOS. Capacity shown is for COS and NCOS combined.

The discussions below refer to numbers extracted from Table 7. Pumping plant and subshed locations are indicated on Figure 1.

Castle Rock

The Castle Rock subshed provides the first significant wastewater flow contributions to the upstream end of the CIS. As such, conveyance capacity is not influenced by upstream wastewater flows. The conveyance capacity downstream of the Castle Rock subshed is limited by the Sunset Pumping Plant, which pumps all Castle Rock sewage to the CIS. The capacity of the Sunset Pumping Plant is approximately 3,000 gpm. The 2020 peak wet weather flow estimated by the model was 1,248 gpm. The wet weather I/I volume generated from the Castle Rock subshed totaled 14,945 gal.

Up to 3.1 MG of the total stormwater volume could be directed into the CIS from the Castle Rock subshed in the 24 hours following the rain event. The maximum that can be directed into the CIS in a 48-hour period is 6.3 MG. Approximately 40 percent of the 16 MG of stored stormwater estimated to be generated from the Castle Rock subshed could therefore be diverted for treatment at Hyperion. The remainder could be put to alternative use.

The Sunset, Temescal, and North Pulga Pumping Plants were upgraded in the mid 1990s; future expansion is therefore not likely.

Santa Ynez Canyon

Like the Castle Rock subshed, flows from the Santa Ynez Canyon subshed are not influenced by upstream wastewater flows, as flows from this subshed are pumped directly into the CIS. Diversion capacity from the Santa Ynez Canyon subshed is limited by the combined pumping capacities of the North Pulga and Temescal Pumping Plants. The combined capacity of these two pumping plants is approximately 4,700 gpm. The 2020 peak wet weather flow estimated by the model was 597 gpm. The wet weather I/I volume generated from the Santa Ynez Canyon subshed totaled 14,839 gal.

The total stored stormwater volume that can be directed into the CIS from the Santa Ynez Canyon subshed in the 24 hours following the rain event is 5.8 MG. The maximum that can be directed into the CIS in a 48-hour period is 11.6 MG. Only approximately 6 MG of stored stormwater is estimated to be generated from this subshed, making the conveyance capacity more than adequate to convey the entire volume in less than 48 hours (5.8 MG of the total 6 MG can be conveyed in the first 24 hours).

Pulga Canyon

Capacity for wastewater contributions from the Pulga Canyon subshed are limited by a combination of upstream wastewater contributions from Castle Rock and Santa Ynez Canyon subsheds, and downstream pipe capacity. The downstream limitation for pipe flow is approximately 8,930 gpm. The 2020 peak wet weather flow estimated by the model was 139 gpm. The wet weather I/I volume generated from the Pulga Canyon subshed totaled 3,134 gal.

The total stored stormwater volume that can be directed into the CIS from the Pulga Canyon subshed in the 24 hours following the rain event is 11.8 MG. The maximum that can be directed into the CIS in a 48-hour period is 21.4 MG. Only approximately 7 MG of stored stormwater is estimated to be generated by the Pulga Canyon subshed, making the conveyance capacity more than adequate to convey the entire volume in less than 48 hours.

Santa Monica Canyon

Capacity for wastewater contributions from the Santa Monica Canyon subshed is limited by a combination of upstream contributions from the three subsheds discussed above as well as by downstream pipe capacity. Although the local pipe capacity is approximately 13,060 gpm, pipe capacity further downstream (below Santa Monica) limits the volume of runoff that can be diverted from this subshed. The 2020 peak wet weather flow estimated by the model was 2,280 gpm. The wet weather I/I volume generated from the Santa Monica Canyon subshed totaled 348,435 gal.

The total stored stormwater volume that can be directed into the CIS from the Santa Monica Canyon subshed in the 24 hours following the rain event is 10.7 MG. The maximum that can be directed into the CIS in a 48-hour period is 22.3 MG. Approximately 33 MG of stored stormwater is estimated from the Santa Monica Canyon subshed. Approximately 68 percent of the estimated stored runoff could therefore be conveyed to the CIS for treatment in 48 hours.

Santa Monica

Wastewater contributions from the City of Santa Monica subshed are limited by a combination of upstream contributions from the four subsheds discussed above, and by restrictions on the downstream pipe capacity.

Situated within the City of Santa Monica, the Moss Pumping Plant conveys all CIS flows, including those from Santa Monica. With a stated capacity of 18,056 gpm, the Moss plant is adequate to carry the 2020 modeled PWWF of 10,839 gpm.

The City of Santa Monica recently (2002 and more recently) added a force main ranging in diameter from 48 to 60 inches between the upstream and downstream boundaries of the City of Santa Monica (including Moss Pumping Plant). Downstream of the enlarged City of Santa Monica force main (and outside the City of Santa Monica), a smaller 48-inch diameter pipe has a flow capacity of approximately 14,450 mgd.

The 2020 peak wet weather flow estimated by the model was 10,839 gpm. The wet weather I/I volume generated from the Santa Monica subshed totaled 732,526 gal.

The total stored stormwater volume that can be directed into the CIS from the Santa Monica subshed in the 24 hours following the rain event is 10.7 MG. The maximum that can be directed into the CIS in a 48-hour period is 22.3 MG. Approximately 63 MG of stored stormwater is estimated to be generated from the Santa Monica subshed. Approximately 35 percent of the stored runoff could be directed into the CIS for treatment.

Venice Beach

Conveyance capacity for flow contributions from the Venice Beach subshed is limited by a combination of upstream contributions from Moss Pumping Plant and the downstream pipe capacity. The downstream flow capacity is approximately 21,993 gpm. The 2020 peak wet weather flow estimated by the model was 2,989 gpm. The wet weather I/I volume generated from the Venice Beach subshed totaled 326,878 gal.

The total stored stormwater volume that can be directed into the CIS from the Venice Beach subshed in the 24 hours following the rain event is 17.3 MG. The maximum that can be directed into the CIS in a 48-hour period is 37.9 MG. Approximately 0.3 MG of stored stormwater is estimated from the Venice Beach subshed. Therefore the stormwater volume to be diverted is negligible relative to capacity.

Dockweiler

The Dockweiler subshed is unique in that it discharges most of its wastewater to two of the largest outfall sewers in the City of Los Angeles just before they terminate at Hyperion: the Central Outfall Sewer (COS), and the North Outfall Sewer (NOS). These sewers are shown on Figure 1.

Two other outfall sewers pass through the center of the Dockweiler subshed but pick up little if any wastewater flow. These are the North Central Outfall Sewer (NCOS), and the North Outfall Relief Sewer (NORS).

The COS and NCOS were considered for diversion in this analysis. NORS was not considered for runoff diversion because it is relatively inaccessible due to its depth of cover (up to 50 feet below the ground surface) through most of the subshed. NOS accepts flow from the CIS upstream of Hyperion, and capacity in the NOS was therefore left for CIS and other HSA contributions.

It is not possible to isolate Dockweiler wet weather flows from the MOUSE model results, but this does not affect the capacity assessment.

Considering only the capacities of the COS and NCOS, wastewater flow contributions from the Dockweiler subshed are limited by a combination of upstream contributions from the Hyperion Service Area and the treatment capacity of Hyperion (discussed below).

The limitation for contribution of flows from Dockweiler subshed is approximately 198,380 gpm. The peak wet weather and I/I flows estimated for Dockweiler were not separable from other model results, and could not be determined.

The total stored stormwater volume that can be directed into the COS and NCOS from the Dockweiler subshed in the 24 hours following the rain event is 60.4 MG. The maximum that can be directed into the COS and NCOS in a 48-hour period is 90.9 MG. Approximately 49 MG of stored stormwater is estimated from the Dockweiler subshed. The entire Dockweiler stored volume can therefore be diverted and treated within the 48 -hour period.

Hyperion Treatment Plant

The 2020 average PDWF at Hyperion was estimated to be approximately 399,850 gpm. The peak wet weather flow was estimated to be approximately 430,790 gpm, or an increase of 8 percent over the PDWF.

The permitted wet weather peak hydraulic capacity of 850 MGD (590,210 gpm) was used as the upper limit for treatment capacity at Hyperion. While the plant can operate at this flow rate, it is acknowledged that secondary clarification is more effective, and operations staff are more comfortable with a lower peak flow. Since diverting stored runoff to Hyperion would create a sustained (24- or 48-hour) peak, and a factor of safety would be prudent, a lower peak capacity of 650 MGD (451,389 gpm) was also assessed (the peak wet weather flow estimated by the model for this analysis was 620 MGD, or 430,556 gpm).

Using the 850 MGD capacity, Hyperion can accommodate 356.8 MG of additional inflow volume in a 24-hour period, and 724.4 MG of additional inflow volume in a 48-hour period. This far exceeds the 49 MG of stored runoff from Dockweiler and the 22.3 MG of stored runoff that can be conveyed from Santa Monica or Santa Monica Canyon subsheds[8]. To place the

[8] The Santa Monica and Santa Monica Canyon subsheds are considered because they could provide the greatest volume of flow that would contribute to Hyperion through the CIS.

stored runoff in context, the 71.3 MG of runoff over 48-hours represents less than 5 percent of the treated volume.

Using the 650 MGD capacity, Hyperion can accommodate 168.9 MG of additional inflow volume in a 24-hour period, and 350.7 MG of additional volume of inflow in 48 hours. This also far exceeds the 71.3 MG of combined stored runoff from Dockweiler and Santa Monica or Santa Monica Canyon subsheds.

4.2 Conceptual Level Cost

For regional runoff management options such as this storage and diversion approach, the IRP developed a conceptual level cost estimate of $1.56M/mgd. This cost was developed from a series of diversion projects, and includes diversion to temporary storage, storage facilities, pumping to the wastewater system, and also project management, planning design, construction management and startup costs.

5.0 Conclusions

The capacity of the coastal wastewater collection system was assessed for the purposes of conveying and treating stored off-peak stormwater runoff. The runoff would first be stored temporarily (maximum 24 to 48 hours typically) in purpose-built storage facilities, and then released in a controlled manner into either the CIS or, for Dockweiler subshed, into the COS or NCOS for ultimate treatment at Hyperion.

Given the cumulative effect of flows added along the course of the CIS, simultaneous release of stored runoff would require additional analysis and modeling to determine possible subshed combinations and diversion volumes. Dockweiler, however, is in the unique position of not requiring the CIS to convey stored runoff to Hyperion. Stored runoff from Dockweiler could be diverted to Hyperion independently of the other subsheds.

This approach may be combined with other options, whereby a portion of one or more stored runoff volumes could be diverted and treated as described, with the remainder of the runoff handled through on-site infiltration, regional groundwater recharge, irrigation, or other reuse alternative[9]. This is particularly true for the Castle Rock, Santa Monica Canyon and Santa Monica subsheds, which would require these additional measures to manage all of their estimated stored runoff volumes. The wastewater system is currently more than adequate, however, to convey and treat the estimated stored runoff volumes from Santa Ynez Canyon, Pulga Canyon, Venice Beach and Dockweiler subsheds.

The available conveyance and treatment capacity could also allow a series of smaller, staged diversions to the collection system as an interim measure during long-term implementation of

[9] See the Technical Memorandum titled, "*Beneficial Use Evaluation – Task 5*"

measures. This may be particularly helpful in cutting down on a number of small storm exceedances, and could be phased back as long-term measures come on line.

6.0 References

City of Los Angeles Integrated Resources Plan Facilities Plan Interim Deliverable. Volume 3 Runoff Management, August 2003. Prepared by CH:CDM and City of Los Angeles Department of Public Works, Bureau of Sanitation.

City of Los Angeles Integrated Resources Plan Facilities Plan Interim Deliverable. Volume 1 Wastewater Management, Section 5, Existing Collection System, August 2003. Prepared by CH:CDM and City of Los Angeles Department of Public Works, Bureau of Sanitation.

City of Los Angeles Clean Water Program Advanced Planning Report, Memorandum No. 3K, Existing Wastewater Collection System, October 1989. Prepared by CH2M Hill and the City of Los Angeles Wastewater Program Management Division.

Metzger, M. E., 2004. Managing Mosquitoes in Stormwater Treatment Devices. University of California Division of Agriculture and Natural Resources, Publication 8125. Available for free download from the UC ANR Communication Services Web site at http://anrcatalog.ucdavis.edu.

Western Regional Climate Center Web Site: http://www.wrcc.dri.edu/summary/climsmsca.html

City of Los Angeles Navigate LA Web Site: http://navigatela.lacity.org

City of Los Angeles Electronic Vault Web Site: http://engvault.lacity.org/apps/vault/index.htm, Plan D30700 (and others): 1994 CIS Upgrade Project..

City of Santa Monica Wastewater Collection System GIS data, March 2004. City of Santa Monica.

Santa Monica Bay Beaches Wet Weather Bacteria TMDL Implementation Plan. Task 4 Hydrologic Analysis, March 2004. Prepared by CH:CDM and City of Los Angeles Department of Public Works, Bureau of Sanitation.

Santa Monica Bay Beaches Wet Weather Bacteria TMDL Implementation Plan. Task 5 Beneficial Use Evaluation, April 2004. Prepared by CH:CDM and City of Los Angeles Department of Public Works, Bureau of Sanitation.

Santa Monica Bay Beaches Wet Weather Bacteria TMDL Implementation Plan. Task 6 Treatment and Management Options, May 2004. Prepared by CH:CDM and City of Los Angeles Department of Public Works, Bureau of Sanitation.

City of Los Angeles, Department of Public Works, Bureau of Sanitation. 2002. Development Handbook.

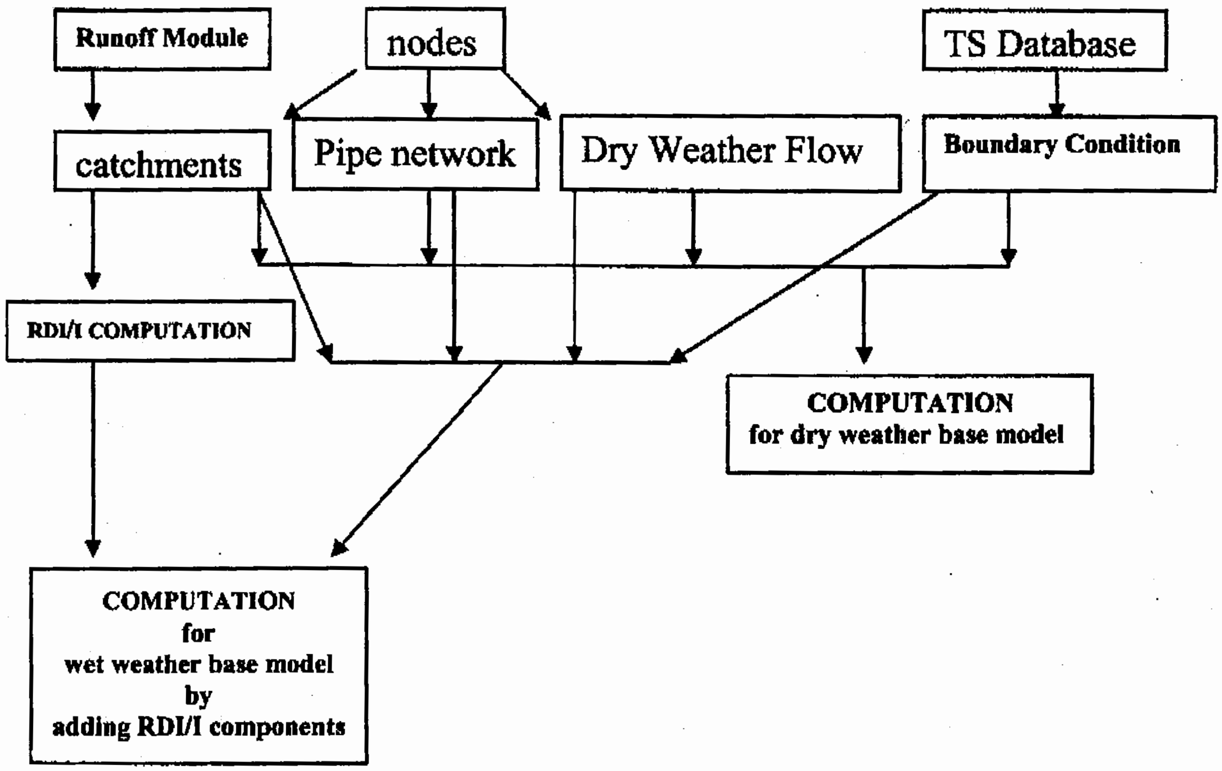
Santa Monica Bay Beaches Wet Weather Bacteria TMDL.

Computer modeling
For
The City of Los Angeles Outfall Sewer System

The City of Los Angeles provides services to 3.5 million people in about 650 square miles of service area. It owns and operates a collection system that consists of 6500 miles of sewers varying in size from 8 to 150 inches in diameter and numerous sewer appurtenances such as diversion structures and inverted siphons.
It was realized that a collection system model is needed to obtain overall comprehensive information for City's complicated wastewater collection system. Wastewater Engineering Services Division (WESD) has developed and maintains a sophisticated computer model of the wastewater collection system. The development of base model for both dry weather and wet weather conditions is hereby presented to facilitate updating model database in the future. In addition, this document is also required under CDO No. 00-128 for the purposes of model verification and hydraulic capacity analysis.

Model of Urban Sewer System (MOUSE) is a state-of –the-art hydraulic modeling software package designed to simulate unsteady flow in pipe networks. It was developed by the Danish Hydraulic Institute (DHI) and introduced to the United States in the early 1990s. MOUSE is, currently, the most widely used, commercially available, fully dynamic software for collection system analysis. The City's MOUSE model was originally developed in 1995-6 in response to the need for a planning and analysis tool. MOUSE package consists of many modules: hydrodynamic, surface runoff, real time control, rain dependent inflow/infiltration and water quality etc. the combination of modules will be varied for different purpose. For example: the scenario of consecutive storms needs a combination of hydrodynamic, surface runoff, and rain dependent inflow/infiltration to simulate the compound effect of storms.

A complete data set used by MOUSE consists of various input files and databases. MOUSE data are organized into a number of files (and databases). Each file (database) contains a set of data belong to a specific category. MOUSE use 'project' to select proper input files (databases) to perform computation. Therefore, for different purpose, input files (databases) may vary based on the needs. Following is an input files scheme to depict the difference in terms of input data set between dry weather base model and wet weather base model.



As shown above, the wet weather component (RDI/I) is added on the dry weather flow to generated wet weather flow. This document consists of two parts: dry weather base model and wet weather base model. In part one – Dry weather base model, we will discuss all components but runoff module and RDI/I computation. In part two – Wet weather base model, we will focus on the discussion of these two components.

PART ONE
Dry Weather Base Model

Introduction

Base model is always the first model that has to be established prior to any applications. Base model, herein, is defined as the scenario of current conditions. In other words, input data such as pipe network, system operation strategies, and flow generation of each sub-basin should be close to the results of field investigation. That makes model verification possible through the comparison of field results with model runs. The fabrication of input data files, model verification and modification in each stage will be documented in details so that the reliability of the modeling results can be no doubt.

Model Fabrication

Pipes and Nodes

Dimensions of pipes, inverts and ground elevations of nodes, were taken from the inventory component of the City of Los Angeles Sewer Information and Maintenance System (SIMMS). Coordinates of nodes were taken from the GIS sewer network coverage. Special pipe Cross-Sections such as semi-elliptical, oval, and Bruns-McDonnel are all customized.

Data extracting from SIMMS and GIS was copied to a MOUSE readable text file and then data can be imported and converted to a MOUSE sewer network file.

Catchments

The overall Hyperion Service Area was sub-divided into 350 sub-basins (see Figure 1). GIS has been used as a tool for defining the sub-basins. The service area in acres can be obtained immediately from the GIS attribute table. For population (or its projection) in sub-basins, the sub-basin layer was overlaid with the population layer and population of sub-basins can be obtained by a tool built in ArcView Spatial Analyst.

Dry Weather Flow Generation

Dry weather flow contains four components: residential flow, commercial flow, industrial discharge, and groundwater infiltration. Although these four components can be distinctively identified in GIS, current MOUSE model can only calculate dry weather flow based on "population" or "acres". Therefore, "equivalent population" has been used to incorporate all components into one factor (i.e. equivalent population). Gallon per capita per day for residential flow and commercial flow are 78 and 23 respectively. Industrial flow consists of 109 point sources that have daily discharge more than 50000 gallon per day. For dry weather condition, the GWI is neglected. The total flow in gallon generated in each individual catchment is subdivided by 100 to get equivalent population that is the number input into MOUSE model.

Diurnal curves

The variations in wastewater flows tend to follow a somewhat diurnal pattern. Flow rate actually is a function of time. Lowest flows could be close to zero in some area and peak flows, in most cases, are double or triple of the average. From place to place, Diurnal patterns are different. Twenty-three diurnal patterns were selected to represent three hundred fifty sub-basins' flow patterns (see Figure 3). The selected locations (marked red in Figure 3) were gauging and hourly flow rates were converted to dimensionless coefficients by normalizing flow rates with the average.

Other Hydraulic Settings

Modeling of overflow weirs, pump's wet wells and other flow control structures were based on the City's As-Built records. For operation purpose or some other unknown reasons, current settings, in most cases, are different from the original drawing. Major diversion structures and treatment plants in-take need to be calibrated to properly simulated measured flow.

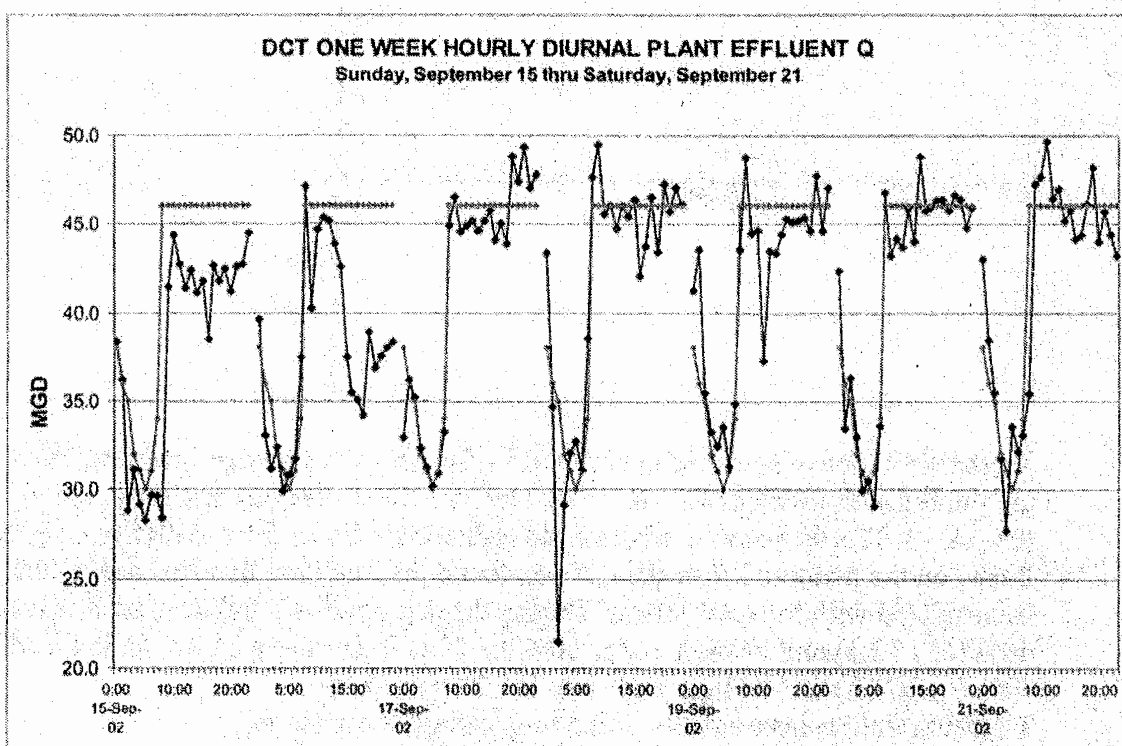
Model Verification / Calibration

The Calibration of Dry Weather Base Model

Since collection system has been improved from time to time and the system operation also changes to match the system change, collection system model must be up-to-date periodically to keep its validation. WESD updates and verifies its MOUSE model in every another year.

Base model is calibrated according to field flow measurements. Total wastewater volume, peak/low flow and peaking time are the criteria used to verify dry weather base model. Good match between field measurements and MOUSE model results is needed. Tributary areas, diurnal curves, flow splits, pumping strategies, and many other factors that may cause the modeling results deviated from field measurements shall be carefully adjusted until the results are matched within 15 %.

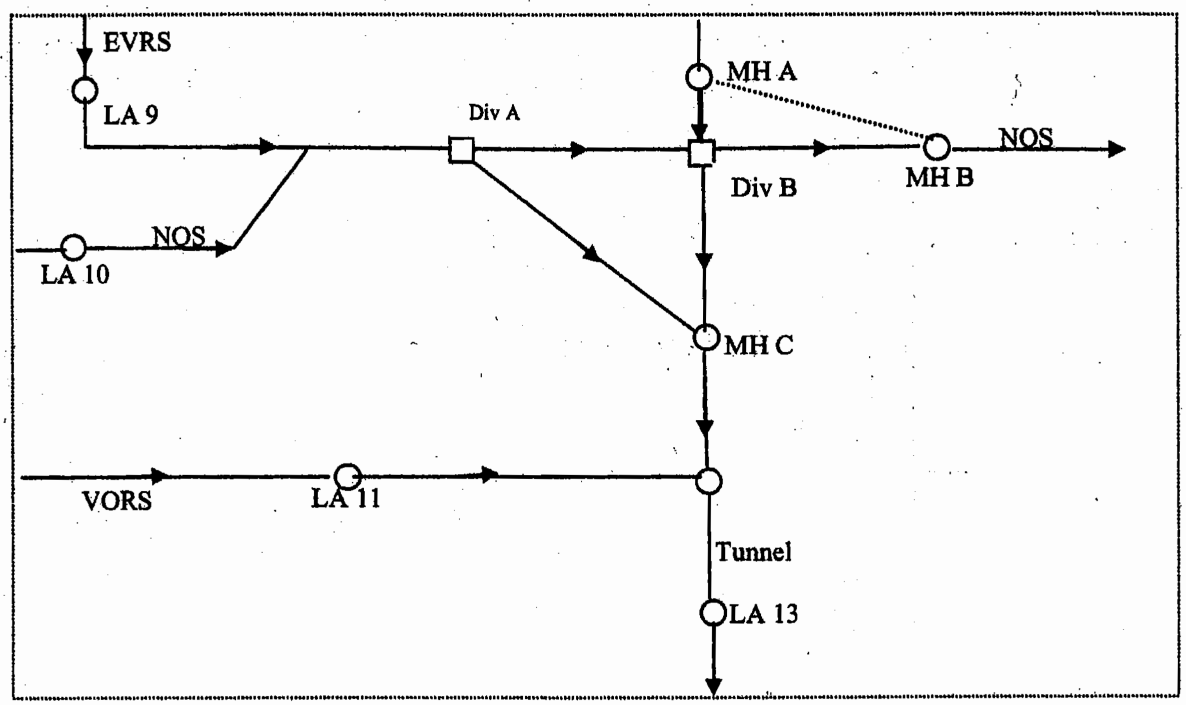
1. Tillman Plant In-take



The typical weekly effluent hydrograph (blue line) and model's effluent pumping curve (red line) are shown on above diagram. Model can not exactly duplicate the real effluent, but it is able to have a pumping curve to represent the significance of the effluent.

In general, the pumping curve starts with 38 mgd and gradually drops to 30 mgd at 5:00 a.m., then it raises in a relatively faster speed to 46 mgd at 8:00 a.m., this pumping rate will lasts until 11:00p.m.

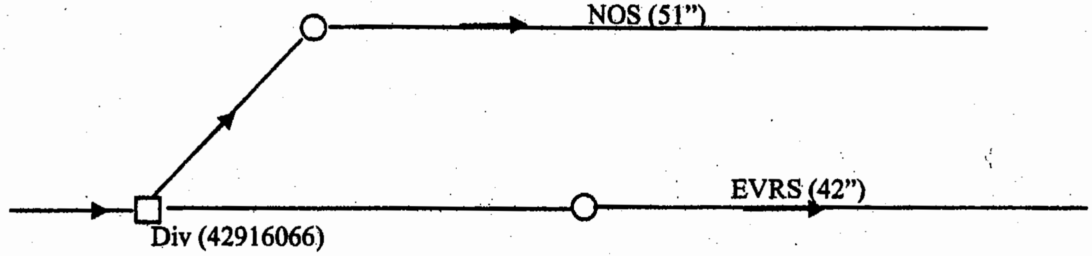
2. Valley Spring and Foreman Diversion Structure
The diversion structure at the intersection of Valley Spring Lane and Forman Avenue is the most important flow diversion structure for City's wastewater collection system. It control the distribution of 40 MGD flow generated from San Fernando Valley daily and the flow through the structure could be up to 80 MGD during a significant storm. Without an appropriate control, the excessive flow may cause wet weather overflows at MAZE area and LCIS.



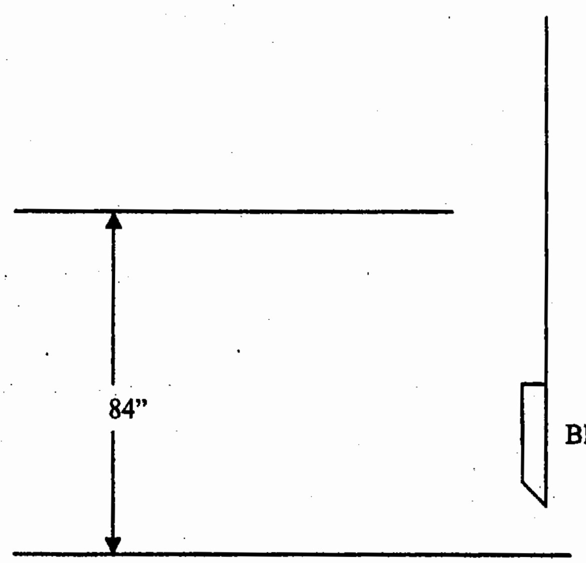
As shown in above sewer scheme, EVRS (also known as sludge line) and NOS are jointed at the west of Div A. VORS by pass the diversions and flow directly to the LA 13. The diversion structures can redistribute flows from EVRS and NOS. Based on the historical flow data, it was found that the flow diverted to the tunnel is correlated with the total inflow. During the dry weather condition, its low end is 40% (or 17 cfs) and its high end is 60% (or 45 cfs). During a storm, its low end is 40% (or 20 cfs) and its high end is up to 70% (or 70 cfs).
To match field measurements, following settings are assigned:

- Div A is a diversion with flow split ratio
- Div B is a diversion with on/off function
- A non-return regulator in pipe between Div A and MH C to prevent backflow
- A overflow weir at MH A (to MH B)

3. Magnolia & Kester Diversion Structure
AVORS ends at MH 42916066 (the junction of AVORS, EVRS, and NOS), the pipe size is constricted from 84" (AVORS) to 42" (EVRS). NOS is the relief line to accept excessive flow diverted from AVORS. Following is the flow scheme to depict the flow split.

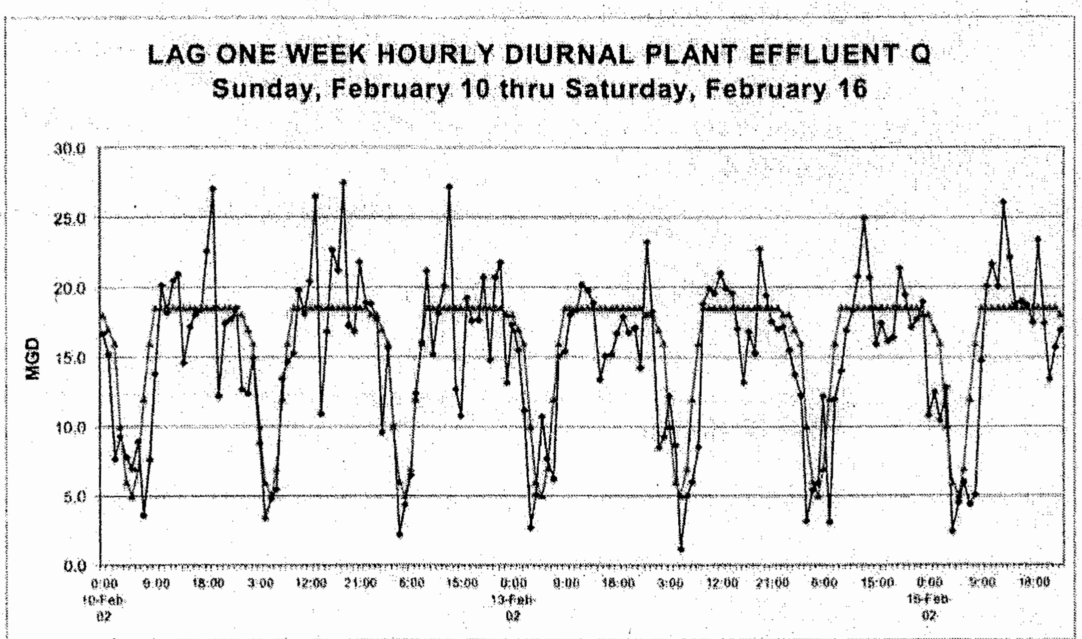


The hydraulic device used for this diversion is a flow control sluice gate as shown below. The blade can move up/down to control water level so that excessive flow during the high flow can be overflow to NOS.



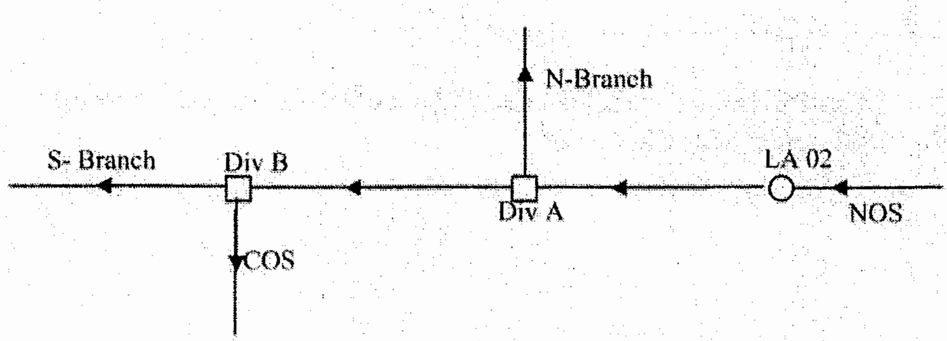
In City's MOUSE model, we model this flow control sluice gate by using a overflow weir and a underflow gate.

4. LA/Glendale Plant In-take



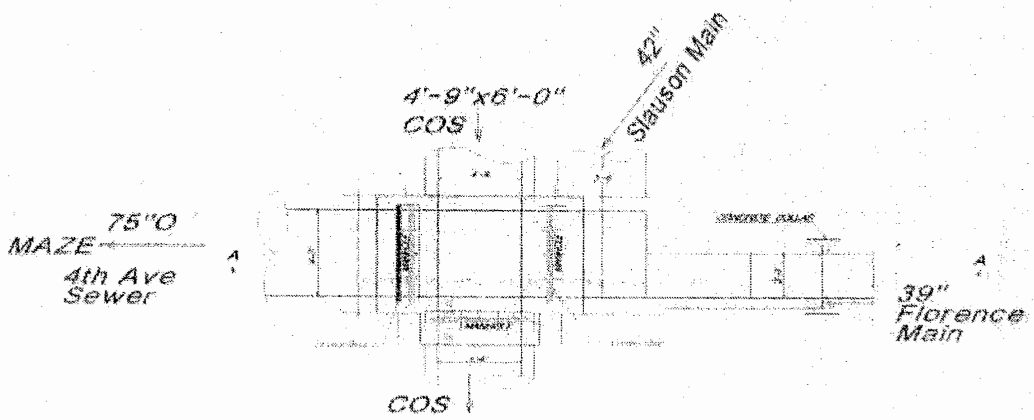
The typical weekly effluent hydrograph (blue line) and model's effluent pumping curve (red line) are shown on above diagram. As mentioned, model can not exactly duplicate the real effluent, but it is able to have a pumping curve to represent the significance of the effluent.
In general, the pumping curve starts with 18 mgd and gradually drops to 5 mgd at 5:00 a.m., then it raises in a relatively faster speed to 18.5 mgd at 9:00 a.m., this pumping rate will lasts until 10:00p.m. and it will drop back to 18 mgd at 11:00 p.m. This is existing condition of LA/G effluent. For further effluent reduction, for example 9 mgd, the current flow higher than 9 mgd will be reduced to 9 mgd and the flow lower than 9 mgd will be kelp the same.

5. Maze Diversion Structures
Wastewater flow at the west side of LA 02 is distributed into three different branches: N-Branch, S- Branch, and COS. The diversion structures at div A and div B are two devices used to ensure that flow fill the N-Branch first during the low flow period, and then it will fill S-Branch, the excessive flow during the peak flow period then overflow to COS. Following is the flow scheme to illustrate this flow distribution.

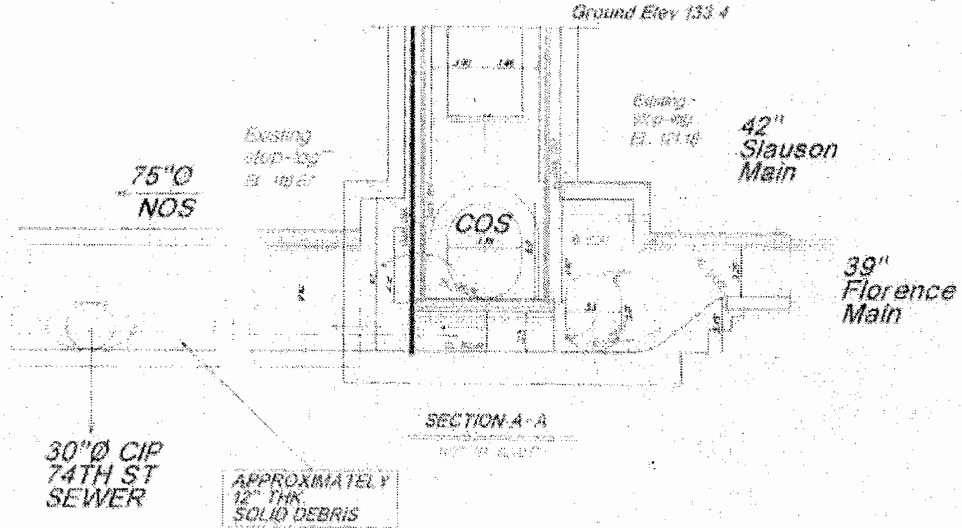


Stop logs are used to control the flow into N-branch and S-branch. Its principle is very similar to the flow control sluice gate described previously. Since the flow redistribution is accomplished by raising the water level, d/D at those two diversion structures and their vicinity is very high during the dry weather peak. Flow monitor at LA 02 indicates that dry weather peak d/D is about 0.8 in most cases.

6. NOS/COS Junction Structure
This junction structure is used to allow two trunk sewers to go down under the COS to reach S-branch. In the meantime, a weir adjusted by stop logs is used to allow overflow from the COS to S-branch in case that COS has too much flow. Followings are the plan and the profile of this junction structure:



PLAN
NOS/COS JUNCTION STRUCTURE



SECTION A-A

Model Verification

Measurement data from 33 ADS flow monitors was used for comparison with results computed by the model. In this way, the accuracy after model calibration and model's stability under different scenarios could be verified. However, due to the malfunction of some flow monitors, the comparison for all ADS flow monitors is impossible.

The dry weather flow was calibrated by adjusting parameter values until the hydrograph peaks matched within 15 %.

1. Case 1. Flow simulation for April 15, 12:00 a.m. to April 17, 12:00 a.m.