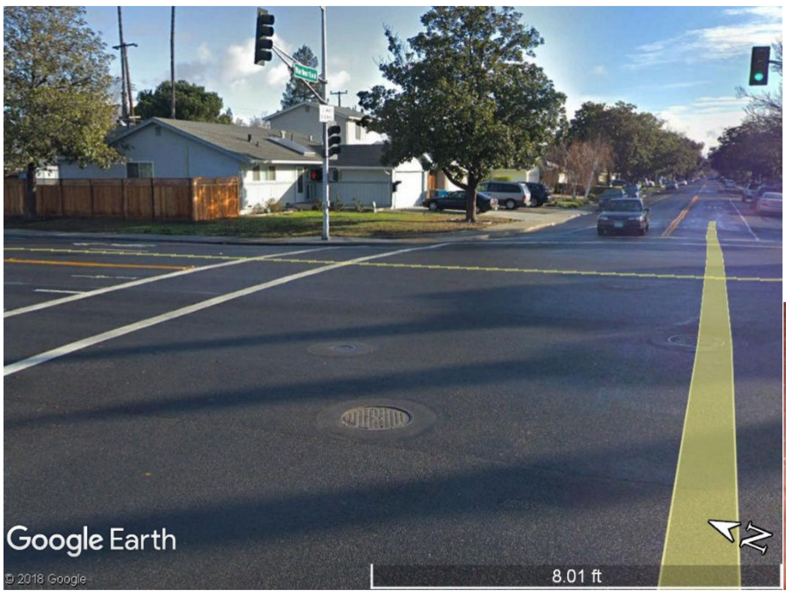
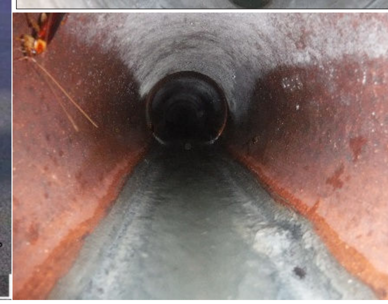
# City of Santa Clara

## 3035 El Camino Real Flow Monitoring Study



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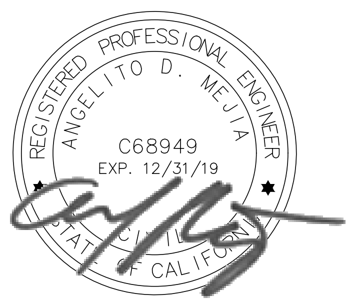


Date: Original Submittal: October 22, 2018
Revised Submittal: October 24, 2018

Prepared by: V&A consulting engineers

<V&A Project No. 18-0127>

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# 1 Introduction

V&A Consulting Engineers (V&A) was retained by HMH Engineers to perform sanitary sewer flow monitoring and capacity analysis within the City of Santa Clara, California (City). Open-channel flow monitoring was performed at one manhole for one week from October 4, 2018 through October 15, 2018. The purpose of this study was to identify the average and peak flows and determined the available capacity of the subject pipes.

Flow monitoring sites are identified as the manholes where the flow monitors were secured and the pipelines wherein the flow sensors were placed.

The flow monitoring site was selected and approved by HMH Engineers. Information regarding the flow monitoring location is listed in Table 1-1 and shown in Figure 1-1. Figure 1-2 illustrates the location of the development site at 3035 El Camino Real and its proximity to the flow monitoring site. A detailed description of the flow monitoring site, including photographs, is included in Appendix A.

Table 1-1. List of Flow Monitoring Locations

| Manhole ID | Location | Pipe Diameter | Pipe Material | Inlet |
|---|---|---|---|---|
| MH 75 | Warburton Avenue and Bowers Avenue | 8” | VCP | West |

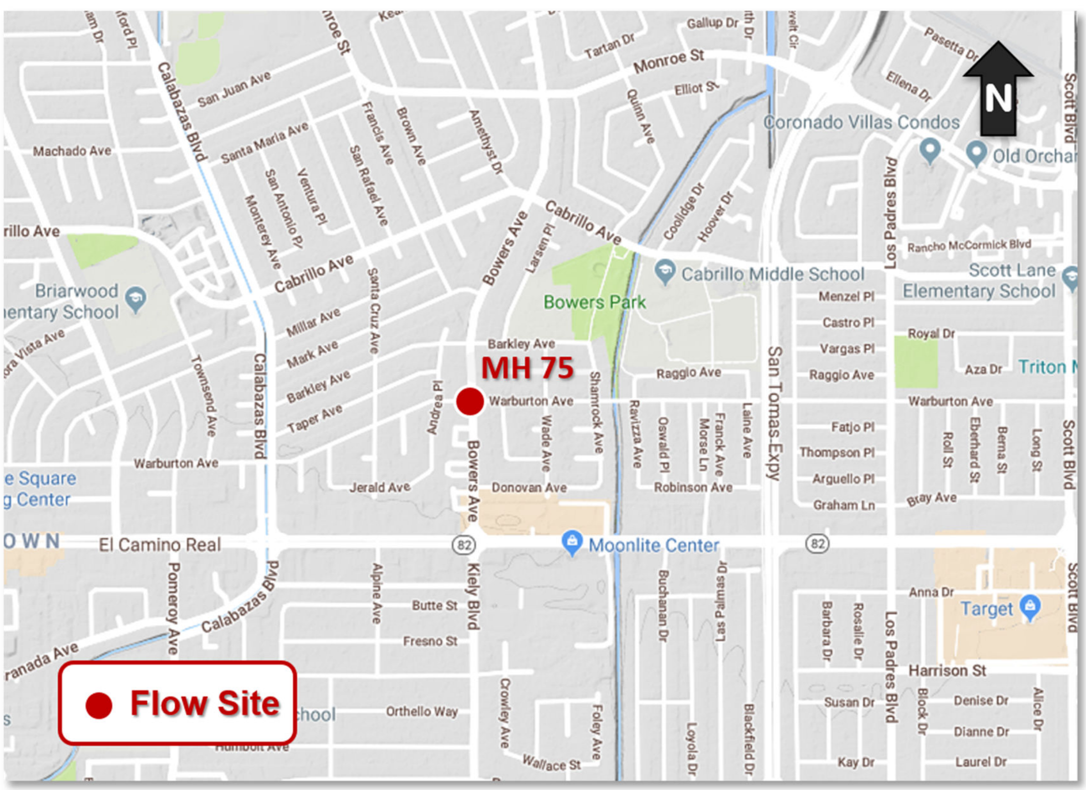



Figure 1-1. Map of Flow Monitoring Site

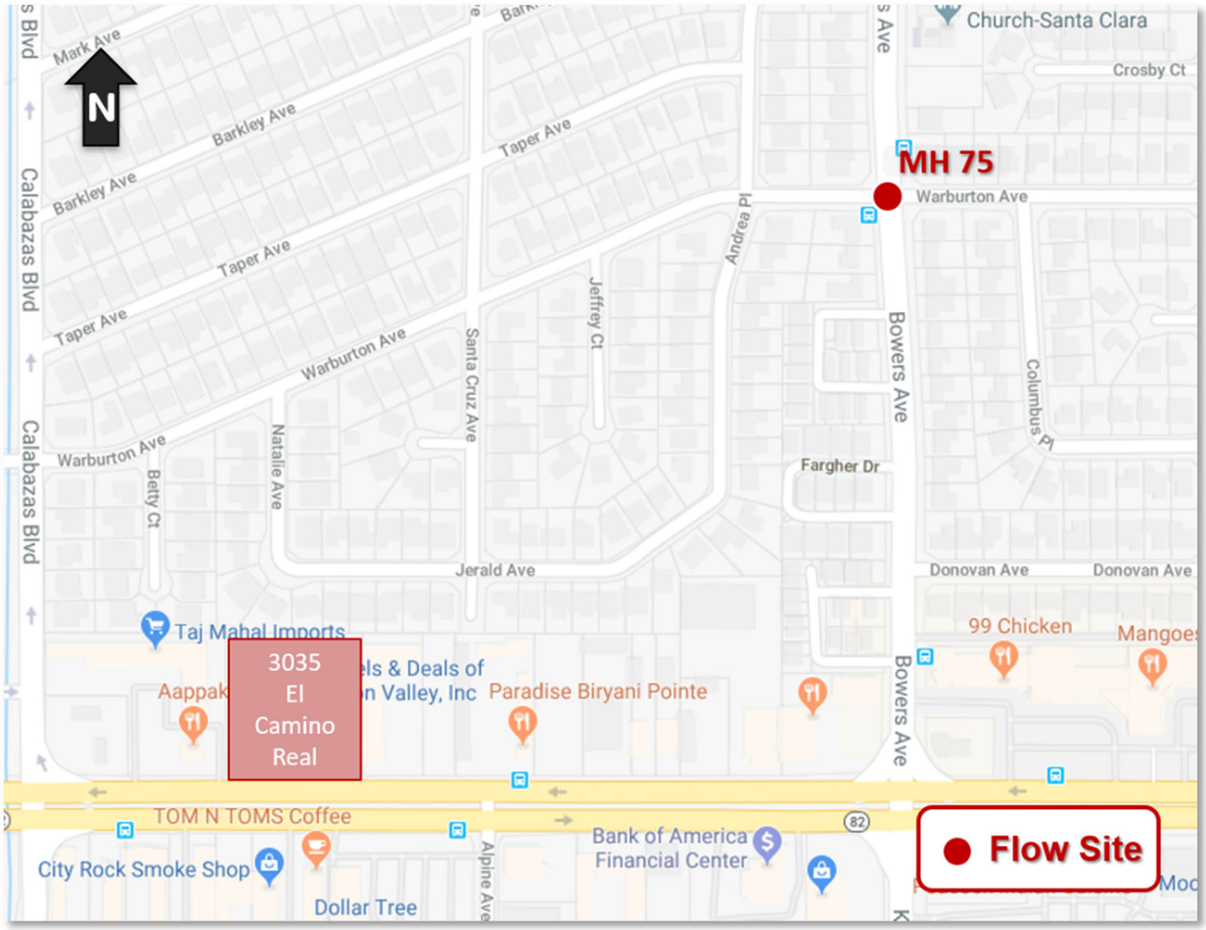



Figure 1-2. Location of Development at 3035 El Camino Real

# 2 Methods and Procedures

## 2.1 Confined Space Entry

A confined space (Photo 2-1) is defined as any space that is large enough and so configured that a person can bodily enter and perform assigned work, has limited or restricted means for entry or exit and is not designed for continuous employee occupancy. In general, the atmosphere must be constantly monitored for sufficient levels of oxygen (19.5% to 23.5%), and the presence of hydrogen sulfide ($H_2S$) gas, carbon monoxide (CO) gas, and lower explosive limit (LEL) levels. A typical confined space entry crew has members with OSHA-defined responsibilities of Entrant, Attendant and Supervisor. The Entrant is the individual performing the work. He or she is equipped with the necessary personal protective equipment needed to perform the job safely, including a personal four-gas monitor (Photo 2-2). If it is not possible to maintain line-of-sight with the Entrant, then more Entrants are required until line-of-sight can be maintained. The Attendant is responsible for maintaining contact with the Entrants to monitor the atmosphere using another four-gas monitor and maintaining records of all Entrants, if there is more than one. The Supervisor is responsible for developing the safe work plan for the job at hand prior to entering.

Photo 2-1. Confined Space Entry

Photo 2-2. Typical Personal Four-Gas Monitor

## 2.2 Flow Meter Installation

V&A installed one Isco 2150 area-velocity flow meter for temporary metering within the collection system. Isco 2150 meters use submerged sensors with a pressure transducer to collect depth readings and an ultrasonic Doppler sensor to determine the average fluid velocity. The ultrasonic sensor emits high-frequency (500 kHz) sound waves, which are reflected by air bubbles and suspended particles in the flow. The sensor receives the reflected signal and determines the Doppler frequency shift, which indicates the estimated average flow velocity. The sensor is typically mounted at a manhole inlet to take advantage of smoother upstream flow conditions. The sensor may be offset to one side to lessen the chances of fouling and sedimentation where these problems are expected to occur. Manual level and velocity measurements were taken during installation of the flow meters and again when they were removed and compared to simultaneous level and velocity readings from the flow meters to ensure proper calibration and accuracy. Figure 2-1 shows a typical installation for a flow meter with a submerged sensor.

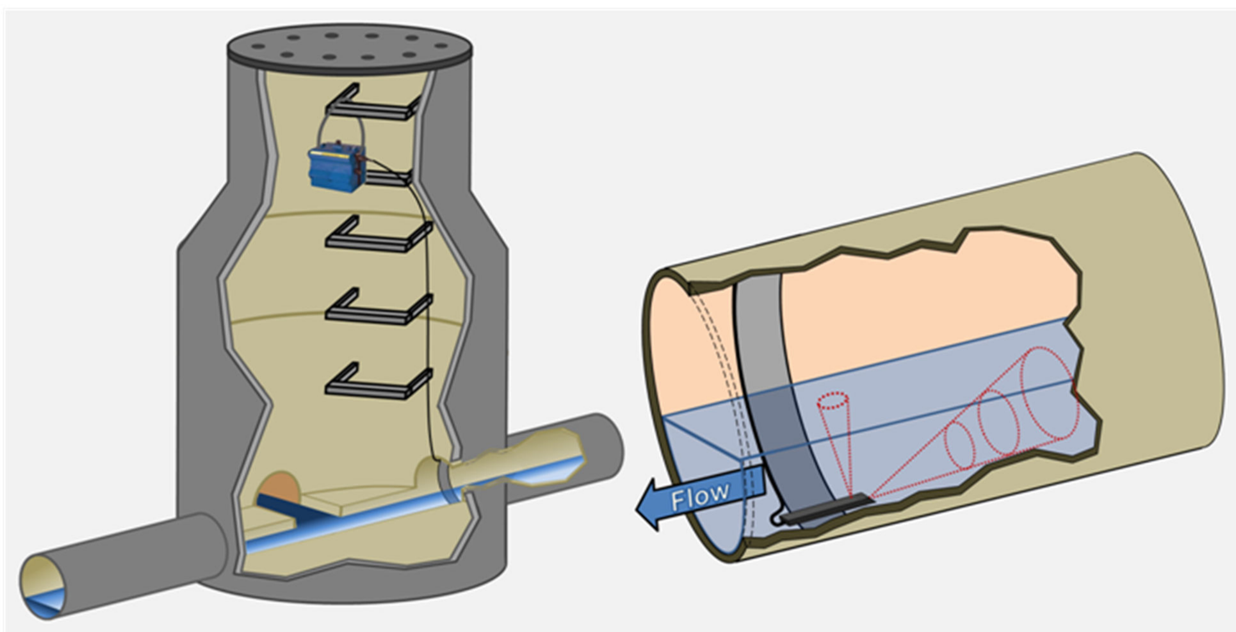



**Figure 2-1. Typical Installation for Flow Meter with Submerged Sensor**

## 2.3 Flow Calculation

Data retrieved from the flow meter was placed into a spreadsheet program for analysis. Data analysis includes data comparison to field calibration measurements, as well as necessary geometric adjustments as required for sediment (sediment reduces the pipe's wetted cross-sectional area available to carry flow). Area-velocity flow metering uses the continuity equation,

$$Q = v \cdot A = v \cdot (A_T - A_S)$$

where $Q$ : volume flow rate

$v$: average velocity as determined by the ultrasonic sensor

$A$: cross-sectional area available to carry flow

$A_T$: total cross-sectional area with both wastewater and sediment

$A_S$: cross-sectional area of sediment.

For circular pipe,

$$A_T = \left[\frac{D^2}{4}\cos^{-1}\left(1-\frac{2d_W}{D}\right)\right]-\left[\left(\frac{D}{2}-d_W\right)\left(\frac{D}{2}\right)\sin\left(\cos^{-1}\left(1-\frac{2d_W}{D}\right)\right)\right]$$

$$A_S = \left[\frac{D^2}{4}\cos^{-1}\left(1-\frac{2d_S}{D}\right)\right]-\left[\left(\frac{D}{2}-d_S\right)\left(\frac{D}{2}\right)\sin\left(\cos^{-1}\left(1-\frac{2d_S}{D}\right)\right)\right]$$

where $d_W$: distance between wastewater level and pipe invert

$d_S$: depth of sediment

$D$: pipe diameter

Weekday and weekend flow patterns differ and are separated when determining average dry weather flows (ADWF). The Overall ADWF was determined from:

$$ADWF = \left(ADWF_{Mon-Fri} \times \frac{5}{7}\right) + \left(ADWF_{Sat-Sun} \times \frac{2}{7}\right)$$

# 3 Results and Analysis

## 3.1 Design Flow Determination

The flow monitoring design flow determination as defined by the City Standard is as follows:

$$Q_D = Q_M + Q_{WWGWI} + Q_{RD\ I/I} + Q_{PD}$$

Where:

$Q_D$ = Design Flow
$Q_M$ = Peak Monitored Flow
$Q_{WWGWI}$ = Wet Weather Groundwater Infiltration
$Q_{RD\ I/I}$ = Rainfall-Dependent Infiltration and Inflow
$Q_{PD}$ = Proposed Development Peak Flow

## 3.2 Flow Monitoring Results

Table 3-1 lists the ADWF, peak measured flow and other calculated factors used to determine the pipeline capacity. Detailed graphs of the flow monitoring data are included in *Appendix A*.

**Table 3-1. Dry Weather Flow Monitoring Summary**

| Item | Value |
|---|---|
| Pipe Diameter (in): | 8 |
| Weekday ADWF (gpm): | 19.1 |
| Weekend ADWF (gpm): | 26.0 |
| Overall ADWF (gpm): | 21.0 |
| Peak Measured Flow (gpm): | 57.1 |
| Peak Level (in): | 1.60 |
| d/D Ratio: | 2.7 |

There was no rainfall during the flow monitoring period. The impact of inflow and infiltration was not evaluated as this is a dry weather study. Under wet weather flow conditions, the available capacity may be less due to inflow and infiltration.

# 3.3 Derived Flow Results

## 3.3.1 Peak Monitored Flow

Per the City's Standards for the flow monitoring design flow determination, the monitored flow ($Q_M$) is the greater of the following:

$Q_M$ = Monitored Peak Flow = 57.1 gpm

OR

$Q_M$ = 2.5 X Monitored Average Flow = 2.5 x 21.0 gpm = 52.5 gpm

THEREFORE,

$$\boxed{Q_M = 57.1 \text{ gpm}}$$

## 3.3.2 Proposed Development Flows

The proposed development is a mix of residential apartments, hotel, and retail space. The peak development flow ($Q_{PD}$) is calculated in Table 3-2. The Base Wastewater Unit Flow Factors established by the City can be found in Appendix B.

Table 3-2. Flow Generation from Proposed Development

| Type of Development | Unit Flow Factor | Number of Units | Flow Generation (gpm) |
|---|---|---|---|
| Townhouses/Condominiums | 175 gpd/DU | 48 | 5.8 |
| | | Total: | 5.8 |
| | | Peaking Factor: | 2.5 |
| Peak Development Flow ($Q_{PD}$) | | | 14.6 |

$$\boxed{Q_{PD} = 14.6 \text{ gpm}}$$

### 3.3.3 Wet Weather Groundwater Infiltration ($Q_{WWGWI}$)

The wet weather groundwater infiltration ($Q_{WWGWI}$) is derived from multiplying the wet weather groundwater infiltration (factor) by the tributary area served by the sanitary sewer main being monitored. The project site is located within the tributary area M_12 (Appendix B). The factor for this area is 0 gpd/acre established by the City Standard as shown in Appendix B.

$$\boxed{Q_{WWGWI} = 0.0 \text{ gpm}}$$

### 3.3.4 Rainfall-Dependent Infiltration and Inflow ($Q_{RDI/I}$)

The rainfall-dependent infiltration and inflow (QRDI/I) is derived the same way as the wet weather groundwater infiltration. Per City Standards, 1,000 gpd/acre is used for $Q_{RDI/I}$ flow determination. The tributary area upstream of the monitored site is shown in Figure 3 3. The tributary area was estimated from sanitary maps.


Figure 3-1. Approximate Tributary Area of Monitored Site

$Q_{RDI/I}$ = RDI/I x Tributary Area
= 1,000 gpd/acre x 38.4 acres = 38,400 gpd or 26.7 gpm

$$\boxed{Q_{RDI/I} = 26.7 \text{ gpm}}$$

### 3.3.5 Design Flow ($Q_D$)

Table 3-3 shows the summary of the design flow results including both monitored flow results and derived flow results.

**Table 3-3. Design Flow Results Summary**

| Item | Flow (gpm) |
|---|---|
| $Q_M$, Monitored Peak Flow: | 57.1 |
| $Q_{WWGWI}$, Wet Weather Groundwater Infiltration: | 0.0 |
| $Q_{RDI/I}$, Rainfall Dependent Infiltration and Inflow: | 26.7 |
| $Q_{PD}$, Proposed Development Peak Flow: | 14.6 |
| $Q_D$, Design Flow: | 98.4 |

$$\boxed{Q_D = 98.4 \text{ gpm}}$$

### 3.3.6 Pipeline Capacity

The pipeline capacity was estimated by using the Manning equation:

$$Q = \frac{669 \times R^{2/3} \times S^{1/2} \times A}{n}$$

where

*A:* Cross-sectional area of flow ($ft^2$)
*R:* hydraulic radius (ft), calculated from flow level *d* and pipe diameter *D*
*S*: Pipeline slope (ft/ft)
*n*: Roughness coefficient (unitless)
*Q:* Flow rate ($ft^3/s$)

The following factors were selected to determine the pipeline capacity.

- **Roughness coefficients:** 0.013 for VCP pipe as a widely accepted number for sanitary sewer design.
- **Pipeline Slopes:** The pipeline slope (0.00375) was provided from the City's Sanitary Sewer System Index Map (page S43).
- **Design Flow Depth**: The City Standard requires that sewer should be designed for peak flow rate not to exceed 75% full pipe.

**Table 3-4. Pipeline Capacity**

| Item | Value |
|---|---|
| **CAPACITY** | |
| Manhole ID: | MH 75 |
| Slope: | 0.00375 |
| Roughness Coefficient: | 0.013 |
| Pipe Diameter (in): | 8.0 |
| Full-Pipe Capacity (gpm): | 332.1 |
| City Allowable Peak Flow at 0.75 d/D (gpm): | 302.8 |

### 3.3.7 Post-Development Pipeline Capacity Analysis

Table 3-5 summarizes the capacity analysis for the pipelines that would be affected by the proposed development area.

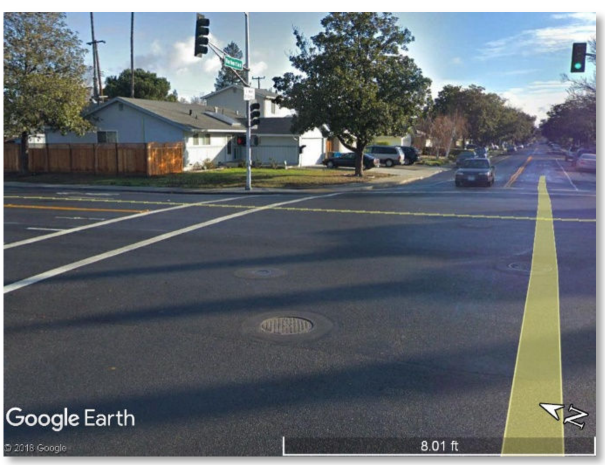
**Table 3-5. Pipeline Capacity Results Summary**

| Item | Flow (gpm) |
|---|---|
| City Allowable Peak Flow at 0.75 d/D (gpm): | 302.8 |
| $Q_D$, Design Flow (gpm): | 98.4 |
| Remaining Capacity (gpm): | 204.4 |
| ***Has Capacity?*** | ***Yes*** |

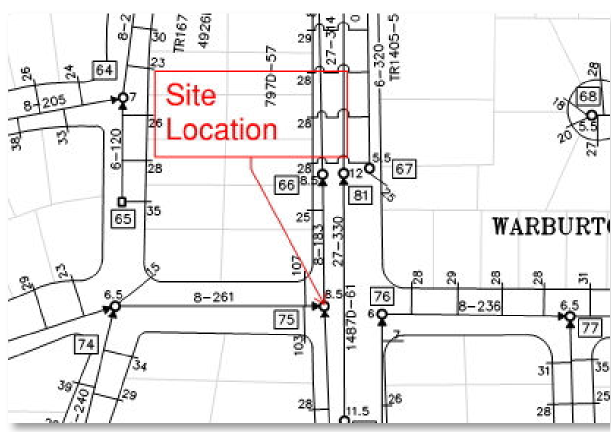
The affected pipelines have adequate capacity to convey additional post-development peak flows per the City's peak allowable flow standards.

# Appendix A
# Flow Monitoring Site Report: Data, Graphs, Information

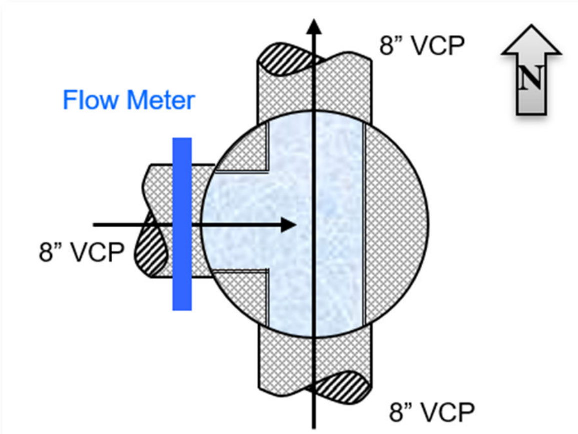

Satellite View




Street View




Sanitary Sewer Map



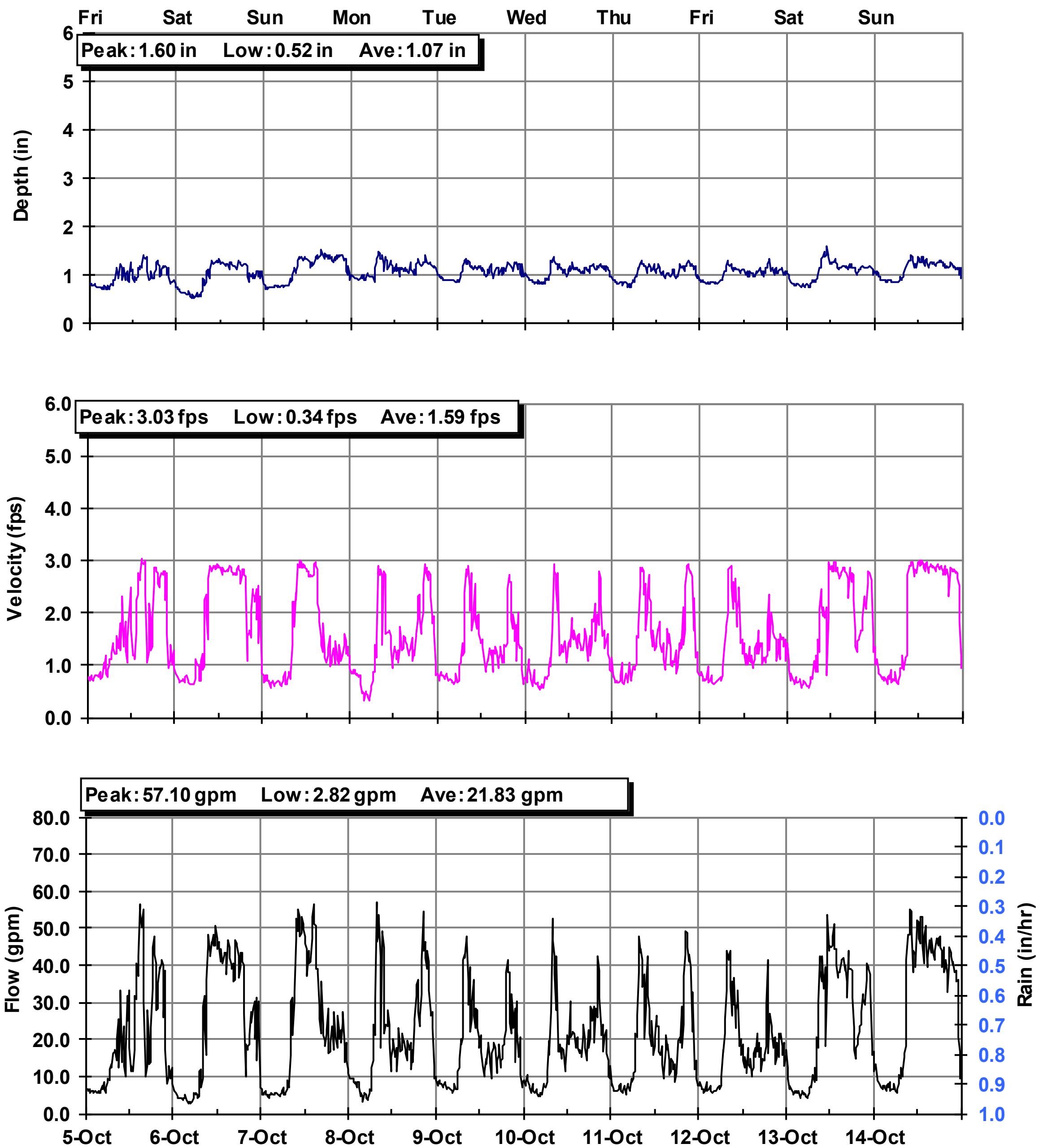

Flow Diagram

Plan View

Effluent Pipe

South Influent Pipe

West Influent Pipe




Flow Monitoring Details (10/5/18 to 10/14/18)

# Appendix B City of Santa Clara: Sanitary Sewer Capacity Assessment Standards

# DESIGN CRITERIA

**for Improvements in Public Right-of-Ways and City Easements**

# City of Santa Clara

**Public Works Department**

SANTA CLARA CALIFORNIA

The Mission City

INCORPORATED 1852

**September 2014**

Prior to any flow monitoring work, the proposed monitoring location(s) shall be reviewed and approved by the Director of Public Works/City Engineer. Flow monitoring measurements to determine average and peak flows, in existing pipes, shall be done over a period of at least seven (7) consecutive days with continuous mechanical/electronic measurements in a manner acceptable to the Director of Public Works/City Engineer.

An Encroachment Permit (EP) is required to allow developer to monitor the sanitary sewer flows.

. Design flow determination shall be as follows:

$Q_D = Q_M + Q_{WWGWI} + Q_{RDI/I} + Q_{PD}$

Where:

| | | |
|---|---|---|
| Q | = | Flow |
| D | = | Design |
| M | = | Monitored |
| WWGWI | = | Wet Weather Groundwater Infiltration |
| RDI/I | = | Rainfall-Dependent Infiltration and Inflow |
| PD | = | Proposed Development |

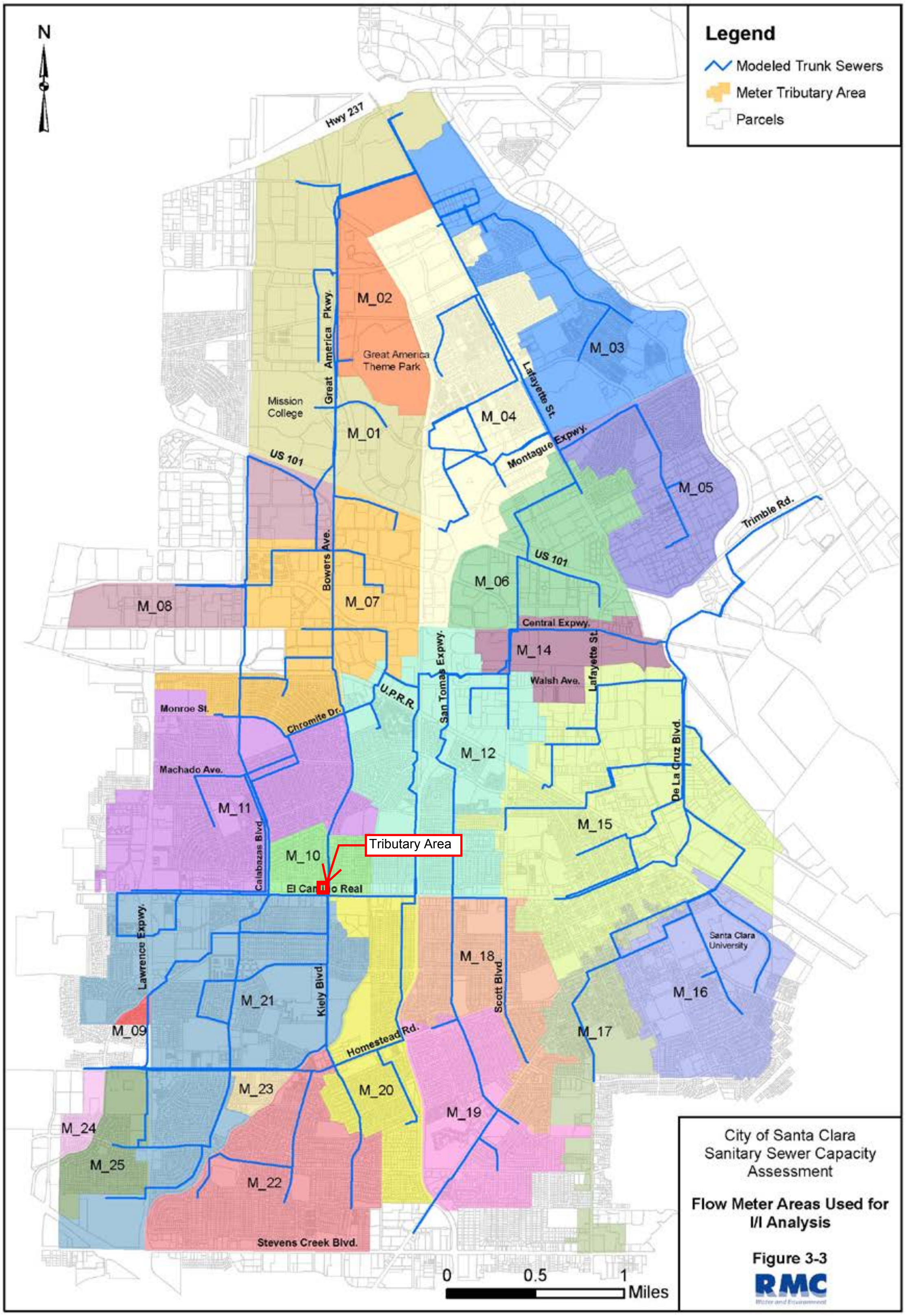
| | | |
|---|---|---|
| $Q_D$ | = | Design Flow |
| $Q_M$ | = | The Monitored Peak Flow or 2.5 times the Monitored Average Flow, whichever is greater. |
| $Q_{WWGWI}$ | = | The gpd/acre value is obtained by using Figure 3-3 on page 3-5 (see Exhibit "D" of this Design Criteria) and Table 3-2 on page 3-11 (see Exhibit "E" of this Design Criteria) of the Sanitary Sewer Capacity Assessment Report, May 2007. Multiply the factor by the Tributary Area served by the sanitary sewer main being monitored. |
| $Q_{RDI/I}$ | = | Same as $Q_{WWGWI}$ above. For now, use 1,000 gpd/acre. |
| $Q_{PD}$ | = | Proposed Development Peak Flow. |

5.5 At all changes of direction, a drop in flow line shall be installed equal to the velocity head times the ratio of angular change to 90 degrees.

$$\frac{V^2}{2g} \times \frac{A^{\circ}}{90^{\circ}} = \text{Head Loss} = \text{drop in flow line*}$$

**EXHIBIT D**

**Figure 3-3 of Sanitary Sewer Capacity Assessment Report, May 2007**



## EXHIBIT E

**Table 3-2 of Sanitary Sewer Capacity Assessment Report, May 2007**



**Table 3-2 GWI and RDI/I Parameters by Meter Area**

| Meter Area[a] | Dry Weather GWI[b] (gpd/acre) | Wet Weather GWI[c] (gpd/acre) | R1 RDI/I Vol. (%) (2 hrs. to peak) | R2 RDI/I Vol. (%) (6 hrs. to peak) | R3 RDI/I Vol. (%) (12 hrs. to peak) |
|---|---|---|---|---|---|
| M_01 | 0 | 0 | 0.5 | 0.8 | 0.8 |
| M_02 | 0 | 0 | 0.5 | 0.8 | 0.8 |
| M_03 | 0 | 0 | 0.6 | 0.1 | 0.1 |
| M_04 | 500 | 1,300 | 0.6 | 0.1 | 0.1 |
| M_05 | 700 | 1,000 | 0.6 | 0.1 | 0.1 |
| M_06 | 0 | 0 | 0.6 | 0.1 | 0.1 |
| M_07 | 1,900 | 1,900 | 0.3 | 0.5 | 0.5 |
| M_08 | 0 | 0 | 0.3 | 0.5 | 0.5 |
| M_09 | 0 | 0 | 0.6 | 0.1 | 0.1 |
| M_10 | 0 | 0 | 0.6 | 0.1 | 0.1 |
| M_11 | 1,600 | 2,300 | 0.9 | 1.7 | 6.0 |
| M_12 | 0 | 0 | 0.9 | 1.0 | 0.5 |
| M_14 | 0 | 0 | 0.6 | 0.1 | 0.1 |
| M_15 | 300 | 700 | 1.0 | 0.2 | 0.2 |
| M_16 | 900 | 1,600 | 1.0 | 0.2 | 0.2 |
| M_17 | 200 | 200 | 0.6 | 0.1 | 0.1 |
| M_18 | 0 | 0 | 0.8 | 1.0 | 0.1 |
| M_19 | 0 | 0 | 0.3 | 0.1 | 0.1 |
| M_20 | 0 | 0 | 0.6 | 0.1 | 0.1 |
| M_21 | 0 | 0 | 0.6 | 0.1 | 0.1 |
| M_22 | 0 | 0 | 0.6 | 0.1 | 0.1 |
| M_23 | 0 | 0 | 0.6 | 0.1 | 0.1 |
| M_24 | 0 | 0 | 0.6 | 0.1 | 0.1 |
| M_25 | 0 | 0 | 0.6 | 0.1 | 0.1 |
| CuSD | 0 | 0 | 0.5 | 0.2 | 0.4 |

(a) See Figure 3-3.
(b) Represents GWI during non-rainfall periods (e.g., early to mid-February) of the 2006 flow monitoring period.
(c) Represents GWI immediately following rainfall events.

City of Santa Clara Water & Sewer Utility

# Sewer System Management Plan

**Approved by City Council: Resolution #** [TBA]

**Table 2-5 Base Wastewater Flow Unit Flow Factors**

| Type of Development | Unit Flow Factor | Basis |
|---|---|---|
| Single Family Detached | 245 gpd/DU | 3.5 people/DU @ 70 gpcd |
| Townhouses/Condominiums | 175 gpd/DU | 2.5 people/DU @ 70 gpcd |
| Apartments | 154 gpd/DU | 2.2 people/DU @ 70 gpcd |
| Hotels | 100 gpd/room | |
| Commercial/Office | 0.1 gpd/sq. ft. | |
| Office/R&D | 0.15 gpd/sq. ft. | |
| Moderate Density Residential (Mixed Use) | 3,200 gpd/acre | 21 DU/acre @154 gpd/DU |
| Medium Density Residential (Transit-Oriented Mixed Use) | 4,600 gpd/acre | 30 DU/acre @ 154 gpd/DU |
| Commercial/Office/R&D Intensification[a] | + 300 gpd/acre | + 0.04 FAR @ 0.15 gpd/sq. ft. |

(a) Applied to areas of North Santa Clara where existing development is anticipated to increase in intensity from a current average floor-area-ratio (FAR) of 0.41 to a future average of 0.45.

### 2.3.3 Diurnal Base Wastewater Flow Patterns

In most sewer systems, BWF exhibits typical diurnal patterns depending on the type of land use. For Santa Clara, typical diurnal curves were developed for residential, commercial, and industrial areas, for both weekend and weekday conditions. These curves are shown in **Figure 2-4**. Each area of the system was assigned a diurnal curve according to its predominant land use type.

# APPENDIX K

# 2009 SANITARY SEWER CAPACITY ASSESSMENT

**Table 2-1: Base Wastewater Unit Flow Factors**

| Land Use | Unit Flow Factor | Basis |
|---|---|---|
| Low Density Residential | 245 gpd/DU[a] | 2007 Capacity Assessment |
| Medium Density Residential | 154 gpd/DU | 2007 Capacity Assessment |
| High Density Residential | 154 gpd/DU | 2007 Capacity Assessment |
| Retail & Residential [b] | 154 gpd/DU | 2007 Capacity Assessment |
| Commercial [c] | 0.1 gpd/sq. ft.[d] | 2007 Capacity Assessment |
| Hotel | 0.48 gpd/sq. ft. | Standard Unit Flow Factor per SJ/SC WPCP[e] |
| Industrial/Office/R&D[f] (higher intensity) | 0.15 gpd/sq. ft. | 2007 Capacity Assessment |
| Warehouse Manufacturing | 0.052 gpd/sq. ft. | Standard Unit Flow Factor per SJ/SC WPCP |
| Public/Institutional | 0.15 gpd/sq.ft | Assumed to be similar to Office/R&D uses |
| Parks/Recreation | -- | Assumed to generate little or no flow |

a. gpd/DU = gallons per day per dwelling unit
b. Flow assumed to be primarily residential
c. Including neighborhood and regional commercial services, retail, office, and auto sales
d. gpd/sq. ft. = gallons per day per square foot of building floor space
e. SJ/SC WPCP = San Jose / Santa Clara Water Pollution Control Plant
f. R&D = Research & Development

In some cases, the demolition of existing development was identified by City staff. In these cases, the estimated flow from the existing development was subtracted out from the model baseline flow.

In general, the BWF generated by a development parcel was calculated as follow:

*BWF = (Size of New Development x Unit Flow Factor) – (Demolition of Existing Development x Unit Flow Factor)*

A table of the computed BWF for each sewer subbasin can be found in **Appendix B**.

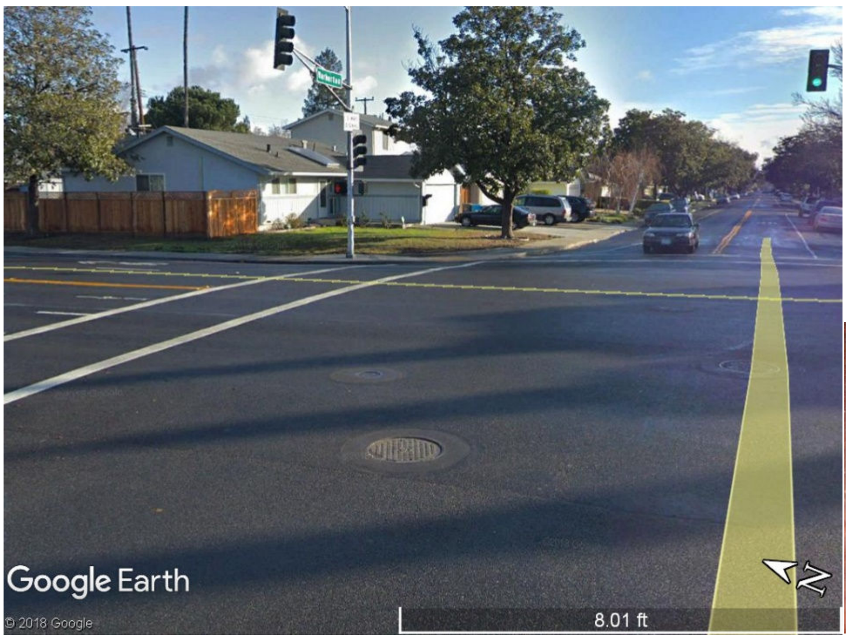
**Table 2-2** shows the estimated average dry weather flow (ADWF), peak dry weather flow (PDWF), and peak wet weather flow (PWWF) for each of the three General Plan Update phases. As per the 2007 Capacity Assessment, flows from Cupertino Sanitary District were included in the model up to the District's contracted maximum capacity in the City's sewer system.

**Table 2-2: Summary of Wastewater Flow Estimates**

| Scenario | ADWF [a] (MGD) | PDWF [a] (MGD) | PWWF [b] (MGD) |
|---|---|---|---|
| Phase 1 | 26.8 | 34.9 | 53.5 |
| Phase 2 | 28.7 | 37.2 | 56.0 |
| Phase 3 | 30.6 | 39.5 | 57.8 |

a. ADWF and PDWF represent a non-rainfall wintertime condition and include groundwater infiltration.
b. PWWF represents peak flow for a 10-year frequency design storm.

V&A Project No. 18-0127

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