TABLE OF CONTENTS

INTRODUCTION ........................................................................................................................................ 1

METHODS AND PROCEDURES ............................................................................................................ 2
  2.1 Confined Space Entry .................................................................................................................. 2
  2.2 Flow Meter Installation .............................................................................................................. 3
  2.3 Flow Calculation ........................................................................................................................ 4
  2.4 Pipeline Capacity Calculation ................................................................................................... 5

RESULTS AND ANALYSIS .................................................................................................................. 6
  3.1 Flow Monitoring ........................................................................................................................ 6
  3.2 Pipeline Capacity Analysis ......................................................................................................... 8

TABLES

Table 3-1. Flow Monitoring Summary .................................................................................................. 7
Table 3-2. Flow Estimate from the New Development ......................................................................... 8
Table 3-3. Pipeline Capacity Summary ................................................................................................ 8

FIGURES

Figure 1-1. Flow Monitoring Locations .............................................................................................. 1
Figure 2-1. Typical Installation for Flow Meter with Submerged Sensor ............................................. 3
Figure 3-1. Site 1 Monitoring Location ............................................................................................... 6
Figure 3-2. Site 2 Monitoring Location ............................................................................................... 6

APPENDICES

Appendix A. Detailed Flow Monitoring Data
1.0 INTRODUCTION

V&A Consulting Engineers (V&A) was retained by Samaritan Medical Center to perform sanitary sewer flow monitoring and sewer capacity study within the City of San Jose (City). The flow monitoring was in support of three new development projects at Samaritan Drive. This study identified the average and peak flows and determined the available capacity of the subject pipelines.

The flow monitoring was performed at Manhole 991 (8-inch) and Manhole 80806 (18-inch) for two weeks from March 18, 2016 to March 31, 2016. The flow monitoring locations are shown in Figure 1-1.

Figure 1-1. Flow Monitoring Locations
2.0 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 absence of hydrogen sulfide (H₂S) 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 are 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

A Teledyne Isco 2150 meter was installed by V&A in the sewer line. 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 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 were compared to simultaneous level and velocity readings from the flow meters to ensure proper calibration and accuracy. The pipe diameter was also verified in order to accurately calculate the flow cross-section. The continuous depth and velocity readings were recorded by the flow meters on 5-minute intervals. 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](image)
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 surface 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:

\[ ADWF = \left( ADWF_{Mon–Fri} \times \frac{5}{7} \right) + \left( ADWF_{Sat–Sun} \times \frac{2}{7} \right) \]
2.4 Pipeline Capacity Calculation

The pipeline capacity was calculated by using the Manning equation:

\[ Q = v \times A = \frac{1.49 \times R^{2/3} \times S^{1/2} \times A}{n} \]

where

- \( v \): Flow velocity (ft/s)
- \( A \): Cross-sectional area of flow (ft²)
- \( R \): Hydraulic radius (ft), calculated from flow level \( d \) and pipe diameter \( D \)
- \( S \): Pipeline slope (ft/ft)
- \( n \): Roughness coefficient (unitless)
- \( Q \): Flow rate (ft³/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 slopes were obtained from the City’s Sanitary Sewer Map.
- Design Flow Depth: The City Standard requires that sewer should be designed for peak flow rate not to exceed 75% full pipe.
3.0 RESULTS AND ANALYSIS

3.1 Flow Monitoring Sites

The flow monitoring location and plan view for each site are shown below.

Figure 3-1. Site 1 Monitoring Location

Photo 3-1. Site 1 Plan View

Figure 3-2. Site 2 Monitoring Location

Photo 3-2. Site 2 Plan View
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>
<thead>
<tr>
<th>Monitored Items</th>
<th>Site 1</th>
<th>Site 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter (in.)</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Sediment (in.)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Weekday ADWF (mgd)</td>
<td>0.107</td>
<td>1.017</td>
</tr>
<tr>
<td>Weekend ADWF (mgd)</td>
<td>0.056</td>
<td>1.045</td>
</tr>
<tr>
<td>Overall ADWF (mgd)</td>
<td>0.092</td>
<td>1.025</td>
</tr>
<tr>
<td>Peak Dry Weather Flow (mgd)</td>
<td>0.280</td>
<td>1.752</td>
</tr>
<tr>
<td>Peaking Factor</td>
<td>3.05</td>
<td>1.71</td>
</tr>
<tr>
<td>Peak Flow Level (in.)</td>
<td>3.89</td>
<td>8.99</td>
</tr>
<tr>
<td>d/D Ratio</td>
<td>0.49</td>
<td>0.50</td>
</tr>
</tbody>
</table>

The following information should be noted.

- There was no rainfall during the flow monitoring period. All 14 days were used to calculate the ADWF.
- Capacity analysis data is presented on a site-by-site basis and represents the hydraulic condition only at the site location. Hydraulic conditions in other areas of the collection system will differ.
3.3 Pipeline Capacity Analysis

The estimated average and peak flows from the new development areas were calculated in Table 3-2. The average sewage generation rates were per City standards. The expected peak flow can be calculated with the following formula:

\[ Q_{\text{peak}} = 2.5 \left( Q_{\text{avg}} \right)^{0.91} \]

Table 3-2. Flow Estimate from the New Development

<table>
<thead>
<tr>
<th>Project No.</th>
<th>Project Location</th>
<th>Project Type and Size</th>
<th>Average Flow (mgd)</th>
<th>Peak Flow (mgd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2506 Samaritan Court</td>
<td>69,250 ft² of medical offices</td>
<td>0.099</td>
<td>0.305</td>
</tr>
<tr>
<td>2</td>
<td>2515 Samaritan Court</td>
<td>46,000 ft² of medical offices</td>
<td>0.0686</td>
<td>0.218</td>
</tr>
<tr>
<td>3</td>
<td>2507-2577 Samaritan Drive</td>
<td>360,000 ft² of medical offices</td>
<td>0.437</td>
<td>1.177</td>
</tr>
<tr>
<td></td>
<td><strong>Total Flow (mgd)</strong></td>
<td></td>
<td><strong>0.605</strong></td>
<td><strong>1.700</strong></td>
</tr>
</tbody>
</table>

Table 3-3 summarizes the capacity analysis.

Table 3-3. Pipeline Capacity Summary

<table>
<thead>
<tr>
<th>Item</th>
<th>Segment 1010</th>
<th>Segment 80702</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capacity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitored Location</td>
<td>Site 1 (MH 991)</td>
<td>Site 2 (MH 80806)</td>
</tr>
<tr>
<td>Pipe Diameter (inch)</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>City Allowable Peak Flow by Level (inch)</td>
<td>6</td>
<td>13.5</td>
</tr>
<tr>
<td>Slope</td>
<td>0.004</td>
<td>0.004</td>
</tr>
<tr>
<td>Roughness Coefficient (VCP)</td>
<td>0.013</td>
<td>0.013</td>
</tr>
<tr>
<td>Full-Pipe Capacity (mgd)</td>
<td>0.495</td>
<td>4.302</td>
</tr>
<tr>
<td>75% Full Peak Allowable Flow per City Standards (mgd)</td>
<td>0.451</td>
<td>3.923</td>
</tr>
<tr>
<td><strong>Flow Measurement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured ADWF (mgd)</td>
<td>0.092</td>
<td>1.025</td>
</tr>
<tr>
<td>Measured Peak Dry Weather Flow (PDWF in mgd)</td>
<td>0.281</td>
<td>1.751</td>
</tr>
<tr>
<td><strong>Available Capacity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Available Flow (City Peak Allowable Flow less Measured PDWF)</td>
<td>0.170</td>
<td>2.172</td>
</tr>
</tbody>
</table>
The following information is noted.

- 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.

- The existing 8-inch VCP line doesn’t have enough capacity for any proposed development as the available capacity is less than the peak flow for any development.

- The existing 18-inch VCP line has enough capacity for any of the proposed developments as the available capacity is more than the total peak flow from all the developments.
APPENDIX A. FLOW MONITORING DATA GRAPHS (15-MINUTE INTERVAL)

Site 1 Flow Monitoring Details (3/18 to 3/24, 2016)
Site 1 Flow Monitoring Details (3/25 to 3/31, 2016)
Site 2 Flow Monitoring Details (3/18 to 3/24, 2016)
Site 2 Flow Monitoring Details (3/25 to 3/31, 2016)