Appendix E: V&A Condition Assessment Report

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CCTV VIDEO REVIEW AND MANHOLE CONDITION ASSESSMENT

City of Los Altos

November 2009

V&A

City of Los Altos
CCTV VIDEO REVIEW AND
MANHOLE CONDITION ASSESSMENT

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1 EXECUTIVE SUMMARY

1.1 Introduction

V&A was retained by CSG Consultants (CSG) to perform a condition assessment of approximately 32,000 feet of sanitary sewer and 85 manholes that are part of the trunk sewer that serves the City of Los Altos (City). V&A was tasked to review CCTV video tapes of the sanitary sewer alignment. The condition assessment of this alignment is part of a larger sanitary sewer rehabilitation effort with various associated projects. The sanitary sewer alignment, as seen in Figure 1-1, begins at Covington Road and Seena Avenue, and heads in a northerly direction along Springer Road, Del Medio Road, and San Antonio Road. Some sections of the trunk sewer follow a westerly alignment direction along Marich Way and El Camino Real, among other roadways.

There were two primary tasks on this particular project: manhole condition assessment and CCTV video review. V&A conducted topside condition assessments of 82 of 85 manholes (3 manholes were inaccessible). The condition assessments did not involve a confined space entry. From the results of the topside condition assessments and the CCTV video review, approximately 20% of the manholes were selected for a confined space entry condition assessment. The confined space entry condition assessments included physical evaluation, such as penetration measurements, concrete pH testing and sulfide measurements to verify visual condition documentation. The topside assessments were performed from June 30 through July 15, 2009, and the confined space entry condition assessments were performed from July 9 through 15, 2009.

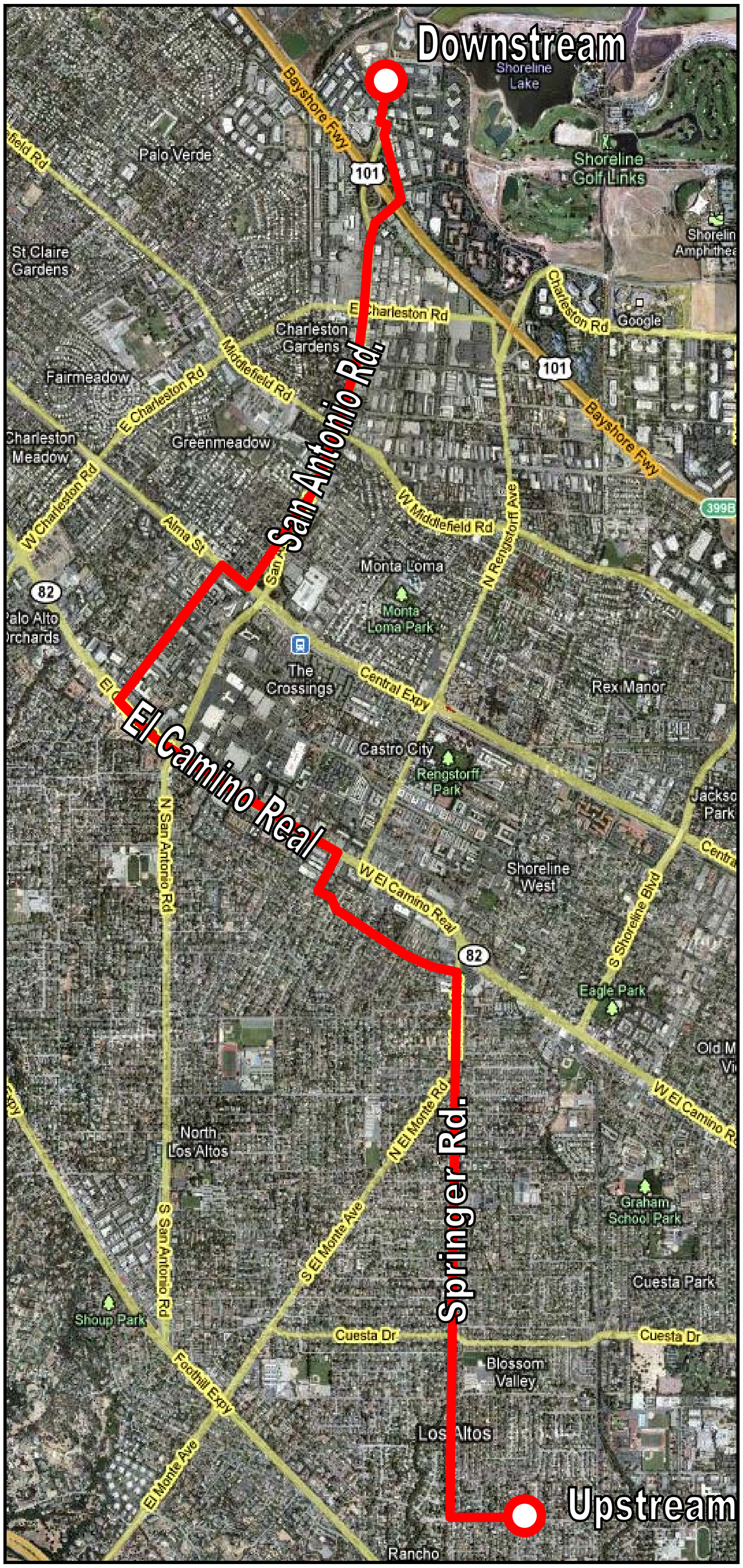


Figure 1-1. Overview of Los Altos Sanitary Sewer

1.2 CCTV Video Review

V&A reviewed CCTV videos (originally conducted in August, 2002) of the alignment provided by the City and assessed the condition of the pipeline using the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment Condition Program (PACP) standardized ratings. NASSCO has developed this standardized system in order to provide a consistent assessment of sanitary sewer conditions, as well as to provide the capability of benchmarking sewer conditions in order to track deterioration over time. More information on the PACP program can be found in Section 3.8 of this report. Table 1-1 and Table 1-2 present a summary of the number of occurrences of structural and operational and maintenance (O&M) defects observed in the 32,058 feet of CCTV video evaluated.

Table 1-1
Summary of Structural PACP Defects

Rating	Number of Occurrences	% per foot of pipe evaluated	Defect Types (quantity)
5	21	1	Surface Reinforcement Visible (19) Surface Missing Wall (1) Surface Reinforcement Corroded (1)
4	65	19	Surface Aggregate Missing (64) Deformed 10% - at joint (1)
3	7	1	Surface Aggregate Visible (4) Crack Multiple (3)
2	143	41	Surface Spalling (139) Crack Longitudinal (4)

Table 1-2
Summary of O&M PACP Defects

Rating	Number of Occurrences	% per foot of pipe evaluated	Defect Types (quantity)
4	3	< 1	Alignment Left, 30° (1) Obstacles Built Into Structure (1) Infiltration Runner (1)
3	7	< 1	Roots Medium Lateral (2) Roots Medium Joint (2) Roots Medium Connection (1) Water Level Sag 40-50% (1) Tap Break-In Defective (1)
2	56	2	Water Level Sag 10-20% (37) Alignment Change 15° to 20° (9) Tap Break-In Intruding (6) Roots Medium (2) Deposits Attached Grease (2)
1	12	< 1	Roots Fine (5) Alignment Change 5° to 10° (5) Vermin Cockroach (2)

The total frequency of structural defects observed represents approximately 62% of the pipe evaluated. The most frequent type of defect is hydrogen sulfide (H_2S) chemical damage. The damage occurs in various levels of severity, from surface concrete spalling to corroded reinforcement.

1.3 Manhole Condition Assessment Results

1.3.1 Topside – Manhole Condition Assessment Results

Topside evaluations were conducted for each manhole along the alignment. The VANDA™ Ratings provide a quick indication of the concrete surface condition. The results of the topside evaluations are presented in Table 1-3.

Table 1-3
Summary of Condition Assessment Findings

Category	Measurement	Degree of Corrosivity	Manholes Evaluated
VANDA™ Concrete Index[A]	1	Negligible	79 of 82 (96%)
	2	Minor	3 of 82 (4%)

[A] Table 3-3 VANDA™ Reinforced Concrete Condition Index Rating System, p 9

1.3.2 Confined Space Entry – Manhole Condition Assessment Results

A variety of methods was used to assess the condition of each manhole. These methods included taking samples of the concrete for pH testing, penetration testing to assess the hardness of the concrete, visual observations and digital photographs. Table 1-4 provides a summary of the pH measurements collected from the confined space entry evaluations.

Table 1-4
Summary of Condition Assessment Findings

Category	Measurement	Degree of Corrosivity[B]	Manholes Evaluated
Concrete pH	5.5 – 6.5	Moderate	1 of 18 (6%)
	< 5.5	Severe	17 of 18 (94%)

[B] Section 3.4 pH data

1.4 Recommendations

The following recommendations are summarized from Section 5 and are based on the results of the manhole condition assessments and the CCTV documentation review.

- Conduct a wastewater sampling and atmospheric monitoring study to quantify the extent and concentration of liquid and vapor phase sulfides in the sewer. The sulfide study can be used to develop mitigation measures in order to forestall further corrosion degradation due to hydrogen sulfide exposure.
- V&A recommends additional CCTV inspection of various segments to verify how conditions may have changed since August 2002 when the original CCTV documentation was conducted. The 16 segments, an approximate length of 6,400 feet, recommended for CCTV inspection are listed in Table 5-1.
- V&A recommends expanding the list of segments for cured-in-place pipe (CIPP) rehabilitation. The 9 segments, an approximate length of 4,000 feet, recommended for CIPP rehabilitation are listed in Table 5-2. The segments should be rehabilitated over the next 5 years.
- Manholes are important components in sanitary sewer systems that tend to be overlooked. The manholes are subjected to the same hydrogen sulfide chemical corrosion as the pipe segments; although they are generally in good condition by comparison. V&A advocates proactively addressing manhole rehabilitation needs in conjunction with pipeline rehabilitation.

2 INTRODUCTION

V&A was retained by CSG to assess the condition of 85 manholes that are part of a main sanitary sewer that services the City. The scope of this phase of the project (Figure 1-1) begins at the intersection of Covington Road and Seena Avenue. The pipeline travels north on Springer Road before turning west on Marich Way. The pipeline then reaches El Camino Real via Distal Way and turns north on Del Medio Drive. After traveling underneath the Caltrain tracks, it jogs briefly southeast on Central Expressway before resuming its northerly trajectory along San Antonio Road and eventually terminating at a metering station north of Highway 101.

This particular project, which is part of a larger rehabilitation project, concerns the physical condition of the manholes. The locations, materials and pipe diameters that comprise 85 topside condition assessments can be found in Table 2-1. The manholes, which are in parenthesis and highlighted in red, comprise those that were assessed further during a confined space entry. Table 2-2 highlights manholes that do not exist, are marked incorrectly on the drawings or have another issue.

Table 2-1
Los Altos Sewer – Manhole Designations, Locations and Pipeline Diameter

Manhole Designation	Location	Pipeline Diameter	
		Influent	Effluent
H4S-503	Covington Rd. & Seena Ave.	24-inch	24-inch
H4S-501	Covington Rd. & Leonella Ave. (781 Covington Rd.)	24-inch	24-inch
(H4S-509)	Filip Rd./Spenser Way & Covington Rd.	24-inch	24-inch
H4S-401	Covington Rd. & Springer Rd.	24-inch	30-inch
H4S-103	926 Springer Rd.	30-inch	30-inch
H4S-105	848 Springer Rd.	30-inch	30-inch
G4S-409	Riverside Dr. & Springer Rd.	30-inch	30-inch
(G4S-410)	758 Springer Rd.	30-inch	30-inch
G4S-414	Rosita Ave. & Springer Rd.	30-inch	30-inch
G4S-118	640 Springer Rd. / Shady Creek Lane	30-inch	30-inch
(G4S-105)	Arboleda Dr. & Springer Rd.	30-inch	30-inch
G4S-106	Cuesta Dr. & Springer Rd.	30-inch	30-inch
F4S-409	442 Springer Rd.	30-inch	30-inch
(F4S-410)	Paco Dr. & Springer Rd.	30-inch	30-inch
F4S-107	Sunshine Dr. & Springer Rd.	30-inch	30-inch
F4S-108	Giralda Dr. & Springer Rd.	30-inch	30-inch
F4S-106	San Martin Pl./Terrace Ct. & Springer Rd.	30-inch	30-inch
F4S-103	Rivera Dr./Sunshine Dr. & Springer Rd.	30-inch	30-inch
E4S-412	Springer Terrace & Springer Rd.	30-inch	30-inch

Manhole Designation	Location	Pipeline Diameter	
		Influent	Effluent
E4S-409	Camellia Way & Springer Rd.	30-inch	30-inch
E4S-402	Coral Court & Springer Rd.	30-inch	30-inch
(E4S-105)	76 Springer Rd.	30-inch	30-inch
E4S-106	106 Springer Rd. near Raymundo Ave.	30-inch	30-inch
E4S-109	Blinn Court	30-inch	30-inch
E4S-112	160 Springer Rd.	30-inch	30-inch
E4S-111	184 Springer Rd., 50 feet north of E4S-112	30-inch	30-inch
D4S-407	Todd St. & Springer Rd.	30-inch	30-inch
D4S-409	El Monte Rd. & Springer Rd. (Jay St. not through)	30-inch	30-inch
D4S-401	Spargur Dr. & El Monte Rd.	30-inch	30-inch
D4S-202	Hollingsworth Dr. & El Monte Rd.	30-inch	30-inch
D4S-201	Pilgrim Ave. & El Monte Rd.	30-inch	30-inch
C4S-501	Marich Way & El Monte Rd.	30-inch	30-inch
(C4S-403)	1755 Marich Way	30-inch	30-inch
C4S-402.5	1795 Marich Way	30-inch	30-inch
C4S-401	Judson Dr. & Marich Way	30-inch	30-inch
C3S-601	Easement between Marich Way at Karen Way	30-inch	30-inch
(C3S-213)	454 Marich Way 50 ft east of Casita Way	30-inch	30-inch
C3S-206	431 Marich Way	30-inch	30-inch
(C3S-205)	Distel Dr. & Marich Way	30-inch	30-inch
C3S-211	5100 El Camino / Apts. along Distel Dr.	30-inch	30-inch
(B3S-503)	Distel Dr. & El Camino Real	30-inch	27-inch
B3S-502	Distel Dr. & El Camino Real	27-inch	27-inch
B3S-505	5050 El Camino Real	27-inch	27-inch
B3S-508	Distel Circle & El Camino Real	27-inch	27-inch
B3S-509	4984 El Camino Real	27-inch	27-inch
B3S-402	4962 El Camino Real near Ortega Ave.	27-inch	27-inch
B3S-404	4916 El Camino Real	27-inch	27-inch
B3S-401	Jordan Ave. & El Camino Real	27-inch	27-inch
(B3S-302)	4856 El Camino Real	27-inch	27-inch
B3S-303	Whole Foods 4800 El Camino Real / Showers Dr.	27-inch	27-inch
B2S-305	Whole Foods 4800 El Camino Real	27-inch	27-inch
B2S-306	4710 El Camino Real / Marie Callender's	27-inch	27-inch
B2S-311	Sherwood Ave. & El Camino Real	27-inch	27-inch
B2S-313	El Camino Real & San Antonio Rd.	27-inch	27-inch

Manhole Designation	Location	Pipeline Diameter	
		Influent	Effluent
A2S-504	4540 El Camino Real	27-inch	27-inch
(A2S-506)	Rambus at El Camino Real	27-inch	27-inch
A2S-408	4410 El Camino Real	27-inch	30-inch
A2S-202	480 Del Medio Ave.	30-inch	30-inch
(A2S-203)	450 Del Medio Ave.	30-inch	30-inch
A2S-201	Miller Ave. & Del Medio Ave.	30-inch	30-inch
Z1S-126	Silva & Del Medio Ave.	30-inch	30-inch
Z1S-125	Del Medio Court & Del Medio Ave.	30-inch	30-inch
Z1S-124	West of 4243 Alma St. (Central Expwy)	30-inch	30-inch
Z1S-128	4245-4265 Alma St. (Central Expwy)	30-inch	30-inch
Z1S-129	Adjacent to offramp on Alma St. (Central Expwy)	30-inch	33-inch
(Z1S-127)	Alma St. (Central Expwy) & San Antonio Road	33-inch	30-inch
Z1S-122	Briarwood Way & San Antonio Rd.	30-inch	30-inch
Z1S-120	Dake Ave. & San Antonio Way	30-inch	30-inch
Z1S-119	Ferne Ave. & San Antonio Way	30-inch	39-inch
Z1S-109	San Antonio Rd. & Middlefield Rd.	39-inch	39-inch
(Z1S-116)	Bach Co. on San Antonio north of Leghorn	39-inch	39-inch
(Z1S-115)	Studio Kicks & San Antonio Rd.	39-inch	39-inch
Z1S-114	Fabion & San Antonio Rd.	39-inch	39-inch
Z1S-113	San Antonio Rd. at frontage road offramp (one way)	39-inch	39-inch
(Z1S-110)	988 San Antonio Rd.; offramp	39-inch	39-inch
Z1S-108	998 San Antonio Rd.; offramp	39-inch	39-inch
Z1S-111	Transport St. & San Antonio Rd.	39-inch	36-inch
(Z1S-107)	2632 E. Bayshore Pkwy	36-inch	42-inch
Z1S-106.5	Garcia Ave. & Bayshore Pkwy	42-inch	42-inch
Z1S-106	2644 E. Bayshore Pkwy	42-inch	42-inch
Z1S-105	In front of 2672-2680 Bayside Business Plaza	42-inch	42-inch
Z1S-104.5	2680 Bayshore Pkwy	42-inch	42-inch
(Z1S-104)	North parking lot 2672-2680 Bayside Business Plaza	42-inch	39-inch
Z1S-103	Entrance to Bayview Business Park	39-inch	42-inch
Z1S-102	Meter Station on San Antonio Rd between E. Bayshore Pkwy & Casey Ave.	42-inch	42-inch

Table 2-2
Los Altos Sewer – Manhole Discrepancy

Manhole Designation	Location	Discrepancy
D4S-413	Lloyd St. & El Monte Rd.	No manhole found
C4S-402.5*	1795 Marich Way	Could be C4S-402 that is placed in wrong location on drawing.
C4S-402*	Blackfield & Marich	Not a 30-inch line; only 6 or 8-inch residential. Actual line could be C4S-402.5 at 1795 Marich Way.
C3S-602	2067 Marich Way (across from small park)	No manhole found; large asphalt patch
Z1S-121	Mackay & San Antonio Frontage	Southbound curb lane on San Antonio Rd., directly across from Mackay Ave., on east side of San Antonio Way – San Antonio Rd. concrete divider. Not a 30-inch line.
Z1S-118	Byron & San Antonio Frontage	Not found (no evidence in road)
Z1S-117	Loewen Windows on San Antonio	Not found (there is an asphalt patch just south of Loewen Windows and 756 Greenhouse II that could be former M.H.)
Z1S-112	960 San Antonio offramp	No 30-inch line here, just smaller shallow laterals. Apparently no 30-inch manhole here.
Z1S-106.5	Garcia Ave. & Bayshore	Extra manhole found between Z1S-107 and Z1S-106
Z1S-104.5	2680 Bayshore	Extra manhole found between Z1S-105 and Z1S-104

*The manholes on Los Altos Sanitary Sewer drawing C4-SS appear to be mislabeled. In most City sanitary drawings, the designation begins with a letter ('C') and then a number ('4'). In this drawing, the first two characters are reversed.

3 METHODS AND PROCEDURES

3.1 Hydrogen Sulfide and Corrosion

An important naturally occurring process in wastewater systems is the production of hydrogen sulfide (H_2S) from decaying organic matter. H_2S exists in a dissolved state within the wastewater, but may be released into a gaseous state, resulting in corrosion and unpleasant odors. It can also create health risks and safety concerns. It is important to note that H_2S does not cause corrosion of concrete in the dissolved form. Only the atmospheric H_2S can oxidize to form sulfuric acid, which corrodes concrete and steel.

Hydrogen sulfide is produced from sulfates found in the wastewater by sulfate-reducing bacteria. The bacteria are found in the "slime layer" that is located on the submerged portions of the pipe walls. Anaerobic conditions are required for the bacteria to reduce the sulfates to sulfides. These conditions exist just below the surface of the slime layer where the available oxygen in the wastewater has been depleted (Figure 3-1). The presence of oxygen will cause the microbes to become dormant; however, they will resume their sulfate reduction as soon as anaerobic conditions return.

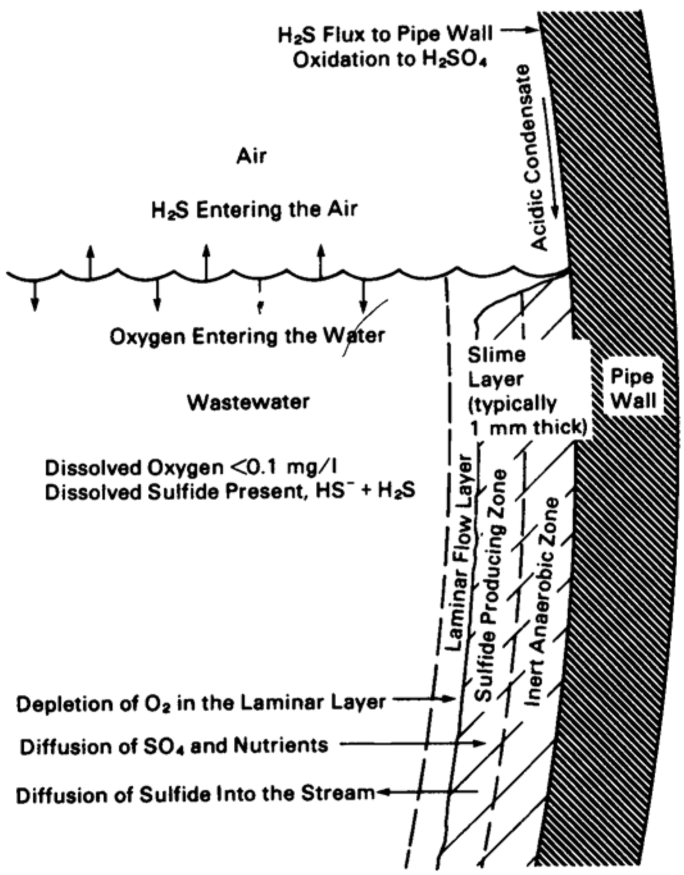


Figure 3-1. Illustration of Slime Layer, Propagation of H_2S[1]

[1] ASCE Manual No. 69, Sulfide in Wastewater Collection & Treatment Systems-inch, American Society of Civil Engineers, p. 34 (1989)

3.2 Retention Time

Retention time affects the amount of sulfides that are generated in a sanitary sewer. Longer retention times, such as in trunk sewers, allow for the available oxygen to be used up; thus, allowing anaerobic bacteria to convert sulfates into sulfides.

3.3 Release of H_2S

Dissolved sulfides are not detrimental to concrete unless they are released into the atmosphere. A primary factor in the release of dissolved hydrogen sulfide into the atmosphere is turbulence.

Other factors that affect the release of dissolved hydrogen sulfide into the atmosphere include the following:

- Temperature: The solubility of H_2S in water decreases as the temperature increases.
- pH: In alkaline environments, the majority of dissolved sulfides are bound in a form that cannot readily release into the atmosphere as H_2S. At a pH above 8, 90% of the dissolved sulfides are in this bound form (HS^-). At a pH of 5 or less, 99% of the sulfides are present as H_2S and are released into the atmosphere due to the low solubility of H_2S in water.

When atmospheric H_2S comes in contact with the moist surfaces of a structure or pipeline, it undergoes a biological conversion to sulfuric acid (H_2SO_4), which quickly leads to the decomposition of concrete and steel. H_2S measurements in an active system may range from 0 to 500 ppm. Generally, values of 5 ppm or greater can result in odors and corrosive conditions depending on the physical features of the sanitary sewer. Atmospheric H_2S above 10 ppm is hazardous to humans (refer to Table 3-1).

Table 3-1
Effects of H_2S on Humans

Concentration of H_2S (ppm)	Effect
0.5 to 30	Strong Odor
10 to 50	Headache, Nausea and Eye, Nose and Throat Irritation
50 to 300	Eye and Respiratory Injury
300 to 500	Life Threatening
> 700	Immediate Death

3.4 pH Data

The best indicator of how corrosive the environment has been in the past is to evaluate the condition of the existing concrete, where applicable. This evaluation assumes the hydraulic conditions of the past, present and future will remain relatively unchanged. Samples of the surface concrete from the penetration tests were collected and tested for pH. The pH probe was calibrated prior to testing using pH 4.01 and 10.00 buffer solution. V&A has developed a table correlating the effect of the pH of the environment on the rate of corrosion of concrete, as shown in Table 3-2. The data in Table 3-2 is derived from past experience and review of the literature, e.g., ACI International Technical Document C-24 Durable Concrete.

Table 3-2
pH-Corrosion Correlation Table for Concrete

pH	Degree of Corrosivity
< 5.5	Severe
5.5 - 6.5	Moderate
6.5 - 7.5	Neutral
> 7.5	Negligible

3.5 Observations

Often, the optimal method for a structure condition assessment is a physical investigation involving a combination of visual observations, documented with digital photographs, and substrate testing. It should be noted that much of the condition assessment data is subjective and based on the evaluator's expertise.

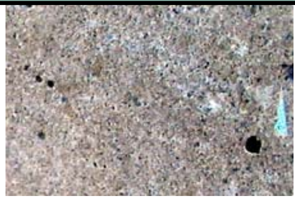
3.6 Penetration Data

Penetration measurements involve applying a consistent level of force from a chipping hammer to the concrete surface and then measuring the depth of the resulting cavity. The depth of the cavity provides qualitative data on the hardness and condition of the concrete surfaces.

3.7 Concrete Condition Rating System

V&A developed the VANDA™ Reinforced Concrete Condition Index Rating System as a means to consistently identify the condition of concrete. The concrete surfaces were rated according to Table 3-3, which summarizes this concrete rating system. The extent of the concrete damage can vary from Level 1 to Level 4, with Level 1 indicating the best case and Level 4 indicating severe damage.

Table 3-3
VANDA™ Reinforced Concrete Condition Index Rating System

Condition Rating	Description	Descriptive Photograph
Level 1	**No/Minimal Damage to Concrete** Hardness: No loss of hardness of mortar Surface: No loss of smoothness Cracking: No cracks Spalling: No spalling Reinforcing steel: Not exposed or damaged	
Level 2	**Damage to Concrete Mortar** Hardness: Some loss of hardness of mortar Surface: Small-diameter exposed aggregate Cracking: Thumbnail-sized cracks of minimal frequency Spalling: Shallow spalling of minimal frequency, no related reinforcing steel damage Reinforcing steel: May be exposed but not damaged or corroded	
Level 3	**Loss of Concrete Mortar/Damage to Reinforcing Steel** Hardness: Complete loss of hardness of mortar Surface: Larger-diameter exposed aggregate Cracking: ¼-inch to ½-inch cracks, moderate frequency Spalling: Deep spalling of moderate frequency, related reinforcing steel damage Reinforcing steel: Exposed, damaged and corroded, but can be rehabilitated	
Level 4	**Reinforcing Steel Severely Corroded/Significant Damage to Structure** Hardness: Complete loss of hardness of mortar Surface: Large-diameter exposed aggregate Cracking: ½-inch cracks or greater, high frequency Spalling: Deep spalling at high frequency, related reinforcing steel damage Reinforcing steel: Corroded or consumed, loss of structural integrity	

Evaluation methods are both qualitative and quantitative. Qualitative methods consisted of visual examinations and documentation with digital photographs. It is noted that qualitative condition assessment observations were based on the evaluator’s expertise.

3.8 NASSCO Pipeline Assessment Condition Program (PACP)

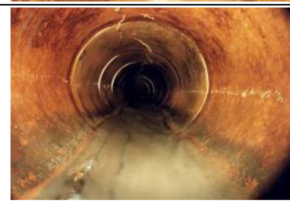
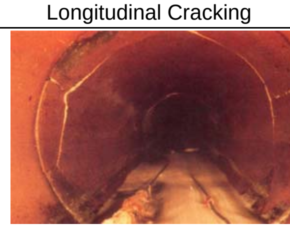
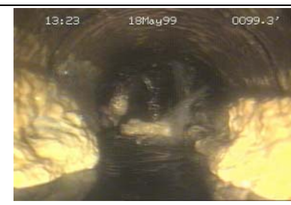
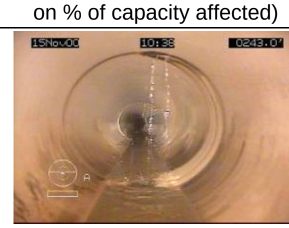
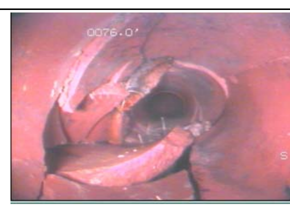
NASSCO PACP provides a standardized system for the consistent assessment of sanitary sewer conditions. PACP provides the capability to benchmark sewer conditions in order to track deterioration over time.

Two key concepts in collection system asset management are criticality and condition severity. Critical sewers can be classified as sewers where costs associated with the failure are likely to be high. These are generally strategically important sewers where costs of failure are driven by high construction costs associated with repairs, costly traffic delays and impacts on property owners, customers and stakeholders. Critical sewer ratings are assigned by the owner and help to prioritize which sewers are investigated. Ratings of condition severity are provided by the PACP process and assist the owner in prioritizing the sewers to be considered for renovation.

The PACP process identifies the major deterioration factors and assigns a rating that is related to the likelihood of failure or collapse. Deterioration factors include surrounding soil condition, position of groundwater table, frequency of sewer surcharging, above ground traffic loading, methods and materials used in construction, third party damages and defects such as roots, grease and debris causing more frequent cleaning. It is important to note that the condition of the sewer involves many deterioration factors, both internal and external. A CCTV inspection can only determine the internal defects that affect the sewer condition.

Deterioration factors are classified into categories of structural defects and operational and maintenance (O&M) defects. PACP defects are assigned a grade of 1 to 5 in order of increasing severity, as described in Table 3-4.

Table 3-4
NASSCO PACP Ratings

Rating	Importance	Likelihood of Failure	Structural Rating Example	O&M Rating Example
1 Excellent	Minor defects	Failure unlikely in the foreseeable future		
2 Good	Defects that have not begun to deteriorate	Pipe unlikely to fail for at least 20 years	 Longitudinal Cracking	 Fine Roots
3 Fair	Moderate defects that will continue to deteriorate	Pipe may fail in 10 to 20 years	 Multiple Fractures	 Deposits = 15% (rating based on % of capacity affected)
4 Poor	Severe defects	Pipe will probably fail in 5 to 10 years	 Broken Pipe	 Infiltration – Runner (rating based on flow estimate)
5 Immediate Attention	Defect requires immediate action	Pipe has failed or will likely fail within the next 5 years	 Collapsed Pipe	 Root Ball (> 50% of capacity)

* Example photos are not from the Los Altos collection system.

3.9 Confined Space Entry

A confined space (Photo 3.1) 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. Title 8, Section 5158 of the California Code of Regulations provides the guidelines and rules for working in these environments. In general, the atmosphere must be constantly monitored for sufficient levels of oxygen (19.5 to 23.0%), and the absence of hydrogen sulfide (H_2S) gas, carbon monoxide (CO) gas and lower explosive limit (LEL) levels. A typical confined space entry crew has at least three members: the entrant, the attendant and the supervisor. The entrant is the individual who will be performing the work. The entrant is equipped with personal protective equipment needed to perform the job safely, including a personal 4-gas monitor (Photo 3.2). 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 entrant(s) to monitor the atmosphere on another 4-gas monitor and maintaining records of all entrants, if there is more than one. The supervisor develops the safe work plan for the job at hand.

Photo 3.1 – Confined Space Entry

Photo 3.2 – Typical Personal 4-Gas Monitor

4 SUMMARY OF OBSERVATIONS

4.1 CCTV Video Review

V&A reviewed CCTV videos to assess the condition of the pipeline using NASSCO PACP standardized ratings. The following table is a summary of the number of occurrences of structural defects observed in the 32,058 feet of CCTV video evaluated.

Table 4-1
Summary of Structural PACP Defects

Rating	Number of Occurrences	% per foot of pipe evaluated	Defect Types (quantity)
5	21	1	Surface Reinforcement Visible (19) Surface Missing Wall (1) Surface Reinforcement Corroded (1)
4	65	19	Surface Aggregate Missing (64) Deformed 10% - at joint (1)
3	7	1	Surface Aggregate Visible (4) Crack Multiple (3)
2	143	41	Surface Spalling (139) Crack Longitudinal (4)

Total frequency of structural defects observed represents approximately 62% of pipe evaluated.

Table 4-2 presents the number of occurrences of operational and maintenance defects observed in the 32,058 feet of CCTV video evaluated.

Table 4-2
Summary of O&M PACP Defects

Rating	Number of Occurrences	% per foot of pipe evaluated	Defect Types (quantity)
4	3	< 1	Alignment Left, 30° (1) Obstacles Built Into Structure (1) Infiltration Runner (1)
3	7	< 1	Roots Medium Lateral (2) Roots Medium Joint (2) Roots Medium Connection (1) Water Level Sag 40-50% (1) Tap Break-In Defective (1)
2	56	2	Water Level Sag 10-20% (37) Alignment Change 15° to 20° (9) Tap Break-In Intruding (6) Roots Medium (2) Deposits Attached Grease (2)
1	12	< 1	Roots Fine (5) Alignment Change 5° to 10° (5) Vermin Cockroach (2)

Upon review of the PACP data, the most frequent type of defect is hydrogen sulfide (H_2S) chemical damage in various levels of severity, from surface concrete spalling to corroded reinforcement. It is important to note that the original CCTV inspection was conducted in August, 2002. Sanitary sewer systems are dynamic, and the conditions observed in the review of the CCTV videos may have worsened over the past 7 years.

Currently, the City is in the process of developing plans and specifications to rehabilitate four segments of the sewer using the cured-in-place pipe (CIPP) method. The four segments to be rehabilitated are shown as highlighted in Table 4-3. Table 4-3 also includes the structural NASSCO PACP ratings based on the CCTV review for quick structural rating (QSR), structural pipe rating (SPR) and structural pipe rating index (SPRI). These three ratings assist with determining the both the magnitude and extent of the structural defects. Similar NASSCO PACP ratings are developed for operational and maintenance (O&M) type of defects. A complete table of NASSCO ratings for the sewer segments evaluated can be referenced in Appendix A. Only an abbreviated list of structural ratings is shown as it pertains to the sewer segments selected for CIPP rehabilitation.

QSR is a short hand way of expressing the number of occurrences for the two highest severity grades using four characters. The first character is the highest severity grade occurring along the segment length. The second character is the total number of occurrences of the highest severity grade. If the total number exceeds 9, then alphanumeric characters are used as follows: A = 10 to 14; B = 15 to 19, C = 20 to 24; etc. The third character is the next highest severity grade along the segment. The fourth character is the total number of occurrences of the second highest severity grade using the same counting methodology.

The structural pipe rating (SPR) is a summation of the top two severity ratings multiplied by the total number of occurrences. Structural Pipe Rating (SPR) = ((First Highest Level x Quantity) + (Second Highest Level x Quantity)). The SPR provides an indication of the segments with the greatest severity and occurrences of defects.

The structural pipe rating index (SPRI) is an indicator of the distribution of defect severity. The SPRI is calculated by dividing the pipe rating by the number of defects. Similar to an average rating, the SPRI is useful in determining the extent of the defects. Both QSR and SPRI are useful in determining the priority of sewer segments in need of rehabilitation.

Based on the NASSCO PACP ratings for the segments evaluated, V&A was able to select additional segments of similar condition in need of rehabilitation. The segments are prioritized by level and then by the structural pipe rating. NASSCO defines Level 5 as requiring immediate attention. A Level 5 defect indicates that the pipe has failed or will likely fail within a 5-year time frame. Level 4 defects are categorized as severe defects that warrant attention for the probability of pipe failure in a 5 to 10-year time frame.

V&A sorted the NASSCO ratings by Level 5 and Level 4 defects to present the information in Table 4-3. The table shows the sewer segments of similar condition to the four segments identified by the City for rehabilitation. The four segments initially selected by the City for rehabilitation in the City of Los Altos Sewer Main Corrosion Rehabilitation (Project 09-28) are highlighted in Table 4-3. The City is reconsidering this selection based on the preliminary findings for this report.

Table 4-3
Los Altos – Sewer Main Segments in Need of Rehabilitation

Rank	Manhole		Location	Pipeline		Level	NASSCO Ratings			Selected by
	Upstream	Downstream		Length (feet)	Diameter (inches)		QSR	SPR	SPRI	
1	C3S-205	C3S-211	Distel Dr.	550	30	5	534L	357	3.28	V&A
2	E4S-412	E4S-409	S. Springer Rd.	324	30	5	5A4L	318	4.13	V&A
3	Z1S-121	Z1S-120	San Antonio Rd.	611	30	5	512W	251	2.02	V&A
4	C4S-501	C4S-403	Marich Way	335	30	5	5C2L	250	2.81	V&A
5	Z1S-122	Z1S-121	San Antonio Rd.	601	30	5	512W	245	2.02	V&A
6	H4S-509	H4S-401	Covington Rd.	519	24	5	522S	214	2.06	Los Altos
7	Z1S-128	Z1S-129	Alma St.	394	30	5	5A2I	152	2.49	V&A
8	B3S-401	B3S-302	El Camino Real	269	27	5	552H	111	2.31	V&A
9	Z1S-124	Z1S-128	Alma St.	360	30	5	5A22	74	4.63	V&A
10	B3S-404	B3S-401	El Camino Real	281	27	5	522C	48	2.29	V&A
11	A2S-203	A2S-201	Del Medio Ave.	492	30	5	5200	10	5	Los Altos
12	G4S-105	G4S-106	S. Springer Rd.	297	30	5	5122	9	3	V&A
13	Z1S-119	Z1S-118	San Antonio Rd.	502	30	4	4S00	404	4	V&A
14	D4S-201	C4S-501	N. El Monte Ave.	471	30	4	4R26	392	3.88	V&A
15	C3S-602	C3S-601	Marich Way	480	30	4	4O2C	376	3.58	V&A
16	D4S-202	D4S-201	N. El Monte Ave.	427	30	4	4O28	340	3.82	V&A
17	C4S-402	C4S-401	Marich Way	387	30	4	4N00	304	4	V&A
18	C4S-401	C3S-602	Marich Way	537	30	4	4D2N	274	2.54	V&A
19	D4S-401	D4S-202	N. El Monte Ave.	333	30	4	4L00	264	4	V&A
20	F4S-103	F4S-412	S. Springer Rd.	325	30	4	4K00	256	4	V&A
21	H4S-105	G4S-409	S. Springer Rd.	490	24	4	4D2L	246	2.56	V&A
22	C4S-403	C4S-402	Marich Way	280	30	4	4J21	226	3.96	V&A
23	E4S-409	E4S-402	S. Springer Rd.	276	30	4	4I24	208	3.85	V&A
24	Z1S-128	Z1S-124	Alma St.	270	30	4	4I00	204	4	V&A
25	D4S-407	D4S-409	N. Springer Rd.	256	30	4	4G2A	184	3.54	V&A
26	G4S-409	G4S-410	S. Springer Rd.	238	30	4	4H00	184	4	Los Altos
27	C3S-601	C3S-213	Marich Way	385	30	4	4B2J	182	2.49	V&A
28	F4S-106	F4S-103	S. Springer Rd.	330	30	4	4C2G	174	2.72	V&A
29	E4S-402	E4S-105	N. Springer Rd.	335	30	4	4D2D	164	3.04	V&A
30	E4S-105	E4S-106	N. Springer Rd.	335	30	4	4A2J	154	2.33	V&A
31	H4S-103	H4S-105	S. Springer Rd.	490	30	4	492J	152	2.27	V&A
32	H4S-503	H4S-501	Covington Rd.	269	24	4	412I	108	2.04	V&A
33	F4S-107	F4S-108	S. Springer Rd.	60	30	4	4A00	44	4	V&A
34	A2P-501	A2S-506	El Camino Real	201	27	3	3F00	114	3	Los Altos
35	A2S-504	A2P-501	El Camino Real	834	27	3	3D00	81	3	V&A

The segments listed above are selected based on sorted NASSCO ratings. The importance of each segment recommended for rehabilitation is based on the severity and the quantity of the defects. Ultimately, prioritizing of segments for rehabilitation within Level 5 and Level 4 conditions should include a subjective evaluation of the criticality of the sewer alignment. Critical segments can be classified as sewers where potential external impacts (public, traffic, environmental) of failure are

Updated Rating Table 4-3 received from V&A on 3/30/2012

Rank	Previous Rank	Start MH	End MH	Street	Distance	Diameter	Level	QSR	SPR	SPRI	Selected by
1	1	C3S-205	C3S-211	Distel Dr.	550	30	5	534L	357	3.28	V&A
2	2	E4S-412	E4S-409	S. Springer Rd.	324	30	5	5A4L	318	4.13	V&A
3	3	Z1S-121	Z1S-120	San Antonio Rd.	611	30	5	512W	251	2.02	V&A
4	4	C4S-501	C4S-403	Marich Way	335	30	5	5C2L	250	2.81	V&A
5	5	Z1S-122	Z1S-121	San Antonio Rd.	601	30	5	512W	245	2.02	V&A
6	6	H4S-509	H4S-401	Covington Rd.	519	24	5	522S	214	2.06	Los Altos
7	7	G4S-409	G4S-410	S. Springer Rd.	238	30	5	514H	189	4.02	Los Altos
8	8	Z1S-128	Z1S-129	Alma St.	394	30	5	5A2I	152	2.49	V&A
9	9	A2P-501	A2S-506	El Camino Real	201	27	5	513G	119	3.05	Los Altos
10	10	B3S-401	B3S-302	El Camino Real	269	27	5	552H	111	2.31	V&A
11	11	Z1S-124	Z1S-128	Alma St.	360	30	5	5A22	74	4.63	V&A
12	12	B3S-404	B3S-401	El Camino Real	281	27	5	522C	48	2.29	V&A
13	13	A2S-203	A2S-201	Del Medio Ave.	492	30	5	5200	10	5	Los Altos
14	14	G4S-105	G4S-106	S. Springer Rd.	304	30	5	5122	9	3	V&A
15	15	Z1S-119	Z1S-118	San Antonio Rd.	502	30	4	4S00	404	4	V&A
16	16	D4S-201	C4S-501	N. El Monte Ave.	471	30	4	4R26	392	3.88	V&A
17	17	C3S-602	C3S-601	Marich Way	480	30	4	4O2C	376	3.58	V&A
18	18	D4S-202	D4S-201	N. El Monte Ave.	427	30	4	4O28	340	3.82	V&A
19	19	C4S-402	C4S-401	Marich Way	387	30	4	4N00	304	4	V&A
20	20	C4S-401	C3S-602	Marich Way	537	30	4	4D2N	274	2.54	V&A
21	21	D4S-401	D4S-202	N. El Monte Ave.	333	30	4	4L00	264	4	V&A
22	84	Z1S-108	Z1S-111	Transport St.	531.4	39	4	4G2D	264	2.44	V&A
23	22	F4S-103	F4S-412	S. Springer Rd.	325	30	4	4K00	256	4	V&A
24	23	H4S-105	G4S-409	S. Springer Rd.	490	24	4	4D2L	246	2.56	V&A
25	24	C4S-403	C4S-402	Marich Way	280	30	4	4J21	226	3.96	V&A
26	25	E4S-409	E4S-402	S. Springer Rd.	276	30	4	4I24	208	3.85	V&A
27	26	Z1S-128	Z1S-124	Alma St.	270	30	4	4I00	204	4	V&A
28	85	Z1S-111	Z1S-107	Frontage Rd.	285.5	36	4	4C3D	185	2.94	V&A
29	27	D4S-407	D4S-409	N. Springer Rd.	256	30	4	4G2A	184	3.54	V&A
30	83	Z1S-110	Z1S-108	San Antonio Rd.	296.8	39	4	4E2C	184	3.17	V&A
31	28	C3S-601	C3S-213	Marich Way	385	30	4	4B2J	182	2.49	V&A
32	29	F4S-106	F4S-103	S. Springer Rd.	336	30	4	4D2G	174	2.72	V&A
33	75	Z1S-118	Z1S-109	San Antonio Rd.	498.5	39	4	412M	173	1.73	V&A
34	30	E4S-402	E4S-105	N. Springer Rd.	335	30	4	4D2D	164	3.04	V&A
35	31	E4S-105	E4S-106	N. Springer Rd.	335	30	4	4A2J	154	2.33	V&A
36	32	H4S-103	H4S-105	S. Springer Rd.	499	30	4	492K	152	2.27	V&A
37	82	Z1S-112	Z1S-110	San Antonio Rd.	252	39	4	4C2D	150	2.88	V&A
38	33	H4S-503	H4S-501	Covington Rd	263	24	4	412I	108	2.04	V&A
39	34	F4S-107	F4S-108	S. Springer Rd.	61	30	4	4A00	44	4	V&A
40	86	Z1S-107	Z1S-106	Bayshore Blvd.	548.7	42	3	352G	155	1.48	V&A
41	35	A2S-504	A2P-501	El Camino Real	834	27	3	3D00	81	3	V&A
42	36	G4S-118	G4S-105	S. Springer Rd.	337	30	3	3224	14	2.33	V&A
43	37	F4S-409	F4S-410	S. Springer Rd.	445	30	3	3123	9	2.25	V&A
44	38	Z1S-127	Z1S-122	San Antonio Rd.		30	2	2S00	208	2	V&A
45	39	Z1S-120	Z1S-119	San Antonio Rd.	506.2	30	2	2S00	200	2	V&A
46	40	A2S-201	Z1S-126	Del Medio Ave.	397.9	30	2	2S00	198	2	V&A

Rank	Previous Rank	Start MH	End MH	Street	Distance	Diameter	Level	QSR	SPR	SPRI	Selected by
47	41	Z1S-126	Z1S-125	Del Medio Ave.	502.7	30	2	2S00	198	2	V&A
48	42	Z1S-125	Z1S-124	Del Medio Ave.	493.7	33	2	2S00	198	2	V&A
49	43	H4S-401	H4S-103	S. Springer Rd.	480	30	2	2R00	190	2	V&A
50	44	D4S-409	D4S-401	N. El Monte Ave.	392	30	2	2N00	152	2	V&A
51	76	Z1S-109	Z1S-117	San Antonio Rd.	361	39	2	2M00	144	2	V&A
52	45	H4S-501	H4S-509	Covington Rd.	323	24	2	2L00	128	2	V&A
53	46	E4S-111	D4S-407	N. Springer Rd.	321	30	2	2L00	126	2	V&A
54	47	F4S-410	F4S-107	S. Springer Rd.	331	30	2	2K00	124	2	V&A
55	48	F4S-108	F4S-106	S. Springer Rd.	289	30	2	2J00	114	2	V&A
56	49	B3S-505	B3S-508	El Camino Real	280	27	2	2J00	110	2	V&A
57	79	Z1S-115	Z1S-114	San Antonio Rd.	499.8	39	2	2A1P	109	1.11	V&A
58	50	A2S-408	A2S-202	Del Medio Ave.	495.2	30	2	2J00	108	2	V&A
59	51	B3S-508	B3S-509	El Camino Real	281	27	2	2J00	106	2	V&A
60	52	B2S-311	B2S-313	El Camino Real	282	27	2	2J00	106	2	V&A
61	53	B3S-502	B3S-505	El Camino Real	273	27	2	2I00	100	2	V&A
62	54	B2S-306	B2S-311	El Camino Real	271	27	2	2I00	98	2	V&A
63	55	C3S-213	C3S-206	Marich Way	244	30	2	2H00	94	2	V&A
64	56	B3S-302	B3S-303	El Camino Real	257	27	2	2H00	94	2	V&A
65	57	B2S-305	B2S-306	El Camino Real	281	27	2	2H00	94	2	V&A
66	81	Z1S-113	Z1S-112	San Antonio Rd.	403.9	39	2	211Q	92	1.01	V&A
67	58	C3S-206	C3S-205	Marich Way	229	30	2	2H00	88	2	V&A
68	59	B3S-303	B2S-305	El Camino Real	281	27	2	2G00	82	2	V&A
69	60	E4S-109	E4S-112	N. Springer Rd.	215	30	2	2G00	78	2	V&A
70	89	Z1S-104	Z1S-103	Bayshore Blvd.	283	39	2	2A1G	61	1.2	V&A
71	61	E4S-106	E4S-109	N. Springer Rd.	205	30	2	2D00	48	2	V&A
72	62	A2S-506	A2S-408	El Camino Real	511	27	2	2D00	48	2	V&A
73	87	Z1S-106	Z1S-105	Bayshore Blvd.	547.2	42	2	291C	39	1.3	V&A
74	88	Z1S-105	Z1S-104	Bayshore Blvd.	242	42	2	211E	32	1.03	V&A
75	63	E4S-112	E4S-111	N. Springer Rd.	55	30	2	2A00	22	2	V&A
76	77	Z1S-117	Z1S-116	San Antonio Rd.	492	39	2	241A	19	1.27	V&A
77	64	B3S-509	B3S-402	El Camino Real	281	27	2	2200	4	2	V&A
78	65	A2S-202	A2S-203	Del Medio Ave.	489.9	30	2	2200	4	2	V&A
79	66	G4S-106	F4S-409	S. Springer Rd.	482	30	2	2100	2	2	V&A
80	67	C3S-211	B3S-503	Distel Dr.	187	30	2	2100	2	2	V&A
81	68	B3S-402	B3S-404	El Camino Real	280	27	2	2100	2	2	V&A
82	80	Z1S-114	Z1S-113	San Antonio Rd.	500	39	1	1S00	102	1	V&A
83	78	Z1S-116	Z1A-115	San Antonio Rd.	503.4	39	1	1200	2	1	V&A
84	69	G4S-410	G4S-414	S. Springer Rd.	380	30	0	0000	0	0	V&A
85	70	G4S-414	G4S-118	S. Springer Rd.	440	30	0	0000	0	0	V&A
86	71	B3S-503	B3S-502	El Camino Real		30	0	0000	0	0	V&A
87	72	B2S-313	A2S-504	El Camino Real	489	27	0	0000	0	0	V&A
88	73	A2S-504	Unmarked MH	El Camino Real	491	27	0	0000	0	0	V&A
89	74	Z1S-129	Z1S-127	Alma St.		30	0	0000	0	0	V&A

likely to be high. The City should investigate the criticality of the sewers in order to evaluate costs associated with construction and potential impacts to traffic and property owners. Regardless of the criticality, the above segments are recommended for rehabilitation. Cost considerations should also be made for planning rehabilitation for groups of adjacent sewer segments in need of rehabilitation.

4.2 Manhole Condition Assessments

4.2.1 Topside Evaluations

V&A provided condition assessment services for the 85 manholes listed in Table 2-1. The majority of condition assessments were conducted during the first two weeks of July 2009. The assessments were conducted during nighttime hours to minimize disruptions to the public and to reduce traffic impacts. A Caltrans encroachment permit was required for the manhole condition assessments on El Camino Real. The permit was received July 13, and the remaining manholes along El Camino Real were evaluated on July 14 and July 15, 2009. Based on the reconnaissance in the field, approximately 92 manholes were identified along the alignment. It is possible that manholes were added to the alignment by developers after the maps were produced. Most of the manhole locations were as noted on the maps provided by the City. Location discrepancies are listed in Table 2-2.

The purpose of the manhole assessments was to document the condition of each manhole structure and note defects that would require rehabilitation. V&A utilized NASSCO's Manhole Assessment Certification Program (MACP) format for documenting manhole conditions. The MACP method is similar to the PACP system. The MACP process provides a system for identifying and documenting specific defects within the manhole. Furthermore, the MACP documentation includes taking note of physical features of the manholes which can be valuable in developing an asset management and collection system maintenance program and can provide useful information for determining rehabilitation options.

The manholes along the alignment were determined to be in satisfactory condition. Approximately 96% of the manholes were assigned a VANDA Level 1 rating, indicating only minimal damage to concrete surfaces. The remaining manholes were rated a VANDA Level 2, which indicates that there was some exposed aggregate observed. No manholes were rated greater than Level 2. None of the manholes evaluated had a protective liner or coating.

The average depth of the manholes was 13.1 feet. Most of the manholes had steel ladder rungs with some surface corrosion. The same surface corrosion was evident on the undersides of the cast iron manhole lids. About a dozen of the manholes had a bolted inner steel lid to serve as a rain catcher in order to prevent storm water inflow. Although, the interior bolted lids were difficult to open, they were in good condition. Some of the manholes are located alongside the roadway near the gutter where rain water collects. There was no evidence of infiltration staining caused by water deposits, so it appears that the rain catchers are effective at eliminating storm water inflow.

Estimates of flow velocities were in the normal range of 1 to 4 feet per second, with water level depths ranging from ¼ full to ½ full. It is important to note that the assessments were conducted at night during low flow hours. Planning bypass flow requirements for CIPP rehabilitation would likely require temporary flow monitoring in order to establish baseline flows. It also appears that the flow reaches scouring velocities since there was no evidence of silt deposits observed in the assessment. Only a few manholes had some debris in the pipe channel. There were only slight grease deposits observed at the normal waterline. Some of the manholes had evidence of prior surcharge events based on the observation of debris that was clinging to the manhole rungs.

Additional details for manhole conditions are included in Appendix B.

4.2.2 Confined Space Entry Condition Assessments

The purpose of conducting confined space evaluations was to obtain physical measurements in order to verify the visual conditions observed. Oftentimes, the level of corrosion degradation can be difficult to assess from visual evidence only. Concrete corrosion results in the formation of gypsum, a soft material that lacks the structural strength of concrete and does not protect the embedded reinforcing steel from corrosion. Gypsum is an expanded formation of corroding concrete that prevents the ability to accurately assess the extent of corrosion. V&A recognizes the importance of calibrating visual observations of corrosion with physical measurements. Based on review of the CCTV documentation and the results of the topside manhole condition assessments, V&A selected 18 manholes (approximately 20% of the total) which were deemed to be in the worst condition for further evaluation. V&A performed the following additional physical condition assessments:

- Measurements of atmospheric hydrogen sulfide concentrations
- Wastewater field test of liquid phase sulfides
- Collection of concrete samples for pH testing
- Penetration measurements to quantify concrete hardness
- Wastewater level and velocity spot measurements using temporary flow monitoring devices

The 18 manholes selected for further confined space entry evaluation are listed in Table 4-4. The results of the physical measurement are also included in this table.

Table 4-4
Summary of Confined Space Entry Manhole Assessments

Manhole	Street	Time	Penetration (inch)	Vanda Rating	H_2S (ppm)	Sulfides (mg/L)	Flow		pH	
							Depth (inches)	Velocity (fps)	Up stream	Down stream
H4S-509	Covington	01:15	1/8	1	0	0.04	13	4.5	5.1	4.2
G4S-105	Springer	02:35	1/8	1	0	0			4.8	5.2
G4S-410	Springer	03:11	1/8	1	0	0.02	3.5	3.5	4.2	3.6
F4S-410	Springer	04:25	1/8	1	0	0	4	2.0	3.9	5.3
E4S-105	Springer	02:14	1/8	1	0	0	5.75	1.5	5.8	5.1
C4S-403	Marich	03:45	1/8	1	0	0	7.5	1.5	4	3.7
C3S-213	Marich	01:23	1/8	1	0	0	6.25	2	3.5	3.2
C3S-205	Distel	01:43	1/8	1	0	0	1.5	5.5	3	3.1
B3S-503	El Camino	05:07	1/8	2	0	0	3.25	4	4.1	5.8
B3S-302	El Camino	03:00	1/8	1	0	0	8.75	3.5	6.6	5.7
A2S-506	El Camino	00:51	1/8	2	0	0.01			3.5	5
A2S-203	Del Medio	02:18	1/16	1	0	0	7.25	3.0	3.8	4.5
Z1S-127	Alma	03:42	1/2	1	0	0	8.25	2.0	3.9	3.6
Z1S-116	San Antonio	01:13	3/8	1	0	0	8	1.5	3.8	3.7
Z1S-115	San Antonio	01:36	1/8	1	0	0	7.5	2	6.1	4
Z1S-110	San Antonio	02:15	1/8	1	0	0	7.25	2	6.2	3.2
Z1S-107	Bayshore	02:40	1/8	1	6	0	7.5	2	5.8	4.5
Z1S-104	Bayshore	01:18	1/16	2	5	0	8	2	4.6	3.5

The manholes are in good condition, with most having concrete condition ratings of VANDA Level 1. The penetration measurements indicated hard concrete surfaces.

Sulfide measurements were minimal. The generation of sulfides is dependent on various factors, such as temperature, wastewater pH, flow retention time and flow hydraulics. The sulfide measurements were collected during nighttime hours (low flow times) and may not be representative of the peak sulfide concentration potentials for this sewer.

The pH readings were low, indicating the concrete surfaces of the manholes are exposed to a severely corrosive environment. The pH samples were collected from the manhole walls just above the crown of the pipe. The pH readings may be slightly lower than the concrete pH on the upper wall or cone surfaces. This is the result of H_2S-laden air flowing in the sewer headspace and concentrating on surfaces just above the pipe crown. As a result, downstream pH values are typically lower. These pH values can be used as a worst case condition of concrete pH.

Based on the review of the data, there are no apparent trends in the measurements that can be useful in identifying potential areas for corrosive conditions. The low pH measurements indicate that the sewer manholes are exposed to corrosive conditions along the entire alignment.

5 RECOMMENDATIONS

Based on the manhole condition assessments and review of the CCTV documentation, V&A presents the following recommendations for the City's consideration:

- A NASSCO PACP review of CCTV documentation indicates that a majority of the exposed pipe crown surfaces are corroding due to hydrogen sulfide exposure. It is important to take action to protect the pipe surfaces from further degradation. To accomplish this, the following tasks are recommended:
    - Conduct a wastewater sampling and atmospheric monitoring study to quantify the extent and concentration of liquid and vapor phase sulfides. The sulfide study will assist in developing possible sulfide mitigation measures in order to forestall the root cause of the corrosion degradation. A secondary benefit would be the reduction of potential odor emissions along the sewer alignment.
    - The CCTV documentation reviewed was originally conducted in August, 2002. Sanitary sewer systems are dynamic and the exposed pipe crown surfaces may have an accelerated rate of corrosion degradation. It is possible that conditions may have worsened over the past 7 years. V&A recommends additional CCTV documentation of selected segments (Table 5-1) of the pipe to assess the possible changes in condition, and subsequently, update results. Additional CCTV should be conducted on the four segments identified by the City for rehabilitation prior to CIPP installation. This CCTV work would most likely be conducted by the selected contractor as part of a pre- and post-rehabilitation for installation acceptance.

Table 5-1

Sewer Main Segments Recommended for CCTV

Manhole		Location	Length (feet)	Reason for CCTV
Upstream	Downstream			
E4S-412	E4S-409	S. Springer Rd.	324	Verify changes in condition
C4S-501	C4S-403	Marich Way	335	Verify changes in condition
C3S-205	C3S-211	Distel Dr.	550	Verify changes in condition
B3S-404	B3S-401	El Camino Real	281	Verify changes in condition
B3S-401	B3S-302	El Camino Real	269	Verify changes in condition
A2S-504	A2P-501	El Camino Real	834	Verify changes in condition
Z1S-124	Z1S-128	Alma St.	91	Verify changes in condition
Z1S-128	Z1S-129	Alma St.	394	Verify changes in condition
Z1S-129	Z1S-127	Alma St.	Unk.	Missing CCTV video
Z1S-122	Z1S-121	San Antonio Rd.	601	Verify changes in condition
Z1S-121	Z1S-120	San Antonio Rd.	611	Verify changes in condition
Z1S-119	Z1S-118	San Antonio Rd.	502	Verify changes in condition
A2S-203	A2S-201	Del Medio Ave.	492	Pre-Rehab Survey
A2P-501	A2S-506	El Camino Real	201	Pre-Rehab Survey
G4S-409	G4S-410	S. Springer Rd.	238	Pre-Rehab Survey
H4S-509	H4S-401	Covington Rd.	519	Pre-Rehab Survey

- V&A recommends that the City continue to expand the cured-in-place pipe (CIPP) rehabilitation of this sanitary sewer. CIPP rehabilitation can be staged over time with emphasis given to segments that are in the worst condition and/or segments that are along major thoroughfares. Although the entire alignment would benefit from rehabilitation, the following table lists the segments rated NASSCO Level 5 which are recommended for rehabilitation within 5 years:

Table 5-2

Additional Sewer Main Segments Recommended for Rehabilitation Within 5 Years

Rank	Manhole		Location	Pipeline		NASSCO Level	Conceptual Estimate[1,2]
	Upstream	Downstream		Length (feet)	Diameter (inches)		
1	C3S-205	C3S-211	Distel Dr.	550	30	5	$171,600
2	E4S-412	E4S-409	S. Springer Rd.	324	30	5	$101,088
3	Z1S-121	Z1S-120	San Antonio Rd.	611	30	5	$187,200
4	C4S-501	C4S-403	Marich Way	335	30	5	$104,520
5	Z1S-122	Z1S-121	San Antonio Rd.	601	30	5	$187,512
6	H4S-509	H4S-401	Covington Rd.	519	24	5	$131,826
7	Z1S-128	Z1S-129	Alma St.	394	30	5	$122,928
8	B3S-401	B3S-302	El Camino Real	269	27	5	$76,396
9	Z1S-124	Z1S-128	Alma St.	360	30	5	$112,320

Note 1: Pricing is as follows: $254/linear foot (24”), $284/linear foot (27”), $312/linear foot (30”).
Note 2: Pricing includes allowance for reinstating laterals, correcting sags and a contingency but does not include engineering, design, administration and supervision.

- The manholes evaluated are in satisfactory condition. Over 95% of the manholes were assigned a VANDA Level 1 rating (Table 3-3), indicating no/minimal damage to concrete surfaces. However, it is important to note that manholes are subjected to the same corrosive conditions as the pipe; therefore, it is recommended that the exposed concrete surfaces be proactively protected with a coating or liner. There are various methods for manhole rehabilitation. The City should consider having contractors’ bids include an optional cost estimate for coating manholes during the anticipated CIPP rehabilitation of the pipes. The useful life of the manholes may be extended by applying a protective coating, and cost savings may be realized by combining this work with pipeline rehabilitation efforts.
  - One possible manhole rehabilitation method is low pressure spray application of a cementitious calcium aluminate mortar. A planning level cost estimate for calcium aluminate mortar is $180 per foot of manhole depth. The price per foot of depth includes mobilization, traffic control, surface preparation, and mortar application and is based on a standard 5-foot diameter manhole. This price is subject to change based on the quantity of manholes being rehabilitated.
  - Epoxy protective coating is another alternative manhole rehabilitation method. The planning level cost estimates for epoxy coating are greater than the cementitious calcium aluminate ($225 per foot of manhole depth). The extra cost can be attributed to additional surface preparation, specialized equipment required, and raw material costs. Again, this cost is based on a 5-foot diameter manhole, inclusive of mobilization, traffic control, surface preparation, application and is dependent on the quantity of manholes being coated.

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