Wastewater Collection System Condition Assessment Report

VOLUME I of II – Report and Appendices A-B, D-J

August 2016
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FINAL

Wastewater Collection System
Condition Assessment Report

Prepared for
City of Modesto, CA
August 24, 2016

BC Project No. 147759

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Acknowledgements

Brown and Caldwell (BC) acknowledges the valuable contributions made by the City of Modesto in conducting the Wastewater Collection System Condition Assessment Report.

Specifically, the project team recognizes the following personnel for their efforts:

- Larry Parlin, Director of Utilities
- William Wong, Engineering Division Manager
- Miguel Alvarez, Associate Engineer, Project Manager
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- Pete Kambel, Associate Engineer
- Jim Alves, Associate Civil Engineer
- Robert Englent, Wastewater Collections Manager
- John Adams, Wastewater Collections Inspection Coordination

The BC project team members included:

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- Ari Elden, Project Engineer
- Pete Bellows, Technical Advisor
- Gary Skipper, Technical Advisor
- National Plant Services, Collection System Inspection
- PICA Corporation, Siphon Inspection
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List of Abbreviations

3D  three-dimensional                      MCC  motor control centers
ACP  asbestos cement pipe              MH  manhole
ANSI/HI  American National Standards    mm  millimeters
   Institute/ Hydraulic Institute     NASSCO  National Association of Sewer Service
ASCE  American Society of Civil Engineers Companies
BC  Brown and Caldwell               O&M  operations and maintenance
Cal/OSHA  California Division of Occupational Safety    OSHA  Occupational Safety and Health Act
   and Health                       PACP  Pipeline Assessment and Certification
Caltrans  California Department of Transportation Program
CCP  Concrete Cylinder Pipe            PDF  Portable Document Format
CCTV  Closed Circuit Television       PICA  Pipeline Inspection & Condition Analysis
CIP  Capital Improvement Projects      Corporation
CIPP  Cured-in-Place Pipe             QA/QC  Quality Assurance/Quality Control
City  City of Modesto                    RCCP  reinforced concrete cylinder pipe
CIWQS  California Integrated Water Quality System     RCP  reinforced concrete pipe
CMMS  Computerized Maintenance Management System     RFT  Remote Field Testing
COF  consequence of failure           River  Tuolumne River
CR  criticality rating                ROW  rights-of-way
DSMH  downstream manhole              SAPTP  Sutter Avenue Primary Treatment Plant
DVD  Digital Versatile Disc           SSO  Sanitary Sewer Overflows
DVS  Digital Video Survey             SWRCS  State Water Resources Control Board
ENRCCI  Engineering News Report       USEPA  U.S. Environmental Protection Agency
   Construction Cost Index            USMH  upstream manhole
ft  feet                               VCP  vitrified clay pipe
FWSP  Fieldwork Safety Plan           WERF  Water Environment Research Foundation
GIS  Geographical Information System  WWTP  Wastewater Treatment Plant
gpm  gallons per minute               kW  kilowatt
H2S  Hydrogen Sulfide                LF  Linear Feet
HD  high definition (as in digital image)     LOF  likelihood of failure
HVAC  Heating, ventilation, and cooling  MACP  Manhole Assessment and Certification
ILJ  in-line inspection                   Program
In  inches
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Executive Summary

This project provides the City of Modesto (City) with an understanding of current pipeline and manhole conditions in the collection system by inspecting and assessing a representative number of unlined reinforced concrete pipe (RCP) reaches and manholes. This report documents procedures and findings of the investigation and provides recommendations for repair and rehabilitation of pipeline and manhole assets.

Background

As with many older collection systems, the City has experienced a number of issues related to system deterioration. Portions of the collection system are more than 100 years old and do not meet modern standards. Much of the large diameter trunk sewer system is constructed of unlined concrete pipe that is susceptible to H2S induced corrosion. The City has completed or is undergoing rehabilitation projects to address deterioration on several trunk sewers.

As a result of these ongoing issues, the City has taken a proactive asset management approach to update its 2005 collection system condition assessment. This updated assessment will allow the City to evaluate the current system condition and quantify system deterioration over the past 10 years. It will also be the basis to develop a capital improvement program (CIP) to rehabilitate severely deteriorated portions of the collection system.

Methodology

A selection of 210 manholes and 25,000 linear feet (LF) of unlined RCP gravity mains were selected for inspection. Additionally, the City selected 360 LF of the Shackelford Siphon and the No. 39 Woodland Lift Station to inspect as part of this project. The wastewater collection system project inspection and condition assessment methodology is presented below.
Pipeline Condition Assessment Results

Pipeline structural and operational condition assessment results are presented below. A few of the pipelines on the original inspection list were not completed due to debris or high water level. If they could not be completed, other pipelines were inspected as directed by the City.

Structural Condition

Figure ES-2 presents the distribution of structural condition grades for pipeline reaches assessed. Structural defects identified include unlined RCP with reinforcement visible/projecting and aggregate visible, projecting or missing. Pipeline reaches assessed were primarily in moderate condition with 23 percent (19 reaches) in poor condition or requiring immediate attention. The poor and immediate-attention reaches were typically reaches with exposed, projecting or corroded reinforcement observed.
Operational Condition

Figure ES-3 presents the distribution of operational condition grades for pipeline reaches assessed. Operational defects found included minor roots and debris. Pipeline reaches are generally in good operational condition with only approximately ten percent (eight reaches) and 2 percent (two reaches) in moderate and poor condition, respectively. Pipelines with any significant level of debris that affected the inspection of the pipeline were not cleaned as part of this investigation.
Manhole Condition Assessment Results

Inspections were attempted on a total of 219 manholes. Ten manholes could not be inspected due to access issues or were not found. At total of 209 manholes were inspected, coded, and assessed. The resulting condition rating distributions for these 219 manholes are presented in Figure ES-4. Defects found include settled deposits and debris, spalling, and severe corrosion. Manholes are generally in fair condition with 63 percent (138 manholes) in good or excellent condition, 25 percent (55 manholes) in fair condition, and 7 percent (16 manholes) in poor condition. Two manholes were designated for immediate attention based on their structural condition and 14 were recommended for repair or rehabilitation within 5 years.

![Figure ES-4. Manhole Condition Rating Distribution](image)

Lift Station Condition Assessment Results

BC completed a condition assessment of the Woodland Lift Station. Based on the observations from the condition assessment, discussions with operation and maintenance staff from the City and review of past reports, the following major improvements are recommended. Additional recommendations are provided in Section 5.5.5.

- The corroded concrete in the wet well should be repaired. The wet well could not be inspected as part of this condition assessment because of safety concerns.
- Repair the concrete around the frame or replace the leaking isolation gate for the wet well. The isolation gate could not be inspected as part of this condition assessment because of safety concerns.
- Replace the fiberglass stairs into the wet well. Current access is limited due to the compromised integrity of the stairs.
- Replace the MCCs and consider moving the MCCs to an above grade location.
- The standby generator size should be increased to operate all five pumps during a power outage.
• Provide a “fresh-air” supply ventilation into the wet well and replace the existing exhaust foul air fans with exhausts fans that can provide at least 20 air exchanges per hour to reduce the level of corrosion in the wet well.

• Replace the 2,000 and 3,500 gpm pump per the Collection System Master Plan schedule to meet future peak wet weather flow requirements.

• Consider adding a flow meter to the pump station. The flow meter can provide input into trouble shooting pump performance.

• The suction and discharge piping do not meet Hydraulic Institute standards. This can affect pumping capacity and pump service life. When a major rehabilitation occurs at the lift station, the suction and discharge piping configuration should be reviewed and improvements completed to meet Hydraulic Institute standards where feasible.

• The wet well does not meet Hydraulic Institute standards. This can affect pumping capacity and pump service life. When a major rehabilitation occurs at the lift station, the wet well configuration should be reviewed and improvements completed to meet Hydraulic Institute standards where feasible.

Siphon Condition Assessment Results

BC and Pipeline Inspection & Condition Analysis Corporation (PICA) performed the physical pipeline inspection of the Shackelford Siphon during the week of November 16, 2015. Approximately 60 LF of the siphon was inspected from the siphon inlet manhole on the eastern bank of the Tuolumne River (River). Inspection was not attempted from the western bank of the River, within the Dryden Park Golf Course, because access was not granted at this location. At 60 LF, impassable obstructions were encountered. Multiple unsuccessful attempts were made by PICA and the City to clear the obstructions; however, the obstructions could not be cleared and the inspection could not be fully completed.

The inspections concluded that areas above the invert elevation of the siphon outlet (EL 51.50) were very likely to have been subjected to corrosive environments, including H₂S gases since approximately 10 percent of the pipe wall of the steel cylinder remained. In areas where the pipe was submerged within the first 60 LF of inspection, approximately 99 percent of the pipe wall remained.

Based on the inspections, condition assessment and analysis performed, it has been determined that the pipeline has not held its integrity. If the pipeline will be reinstated for wastewater conveyance, renewal of the pipeline via rehabilitation, repair or replacement is needed from Station 3+50 to Station 3+28.9. Additionally, the pipeline will require cleaning to remove the obstruction(s) and allow additional inspection, condition assessment, and analysis of the pipeline downstream of Station 2+90.

Rehabilitation Projects and Construction Costs

A ten-year rehabilitation or replacement CIP was developed utilizing structural Grade 4 and 5 pipeline reaches and manholes and pole camera data. Since limited assessment data was available, neighboring reaches’ likelihood of failure and consequence of failure ratings were utilized to form larger rehabilitation projects. Projects were then refined based on the type of rehabilitation, criticality rating, locations and potential for cost savings. Lastly, these projects were assigned a level of rehabilitation to assist in prioritizing and developing a schedule for rehabilitation over the next ten years.
The four priority levels are as follows:

- **Level A** – Repair/rehabilitation recommended for completion as soon as possible.
- **Level B** – Repair/rehabilitation recommended for completion within three years.
- **Level C** – Repair/rehabilitation recommended for completion within three to five years.
- **Level D** – Repair/rehabilitation recommended for completion within five to ten years.

These projects and their associated costs are located in Table ES-1. The locations of these projects are displayed in Figure ES-5. See Appendix I for a more detailed cost breakdown and project location map.

<table>
<thead>
<tr>
<th>Project No.</th>
<th>Project Segment (Start Manhole to End Manhole)¹</th>
<th>Recommended Method of Repair</th>
<th>Pipe Sizes (in)</th>
<th>Trunk(s) or Tributaries</th>
<th>Total Length (ft)</th>
<th>Capital Costs²</th>
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<td>A-1</td>
<td>SSMH2703090115 to SSMH3303090704</td>
<td>CIPP</td>
<td>16 - 30</td>
<td>Rose/Celeste Trunk Santa Rosa Trunk</td>
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<td>A-2</td>
<td>SSMH0604091603 to SSMH0504091306 SSMH0804090103 to SSMH0504091307</td>
<td>CIPP</td>
<td>24 - 33</td>
<td>Sutter Trunk South Trunk</td>
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<td>A-3</td>
<td>SSMH1903091002 to SSMH1903090121</td>
<td>CIPP</td>
<td>18</td>
<td>Emerald Trunk/ Northwest Tributary</td>
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<td>A-4</td>
<td>SSMH2603090301 to SSMH2603090402 SSMH2303091619 to SSMH2503091305</td>
<td>CIPP</td>
<td>33-36</td>
<td>Sonoma Trunk Lakewood Trunk</td>
<td>8,932</td>
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**SUB-TOTAL OF “A” PROJECT COSTS = $15,295,000**

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<th>Project No.</th>
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<th>Pipe Sizes (in)</th>
<th>Trunk(s) or Tributaries</th>
<th>Total Length (ft)</th>
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<td>SSMH0804091201 to SSMH0504091202</td>
<td>CIPP</td>
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<td>SSMH2503080106 to SSMH3003090712</td>
<td>CIPP³</td>
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<td>West Trunk/ Emerald South Tributary</td>
<td>7,436</td>
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**SUB-TOTAL OF “B” PROJECT COSTS = $8,064,000**

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<th>Recommended Method of Repair</th>
<th>Pipe Sizes (in)</th>
<th>Trunk(s) or Tributaries</th>
<th>Total Length (ft)</th>
<th>Capital Costs²</th>
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<tr>
<td>C-1</td>
<td>SSMH2503080105 to Dryden Box</td>
<td>Slipping or CIPP</td>
<td>54 - 60</td>
<td>West Trunk</td>
<td>25,893</td>
<td>$18,934,000 (Slipping Only) $27,550,000 (CIPP Only)</td>
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<td>SSMH2903091315 to SSMH2903091310</td>
<td>CIPP</td>
<td>18</td>
<td>Sutter Trunk</td>
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<td>SSMH2903090905 to SSMH2903091414</td>
<td>CIPP</td>
<td>27</td>
<td>Downtown Tributary</td>
<td>3,289</td>
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### Table ES-1. Summary of Sewer Rehabilitation Costs

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<th>Recommended Method of Repair</th>
<th>Pipe Sizes (in)</th>
<th>Trunk(s) or Tributaries</th>
<th>Total Length (ft)</th>
<th>Capital Costs²</th>
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<td></td>
<td>(Sliplining/CIPP)</td>
<td>$29,991,000</td>
<td>(CIPP Only)</td>
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</tr>
<tr>
<td>D-1</td>
<td>SSMH3303090541 to SSMH3303090618</td>
<td>CIPP</td>
<td>27</td>
<td>Downtown Tributary</td>
<td>1,480</td>
<td>$1,060,000</td>
</tr>
<tr>
<td>D-2</td>
<td>SSMH1703091315 to SSMH1703091316</td>
<td>CIPP</td>
<td>30</td>
<td>Emerald Trunk</td>
<td>110</td>
<td>$320,000</td>
</tr>
<tr>
<td></td>
<td>SUB-TOTAL OF &quot;D&quot; PROJECT COSTS = $1,380,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL 10-YEAR CAPITAL IMPROVEMENT PLAN COST =</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$46,114,000</td>
</tr>
<tr>
<td></td>
<td>(Sliplining/CIPP)</td>
<td>$54,730,000</td>
<td>(CIPP Only)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1. See Figure ES-5 for extents of project.
2. Costs are for planning purposes only and were developed based on rehabilitation projects constructed within the past five years.
3. Sliplining rehabilitation methods considered for all pipe diameters 36 inches or larger. Project costs were calculated with a combination of sliplining and CIPP or CIPP only.

### Additional Recommendations

During the investigation there were some additional concerns that should be addressed. These items are not a priority relative to the rehabilitation projects identified above, but should be addressed by City staff.

- **Pipelines requiring cleaning and debris removal.** There were eight pipe segments that required cleaning to allow the pipe inspection to be completed. Future investigation and cleaning of these segments by City Maintenance Crews should be conducted to monitor potential re-accumulation and needs for periodic maintenance. The pipe segments are listed in Table 5-2.

- **Inaccessible Manholes and Manholes Not Found.** There were seven manholes that could not be found or were inaccessible due to their location. The manholes are listed in Table 5-4.

- **Pipelines to be inspected under other programs.** There are several unlined RCP reaches that should be further explored and inspected. The pipelines are detailed in Section 7.

- **Manhole Rehabilitation/Replacements.** There are six manholes that require rehabilitation or replacement that are currently not grouped into a Capital Improvement Project or current City emergency repair projects. These manholes are listed in Table 7-1. We also recommend that the City consider inspecting other manholes in the vicinity of the damaged manholes.
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Section 1

Introduction

The purpose of this project is to investigate a representative sample of the current wastewater collection pipeline, manhole, siphon, and lift station conditions; and to identify maintenance or repair projects that may be required to properly maintain the operation of these facilities.

1.1 Background

The City owns and operates over 600 miles of gravity and pressure collection system pipes and associated manholes and junction structures. The City also has approximately 40 lift stations. The wastewater generated in the collection system service area is conveyed to the Sutter and Jennings primary and secondary wastewater treatment facilities for treatment and disposal.

Portions of the City’s collection system are more than 100 years old and a significant amount of the large diameter trunk sewer system are comprised of unlined RCP that is susceptible to H₂S induced corrosion. The City completed a condition assessment study of the large diameter trunk sewer system in 2005 and additional studies in 2009 and 2014; however, the studies did not encompass all large diameter, unlined RCP trunk sewers. The City retained Brown and Caldwell (BC) to investigate and assess the condition of approximately 25,000 LF of unlined RCP sewers greater or equal to 16 inches in diameter.

The 2005 condition assessment study identified several segments requiring rehabilitation or reinspection in the future. This project provides an update to the condition of high priority sewers identified by the 2005 study that have not been rehabilitated or were recommended for reinspection. This project also includes the inspection of large diameter, unlined RCP sewers that were not previous investigated in previous studies.

Additionally, the City requested BC to perform a mechanical inspection of the No. 39 Woodland Lift Station (Woodland LS) and the siphons within their system. The Woodland LS was inspected as an update to an inspection completed in 2005. The Shackelford siphon was inspected using PICA SeeSnake Technology (Section 3-4). The remaining siphons were not inspected; however, inspection of the upstream and downstream siphon structures provided some preliminary information on the condition of the siphons at each end.

1.2 Project Location

The overall project area and major trunk sewers are shown on Figure 1-1. The project pipelines and manholes are primarily located between Sylvan Ave and Whitmore Ave at the North and South boundaries, respectively, and Stoddard Road and Langworth Road at the West and East boundaries, respectively, within the City of Modesto.
1.3 Scope of Work

The purpose of this investigation is to identify the current conditions within the pipelines, manholes, siphons and lift station; and recommend future rehabilitation, replacement and re-investigation needs for the City. The project scope included the following tasks:

- **Review Existing Information.** Review background data provided by the City to identify areas of the system with historic maintenance and structural issues.

- **Risk Assessment and Inspection Prioritization.** Identify critical wastewater collection system infrastructure by determining the asset’s criticality. Asset criticality was used to prioritize inspections for this project and recommend long-term inspection intervals for the City’s large diameter sewers.

- **Field Investigations.** Field investigations included CCTV investigations of approximately 25,000 LF of sewer pipelines and 210 manholes to collect data pertaining to their condition and identification of defects. Field investigations also included PICA SeeSnake inspection of 360 LF of siphon pipe and mechanical inspection of the Woodland LS.

- **Condition Assessment.** Based on identified defects, pipe, manhole, siphon and lift station conditions were assessed using observed defects.

- **Recommendations.** Recommendations for maintenance, re-investigation, repair or rehabilitation were made based on the condition assessment.

- **Capital Improvement Projects.** BC developed Capital Improvement Projects (CIP), planning level cost estimates, and a proposed implementation schedule for all assets requiring repair, rehabilitation, or replacement within the next ten years.

- **Condition Assessment Report.** This report was prepared to summarize the findings of the project.
Section 2
Risk Assessment and Inspection Prioritization

2.1 Introduction

It is the City’s goal to develop a more proactive, system-wide inspection approach of their collection system to support its CIP. System-wide inspection programs can take a variety of forms. Some agencies approach the task systematically by regularly inspecting their system in logical geographic components (i.e., sewer basin or atlas map page). Other agencies use risk-based approaches, with varying inspection frequencies for different parts of the system depending on an asset’s criticality (likelihood and consequence of failure). It is the intention of this plan to incorporate the benefits of each of these programs so the City’s plan is risk-based, while remaining systematic and cost-effective.

As part of this project, BC will be inspecting up to a total of 25,000 linear feet (lf) of large diameter gravity sewers (greater than or equal to 16 inches) within the City’s system. An allowance of 2,500 lf for re-inspection is included in the total of 25,000 lf. The City has selected 11,917 lf of gravity sewers to inspect as part of this project based on known operational and maintenance issues and critical location within the system. The remaining 10,583 lf of gravity sewers for inspections were selected using a risk-based approach.

This section discusses BC’s approach for ranking, prioritizing and selecting sewers to be inspected during this project. Inspection prioritization will also facilitate the development of long-term inspection intervals.

2.2 Desktop Data Review

BC reviewed the following data sources provided by the City and obtained from other sources:

- Current City Sewer GIS layers
- Sanitary Sewer Overflows (SSOs) as documented in the State Water Resources Control Board California Integrated Water Quality System (SWRCB CiWQS)
- Summary inspection results and defect maps of current Sutter Trunk, River Trunk, and Cannery Segregation Trunk (not including review of CCTV video)
- Previous Reports and Studies
  - 2007 Wastewater Collection System Master Plan
  - 2005 Collection System Condition Assessment
  - 2011 Hydrogen Sulfide Manhole Study
  - 2009 West Trunk Condition Assessment
  - 1994 Manhole Inspection Results
2.3 Inspection Frequency Benchmarking

CCTV inspection is a common technology used for condition assessment of wastewater collection system gravity pipes. In 1999, the American Society of Civil Engineers (ASCE) and the U.S. Environmental Protection Agency (USEPA) produced a report entitled “Optimization of Collection System Maintenance Frequencies and System Performance,” whose goal was to develop an optimized approach for collection system maintenance. This report included the results of a national survey of 42 wastewater agencies on various wastewater collection maintenance practices and performance parameters. In this report, CCTV inspection was identified as the most important collection system inspection tool, and the fourth most important operation and maintenance activity behind cleaning, pump station service and mainline rehabilitation.

The ASCE/USEPA report survey discussed above identified that CCTV inspection frequencies vary widely throughout the country, with some agencies inspecting their entire system every five years, while most agencies had inspected less than half of their systems in the previous 20 years.

Another recent USEPA White Paper entitled “Condition Assessment of Wastewater Collection Systems,” discusses a risk-based decision-making processes that can be used to prioritize condition assessment. The report summarizes a number of models and tools available, one of which is a relatively simple matrix approach to establish varying inspection frequencies based on asset risk. In this example, inspection frequencies range from two to 25 years depending on the asset’s condition and its consequence of failure. A 2004 Water Environment Research Foundation (WERF) study entitled “Development of a Tool to Prioritize Sewer Inspections” also supports the risk-based decision making process.

In general, a ten-year, system-wide inspection program is sufficient for inspecting all gravity pipes to identify and address structural or operational problems for utilities that already have an investigative CCTV program in place. As experience dictates, some pipes may require more frequent inspection due to their likelihood or consequence of failure. For some pipes, the frequency may be longer than ten years. For this reason, a risk-based approach is considered appropriate to identify the inspection frequency of each collection system pipe.

2.4 Proposed Approach

The proposed approach to develop the City’s system-wide large diameter trunk sewer inspection frequency is two-fold. The initial inspection priority was developed by performing a risk assessment on each trunk sewer pipe reach (manhole to manhole) in the City’s service area. Pipes with a high criticality rating were inspected first as a part of this project. Additional trunk sewers can be identified and prioritized using the pipe criticality ratings for more efficient inspections. Following this project, BC recommends a new inspection priority and schedule be established based on each pipe’s condition (likelihood of failure) and the impacts if the pipe were to fail (consequence of failure).

This approach relies on the concepts established in the USEPA and WERF documents, while leveraging available attribute data within the City’s existing GIS and CMMS, and other relevant information provided by the City.

2.5 Initial Inspection Prioritization

In order to develop the prioritized inspection program, each pipe was assigned an overall criticality rating (CR). The CR is calculated by multiplying the pipe’s likelihood of failure (LOF) rating by its consequence of failure (COF) rating; CR = (LOF) x (COF). This section describes that procedure.
The risk assessment process utilizes existing attribute data from the City’s GIS and CMMS to assign a series of LOFs and a COF for each pipe. Each pipe’s final LOF and COF rating will be determined using the highest LOF and COF score, unless the pipe has been rehabilitated in the past ten years. Pipes that have a criticality rating greater than or equal to 15 are considered the most critical pipes and will be inspected first. Pipes with a criticality rating of less than 5 are considered lower priority and their inspection will be systematic as part of a future system-wide inspection plan. Inspection priority is summarized in Table 2-1.

<table>
<thead>
<tr>
<th>Priority</th>
<th>Criticality Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>15 to 25</td>
</tr>
<tr>
<td>Medium</td>
<td>5 to 14</td>
</tr>
<tr>
<td>Low</td>
<td>&lt; 5</td>
</tr>
</tbody>
</table>

Trunk sewers will be prioritized using the average criticality rating for the remaining uninspected pipes that compose that trunk.

### 2.5.1 Likelihood of Failure Rating

Each of the three ratings below is associated with the LOF analysis and will produce a score of 1, 3, or 5. The peak value from these three ratings will serve as the overall LOF rating. Lined RCP and non-RCP materials do not receive a Crown Surface pH Rating, Peak H2S Rating, and Location Downstream of Major Lift Station Rating, since their materials are less affected by these factors. Therefore, lined RCP and non-RCP reaches receive a peak LOF of 1.

**Age and Material Rating.** Age and material factors are used to determine the criticality of a sewer pipe. Unlined RCP is susceptible to H2S induced corrosion; and pipes become more weathered and corroded with age. Age and material ratings were assigned according to the following rules:

- 5 = Unlined RCP installed before or during 1960
- 3 = Unlined RCP installed after 1960
- 1 = Lined RCP and non-RCP

**Crown Surface pH Rating.** In 2011, the City measured the pH of the pipe crown at select manholes throughout the collection system. Pipes with a lower pH indicate a higher degree of active sulfuric acid corrosion. New pipes typically have an alkaline surface pH (greater than 7) and weathered pipes typically have a pH of about 6. The more acidic environment, the more corrosive the environment; therefore, Crown Surface pH Ratings were assigned as follows:

- 5 = <pH 2
- 3 = Between pH 2 and pH 5
- 1 = Greater than pH 5 or no measurement

**Peak H2S Gas Rating.** In addition to the Crown Surface pH, H2S gas measurements were taken at select manholes throughout the collection system. H2S gas is the only form of sulfide than can be released from the wastewater solution. The released H2S combines with moisture on the pipe surfaces above the water surface, where it is converted to sulfuric acid by aerobic bacteria. The
greater the H2S gas concentration, the greater the potential for sulfuric acid production; thus, producing a more corrosive environment. Peak H2S Gas Ratings were assigned as follows.

- 5 = 25 ppm or greater
- 3 = Between 10ppm and 25 ppm
- 1 = Less than 10 ppm or no measurement

**Location Downstream of Major Lift Station Rating.** Pipes located downstream of major lift stations have been observed to experience increased corrosion within the City’s system. This is likely due to the high concentration of H2S at the pump stations that migrates downstream. The rating for pipes downstream of a major lift station is assigned as follows:

- 5 = Downstream of a major lift station
- 1 = Not downstream of a major lift station

**2.5.2 Consequence of Failure Rating**

The COF rating is used to evaluate potential impacts to the environment, traffic and commerce, and the difficulty of accessing the sewer for maintenance or repair and rehabilitation activities. The COF rating for each sewer pipe is established according to the following rules:

- 5 = Within 200 feet of a water body
- 3 = Located in or crossing a major road or railroad
- 1 = All other pipes

**2.5.3 Criticality Rating**

As described above, the overall CR was calculated for each large diameter gravity sewer pipe by multiplying the peak rating from the LOF categories and the COF. The resulting pre-inspection pipe criticalities are displayed on Figures 2-1, 2-2, and 2-3. Since the Can-Seg and River Trunks overlap, Figures 2-2 and 2-3 provide a more detailed look at each trunk separately.
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2.6 Pipe Selection

While the pipe criticality helps establish a system-wide inspection prioritization, it is not the only factor to consider in selecting pipes to inspect during this project. In order to select the remaining 10,583 of gravity sewers for inspection, BC considered a combination of other factors in addition to the criticality ratings, such as historic maintenance and structural issues, past inspections and rehabilitation projects.

The City completed the inspection in July 2004 of four of the five trunk sewer reaches that cross Highway 99 and of selected segments of unlined RCP based on pipe size, age and alignment. The condition assessment of these pipes identified several that were in poor structural condition, and the majority of those pipes were rehabilitated. Rehabilitated pipes are not slated for reinspection in the current project.

There are three sections of pipe that will be included in this project’s inspections from the July 2004 condition assessment. Due to their condition in 2004, these sections will be inspected to determine if their conditions have worsened. These sections are as follows:

- **Highway 99 at Conant Avenue (SSMH1303081105 to SSMH1303081401).** Observations included unlined RCP with heavy corrosion, erosion of pipe walls, and spalling of concrete. Since this section is location beneath Highway 99, it has a high consequence of failure.

- **Kearney Avenue – Princeton Avenue to Coldwell Avenue (SSMH1903091116 to SSMH1903091509).** This section of sewer is located downstream of a variety of industries and businesses. During the 2004 condition assessment, loss of cement and exposed aggregate was observed.

- **Las Palmas between Pequeño Avenue and Yosemite Boulevard (SSMH2803091623 to SSMH3303090406).** One section of pipe (SSMH2803091623 to SSMH3303090406) was recommended for reinspection in 2004 based on visible aggregate, exposed rebar and the pipe’s age. Information in GIS does not indicate that the pipe has been reinspected or rehabilitated; therefore, this section of pipe is recommended for reinspection under this project to determine the progression of corrosion.

The City also completed partial inspections of the River Trunk, the Sutter Trunk, the Cannery Segregation (Can-Seg) Trunk, and the West Trunk Sewer from 2010 to 2014. Only the lower reaches of the River, Sutter and Can-Seg Trunks were inspected to control costs. However, these inspections provided a good representation of the remaining trunks’ condition. A summary of the pipes and manholes inspected from 2010 to 2014 is found in Table 2-2. Since these pipes were recently inspected, they will be excluded from this project’s inspections despite their criticality.

<table>
<thead>
<tr>
<th>Trunk</th>
<th>Approximate Location</th>
<th>Length</th>
<th>Manholes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can-Seg</td>
<td>Starting at the SAPTF and continuing upstream to S Morton Blvd and 11th St</td>
<td>6,662</td>
<td>26</td>
</tr>
<tr>
<td>River</td>
<td>Starting at the SAPTF and continuing upstream to S Morton Blvd and 11th St</td>
<td>14,496</td>
<td>40</td>
</tr>
<tr>
<td>Sutter</td>
<td>Starting at the SAPTF and continuing upstream to Paradise Rd and Tuolumne Blvd</td>
<td>6,493</td>
<td>15</td>
</tr>
<tr>
<td>West</td>
<td>Intersection of Elm Ave and the West Trunk to the Influent Lift Station at the SAPTF</td>
<td>18,695</td>
<td>23</td>
</tr>
</tbody>
</table>
BC also reviewed information about SSO that occurred in the City from January 1, 2010 to the present and was available in the California Integrated Water Quality System (CIWQS) database. Only one SSO was reported on a large diameter trunk sewer (the Can-Seg Trunk Sewer), and it was due to sewage seeping through a fracture in the pipe. That pipe has since been repaired. Many of the diameter fields in the CIWQS database were blank, so it was not possible to determine from the database if any other SSOs occurred on large diameter sewers.

The remaining pipes selected for inspection under this project were selected to provide a representative sample of pipes within the system based on a criticality of 15 or higher. Pipes selected for inspection by BC and the City are displayed in Table 2-3 and Figure 2-4, 2-5, and 2-6. Figures 2-5 and 2-6 provide detailed views of the Can-Seg and River Trunk inspection areas for clarity.

### Table 2-3. Inspection Areas

<table>
<thead>
<tr>
<th>Segment No.</th>
<th>Trunk Name</th>
<th>Location</th>
<th>Beginning Manhole to End Manhole</th>
<th>Size (in)</th>
<th>GIS Length (ft)</th>
<th>Grid Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>West</td>
<td>Highway 99 at Conant Ave</td>
<td>SSMH1303081104 to SSMH1303081401</td>
<td>51</td>
<td>545</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>Emerald</td>
<td>Kearney Ave between Princeton Ave and Coldwell Ave</td>
<td>SSMH1903091116 to SSMH1903091509</td>
<td>30</td>
<td>1330</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>Sutter</td>
<td>Highway 99 at Jefferson Ave</td>
<td>SSMH2903091315 to SSMH2903091310</td>
<td>16</td>
<td>383</td>
<td>22</td>
</tr>
<tr>
<td>4</td>
<td>Santa Rosa</td>
<td>Las Palmas Ave between Pequeño Ave and Yosemite Ave; Yosemite Blvd between Las Palmas Ave and S. Santa Rosa Ave; S. Santa Rosa between Yosemite Blvd</td>
<td>SSMH2803091623 to SSMH3303090402</td>
<td>30</td>
<td>1718</td>
<td>23-24</td>
</tr>
<tr>
<td>5</td>
<td>Emerald</td>
<td>Tully Rd at Briggsmore Ave</td>
<td>SSMH1703091315 to SSMH1703091316</td>
<td>30</td>
<td>109</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>West</td>
<td>Dirt Lot; Property of Stanislaus County to Sutter Plant</td>
<td>SSMH0604091505 to Dryden Box</td>
<td>60</td>
<td>2680</td>
<td>33</td>
</tr>
<tr>
<td>7</td>
<td>Sutter</td>
<td>Treatment Plant Site</td>
<td>SSMH0504090906 to Dryden Box</td>
<td>24</td>
<td>1854</td>
<td>33</td>
</tr>
<tr>
<td>8</td>
<td>South</td>
<td>Treatment Plant Site</td>
<td>SSMH0804090102 to Headworks</td>
<td>33</td>
<td>906</td>
<td>33 &amp; 36</td>
</tr>
<tr>
<td>9</td>
<td>Cannery Segregation</td>
<td>Treatment Plant Site</td>
<td>SSMH0504091401 to Cannery Segregation Lift Station to Headworks</td>
<td>66</td>
<td>1562</td>
<td>33</td>
</tr>
<tr>
<td>10</td>
<td>Combined</td>
<td>Treatment Plant Site</td>
<td>Dryden Box to Headworks</td>
<td>60</td>
<td>100</td>
<td>33</td>
</tr>
<tr>
<td>11</td>
<td>River</td>
<td>Treatment Plant Site</td>
<td>SSMH0504091308 to Dryden Box</td>
<td>60</td>
<td>730</td>
<td>37</td>
</tr>
<tr>
<td>12</td>
<td>Lakewood</td>
<td>Creekside Golf Course</td>
<td>SSMH2503090103 to SSMH2503090105</td>
<td>36</td>
<td>575</td>
<td>19</td>
</tr>
<tr>
<td>13</td>
<td>Rumble</td>
<td>Rumble Road between Paso Robles Dr and Hunt Ave</td>
<td>SSMH1803090207 to SSMH1803090201</td>
<td>33</td>
<td>600</td>
<td>8</td>
</tr>
<tr>
<td>14</td>
<td>Lakewood</td>
<td>Lakewood Ave between E Orangeburg Ave and Laramie Dr</td>
<td>SSMH2303090808 to SSMH2303090810</td>
<td>33</td>
<td>767</td>
<td>15</td>
</tr>
<tr>
<td>Segment No.</td>
<td>Trunk Name</td>
<td>Location</td>
<td>Beginning Manhole to End Manhole</td>
<td>Size (in)</td>
<td>GIS Length (ft)</td>
<td>Grid Number</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------------</td>
<td>-----------------------------------------------</td>
<td>--------------------------------------------</td>
<td>-----------</td>
<td>----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>15</td>
<td>N/A</td>
<td>9th St and L St; 9th St and K St</td>
<td>SSMH2903091417 to SSMH2903091416</td>
<td>27</td>
<td>810</td>
<td>23</td>
</tr>
<tr>
<td>16</td>
<td>N/A</td>
<td>S Morton Blvd and 11th St</td>
<td>SSMH3303090611 to SSMH3303090614</td>
<td>27</td>
<td>562</td>
<td>28</td>
</tr>
<tr>
<td>17</td>
<td>Lakewood</td>
<td>Beard Ave and Rodney Ave</td>
<td>SSMH3503090401 to SSMH3503090402</td>
<td>45</td>
<td>643</td>
<td>25</td>
</tr>
<tr>
<td>18</td>
<td>Tributary to Emerald Trunk</td>
<td>Woodland Ave Between Yellowstone Ave and Shasta Ave</td>
<td>SSMH2503080301 to SSMH2503080304</td>
<td>27</td>
<td>659</td>
<td>16</td>
</tr>
<tr>
<td>19</td>
<td>Tributary to Emerald Trunk</td>
<td>N Emerald Ave between Reno Ave and One Palm Ave</td>
<td>SSMH3003090104 to SSMH3003090201</td>
<td>27</td>
<td>635</td>
<td>17</td>
</tr>
<tr>
<td>20</td>
<td>Tributary to Emerald Trunk</td>
<td>Carver Road south of Rosenburg Ave</td>
<td>SSMH1903091002 to SSMH1903091004</td>
<td>18</td>
<td>897</td>
<td>12</td>
</tr>
<tr>
<td>21</td>
<td>West</td>
<td>Hahn Dr between Veneman Ave and Standford Ave</td>
<td>SSMH1203080910 to SSMH1203081306</td>
<td>39</td>
<td>914</td>
<td>4</td>
</tr>
<tr>
<td>22</td>
<td>Tributary to Emerald Trunk</td>
<td>W Granger Ave between Tully Ave and Concord Ave</td>
<td>SSMH2003090126 to SSMH2003090101</td>
<td>18</td>
<td>948</td>
<td>12</td>
</tr>
<tr>
<td>23</td>
<td>Tributary to Emerald Trunk</td>
<td>Tully Ave between Woodman Wy and Granger Ave</td>
<td>SSMH1703091316 to SSMH1203090101</td>
<td>21</td>
<td>905</td>
<td>12</td>
</tr>
<tr>
<td>24</td>
<td>South</td>
<td>Ustick Road between Boise Ave and Imperial Ave</td>
<td>SSMH0804090905 to SSMH0804090902</td>
<td>33</td>
<td>517</td>
<td>36</td>
</tr>
<tr>
<td>25</td>
<td>Santa Rosa</td>
<td>Santa Barbara Ave between Encina Ave and Robie Ave</td>
<td>SSMH2803090810 to SSMH2803091221</td>
<td>24</td>
<td>840</td>
<td>24</td>
</tr>
<tr>
<td>26</td>
<td>Crows Landing South Tributary</td>
<td>Spokane St between Amador Ave and West Hatch Rd</td>
<td>SSMH0804090405-SSMH0504091605</td>
<td>30</td>
<td>656</td>
<td>36</td>
</tr>
<tr>
<td>27</td>
<td>Rumble</td>
<td>Woodrow Ave between Tully Rd and Lord Ave</td>
<td>SSMH0803091302-SSMH0803091301</td>
<td>30</td>
<td>766</td>
<td>5</td>
</tr>
<tr>
<td>28</td>
<td>River</td>
<td>Oregon Dr between South Santa Cruz Ave and Dry Creek</td>
<td>SSMH3303090802-SSMH3303090710</td>
<td>45 - 48</td>
<td>2029</td>
<td>28 &amp; 29</td>
</tr>
<tr>
<td>29</td>
<td>Crows Landing South Tributary</td>
<td>Open Space between Crater Ave and Tuolomne River</td>
<td>SSMH0504091503-SSMH0504091207</td>
<td>30</td>
<td>620</td>
<td>34</td>
</tr>
</tbody>
</table>

### 2.7 Manhole Selection

City staff provided a list of priority manholes they wanted to inspect based on the results of their 1994 manhole inspection project and a Hydrogen Sulphide Manhole Study completed in 2011. The priority list of manholes was cross-checked with the manholes that were inspected as part of the Can-Seg Trunk, River Trunk, Sutter Trunk and West Trunk from 2010 to 2014. Manholes inspected as part of these condition assessment projects were removed from the inspection list since they were recently inspected.

Additionally, force main discharge manholes, siphon manholes and manholes downstream of each of the lift stations were selected by the City for inspection due to their high potential for corrosion. A total of 45 manholes downstream of the City's lift stations were selected for inspection.
Siphon structures included in the inspection are included in Table 2-4. The Shackelford siphon was inspected using PICA SeeSnake Technology (Section 3.4). Since these siphons were not inspected by sonar, select siphon structure inspections provided some preliminary information on the condition of the siphons at each end.

<table>
<thead>
<tr>
<th>Siphon</th>
<th>Upstream Structure</th>
<th>Downstream Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shackelford</td>
<td>SSMH0504091203</td>
<td>SSMH0504091106</td>
</tr>
<tr>
<td>Thousand Oaks</td>
<td>SSMH2703090501</td>
<td>SSMH2703090503</td>
</tr>
<tr>
<td>River Trunk</td>
<td>SSMH3303091004</td>
<td>SSMH3303091005</td>
</tr>
<tr>
<td>Cannery Segregation</td>
<td>SSMH3303090706</td>
<td>SSMH3303090607</td>
</tr>
<tr>
<td>South Trunk</td>
<td>SSMH0804090103</td>
<td>SSMH0804090102</td>
</tr>
</tbody>
</table>

The remaining manholes were selected by using the pipe’s criticality rating and where manholes are located at 90-degree bends or junctions. A minimum of one project manhole was selected per project pipe selected for inspection. Additional project manholes were selected on pipes in the vicinity of the project pipes to gauge the condition of the upstream and downstream pipe segments.

Due to the limitation on pipe inspection footage, all medium- to high-criticality rated pipes could not be selected for inspection. Therefore, manholes located on these pipes were selected to provide some degree of insight into the pipes’ condition.

Lastly, the remaining project manholes were selected at 90-degree bends or at pipe junctions. These locations were selected due to high corrosion potential typically caused by high turbulence and subsequent generation of hydrogen sulfide gas.
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Section 3

Field Investigations

Field investigations conducted as part of this condition assessment are discussed in this section. Field investigations include gravity main inspections, manhole and junction structure inspections, lift station inspection, and siphon inspection.

3.1 Gravity Main Field Data Collection

Internal sewer pipeline inspections were performed using the IBAK Panoramio 3D Optoscanner®, supported by PipeLogix® software. For a few locations where this technology could not be used, pipe reaches were inspected with a standard closed-circuit television (CCTV) camera set-up mounted on a floating platform.

Digital images of the pipelines interior were captured as IPF 360 viewer files. The scanner was equipped with two high-resolution digital cameras, front- and rear-facing with 185-degree lenses, enabling the scanner to capture 360-degree images. A full cross-sectional pipeline image was created by the PipeLogix® software by taking pictures in rapid succession. The standard 360 forward view, as shown in Figure 3-1, is similar to conventional CCTV imagery. Combining digital imagery and software allows reviewers of the recorded survey to actively pan and tilt the image. The software also provides an unfolded longitudinal section of the pipeline reach, as shown in Figure 3-2. This screen allows the observer to quickly review attributes of a pipeline reach, such as material changes, lateral connections, and major defects.

![PipeLogix® CCTV Survey Inspection Screen: 360 Viewer](image-url)
NASSCO’s PACP maximum allowable speed for conventional CCTV is 30 feet per minute. The Panorama scanner can record footage at up to 70 feet per minute since defects are not coded during the field inspection. Typically, inspections were conducted at a maximum of 60 feet per minute.

The deployed Panorama scanner can traverse roughly 1,600 ft. Range is limited by the length of data and retrieval cable, friction maintained in the sewer by the scanner’s wheels, and alignment of the sewer system. Limitations that affect inspection quality and completion include flow depth and velocity of the flow that may obscure the lens or make it difficult for the camera to traverse through the sewer.

Pipeline inspections were allowed to be performed from either direction as long as the quality of inspection was not compromised. This allowed for better efficiency in the field, limited disruption to the community where upstream manholes were located in busy intersections, and greater flexibility to complete inspections where manholes were inaccessible (i.e., abandoned or buried). Direction of inspection is provided as part of the inspection data.

When possible, each pipeline inspection commenced at the center of the starting manhole’s frame and cover, showing the sewer entrance at the manhole wall and traversing the full length of the pipeline reach to the center of the ending manhole’s frame and cover. Subsequently, inspection lengths were measured from the center of the starting manhole frame and cover to the center of the ending manhole frame and cover.

Pipelogix® Software was used to record the inspection data. Examples of the pipeline inspection forms are located in Appendix B. A separate form was started for each reach of sewer surveyed. Inspection data consisted of the following, where available and applicable:

- **Reach Data.** General information about the inspection, such as the company and operator performing the inspection, date and time of survey, identification numbers of the upstream and
downstream manholes, sewer defect identification and location, direction of survey, pipe diameter, pipe material and reach length.

- **Defect Data.** Locations of features and defects were recorded by length along the reach from the adjusted zero point and by clock reference that describe the circumferential location of features found in the sewer. Clock references start at 12 o’clock at the crown of the pipe and progress clockwise around the pipe interior as viewed by the camera. For manholes, clock references start at 6 o’clock at the outgoing sewer pipe and progress clockwise as viewed from the ground surface. Sewer defects identified during inspections were recorded using standardized defect identification procedures contained within the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment Certification Program (PACP) and Manhole Assessment Certification Program (MACP) manuals.

- **Field Comments.** Supplemental information beyond the reach data and defect data were recorded as field comments such as reasons for abandoning a survey, new manholes found in the field, and descriptions supplementing the defect coding.

- **Survey Data.** The measurement of each reach and the locations of pipe features were documented utilizing the camera’s distance counter. Manhole depths (from surface to invert) were also measured for manholes that were inspected from the surface during CCTV investigations. The survey data may be used to adjust reach length and manhole depth data within the City’s Geographical Information System (GIS).

Detailed specifications for the equipment and inspection techniques for the project were developed to ensure quality and consistency. In addition, BC personnel conducted periodic quality control during the field investigations through observing the pipeline inspections and working with the operators to ensure adherence to the specifications and techniques. All field investigation results were reviewed before acceptance for overall quality. Inspection footage that was not completed per specification was re-inspected.

### 3.2 Manhole Field Data Collection

Selected manholes were inspected from the ground surface, and conditions were recorded on a NASSCO MACP modified inspection form tailored to this project. These forms can be found in Appendix C. Defects and the overall condition of the inspected manholes were documented on the inspection form and with digital images. Images included those specified on the inspection form, including shots of the interior of all connecting trunk sewer pipes.

Manhole inspections were performed separate from the pipeline inspections. The two types of manhole inspection documentation completed for this project are non-entry surface inspection and PoleCam inspections.

- **Non-Entry, Surface Manhole Inspections.** Manholes were inspected from the ground surface with the overall condition documented by camera at the surface. Defects were recorded on an MACP-modified inspection form and with photographs.

- **PoleCam Inspections.** Inspection crews also recorded images of defects within the manholes and many of the connecting pipe segments using a pole-mounted zoom camera specifically design for this type of inspection.

During non-entry manhole inspections, penetration/scratch and hammer tests were performed. These tests were performed so that the inspection results could be correlated with conditions observed in manhole inspections that were only viewed from the pipe invert during CCTV inspections.

Penetration/scratch and hammer tests were performed on the manholes below the rim. The Contractor determined soundness of the concrete/mortar in the manholes by penetration/scratch
and hammer tests at locations representative of the overall condition of the manhole. The results of
the penetration/scratch and hammer tests were recorded on the manhole inspection form. The two
methods are described as follows:

- **Penetration/Scratch Test.** The Contractor performed a penetration/scratch test on the
concrete/mortar with a steel probe or screwdriver mounted on a pole. The test was performed in
a minimum of three areas approximately five ft below the rim. The inspector applied pressure
against the wall to measure penetration depth and assigned a surface “ST” rating on a scale of 1
to 4:
  1. Cannot be scratched (surface is hard and intact).
  2. Can be penetrated/scratched to no more than approximately 1/8-inch depth (surface is
     hard but exhibits beginning signs of deterioration).
  3. Can readily be penetrated/scratched to between 1/8-inch and 1/2-inch depth and may
     cause the surface to fall away and aggregate be exposed (surface is soft and deterioration is
     obvious and evident).
  4. Penetration/scratch test not performed for safety reasons due to advanced degree of
corrosion (surface is obviously deteriorated including aggregate or material missing) or
penetration/scratch test of greater than 1/2-inch depth.

- **Hammer Test.** The inspector also performed a hammer test on the concrete/mortar with a small
(8 to 12 oz.) ball pein hammer as far down into the manhole as he could reach. The inspector
lightly tapped/striking the manhole wall with the ball of the hammer and assigned a surface “HT”
rating on a scale of 1 to 4:
  1. Hammer rebounds and no indentation is made (surface is hard and intact).
  2. Hammer rebounds and insignificant indentation is made. Does not rebound as it would on
sound, solid concrete and the hammer may make a minimal indentation at the immediate
surface indicating that the surface has softened (surface is hard but exhibits beginning signs of
deterioration).
  3. Hammer does not readily rebound. The strike sounds dulled as opposed to a hard surface
and the hammer easily makes an indentation in the surface of the concrete and may cause
the surface to fall away and aggregate be exposed (surface is soft and deterioration is
obvious and evident).
  4. Hammer test not performed for safety reasons due to advanced degree of corrosion
(surface is obviously deteriorated including aggregate or material missing) or
penetration/scratch test of greater than 1/2-inch.

### 3.3 Pipeline and Manhole Inspection and Assessment Data Management

#### 3.3.1 Inspection Data

Pipeline inspection data for this project were recorded in the field using Pipelogix® software that is
integral to the inspection system. Manholes inspected by using the camera to pan from the invert
during pipeline inspections were also recorded in the field using Pipelogix® software. All inspection
data was directly written to a computer hard drive in the inspection vehicle. The data were
transferred to external hard drives and given quality reviews in the office. The inspection videos are
viewable using Pipelogix® software Screen captures from the pipeline inspections were saved as
electronic photographs in JPEG format. Screen captures were taken at the defects noted on the
defect coding forms and within the reaches to characterize general pipe conditions.
Manhole inspection data for surface-inspected manholes was collected on an iPad using a customized inspection form developed in the iForm app (Zerion Software). Daily inspection data is synched with the iForm cloud, and BC engineers were able to immediately access the data to conduct quality control and other analysis as required. Upon completion, inspection forms were exported in pdf format and printed from the iForm website, and the inspection data was downloaded as a single Excel file for post-processing and analysis. Images captured during inspection can be viewed either on the printed forms or through links to the data image stored on the cloud.

3.3.2 Geographical Information System Service

The City’s GIS database and shape files were used to generate maps that illustrate the sewer locations for the scheduling, execution and tracking of inspection work. GIS maps were also generated to display pipeline condition ratings of mild, moderate, and severe that were assigned during the assessment phase. Condition ratings for both structural and O&M conditions for each reach of sewer and an overall condition rating for manholes (Appendices E and F) are displayed graphically in GIS. Color coding distinguishes condition grades on the GIS maps.

3.4 Siphon Inspection

Siphon inspections include PICA SeeSnake inspection of approximately 60 LF of the Shackelford Crossing (total length is 360 LF). SeeSnake technology is proprietary to PICA Corporation. The existing Shackelford Crossing pipeline is constructed of 18-inch-diameter bar-wrapped, reinforced concrete cylinder pipe (RCCP).

Prior to inspection, the pipe crossing was prepared by running cleaning pigs (Photograph 3-1) and a gauge tool (Photograph 3-2) through the line. The purpose of the preparatory pigging runs is to perform basic cleaning and to bore-proof the siphon ahead of the inspection tool. All pigging was performed using PICA’s synthetic wire rope, spooled onto winches on both sides of the river.
PICA used SeeSnake equipment (Photographs 3-3 and 3-4) to inspect the siphon. The SeeSnake utilizes remote field eddy current technology to determine the thickness of the steel cylinder and the rebar wrap. The SeeSnake consists of one exciter coil and one detector coil. Both coils are wound co-axially with respect to the examined pipe and are separated by a distance greater than two times the pipe diameter. The actual separation depends on the application, but will always be a minimum of two pipe diameters. The detector measures the electromagnetic field remote from the exciter. Although the fields have become very small at this distance from the exciter, they contain information on the full thickness of the pipe wall.

The detector electronics include high-gain instrumentation amplifiers and steep noise filters. These are necessary in order to retrieve the remote field signals. The detector electronics output the remote field signal to an on-board storage device.

The data is recalled for display, analysis and reporting purposes after the examination process is completed. Analysis of the data then identifies any spots that have thinned due to corrosion.

### 3.5 Lift Station Inspection

BC performed a mechanical inspection of Woodland LS as an update to the inspection conducted for the 2005 Study. The inspection included a review of existing information, record drawings and maintenance history for the lift station provided by the City. Following this review, BC met with the City maintenance and engineering staff for a site visit at the lift station. BC conducted a visual inspection of the general site and of mechanical, structural and electrical components at the lift station. BC also performed a visual inspection of the sluice gate and gasket. The lift station inspection did not include any diagnostic testing such as (but not limited to) pump testing, vibration monitoring, or electrical thermography.
3.6 Quality Control and Quality Assurance

3.6.1 Field Visits
BC worked with the inspection operators during inspections to increase the reproducibility of the inspection data and the resultant condition grades. BC personnel conducted field visits to provide periodic quality review of the classification of sewer defects.

3.6.2 Video and Data Review
The inspection footage and data was reviewed during the assessment phase of the project. Inspections that did not conform to the specifications were re-inspected. Inspections not in conformance include footage that was blurry or dark, did not provide detailed views of major defects, was not zeroed or restarted at each new manhole, and did not provide accurate survey lengths. Defects not observed and recorded in the inspection form by the inspection operator were noted internally by BC in an assessment database.
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Section 4
Condition Assessment

Condition assessment of pipelines and manholes consists of:

- Identifying defects along each pipeline reach and within each manhole through visual inspection and/or physical tests.
- Assigning individual defect grades to each defect based on type and severity.
- Developing an overall Condition Grade for each pipeline reach or manhole by assessing type and number of defects along the pipeline reach or manhole.
- Assigning a final Condition Rating to each pipeline reach and manhole based on the condition grades and the potential for further deterioration and/or failure.
- Considering the criticality rating (Section 2) to determine the urgency of each repair, rehabilitation, or replacement recommendation.
- The condition assessment process is described in detail in the following sections.

4.1 Pipeline Defects

NASSCO PACP and MACP were selected for the identification and coding of pipeline defects for this project. This program provides uniformity in personnel training, terminology, and the assignment of defect type and severity for a variety of pipe and manhole materials. All inspection and condition assessment work for this project is performed by personnel trained and certified in PACP. Under PACP/MACP, defects are categorized as either structural or operations and maintenance (O&M) related.

Structural Defects. Structural defects are those that directly impair the structural condition of the pipeline or manhole such as joint separation, joint deflections, cracks, fractures, broken and collapsed pipe or wall, corrosion, worn inverts, and sag conditions. Structural defects are those that must be addressed through repairs, rehabilitation, or replacement. The vast majority of structural defects encountered during the project’s pipe inspections relate to corrosion in RCP pipelines. Since corrosion is typically continuous and consistent throughout a given pipeline reach, the worst corrosion defect grade is typically extrapolated to become the structural condition rating of the pipeline reach.

O&M Defects. O&M defects include a range of conditions that can either directly affect the performance of the sewer or are indicators of potential structural defects. O&M conditions include debris, grease, infiltration, intrusions (root or service laterals), and hydraulic problems. O&M defects are those that can be addressed through maintenance.

4.1.1 Sewer Defect Grades

Each structural and each O&M defect is assigned a corresponding condition grade based on its type and severity. Grades range from one to five: a grade one defect is defined as a defect that has not yet begun to deteriorate or cause significant problems, and a grade five defect is defined as a defect requiring immediate attention. The defect grade provides a means for comparing the severity of each defect relative to other defects, and a quantitative measure of the difference in condition between subsequent inspections of the same pipeline. Individual defect grade descriptions typically
encountered are shown in Table 4-1. Additional defect grades and descriptions may be found in the latest version of the NASSCO PACP and MACP manuals. Since the majority of pipelines inspected as part of this project are unlined RCP, the predominate defects included surface damage (corrosion) defects as highlighted below. Overall condition ratings are described in subsequent sections.

<table>
<thead>
<tr>
<th>Table 4-1. Sewer Defect Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Defect Type</strong></td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Structural Defects</td>
</tr>
<tr>
<td>Broken</td>
</tr>
<tr>
<td>Crack and Fractures</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Deformation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Hole in Pipe</td>
</tr>
<tr>
<td>Joint Displacement</td>
</tr>
<tr>
<td>Surface Damage (Corrosion)</td>
</tr>
<tr>
<td>Taps</td>
</tr>
<tr>
<td>O&amp;M Defects</td>
</tr>
<tr>
<td>Debris</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Roots</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

*X is a modifier that is used to describe the location of root intrusion: B for barrel, L for lateral, C for Connection, and J for Joint.
4.1.2 Pipeline Structural and O&M Condition Grades and Ratings

All CCTV and inspection data collected during the field activities were reviewed. Special attention was provided for defects with NASSCO PACP scores of three, four, and five. The coding of defects is important because they help establish current conditions within the pipe that can be compared to previous or future investigations. The overall condition grade applied to each pipeline reach is based on the defect types observed, and is typically equal to the worst corrosion grade for RCP reaches. Finally, the Condition Rating is based on the condition grade and the potential for further deterioration of these pipes. This procedure is the basis of the condition assessment of each asset, and is based on inspection data, GIS data, other available information and engineering judgment. It is important to note that assessment ratings are dynamic and are subject to change as pipe conditions change and additional inspection data becomes available.

Structural condition grades and ratings are detailed in Table 4-2. Grade 5 represents the worst condition, while Grade 1 represents a sewer in good condition. The overall Condition Rating condenses the five grades into three levels for use in developing rehabilitation recommendations.

<table>
<thead>
<tr>
<th>Condition Grade</th>
<th>Condition Rating</th>
<th>Defect Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mild</td>
<td>Minor defects.</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Defects that have not begun to deteriorate.</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
<td>Moderate defects that will continue to deteriorate.</td>
</tr>
<tr>
<td>4</td>
<td>Severe</td>
<td>Severe defects that will become Grade 5 defects within the foreseeable future.</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Defects requiring attention soon.</td>
</tr>
</tbody>
</table>

O&M condition grades and ratings are displayed in Table 4-3. Moderate and severe O&M condition ratings facilitate identification of needed maintenance activities such as cleaning and implementing preventative measures (root treatment). It is important to note that O&M ratings are assigned based on the conditions at the time of inspection and are subject to change. If pipes were recently cleaned before the inspections, the inspections cannot determine the need for future cleaning.

<table>
<thead>
<tr>
<th>Condition Grade</th>
<th>Condition Rating</th>
<th>Defect Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mild</td>
<td>No O&amp;M defects found; Vermin (roaches, no rats) and construction features (line left/right or up/down) that do not affect operation observed.</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Typically roots, obstacles, deposits, and intruding sealing rings observed that are less than 10 percent of pipe cross-sectional area.</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
<td>Typically roots, obstacles, deposits, and intruding sealing rings observed that are between 10 percent and 20 percent of pipe cross-sectional area.</td>
</tr>
<tr>
<td>4</td>
<td>Severe</td>
<td>Typically roots, obstacles, deposits, and intruding sealing rings observed that are between 20 percent and 30 percent of pipe cross-sectional area.</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Typically roots, obstacles, deposits, and intruding sealing rings observed that are greater than 30 percent of pipe cross-sectional area. Objects in pipe prevented completion of full inspection.</td>
</tr>
</tbody>
</table>
4.1.3 Manhole Condition Ratings

Condition data on the manholes were collected using non-entry inspections including surface inspections at CCTV camera insertion points and views from the pipeline using the CCTV camera to pan up at the end of pipeline inspections. Manholes inspected from the surface underwent a scratch and hammer test at the three o’clock, nine o’clock, and eleven o’clock manhole positions (the six o’clock position indicates the position of the outgoing pipe) below the manhole rim. The objective of the surface manhole inspections was not to inspect every part of every manhole, but to obtain a reasonable sample from surface inspection to allow characterization of the overall manhole condition, and supplement this information with CCTV and Polecam camera inspection data and scratch and hammer tests.

Table 4-4 presents the manhole structural Condition Rating system. O&M condition ratings were not assigned to manholes. Note that since individual defect grades were not recorded, manhole condition assessment jumps straight from inspection to Condition Rating without the intermediate steps of defect coding and assigning an overall condition grade.

<table>
<thead>
<tr>
<th>Condition Rating</th>
<th>Defect Description/Examples</th>
<th>Condition Implication</th>
</tr>
</thead>
</table>
| Mild             | • No defects or minor defects observed.  
|                  | • Increased surface roughness of manhole interior observed.  
|                  | • Sound surface or minor scratch (less than 1/8 inch) resulting from scratch test.  
|                  | • Hammer rebounds and insignificant indentation is made during hammer test. | Re-Assess within 10 years. |
| Moderate         | • Surface spalling corrosion and/or exposed aggregate observed.  
|                  | • Moderate defects that will continue to deteriorate.  
|                  | • Moderate scratch (less than 1/2 inch) resulting from scratch test.  
|                  | • Hammer does not readily rebound during hammer test. Strike sounds dulled as opposed to a hard surface and easily makes an indentation in the surface. | Re-Assess within 5 years. |
| Severe           | • Surface aggregate projecting or missing observed.  
|                  | • Severe defects that will become Grade 5 defects within the foreseeable future.  
|                  | • Severe defects requiring attention soon.  
|                  | • Severe scratch (greater than 1/2 inch) or indentation resulting from scratch test.  
|                  | • Hammer test not performed for safety reasons due to advanced degree of corrosion (surface is obviously deteriorated including aggregate or material missing). | Rehabilitate soon. |

4.2 Recommendation Descriptions

Descriptions of the structural and O&M recommendations are provided in the following sections to give the City a general idea of the impacts of addressing the problems identified.

4.2.1 Re-inspection and Tracking to Identify Maintenance Problems

In order to determine O&M and maintenance problems, we suggest that the pipes with known O&M defects, such as roots, grease, and sags be tracked such that the frequency of problematic O&M
defect occurrence may be determined. Once the frequency of occurrence is found, scheduled maintenance (i.e., cleaning and root treatment) can be established to mitigate the impacts of these defects. Ways to track O&M problems include logging pipe blockages/stoppages, odor complaints, or even frequent re-inspections to monitor maintenance problems. If O&M re-inspections are employed, one method to determine the frequency of occurrence may be to double the time between re-inspections if no O&M defect is found and halving the time between re-inspections if an O&M defect is found. Once frequency of occurrence is found, scheduled maintenance or cleaning routines can be established to mitigate the impacts of these defects. Another method is to monitor the debris removed during cleaning cycles. The frequency of cleaning may be increased or decreased based on the type and amount of debris removed.

The presence of roots may be the most destructive O&M defect found in a sewer system because they can lead to structural damage to the pipeline and provide a means for infiltration which may further deteriorate any structural defects within the pipe. Roots may enter cracks in the pipe, laterals, and pipe joints. Roots may also cause debris and grease accumulation that may cause pipe blockages. It is difficult to determine the rate of root growth; therefore, root treatment (foaming) is usually completed on a two to three-year cycle. Otherwise, re-inspections or tracking complaints may offer other ways to plan scheduled maintenance for root treatment.

4.2.2 Re-inspection to Monitor Structural Defects

This project helps establish a baseline of the structural condition of the City’s trunk sewer system; however, the inspections only included a representative sample of pipelines based on the pipes’ criticality. Since the structural condition of pipelines is dynamic, it is imperative that the City continue to monitor their trunk sewer system for new structural defects or the deterioration of current structural defects. BC recommends that a ten-year re-inspection cycle be implemented based on industry standard and BC’s professional knowledge and experience.

Pipes that have no or minor defects do not require frequent inspection as they currently do not exhibit characteristics that put them at risk for failure. Instead, we recommend that for moderate rated pipes, more frequent inspection is warranted to monitor defects that may worsen. Severe rated pipes are recommended for repair, rehabilitation, or replacement. Re-inspection intervals were assigned based on the resulting structural grades/ratings as shown in Table 4-5. Higher structural condition grade reaches require re-inspections sooner, while lower structural condition grade reaches are in fairly good condition and may be re-inspected further into the future.

<table>
<thead>
<tr>
<th>NASSCO Condition Grade</th>
<th>Condition Rating</th>
<th>Defect Description</th>
<th>Re-Inspection/Repair Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 2</td>
<td>Minor</td>
<td>Minor Defects; Defects that have not begun to deteriorate</td>
<td>Within ten years.</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>Moderate defects that will continue to deteriorate</td>
<td>Within five years.</td>
</tr>
<tr>
<td>4 - 5</td>
<td>Severe</td>
<td>Severe defects that will become Grade 5 defects within the foreseeable future; Defects requiring attention soon.</td>
<td>Repair, rehabilitate, or replace soon.</td>
</tr>
</tbody>
</table>

4.2.3 Repair, Rehabilitation, and Replacement Methods for Pipelines

Based on the types of severe structural defects identified, the following methods of manhole-to-manhole rehabilitation or replacement are recommended: 1) Cured-in-Place Pipe (CIPP), 2) sliplining,
3) open cut, and 4) pipe bursting. These rehabilitation and replacement methods are described below.

### 4.2.3.1 Rehabilitation

Trenchless rehabilitation is a popular alternative to dig-and-replace methods and is frequently used for reaches of pipe that have continuous structural defects. Manhole-to-manhole rehabilitation may consist of CIPP or sliplining methods.

**CIPP (Manhole-to-Manhole).** The CIPP process involves inserting a flexible, resin-impregnated liner into the sewer, filling the liner with steam or water, and then heating the steam or water to cure the resin. The resulting cast-in-place pipe forms a permanent barrier that prevents corrosion, infiltration, exfiltration, and root intrusion; and it also provides added structural strength. The liner is typically composed of layers of polyester felt or woven fiberglass fabric that are saturated with thermosetting polyester, vinylster, or epoxy resins immediately before installation. The lining may be manufactured to accommodate small deformations and alignment or diameter changes in the sewer. The liner can be designed to be provide full structural rehabilitation if the integrity of the pipe is compromised.

Full bypassing of flow is necessary to install and cure the liner. Continuous bypassing is typically required for several days for each liner insertion. During this period, the pipeline invert would need to be cleaned of debris, but the walls do not require significant cleaning.

**Sliplining.** Sliplining is the process of inserting a new pipe within an existing pipe and can be installed using the continuous or sectional pipe method. The slipliner pipe is manufactured of corrosion resistant material, and provides long-term protection of the existing pipe from additional deterioration. The slipliner pipe can also be specified to provide additional structural capacity to the pipeline where needed.

With the sectional pipe slipliner method, slipliner pipe is placed into the existing pipe via an insertion pit. The slipliner pipe sections are typically joined together using gaskets or mechanical joints at the insertion pit and pushed into place. In the continuous slipliner method, the pipe is typically butt-fusion welded together into a continuous length of pipe before inserting into the sewer. These processes work best when some wastewater remains in the interceptor to provide flotation of the slipliner pipe while it is being inserted.

Insertion pits are required to place the slipliner pipe into the interceptor. The insertions pits would extend down to about the spring line of the interceptor and the top half of the existing interceptor pipe would be removed. The pits would need to be 20 to 30 ft long. After the slipliner is inserted, a reinforced concrete cap is constructed over the pipeline to prevent overloading the slipliner.

After the slipliner pipe is in place, the annular space between the existing pipe and the slipliner pipe is filled with grout to anchor the slipliner pipe. The grouting process must be carefully performed to prevent damaging the slipliner pipe or leaking grout into the existing pipe. Sliplining reduces the cross-sectional area and hydraulic capacity of the pipeline.

### 4.2.3.2 Replacement

Replacement entails constructing a new pipe along a parallel alignment or replacing the existing pipe with a new pipe. Replacement is typically used when the existing pipeline has hydraulic constraints that prevent rehabilitation by other means, the pipeline needs to be realigned, or the existing pipeline is very short and replacement is the easiest rehabilitation method to apply. If the existing pipeline is replaced with a new pipeline along the same alignment, flow bypassing is required.
Dig and Replace. A replacement pipeline or pipe segment would be installed primarily by traditional open trench excavation. However, crossing of railroad tracks or storm drain culverts would need to be jack and bore or tunneling. The replacement pipe material should be resistant to corrosion.

Pipe Bursting. Pipe bursting is a trenchless method of installing a new pipe in place of the existing pipe. Pipe bursting is similar to the sliplining rehabilitation method, except an expander head is used at the beginning of the new pipe to break or burst the old pipe to make room for the new pipe that is of the same size as or slightly larger than the existing pipe. Also, pipe that is installed using pipe bursting is typically pulled into the place of the existing pipe, which leaves no annular space between the old and new pipes. Pipe bursting is used when the pipeline requires upsizing or when reduction in capacity is not acceptable.

4.2.4 Repair, Rehabilitation, and Replacement Methods for Manholes
The following methods of repair and rehabilitation are recommended for manholes: 1) point repairs, 2) manhole rehabilitation, 3) dig and replace, and 4) manhole inserts. These repair and rehabilitation methods are described below.

4.2.4.1 Point Repairs
Manhole point repairs are recommended where defects are found in generally sound manholes or where there are defects on a limited number of manhole components that do not warrant full rehabilitation or replacement. They include a variety of repairs, such as patching gaps in the adjustment rings, rebuilding and/or resurfacing the bench or channel, and installing inside drops. The City will likely be able to address the majority of these repairs by utilizing their maintenance crews.

4.2.4.2 Manhole Rehabilitation
If active surface corrosion is occurring within the manhole and the manhole is not structurally compromised, manhole rehabilitation may be used to resurface the manhole interior and eliminate potential for further corrosion by coating or lining. Manhole preparation is typically accomplished by removing soft, corroded material through sandblasting down to sound material. The interior surface is rebuilt utilizing grout or mortar underlayment and a corrosion-resistant coating or material is applied over the underlayment.

4.2.4.3 Manhole Replacement
There are two methods for manhole replacement: 1) dig and replace and 2) manhole inserts. Dig and replace provides a whole new manhole, while manhole inserts provide a new manhole within the existing manhole.

Dig and Replace. In some cases, the manhole is structurally compromised and cannot be rehabilitated with the installation of a corrosion-resistant coating system or CIPM liner. In these cases, it is better to remove and replace the defective manhole to eliminate potential for collapse and safety risks to the public.

Manhole inserts. Manhole inserts consist of fiberglass-reinforced, polyester or polymer manhole inserts that are corrosion resistant and can be installed within an existing manhole. These inserts are typically designed to withstand HS-20 traffic loading. Typical manhole insert installation procedures include cutting the asphalt, excavating, and removing the existing manhole cone, power washing the inside of the manhole, placing the manhole insert inside the manhole barrel to cut to fit, rebuilding and/or rehabilitating the bench area, installing the insert and filling the annular space between the insert and existing manhole walls with grout. In some cases, manhole inserts may be installed when dig and replace costs exceed the costs for manhole insert installation. However,
installation of manhole inserts still requires excavation of the existing cone and rehabilitation of the bench area which may not be more cost effective than dig and replace methods. The diameter of the manhole is slightly reduced with placement of the manhole insert.

4.2.5 Repair, Rehabilitation, and Replacement Prioritization

Criticality ratings were assigned to each pipeline reach to identify sewers with high likelihood and consequences of failure. Criticality was performed as part of the prioritization of inspection effort and is discussed in detail in Section 2. Experience has shown that the City will receive the greatest benefit from investing rehabilitation and repair resources in the most critical sewers. Therefore, the criticality was considered in the repair, rehabilitation, and replacement recommendations and prioritization.

4.2.6 O&M Recommendations

Typical O&M recommendations involve general cleaning, root treatment, and grease mitigation. These recommendations are described briefly below.

4.2.6.1 General Cleaning

Foreign materials, debris, grease, and accumulated sediments may be dislodged, collected, and removed from pipelines using an industry standard, high-pressure water jetter and Vector truck. More than one cleaning pass with the water jetter may be needed to remove the accumulated debris. If several cleaning passes cannot remove the debris, then heavy cleaning may be needed. Heavy cleaning is defined as cleaning activities requiring use of a specialized head or attachment if the standard water jetter is not sufficient.

Pipelines where sags are identified may require frequent cleaning as they tend to accumulate debris at a faster rate due to the low point in the pipe. Cleaning may also be used to remove some roots, but does not completely eliminate the problem.

4.2.6.2 Root Treatment

Root treatment can be achieved through mechanical or chemical methods. Mechanical root treatment involves the use of machines (e.g., drilling machines, rodding machines, jetters, or winches) that are specifically designed to cut, scrape, or pull roots. Mechanical means of root treatment provide immediate removal and are useful in removing large blockages; however, roots may still grow back since damaged roots tend to grow back thicker and form a protective barrier at the cut ends. Chemical methods involve the application of a contact herbicide or a systemic herbicide. Contact herbicides only kill the parts exposed to the herbicide and systemic herbicides typically kill the whole plant.

A common chemical root treatment is the application of Metam-Sodium and Dichlofenyl foam that both kills the roots and inhibits root growth. The foam may be applied throughout the entire pipeline or at select spots. Treated roots are killed within hours of application. Through the use of this method, root treatment is likely needed every three years (University of California, Davis, 1996).

4.2.6.3 Grease Mitigation

If grease accumulation is a frequent problem in select sewer pipelines, frequent cleaning may help, but identifying and eliminating the source of the problem is often a more effective long-term solution. The City currently has a grease education program in place. If grease accumulation is seen in a particular area, the City may need to revisit these areas to identify restaurants without grease control devices (e.g., grease traps and interceptors) and/or to educate neighborhoods about ways to reduce grease accumulation in the sewer system.
Section 5
Condition Assessment Results

The condition assessment results of the gravity main, manholes, siphon, and lift station are summarized in the following sections.

5.1 Gravity Main Assessment Results

The following section summarizes structural and operational grade distributions for pipelines assessed during this project.

5.1.1 Gravity Main Structural Assessment Results

Figure 5-1 illustrates the distribution of pipe reaches by structural condition grades for the entire project system. The percentages of each grade are based on the number of reaches with a defect of the corresponding grade divided by the total number of trunk sewer reaches (81). Structural defects found include unlined reinforced concrete pipe (RCP) with reinforcement visible/projecting and aggregate visible, projecting or missing. Pipeline reaches assessed were primarily in moderate condition with 23 percent (19 reaches) in poor condition or requiring immediate attention. The poor and immediate-attention reaches were due to unlined RCP corrosion resulting from exposure to the corrosive sewer environment.

![Pie chart showing structural condition grades for gravity main]

**Figure 5-1. Gravity Main Structural Condition Grade Distribution**

5.1.1.1 Structural Grade 5 Reaches

Examples of structural Grade 5 defects are highlighted below. Grade 5 structural defects in RCP included corroded, missing and protruding reinforcement; missing portions of wall; and holes. A
sample of these defects is displayed in Photographs 5-1 to 5-5. Some of the worst defects may be spot repaired; however, we generally recommend that RCP reaches with such advanced corrosion undergo CIPP rehabilitation to prevent further deterioration.

Photographs 5-1 to 5-3 display various examples of visible, corroded, and missing reinforcement. Photograph 5-1 shows reinforcement corroded and missing with some missing wall. This missing wall occurred in an isolated area with visible and corroded reinforcement in the remainder of the pipe (Photograph 5-2). Photograph 5-3 shows another example of visible and corroded reinforcement. Within this reach, much of the concrete is deteriorating or missing above the flow line. However, soil has not begun to show. These pipes are recommended for immediate rehabilitation.
Photograph 5-3. Reach SSMH2503080304 to SSMH2503080301
(Tributary to Emerald Trunk – Woodland Ave): Reinforcement Corroded

Photographs 5-4 and 5-5 are examples of additional severe defects. Within Reach SSMH2803090810 to SSMH2803090811, a hole with a void visible was observed. In addition, filamentous growth indicative of severely corrosive environments was found. This filamentous growth has been observed by BC in the past in severely corroded unlined, RCP. Photograph 5-5 includes a photograph of roots that appear to be growing through the barrel of the pipe. The roots do not appear to originate outward from a joint, but through the concrete. If the roots are indeed growing through the concrete, the concrete’s structural integrity has been compromised. These pipes were also recommended for immediate repair/rehabilitation.

Photograph 5-4. Reach SSMH2803090810 to SSMH2803090811
(Santa Rosa Trunk): Hole Void Visible
Assessments and recommendations for all project reaches can be found in Appendix D. Structural assessment ratings for all reaches are displayed graphically in Appendix E. The City may also consult the project wash book, located in Appendix J, for an alternative arrangement of pipe and manhole locations in conjunction with Appendix D. Table 5-1 presents a summary with line assessment and recommendations for all structural severe-rated reaches found during our investigation.
<table>
<thead>
<tr>
<th>Reach</th>
<th>Pipe Size (in)</th>
<th>GIS Length (ft)</th>
<th>Inspection Length (ft)</th>
<th>Trunk (Road)</th>
<th>Assessment</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSMH0504091502-SSMH0504091207</td>
<td>30</td>
<td>567</td>
<td>289</td>
<td>South Modesto Tributary to Ceres Trunk</td>
<td>Surface reinforcement visible with projecting aggregate and missing aggregate also observed. Full inspection could not be completed due to debris.</td>
<td>Clean pipe to remove debris, rehabilitate to prevent further corrosion.</td>
</tr>
<tr>
<td>SSMH0604091612 - SSMH0504091613</td>
<td>24</td>
<td>45</td>
<td>38</td>
<td>Sutter</td>
<td>Rebar missing and wall missing at SSMH0604091613. Rebar visible and corroded in some areas.</td>
<td>Rehabilitate pipe soon to prevent further deterioration of RCP.</td>
</tr>
<tr>
<td>SSMH0604091614-SSMH0504091306</td>
<td>24</td>
<td>235</td>
<td>134</td>
<td>Sutter</td>
<td>Surface aggregate visible with some areas of projecting and missing aggregate for the first 102 ft. Remainder of reach lined. Inspection couldn’t be completed due to alignment change.</td>
<td>Rehabilitate the first 102 ft to prevent further deterioration of RCP.</td>
</tr>
<tr>
<td>SSMH1703091315-SSMH1703091316</td>
<td>30</td>
<td>110</td>
<td>107</td>
<td>Emerald</td>
<td>Surface corroded with coating missing. Thickness of CMP unknown. Settled deposits observed.</td>
<td>Rehabilitate soon due to unknown thickness and extent of corrosion (outside of pipe).</td>
</tr>
<tr>
<td>SSMH1903091002-SSMH1903091003</td>
<td>18</td>
<td>448</td>
<td>428</td>
<td>Tributary to Emerald Trunk (Carver Road)</td>
<td>Full inspection not achieved with inspection from either direction due to debris within flow. Fine roots through barrel in many areas affecting structural integrity. Surface aggregate visible throughout with areas of projecting and missing aggregate.</td>
<td>Clean pipe and complete full inspection. Rehabilitate soon to prevent further deterioration of RCP.</td>
</tr>
<tr>
<td>SSMH2503080301-SSMH2503080304</td>
<td>27</td>
<td>659</td>
<td>657</td>
<td>Tributary to Emerald Trunk (Woodland Ave)</td>
<td>Surface reinforcement visible throughout, except from 638 ft to 658 ft upstream of SSMH2503080304 where reinforcement is corroded. Settled debris observed.</td>
<td>Rehabilitate pipe soon to prevent further deterioration of RCP.</td>
</tr>
<tr>
<td>SSMH2803090810-SSMH2803090811</td>
<td>24</td>
<td>110</td>
<td>103</td>
<td>Santa Rosa</td>
<td>Surface reinforcement visible. Missing wall and attached deposits throughout. Hole with void visible at 16 ft downstream of SSMH2803090810. Pipe appears to surcharge.</td>
<td>Rehabilitate pipe soon to prevent further deterioration of RCP.</td>
</tr>
<tr>
<td>SSMH2803090811-SSMH2803091222</td>
<td>24</td>
<td>369</td>
<td>365</td>
<td>Santa Rosa</td>
<td>Reinforcement visible in several locations with some corroded. Aggregate projecting throughout.</td>
<td>Rehabilitate pipe soon to prevent further deterioration of RCP.</td>
</tr>
<tr>
<td>SSMH2903091417-SSMH2903091426</td>
<td>27</td>
<td>203</td>
<td>202</td>
<td>Tributary to River Trunk (9th Sq)</td>
<td>Surface aggregate projecting and spalling throughout with areas of missing aggregate. Settled gravel observed.</td>
<td>Rehabilitate pipe soon to prevent further deterioration.</td>
</tr>
<tr>
<td>Reach</td>
<td>Pipe Size (in)</td>
<td>GIS Length (ft)</td>
<td>Inspection Length (ft)</td>
<td>Trunk (Road)</td>
<td>Assessment</td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>----------------</td>
<td>-----------------</td>
<td>------------------------</td>
<td>---------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>SSMH2903091426-SSMH2903091501</td>
<td>27</td>
<td>258</td>
<td>258</td>
<td>Tributary to River Trunk (9th St)</td>
<td>Surface projecting and surface spalling throughout. Some areas of missing aggregate, settled gravel observed.</td>
<td></td>
</tr>
<tr>
<td>SSMH2903091501-SSMH2903091416</td>
<td>27</td>
<td>350</td>
<td>327</td>
<td>Tributary to River Trunk (K St)</td>
<td>Aggregate projecting and spalling throughout with some aggregate missing. Debris/obstacle prevented full inspection.</td>
<td></td>
</tr>
<tr>
<td>SSMH3003090104-SSMH3003090105</td>
<td>27</td>
<td>153</td>
<td>147</td>
<td>Tributary to Emerald Trunk (N. Emerald Ave)</td>
<td>Surface reinforcement visible from 1 to 3 o’clock throughout with reinforcement projecting and corroded near upstream manhole.</td>
<td></td>
</tr>
<tr>
<td>SSMH3003090105-SSMH3003090201</td>
<td>27</td>
<td>481</td>
<td>455</td>
<td>Tributary to Emerald Trunk (N. Emerald Ave)</td>
<td>Surface aggregate visible throughout. Surface reinforcement visible throughout with some areas of corrosion. However, it could also be lined CMP.</td>
<td></td>
</tr>
<tr>
<td>SSMH3303090401-SSMH3303090402</td>
<td>30</td>
<td>307</td>
<td>304</td>
<td>Santa Rosa</td>
<td>Surface aggregate projecting and visible throughout. Reinforcement also visible.</td>
<td></td>
</tr>
<tr>
<td>SSMH3303090611-SSMH3303090614</td>
<td>27</td>
<td>562</td>
<td>561</td>
<td>Tributary to River Trunk (S. Morton Blvd)</td>
<td>Surface roughness increased throughout with surface aggregate projecting and missing wall within flow line, especially near downstream manhole, SSMH 3303090614.</td>
<td></td>
</tr>
<tr>
<td>SSMH3303090711-SSMH3303090710</td>
<td>48</td>
<td>56</td>
<td>66</td>
<td>River</td>
<td>Surface reinforcement visible throughout. Unable to see whether reinforcement is corroded.</td>
<td></td>
</tr>
<tr>
<td>SSMH3303090705-SSMH3303090711</td>
<td>48</td>
<td>38</td>
<td>23</td>
<td>River</td>
<td>Surface reinforcement visible at downstream manhole.</td>
<td></td>
</tr>
<tr>
<td>SSMH3303091106-SSMH3303091101</td>
<td>48</td>
<td>144</td>
<td>141</td>
<td>River</td>
<td>Surface reinforcement visible around 100 ft downstream of SSMH3303091101. Surface aggregate visible and projecting throughout.</td>
<td></td>
</tr>
<tr>
<td>SSMH3303091104-SSMH3303091106</td>
<td>48</td>
<td>379</td>
<td>392</td>
<td>River</td>
<td>Reinforcement visible, aggregate projecting, and aggregate visible throughout.</td>
<td></td>
</tr>
</tbody>
</table>

**Recommendation:**
- Rehabilitate pipe soon to prevent further deterioration.
- Clean pipe to remove debris, rehabilitate soon to prevent further deterioration of pipe.
- Rehabilitate pipe soon to prevent further deterioration of RCP.
- Rehabilitate pipe soon to prevent further deterioration of RCP.
- Rehabilitate pipe soon to prevent further deterioration of RCP.
- Rehabilitate reach soon to prevent further deterioration of RCP.
- Rehabilitate pipe soon to prevent further deterioration of RCP.
- Rehabilitate pipe soon to prevent further deterioration of RCP.
- Rehabilitate pipe soon to prevent further deterioration of RCP.
- Rehabilitate pipe soon to prevent further deterioration of RCP.
- Rehabilitate pipe soon to prevent further deterioration of RCP.
5.1.2 Gravity Main Operational Assessment Results

Figure 5-2 represents the distribution of the operational condition grades. Operational defects found in this project include debris and roots. Pipeline reaches are generally in good operational condition with only approximately ten percent (eight reaches) and two percent (two reaches) in moderate and poor condition, respectively. Pipelines with any significant level of debris that affected the inspection of the pipeline were not cleaned as part of this investigation.

![Figure 5-2. Pipeline Operational Condition Grade Distribution](image)

A summary with the pipe size, pipe material and the type of operational defect for all reaches is provided in Appendix D. The operational ratings for pipes are also displayed graphically in Appendix F. The City may also consult the project wash book, located in Appendix J, for an alternative arrangement of pipe and manhole locations in conjunction with Appendix D. Table 5-2 includes reaches where debris or obstacles prevented their full inspection. These reaches were given and operational rating of moderate or severe, and should be cleaned to complete a full inspection of the reach.
Table 5-2. Reaches Requiring Cleaning for Full Inspection

<table>
<thead>
<tr>
<th>Reach</th>
<th>Trunk</th>
<th>Pipe Size (in)</th>
<th>GIS Length (LF)</th>
<th>Inspection Length (LF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSMH0604091611-SSMH0604091612</td>
<td>Sutter</td>
<td>24</td>
<td>314</td>
<td>54</td>
</tr>
<tr>
<td>SSMH0504091502-SSMH0504091207</td>
<td>Tributary to Ceres Trunk</td>
<td>30</td>
<td>567</td>
<td>289</td>
</tr>
<tr>
<td>SSMH0504091503-SSMH0504091502</td>
<td>Tributary to Ceres Trunk</td>
<td>30</td>
<td>53</td>
<td>34</td>
</tr>
<tr>
<td>SSMH0804090405-SSMH0804090404</td>
<td>Tributary to Ceres Trunk</td>
<td>30</td>
<td>497</td>
<td>197</td>
</tr>
<tr>
<td>SSMH1203080912-SSMH1203081401</td>
<td>West</td>
<td>39</td>
<td>214¹</td>
<td>230</td>
</tr>
<tr>
<td>SSMH2503090102-SSMH2503090103</td>
<td>Lakewood</td>
<td>36</td>
<td>253</td>
<td>223</td>
</tr>
<tr>
<td>SSMH1903091002-SSMH1903091003</td>
<td>Tributary to Emerald Trunk</td>
<td>18</td>
<td>448</td>
<td>428</td>
</tr>
<tr>
<td>SSMH2903091501-SSMH2903091416</td>
<td>Tributary to River Trunk</td>
<td>27</td>
<td>350</td>
<td>327</td>
</tr>
</tbody>
</table>

Note:
¹ GIS shape length may be a discrepancy.

5.2 Manhole Assessment Results

Inspections were attempted on a total of 219 manholes. Ten manholes were not inspected. Three of the ten were part of the original project list; but were substituted with a nearby manhole or another manhole within the system. Seven could not be inspected due to access issues or were not found. A total of 209 manholes were inspected, coded, and assessed. The resulting condition rating distributions for these 219 manholes are presented in Figure 5-3. Defects found include settled deposits and debris, spalling, and severe corrosion. Manholes are generally in fair condition with 63 percent (138 manholes) in good or excellent condition, 25 percent (55 manholes) in fair condition, and 7 percent (16 manholes) in poor condition. Four manholes were designated for immediate attention based on their structural condition and 12 were recommended for repair or rehabilitation in Table 5-3.

Figure 5-3. Manhole Condition Rating Distribution

Use of contents on this sheet is subject to the limitations specified at the end of this document.
\bcwckfp01\projects\147000\147789 - Modesto WW Collection System\Report\03_Final\WW Collection System Report-Final-20160819.docx
Some of the defects identified in poor-rated manholes are displayed in the photographs below. Photograph 5-6 shows an uncoated manhole with corroded walls and exposed aggregate in the concrete.

Photograph 5-6. SSMH3203091219: Heavy Wall Deterioration with Projecting and Missing Aggregate

Photograph 5-7 shows a manhole with brick that appears to have collapsed at the pipe connection with soil visible. Photograph 5-8 displays a manhole with visible reinforcement in the lower wall.

Photograph 5-7. SSMH3203090907: Missing brick with void visible

Photograph 5-8. SSHM2103090405: Walls spalling with reinforcement visible
The manholes pictured in Photographs 5-6 and 5-7 are recommended for immediate repair or replacement. The manhole in Photograph 5-6 is located in the emergency River Trunk rehabilitation project. The manhole in Photograph 5-8 should be rehabilitated soon to prevent further structural deterioration.

<table>
<thead>
<tr>
<th>Manhole ID</th>
<th>Trunk</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSMH2303091620</td>
<td>Lakewood</td>
<td>Reinforcement visible and projecting. Heavy spalling.</td>
</tr>
<tr>
<td>SSMH3203090907</td>
<td>Sutter</td>
<td>Brick covered with cementitious coating. Coating deteriorating with brick exposed in lower half of the manhole. Missing brick with void and soil visible.</td>
</tr>
<tr>
<td>SSMH3303091004</td>
<td>River</td>
<td>Reinforcement visible and corroded and wall heavily deteriorated and soft. Heavy grease in manhole.</td>
</tr>
<tr>
<td>SSMH0504091106</td>
<td>Ceres</td>
<td>Hole for bolt stripped out. Manhole surcharged. Reinforcement visible and corroded in wall and aggregate projecting.</td>
</tr>
<tr>
<td>SSMH0504091203</td>
<td>Ceres</td>
<td>Penetration test and hammer test resulted in determination of severe corrosion. Sediment estimate approximately 3 inches. Missing wall and corroded reinforcement observed.</td>
</tr>
<tr>
<td>SSMH0504091502</td>
<td>Tributary to Ceres Trunk</td>
<td>Approximately 5 inches of sediment observed with grease on bench. Surface aggregate projecting in lower wall with aggregate missing near bench.</td>
</tr>
<tr>
<td>SSMH0604091403</td>
<td>West</td>
<td>Bolted cover frame style and cover but it is not bolted down. Penetration test resulted in 1/8 inch to 1/2 inch scratch. Aggregate visible and projecting with aggregate missing near pipe mouth.</td>
</tr>
<tr>
<td>SSMH1903091002</td>
<td>Tributary to Emerald Trunk</td>
<td>Most of the manhole in fair condition, except that there is spalling and corroded reinforcement at a lateral.</td>
</tr>
<tr>
<td>SSMH2103090405</td>
<td>Tributary to Emerald Trunk</td>
<td>Wall's spalling with reinforcement visible in the lower wall. Projecting aggregate in the chimney.</td>
</tr>
<tr>
<td>SSMH2803090806</td>
<td>Santa Rosa</td>
<td>Aggregate projecting and some aggregate missing on bench.</td>
</tr>
<tr>
<td>SSMH2803090809</td>
<td>Santa Rosa</td>
<td>Aggregate projecting and missing. Heavy spalling throughout manhole.</td>
</tr>
<tr>
<td>SSMH2803090811</td>
<td>Santa Rosa</td>
<td>Aggregate projecting and missing. Missing mortar medium in brick near bench.</td>
</tr>
<tr>
<td>SSMH2903090908</td>
<td>Tributary to River Trunk</td>
<td>Manhole severely corroded with reinforcement visible ad corroded and missing wall.</td>
</tr>
<tr>
<td>SSMH3303090531</td>
<td>Not Provided</td>
<td>Aggregate visible within manhole with aggregate projecting and missing on bench.</td>
</tr>
<tr>
<td>SSMH3303090709</td>
<td>River Trunk</td>
<td>Manhole full of grease and surcharged to height of 41 inches from rim. Reinforcement within manhole projecting and corroded.</td>
</tr>
</tbody>
</table>

The seven manholes that were inaccessible or not found are displayed below in Table 5-4. Manholes that were not found may be buried or paved over.
<table>
<thead>
<tr>
<th>Manhole ID</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSMH0904091008</td>
<td>Train track easement, unable to access.</td>
</tr>
<tr>
<td>SSMH2903090215</td>
<td>Not Found</td>
</tr>
<tr>
<td>SSMH3003100904</td>
<td>Not Found</td>
</tr>
<tr>
<td>SSMH3303090626</td>
<td>Not Found</td>
</tr>
<tr>
<td>SSMH3303090706</td>
<td>Can’t access; unable to lift lid.</td>
</tr>
<tr>
<td>SSMH3403090703</td>
<td>Not Found</td>
</tr>
<tr>
<td>SSMH3503091102</td>
<td>Unable to inspect because too close to train tracks.</td>
</tr>
</tbody>
</table>

### 5.3 Priority Assets Requiring Immediate Rehabilitation

Field investigation protocol included the identification of priority manholes and pipelines requiring immediate rehabilitation. The investigation identified three pipelines and four manholes requiring immediate attention. The following manholes and pipelines considered to be in need of immediate rehabilitation.

<table>
<thead>
<tr>
<th>Reach/Manhole</th>
<th>Pipe Size (in)</th>
<th>GIS Length (ft)</th>
<th>Inspection Length (ft)</th>
<th>Trunk</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSMH0604091612 to SSMH0604091613</td>
<td>24</td>
<td>45</td>
<td>38</td>
<td>Sutter</td>
<td>Rebar missing and wall missing at SSMH0604091613. Rebar visible and corroded in some areas.</td>
</tr>
<tr>
<td>SSMH1903091002 to SSMH1903091003</td>
<td>18</td>
<td>448</td>
<td>428</td>
<td>Tributary to Emerald Trunk (Caner Road)</td>
<td>Full inspection not achieved with inspection from either direction due to debris within flow. Fine roots through barrel in many areas affecting structural integrity. Surface aggregate visible throughout with areas of projecting and missing aggregate.</td>
</tr>
<tr>
<td>SSMH2803090810 to SSMH2803090811</td>
<td>24</td>
<td>110</td>
<td>103</td>
<td>Santa Rosa</td>
<td>Surface rebar visible. Missing wall and attached deposits throughout. Hole with void visible at 16 ft downstream of SSMH2803090810. Pipe appears to surcharge.</td>
</tr>
</tbody>
</table>

**Manholes**

<table>
<thead>
<tr>
<th>Manhole ID</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSMH2303091620</td>
<td>Reinforcement visible and projecting. Heavy spalling.</td>
</tr>
<tr>
<td>SSMH3203090907</td>
<td>Brick covered with cementitious coating. Coating deteriorating with brick exposed in lower half of the manhole. Missing brick with void and soil visible.</td>
</tr>
</tbody>
</table>
### Table 5.5. Structural Severe Rated Pipes and Manholes

<table>
<thead>
<tr>
<th>Reach/Manhole</th>
<th>Pipe Size (in)</th>
<th>GIS Length (ft)</th>
<th>Inspection Length (ft)</th>
<th>Trunk</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSMH3203091219</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>River</td>
<td>Exterior manhole broken at surface. Aggregate missing and projecting. Reinforcement visible and corroding.</td>
</tr>
<tr>
<td>SSMH3303091004</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>River</td>
<td>Reinforcement visible and corroded and wall heavily deteriorated and soft. Heavy grease in manhole.</td>
</tr>
</tbody>
</table>

The pipe reaches listed above are recommended for rehabilitation as part of a larger capital improvement project. Manholes SSMH3203091620 and SSMH3203090907 are not grouped in a larger capital improvement project as there was insufficient project to build a project around these areas; therefore, these manholes should be addressed separately. The two manholes, SSMH3203091219 and SSMH3303091004, are located on the River Trunk which is currently planned for emergency repair and rehabilitation.

### 5.4 Siphon Inspection and Assessment Results

Siphon inspections consisted of PICA SeeSnake inspection of the Shackelford siphon, and siphon structure inspection to gauge the condition of the siphon pipes. These results are presented below.

#### 5.4.1 Shackelford Siphon Inspection

The City of Modesto retained BC to conduct an inspection of the existing Shackelford Sewer Siphon. Per documents provided by the City, the 18-inch diameter pipeline was constructed in the early 1970s and the pipe material is Concrete Cylinder Pipe (CCP). The pipeline is currently not in service. The purpose of the inspection was to satisfy the requirements set forth in the State Lands Lease, dated September 20, 2013. The requirements include:

- A complete analysis of the pipeline
- A determination if the pipeline has held its integrity or if rehabilitation is needed

BC and PICA performed the physical pipeline inspections during the week of November 16, 2015. PICA's in-line inspection (ILI) tool, called the See Snake, utilizes Remote Field Testing (RFT) technology. The Chimera model of the See Snake was selected based on its capability of measuring the full length 360-degree wall thickness of the steel cylinder embedded in the CCP.

Site conditions at the siphon outlet manhole located on the western bank of the Tuolumne River, within the Dryden Park Golf Course, did not allow for the deployment of the Chimera at this location. Thus, the tool was deployed into the pipeline at the siphon inlet manhole on the eastern bank of the river. The tool traveled approximately 60 LF downstream as measured from the effluent wall of the siphon inlet manhole (approximate STA 3+50), collecting data, until an impassable obstruction(s) was encountered at approximate STA 2+90. Multiple unsuccessful attempts were made by PICA and the City to clear the obstruction(s). The obstruction(s) caused the inspection to be abandoned. Figure 5-4 displays the extents of the inspection.

Analysis of the inspection data obtained in the field yielded the following findings:

1. STA 3+50 – 3+38.6: No inspection data obtained due to the configuration of the Chimera tool
2. STA 3+38.6 - 3+28.9: Approximately 10 percent of the pipe wall of the steel cylinder is remaining

3. STA 3+28.9 - 2+90: Approximately 99 percent of the pipe wall of the steel cylinder is remaining

Based on the vertical alignment in the 1970 record drawings, the pipeline’s hydraulics are such that it is anticipated that the entire pipeline was not fully submerged during operation of the pipeline. Areas above the invert elevation of the siphon outlet (EL 51.50) were very likely to have been subjected to corrosive environments, including H₂S gases. The elevation at STA 3+28.9 corresponds to an approximate elevation of 51.50. Thus, it can be concluded that the pipe from STA 3+50 – 3+38.6 is in similar deteriorated condition to that of STA 3+38.6 – 3+28.9.

Based on the inspections, condition assessment, and analysis performed, it has been determined that the pipeline has not held its integrity. If the pipeline is to be reinstated for wastewater conveyance, renewal of the pipeline via rehabilitation, repair, or replacement is needed from STA 3+50 – STA 3+28.9. Additionally, the pipeline will require cleaning to remove the obstruction(s) and allow inspection, condition assessment, and analysis of the pipeline downstream of STA 2+90. A copy of the PICA report is located in Appendix G.
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EXISTING 18" W.S. PIPE AND 10" W.S. PIPE TO BE PLUGGED AT BOTH ENDS AT COMPLETION OF PROJECT

99% wall remaining of embedded steel cylinder remaining in this section.
Section length = 38.9 LF

10% wall remaining of embedded steel cylinder remaining in this section.
Section length = 9.7 LF

No inspection data obtained due to configuration of the inspection tool.
Section length = 11.4 LF

Figure 5-4. Shackelford Siphon Plan and Profile
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5.4.2 Siphon Structure Inspection

Select siphon structure inspections provided some preliminary information on the condition of the siphons at each end. Table 5-6 summarizes the results of the surface inspections of these structures and any ratings of the siphon pipes from PoleCam photographs.

<table>
<thead>
<tr>
<th>Siphon</th>
<th>Upstream Structure</th>
<th>Manhole Condition Rating</th>
<th>Downstream Structure</th>
<th>Manhole Condition Rating</th>
<th>PoleCam Rating of Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shackelford</td>
<td>SSMH0504091203</td>
<td>Severe</td>
<td>SSMH0504091106</td>
<td>Severe</td>
<td>N/A</td>
</tr>
<tr>
<td>Thousand Oaks</td>
<td>SSMH2703090501</td>
<td>Severe</td>
<td>SSMH2703090503</td>
<td>Mild</td>
<td>Mild</td>
</tr>
<tr>
<td>River Trunk</td>
<td>SSMH3303091004</td>
<td>Severe</td>
<td>SSMH3303091005</td>
<td>Mild</td>
<td>Unable to view pipes due to surcharging and/or grease.</td>
</tr>
<tr>
<td>Cannery Segregation</td>
<td>SSMH3303090706</td>
<td>Not Accessible</td>
<td>SSMH3303090607</td>
<td>Not Inspected</td>
<td>N/A</td>
</tr>
<tr>
<td>South Trunk</td>
<td>SSMH0804090103</td>
<td>Moderate</td>
<td>SSMH0804090102</td>
<td>Mild</td>
<td>Unable to view well due to grease build up.</td>
</tr>
</tbody>
</table>

Based on the surface manhole inspections, manholes SSMH0504091203 and SSMH0504091106 (Shackelford) and SSMH3303091004 (River) are recommended for rehabilitation. Manhole inspection observations at these manholes included heavy corrosion and deterioration of the manhole wall.

The Thousand Oaks Siphon Structures were in fair condition; however, PoleCam photographs revealed heavy deterioration in the adjacent pipes. PoleCam photographs of SSMH2703090501 are displayed below in Photographs 5-9 and 5-10.

Photograph 5-9. SSMH2703090501: Adjacent Pipe View with Aggregate Projecting and Possibly Missing

Photograph 5-10. SSMH2703090501: Heavy Deterioration of Adjacent Pipe Wall
The remaining siphon pipes could not be viewed due to grease build up or surcharging of the manholes. At a minimum, the Thousand Oaks siphon should be inspected further and will likely require rehabilitation in areas that are frequently not submerged. Additionally, the Can-Seg siphon structures should be inspected to determine the general condition of the structures as an indication of the siphon condition.

5.5 Woodland Lift Station Inspection and Assessment Results

This section provides background information on the Woodland Lift Station and discusses the condition assessment procedures, results from the condition assessment, and recommendations.

5.5.1 Woodland Lift Station Background

The Woodland Lift Station is one of 40 lift stations that the City of Modesto owns and operates. The Woodland Lift Station is located on the northeast corner of Woodland Avenue and Poust Road in a residential area with homes very near the property line. It was originally built in 1968 with major rehabilitation of the pumps and electrical equipment occurring over several projects in the 1990s.

The entrance to the Woodland Lift Station is from Poust Road. A chain-link fence with PVC slats and vegetation surrounds the site and provides a visual screen from the street and the next-door neighbors. Asphalt pavement surrounds the Lift Station Building and additional vegetation is located on the south side of the property.

Two above grade masonry block structures provide access to the wet well and dry well where the pumps are located. The above grade structures are separated by an open mezzanine area.

Raw sewage from the West Trunk Sewer enters the Woodland Lift Station in a 51-inch RCP and it is pumped approximately 100 feet in a 36-inch welded steel force main to a manhole on the south side of Woodland Avenue. The raw sewage then gravity flows to the Sutter Avenue Plant where it receives primary treatment. Originally, the raw sewage at the Woodland Lift Station was screened with a manual bar rack prior to being pumped but the screen was removed for safety reasons.

The Woodland Lift Station is a wet well/dry well configuration with five pumps. Pump 1 is 2,000 gallons per minute (gpm), Pump 2 is 3,500 gpm and Pumps 3, 4, and 5 are each 4,500 gpm. The pumps range from 25 to 50 horsepower and are manufactured by Wemco. The firm pumping capacity of the Woodland Lift Station based on the pump nameplate data is 14,500 gpm with one of the largest pumps out of service and the peak pumping capacity with all pumps in service is 19,000 gpm.

The electrical equipment is located on an intermediate floor below grade. A 150 kilowatt (kW) generator manufactured by Onan provides standby power. The diesel fuel for the standby generator is located below the standby generator. The standby generator only has capacity to operate three of the five pumps. A load bank with a resistive capacity of 150 kW accompanies the standby generator.

Odor control for the Woodland Lift Station is provided by a soil bed filter.

5.5.2 Lift Station Condition Assessment

The evaluation of the lift stations included development of an inspection form to be used for the field investigation, field investigations at the lift station with City maintenance staff familiar with the maintenance history of the lift station, and rating the lift station.

Four documents were reviewed as part of the condition assessment. The documents reviewed included:

- Collection System Condition Assessment, August 2005 – Carollo Engineers
• Wastewater Collection System Master Plan, March 2007 – Carollo Engineers
• O&M Comments on the Woodland Lift Station
• Draft Wastewater Collection System Master Plan, November 2015 – Carollo Engineers

The following items were recommended for consideration at the Woodland Lift Station as part of these reports.

1. Install new motor control centers (MCC) and relocate them above grade to reduce the potential for the MCCs to be flooded
2. Install awning between the above grade structures for weather protection from rain and sun
3. Provide additional site lighting and replace interior lighting
4. Replace pumps and valves on pumps and valves that have reached the end of their useful life
5. Replace sluice gate that isolates wet well from the collection system
6. Install a hatch for better access to the influent manhole
7. Inspect and replace media in the soil bed filter used for odor control
8. Repair asphalt on the site

The pumps and valve replacement have been or are planned for completion by the City.

5.5.3 Lift Station Investigation Procedures

Investigation forms and procedures for the condition assessment were developed by BC prior to the lift station investigation. A description of the forms is provided in the following sections.

5.5.3.1 Condition Assessment Forms

The forms were developed to capture specific information on the physical condition and reliability of each lift station investigated based on a visual inspection of the equipment and discussion with City staff familiar with the operation and maintenance of the Woodland Lift Station. The forms are based on condition assessment forms used on other BC projects and customized to capture specific information needed for this project.

Condition and reliability data collected on the forms is grouped into the following categories:

Inventory Confirmation

Basic information provided by the City in the lift station inventory was confirmed during the site visits and included the following items:
• Number of pumps
• Standby power
• Pump controls
• Other equipment such as odor control facilities, hoists, flow meter, etc.
• Site Condition

Site conditions included the following items:
• Access
• Turf/landscaping maintenance.
• Future expansion (proximity to residents and pedestrian access).
• Fall Protection - Occupational Safety and Health Act (OSHA) Standard 1926.501(b)(1) states “Each employee on a walking/working surface (horizontal and vertical surface) with an
unprotected side or edge which is 6 feet or more above a lower level shall be protected from falling by the use of guardrail systems, safety net systems, or personal fall arrest systems”.

**Structural Condition**

Deteriorated structural condition can lead to staff injuries or overflows if the lift station fails. Structural conditions were completed visually in the dry well but because of safety concerns, the wet well was not inspected. The following items were visually observed:

- Dry well/wet well corrosion.
- Building condition including walls, finish, roof, doors, windows, etc.
- Metal corrosion (hatches, railings, etc.).
- Equipment layout (e.g., sufficient working space).

**Pumping System**

The pumping system was visually investigated where access was available to identify specific reliability problems. It should be noted that the pumping system operation was observed under the conditions occurring at the time of the investigation (dry weather flow) and could significantly vary under peak wet weather flow conditions. City staff provided additional information about previous operational problems. The following pumping system components were part of the assessment:

- Pump operation including vibration, cavitation, bearing noise, and motor temperature (assessment of these items was based on conversations with City staff; physical measurements were not performed).
- Pump suction and discharge piping and valves.

**Standby Generator**

Standby generators are one of the primary sources of redundancy in a lift station. The following components of the standby generator system were part of the condition assessment:

- Standby generator size
- Fuel tank storage and spill containment
- Portable generator connections
- Automatic transfer switch

**Electrical and Instrumentation and Control System**

Electrical systems include power systems and control systems. These systems can become antiquated and obsolete sooner than other equipment at a lift station. These systems can become difficult to maintain and find spare parts for, which increases the risk of a failure. Observations of the electrical system were made by visual investigation and discussion with City staff. An operational assessment of the electrical power and control systems was not performed. The following electrical components were part of the condition assessment:

- Motor control center (MCC) and power
- Lighting (power)
- Controls (control)
- Alarms and sensors (control)
**Other Mechanical Systems**

These systems do not generally lead to a pumping system failure. However, the condition of these systems will factor into the overall assessment in determining if a lift station is part of an improvement project. The following components were part of the condition assessment:

- Heating, ventilation, and cooling (HVAC).
- Odor control facilities.
- Auxiliary equipment such as hoists and bar screens.

The condition assessment forms have a condition and functional system rating for each group. The ratings are from one to five. A general definition of the ratings is as follows:

- **Rating 5** - Structure or equipment integrity severely compromised by corrosion and wear or systems are unreliable. Possible imminent failure. Structure or equipment is not currently functioning for its intended use.
- **Rating 4** - Structure or equipment integrity is compromised. Structure or equipment is in service but function or reliability is compromised.
- **Rating 3** - Visible degradation of equipment or structure. Structure or equipment is in service but maintenance or operational requirements are excessive.
- **Rating 2** - Well maintained, like-new condition of equipment or structure. Structure or equipment functions as intended.
- **Rating 1** - New or nearly-new structure or equipment. Structure or equipment functions like new equipment.

**Hydraulic Institute Standards**

The American National Standards Institute/Hydraulic Institute (ANSI/HI) has developed standards for pumps and pumping stations. The ANSI/HI Standards were created to help eliminate misunderstandings related to pump performance between the manufacturer and the end user and to provide guidance on pump selection. Pumps and pumping stations that do not meet ANSI/HI Standards may not meet flow and pressure requirements, have higher power consumption, require greater maintenance, and have reduced service life than pumps and pumping stations that do meet the ANSI/HI Standards. Compliance with the ANSI/HI Standards are voluntary but are recognized as an industry standard. For this evaluation, the following items were assessed:

- Wet well configuration
- Approach conditions for pump inlets
- Suction/discharge pipe and valve configuration

**5.5.4 Lift Station Condition Assessment**

Condition and reliability assessments were performed by a two-person BC crew with assistance from City operation and maintenance staff. Lift station condition assessment occurred on December 1, 2015. A condition assessment form was completed for the lift station and photos were taken to document the condition of the lift station.

The visual condition assessments focused on obtaining the information needed to complete the condition assessment forms and determine the overall condition of the lift station. Consequently, performance testing of the lift station systems including electrical control and SCADA systems, standby generators, sump pumps, seal water systems, and odor control systems were not included. Similarly, the pumps were not tested for vibration or bearing problems. These systems are either in on-going operation or operated/tested as part of the regular operations and maintenance program.
For example, standby generator testing and exercising is a part of the City’s operation and maintenance program. Issues related to the performance of these systems were provided by City staff. Also, maintenance histories were discussed with City staff to identify chronic or acute problems with these systems that may require an improvement project to address.

The wet well wall was visually observed from the ground surface during the site visit and was not entered because of safety concerns.

### 5.5.5 Lift Station Condition Assessment Observations

The following condition assessment observations were made during the lift station investigation. Photos from the condition assessment are located at the end of this section.

- The majority of the Woodland Lift Station is in good condition for a structure nearly fifty years old.
- The lift station is a wet well/dry well configuration.
- Access to the lift station is acceptable and a City truck can drive completely around the lift station building. Large vehicles cannot drive completed around the building.
- Site drainage is adequate except for between the two above grade structures. The asphalt on the site needs to be repaired.
- The lift station is surrounded by a chain-link fence. One break-in has occurred at the lift station.
- The lift station does not have adequate site lighting and the interior lighting needs to be replaced.
- The influent isolation gate leaks or the concrete around the gate has corroded causing the leak. See Photograph 5-11.
- The wet well interior concrete structure and fiberglass stairs are severely corroded. The wet well ventilation only draws air from the wet well and does not have “fresh air” supply ventilation. The wet well ventilation system may not be adequately sized. See Photograph 5-12.
- The original manual bar screen in the wet well was removed because of safety concerns. The Wemco style pumps are able to pump the debris that the lift station experiences but they have clogged on occasion.
- All the pumps are Wemco style pumps. Based on the Draft 2015 Collection System Master Plan, the pump station has adequate capacity for the existing peak wet weather flow but does not have sufficient capacity for future peak wet weather flow. See Photograph 5-13.
- The dry well has limited space to perform maintenance on the pumps.
- The suction and discharge piping and valving configuration do not meet ANSI/HI standards. The straight run of pipe on the suction and discharge pipe for each pump is less than ANSI/HI standards. In addition, the check valve is located in the vertical position, which can allow debris to accumulate on the valve and prevent it from fully opening. See Photograph 5-14.
- The pump discharge manifold pipe is a 36-inch welded steel pipe and appears to be in good condition. See Photograph 5-15.
- Access for removal of equipment and valves from the dry well is acceptable. See Photograph 5-16.
- The site has not flooded but a broken pipe caused the dry well to flood. The dry well has one sump pump. See Photograph 5-17.
- The lift station does not have a flow meter on the force main.
- The MCCs are reaching the end of their useful life and are located on the intermediate floor, which exposes them to potential flooding. See Photograph 5-18.
- The standby generator and load bank are located outdoors. The diesel fuel storage is located below the standby generator and does not contain spill provisions. The standby generator is sized to only operate three pumps. See Photograph 5-19.
- Two ultrasonic level detectors are needed in the wet well to operate the five pumps because one ultrasonic level indicator does not have the ability to control all five pumps. Only one of the level controllers is connected to standby power.
- The dry well does not have gas detection equipment.
- Gas monitoring is not provided in the wet well.
- Mechanical ventilation in the dry well is provided and appears adequate. See Photograph 5-20.
- There have not been odor control complaints at the lift station.

Table 5-7 provides a summary table with each of the lift station categories rated from one to five. The completed forms are located in Appendix H.

<table>
<thead>
<tr>
<th>Condition Assessment Criteria</th>
<th>Overall Rating</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>2/3</td>
<td>Asphalt needs to be repaired at site.</td>
</tr>
<tr>
<td>Structural</td>
<td>3/4/5</td>
<td>Wet well has severe corrosion.</td>
</tr>
<tr>
<td>Pumps and Piping</td>
<td>3</td>
<td>Standby generator only sized to operate three pumps</td>
</tr>
<tr>
<td>Standby Power</td>
<td>3/4</td>
<td>Standby generator only sized to operate three pumps</td>
</tr>
<tr>
<td>Electrical Power</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Control System</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>HVAC</td>
<td>3/4</td>
<td>Wet well should have &quot;fresh-air&quot; supply and increase in ventilation rate to reduce corrosion.</td>
</tr>
<tr>
<td>Odor Control</td>
<td>3/4</td>
<td>The odor control soil media should be replaced.</td>
</tr>
<tr>
<td>Auxiliary Equipment</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Redundancy</td>
<td>3</td>
<td>Redundancy provided for current flows but not future peak wet weather flows.</td>
</tr>
<tr>
<td>Maintenance</td>
<td>2</td>
<td>The lift station is well maintained.</td>
</tr>
</tbody>
</table>

**Notes:**
- **Rating 5**: Structure or equipment integrity severely compromised by corrosion and wear or systems are unreliable. Possible imminent failure. Structure or equipment is not currently functioning for its intended use.
- **Rating 4**: Structure or equipment integrity is compromised. Structure or equipment is in service but function or reliability is compromised.
- **Rating 3**: Visible degradation of equipment or structure. Structure or equipment is in service but maintenance or operational requirements are excessive.
- **Rating 2**: Well maintained, like-new condition of equipment or structure. Structure or equipment functions as intended.
- **Rating 1**: New or nearly new structure or equipment. Structure or equipment functions like a new equipment.
5.5.6 Woodland Lift Station Recommendations

Based on the observations from the condition assessment, discussions with operation and maintenance staff from the City and review of past reports, the following improvements are recommended:

- The corroded concrete in the wet well should be repaired. The wet well could not be inspected as part of this condition assessment because of safety concerns. The wet well should be inspected to determine the extent of damage to the concrete. Bypass pumping will be required to complete the inspection and rehabilitation.
- Repair the concrete around the frame or replace the leaking isolation gate for the wet well. The isolation gate could not be inspected as part of this condition assessment because of safety concerns. The isolation gate should be inspected to determine the extent of repairs needed. Bypass pumping will be required to complete the inspection and rehabilitation.
- Replace the fiberglass stairs into the wet well.
- Replace the MCCs and consider moving the MCCs to an above grade location.
- The standby generator size should be increased to operate all five pumps during a power outage. Spill provisions for diesel fuel should be provided to contain any spills of diesel fuel.
- Provide a “fresh-air” supply ventilation into the wet well and replace the existing exhaust foul air fans with exhaust fans that can provide at least 20 air exchanges per hour to reduce the level of corrosion in the wet well.
- Install an awning over the area between the above grade structures at the lift station to protect the area from rain and sun.
- Improve the site lighting and replace the interior lighting.
- A second sump pump should be added to the dry well to provide a redundant pump.
- Replace the 2,000 and 3,500 gpm pump per the Collection System Master Plan schedule to meet future peak wet well flow requirements.
- Consider adding a flow meter to the pump station. The flow meter can provide input into trouble shooting pump performance.
- Repair the asphalt on the site.
- The suction and discharge piping do not meet Hydraulic Institute standards. This can affect pumping capacity and pump service life. When a major rehabilitation occurs at the lift station, the suction and discharge piping configuration should be reviewed and improvements completed to meet Hydraulic Institute standards where feasible.
- The wet well does not meet Hydraulic Institute standards. This can affect pumping capacity and pump service life. When a major rehabilitation occurs at the lift station, the wet well configuration should be reviewed and improvements completed to meet Hydraulic Institute standards where feasible.
- Consider additional security measures for the exterior fence to improve overall site security.

The following items are recommended for additional investigation:

- A capacity and pump performance analysis of each pump should be completed to confirm the pumping capacity. City operation maintenance staff indicated the lift station has adequate capacity for current flows but this should be verified for future peak wet weather flows with a capacity analysis.
- When the standby generator is replaced with a larger generator, an analysis on diesel fuel storage capacity should be completed.
- Complete a structural seismic analysis to determine improvements to the structures to meet updated building codes.
- A future lift station condition assessment, beyond current preventive maintenance activities and the recommendations for additional investigations, should be completed every ten years.
Photograph 5-19. Woodland Lift Station 150 kW Generator – Only sized for Three Pumps

Photograph 5-20. Woodland Lift Station Odor Control Fans
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Section 6

Capital Improvement Plan

6.1 Introduction

Each pipe reach or manhole requiring repair, rehabilitation or replacement within the next ten years was organized into a ten-year CIP. The individual pipe reaches were assigned a structural condition rating (Sections 2 and 4) and organized into rehabilitation projects based on logical and economic groupings. Then, each project was assigned a priority rating based on COF and urgency of repair to develop the ten-year CIP. The following sections present the formulation of projects; repair, rehabilitation, and replacement costs; prioritization; and a summary of the ten-year CIP.

6.2 Formulation of Projects

As noted above, only a representative selection of trunk sewer pipelines and manholes were visually inspected. This section describes how inspection data and other data were extrapolated to assign structural condition ratings to pipelines that were not visually inspected.

There are 1,240 pipeline reaches (manhole to manhole) in the trunk sewer system as defined above (i.e., >16-inch diameter). Each pipeline reach was assigned a final structural condition rating based on its LOF. This LOF comes from the system described below, which is ranked in order of highest confidence to lowest confidence (in parentheses is the approximate number of pipes that received their ratings from each method):

1. Visual interior inspection, Panoramo or CCTV (165)
2. Visual inspection from upstream or downstream manhole, Polecam (224)
3. Peak LOF from Section 2.5, initial pipeline LOF (851)

The final ratings also reflect additional adjustments made to pipelines that are known to have been rehabilitated, i.e., lined or replaced, with corrosion resistant materials.

Since almost 75 percent of final pipe LOFs were assigned using the third method, the confidence level of this method was further evaluated by comparing pre-inspection LOF ratings with final LOF ratings that are based on visual inspections. The sample set included about 390 pipes that were visually inspected (Panoramo, CCTV or Polecam). Initial and final ratings were compared on a 1-3-5 scale (mild-moderate-severe) that corresponds to the pipeline structural Condition Grade. Data shows the following:

- Approximately 75 percent of the time, the initial rating either matched the final rating or was one level too high (i.e., conservative)
- Approximately 12 percent of the time, the initial rating was one level too low
- Approximately 12 percent of the time, the initial rating was two levels too high (five turned out to be a one)
- Seven times (<two percent), the initial rating was two levels too low (one turned out to be a five)

Based on this analysis, the pre-inspection LOF ratings were generally in agreement with the revised LOF ratings using visual inspection methods. Even though confidence in the third method is relatively high based on the data, pipelines that are recommended for rehabilitation based only on this rating,
and not on one of the visual inspection methods, should be fully inspected using Panoramo or CCTV during the capital project preliminary design phase. In addition, further inspections of pre-inspection LOF ratings of medium to high should be conducted to establish a baseline condition of these sewers as pre-inspection LOF and criticality ratings are not always indicative of actual field conditions.

Figure 6-1 displays the revised LOF ratings based on visual inspection data available from previous studies and this project as the primarily LOF rating. The pre-inspection LOF rating is also display as a secondary rating to facilitate the formulation of CIPs. If pipes were given a moderate to severe pre-inspection LOF and were adjacent to moderate to severe inspected pipes, then they were included in an overall capital improvement project. Projects formed based on identifying areas with a high consequence of failure and generally along the same trunk line.
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6.3 Repair, Rehabilitation and Replacement Costs

Costs presented in this section include unit costs, pipeline construction unit costs, and total capital costs.

6.3.1 Unit Costs

Unit prices for pipeline and manhole rehabilitation were developed by analyzing costs of similar projects in Northern California, Reno, Nevada and Tempe, Arizona and with input from pipe vendors. Cost information was escalated by the July, 2015 Engineering News Report Construction Cost Index (ENRCCI) for the San Francisco Bay Area (11.155.07).

Unit costs per inch diameter per linear foot ($/in-diam.-foot) are displayed below in Table 6-1. These unit prices were utilized to develop CIP project construction costs.

<table>
<thead>
<tr>
<th>Method</th>
<th>$/inch-diam.-foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slipline</td>
<td>$5.27</td>
</tr>
<tr>
<td>CIPP</td>
<td>$7.16</td>
</tr>
<tr>
<td>Pipe burst</td>
<td>$18.66</td>
</tr>
<tr>
<td>Open Cut</td>
<td>$24.22</td>
</tr>
</tbody>
</table>

6.3.2 Pipeline Construction Costs

Table 6-2 presents construction costs per linear foot (rounded up to the nearest dollar) for a range of construction methods and pipe diameters using the costs presented in Table 6-1. Costs include all direct construction-related activities, including mobilization, pipeline and manhole construction, traffic control, and bypass pumping; they do not include procurement of permanent or temporary easements.

<table>
<thead>
<tr>
<th>Diameter, inches</th>
<th>Slipline, $/lf</th>
<th>CIPP, $/lf</th>
<th>Pipe Burst, $/lf</th>
<th>Open Cut, $/lf</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>$85</td>
<td>$115</td>
<td>$299</td>
<td>$388</td>
</tr>
<tr>
<td>18</td>
<td>$95</td>
<td>$129</td>
<td>$336</td>
<td>$437</td>
</tr>
<tr>
<td>21</td>
<td>$111</td>
<td>$151</td>
<td>$392</td>
<td>$509</td>
</tr>
<tr>
<td>24</td>
<td>$127</td>
<td>$172</td>
<td>$448</td>
<td>$582</td>
</tr>
<tr>
<td>27</td>
<td>$143</td>
<td>$194</td>
<td>$504</td>
<td>$655</td>
</tr>
<tr>
<td>30</td>
<td>$159</td>
<td>$215</td>
<td>$560</td>
<td>$727</td>
</tr>
<tr>
<td>33</td>
<td>$175</td>
<td>$237</td>
<td>$616</td>
<td>$800</td>
</tr>
<tr>
<td>36</td>
<td>$190</td>
<td>$258</td>
<td>$672</td>
<td>$873</td>
</tr>
<tr>
<td>39</td>
<td>$206</td>
<td>$280</td>
<td>$728</td>
<td>$945</td>
</tr>
<tr>
<td>42</td>
<td>$222</td>
<td>$301</td>
<td>$784</td>
<td>$1,018</td>
</tr>
</tbody>
</table>
### Table 6.2. Pipeline Construction Unit Costs

<table>
<thead>
<tr>
<th>Diameter, inches</th>
<th>Slipline, $/lf</th>
<th>CIPP, $/lf</th>
<th>Pipe Burst, $/lf</th>
<th>Open Cut, $/lf</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>$238</td>
<td>$323</td>
<td>$840</td>
<td>$1,091</td>
</tr>
<tr>
<td>48</td>
<td>$254</td>
<td>$344</td>
<td>$896</td>
<td>$1,163</td>
</tr>
<tr>
<td>51</td>
<td>$270</td>
<td>$366</td>
<td>$952</td>
<td>$1,236</td>
</tr>
<tr>
<td>54</td>
<td>$285</td>
<td>$387</td>
<td>$1,008</td>
<td>$1,309</td>
</tr>
<tr>
<td>60</td>
<td>$317</td>
<td>$430</td>
<td>$1,120</td>
<td>$1,454</td>
</tr>
<tr>
<td>66</td>
<td>$349</td>
<td>$473</td>
<td>$1,232</td>
<td>$1,599</td>
</tr>
<tr>
<td>72</td>
<td>$380</td>
<td>$516</td>
<td>$1,344</td>
<td>$1,745</td>
</tr>
<tr>
<td>84</td>
<td>$444</td>
<td>$602</td>
<td>$1,568</td>
<td>$2,035</td>
</tr>
</tbody>
</table>

The markups shown in Table 6-3, based on similar projects, were applied to the mobilization, overall rehabilitation costs, bypassing, and traffic control to yield the construction costs for each project.

### Table 6.3. Estimate Markups

<table>
<thead>
<tr>
<th>Item</th>
<th>Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Cost Markups</td>
<td></td>
</tr>
<tr>
<td>Labor, materials, subcontractor, sales tax, equipment, and shipping and handling</td>
<td>8</td>
</tr>
<tr>
<td>Gross Cost Markups</td>
<td></td>
</tr>
<tr>
<td>Contractor general conditions</td>
<td>10</td>
</tr>
<tr>
<td>Contingency</td>
<td>35</td>
</tr>
<tr>
<td>Bonds and insurance</td>
<td>3.5</td>
</tr>
</tbody>
</table>

#### 6.3.3 Total Capital Costs

Total capital costs presented in the remaining subsections herein were developed by adding 30 percent to construction costs as an allowance for engineering design, legal and administrative costs.

#### 6.4 Prioritization of Repairs and Rehabilitation

In Section 5, pipeline reaches with a structural rating of “Severe” (i.e., with grade 4 and/or 5 defects) were indicated as needing repair, rehabilitation or replacement within ten years. A combination of the pipe condition rating (Section 4) and criticality rating (Section 2) was used to determine Rehabilitation Levels. The levels of rehabilitation represent the time frame that repair, rehabilitation or replacement is recommended. Four priority levels were assigned to the “Severe” reaches. The four priority levels are listed below:

- **Level A** – Repair/rehabilitation should be completed as soon as possible.
- **Level B** – Repair/rehabilitation should be completed within three years.
- **Level C** – Repair/rehabilitation should be completed within three to five years.
- **Level D** – Repair/rehabilitation should be completed within five to ten years.
The levels are used to establish prioritized CIPs to address the repairs and rehabilitation and their scheduling over the course of the next ten years.

### 6.4.1 Capital Improvement Plan

Projects were identified based on the type of defect, repair/rehabilitation method, size of pipe, location and criticality. Table 6-4 and Figure 6-2 summarize recommended projects and their priority level and cost. The project number contains “A,” “B” or “C” as a designation representing the priority levels. Detailed descriptions, capital cost calculations, and location maps of each individual project are provided in Appendix I.

<table>
<thead>
<tr>
<th>Project No.</th>
<th>Project Segment (Start Manhole to End Manhole)¹</th>
<th>Recommended Method of Repair</th>
<th>Pipe Sizes (in)</th>
<th>Trunk(s) or Tributaries</th>
<th>Total Length (ft)</th>
<th>Capital Costs²</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>SSNH2703090115 to SSNH3303090704</td>
<td>CIPP</td>
<td>16 - 30</td>
<td>Rose/Celeste Trunk</td>
<td>8,707</td>
<td>$5,349,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Santa Rosa Trunk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-2</td>
<td>SSNH0604091603 to SSNH0504091306</td>
<td>CIPP</td>
<td>24 - 33</td>
<td>Sutter Trunk</td>
<td>2,111</td>
<td>$1,424,000</td>
</tr>
<tr>
<td></td>
<td>SSNH0804091003 to SSNH0504091307</td>
<td></td>
<td></td>
<td>South Trunk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-3</td>
<td>SSNH1903091002 to SSNH1903091521</td>
<td>CIPP</td>
<td>18</td>
<td>Emerald Trunk/</td>
<td>2,957</td>
<td>$1,567,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Northwest Tributary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-4</td>
<td>SSNH2603090301 to SSNH2603090402</td>
<td>CIPP</td>
<td>33-36</td>
<td>Sonoma Trunk</td>
<td>8,932</td>
<td>$6,955,000</td>
</tr>
<tr>
<td></td>
<td>SSNH2303091619 to SSNH2503091305</td>
<td></td>
<td></td>
<td>Lakewood Trunk</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>SUB-TOTAL OF “A” PROJECT COSTS =</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$15,295,000</td>
</tr>
<tr>
<td>B-1</td>
<td>SSNH0804091201 to SSNH0504091202</td>
<td>CIPP</td>
<td>30</td>
<td>Ceres Trunk/South</td>
<td>5,620</td>
<td>$3,794,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Modesto Tributary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B-2</td>
<td>SSNH2503080106 to SSNH3003090712</td>
<td>CIPP³</td>
<td>18 - 27</td>
<td>West Trunk/Emerald</td>
<td>7,436</td>
<td>$4,270,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>South Tributary</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>SUB-TOTAL OF “B” PROJECT COSTS =</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$8,064,000</td>
</tr>
<tr>
<td>C-1</td>
<td>SSNH2503080105 to Dryden Box</td>
<td>Sliping or CIPP</td>
<td>54 - 60</td>
<td>West Trunk</td>
<td>25,893</td>
<td>$18,934,000 (Sliping Only) $27,550,000 (CIPP Only)</td>
</tr>
<tr>
<td>C-2</td>
<td>SSNH2903091315 to SSNH2903091310</td>
<td>CIPP</td>
<td>18</td>
<td>Sutter Trunk</td>
<td>374</td>
<td>$379,000</td>
</tr>
<tr>
<td>C-3</td>
<td>SSNH2903090905 to SSNH2903091414</td>
<td>CIPP</td>
<td>27</td>
<td>Downtown Tributary</td>
<td>3,289</td>
<td>$2,062,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>SUB-TOTAL OF “C” PROJECT COSTS =</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$21,375,000 (Sliping/CIPP) $29,991,000 (CIPP Only)</td>
</tr>
</tbody>
</table>

¹ Numbers followed by “S” are sanitary, SMI = Sanitary Manhole Inlet, SMO = Sanitary Manhole Outlet

² Capital Cost includes materials, labor, equipment, and contingencies

³ Sliping and CIPP are alternative technologies and can be used interchangeably.
### Table 6.4. Summary of Sewer Rehabilitation Costs

<table>
<thead>
<tr>
<th>Project No.</th>
<th>Project Segment (Start Manhole to End Manhole)</th>
<th>Recommended Method of Repair</th>
<th>Pipe Sizes (in)</th>
<th>Trunk(s) or Tributaries</th>
<th>Total Length (ft)</th>
<th>Capital Costs $</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-1</td>
<td>SSMH3303090541 to SSMH3303090618</td>
<td>CIPP</td>
<td>27</td>
<td>Downtown Tributary</td>
<td>1,480</td>
<td>$1,060,000</td>
</tr>
<tr>
<td>D-2</td>
<td>SSMH1703091315 to SSMH1703091316</td>
<td>CIPP</td>
<td>30</td>
<td>Emerald Trunk</td>
<td>110</td>
<td>$320,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>SUB-TOTAL OF “D” PROJECT COSTS =</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>TOTAL 10-YEAR CAPITAL IMPROVEMENT PLAN COST =</strong></td>
</tr>
</tbody>
</table>

**Notes:**

1. See Figure ES-5 for extents of project.
2. Costs are for planning purposes only and were developed based rehabilitation projects constructed within the past five years.
3. Slip lining rehabilitation methods considered for all pipe diameters 36 inches or larger. Project costs were calculated with a combination of slip lining and CIPP or CIPP only.
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Section 7

Additional Recommendations

During the investigation there were some additional concerns that should be addressed. These items are not a priority relative to the rehabilitation projects identified in Section 6, but should be addressed by City staff.

7.1 Additional Pipeline Inspections

There are several unlined RCP reaches that should be further explored as part of the Trunk Sewer Condition Assessment program. The Rumble, Sonoma, and upper portions of Lakewood Trunk Sewers consist of unlined RCP that were not selected for inspection under this project due to their locations upstream of major pump stations and their age. Although these trunk sewers may not be as old as the other pipes within the City’s system, additional inspection along these trunks is recommended. At a minimum, PoleCam photographs may be taken on trunk manholes to obtain representative samples if CCTV cannot be performed along the entire trunk. PoleCam photographs can also help identify reaches that further investigation will be warranted.

7.2 Manhole Rehabilitation/Replacement

The following six manholes require rehabilitation or replacement. They are currently not grouped into a Capital Improvement Project or current City emergency repair projects due to their location and/or proximity to severe –rated pipes. These manholes are listed in Table 7-1.

<table>
<thead>
<tr>
<th>Manhole ID</th>
<th>Trunk Name/ (Street Name)</th>
<th>Assessment</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSMH3303090709</td>
<td>River Trunk</td>
<td>Manhole full of grease and surcharged to height of 41 inches from rim. Reinforcement within manhole projecting and corroded.</td>
<td>Rehabilitate soon.</td>
</tr>
<tr>
<td>SSMH0504091106</td>
<td>Ceres</td>
<td>Hole for bolt stripped out. Manhole surcharged. Reinforcement visible and corroded in wall and aggregate projecting.</td>
<td>Rehabilitate soon.</td>
</tr>
<tr>
<td>SSMH0504091203</td>
<td>Ceres</td>
<td>Penetration test and hammer test resulted in determination of severe corrosion. Sediment estimate approximately 3 inches. Missing wall and corroded reinforcement observed.</td>
<td>Rehabilitate soon.</td>
</tr>
<tr>
<td>SSMH2303091620</td>
<td>Lakewood</td>
<td>Reinforcement visible and projecting. Heavy spalling.</td>
<td>Rehabilitate immediately.</td>
</tr>
<tr>
<td>SSMH2103090405</td>
<td>(E. Orangeburg Ave)</td>
<td>Walls spalling with reinforcement visible in the lower wall. Projecting aggregate in the chimney.</td>
<td>Perform spot repairs or rehabilitate soon.</td>
</tr>
<tr>
<td>SSMH3203090907</td>
<td>Sutter</td>
<td>Brick covered with cementitious coating. Coating deteriorating with brick exposed in lower half of the manhole. Missing brick with void and soil visible.</td>
<td>Rehabilitate immediately.</td>
</tr>
</tbody>
</table>
Manholes SSMH2303091620 and SSMH3203090907 are recommended for immediate rehabilitation. The remaining manholes are recommended for repair/rehabilitation soon. It is recommended that the manholes and pipes within the vicinity of the manholes listed above also be inspected.
Section 8

Limitations

This document was prepared solely for City of Modesto in accordance with professional standards at the time the services were performed and in accordance with the contract between City of Modesto and Brown and Caldwell dated March 24, 2015. This document is governed by the specific scope of work authorized by City of Modesto; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by City of Modesto and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.
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Section 9

References


National Association of Sewer Service Companies (NASSCO), *NASSCO Pipeline Assessment and Certification Program, Version 6.0.1*, NASSCO, Owings Mills, MD, November 2010, Page numbers 1-362.


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