



**CARMEL AREA WASTEWATER DISTRICT**

# Wastewater Collection System Asset Management Plan

**DECEMBER 2018**



**WEST YOST ASSOCIATES**

# Wastewater Collection System Asset Management Plan

Prepared for

## Carmel Area Wastewater District

Project No. 683-21-17-03



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- Appendix A: CCTV Defect Code List
- Appendix B: Detailed Gravity Sewer Risk Assessment Results
- Appendix C: Gravity Sewer Rehab/Replacement Program Details

### List of Acronyms and Abbreviations

|          |                                            |
|----------|--------------------------------------------|
| AMP      | Asset Management Plan                      |
| ARV      | Air Relief Valve                           |
| BEM      | Broadband Electro-Magnetic                 |
| CCTV     | Closed-Circuit Television                  |
| CIP      | Cast Iron Pipe                             |
| CIPP     | Cured-in-Place Pipe                        |
| CIWQS    | California Integrated Water Quality System |
| CMMS     | Computerized Maintenance Management System |
| District | Carmel Area Wastewater District            |
| ENR      | Engineering New Record                     |
| FEMA     | Federal Emergency Management Agency        |



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|           |                                                 |
|-----------|-------------------------------------------------|
| GIS       | Graphic Information System                      |
| HDPE      | Joint High-Density Polyethylene                 |
| HDPE      | High-Density Polyethylene                       |
| M         | Million Dollars                                 |
| MFL       | Magnetic Flux Leakage                           |
| MWLS      | Mean Water Levels                               |
| NASSCO    | National Association of Sewer Service Companies |
| PACP      | Pipeline Assessment Certification Program       |
| PVC       | Polyvinylchloride                               |
| RFEC      | Remote Field Eddy Current                       |
| SCADA     | Supervisory Control and Data Acquisition        |
| SSO       | Sanitary Sewer Overflow                         |
| VCP       | Vitrified Clay Pipe                             |
| VRV       | Vacuum Relief Valve                             |
| West Yost | West Yost Associates                            |

# Wastewater Collection System Asset Management Plan

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## 1.0 INTRODUCTION

This report presents the Asset Management Plan (AMP) for the Carmel Area Wastewater District's (District) existing wastewater collection system infrastructure. Like public agencies everywhere, the District is facing important challenges in managing aging collection system infrastructure and balancing utility services and costs. The decision between maintaining individual collection system assets versus repairing or replacing them involves many factors such as capital and long-term costs and the risk of potential failures.

This AMP includes three major asset classes in the collection system: gravity sewers, pump stations, and force mains. While the District is operating at different stages of asset management with each of these three asset classes (with gravity sewers being the most mature program), the intent of this AMP is to document the current status of each facet of the collection system program and provide recommendations for future improvements and next steps. Manholes, the fourth asset class, are not separately assessed at this time, but can generally be considered similar in condition and risk to the adjacent gravity sewers.

### 1.1 Purpose and Organization

The goal of this AMP is to use a robust risk assessment process to prioritize a long-term Rehabilitation and Replacement Program (Rehab/Replacement) for gravity sewers, pump stations, and force mains.

The major elements of this report include the following:

- Section 1 Introduction
- Section 2 Gravity Sewer Asset Management Plan
- Section 3 Pump Station Asset Management Plan
- Section 4 Force Main Asset Management Plan
- Section 5 Summary and Next Steps

### 1.2 Information Sources

The following information sources were provided by the District and were used for this analysis:

- Carmel Area Wastewater District Geographic Information System, provided in December 2016 and partially supplemented in July 2018 (District GIS)
- Closed-circuit television (CCTV) inspection records database *Carmel, CA FULL PACP.mdb*, provided on March 20, 2018
- Carmel Area Wastewater District ICOMM asset registry and related *Age of Sewers at CAWD.xls* and *revised MH data.xls* (provided May 2018)



# Wastewater Collection System Asset Management Plan



- Sewer Repair Records (*2001 replaced.xls*, *Rehab since 2001.xls*, *Spot repairs.xlsx*), provided April 2018
- California Integrated Water Quality System Public Records (CIWQS database) and District Sanitary Sewer Overflow (SSO) records *SSO History.xls*, provided April 2018
- Carmel Area Wastewater District Draft Collection System Hydraulic Modeling Notebook by West Yost Associates, dated December 23, 2016
- Carmel Area Wastewater District Draft Collection System Hydraulic Modeling Phase 2 Notebook by West Yost Associates, dated June 29, 2018 and the associated hydraulic model output
- Pump Station Inspection Forms, provided on April 4, 2018
- Carmel Area Wastewater District Pump Station Evaluation Report of Observations by V&A Consulting Engineers, Inc. dated November 1999
- Carmel Area Wastewater District 2013 Sewer System Management Plan, dated October 2013
- Sewer System Record Drawings *ALL-AS-BUILT.pdf*, provided in March 2018

## 1.3 System Description

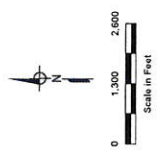
The District's wastewater collection system is comprised of approximately 77.3-miles of gravity sewers, seven pump stations, and approximately 4.4 miles of force mains (shown in Figure 1). The District currently has a fairly robust asset registry in its computerized maintenance management system (CMMS), ICOMM, which stores physical asset properties (including pipe diameter, material, and installation date), and maintenance work order history such as preventative maintenance schedules and blockage and SSO records. The District's graphic information system (GIS) is also populated with the geospatial coordinates of the collection system assets.

## 2.0 GRAVITY SEWER ASSET MANAGEMENT PLAN

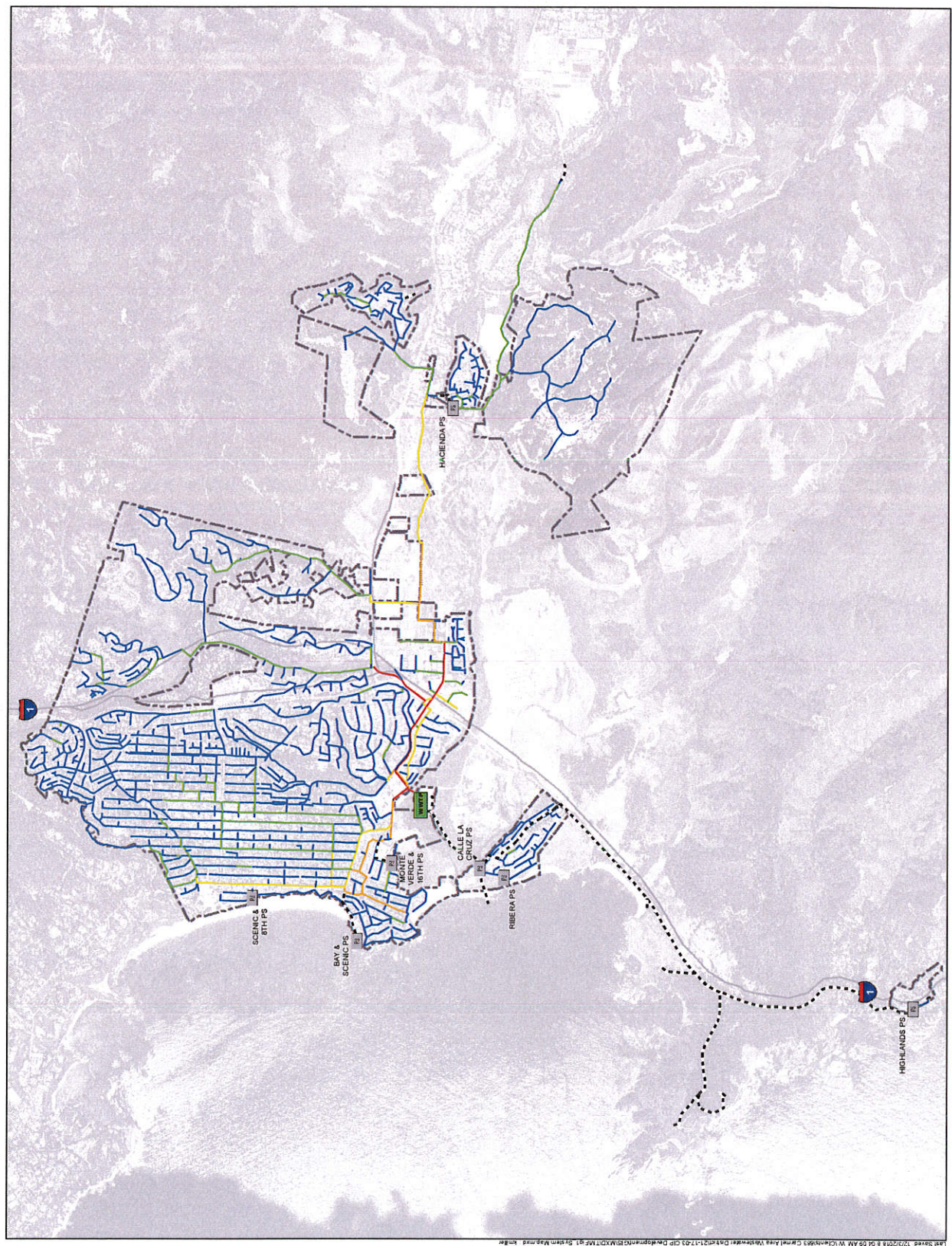
### 2.1 Gravity Main Asset Inventory

The majority of collection system's 77.3 miles of gravity sewer mains are composed of vitrified clay pipe (VCP) with newer installations being primarily constructed with polyvinylchloride (PVC) pipe, as shown in Table 1.

Figure 2 shows the installation decade of the gravity sewers in the collection system. The average gravity sewer age in the system as a whole is 59-years, indicating that a significant portion of the system is nearing the end of its useful life.



- Symbology**
- CAWD Service Area
  - Wastewater Treatment Plant
  - Pump Station
  - Force Main
- Gravity Main by Diameter**
- ≤ 6-inch
  - 8-inch
  - 10-inch
  - 12-inch
  - ≥ 15-inch



**Figure 1**  
**System Map**  
 Carmel Area Wastewater District  
 Wastewater Collection System  
 Asset Management Plan

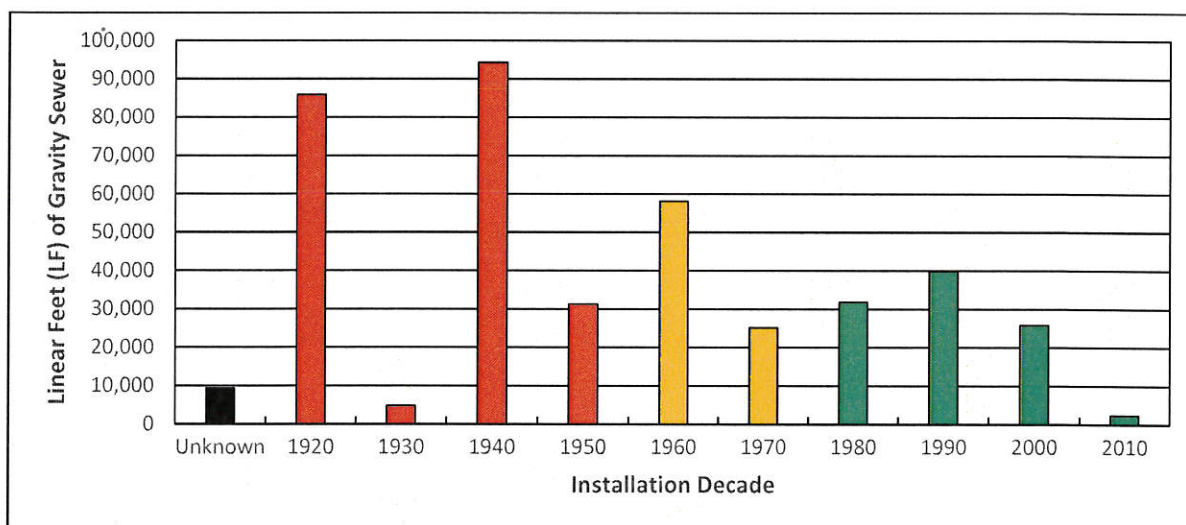
# Wastewater Collection System Asset Management Plan



**Table 1. Installed Gravity Main Pipe Materials**

| Material Type  | Length of Pipe (LF) Sewer Diameter |               |               |              | Total LF       | % of System |
|----------------|------------------------------------|---------------|---------------|--------------|----------------|-------------|
|                | ≤ 6"                               | 8"            | 10" - 18"     | > 18"        |                |             |
| AC             |                                    |               |               | 2,925        | 2,925          | 0.7         |
| AT             |                                    | 395           | 7,933         |              | 8,328          | 2.0         |
| Cast Iron Pipe | 1,318                              | 972           | 122           |              | 2,412          | 0.6         |
| HDPE           | 582                                | 4,302         |               |              | 4,884          | 1.2         |
| PVC            | 48,770                             | 21,510        | 3,209         |              | 73,489         | 18.0        |
| Steel          | 1,130                              |               |               | 409          | 1,539          | 0.4         |
| VCP            | 245,861                            | 29,856        | 18,869        | 1,761        | 296,347        | 72.5        |
| VCP/PVC        | 16,115                             | 1,985         | 539           |              | 18,639         | 4.6         |
| <b>Total</b>   | <b>313,776</b>                     | <b>59,020</b> | <b>30,672</b> | <b>5,095</b> | <b>408,563</b> | <b>100%</b> |

**Figure 2. Gravity Main Asset Age**



VCP sewers installed before 1958 (shown in red on Figure 2) have short lengths (therefore, numerous joints) with cement mortar joints, which shrink and crack and allow much higher rates of infiltration and root intrusion<sup>1</sup> than post-1958 sewers that use rubber-gasket joints. While VCP

<sup>1</sup> Control of Infiltration and Inflow into Sewer System Manual of Practice, USEPA, January 1971

# Wastewater Collection System Asset Management Plan

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is reported to have a structural life expectancy of 70-100 years, the failure of its joints in pre-1958 sewers increase maintenance failures, and in some cases capacity failure through I/I. The majority of these pre-1958 sewers are also 6-inches in diameter or less, which carry a higher probability of maintenance blockages occurring from root intrusion, sediment, or grease accumulation since 6-inch diameter sewers have only half the cross-sectional area of 8-inch diameter sewers. These pre-1958 sewers, which make up approximately 55 percent of the gravity sewer system, have reached the 70-year life expectancy mark and have also experienced significant structural failures, as evidenced by the District's CCTV inspection program discussed further in Section 4.0.

## 2.2 Replacement Values

A planning level replacement value estimate was developed for the gravity portion of the collection system. The estimate varies by depth of cover and construction method, and was prepared using West Yost Associates (West Yost) experience and recent bid results from similar projects. A combined estimating and construction contingency of 30 percent is included in the unit costs to account for unknown conditions, design completion level of the project, and bidding climate factors. The total capital costs include an allowance of 30 percent to account for planning level activities, design, environmental reviews, legal administration, construction services, change orders, and other related items.

The replacement of the gravity portion of the collection system is currently valued at approximately \$169 million (M) in September 2018 dollars Engineering New Record (ENR) Construction Index of 12103.88), as summarized in Table 2. Note that this estimate assumes that sewer mains 6-inches in diameter or less are upsized to 8-inches upon replacement, which meets the District's current minimum design standard.

# Wastewater Collection System Asset Management Plan



**Table 2. Gravity Sewer Replacement Values**

| Average Depth:<br>Construction Method:<br>Unit Cost: |                | Less than 15 feet<br>Pipe Bursting<br>\$25/in-Diameter-LF |            | Greater than 15 feet<br>Open Cut<br>\$42/in-Diameter-LF |                                               |                      |
|------------------------------------------------------|----------------|-----------------------------------------------------------|------------|---------------------------------------------------------|-----------------------------------------------|----------------------|
| Pipe Diameter, inch                                  | Length,<br>LF  | Unit Cost<br>(per LF) \$                                  | Cost \$    | Length,<br>LF                                           | Unit Cost<br>(per LF) \$                      | Cost \$              |
| 4                                                    | 219            | 224                                                       | 49,000     | -                                                       | 376                                           | -                    |
| 5                                                    | 105            | 224                                                       | 24,000     | -                                                       | 376                                           | -                    |
| 6                                                    | 310,342        | 224                                                       | 69,517,000 | 3,110                                                   | 376                                           | 1,169,000            |
| 8                                                    | 58,780         | 224                                                       | 13,166,720 | 240                                                     | 376                                           | 90,000               |
| 10                                                   | 17,190         | 280                                                       | 4,813,000  | -                                                       | 470                                           | -                    |
| 12                                                   | 11,202         | 336                                                       | 3,764,000  | -                                                       | 564                                           | -                    |
| 15                                                   | 1,766          | 420                                                       | 742,000    | -                                                       | 705                                           | -                    |
| 18 <sup>(a)</sup>                                    |                |                                                           |            | 514                                                     | 756                                           | 435,000              |
| 24 <sup>(a)</sup>                                    |                |                                                           |            | 2,375                                                   | 1,008                                         | 2,679,000            |
| 27 <sup>(a)</sup>                                    |                |                                                           |            | 2,721                                                   | 1,134                                         | 3,453,000            |
| <b>Subtotal by Depth:</b>                            | <b>75.6 mi</b> | <b>\$82,210,000</b>                                       |            | <b>1.7 mi</b>                                           | <b>\$7,826,000</b>                            |                      |
| <b>Gravity Sewer Subtotal:</b>                       |                |                                                           |            | <b>77.3 mi</b>                                          | <b>\$99,902,000</b>                           |                      |
|                                                      |                |                                                           |            |                                                         | 30% Contingency:                              | \$29,971,000         |
|                                                      |                |                                                           |            |                                                         | <b>Construction Cost Subtotal:</b>            | <b>\$129,873,000</b> |
|                                                      |                |                                                           |            |                                                         | 30% Engineering, Legal, Administration, etc.: | \$38,962,000         |
|                                                      |                |                                                           |            |                                                         | <b>Total Capital Cost:</b>                    | <b>\$168,835,000</b> |

(a) All pipes greater than 18" in diameter assume open cut method of construction.

Assuming a 75-year replacement cycle, an average of one-mile of gravity sewers should be replaced per year to keep pace with the average rate of sewers exceeding their useful lives. Considering average gravity sewer depth and diameter, the average replacement value is \$2.0 M per mile.

## 2.3 Gravity Sewer Inspections

The methodology used to assess the condition of the sewers that have valid CCTV inspection data available consists of the following two-step process:

1. **Defect Scoring:** Score the severity of individual defects
2. **Pipe Segment Scoring:** Assign a severity score to each pipe segment (from manhole to manhole) based on the severity of the individual defects on that pipe segment

# Wastewater Collection System Asset Management Plan



## 2.3.1 Defect Scoring

Gravity sewer structural defect coding and scoring is based on the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment Certification Program (PACP), which is the North American Standard for pipeline defect identification and assessment. A summary of the PACP defect scoring system is located in Appendix A for reference.

Based on the significance of the defect, extent of damage, percentage of restriction to flow capacity, or the amount of wall loss due to deterioration, PACP grades each recorded defect according to the 1 to 5 scale (with 5 being the most severe) shown in Table 3.

| Condition Grade | Severity                       |
|-----------------|--------------------------------|
| 5               | Most significant defect grade  |
| 4               | Significant defect grade       |
| 3               | Moderate defect grade          |
| 2               | Minor to moderate defect grade |
| 1               | Minor defect grade             |

## 2.3.2 Pipe Segment Scoring

For each CCTV inspection, the defects recorded for each pipe segment (from manhole to manhole) were compiled into a four-digit code denoted as the “Pipe Segment Quick Score” (shown below) through a count of the number of defects rated 1, 2, 3, 4, and 5. Any count greater than nine defaulted to a count of nine to adhere to the four-digit system. Any score of 0 through this system refers to an inspection with zero defects.

|                        |                                                 |                             |                                                          |
|------------------------|-------------------------------------------------|-----------------------------|----------------------------------------------------------|
| <b>3</b>               | <b>2</b>                                        | <b>2</b>                    | <b>4</b>                                                 |
| Highest severity grade | Number of occurrences of highest severity grade | Next highest severity grade | Number of occurrences of the next highest severity grade |

## 2.4 Gravity Sewer Risks

This risk assessment evaluated the likelihood and consequence of a gravity sewer failure. For this analysis, a sewer failure is considered to be a failure that could result in a SSO. SSOs are violations of state and federal laws and can adversely impact the environment and public health. SSOs can also require costly emergency repairs which are disruptive to the community.

# Wastewater Collection System Asset Management Plan

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The likelihood of failure assesses the probability that a failure will occur. The consequence of failure considers the impact an SSO may have on public health, the environment, and the community. A risk model was developed in MS Access to perform the risk assessment calculations. A rating for both likelihood and consequence of failure was assigned by the model to each pipe segment. The risk assessment model then combined the likelihood of failure ratings with the consequence of failure ratings to develop a comprehensive risk rating. This section summarizes the analysis that used available information to assign a risk level for each pipeline segment.

## 2.4.1 Likelihood of Failure Analysis

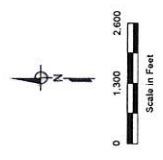
The likelihood of failure analysis considers the probability that a failure will occur in a given pipeline segment. The District's collection system consists primarily of VCP and PVC. These sewer pipelines have the following principal failure modes:

1. Structural Failure
2. Maintenance Blockages
3. Capacity-Related SSOs

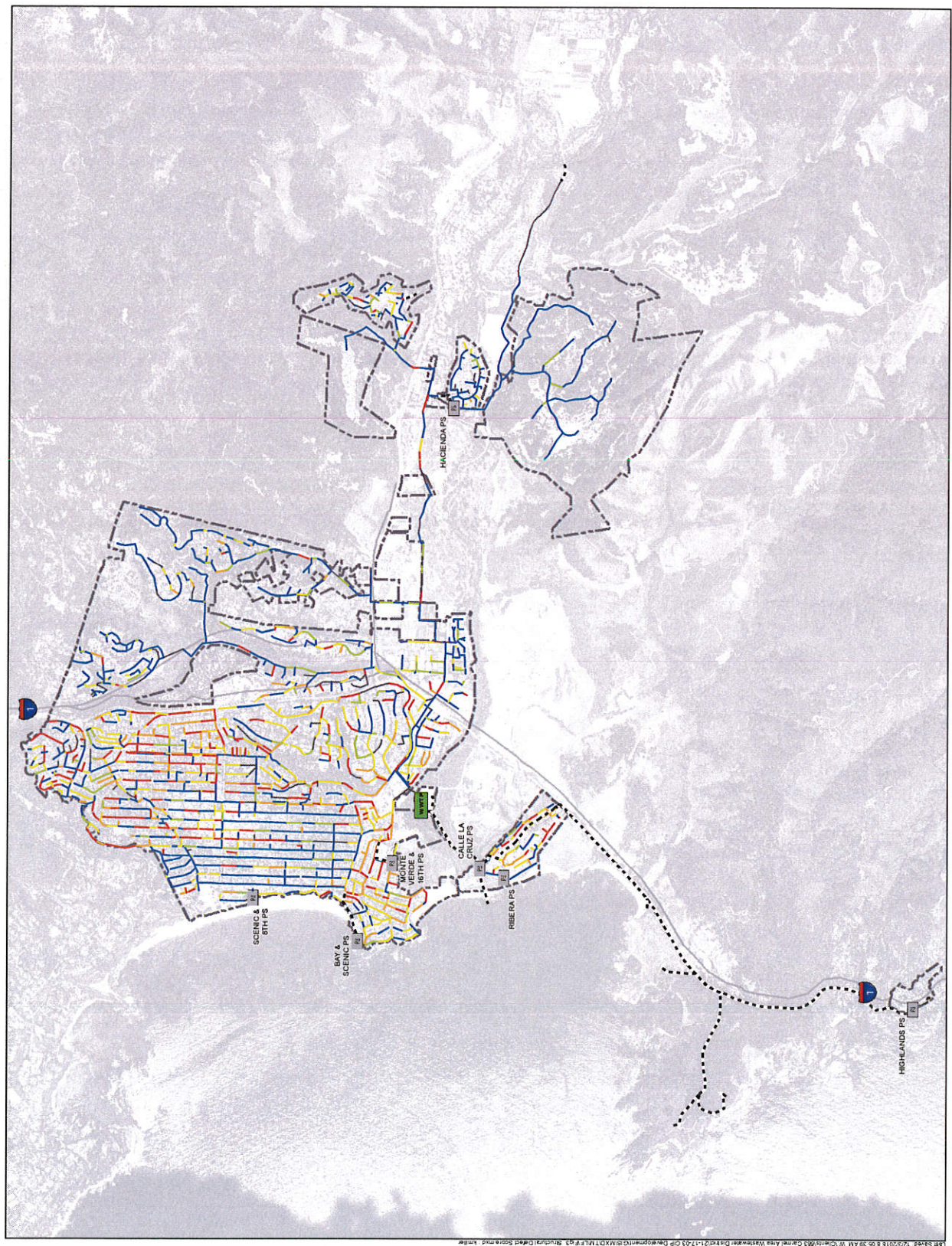
For each failure mode, one or more factors are considered in determining the likelihood of a failure, as discussed below.

**Structural Failure:** VCP is brittle, and cracks or breaks can progress to pipeline collapse. The severity of cracks and defects is documented through CCTV inspection. The likelihood of structural failure is determined by using the PACP Structural Quick Score (shown on Figure 3), which provides a standardized metric for comparing CCTV defects across the system. Of the 1,848 gravity pipes in the system, 148 pipes (eight percent) did not have any history of CCTV inspection. The missing CCTV inspection can either be due to miscoded inspections that do not link back to the proper pipe or areas of the system that the District has not inspected since 2007. When CCTV inspection data was not available, the structural failure likelihood was assessed using the installation year (shown on Figure 4).

**Maintenance Blockages:** Maintenance problems related to root intrusions, grease accumulations, and debris can cause blockages and result in SSOs. The likelihood of maintenance failure is determined by using both the PACP Maintenance Defect Score (shown on Figure 5) and the root and grease condition recorded during cleaning (shown on Figure 6). The severity of maintenance issues with root intrusion and grease accumulation was analyzed from District-recorded maintenance information for each asset from 2007 to 2017. Additionally, the severity of maintenance defects is documented through CCTV inspection. The PACP Maintenance Quick Score (discussed in Section 4.1) provides a standardized metric for comparing CCTV defects across the system.

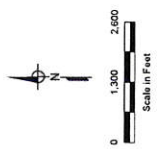


- Symbology**
- CAWD Service Area
  - Wastewater Treatment Plant
  - Pump Station
  - Force Main
  - Gravity Main - Structural Peak Score
  - Grade 1 Defect or No Defect
  - Grade 2 Defect
  - Grade 3 Defect
  - Grade 4 Defect
  - Grade 5 Defect
  - No Inspection

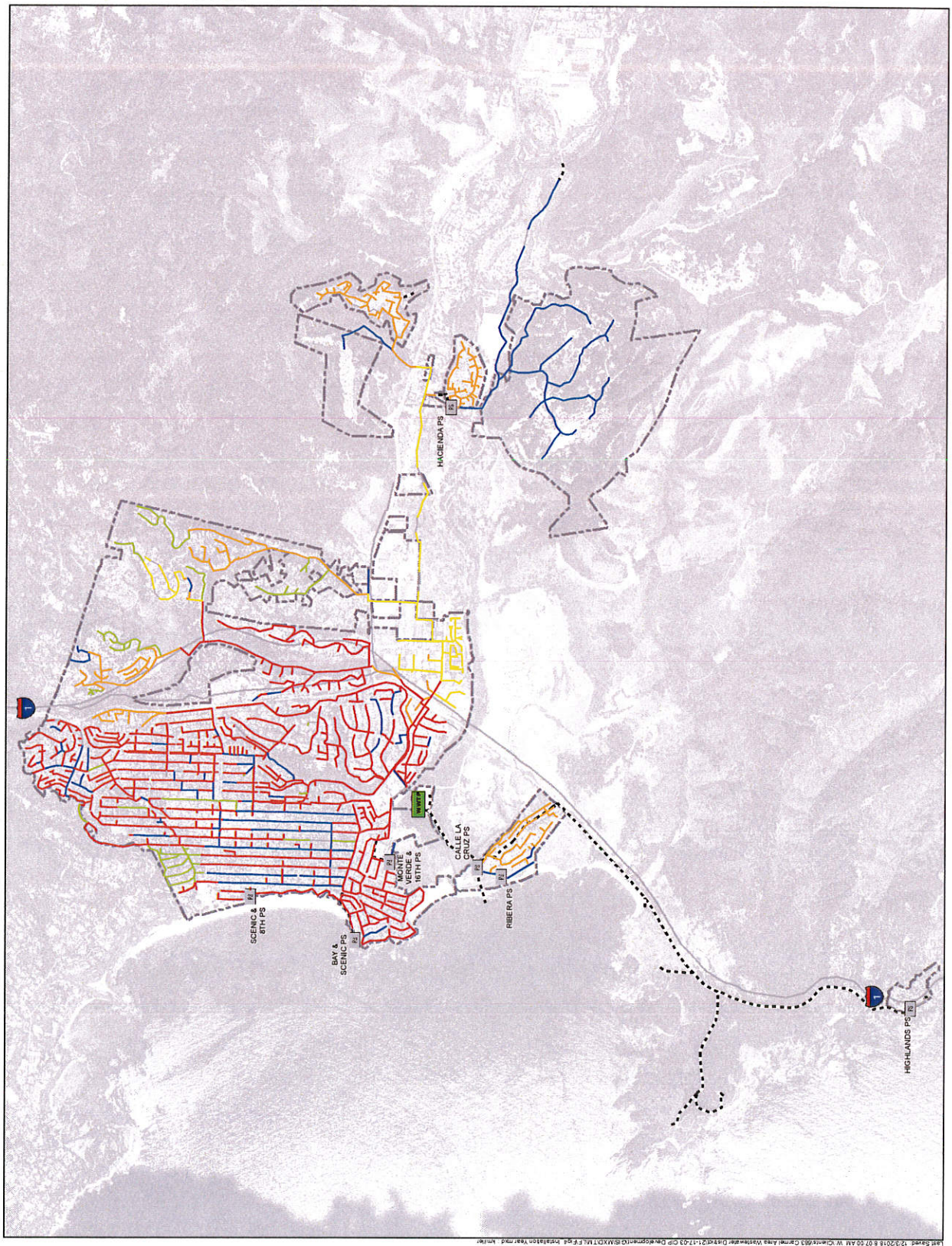


**Figure 3**  
**Likelihood of Failure Structural Failure by Defect Score**  
 Carmel Area Wastewater District  
 Wastewater Collection System  
 Asset Management Plan

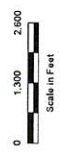




- Symbology**
- CAWD Service Area
  - Wastewater Treatment Plant
  - Pump Station
  - Force Main
  - Gravity Main - Installation Year
  - 1980s
  - 1970s
  - 1960s
  - Pre-1960
  - Unknown



**Figure 4**  
**Likelihood of Failure Structural Failure by Installation Year**  
 Carmel Area Wastewater District  
 Wastewater Collection System  
 Asset Management Plan



- Symbology**
- CAWD Service Area
  - Wastewater Treatment Plant
  - Pump Station
  - Force Main
- Gravity Main - Peak Maintenance Defect Rating**
- Grade 1 Defect or No Defect
  - Grade 2 Defect
  - Grade 3 Defect
  - Grade 4 Defect
  - Grade 5 Defect
  - No Inspection

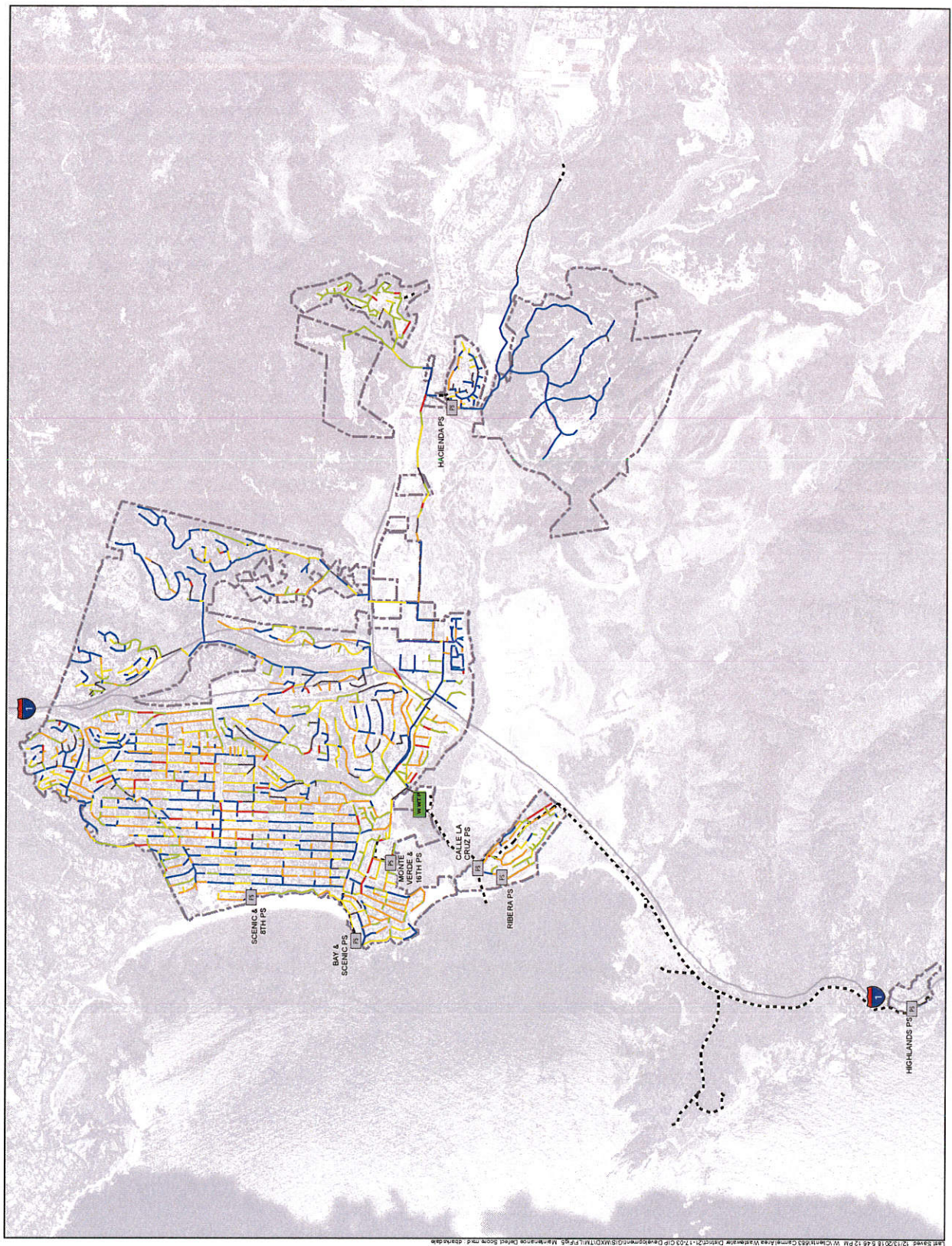
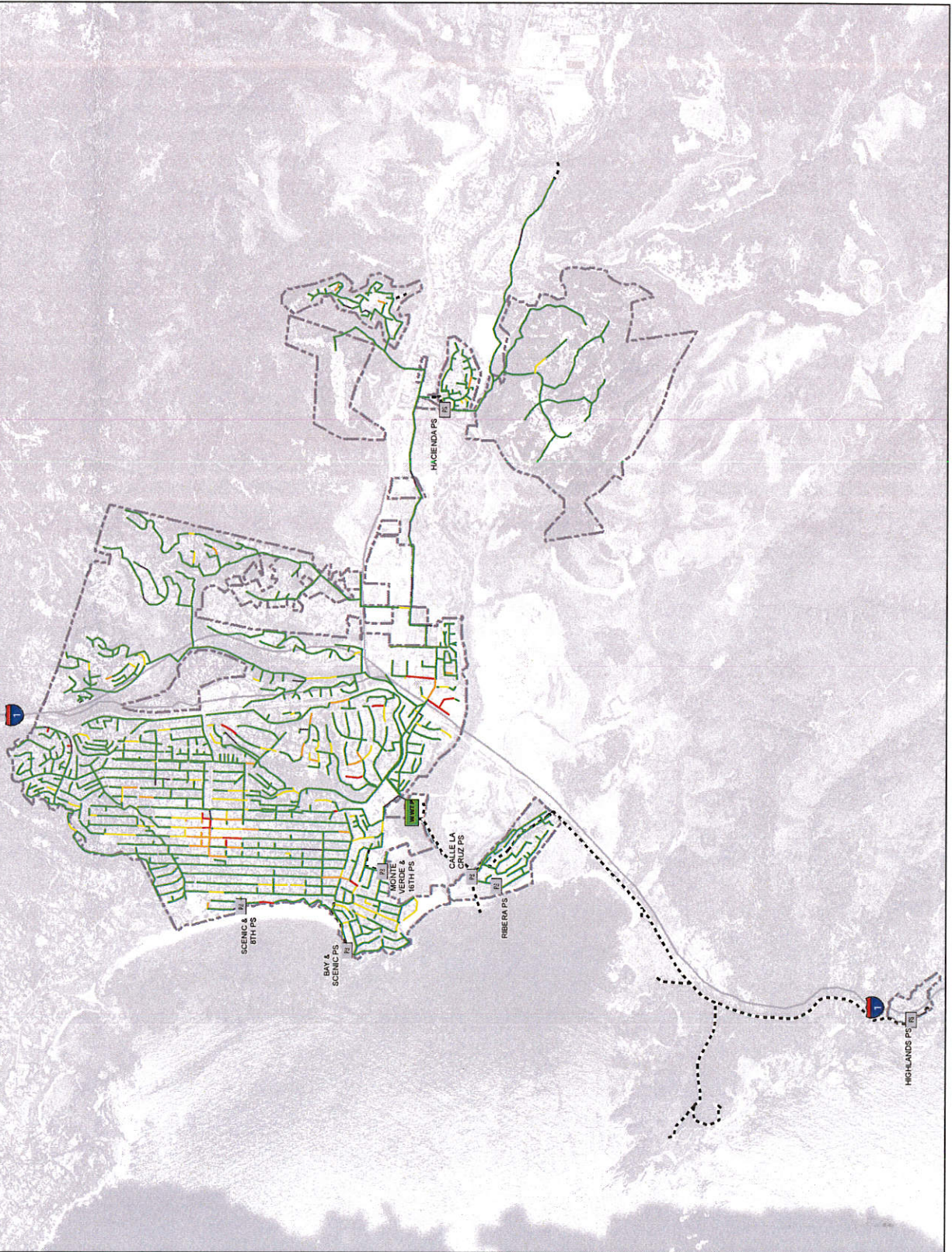


Figure 5  
Likelihood of Failure  
Maintenance Failure by  
Defect Score

Carmel Area Wastewater District  
Wastewater Collection System  
Asset Management Plan



- Symbology**
- CAWD Service Area
  - Wastewater Treatment Plant
  - PS Pump Station
  - Force Main
  - Gravity Main - Root/Grease Condition
  - Good Condition
  - Light
  - Medium
  - Heavy
  - No Records



**Figure 6**  
**LOF Maintenance Failure by Root/Grease Observed During Cleaning**

Carmel Area Wastewater District  
 Wastewater Collection System  
 Asset Management Plan

# Wastewater Collection System Asset Management Plan



**Inadequate Hydraulic Capacity:** Hydraulic restrictions or bottlenecks cause surcharging, which can lead to SSOs at, or upstream of, the location of the restriction. A sewer main with inadequate hydraulic capacity is defined as a segment for which the projected maximum depth of flow ( $d$ ) exceeds the diameter of the pipe ( $D$ ), as estimated by the District's hydraulic model. The hydraulic model, updated in 2018, was used to identify areas of hydraulic capacity deficiency (Figure 7).

Each pipe segment is rated by the risk model for each likelihood of failure category factor on a scale of 1 to 5, with 5 indicating the highest likelihood of failure. The methodology for rating each pipeline segment is summarized in Table 4.

Once rated for each factor, the risk model is applied to each pipe segment to produce a single rating for each category on a scale of 1 to 5 with 5 being the highest possible score. This rating is determined according to the Rating Logic shown in Table 4. Finally, the risk model calculates the total of the three scores for each category as the single Likelihood of Failure rating with 23 and 115 being the lowest and highest possible ratings, respectively.

## 2.4.2 Consequence of Failure Analysis

The consequence of failure is based on the potential impacts from an SSO in each segment of the collection system.

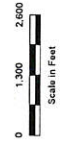
### 2.4.2.1 *Consequence Criteria*

The consequence of failure analysis is divided into four categories:

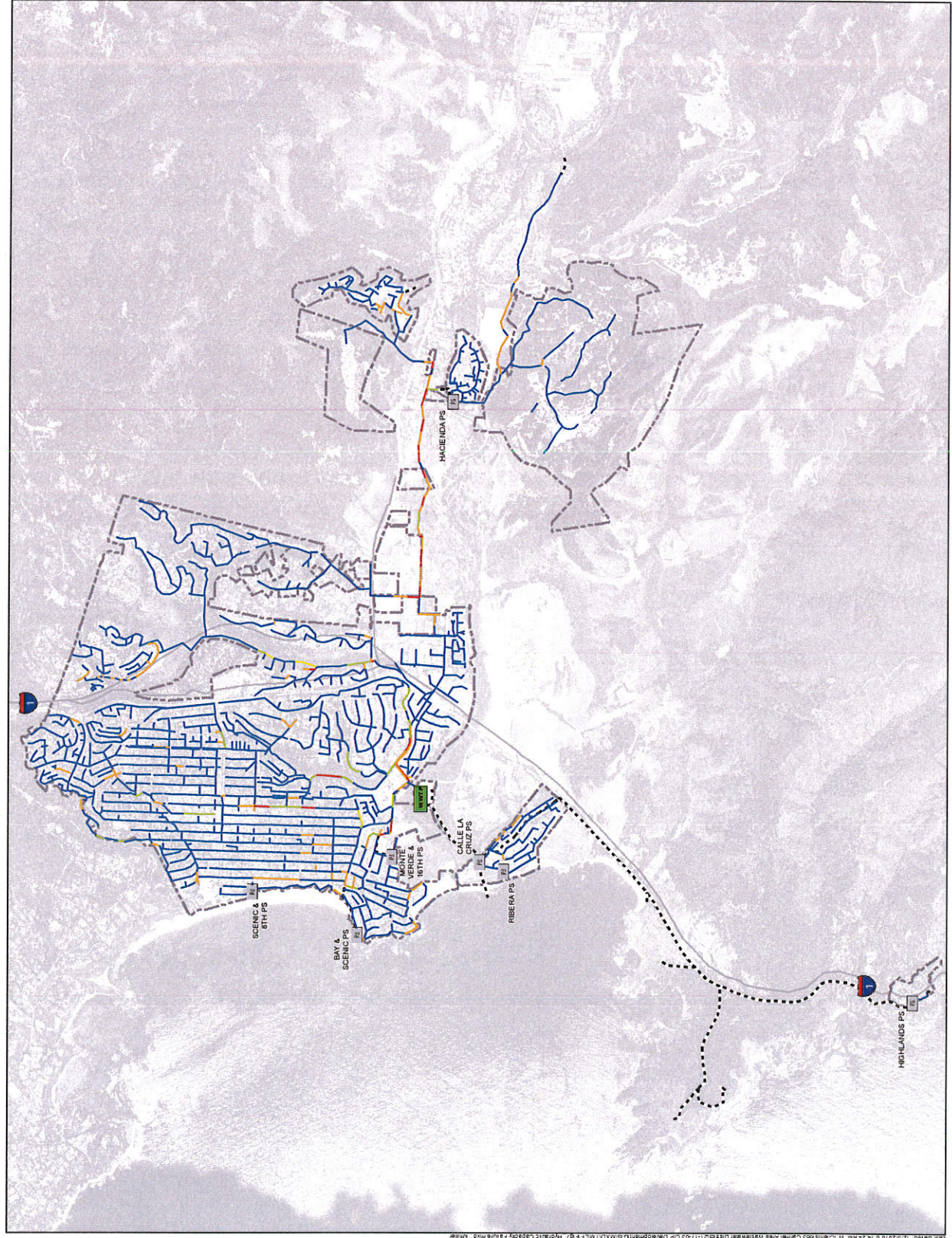
1. Potential Spill Volume
2. Environmental Impact
3. Emergency Response and Traffic Impact
4. Public Health Impact

For each category, one or more factors are considered in determining the potential consequence of a failure, as discussed below.

**Potential Spill Volume:** SSOs are prohibited by state and federal environmental laws because of their potential adverse impacts on the environment and public health. Large-volume SSOs have greater potential to adversely impact the environment and public health. The potential SSO volume was estimated from the peak wet weather flow in each pipe, as estimated by the District's hydraulic model. Flow in any pipes with missing or suspect hydraulic model flow projections were estimated using pipe diameter. The results are shown on Figure 8.



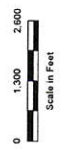
- Symbology**
- CAWD Service Area
  - Wastewater Treatment Plant
  - Pump Station
  - Force Main
  - Gravity Main - PWWF d/D Ratio
  - < 0.5 or Unmodeled
  - 0.75 - 0.99
  - Surcharge due to Backwater
  - Surcharge due to Throttle



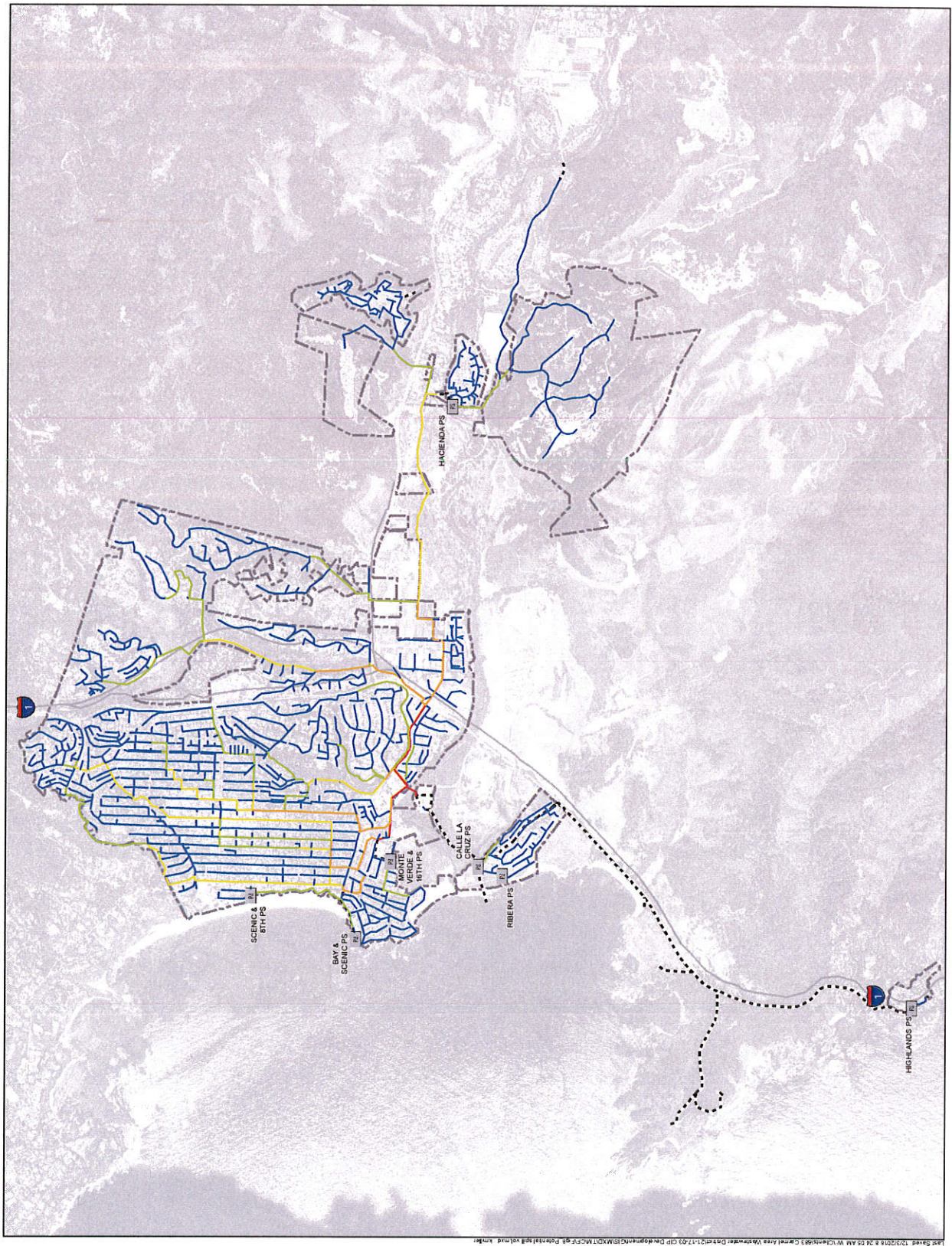
**Figure 7**  
**Likelihood of Failure**  
**Hydraulic Capacity Failure**  
 Carmel Area Wastewater District  
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**Table 4. Likelihood of Failure Rating Factors**

| Category                   | Factor                                     | Rating (1 being the lowest, 5 being the highest) |                   |                   |                            |                           | Rating Logic                                              | Weighting Factor |
|----------------------------|--------------------------------------------|--------------------------------------------------|-------------------|-------------------|----------------------------|---------------------------|-----------------------------------------------------------|------------------|
|                            |                                            | 1                                                | 2                 | 3                 | 4                          | 5                         |                                                           |                  |
| Structural Failure         | Highest Severity Structural Defect Rating  | Grade 1 Defect or No Defect                      | Grade 2 Defect    | Grade 3 Defect    | Grade 4 Defect             | Grade 5 Defect            | Defect Rating (if no CCTV record, then Installation Year) | 8                |
|                            | Installation Year                          | Post-1990                                        | Between 1980-1990 | Between 1970-1980 | Between 1960-1970          | Pre-1960 or Unknown       |                                                           |                  |
| Maintenance Failure        | Highest Severity Maintenance Defect Rating | Grade 1 Defect or No Defect                      | Grade 2 Defect    | Grade 3 Defect    | Grade 4 Defect             | Grade 5 Defect            | Maximum of Two Rating Values                              | 10               |
|                            | Roots/Grease Observed During Cleaning      | Good Condition                                   | -                 | Light             | Medium                     | Heavy                     |                                                           |                  |
| Hydraulic Capacity Failure | Modeled PWWF d/D Ratio                     | < 0.5 or Not Modeled                             | 0.5 – 0.75        | 0.75 – 1.0        | Surcharge due to Backwater | Surcharge due to Throttle | Single Rating                                             | 5                |



- Symbology**
- CAWD Service Area
  - Pump Station
  - Force Main
  - Gravity Main - Potential Spill Volume**
  - ≤ 0.09 MGD or ≤ 6-inch Diameter
  - 0.09 - 0.25 MGD or 8-inch Diameter
  - 0.26 - 0.5 MGD or 10-inch Diameter
  - 0.51 - 1 MGD or 12-inch Diameter
  - > 1 MGD or ≥15-inch Diameter



**Figure 8**  
**Consequence of Failure**  
**Potential Spill Volume**  
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**Environmental Impact:** Wastewater that contaminates waterways poses a direct impact to the environment. A proximity analysis was performed in GIS to determine which gravity mains were located within 100 and 250 feet of waterways, within intersecting waterways, and within the Federal Emergency Management Agency (FEMA) National Flood Hazard 100-year flood zone, as shown on Figure 9.

**Emergency Response and Traffic Impact:** Emergency response and repair costs can increase substantially when the gravity main is difficult to access by SSO response crews. The District provided accessibility ratings (on an easy to-difficult-to-access scale) for pipelines located in easements. Also, the downtown Carmel-by-the-Sea area (from Monte Verde to Junipero Streets and 5<sup>th</sup> to 8<sup>th</sup> Avenues) is covered by a concrete cap, causing access to buried pipelines under this cap to be slightly more difficult.

Repairs in arterial streets or highways require additional efforts to redirect traffic and are more difficult to respond to than spills on smaller collector streets. A proximity analysis was used to find gravity mains located within these streets. The following facilities were used to identify increased traffic consequences: gravity mains located near highways or in access ramps, along arterial streets, and along collector streets.

The results of the emergency response and traffic impact analysis are shown on Figure 10.

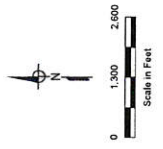
**Public Health Impact:** Human exposure to a wastewater spill poses a public health risk, and the potential for human exposure increases in areas with higher pedestrian traffic such as public facilities like parks and schools, and in tourist areas. The proximity of gravity mains to high pedestrian traffic areas was estimated using GIS data, as shown on Figure 11.

### *2.4.2.2 Consequence Criteria Rating Methodology*

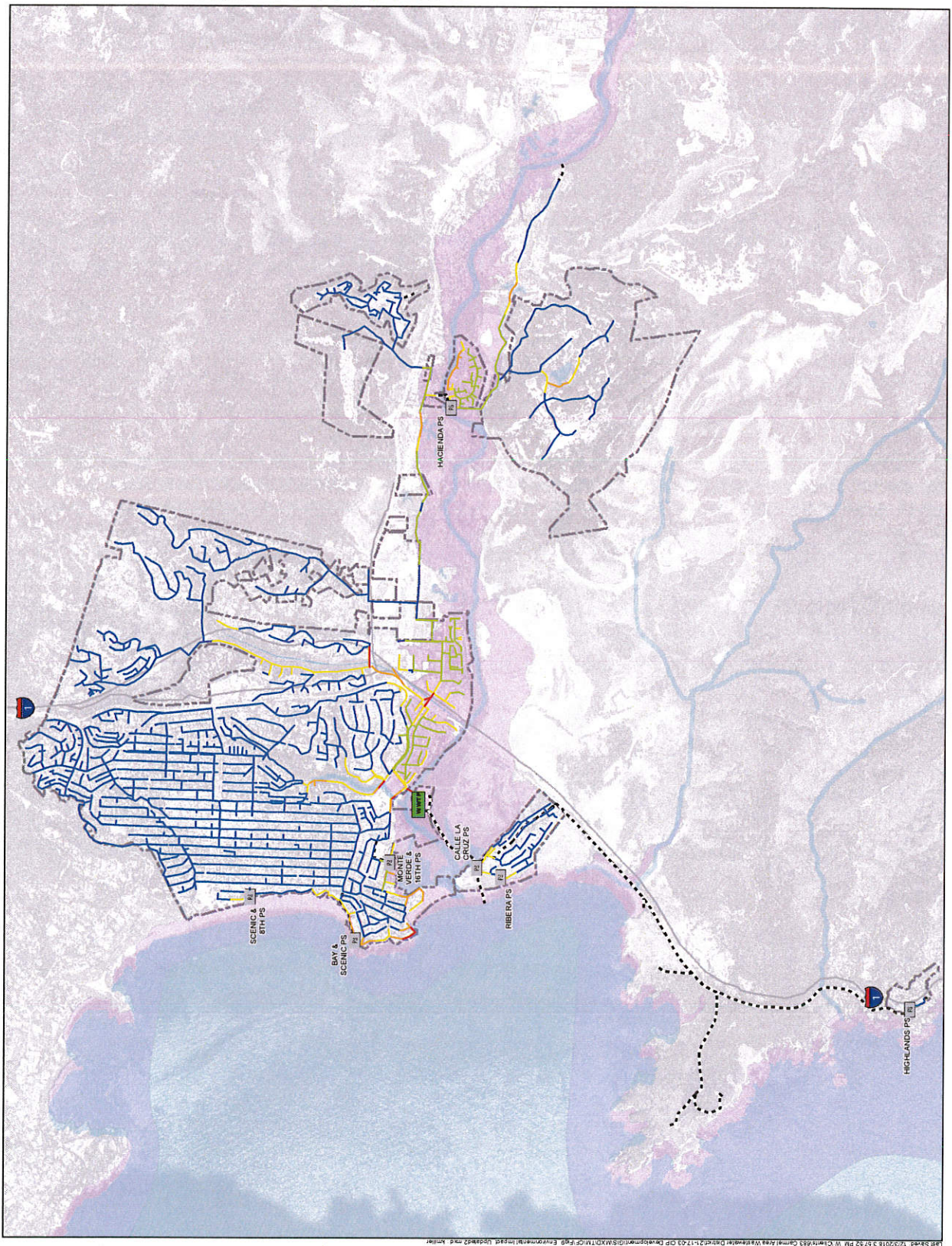
Each pipe segment is rated by the risk model for each consequence of failure factor on a scale of 1 to 5 with 5 indicating the highest adverse consequence of failure. The methodology for rating each pipeline segment is summarized in Table 5.

The risk model is applied to each pipe segment to produce a single rating for each category on a scale of 1 to 5, with 5 being the highest possible score. This rating is determined according to the Rating Logic shown in Table 5. Finally, the risk model calculates the aggregate of the three scores for each category as the single Consequence of Failure rating with 27 and 135 being the lowest and highest possible ratings, respectively.





- Symbology**
- CAWD Service Area
  - Wastewater Treatment Plant
  - Pump Station
  - Force Main
  - Gravity Main - Proximity to Water
  - Other
  - Within FEMA 100 year Flood Zone
  - Within 250' of Waterway
  - Within 100' of Waterway
  - Within/Intersecting Waterway
  - Waterways
  - FEMA National Flood Hazard
  - 100 Year Flood Zone



**Figure 9**  
**Consequence of Failure**  
**Environmental Impact**  
 Carmel Area Wastewater District  
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**Table 5. Consequence of Failure Rating Factors**

| Category                                   | Factor                                    | Rating (1 being the lowest, 5 being the highest) |                                         |                                                         |                                            |                                                                        | Rating Logic                                 | Weighting Factor |
|--------------------------------------------|-------------------------------------------|--------------------------------------------------|-----------------------------------------|---------------------------------------------------------|--------------------------------------------|------------------------------------------------------------------------|----------------------------------------------|------------------|
|                                            |                                           | 1                                                | 2                                       | 3                                                       | 4                                          | 5                                                                      |                                              |                  |
| Potential Spill Volume                     | Modeled Peak Wet Weather Flow (PWWF)      | ≤ 0.09 MGD                                       | 0.09 – 0.25 MGD                         | 0.26 – 0.5 MGD                                          | 0.51 - 1 MGD                               | > 1 MGD                                                                | Modeled PWWF (if not modeled, Pipe Diameter) | 10               |
|                                            | Pipe Diameter                             | ≤ 6-inch                                         | 8-inch                                  | 10 inch                                                 | 12 inch                                    | ≥ 15 inch                                                              |                                              |                  |
| Environmental Impact                       | Proximity to Waterways                    | Other                                            | Within FEMA 100-year Flood Zone         | Within 250 feet of Waterway                             | Within 100 feet of Waterway                | Within/ Intersecting of Waterway                                       | Single Rating                                | 6                |
| Emergency Response and Construction Impact | Location within Streets, and Easements    | Local Street/ Easement with Easy Access          | Collector Street/ Concrete Local Street | Easement with Limited Access/ Concrete Collector Street | Arterial Street                            | Highway/Ramp/ Easement with Difficult Access/ Concrete Arterial Street | Single Rating                                | 3                |
|                                            |                                           | Other                                            | -                                       | Within 150' of High Pedestrian Traffic Area             | Within 75' of High Pedestrian Traffic Area | Within/ Intersecting High Pedestrian Traffic Area                      |                                              |                  |
| Public Exposure                            | Proximity to High Pedestrian Traffic Area | Other                                            | -                                       | Within 150' of High Pedestrian Traffic Area             | Within 75' of High Pedestrian Traffic Area | Within/ Intersecting High Pedestrian Traffic Area                      | Single Rating                                | 8                |

# Wastewater Collection System Asset Management Plan



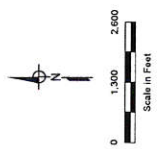
## 2.4.3 Risk Assessment Results

The risk model applies a series of algorithms to generate the total likelihood and consequence of failure scores for each asset, as described above. In Table 6, the scores are divided into five ranges (A through E) for both the likelihood and consequence of failure with E being the highest risk level. By plotting the consequence of failure and the likelihood of failure scores against each other, an overall risk level was assigned to each segment. Risk was prioritized into five levels, as shown in Table 6 (which shows the total number of pipes out of a total of 1,848 that fall into each range). The results of the risk assessment are shown graphically on Figure 12 and are listed in detail in Appendix B.

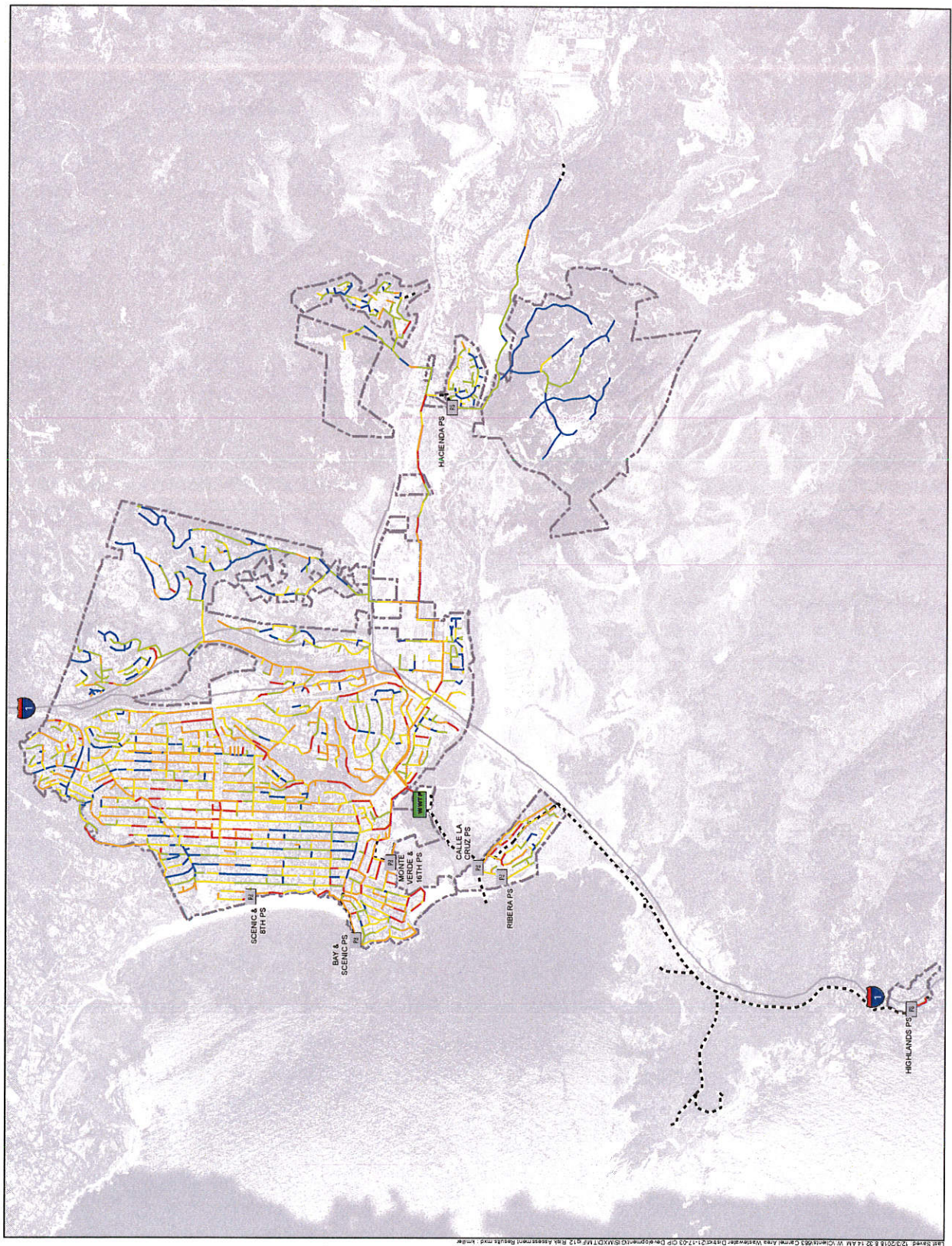
| Number of Pipe         |             | Likelihood of Failure |                 |             |                  |            | Total        |
|------------------------|-------------|-----------------------|-----------------|-------------|------------------|------------|--------------|
|                        |             | A (23-37)             | B (38-48)       | C (49-54)   | D (55-74)        | E (75-115) |              |
| Consequence of Failure | A (27-37)   | 392                   | 157             | 88          | 190              | 160        | 987          |
|                        | B (38-54)   | 184                   | 126             | 40          | 93               | 64         | 507          |
|                        | C (55-77)   | 61                    | 51              | 22          | 70               | 45         | 249          |
|                        | D (78-104)  | 26                    | 24              | 7           | 25               | 12         | 94           |
|                        | E (105-135) | -                     | 6               | -           | 3                | 2          | 11           |
|                        | Total       | <b>663</b>            | <b>364</b>      | <b>157</b>  | <b>381</b>       | <b>283</b> | <b>1,848</b> |
| Risk Level:            |             | Low Risk              | Medium-Low Risk | Medium Risk | Medium-High Risk | High Risk  |              |

**Low Risk:** Approximately 18 percent of the system by length (13.8 out of 77.4 miles) falls in the Low Risk Category, as shown in blue in Table 6 and Figure 12. Gravity mains in this category typically contain the following characteristics:

- At the lower end of the scoring section (and the majority of this risk category), these mains are six-inch pipes and installed after 1990 in residential streets away from public and environmental areas. These mains do not have any structural, maintenance, or hydraulic capacity concerns.
- At the highest end of the scoring section, these mains are eight-inch pipes in a collector street, away from public and environmental areas. These mains have maintenance and hydraulic capacity concerns but have light structural concerns. The structural defects are not more than a severity Grade 2.



- Symbology**
- CAWD Service Area
  - Wastewater Treatment Plant
  - Pump Station
  - Force Main
  - Gravity Main - Risk Level
  - Low Risk
  - Medium-Low Risk
  - Medium Risk
  - Medium-High Risk
  - High Risk



**Figure 12**  
**Risk Assessment Results**  
 Carmel Area Wastewater District  
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**Medium-Low Risk:** Approximately 20 percent of the system by length (15.4 out of 77.4 miles) is Medium-Low Risk, as shown in light green in Table 6 and Figure 12. Gravity mains in this category typically contain the following characteristics:

- At the lower end of the scoring section, these mains are 6-inch sewers located away from public areas. These mains are either within easements with limited access or are under a concrete cap. These mains do not have any structural, maintenance, or hydraulic capacity concerns.
- At the highest end of the scoring section, these mains are 6-inch pipes within easements with limited access or under a concrete cap away from a high pedestrian traffic but within 100-feet of waterways. These mains have no hydraulic capacity or maintenance concerns but have Grade 3 structural defects.

**Medium Risk:** Approximately 26 percent of the system by length (20.2 out of 77.4 miles) is Medium Risk, as shown in yellow in Table 6 and Figure 12. Gravity mains in this category typically contain the following characteristics:

- At the lower end of the scoring section, these mains are 6-inch pipes in Highway/Ramp/Easement with Difficult Access or an Arterial street under a concrete cap. These mains are within 150 feet of a high pedestrian traffic area but are away from waterways. These mains have no hydraulic capacity and maintenance concerns but have Grade 3 structural defects.
- At the highest end of the scoring section, these mains are 10-inch pipes in easements with limited access or a concrete-capped collector street. They are away from waterways, but within 75-feet of high pedestrian traffic areas. These mains have no hydraulic capacity and structural concerns but have moderate maintenance concerns. The most severe pipe maintenance defects are Grade 4 or medium level of Roots/Grease Observed During Cleaning.

**Medium-High Risk:** Approximately 26 percent of the system by length (20.6 out of 77.4 miles) is Medium-High Risk, as shown in orange in Table 6 and Figure 12. Gravity mains in this category typically contain the following characteristics:

- At the lower end of the scoring section, these mains are 6-inch pipes within a high pedestrian traffic area and located within an easement with limited access or a concrete-capped collector street; but are away from waterways and high pedestrian traffic. These mains have no hydraulic capacity and maintenance concerns but have severe Grade 5 structural defects.
- The majority of this risk category have no hydraulic capacity concerns or maintenance defects. However, these mains have high structural concerns with Grade 5 pipe defects.

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- At the highest end of this scoring section, these mains are 12-inch pipes, away from waterways, but within 75-feet of a high pedestrian traffic area. These mains have no structural concerns. However, these mains have high hydraulic capacity and maintenance concerns with Grade 4 maintenance defects.

**High Risk:** Approximately 10 percent of the system by length (7.4 out of 77.4 miles) is High Risk, as shown in red in Table 6 and Figure 12. Gravity mains in this category typically contain the following characteristics:

- At a minimum, these mains are 6-inch pipes within a high pedestrian traffic area and located within a concrete-capped collector street, but are away from waterways. These mains have no hydraulic capacity concerns but have high structural concerns and moderate maintenance concerns. The most severe pipe structural defects are Grade 5, with Grade 3 maintenance defects or observed light root/grease during cleaning.
- At the higher end of the scoring section, these mains are 15-inch pipes and larger within 100-feet of a waterway, within a high pedestrian traffic area, and located within an easement with limited access (or a concrete-capped collector street). These mains have high structural, maintenance and capacity concerns and are surcharged during peak wet weather conditions.

### 2.5 Gravity Sewer Rehab/Replacement Program

This section develops rehab/replacement recommendations and discusses the contributing construction method options, rehab/replacement strategy, and cost assumptions.

#### 2.5.1 Rehab/Replacement Construction Options

A variety of gravity sewer repair, rehabilitation, and replacement methods are available. This section provides an overview of the advantages and disadvantages of the common rehab/replacement construction methods employed by the District, which are listed below in order of construction cost with the least expensive options discussed first.

**CIPP (Cured-in-Place Pipe) Patch (spot repair):** Short CIPP patches use the CIPP lining technology (described in detail below) in short lengths, typically 24- and 48-inches. The patch acts similar to a stent in an artery to repair a localized defect. CIPP patches are a quick and cost-effective method for mitigating isolated defects such as sealing cracks where roots have intruded and can extend the life of the pipe as a whole.

#### Advantages:

- No need for excavation
- Lower cost than full-line rehab/replacement



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### Disadvantages:

- Localized at defects instead of repairing entire sewer
- Effectiveness can vary depending on installation conditions
- Sags, defective taps, and offset joints are not corrected
- Reduction in pipe capacity

**Open Cut Spot Repair:** Spot repairs involve an excavation repair of the underlying sewer pipe over a length less than a full manhole to manhole segment. Spot repairs can repair an isolated defect or correct a sag or severe offset/broken pipe in advance of pipe bursting or CIPP lining. If performed prior to a comprehensive trenchless replacement method, the excavation spot repair would typically use sacrificial PVC pipe material that would be either lined through or replaced via pipe bursting.

Depending on the linear foot unit price, spot repairs beyond a certain length and/or beyond a certain quantity of locations within a single manhole to manhole segment may become more expensive than a full manhole to manhole replacement.

### Advantages:

- Lower cost than full-line rehab/replacement
- Corrects all types of defects

### Disadvantages:

- Localized at defects instead of repairing entire sewer

**CIPP Lining Rehabilitation:** CIPP linings result in a new sewer pipe within the existing pipe without any joints. The method is often described as pipe rehabilitation. The existing pipe is not removed, but the structural CIPP liner is not dependent on the host pipe to maintain integrity of the sewer, even though the existing pipe material remains in place. The installation process involves inverting a fabric liner infused with resin down the sewer pipe. The CIPP liner inversion starts from a manhole-access-point and proceeds by way of water or air pressure. This force pushes the liner through the sewer to an end manhole where it is monitored for proper alignment. The air or water is then heated to a sustained temperature to allow the resin to properly cure. After several hours, where durations depend on factors such as diameter and pipe defects, the liner is allowed to cool and both ends are cut and drained.

The new liner is then CCTV inspected to check the quality and a robotic cutting device is used to reinstate each service lateral. The newly opened lateral connections are then sealed either with grout to fill any void space and seal the wall/liner interface at the lateral opening and/or with a top hat style cured in place lining to add further support at this connection point. The grouting and/or top hat liner help exclude any infiltration that may travel in between the former pipe wall and the

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new CIPP liner. The grouting method typically has a significantly shorter life than the top-hat liner, so the more expensive top-hat liner is preferred.

### Advantages:

- Internal structural pipe replacement
- No need for excavation
- Zero joints, lateral wye joints sealed with grouting

### Disadvantages:

- Effectiveness can vary depending on installation conditions
- Sags, offset joints, and pipe deformities/collapses are not corrected unless spot repaired first
- Reduction in pipe capacity
- Cost increases with the number of lateral connections, especially when top-hat lateral liners are used
- Grouting of lateral and manhole connections may need repairs every 5-10 years
- 6-inch diameter mains will be further reduced in size, restricting maintenance and inspection equipment

**Pipe Bursting Replacement:** Pipe bursting creates a new sewer along the same alignment as the existing pipeline but involves pulling a pneumatic hammer head through the existing sewer pipe to break it apart. This pneumatic head simultaneously pulls through a new fused joint high-density polyethylene (HDPE) plastic sewer pipe in its place from an excavated access pit. This method also allows for upsizing the pipe diameter by up to two sizes (e.g., from 8-inches to 10 or 12 inches), depending on soil conditions, crossing utility locations, and other considerations. Pipe bursting also provides the ability to replace a sewer in its existing location with much less excavation than a full open trench. To access the existing sewer pipe with the bursting device, excavation pits are required approximately every 600-feet, or usually at every other manhole.

Each existing lateral requires an individual open excavation to reconnect the existing service laterals to the newly installed sewer. Sags beyond the 30 percent threshold are recommended for spot repairs, also requiring excavation. The degree to which pipe bursting reduces the amount of excavation and disruption relative to open cut replacement will depend on the distance between lateral connections and the number of sag spot repairs required in a given segment of sewer.

Laterals are reconnected by cutting into the newly installed HDPE pipe and fusing a service lateral saddle at the appropriate location. Again, this fusing of the HDPE material helps minimize joints and prevent future infiltration and other defects. The newly fused service lateral saddle is then connected to the existing lateral pipe. The lack of joints helps prevent future root intrusion and the

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associated increase in infiltration and risk of backups. Pipe bursting does not have the ability to correct existing sags and can sometimes make sags more severe.

### Advantages:

- Full replacement of sewer main and lateral connections
- Can upsize pipe up to two-diameters
- Less excavation and traffic impact to the public than open cut replacement (typically at every two MHs and at lateral connections)
- Zero joints with fused HDPE pipe; laterals and MH connections also fused

### Disadvantages:

- Sags are not corrected unless spot repaired first
- Costs increase with the number of lateral connections
- Excavation access pits needed every two manholes and at each lateral connection
- Certain soil conditions can transmit vibrations and movement of the pipe bursting hammer head to other nearby utilities and structures
- Less desirable in areas with less than three feet of cover or congested utilities due to potential soil heave

**Open Cut Replacement:** Open cut replacement (open cut construction) involves excavating a trench to install a brand-new sewer pipe and manholes. This is the conventional construction method for sewers. The new pipeline can follow an existing alignment or can be relocated to a new alignment. Open cut replacement is typically the costliest option for replacement along an existing alignment, especially in the presence of poor soil conditions or access limitations (e.g., in an easement on private property).

### Advantages:

- Full replacement of sewer main and lateral connections
- The only option for changing pipe horizontal or vertical alignment
- Corrects all types of defects
- Backfill with low density fill could help prevent future uneven settlement
- Can use fused HDPE to eliminate joints

### Disadvantages:

- Usually the costliest option
- In high groundwater, it requires more soil dewatering due to full excavation of the pipe

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- Most disruptive to traffic
- Most likely to encounter other utilities during excavation

### 2.5.2 Rehab/Replacement Strategy

In general, the strategy for specifying gravity sewer rehab/replacement methodologies is as follows:

- Defects of severity Grade 3 or higher are repaired using the least expensive method of construction.
- All sewers 6-inches in diameter or less are upsized to 8-inches.
- Sags are only repaired if they raise the water level at the time of inspection to 30 percent or more of the pipe diameter (PACP defect code meal water levels (MWL)  $\geq 30$  percent).
- If there are significant sags of severity Grade 3 or higher, open cut construction is specified or spot repairs.
- Roots do not trigger repairs, but a high frequency of root intrusion can trigger full-line rehab/replacement instead of performing spot repair(s).

The construction method selection process used is as follows:

- Spot repair methods are selected by their ability to repair each individual structural defect according to the PACP defect code list.
- The District has concerns with the diameter restrictions and poor lateral connections associated with its past CIPP projects. To limit these impacts in the future, 6-inch diameter sewers were only CIPP lined if flows are low (PWWF < 0.1 mgd), there are no severe sags, there are no lateral connections on the pipe, and offset joints are open-cut repaired first.
- Full line replacement is specified if:
  - There are continuous structural defects of severity Grade 3 or higher or roots (of any severity) for more than 25 percent of the pipe length.
  - There are any infiltration defect codes recorded, which applies to 46-sewers (infiltration will simply move to the next defect if spot repairs are performed).
  - More than one spot repair is required per 100-LF of sewer in a single segment (for cost effectiveness).
  - The pipe diameter is less than 6-inches so that it can be upsized to 8-inches to accommodate maintenance equipment.
  - Full line rehab/replacement if spot repairs are more than 50 percent of the cost of full-line rehab.

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- Pipe bursting is selected if cost to CIPP is more than 75 percent of the cost of pipe bursting.
- Open cut construction is selected if cost to pipe burst and repair sags is more than 75 percent of the cost of open cut construction.

## 2.5.3 Unit Construction Costs

Estimated construction costs were developed by applying the unit construction costs listed in Table 7 to the size and scope of each gravity sewer. Construction costs do not include inflation costs. These planning-level unit costs were used to select the most cost-effective construction method and to provide total rehab/replacement costs for each pipe. These unit construction costs include a 30 percent construction contingency in order to estimate construction costs, but do not include additional capital costs for engineering, legal, administration, etc. (typically an additional 30 percent).

| Construction Method        | Unit Construction Cost  |
|----------------------------|-------------------------|
| CIPP Patch                 | \$1,400/inch diameter   |
| Spot Repair (Open Cut)     | \$2,400/inch diameter   |
| CIPP Lining Rehabilitation | \$30/inch diameter-foot |
| Pipe Bursting Replacement  | \$36/inch diameter-foot |
| Open Cut Replacement       | \$60/inch diameter-foot |

## 2.5.4 Rehab/Replacement Program

This section documents the existing rehab/replacement needs, discusses investment strategy options, and presents a 20-year Rehab/Replacement Program for gravity sewers in the collection system.

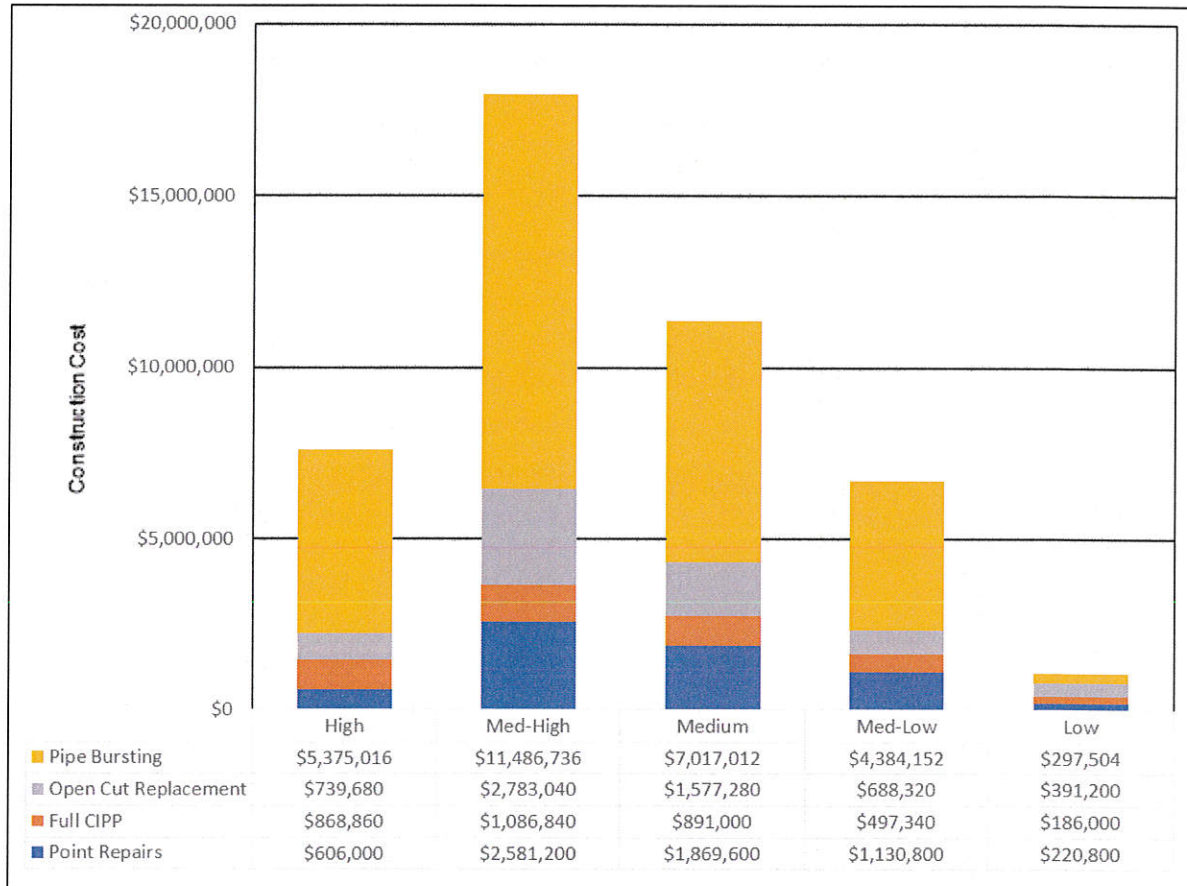
### 2.5.4.1 Existing Rehab/Replacement Needs

The rehab/replacement strategy and unit costs described above were applied to each individual gravity sewer and its PACP-coded defects, and the rehab/replacement needs shown in Figure 13 were identified. Figure 13 shows rehab/replacement construction cost estimates by risk level and construction method. Table 8 shows the system-wide rehab/replacement needs by risk level and capital cost.

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**Figure 13. System-Wide Rehab/Replacement Needs by Construction Method**



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**Table 8. System-Wide Rehab/Replacement Needs by Risk Level**

| Pipeline Infrastructure Risk | Total Length of Sewers (Miles) | Percent of Total System | Repair/ Replacement Construction Cost <sup>(a)</sup> | 30% Capital Cost Markup <sup>(b)</sup> | Total Capital Cost  |
|------------------------------|--------------------------------|-------------------------|------------------------------------------------------|----------------------------------------|---------------------|
| Low Risk                     | 14.14                          | 18                      | 1,096,000                                            | 328,800                                | 1,424,800           |
| Medium-Low Risk              | 17.19                          | 22                      | 6,701,000                                            | 2,010,300                              | 8,711,300           |
| Medium Risk                  | 20.01                          | 26                      | 11,355,000                                           | 3,406,500                              | 14,761,500          |
| Medium-High Risk             | 19.47                          | 25                      | 17,938,000                                           | 5,381,400                              | 23,319,400          |
| High Risk                    | 6.57                           | 8                       | 7,590,000                                            | 2,277,000                              | 9,867,000           |
| <b>Total</b>                 | <b>77.38</b>                   | <b>100%</b>             | <b>\$44,680,000</b>                                  | <b>\$13,404,000</b>                    | <b>\$58,084,000</b> |

(a) Includes 30 percent construction cost contingency.  
(b) Includes 30 percent for Engineering, Legal, Administration, etc.

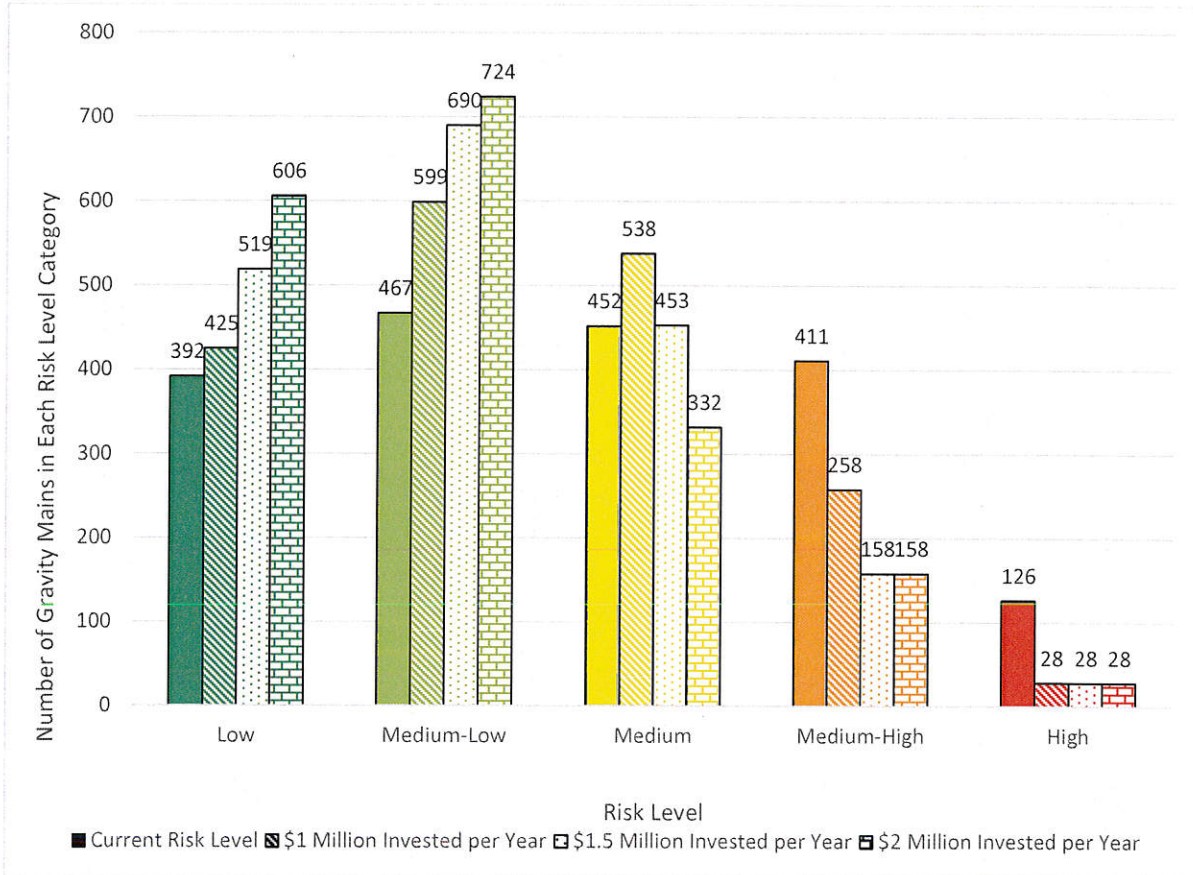
## 2.5.4.2 Investment Strategy Options

In recent years, the District has invested approximately \$750,000 per year (in construction costs) in collection system rehab/replacement projects. As discussed previously in this report, an increase in the level of investment is warranted due to the age and condition of the system. Figure 14 and Table 9 explore new annual investment strategies: \$1M/year, \$1.5M/year, and \$2M/year. Figure 14 shows the current risk level of the system (in solids bars) and compares that to the risk level of the system after a 20-year rehab/replacement program at each of the three annual investment strategy scenarios. Figure 14 also shows the impacts to the existing system risk levels under each scenario improvements are made. It should be noted that under the \$1M/year investment option, it takes nearly 26-years to complete the existing backlog of high and medium-high risk repair projects.

# Wastewater Collection System Asset Management Plan



**Figure 14. Risk Level of All Pipes After 20-Year Rehab/Replacement Program Options**





**Table 9. Investment Strategy Options for 20-Year Rehab/Replacement Program**

| R/R Program Year                     | \$1.0M/Year |               |                      |                      | \$1.5M/Year |               |                |                      | \$2.0M/Year |               |             |                      |           |               |             |                      |
|--------------------------------------|-------------|---------------|----------------------|----------------------|-------------|---------------|----------------|----------------------|-------------|---------------|-------------|----------------------|-----------|---------------|-------------|----------------------|
|                                      | High Risk   | Med-High Risk | Total Gravity Sewers | Total Gravity Sewers | High Risk   | Med-High Risk | Medium Risk    | Total Gravity Sewers | High Risk   | Med-High Risk | Medium Risk | Total Gravity Sewers | High Risk | Med-High Risk | Medium Risk | Total Gravity Sewers |
| Years 1-5                            | \$5.0M      | -             | \$5.0M               | \$7.5M               | \$7.5M      | -             | -              | \$7.5M               | \$7.6M      | \$2.4M        | -           | \$10.0M              | -         | -             | -           | \$10.0M              |
| Years 6-10                           | \$2.6M      | \$2.3M        | \$4.9M               | \$0.1M               | \$7.4M      | -             | -              | \$7.5M               | -           | \$10.0M       | -           | \$10.0M              | -         | -             | -           | \$10.0M              |
| Years 11-15                          | -           | \$5.1M        | \$5.1M               | -                    | \$7.6M      | -             | -              | \$7.6M               | -           | \$5.5M        | \$4.5M      | \$10.0M              | -         | -             | -           | \$10.0M              |
| Years 16-20                          | -           | \$5.0M        | \$5.0M               | -                    | \$3.0M      | \$4.5M        | \$7.5M         | \$7.5M               | -           | -             | \$6.9M      | \$10.0M              | \$3.1M    | -             | -           | \$10.0M              |
| <b>Total Construction Costs</b>      |             |               | <b>\$20.0M</b>       |                      |             |               | <b>\$30.1M</b> |                      |             |               |             | <b>\$40.0M</b>       |           |               |             | <b>\$52.0M</b>       |
| 30% Engineering, Legal, Admin., etc. |             |               | \$6.0M               |                      |             |               | \$9.0M         |                      |             |               |             | \$12.0M              |           |               |             | \$12.0M              |
| <b>Total Capital Costs</b>           |             |               | <b>\$26.0M</b>       |                      |             |               | <b>\$39.1M</b> |                      |             |               |             | <b>\$52.0M</b>       |           |               |             | <b>\$52.0M</b>       |

# Wastewater Collection System Asset Management Plan



## 2.5.4.3 Recommended 20-Year Rehab/Replacement

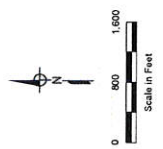
To develop a 20-year Rehab/Replacement, annual projects are prioritized by the risk level of each sewer, with the highest-risk pipes prioritized for rehab/replacement first. At an investment level of \$1M in construction costs per year, the Rehab/Replacement summarized in Table 10 shows that high risk pipes are repaired first in years one through eight of the program, followed by medium-high risk pipes in years eight through 20. The location of the sewers in the 20-year Rehab/Replacement are shown in Figure 15 by priority, and Figure 16 by construction method. Pipe-by-pipe cost estimates and Rehab/Replacement details are provided in Appendix C.

| <b>Table 10. 20-Year Gravity Sewer Rehab/Replacement Program by Risk Level<br/>(Annual Investment of \$1M)</b> |                         |                             |                     |
|----------------------------------------------------------------------------------------------------------------|-------------------------|-----------------------------|---------------------|
| <b>Rehab/Replacement Year</b>                                                                                  | <b>High Risk Sewers</b> | <b>Med-High Risk Sewers</b> | <b>Total</b>        |
| Years 1-5                                                                                                      | 4,996,000               | -                           | 4,996,000           |
| Years 6-10                                                                                                     | 2,595,000               | 2,324,000                   | 4,919,000           |
| Years 11-15                                                                                                    | -                       | 5,070,000                   | 5,070,000           |
| Years 16-20                                                                                                    | -                       | 5,002,000                   | 5,002,000           |
| <b>Total Construction Costs<sup>(a)</sup></b>                                                                  |                         |                             | <b>\$19,987,000</b> |
| 30 percent Engineering, Legal, Administration, etc.                                                            |                         |                             | \$5,996,100         |
| <b>Total Capital Costs</b>                                                                                     |                         |                             | <b>\$25,983,100</b> |
| <small>(a) Includes 30 percent construction cost contingency.</small>                                          |                         |                             |                     |

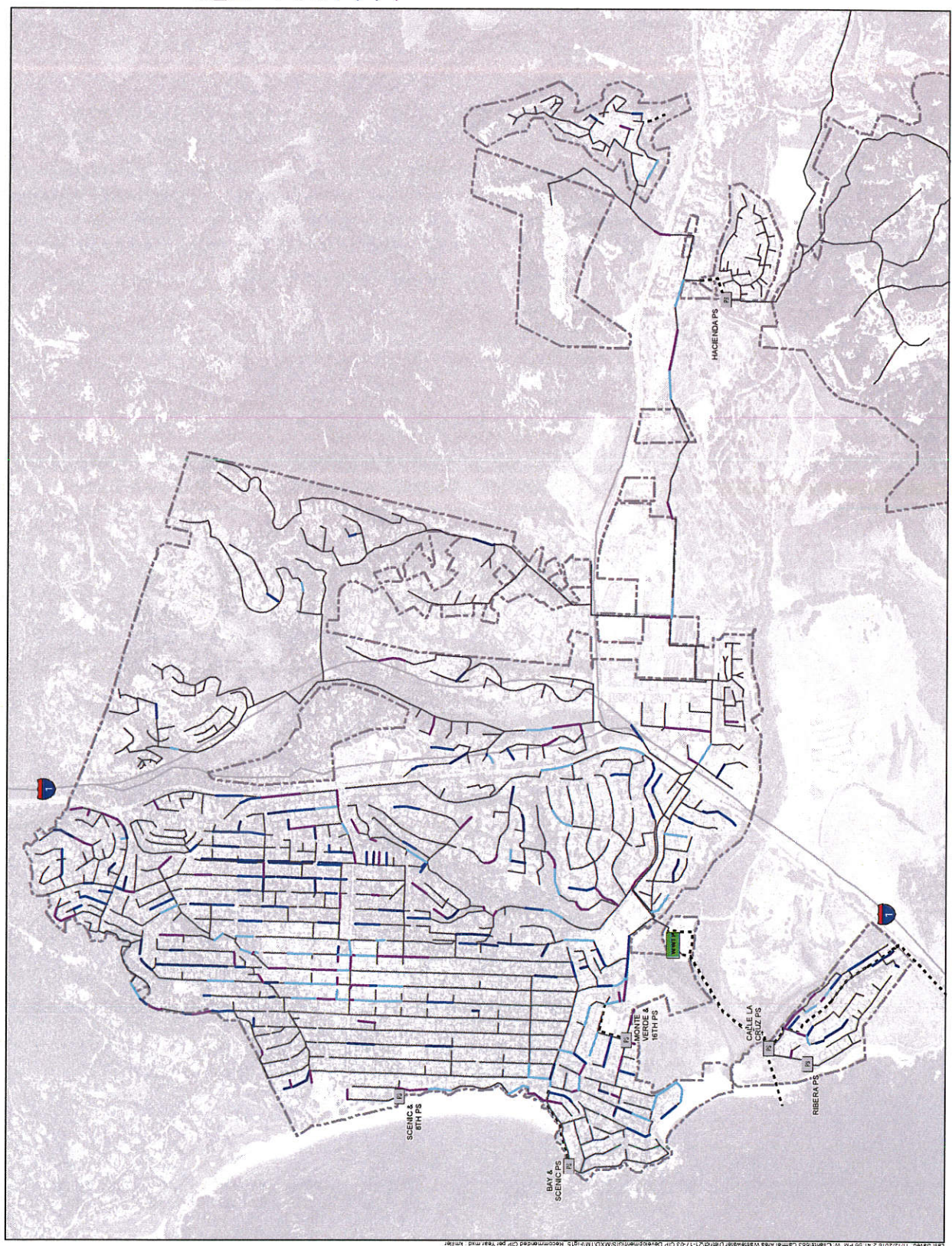
## 3.0 PUMP STATION ASSET MANAGEMENT PLAN

### 3.1 Pump Station Asset Inventory

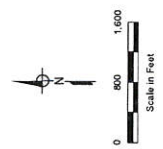
The District's collection system includes seven pump stations, which are described in Table 11. ICOMM, the District's CMMS has a partially-developed pump station asset registry, which stores these physical asset properties (including size, material, manufacturer, and installation date) and maintenance work order history.



- Symbology**
- CAWD Service Area
  - Wastewater Treatment Plant
  - Pump Station
  - Gravity Main
  - Force Main
  - CIP Year**
  - 1 - 5
  - 6 - 10
  - 11 - 15
  - 16 - 20



**Figure 15**  
**Recommended Gravity Sewer R/R Program by Year**  
 Carmel Area Wastewater District  
 Wastewater Collection System  
 Asset Management Plan



- Symbology
- CAWD Service Area
  - Wastewater Treatment Plant
  - Pump Station
  - Gravity Main
  - Force Main
  - Rehab Method
  - Pipe Bursting
  - Open Cut Replacement
  - Full CIPP
  - Point Repairs

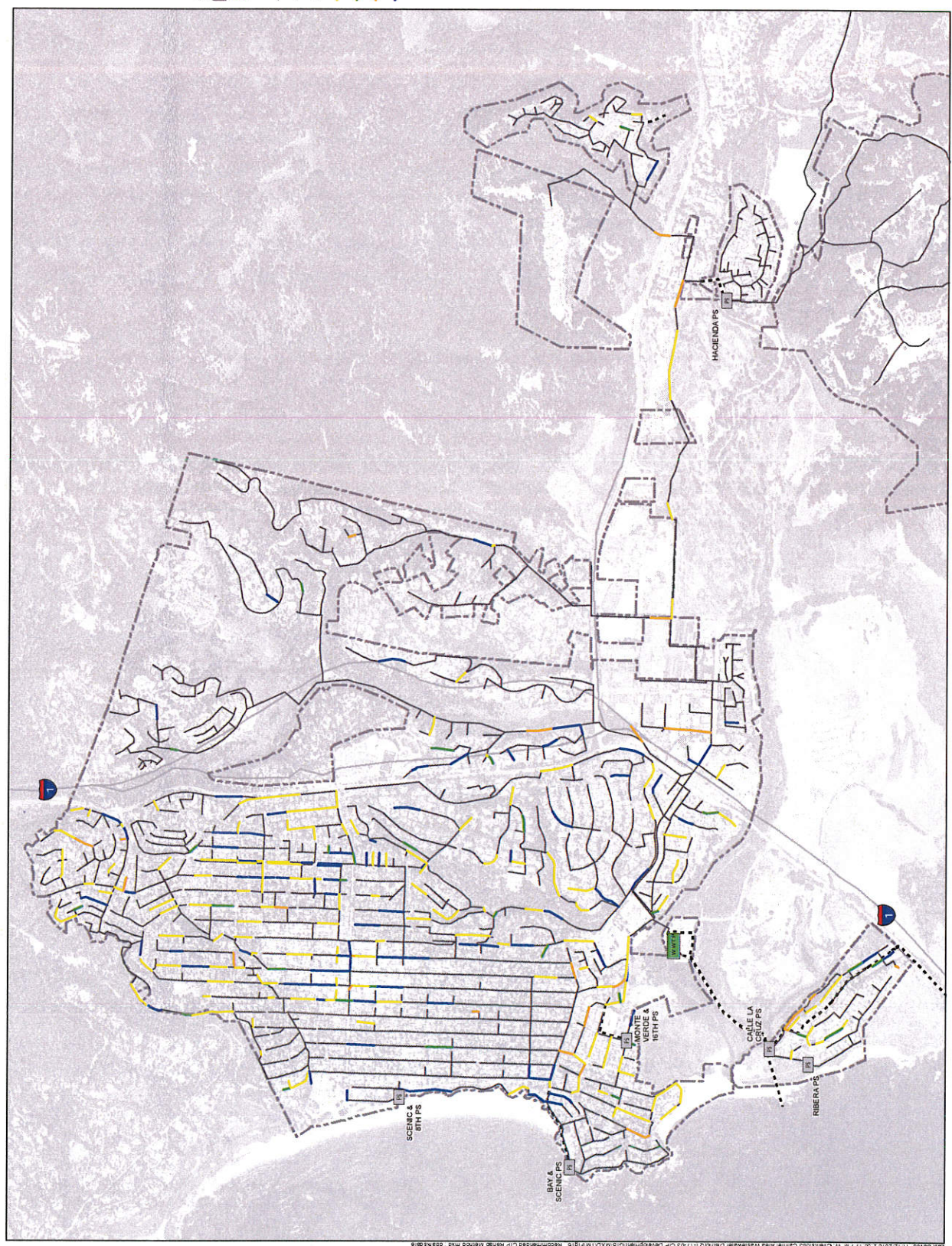


Figure 16  
 Recommended Gravity Sewer  
 R/R Program by  
 Construction Method  
 Carmel Area Wastewater District  
 Wastewater Collection System  
 Asset Management Plan

**Table 11. Pump Station Descriptions**

| Pump Station Name  | Location                                  | Construction Year | No. of Pumps | Pump HP | Pump GPM |        | PS Firm Capacity (GPM) | Standby Generation, kW <sup>(a)</sup> |
|--------------------|-------------------------------------------|-------------------|--------------|---------|----------|--------|------------------------|---------------------------------------|
|                    |                                           |                   |              |         | Pump 1   | Pump 2 |                        |                                       |
| Scenic & 8th       | West of intersection of 8th Ave & Scenic  | 1949              | 2            | 3.2     | 157      | 136    | 136                    | 20                                    |
| Bay & Scenic       | Across from 26189 Scenic Rd.              | 1938              | 2            | 10      | 78       | 69     | 69                     | External <sup>(b)</sup>               |
| Monte Verde & 16th | SE Corner of Monte Verde St. at 16th Ave  | 1938              | 2            | 10      | 215      | 187    | 187                    | External <sup>(b)</sup>               |
| Calle la Cruz      | Behind 2737 Calle La Cruz                 | 1950's            | 2            | 18      | 435      | 421    | 421                    | 60                                    |
| Ribera             | West of Ribera Rd along walking trail     | 1953              | 2            | 3.2     | 84       | 98     | 84                     | External <sup>(c)</sup>               |
| Hacienda           | West of Hacienda Carmel at T intersection | 1966              | 2            | 5       | 392      | 277    | 277                    | 35                                    |
| Highlands          | ~104 Highlands Drive.                     | 2004              | 2            | 23      | 114      | 109    | 109                    | 75                                    |

(a) Standby generation is portable unless otherwise noted.

(b) This station is equipped with a transfer switch and external power connection port.

(c) Backup power is handled by the Calle la Cruz pump station and only a single power feed connects to the Ribera Pump Station.

# Wastewater Collection System Asset Management Plan

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## 3.2 Pump Station Inspections

West Yost prepared Visual Inspection Instruction Forms for District staff to use to perform evaluations of its pump stations. The forms provided suggestions and instructions on who should perform the inspections, when to perform the inspections, how to perform the inspections, and which assets should be inspected. The forms also provide suggested rankings for condition and performance and standard life expectancies for assets that are commonly associated with pump stations. A facility summary sheet is included, as well as separate inspection sheets for performing condition assessments on the civil, structural, mechanical, electrical and instrumentation assets.

The District performed inspections for each of its seven pump stations in January 2018. The scope of the visual assessment was to provide a broad overview of the most pressing issues at each pump station. Supervisory control and data acquisition (SCADA) upgrade needs were not included because a SCADA upgrade for all pump stations is planned for fiscal year 2018/19. The results of the District's visual inspections are summarized below for each pump station.

### 3.2.1 Eighth & Scenic Pump Station

#### **PRIORITY: Low**

##### Observations:

- Original pump station constructed in 1949
- New submersible Flygt pumps in 2012
- New Onan Generator in 2011
- New Tesco electrical panel in 2017

##### Condition Defects:

- The wet well has some metal struts that do not seem to serve any further purpose since construction was completed. Removal of this cumbersome interference will allow better access to the pumps during installation and removal.
- Needs the addition of a float tree and a better transducer mount to more easily access these critical components during repairs or servicing without the need for a confined space entry.
- This station location is near the Pacific Ocean, and sea mist and coastal weather accelerate corrosion.
- This station is susceptible to vandalism.

##### Force Main Notes:

- Force main is very short: 179-LF, 4-inch diameter DIP. Staff can by-pass sewage if it fails.

## Wastewater Collection System Asset Management Plan

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### 3.2.2 Bay & Scenic Pump Station

#### **PRIORITY: Medium-High**

##### Observations:

- Original pump station constructed in 1939
- Last rehabilitation in 2006
- New dry-pit Flygt pumps in 2006
- Flygt control panel in 2006
- No generator on site, staff use portable Generac generator
- New power service installed in 2016 from power pole to station

##### Condition Defects:

- This station is adjacent to the Pacific Ocean, and sea mist and coastal weather accelerate corrosion
- Subject to tidal flooding when big waves hit the station; under a sea level rise study
- Need coastal retaining wall to prevent erosion
- Subject to vandalism

##### Force Main Notes:

- 6-inch DIP 1,512 feet force main is too long to bypass. Requires hauling of sewage from the pump station wetwell if the force main needs to be replaced/repared

### 3.2.3 Monte Verde and 16<sup>th</sup> Pump Station\*

#### **PRIORITY: Medium**

##### Observations:

- Original pump station constructed in 1939
- Last rehabilitation in 2005
- Flygt submersible pumps 2005
- Flygt control panel in 2005
- Built in by-pass pump quick-connect in force main at station
- No generator on site (Staff use portable Onan generator)

## Wastewater Collection System Asset Management Plan



### Condition Defects:

- Subject to tidal flooding; when last flooded in 2008, lost all electrical and SCADA; currently under a sea level rise study.
- Wet well hatch is not traffic rated and needs to be replaced
- Needs new transfer switch

### Force Main Notes:

- 6-inch, 998-LF DIP force main

### 3.2.4 Calle La Cruz Pump Station

#### **PRIORITY: High**

- It is crucial that this station remains operational. It has 3 major pump stations (Highlands, Point Lobos, Ribera) and several smaller pocket stations (Highlands fire O'Boyle) and a local neighborhood that feed into it. Therefore, any problem with the functionality of this station is a critical matter.

Although the station has a bypass connection to the force main, it only allows a bypass of the pumps. If something were to happen to the force main itself, which crosses a waterway, it would be difficult to manage incoming flows. There is virtually no storage for influent flows in the pump station wet well, and it would take only minutes before a breach at the station would occur, causing sewage to flow directly into the adjacent lagoon.

### Observations:

- Original pump station constructed in 1953
- New dry pit Flygt pumps in 2004
- Onan Generator and Flygt electrical panel was part of the upgrade in 2004

### Condition Defects:

- Due to the high hydrogen sulfide concentrations at the station, the wet well was lined with a mortar seal (sewer coat) to extend its life. However, the high hydrogen sulfide levels still exist and continue to erode the liner. Furthermore, hydrogen sulfide has caused the surrounding homes and passersby to file multiple odor complaints.
- This station has a history of both vandalism and vegetation overgrowth.
- This station also gets a heavy grease mat build-up on the water surface in the wet well.

### Force Main Notes:

- 2,685-LF, 6-inch DIP force main crosses the lagoon (300-LF span) and state parks. There is no way to by-pass the force main. This requires hauling sewage from the pump station during an emergency.



## Wastewater Collection System Asset Management Plan

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- In March 2018, there was a circumferential crack detected on the force main. This section of the pipe was repaired.

### 3.2.5 Ribera Pump Station

#### **PRIORITY: Low**

##### Observations:

- Original pump station constructed in 1953
- New pumps in 2012 (Flygt Submersible)
- New electrical control panel in 2015 (Tesco)
- Receives power and communication from Calle La Cruz Pump Station through a single feed

##### Condition Defects:

- The wet well has some metal struts that do not seem to serve any further purpose since rehabilitation was completed. Removal of this cumbersome interference will allow better access to the pumps during installation and removal.
- Needs the addition of a float tree and a better transducer mount to more easily access critical components during servicing without the need for a confined space entry.
- This station is susceptible to vandalism and overgrowth of the surrounding vegetation.
- This station location is adjacent to the Pacific Ocean, and sea mist and coastal weather accelerate corrosion.

##### Force Main Notes:

- Force main is very short: 173-LF, 4-inch DIP. Staff can by-pass the force main using District equipment if it fails.

### 3.2.6 Hacienda Pump Station

#### **PRIORITY: Low**

##### Observations:

- Original pump station constructed in 1967
- This station was rehabilitated in 1999
- Flygt Control Panel in 1999
- Submersible Flygt pumps replaced in 1999
- Generac Generator and transfer switch installed in 1999

## Wastewater Collection System Asset Management Plan



- New power service and power panel in 2017
- Wet well is deep, but the working volume of the wet well is only three to four feet

### Condition Defects:

- Many left over metal struts remain after rehabilitation project that could be removed in wet well.

### Force Main Notes:

- Force main is 8-inch DIP and is 740 LF

### 3.2.7 Highlands Pump Station

#### **PRIORITY: Medium**

- This station in the past had a hard time keeping up with the inflows during a massive potable water purge event in the area. Due to a water supply issue, the entire community surrounding the station flushed their lines at practically the same time to purge the bad water that entered the potable water supply. This event caused the station to fill up the main wet well, grinder vault well, and storm drain. Once those were all full, it then started to fill the secondary wet well onsite. Unfortunately, the overflow line in the main wet well is placed too high for it to overflow into the secondary onsite wet well before flooding the grinder vault. Eventually, things equalized, and the pumps returned the water back to normal levels. This event was indicative of a potential future catastrophe. There are plans to add more flow to this station by adding a pump station farther south that would pump to Highlands as well as several more pocket station tie ins. With these added flows, if another purge event were to happen, and it stands to reason that the station will most likely breach and sewage would flow to the ocean. In an extreme case, the additional water, the purge event, and heavy rainfalls would most certainly lead to imminent overflow.

### Observations:

- Original pump station constructed in 2005
- Has Tesco panel and submersible Flygt pumps

### Condition Defects:

- The force main length has caused premature failure of the pumps that operate at the station. Pumps are in the high range of the curve.
- There currently is no bypass set up at this station
- The grinder vault has a broken weir gate handle

### Force Main Notes:

- The force main is approximately three miles in length: 15,312-LF, 4-inch HDPE.

# Wastewater Collection System Asset Management Plan



- If the force main failed, the only solution would be to haul the water out.
- Due to the length of the force main and the amount of pump cycles required to move water from the beginning to the end of the line, hydrogen sulfide builds up tremendously and damages the downstream infrastructure in contact with it.
- The force main has several vaults along the length of it, containing air relief valve's (ARV) vacuum relief valve's (VRV), and flush valves. ARV's need to be replaced with stainless or composite material as they are very corroded.

### 3.3 Pump Station Risks

Based on their working knowledge and recent inspections of the pump stations, District staff evaluated known pump station concerns and risks, which are summarized in Table 12.

| Pump Station       | No. of Pumps | Pump HP | PS Firm Capacity | Standby Generation, kW <sup>(a)</sup> | Risk/Concerns                                                                                                                                                                    | Relative Risk |
|--------------------|--------------|---------|------------------|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Scenic & 8th       | 2            | 3.2     | 136              | 20                                    | By the Ocean in Sand Dunes.                                                                                                                                                      | Low           |
| Bay & Scenic       | 2            | 10      | 69               | External <sup>(b)</sup>               | On Ocean cliffside. No generator. Portable hookup only.                                                                                                                          | Medium-High   |
| Monte Verde & 16th | 2            | 10      | 187              | External <sup>(b)</sup>               | Flooding of pump station electrical. Can bypass station with portable pump.                                                                                                      | Medium        |
| Calle la Cruz      | 2            | 18      | 421              | 60                                    | Right next to body of water with very little retention time in case of dual pump failure or main and standby power failure. Can potentially bypass by running two pumper trucks. | High          |
| Ribera             | 2            | 3.2     | 84               | External <sup>(c)</sup>               | Gets power from Calle La Cruz. Lots of holding time, can truck if necessary in emergency.                                                                                        | Low           |
| Hacienda           | 2            | 5       | 277              | 35                                    | Really deep wet well. Lots of old abandoned metal in wet well. Lots of holding time                                                                                              | Low           |
| Highlands          | 2            | 23      | 109              | 75                                    | Force main hydraulics are difficult to pump due to long distance -> leads to early pump failures. Odor issues downstream caused by long detention time in force main.            | Medium        |

(a) Standby generation is portable unless otherwise noted.  
 (b) This station is equipped with a transfer switch and external power connection port.  
 (c) Backup power is handled by the Calle la Cruz pump station and only a single power feed connects to the Ribera Pump Station.

# Wastewater Collection System Asset Management Plan



## 3.4 Pump Stations Rehab/Replacement Program

Based on their working knowledge, recent inspections, and risk summary of the pump stations, District staff summarized pump station rehabilitation priorities and budget estimates in Table 13.

| Pump Station       | PS Firm Capacity, GPM | Standby Generation, kW <sup>(a)</sup> | Rehabilitation Priorities                                                                                                                                                 | Rehabilitation Budget Estimates                                                                                                                                             |
|--------------------|-----------------------|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Scenic & 8th       | 136                   | 20                                    | No major rehab, except for minor electrical and SCADA work.                                                                                                               | \$~20K per year average for next ~20 years (including force main rehab).                                                                                                    |
| Bay & Scenic       | 69                    | External <sup>(b)</sup>               | Convert to submersible pumps in wet well (currently dry pit submersible). Look at structure erosion issues vs. relocate electrical in a pedestal away from cliff.         | \$350K for converting pump station to submersible and moving electrical out of dry well. \$100K for shotcrete exterior for erosion control. Plan for 5- to 10-year horizon. |
| Monte Verde & 16th | 187                   | External <sup>(b)</sup>               | Waterproof electrical in dry well.                                                                                                                                        | \$200K for new waterproof electrical.                                                                                                                                       |
| Calle la Cruz      | 421                   | 60                                    | Fix H <sub>2</sub> S issues upstream - wet well corrosion. General rehab due to corrosion outside of the station. Need to replace flood door and flood proof the louvers. | Requires a rehab project in next 10 years at a cost of about \$450K.                                                                                                        |
| Ribera             | 84                    | External <sup>(c)</sup>               | None                                                                                                                                                                      | \$5K per year average for next ~20 years (including force main rehab).                                                                                                      |
| Hacienda           | 277                   | 35                                    | Needs new generator transfer switch.                                                                                                                                      | \$~20K per year average for next ~20 years (including force main rehab).                                                                                                    |
| Highlands          | 109                   | 75                                    | Frequent pump rebuilds due to difficult hydraulic conditions.                                                                                                             | \$~20K per year average for next ~20 years.                                                                                                                                 |

(a) Standby generation is portable unless otherwise noted.  
 (b) This station is equipped with a transfer switch and external power connection port.  
 (c) Backup power is handled by the Calle la Cruz pump station and only a single power feed connects to the Ribera Pump Station.

## 4.0 FORCE MAIN ASSET MANAGEMENT PLAN

### 4.1 Force Main Asset Inventory

The District's collection system includes approximately 4.4 miles of wastewater force mains. The older 1.3 miles of force mains are constructed of cast iron pipe (CIP), while the newer installations are of high-density polyethylene (HDPE), as summarized in Table 14.

# Wastewater Collection System Asset Management Plan



**Table 14. Force Main Descriptions**

| Associated Pump Station                                                                | Force Main Asset Information     |                  |                  |                              |                        |
|----------------------------------------------------------------------------------------|----------------------------------|------------------|------------------|------------------------------|------------------------|
|                                                                                        | Installation Year <sup>(a)</sup> | Material Type    | Diameter, Inches | Length, Linear Feet          | Notes                  |
| Scenic & 8th                                                                           | 1949                             | Cement Lined CIP | 4                | 145                          |                        |
| Bay & Scenic                                                                           | 1938                             | Cement Lined CIP | 6                | 1,490                        |                        |
| Monte Verde & 16th                                                                     | 1938                             | Cement Lined CIP | 6                | 1,000                        |                        |
| Calle la Cruz                                                                          | 1950                             | DIP              | 6                | 3,109                        |                        |
| Ribera                                                                                 | 1953                             | Cement Lined CIP | 4                | 135                          |                        |
| Hacienda                                                                               | 1966                             | CIP              | 8                | 727                          |                        |
| Highlands                                                                              | 2006                             | HDPE             | 4                | 16,134                       |                        |
| T12Plug<br>(Southeast of Hacienda PS)                                                  | 2003                             | HDPE             | 4                | 501                          | Not in Use<br>(Future) |
| <b>Total Force Mains</b>                                                               |                                  |                  |                  | <b>23,241-LF (4.4 miles)</b> |                        |
| <i>Source of installation dates: "Age of Sewers CAWD.xls" provided by the District</i> |                                  |                  |                  |                              |                        |

## 4.2 Replacement Values

A planning level replacement value estimate was developed for the District's force mains. The estimate was prepared using West Yost experience and recent bid results from similar projects. A combined estimating and construction contingency of 30 percent is included in the unit costs to account for unknown conditions, design completion level of the project, and bidding climate factors. The total capital costs include an allowance of 30 percent to account for planning level activities, design, environmental reviews, legal administration, construction services, change orders, and other related items. The replacement of the force mains is currently valued at approximately \$5.1 M in September 2018 dollars (ENR Construction Index of 12103.88), as summarized in Table 15.

# Wastewater Collection System Asset Management Plan



**Table 15. Force Main Replacement Values**

| Construction Method<br>Unit Cost (\$/in-Diam-LF)<br>Pipe Diameter, Inch | Pipe Bursting<br>\$28 |                   |                    |
|-------------------------------------------------------------------------|-----------------------|-------------------|--------------------|
|                                                                         | Length, Linear Feet   | Unit Cost (\$/LF) | Cost \$            |
| 4                                                                       | 16,915                | 112               | 1,894,000          |
| 6                                                                       | 5,599                 | 168               | 941,000            |
| 8                                                                       | 727                   | 224               | 163,000            |
| <b>Total</b>                                                            | <b>4.4 Miles</b>      |                   | <b>\$2,998,000</b> |
| 30% Contingency:                                                        |                       |                   | \$899,000          |
| <b>Construction Cost Subtotal:</b>                                      |                       |                   | <b>\$3,897,000</b> |
| Engineering, Legal, Admin., etc. @ 30%:                                 |                       |                   | \$1,169,000        |
| <b>Total Capital Cost:</b>                                              |                       |                   | <b>\$5,066,000</b> |

# Wastewater Collection System Asset Management Plan



## 4.3 Force Main Risks

Based on their working knowledge of the system, District staff evaluated known force main concerns and risks, which are summarized in Table 16.

| Associated Pump Station | Force Main Asset Information     |                  |                     |                  | Risks & Concerns                                                                                                                                                                                                    | Relative Risk |
|-------------------------|----------------------------------|------------------|---------------------|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
|                         | Installation Date <sup>(a)</sup> | Diameter, Inches | Length, Linear Feet | Material Type    |                                                                                                                                                                                                                     |               |
| Scenic & 8th            | 1949                             | 4                | 145                 | Cement Lined CIP | Short run is easy to bypass.                                                                                                                                                                                        | Low           |
| Bay & Scenic            | 1938                             | 6                | 1,490               | Cement Lined CIP | Have had force main blockage caused by pipe corrosion (occlusion) in section of pipe exposed to air pockets. Too long to bypass pump; requires hauling.                                                             | Medium-High   |
| Monte Verde & 16th      | 1938                             | 6                | 1,000               | Cement Lined CIP | Have had force main blockage caused by pipe corrosion (occlusion) in section of pipe exposed to air pockets.                                                                                                        | Medium        |
| Calle la Cruz           | 1950'S                           | 6                | 3,109               | DIP              | Arial crossing over lagoon is high risk. A crack was discovered in the buried force main in the last year and was repaired. This could have been an isolated defect or could be a sign of future failure potential. | High          |
| Ribera                  | 1953                             | 4                | 135                 | Cement Lined CIP | Short run is easy to bypass.                                                                                                                                                                                        | Low           |
| Hacienda                | 1966                             | 8                | 727                 | CIP              | Could bypass if necessary in an emergency.                                                                                                                                                                          | Medium-Low    |
| Highlands               | 2006                             | 4                | 16,134              | HDPE             | Very long pipe with long detention time, material accumulation and H2S formation.                                                                                                                                   | Medium-High   |

(a) Installation dates obtained from "Age of Sewers CAWD.xls" given to West Yost from Carmel Area Wastewater District.

# Wastewater Collection System Asset Management Plan

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## 4.4 Force Main Inspections

Proper inspection of sewer lines is essential to the successful implementation of any collection system management program. Condition assessments are a vital component to risk analysis, ultimately determining a replacement and rehabilitation prioritization schedule. Currently, the District uses CCTV to inspect approximately 77-miles of gravity sewer mains, however, the District does not currently place force mains on a regular inspection schedule.

There are many obstacles to implementing a force main inspection program, including the need to remove the force main from service during inspection, bypass pumping or hauling challenges, as well as difficulties dewatering the force main for interior inspection. Exterior inspection of buried force mains requires expensive excavations and can only provide limited information along the length of the pipe.

### 4.4.1 Inspection Technologies

There are many pressure-pipe assessment technologies, all of which have limitations to their applicability on certain pipe parameters and the level of information provided. Before embarking on an expensive force main condition assessment effort, it is essential to: 1) focus District funds only on the force mains that pose the highest risks to the District, and 2) balance the cost of the inspection technology (and associated bypass pumping/hauling and pipe dewatering costs) with the information provided by the technology. For example, leak detection technologies are less expensive and do not require shut-down and dewatering of the pipeline, however they only provide data on existing leaks and do not identify defects that may lead to future leaks or catastrophic failures.

Inspection technologies can be categorized into: visual inspection, structural condition assessment, leak detection, and multi-sensor platforms.

#### 4.4.1.1 *Visual Inspection*

Visual inspection techniques include CCTV inspection, digital scanning, and laser profiling:

- A permanent video record of the defects of pipe segments is captured through CCTV inspections.
- Digital scanning is a subset of the camera inspection technology where multiple high-resolution cameras are transported through the force main using self-propelled crawlers. The practical applications of CCTV inspection and digital scanning include detection of defects at the downstream sections of the force mains near the discharge point where the pipeline is accessible.
- The changes in pipe shape due to deflections and deformations can be detected through laser-based pipe inspection.



# Wastewater Collection System Asset Management Plan



## 4.4.1.2 Structural Condition Assessment

The structural integrity of the pipes cannot be determined through visual inspection techniques. The structural condition of the pipes can be assessed through ultrasonic wall thickness measurement and electromagnetic corrosion detection techniques.

**Ultrasonic Wall Thickness:** The pipe wall thickness, corrosion intensity and the presence of cracks in ferrous pipeline can be detected through in-line inspection and guided wave ultrasonic testing.

- The external remote detection of pipe structural condition is carried out through Guided Wave Ultrasonic Testing. The guided-wave method is used primarily as a screening tool that indicates an existing wall anomaly along the pipeline but does not return actual wall thickness data.
- The wall thickness and corrosion of the pipelines can be measured by an in-line inspection technique, which uses a piezo-electric transducer to generate an ultrasonic pulse.
- The ultrasonic wave is stopped by the joints in DI and CI pipes and therefore is suitable only for one pipe length.

**Electromagnetic Corrosion Detection:** The defects in ferrous (metallic) pipes are detected using electrical/electromagnetic current. The defects in the pipe wall and the wall thickness are quantified using three major techniques: Magnetic Flux Leakage (MFL), Remote Field Eddy Current (RFEC), and Broadband Electro-Magnetic (BEM):

- Magnetic Flux Leakage: The pipe wall surface is magnetized, and the leakages produced because of defects or metal loss in the pipe wall is measured by the MFL technique. The disadvantages of the MFL technique include the large amount of data that need to be analyzed to quantify the defects. The magnets and the Hall Effect sensors should be placed very close to the pipe wall in the MFL technique, which makes it impractical for the DI and CI pipes due to wall variations and joints. This adds significantly to the cost of inspection.
- Remote Field Eddy Current: The corrosion intensity and location can be evaluated by the RFEC inspection technique. Pipes with internal linings can be scanned using the RFEC tool.
- Broadband Electro-Magnetic: The wall thickness of ferrous pipe is measured through the BEM non-destructive testing technique. The advantage of employing the BEM technology is its ability to scan through coatings and linings without requiring contact with the pipe wall. The disadvantage when scanning pipelines internally, compared to intelligent pigs, is that the process is not continuous and therefore it takes more time to survey a pipeline.

# Wastewater Collection System Asset Management Plan

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## 4.4.1.3 Leak Detection

The leaks in force mains are detected by analyzing the vibrations or sound generated through leak detectors. The various types of leak detectors are hand-held listening devices, leak noise correlators and in-line devices. The major acoustic leak detection monitoring techniques are free-swimming leak detection and tethered leak detection:

- Free-Swimming Leak Detection: SmartBall is a free-swimming leak detection product that continuously measures the acoustic signal and detects an increase in the signal when it encounters a leak. Gas pockets can also be detected through this technique.
- Tethered Leak Detection: The Sahara system is a tethered leak detection product that can detect acoustic signals indicating leaks, gas pockets or areas of turbulence within the pipeline. An advantage of the Sahara system is that it can be used to track the location of the pipeline from the ground surface.

## 4.4.1.4 Multi-Sensor Inspection

Various types of defects in the wastewater collection system can be detected by employing multiple technologies. The extensively used camera-based technologies can be supplemented with other leak detection, ultrasonic testing and electromagnetic technologies to offset the drawbacks of visual inspection technologies. Multi-sensor inspection robots are available that incorporate CCTV, laser profiling etc., to identify the defects in the system. Hydromax USA, Redzone Robotics and Hibbard Inshore provide multi-sensor platforms.

## 4.4.2 Preliminary Inspection Recommendations

Considering the risks identified above, potential inspection methods are recommended for further evaluation in Table 17 for each force main. Each inspection method has limitations on pipe bends, access points, dewatering capabilities, etc., so further evaluation is needed to select the appropriate inspection method.

# Wastewater Collection System Asset Management Plan



**Table 17. Preliminary Force Main Inspection Method Recommendations**

| Associated Pump Station | Force Main Asset Information     |                  |                     |                  | Inspection Methods Recommended for Further Evaluation                                                                                                                                          |
|-------------------------|----------------------------------|------------------|---------------------|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                         | Installation Date <sup>(a)</sup> | Diameter, Inches | Length, Linear Feet | Material Type    |                                                                                                                                                                                                |
| Scenic & 8th            | 1949                             | 4                | 145                 | Cement Lined CIP | Interior inspection using CCTV from discharge point.                                                                                                                                           |
| Bay & Scenic            | 1938                             | 6                | 1,490               | Cement Lined CIP | If dewatering is possible, inspect interior using CCTV. If dewatering is not possible, consider leak detection.                                                                                |
| Monte Verde & 16th      | 1938                             | 6                | 1,000               | Cement Lined CIP | If dewatering is possible, inspect interior using CCTV. If dewatering is not possible, consider leak detection.                                                                                |
| Calle la Cruz           | 1950'S                           | 6                | 3,109               | DIP              | Due to long length with no access points, consider free-swimming leak detection, possibly coupled with exterior ultrasonic wall thickness testing along the exterior of the above-ground pipe. |
| Ribera                  | 1953                             | 4                | 135                 | Cement Lined CIP | Interior inspection using CCTV from discharge point.                                                                                                                                           |
| Hacienda                | 1966                             | 8                | 727                 | CIP              | Progressively-pig, then inspect interior using CCTV.                                                                                                                                           |
| Highlands               | 2006                             | 4                | 16,134              | HDPE             | -                                                                                                                                                                                              |

(a) Installation dates obtained from "Age of Sewers CAWD.xls" given to West Yost from Carmel Area Wastewater District

## 4.5 Force Mains Rehab/Replacement Program

Based on their working knowledge and risk summary, District staff summarized force main rehabilitation priorities and budget estimates in Table 18.

# Wastewater Collection System Asset Management Plan



**Table 18. Force Main Rehabilitation Priorities**

| Associated Pump Station | Diameter, inches | Length, LF | Rehabilitation Priorities                                                                            | Rehabilitation Estimates               |
|-------------------------|------------------|------------|------------------------------------------------------------------------------------------------------|----------------------------------------|
| 8th & Scenic            | 4                | 145        | Assess installing a liner (or likely replace this short pipe) in 10 to 20 years.                     | Included in Pump Station Cost          |
| Bay & Scenic            | 6                | 1,490      | Replace short section of pipe with corrosion with PVC and install air release valves at high points. | \$50K sometime in the next 10 years    |
| Monte Verde & 16th      | 6                | 1,000      | Replace short section of pipe with corrosion with PVC and install air release valves at high points. | \$50K sometime in the next 10 years    |
| Calle la Cruz           | 6                | 3,109      | May need to replace entire pipeline.                                                                 | \$500K in next 10 years                |
| Ribera                  | 4                | 135        | Assess installing a liner (or likely replace this short pipe) in 10 to 20 years.                     | Included in Pump Station Cost          |
| Hacienda                | 8                | 727        | Assess installing a liner in 10 to 20 years.                                                         | Included in Pump Station Cost          |
| Highlands               | 4                | 16,134     | Replace air release and vacuum valves.                                                               | \$50K to replace air and vacuum valves |

## 5.0 SUMMARY AND NEXT STEPS

### 5.1 Rehab/Replacement Program Summary

Table 19 summarizes the total 20-year Collection System Rehab/Replacement Program for each of the primary asset classes in the collection system.

**Table 19. 20-Year Rehab/Replacement Program Summary**

| Program Year                                  | Gravity Sewer \$    | Pump Station \$    | Force Main \$    | Total Rehab/Replacement |
|-----------------------------------------------|---------------------|--------------------|------------------|-------------------------|
| Years 1-5                                     | 4,996,000           | 775,000            | 500,000          | <b>6,271,000</b>        |
| Years 6-10                                    | 4,919,000           | 975,000            | 150,000          | <b>6,044,000</b>        |
| Years 11-15                                   | 5,070,000           | 325,000            | -                | <b>5,395,000</b>        |
| Years 16-20                                   | 5,002,000           | 325,000            | -                | <b>5,327,000</b>        |
| <b>Subtotals</b>                              | <b>\$19,987,000</b> | <b>\$2,400,000</b> | <b>\$650,000</b> | <b>-</b>                |
| <b>Total Construction Costs<sup>(a)</sup></b> |                     |                    |                  | <b>\$23,037,000</b>     |
| 30% Engineering, Legal, Administration, etc.  |                     |                    |                  | \$6,911,100             |
| <b>Total Capital Costs</b>                    |                     |                    |                  | <b>\$29,948,100</b>     |

(a) Includes 30 percent construction cost contingency.

# Wastewater Collection System Asset Management Plan



## 5.2 Next Steps

While this AMP documents the foundation and current status of the District's collection system program, it is also intended to be a working document that the District can use to further advance its program going forward. Recommended next steps for the District are:

- **Gravity Sewer Project Packaging and Prioritization.** Considerations for developing and prioritizing construction project packages for the first five years include:
  - **Capacity/Upsizing.** Coordinate rehab/replacement priorities with capacity improvements identified by the District's on-going hydraulic modeling efforts. Where sewers are upsized for capacity improvements, construct downstream upgrades first in order to avoid moving potential overflow locations downstream.
  - **Public Impacts.** While high-risk sewers should be prioritized for rehab/replacement first, construction impacts on the public must also be balanced. Group rehab/replacement projects so that the same street or major traffic thoroughfares are under construction only once in a five-year period.
  - **Planning/Permitting.** Allow for the appropriate planning and permitting activities to occur before project design begins – including easement acquisitions or rights-of-entry, environmental permitting, City encroachments, etc.
  - **Competitive Pricing.** Pipeline construction packages of less than \$1M tend to limit the bidding pool and attract smaller contractors with less experience – both of which increase the unit costs of the project. To benefit from economies of scale and increase the competitiveness of bids, consider implementing larger construction packages, say every-other year, or issue multi-year on-call contracts with fixed unit pricing and annual increases that guarantee a minimum scope and contract amount per year. Also, where possible, consider allowing multiple construction methods to be bid (e.g. either pipe bursting or open-cut at the contractor's discretion) to broaden the pool of contractors qualified for each project.
  - **Staffing and Resources.** In order to limit the number of contracts for planning, design, construction, and construction management of sanitary sewer projects in any given year, consider implementing larger or multi-year contracts for engineering and construction management services and construction packages.
- **Gravity Sewer Preventative Maintenance Program.** Optimize the preventative maintenance program using the risk assessment results:
  - Review condition assessment data and maintenance records for low risk, high maintenance frequency assets.
  - Confirm the adequacy of routine maintenance for high-risk assets.
- **Pump Station Program.** Build upon the foundation presented in this report in the following areas:

## Wastewater Collection System Asset Management Plan

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- **Tidal Impacts.** Continue the District's efforts to understand the impacts of sea-level rise on tidally-impacted pump stations, and plan accordingly for sea wall or spill containment improvements.
- **Condition Assessment.** Continue to monitor the condition and performance of medium-high and high-risk pump stations and their critical components.
- **Rehab/Replacement.** Refine the next five years of improvements to resolve existing condition defects and maintenance issues, mitigate high risk factors, and improve reliability and emergency response capabilities.
- **Force Main Program.** Build upon the foundation presented in this report by:
  - **Assess Condition.** Inspect high and medium-high risk force mains within the next five years, and medium risk force mains within the next ten years.
  - **Rehab/Replacement Program.** Proactively identify and refine planned improvements on high and medium-high risk force mains. Budget for the replacement of old low and medium-low risk force mains that may be run-to-failure in the next 10 years.
- **Manhole Program.** Develop an AMP for the manholes in the collection system. Begin by collecting condition information for manholes connected to high and medium-high gravity sewers, and applying a risk assessment and rehab/replacement process similar to the gravity sewer risk assessment presented in this AMP.
- **Data and Record Keeping.** Improve District records by:
  - Populating the age of District assets in the ICOMM asset registry.
  - Improving records of asset improvements by populating rehabilitation/replacement projects in the District's CMMS database as a project consisting of a batch of asset ID's, or at a minimum as project name and date fields in the individual asset records.
- **Continuous Improvement.** Continually review and improve this Collection System AMP to improve efficiency and reduce risks to the District over time.

# **APPENDIX A**

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CCTV Defect Code List



Color Coded Chart

NASSCO'S PIPELINE ASSESSMENT CERTIFICATION PROGRAM® (PACP®)

Section 4 — Structural Defect Coding

|                                                                                                                            |                                                                                                                                      |                                                                                                                 |                                                                                                                                 |                                                                                                                                             |                                                                                                                                       |                                                                                                                                             |
|----------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| <b>C CRACK 4-3</b><br>CL Longitudinal<br>CC Circumferential<br>CM Multiple<br>CS Spiral<br>CH Hinge (2, 3, 4)              | <b>F FRACTURE 4-9</b><br>FL Longitudinal<br>FC Circumferential<br>FM Multiple<br>FS Spiral<br>FH Hinge (2, 3, 4)                     | <b>B BROKEN 4-17</b><br>BSV Soil Visible<br>BVV Void Visible                                                    | <b>H HOLE 4-21</b><br>HSV Soil Visible<br>HWV Void Visible                                                                      | <b>D DEFORMED (Rigid) 4-26</b><br>DR Deformed Rigid<br>No modifiers used                                                                    | <b>D DEFORMED (Flexible) 4-26</b><br>DFBR Bulging Round<br>DFBI Bulging Inv. Curv.<br>DFC Creasing<br>DFE Elliptical                  | <b>D DEFORMED (Brick) 4-26</b><br>DTBR Bulging Round<br>DTBI Bulging Inv. Curv.                                                             |
| <b>X COLLAPSE 4-37</b><br>X Collapse<br>No descriptors and no modifiers used.                                              | <b>J JOINT 4-45</b><br>JOS Offset Small<br>JOM Offset Medium<br>JOL Offset Large                                                     | <b>J JOINT 4-45</b><br>JSS Separation Small<br>JSM Separation Med.<br>JSL Separation Large                      | <b>J JOINT 4-45</b><br>JAS Angular Small<br>JAM Angular Medium<br>JAL Angular Large                                             | <b>S SURFACE DAMAGE 4-52</b><br>SRV Reinforcement Visible<br>SRP Reinforcement Projecting<br>SRC Reinforcement Corroded<br>SMW Missing Wall | <b>S SURFACE DAMAGE 4-51</b><br>SRI Roughness Increased<br>SAV Aggregate Visible<br>SAP Aggregate Projecting<br>SAM Aggregate Missing | <b>S SURFACE DAMAGE 4-52</b><br>SRV Reinforcement Visible<br>SRP Reinforcement Projecting<br>SRC Reinforcement Corroded<br>SMW Missing Wall |
| <b>S SURFACE DAMAGE 4-52</b><br>SSS Surface Spalling<br>SSC Surface Spalling<br>SCP Coating<br>SZ Chemical Attack<br>Other | <b>LF LINING FEATURES 4-67</b><br>LFAC Abroad'd Connection<br>LFAS Annular Space<br>LFB Blistered Lining<br>LFCS Service Cut Shifted | <b>LF LINING FEATURES 4-67</b><br>LFD Detached<br>LFDL Discoloration<br>LFDE Defective End<br>LFDL Delamination | <b>LF LINING FEATURES 4-67</b><br>LFOC Overcut Service<br>LFRS Resin Slug<br>LFUC Undercut Service<br>LFW Wrinkled<br>LFZ Other | <b>WF WELD FAILURE 4-85</b><br>WFC Circumferential<br>WFL Longitudinal<br>WFM Multiple<br>WFS Spiral<br>WFZ Other                           | <b>RP POINT REPAIR 4-89</b><br>RPR Replacement<br>RPRD Replmt. Defective<br>RPZ Other<br>RPZD Other Defective                         | <b>RP POINT REPAIR 4-89</b><br>RPL Liner<br>RPLD Liner Defective<br>RPP Patch<br>RPPD Patch Defective                                       |
| <b>BRICKWORK 4-97</b><br>DB Displaced<br>MB Missing<br>DI Dropped Invert                                                   | <b>BRICKWORK 4-97</b><br>MMS Mortar Missing Small<br>MMY Mortar Missing Med.<br>MML Mortar Missing Large                             |                                                                                                                 |                                                                                                                                 |                                                                                                                                             |                                                                                                                                       |                                                                                                                                             |





Color Coded Chart

**NASSCO'S PIPELINE ASSESSMENT CERTIFICATION PROGRAM® (PACP)®**

**Section 5 — Operation and Maintenance**

|          |                                                            |     |
|----------|------------------------------------------------------------|-----|
| <b>D</b> | <b>DEPOSITS (Attached)</b>                                 | 5-3 |
| D        | DAE Encrustation<br>DAGS Grease<br>DAR Raging<br>DAZ Other |     |

|          |                                                          |     |
|----------|----------------------------------------------------------|-----|
| <b>D</b> | <b>DEPOSITS (Settled)</b>                                | 5-4 |
| D        | DSF Fine<br>DSGV Gravel<br>DSC Hard/Compact<br>DSZ Other |     |

|          |                                                  |     |
|----------|--------------------------------------------------|-----|
| <b>D</b> | <b>DEPOSITS (Ingress)</b>                        | 5-4 |
| D        | DNF Fine (silt/sand)<br>DNGV Gravel<br>DNZ Other |     |

|          |                                                          |      |
|----------|----------------------------------------------------------|------|
| <b>R</b> | <b>ROOT (Fine)</b>                                       | 5-11 |
| R        | RFB Barrel<br>REL Lateral<br>RFC Connection<br>RFJ Joint |      |

|          |                                                          |      |
|----------|----------------------------------------------------------|------|
| <b>R</b> | <b>ROOTS (Medium)</b>                                    | 5-12 |
| R        | RMB Barrel<br>RML Lateral<br>RMC Connection<br>RMJ Joint |      |

|          |                                                          |      |
|----------|----------------------------------------------------------|------|
| <b>R</b> | <b>ROOTS (Ball)</b>                                      | 5-12 |
| R        | RBB Barrel<br>RBL Lateral<br>RBC Connection<br>RBJ Joint |      |

|          |                                                          |      |
|----------|----------------------------------------------------------|------|
| <b>R</b> | <b>ROOTS (Tap)</b>                                       | 5-12 |
| R        | RTB Barrel<br>RTL Lateral<br>RTC Connection<br>RTJ Joint |      |

|          |                                                                      |      |
|----------|----------------------------------------------------------------------|------|
| <b>I</b> | <b>INFILTRATION</b>                                                  | 5-20 |
| I        | IS Stain<br>ISB Barrel<br>ISC Connection<br>ISJ Joint<br>ISL Lateral |      |

|          |                                                                       |      |
|----------|-----------------------------------------------------------------------|------|
| <b>I</b> | <b>INFILTRATION</b>                                                   | 5-20 |
| I        | IW Weeper<br>IWB Barrel<br>IWC Connection<br>IWJ Joint<br>IWL Lateral |      |

|          |                                                                        |      |
|----------|------------------------------------------------------------------------|------|
| <b>I</b> | <b>INFILTRATION</b>                                                    | 5-20 |
| I        | ID Dripper<br>IDB Barrel<br>IDC Connection<br>IDJ Joint<br>IDL Lateral |      |

|          |                                                                       |      |
|----------|-----------------------------------------------------------------------|------|
| <b>I</b> | <b>INFILTRATION</b>                                                   | 5-21 |
| I        | IR Runner<br>IRB Barrel<br>IRC Connection<br>IRJ Joint<br>IRL Lateral |      |

|          |                                                                       |      |
|----------|-----------------------------------------------------------------------|------|
| <b>I</b> | <b>INFILTRATION</b>                                                   | 5-21 |
| I        | IG Gusher<br>IGB Barrel<br>IGC Connection<br>IGJ Joint<br>IGL Lateral |      |

|           |                                                                                            |      |
|-----------|--------------------------------------------------------------------------------------------|------|
| <b>OB</b> | <b>OBSTACLES 5-31 OBSTRUCTIONS</b>                                                         | 5-31 |
| OB        | OBB Brick or Masonry<br>OBC Object Through Connection<br>OBI Object Intruding Through Wall |      |

|           |                                                                                                          |      |
|-----------|----------------------------------------------------------------------------------------------------------|------|
| <b>OB</b> | <b>OBSTACLES 5-31 OBSTRUCTIONS</b>                                                                       | 5-31 |
| OB        | OBJ Object in Joint<br>OBM Pipe Material in Invert<br>OBN Construction Debris<br>OBP External Pipe Cable |      |

|           |                                                  |      |
|-----------|--------------------------------------------------|------|
| <b>OB</b> | <b>OBSTACLES 5-32 OBSTRUCTIONS</b>               | 5-32 |
| OB        | OBR Rocks<br>OBS Built in Structure<br>OBZ Other |      |

|          |                                    |      |
|----------|------------------------------------|------|
| <b>V</b> | <b>VERMIN</b>                      | 5-45 |
| V        | VR Rat<br>VC Cockroach<br>VZ Other |      |

|          |                                                                                                            |      |
|----------|------------------------------------------------------------------------------------------------------------|------|
| <b>G</b> | <b>GROUT TEST &amp; SEAL</b>                                                                               | 5-50 |
| G        | GTP Grout Test Passed<br>GTPJ Joint<br>GTPM Lateral<br>GTF Grout Test Failed<br>GTFJ Joint<br>GTFM Lateral |      |

|          |                                                                                |      |
|----------|--------------------------------------------------------------------------------|------|
| <b>G</b> | <b>GROUT TEST &amp; SEAL</b>                                                   | 5-50 |
| G        | GTU Grout Test Unable<br>GTUJ Joint<br>GTUL Lateral<br>GRT Grout Test Location |      |

**Section 7 — Miscellaneous Features**

**Section 6 — Construction Features**

|          |                                                                                                     |     |
|----------|-----------------------------------------------------------------------------------------------------|-----|
| <b>T</b> | <b>TAP</b>                                                                                          | 6-3 |
| T        | TB Break-in/Hammer<br>TBI Intruding<br>TBD Defective<br>TBC Capped<br>TBA Activity<br>TBB Abandoned |     |

|          |                                                                                                  |     |
|----------|--------------------------------------------------------------------------------------------------|-----|
| <b>T</b> | <b>TAP</b>                                                                                       | 6-3 |
| T        | TF Factory Made<br>TFI Intruding<br>TFD Defective<br>TFC Capped<br>TFA Activity<br>TFB Abandoned |     |

|          |                                                                                                   |     |
|----------|---------------------------------------------------------------------------------------------------|-----|
| <b>T</b> | <b>TAP</b>                                                                                        | 6-4 |
| T        | TR Rehabilitated<br>TRI Intruding<br>TRD Defective<br>TRC Capped<br>TRA Activity<br>TRB Abandoned |     |

|          |                                                                                            |     |
|----------|--------------------------------------------------------------------------------------------|-----|
| <b>T</b> | <b>TAP</b>                                                                                 | 6-4 |
| T        | TS Saddle<br>TSI Intruding<br>TSD Defective<br>TSC Capped<br>TSA Activity<br>TSB Abandoned |     |

|           |                                                                                              |      |
|-----------|----------------------------------------------------------------------------------------------|------|
| <b>IS</b> | <b>INTRUDING SEALING MATERIAL</b>                                                            | 6-15 |
| IS        | ISSR Sealing Ring<br>ISSRB Broken<br>ISSRH Hanging<br>ISSRL Loose<br>ISGT Grout<br>IS7 Other |      |

|          |                                                                                                |     |
|----------|------------------------------------------------------------------------------------------------|-----|
| <b>M</b> | <b>MISCELLANEOUS FEATURES</b>                                                                  | 7-1 |
| M        | MCU Camera Underwater<br>MGO General Observation<br>MGP General Photograph<br>MUL Joint Length |     |

|          |                                                                                             |     |
|----------|---------------------------------------------------------------------------------------------|-----|
| <b>M</b> | <b>MISCELLANEOUS FEATURES</b>                                                               | 7-3 |
| M        | MWLS Water Level Sag<br>MWM Water Mark<br>MY Dye Test<br>MYV Dye Visible<br>MYN Not Visible |     |

|          |                                                    |      |
|----------|----------------------------------------------------|------|
| <b>L</b> | <b>LINE (of sewer)</b>                             | 6-21 |
| L        | LD Down<br>LL Left<br>LLD Left Down<br>LLU Left Up |      |

|          |                                                     |      |
|----------|-----------------------------------------------------|------|
| <b>L</b> | <b>LINE (of sewer)</b>                              | 6-21 |
| L        | LR Right<br>LRD Right Down<br>LRU Right Up<br>LU Up |      |

|          |                                                                                 |      |
|----------|---------------------------------------------------------------------------------|------|
| <b>A</b> | <b>ACCESS POINT</b>                                                             | 6-25 |
| A        | ACB Catch Basin<br>ACO Cleanout<br>ACOM Mainline<br>ACOP Property<br>ACOH House |      |

|          |                                                                                       |      |
|----------|---------------------------------------------------------------------------------------|------|
| <b>A</b> | <b>ACCESS POINT</b>                                                                   | 6-25 |
| A        | ADP Discharge Point<br>AEP End of Pipe<br>AJB Junction Box<br>AM Meter<br>AMH Manhole |      |

|          |                                                                                               |      |
|----------|-----------------------------------------------------------------------------------------------|------|
| <b>A</b> | <b>ACCESS POINT</b>                                                                           | 6-26 |
| A        | AOC Other Structure<br>ATC Tee Connection<br>AWA Wastewater Access<br>AWW Wetwell<br>AZ Other |      |

|          |                                                                                                              |     |
|----------|--------------------------------------------------------------------------------------------------------------|-----|
| <b>M</b> | <b>MISCELLANEOUS FEATURES</b>                                                                                | 7-2 |
| M        | MLC Lining Change<br>MMC Material Change<br>MSC Shape/Size Change<br>MSA Survey Abandoned<br>MWL Water Level |     |



Color Coded Chart

NASSCO'S PIPELINE ASSESSMENT CERTIFICATION PROGRAM® (PACP)®

Section 2 — Header Form Fields

|                                                                                                                                                                                                                        |                                                                                                                                                                                        |                                                                                                                                                                |                                                                                                                                                                                                  |                                                                                                                                                                                                   |                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| <b>14 Weather</b> 2-5<br>1 = Dry<br>2 = Heavy Rain<br>3 = Light Rain<br>4 = Snow<br>5 = Dry Weather/Wet Ground                                                                                                         | <b>15 Pre-Cleaning</b> 2-5<br>H = Heavy Cleaning<br>L = Light Cleaning (Jetting)<br>N = No Pre-Cleaning<br>X = Not Known<br>Z = Other                                                  | <b>17 Flow Control</b> 2-6<br>B = Bypassed<br>D = Dewatered/Using Jetter<br>L = Lift Station<br>N = Not Controlled<br>P = Plugged                              | <b>18 Purpose</b> 2-7<br>A = Maintenance<br>B = Infiltration/Inflow Invest.<br>C = Post-Rehabilitation<br>D = Pre-Rehabilitation<br>E = Pre-Acceptance<br>F = Routine Assessment                 | <b>18 Purpose</b> 2-7<br>G = Capital Improvement Program Assessment<br>H = Resurvey<br>I = SSES<br>R = Pre-Existing Video<br>X = Not Known                                                        | <b>19 Direction</b> 2-7<br>D = Downstream<br>U = Upstream                                                                            |
| <b>28 Location Code</b> 2-11<br>A = Primary Major Arterial Road<br>B = Secondary Road<br>C = Local/Rural Street<br>D = Easement/Right-of-Way<br>E = Woods                                                              | <b>28 Location Code</b> 2-11<br>F = Sidewalk<br>G = Parking Lot<br>H = Alley<br>I = Ditch<br>J = Building<br>K = Creek (or any waterway)                                               | <b>28 Location Code</b> 2-11<br>L = Railway<br>M = Airport<br>N = Levee/Floodwall<br>O = Dam<br>P = Levee Pump Station<br>Y = Yard<br>Z = Other                | <b>30 Pipe Use</b> 2-12<br>CB = Combined Pipe<br>DP = Dam Pipe<br>FM = Force Main<br>LG = Levee Gravity Pipe<br>LP = Levee Pressure Pipe                                                         | <b>30 Pipe Use</b> 2-12<br>PR = Process Pipe<br>SS = Sanitary Sewage Pipe<br>SW = Stormwater Pipe<br>XX = Not Known<br>ZZ = Other                                                                 | <b>33 Shape</b> 2-13 E-1<br>R = Rectangular<br>S = Square<br>T = Trapezoidal<br>U = U-Shaped with Flat Top<br>Z = Other              |
| <b>35 Lining Method</b> 2-15 E-17<br>CIP = Cured-In-Place Pipe<br>FF = Fold and Form<br>FP = Formed-In-Place Liner<br>GP = Groud-In-Place Liner<br>GRC = Glass Reinf. Cement<br>N = None<br>SC = Continuous Slip Liner | <b>35 Lining Method</b> 2-15 E-17<br>SE = Sectional Slip Liner<br>SL = Spray Liner<br>SN = Segmented Panel<br>SP = Segmented Pipe<br>SW = Spiral Wound<br>XX = Not Known<br>ZZ = Other | <b>34 Material</b> 2-14 E-4<br>CP = Concrete Pipe<br>CSB = Conc. Segments Bolted<br>CSU = Conc. Segments Unbolted<br>CT = Clay Tile<br>DIP = Ductile Iron Pipe | <b>34 Material</b> 2-14 E-4<br>FRP = Fiberglass Reinforced Pipe<br>OB = Orangeburg/Pitch Fiber<br>PCCP = Pre-Stressed Concrete Cylinder Pipe<br>PCP = Polymer Concrete Pipe<br>PE = Polyethylene | <b>34 Material</b> 2-14 E-4<br>PP = Polypropylene<br>PSC = Plastic/Steel Composite<br>PVC = Polyvinyl Chloride<br>RCP = Reinf. Concrete Pipe<br>RMP = Reinf. Plastic Pipe<br>SB = Segmented Block | <b>34 Material</b> 2-14 E-4<br>SP = Steel Pipe<br>VCP = Vitrified Clay Pipe<br>WD = Wood<br>XXX = Not Known<br>ZZZ = Other           |
| <b>36 Coating Method</b> 2-16 E-23<br>CT = Coal Tar<br>CM = Cement Mortar<br>EP = Epoxy<br>PE = Polyethylene                                                                                                           | <b>36 Coating Method</b> 2-16 E-23<br>PO = Polyurethane<br>PU = Polyurea<br>PVC = Polyvinyl Chloride<br>XX = Not Known<br>ZZ = Other                                                   | <b>36 Coating Method</b> 2-16 E-23<br>PO = Polyurethane<br>PU = Polyurea<br>PVC = Polyvinyl Chloride<br>XX = Not Known<br>ZZ = Other                           | <b>36 Coating Method</b> 2-16 E-23<br>PO = Polyurethane<br>PU = Polyurea<br>PVC = Polyvinyl Chloride<br>XX = Not Known<br>ZZ = Other                                                             | <b>36 Coating Method</b> 2-16 E-23<br>PO = Polyurethane<br>PU = Polyurea<br>PVC = Polyvinyl Chloride<br>XX = Not Known<br>ZZ = Other                                                              | <b>36 Coating Method</b> 2-16 E-23<br>PO = Polyurethane<br>PU = Polyurea<br>PVC = Polyvinyl Chloride<br>XX = Not Known<br>ZZ = Other |

## **APPENDIX B**

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### Detailed Gravity Sewer Risk Assessment Results

## **APPENDIX C**

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### Gravity Sewer Rehab/Replacement Program Details

**Table D-1. System-Wide Rehab/Replacement Needs by Year**

| CIP Year                    | Low                | Med-Low            | Medium              | Med-High            | High               | Grand Total         |
|-----------------------------|--------------------|--------------------|---------------------|---------------------|--------------------|---------------------|
| 1                           |                    |                    |                     |                     | \$1,005,788        | \$1,005,788         |
| 2                           |                    |                    |                     |                     | \$974,208          | \$974,208           |
| 3                           |                    |                    |                     |                     | \$994,980          | \$994,980           |
| 4                           |                    |                    |                     |                     | \$1,006,848        | \$1,006,848         |
| 5                           |                    |                    |                     |                     | \$1,013,488        | \$1,013,488         |
| 6                           |                    |                    |                     |                     | \$999,876          | \$999,876           |
| 7                           |                    |                    |                     |                     | \$968,256          | \$968,256           |
| 8                           |                    |                    |                     | \$289,020           | \$626,112          | \$915,132           |
| 9                           |                    |                    |                     | \$1,029,840         |                    | \$1,029,840         |
| 10                          |                    |                    |                     | \$1,004,544         |                    | \$1,004,544         |
| 11                          |                    |                    |                     | \$1,041,600         |                    | \$1,041,600         |
| 12                          |                    |                    |                     | \$1,039,104         |                    | \$1,039,104         |
| 13                          |                    |                    |                     | \$947,888           |                    | \$947,888           |
| 14                          |                    |                    |                     | \$1,055,856         |                    | \$1,055,856         |
| 15                          |                    |                    |                     | \$985,180           |                    | \$985,180           |
| 16                          |                    |                    |                     | \$908,928           |                    | \$908,928           |
| 17                          |                    |                    |                     | \$1,099,776         |                    | \$1,099,776         |
| 18                          |                    |                    |                     | \$919,668           |                    | \$919,668           |
| 19                          |                    |                    |                     | \$1,052,016         |                    | \$1,052,016         |
| 20                          |                    |                    |                     | \$1,020,876         |                    | \$1,020,876         |
| <b>20-Year CIP Subtotal</b> |                    |                    |                     | <b>\$12,394,296</b> | <b>\$7,589,556</b> | <b>\$19,983,852</b> |
| 21                          |                    |                    |                     | \$997,824           |                    | \$997,824           |
| 22                          |                    |                    |                     | \$968,088           |                    | \$968,088           |
| 23                          |                    |                    |                     | \$912,120           |                    | \$912,120           |
| 24                          |                    |                    |                     | \$1,064,328         |                    | \$1,064,328         |
| 25                          |                    |                    |                     | \$1,044,804         |                    | \$1,044,804         |
| 26                          |                    |                    | \$471,384           | \$556,356           |                    | \$1,027,740         |
| 27                          |                    |                    | \$952,704           |                     |                    | \$952,704           |
| 28                          |                    |                    | \$1,015,344         |                     |                    | \$1,015,344         |
| 29                          |                    |                    | \$987,432           |                     |                    | \$987,432           |
| 30                          |                    |                    | \$1,031,208         |                     |                    | \$1,031,208         |
| 31                          |                    |                    | \$984,684           |                     |                    | \$984,684           |
| 32                          |                    |                    | \$1,008,804         |                     |                    | \$1,008,804         |
| 33                          |                    |                    | \$913,128           |                     |                    | \$913,128           |
| 34                          |                    |                    | \$1,003,776         |                     |                    | \$1,003,776         |
| 35                          |                    |                    | \$1,081,368         |                     |                    | \$1,081,368         |
| 36                          |                    |                    | \$994,668           |                     |                    | \$994,668           |
| 37                          |                    | \$65,880           | \$910,392           |                     |                    | \$976,272           |
| 38                          |                    | \$1,042,932        |                     |                     |                    | \$1,042,932         |
| 39                          |                    | \$919,368          |                     |                     |                    | \$919,368           |
| 40                          |                    | \$1,073,440        |                     |                     |                    | \$1,073,440         |
| 41                          |                    | \$1,000,392        |                     |                     |                    | \$1,000,392         |
| 42                          |                    | \$962,496          |                     |                     |                    | \$962,496           |
| 43                          |                    | \$1,029,600        |                     |                     |                    | \$1,029,600         |
| 44                          | \$384,516          | \$606,504          |                     |                     |                    | \$991,020           |
| 45                          | \$710,988          |                    |                     |                     |                    | \$710,988           |
| <b>Backlog Subtotal</b>     | <b>\$1,095,504</b> | <b>\$6,700,612</b> | <b>\$11,354,892</b> | <b>\$5,543,520</b>  | <b>\$0</b>         | <b>\$24,694,528</b> |