



**FINAL REPORT**

# 2019 Sewer Master Plan Update

Prepared for San Bernardino Municipal Water Department

March 2020



CITY OF SAN BERNARDINO  
MUNICIPAL WATER DEPARTMENT  
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399 CHANDLER PLACE







**San Bernardino Municipal Water  
Department**

2019 Sewer Master Plan Update

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Department

Prepared by:

Stantec Consulting







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## LIST OF ACRONYMS

| <b>Acronym</b> | <b>Definition</b>                              |
|----------------|------------------------------------------------|
| °F             | Degrees Fahrenheit                             |
| ABS            | Acrylonitrile-Butadiene-Styrene                |
| ACP            | Asbestos Cement                                |
| AF             | Acre feet                                      |
| AFY            | Acre feet per year                             |
| AVE            | Avenue                                         |
| CA             | California                                     |
| CALMAT         | Cajon Creek Specific Plan                      |
| CCTV           | Closed-Circuit Television                      |
| CI             | Cast Iron                                      |
| CIP            | Capital Improvement Program                    |
| CIPP           | Cured in Place Pipe                            |
| City PW        | City of San Bernardino Public Works Department |
| CMLC           | Concrete Mortar Lined and Coated               |
| DIP            | Ductile Iron Pipe                              |
| DPW            | Department of Public Works                     |
| DUC            | Disadvantaged Unincorporated Communities       |
| DWR            | Department of Water Resources                  |
| ELA            | Engineering, Legal, and Administration         |
| EPA            | Environmental Protection Agency                |
| EVWD           | East Valley Water District                     |
| FE             | Federal Endangered                             |
| GC             | General Conditions                             |
| GIS            | Geographic Information System                  |
| GPM            | Gallons per Minute                             |
| HDPE           | High Density Polyethylene                      |

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| <b>Acronym</b> | <b>Definition</b>                               |
|----------------|-------------------------------------------------|
| HP             | Horsepower                                      |
| ICM            | Integrated All Source Catchment Modeling        |
| ID             | Identification                                  |
| IDW            | Inverse Distance Weighting                      |
| IVDA           | Inland Valley Development Agency                |
| LA             | Los Angeles                                     |
| LAFCO          | Local Agency Formation Commission               |
| LF             | Linear Feet                                     |
| LS             | Lift Station                                    |
| MGD            | Million Gallons per Day                         |
| MH             | Maintenance Hole                                |
| NOAA           | National Oceanic and Atmospheric Administration |
| NRW            | Non-Revenue Water                               |
| NW             | Northwest                                       |
| PACP           | Pipeline Assessment Certification Program       |
| PCC            | Prestressed Concrete Cylinder                   |
| PDR            | Preliminary Design Report                       |
| PVC            | Polyvinyl Chloride                              |
| QA/QC          | Quality Assurance and Quality Control           |
| RCP            | Reinforced Concrete Pipe                        |
| RDI/I          | Rain Dependent Inflow and Infiltration          |
| RIX            | Rapid Infiltration and Extraction               |
| SANBAG         | San Bernardino Associated Governments           |
| SBMWD          | San Bernardino Municipal Water Department       |
| SBWRP          | San Bernardino Municipal                        |
| SCADA          | Supervisory Control and Data Acquisition        |
| SMH            | Sewer Maintenance Hole ID                       |
| SMP            | Sewer Master Plan                               |

## TABLE OF CONTENTS, TABLES, FIGURES, APPENDICES, AND ACRONYMS

| <b>Acronym</b> | <b>Definition</b>                             |
|----------------|-----------------------------------------------|
| SSOAP          | Sanitary Sewer Overflow Analysis and Planning |
| STL            | Steel                                         |
| TKE            | TKE Engineering                               |
| TRNS           | Transite                                      |
| UNK            | Unknown                                       |
| UWMP           | Urban Water Management Plan                   |
| VCP            | Vitrified Clay Pipe                           |
| WERF           | Water Environment Research Foundation         |
| WFMP           | Water Facilities Master Plan                  |
| WMP            | Water Master Plan                             |
| WRP            | Water Reclamation Plant                       |
| WTP            | Water Treatment Plant                         |



# Executive Summary







# EXECUTIVE SUMMARY

This report documents the 2019 Sewer Master Plan (SMP) Update for the San Bernardino Municipal Water Department (SBMWD). The executive summary is presented to provide background and a summary of key findings and recommendations contained herein. This SMP Update was completed by Stantec consulting, in partnership with V&A Consulting, TKE Engineers, Innovyze, and Innerline Engineering.

## ES.1 BACKGROUND

The City of San Bernardino Public Works Department (City PW) previously updated the SMP in 2002, with a planning horizon of Year 2015. The responsibility for Operation and Maintenance of the Sewer Collections infrastructure was transferred from City PW to the SBMWD on May 1, 2017, necessitating an update of the 2002 SMP. During this update, Stantec created an inventory of existing facilities, a model of the sewer system, identified hydraulic deficiencies, and developed a prioritized 15-year Capital Improvement Program (CIP) among other recommendations.

## ES.2 STUDY AREA

The San Bernardino Municipal Water Department (SBMWD) was formed as a municipal utility by Article 9 of the City of San Bernardino Charter, as adopted on January 6, 1905. A new Charter was approved in 2016, changing the governing structure of the City to a Council-Manager format. SBMWD's potable water service area encompasses approximately 45-square miles of the City's 62 square miles and serves water to roughly 200,000 individuals throughout both the City of San Bernardino and the unincorporated areas of San Bernardino County. The SBMWD service area is bounded by the San Bernardino National Forest to the north, by East Valley Water District (EVWD) and Redlands Municipal Utilities Department to the east, by the cities of Loma Linda and Colton to the south, and by West Valley Water District, the City of Rialto, and the Muscoy Mutual Water Company to the west. SBMWD serves the western two-thirds of the City of San Bernardino, with EVWD serving the eastern third.

The sewer collection system and Water Reclamation Plant (WRP) is currently operated and maintained by the SBMWD. The WRP was constructed in 1958 and is a 33 million gallons per day (MGD) Regional Secondary Treatment facility that provides wastewater treatment services for the Cities of San Bernardino and Loma Linda, East Valley Water District, San Bernardino International Airport, Patton State Hospital, and areas of unincorporated San Bernardino County. The study area for this SMP Update is presented on Figure ES-1.

## ES.3 EXISTING SEWER SYSTEM

The existing wastewater collection system consists of 493 miles of pipes, 15 active lift stations, 12 siphons, approximately 38,300 sewer connections, and a water reclamation plant (WRP). The collection system is comprised primarily (approximately 96 percent) of vitrified clay pipe (VCP) with the remainder of pipelines constructed of Acrylonitrile-Butadiene-Styrene (ABS), concrete, asbestos cement, ductile iron, Polyvinylchloride (PVC), Reinforced Concrete Pipe (RCP), and steel, among others.



## EXECUTIVE SUMMARY

For this SMP Update, model update and many of the condition assessment tasks are based upon SBMWD's GIS database that was updated to include Sewer Collection information provided by the City of San Bernardino Public Works Department in 2017. Attributes used from the GIS data include diameter, depth, invert elevations, material, and length.

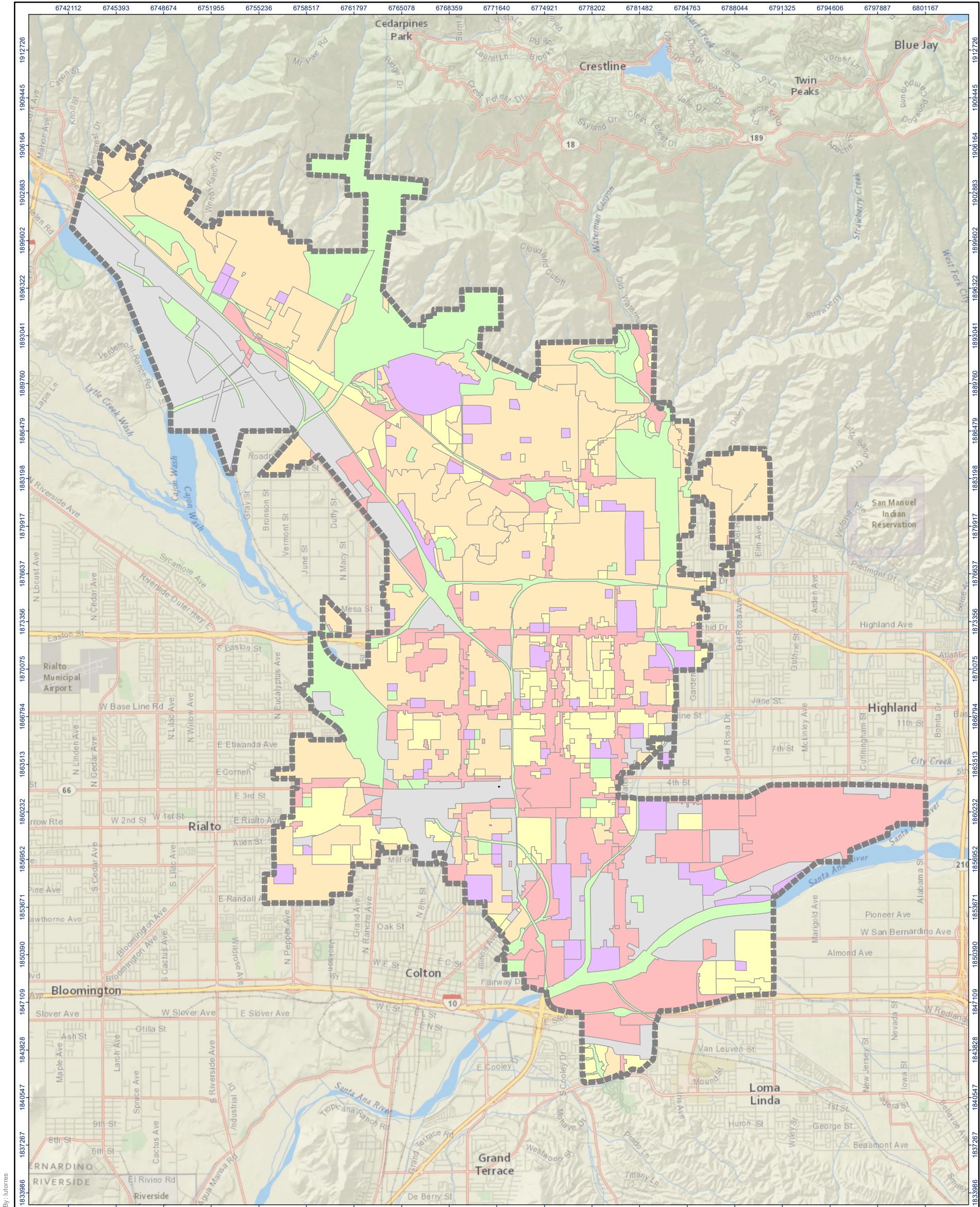
### **ES.4 WATER DEMANDS AND WASTEWATER CHARACTERISTICS**

For this SMP Update, existing sewer demands were estimated based on water billing data; future sewer demands were estimated using projected land use and water demands. Water to wastewater ratios, which compare the amount of wastewater generated for an area against the amount of potable water purchased, were developed for each land use type based on the Flow Study presented in Appendix B. These ratios were applied to the volumes of potable water consumed according to SBMWD billing data to determine existing wastewater demands. Future sewer generation is similarly estimated by applying water to wastewater ratios to future land use and projected water usage.

#### **Wastewater Demand Projections**

Using the water to wastewater ratios developed in Section 4.3.2.1, the general plan land use, and the Year 2060 water demand projections, the Year 2060 wastewater projections total 37,876 AFY or 33.81 MGD. This value represents the ultimate future build-out for the service area based on the general plan and is a conservative estimate of the ultimate conditions in the sewer collection system.





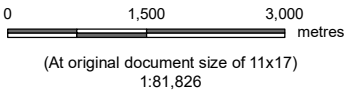
C:\Users\lutorres\OneDrive - Stantec\Office\365\San Bernardino\MXDs\Sec2&3\_Maps.mxd    Revised: 2019-11-22 By: lutorres

Legend

Land Use Classification

- Single-family Residential
- Multi-family Residential
- Commercial
- Industrial
- Public
- Open Space

 SBMWD Water Service Boundary



Project Location      Prepared by L.Torres on 2019-11-22  
San Bernardino County  
California  
Client/Project      Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.  
**ES-1**

Title  
**SBMWD Master Plan Study Area**

**Notes**  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

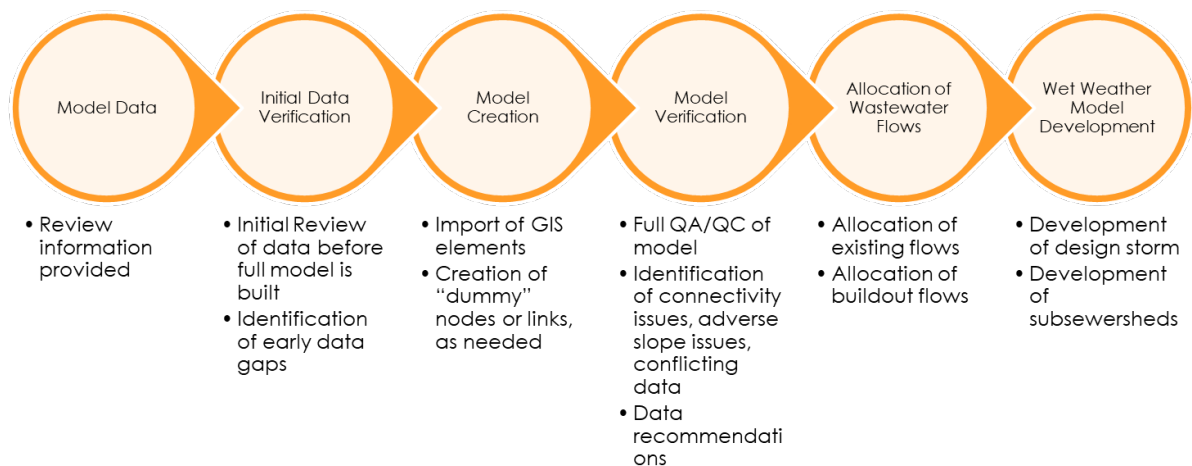
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## ES.5 COMPUTER MODEL DEVELOPMENT

Figure ES-2 shows an overview of the model development. The model development begins with review of data collection and initial data verification. The model is subsequently created and then verified to identify any connectivity issues, adverse slope issues, or conflicting data. After verifying the model, wastewater flows are then allocated for each scenario (existing and build out). Finally, the model is further prepared for wet weather analysis. Each of these steps will be discussed in the section.



**Figure ES-2 Overview of Model Development Process**

### Data Extent

The hydraulic model built for this SMP was an all pipes model. This means that all pipes and maintenance holes in the provided GIS data were included in the model with limited exceptions. Any pipes or maintenance holes that were designated as having a private owner in the GIS metadata were not included in the model unless their removal would cause a connectivity issue within the system. Additionally, cleanouts that were at the end of a line were not included in the model, though cleanouts that were necessary to connect pipe segments remained.

It is noted that in some instances records of the SBMWD system conflicted with each other. Based upon discussion with SBMWD and their recent update of their GIS database prior to and at the beginning of this SMP project, GIS was considered the primary data source for building the model. Discrepancies between data sources were reported to and discussed with SBMWD staff.

### Summary of Model Build

The model build resulted in a functional hydraulic model that incorporated SBMWD most recent GIS database, results of the recently completed LiDAR survey and maintenance hole survey, as well as multiple other data sources

## EXECUTIVE SUMMARY

provided by SBMWD. The model verification process yielded identification of a variety of data inconsistencies that have been addressed and flagged for future investigation. The final model is assigned existing and future flows and is set up for wet weather analysis by creating design storms and discrete subcatchments for assigning wet weather flow to the model nodes.

### ES.6 CALIBRATION

The main objective of the model calibration is to adjust and confirm model parameters such that the model is adequately representing the existing collection system. Calibration is the process of comparing the model simulations with the observed monitoring data and adjusting model assumptions in order to get better agreement with the data. Flow, depth, velocity, volume, and flow patterns information were used in this comparison process during the model calibration. This model calibration consists of two parts: dry weather and wet weather calibration.

Stantec completed the model calibration under dry weather conditions and achieved the following results:

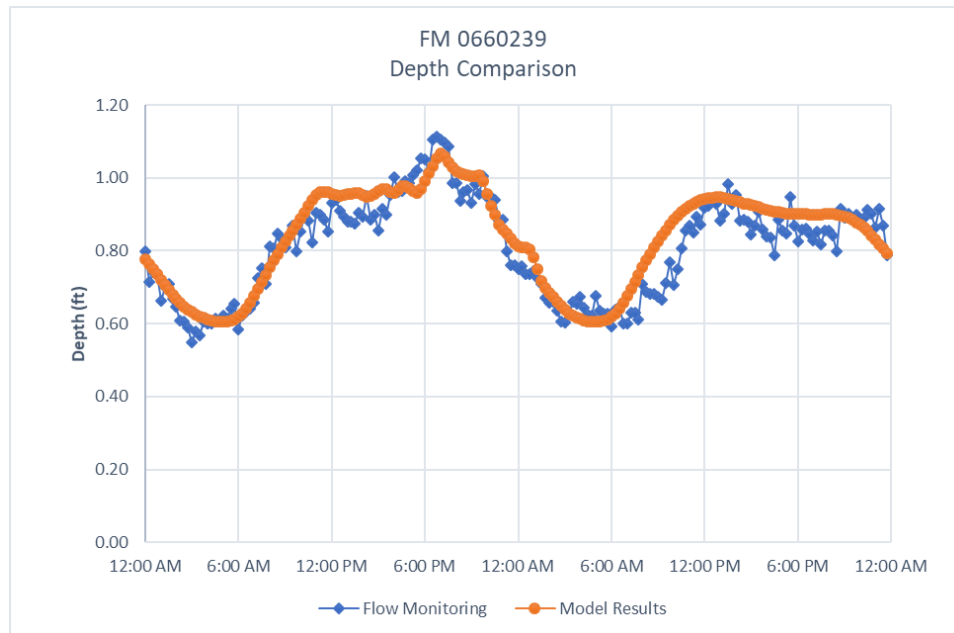
1. Most of the modeled peak flow results are within the 10% of the observed peak under dry weather conditions with two exceptions (FM 0360154 and FM 0740052). Detailed calibration plots for each flow monitoring location can be found in Appendix F. Stantec reviewed the two exceptions and concluded that the model is calibrated and adequate to support the master planning. Section 6.1.1 documents the contributing factors behind these two data outliers.
2. Most of the modeled peak depth results are within the 10% threshold or exactly on the 10% threshold line, except for outlier FM 0740052.
3. Most of the modeled velocity results are within the 10% threshold, with the exception of dry weather flow at FM 740052.

Stantec completed the model calibration under wet weather conditions and achieved the following results:

1. FM 0740052 is outside the 20% difference, and was deemed unsuitable for calibration, per the discussion in Section 6.1.2. The other calibration point outside of the 20% threshold is FM 0640138, specifically during rainfall event 4. This location is discussed further in Section 6.2.4. The remaining flow monitoring points are within the 20% threshold applicable for wet weather calibration and adequately represent peak conditions.
2. The two wet weather events at FM 0740052 are outside of the 20% wet weather calibration threshold. All remaining calibration points for the two wet weather events are within a 20% difference for modeled and observed results and adequately represent peak conditions.
3. Similar to the flow and depth results, the velocity comparison for FM 0740052 is outside of the 20% threshold for both rain events. Additionally, FM 0640138 is also outside of the 20% threshold for velocity during rainfall event 4. The remaining calibration points are within the 20% threshold and match peak conditions.

## EXECUTIVE SUMMARY

Figure ES-3 is an example calibration plot for the SMP Update. All calibration plots are presented in Appendix F.



**Figure ES-3 Example Calibration Plot**

## ES.7 PLANNING AND DESIGN CRITERIA

Table ES-1 summarizes the criteria used for gravity mains for this master plan.

**Table ES-1 Summary of Sewer Design Criteria**

| Design Criteria                                                     | Value  |
|---------------------------------------------------------------------|--------|
| Minimum pipe velocity                                               | 3 ft/s |
| Maximum pipe velocity                                               | 8 ft/s |
| $d/D$ ratio for $d$ less than 15 inches                             | 0.5    |
| $d/D$ ratio for $d$ greater than or equal to 15 inches              | 0.5    |
| $d/D$ ration for initiating improvements                            | 0.75   |
| Manning's $n$ for PVC (gravity sewers)                              | 0.012  |
| Manning's $n$ for VCP (gravity sewers) and all other pipe materials | 0.014  |
| Manhole friction head loss during ADWF                              | 0.1 ft |
| Manhole friction head loss during Peak flow                         | 0.5 ft |



## EXECUTIVE SUMMARY

Recommended design criteria for special projects are summarized in Table ES-2.

**Table ES-2 Design Criteria for Special Projects**

| Item             |                                     | Recommended Values                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|------------------|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Special Projects | Lift Stations, Force Mains, Siphons | <ul style="list-style-type: none"><li>• Lift Stations and force mains will be avoided whenever possible.</li><li>• Average Dry Weather Flow (ADWF) (existing conditions) velocity = 3.0 fps minimum.</li><li>• Hazen-William's "C" factor of 120 will be used to analyze hydraulic conditions for all force mains in the system</li><li>• Force mains shall be sized to provide a design velocity no less than 4 ft. per second with all pumps running and 3.0 fps during normal operations.</li><li>• Maximum velocity shall be 10 fps.</li><li>• Siphons shall achieve a minimum velocity of 4.0 fps at during maximum average day flow</li><li>• Siphons shall have a minimum of two barrels to facilitate maintenance and repair</li></ul> |
|                  | Diversion Structures and Weirs      | <ul style="list-style-type: none"><li>• New diversion structures will be avoided whenever possible</li><li>• Maintain existing diversion structures open with no control setting whenever possible</li><li>• If a gate/stop-log setting is required for a diversion structure, maintain a fixed setting for all flow conditions whenever possible</li></ul>                                                                                                                                                                                                                                                                                                                                                                                    |

## ES.8 SYSTEM ANALYSIS

The system was evaluated using results from the hydraulic model and applying the planning criteria discussed in Section 7. Each scenario, existing and build out, was evaluated for dry and wet weather results. The existing scenario was evaluated for dry weather, three wet weather design storms; a two-, ten-, and 25-year storm. Based on results from the existing analysis and discussion with SBMWD, the build out scenario was evaluated for dry weather and for a 2-year wet weather storm.

According to the planning criteria, a depth/diameter (d/D) ratio of 0.75 for modeled pipes was used as a trigger for this analysis; pipes showing a modeled d/D ration between 0.5 to 0.75 are also shown.

### Existing Dry Weather Analysis

To evaluate the sewer capacity under dry weather condition, the model was built to simulate 24 hours of flow according to the dry weather calibrated results. The continuous simulation provides sufficient information to evaluate the system under all flow (low and peak) conditions during dry weather days.

Results for the existing dry weather analysis showed that 168 pipes reached a capacity of 75% or above under peak dry weather conditions.

### Existing Wet Weather Analysis

To evaluate the sewer capacity under wet weather condition, the model was used to simulate flow for a two-year, ten-year, and 25-year storm.

## EXECUTIVE SUMMARY

### Two-Year Storm Analysis Results

Simulation of a two-year design storm in the model yielded 345 pipes with a d/D ratio greater than 0.75, comprising a total length of 101,878 ft. In addition to these 345 pipes, seven maintenance holes showed flooding during in the model.

### Ten-year Storm Results

The ten-year storm simulation shows 492 pipes with d/D ratios greater than or equal to 0.75 and 15 flooded nodes. 15 maintenance holes showed flooding.

### 25-year Storm Results

The 25-year storm results for the existing scenario show a total of 603 pipes with d/D greater than or equal to 0.75 and 25 total nodes that are flooded. **Error! Reference source not found.** displays a chart of the total length and number of pipes with a d/D ratio greater than or equal to 0.75 for small (less than 15 inches in diameter) and large (15 inches or greater in diameter) pipes, as well as pipes with a d/D ratio between 0.50 and 0.75. 25 nodes showed flooding.

### Build Out Dry Weather Analysis

For the build out dry weather analysis, a total of 461 pipes were identified as having a d/D greater than or equal to 0.75. Additionally, six nodes were identified as flooded during the build out dry weather scenario. These pipes and they are listed in full in Appendix G.

### Build Out Wet Weather Analysis – 2 Year Storm

The wet weather storm that was analyzed for the build out scenario was the two-year design storm. After loading a two-year storm frequency into the build out scenario, 694 pipes showed a d/D greater than or equal to 0.75. In addition to the same six nodes that flooded in the build out dry weather scenario, 16 nodes also flooded during the build out wet weather two-year storm analysis.

## ES.9 CAPACITY RECOMMENDATIONS

### Existing System Improvements

The modeled improvements for both existing dry weather capacity issues and two-year wet weather flooding nodes are listed in Table ES-3.

**Table ES-3 Existing System Capacity Improvements**

| Pipe ID        | d/D at Existing | Old Diameter (in) | New Diameter (in) | d/D at Buildout |
|----------------|-----------------|-------------------|-------------------|-----------------|
| 03800520380106 | 0.83            | 8                 | 12                | 0.61            |
| 03801060380042 | 0.81            | 8                 | 12                | 1               |
| 05501470550146 | 1               | 12                | 15                | 0.66            |
| 05501480550154 | 1               | 15                | 18                | 0.56            |
| 05501540560032 | 1               | 8                 | 12                | 0.63            |
| 05600280660054 | 1               | 8                 | 15                | 0.49            |
| 05600290560028 | 1               | 8                 | 15                | 0.49            |
| 05600310560029 | 1               | 8                 | 15                | 0.51            |
| 05600320560031 | 1               | 8                 | 15                | 0.49            |
| 05700100570006 | 0.77            | 10                | 15                | 0.91            |
| 06600580660073 | 0.76            | 8                 | 12                | 0.53            |
| 06600600660077 | 1               | 8                 | 12                | 0.62            |
| 06600640660077 | 1               | 8                 | 12                | 0.39            |
| 06600720660058 | 0.85            | 8                 | 12                | 0.6             |
| 06600770660072 | 1               | 8                 | 12                | 0.68            |
| 06601020660096 | 0.8             | 8                 | 15                | 0.44            |
| 06601400660141 | 0.75            | 8                 | 15                | 0.64            |
| 06601460660158 | 0.76            | 8                 | 12                | 0.53            |
| 06601580660159 | 0.78            | 8                 | 15                | 0.69            |
| 06600730660092 | 0.74            | 8                 | 12                | 0.76            |
| 06600960660103 | 0.72            | 8                 | 15                | 0.67            |
| 06601440660146 | 0.59            | 8                 | 12                | 0.44            |
| 05600490560039 | 1               | 8                 | 21                | 0.63            |
| 06600230660060 | 1               | 8                 | 12                | 0.51            |
| 06600540660056 | 1               | 8                 | 12                | 0.49            |
| 06600560660023 | 0.87            | 8                 | 12                | 0.49            |
| 06601040660107 | 0.78            | 8                 | 12                |                 |

### Build Out System Improvements

No improvements for build out scenario capacity deficiencies are recommended. Capacity improvements were not recommended as the model shows significant data inconsistency which will require additional field confirmation. The build out scenario also assumes multiple large developments, many of which are in the early planning stages and may change significantly. Additionally, there is a significant length of time until the build out scenario is expected to occur, and many of the improvements would likely be obsolete by the time build out demand is realized in the service

## EXECUTIVE SUMMARY

area. In place of specific projects, areas of concern are identified for the build out system based on the capacity deficiencies identified.

### Final Capacity Recommendations

Modeled capacity improvements should be investigated further before inclusion into a Capital Improvement Program (CIP). Based on the data issues identified during the model build process, further investigation and confirmation of model results with field data is warranted. It is recommended that SBMWD:

- Continue to investigate the data issues identified in Section 5.
- Pursue the special area study for the West Residential area as identified in Section 8.2.1.
- Continue to survey maintenance holes in the system to confirm invert elevations
- Use survey results to confirm connectivity between pipelines
- Conduct flow studies to confirm d/D ratios.
- Update the GIS database with data obtained from these efforts
- Recalibrate the model after updating with these field investigations and reassess the recommended projects and areas of concern.

These steps will help refine the model and confirm if the capacity recommendations identified are indeed necessary.

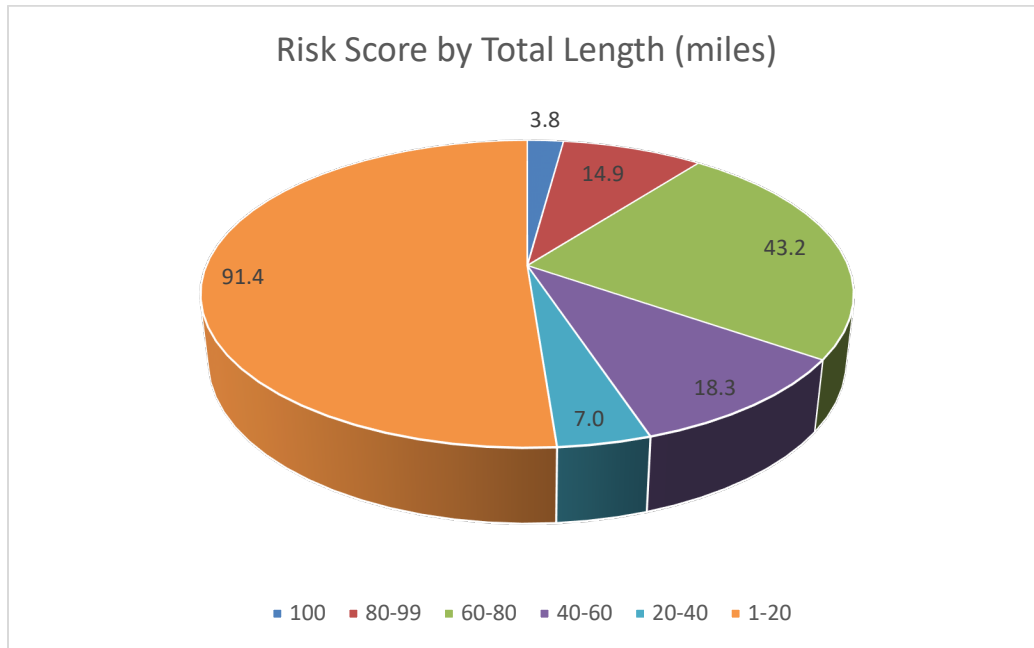
## ES.10 CONDITION ASSESSMENTS

For the SMP Update, Stantec performed an analysis of the condition of the SBMWD gravity pipelines based on the available CCTV videos and analysis by Innerline Engineering (Innerline) and Houston and Harris PCS, Inc., (H&H) and City's GIS data. Stantec also completed inspection of SBMWD lift stations, siphons, and maintenance holes through our subconsultants, V&A Engineers (V&A), and TKE Engineering (TKE), as well as with Stantec staff.

### Condition Assessment of Pipelines

Stantec completed the condition assessment of pipelines using a risk-based assessment to determine recommended actions and the timing of those actions. This risk-based assessment approach consists of determining an overall risk score for individual pipes by factoring both likelihood of failure (LoF) and consequence of failure (CoF). The LoF takes into consideration the physical state of a pipe or factors that will contribute to the deterioration of a pipe to estimate the probability of a pipe collapse. The CoF score focuses on the impact a pipe failure would have on the system by looking at physical, environmental, social, and economic factors surrounding that pipe.

A breakdown of the scoring for pipes with CCTV records is shown in Figure ES-4. Over half the pipes received a score of less than 20, meaning they are of lower priority for rehabilitation or replacement.

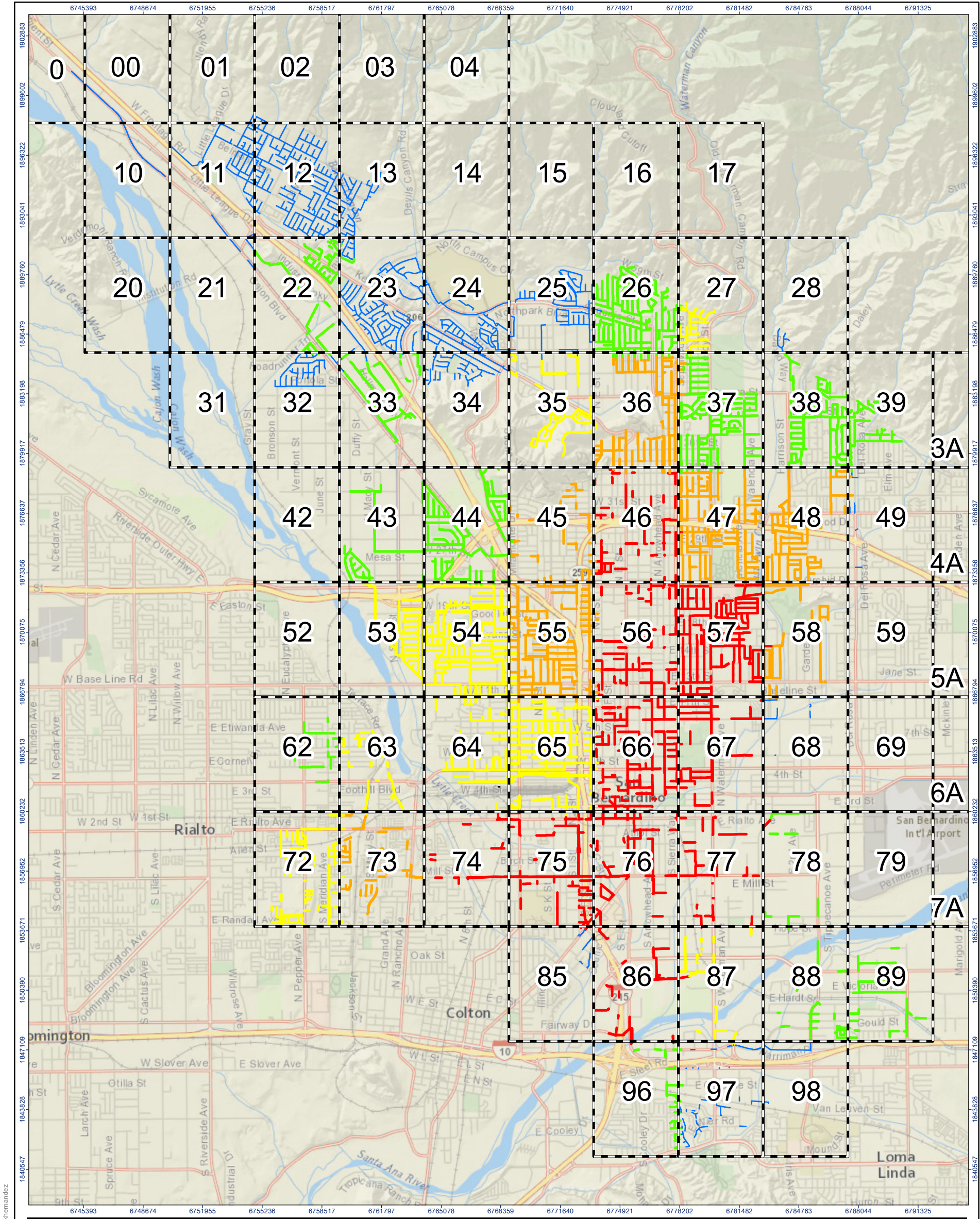


**Figure ES-4 Risk Scores of Pipes with CCTV Footage**

### **Pipes without CCTV Records**

The 304 miles of pipe that do not have recent CCTV footage are spread across 59 grids in the SBMWD service area. Stantec averaged the adjusted risk score for all pipes within each of the 59 grids. Grids were ranked in order of highest average adjusted risk score in order to prioritize future televising efforts. Figure ES-5 shows the grids color coded by the 5 priority levels.



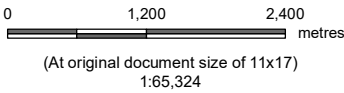


Legend

Sewer Pipes

CCTV Effort Priority

- Highest Priority
- High Priority
- Moderate Priority
- Low Priority
- Lowest Priority
- Grids



Project Location San Bernardino County California  
Client/Project Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.  
ES-5

Grid Prioritization for CCTV Efforts

Notes  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

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## EXECUTIVE SUMMARY

### Lift Stations

After the evaluation of each lift station, recommendations were made based on the findings of the site visits. A Lift Station Assessment Report is presented in Appendix K. These recommendations are used and prioritized in the capital improvement program to produce a final list of projects. While the Lift Station Assessment Report categorizes individual issues by priority, the CIP prioritizes improvements by lift station so that repairs don't need to be made on multiple occasions at a single lift station.

It is noted that SBMWD has expressed interest in phasing out self-priming type lift stations. As SBMWD addresses the condition assessment recommendations listed here for self-priming type lift stations, analysis should be done to assess the relative cost of rehabilitating the lift stations versus replacement.

### Siphons Assessments

Eighteen existing siphon structures were evaluated by V&A Consulting Engineers who performed confined space entry and documented the condition of the structures. Recommendations for siphon structure rehabilitation are based on V&A's assessment. The full report from V&A's assessment is included as Appendix L.

### Detailed Maintenance hole Inspections

A sample of 101 maintenance holes was selected from SBMWD's GIS for condition assessment. These maintenance holes were selected from across the SBMWD system to represent different system conditions. TKE Engineering performed field assessments from grade and provided photographs of the interior and surface of each maintenance hole assessed. Recommendations for each maintenance hole were developed from TKE's findings and scaled to SBMWD's entire system of 8,009 maintenance holes to develop anticipated rehabilitation and replacement actions that may be needed in the future.

## ES.11 CAPITAL IMPROVEMENT PROJECTS

The CIP recommendations are presented by facility type in Table ES 4. CIP cutsheets—single page summaries of capital improvement budget line items—are presented in Appendix N for all recommendations in this CIP. Appendix O presents the CIP summary workbook provided to SBMWD for this update.

**Table ES 4 Summary of CIP Recommendations by Facility Type (2019 Q1 Dollars)**

| Improvement Type                                                                                                                                                                                                                                     | Length (ft)                                                        | Total Cost <sup>1</sup>         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|---------------------------------|
| <b>Capacity Recommendations</b>                                                                                                                                                                                                                      |                                                                    |                                 |
| Pipeline and Siphon Flow Study                                                                                                                                                                                                                       | Flow Monitoring of 40 sites at an assumed cost of \$3,800 per site | \$150,000                       |
| Special Area GIS Study - West Residential                                                                                                                                                                                                            | [100 MHs + 1 month of Flow Monitoring at 3 locations]              | \$100,000                       |
| Pipeline Flow Study                                                                                                                                                                                                                                  | Flow Monitoring of 40 sites at an assumed cost of \$3,800 per site | \$150,000                       |
| GIS Study                                                                                                                                                                                                                                            | Survey of 900 manholes                                             | \$100,000                       |
| <i>Subtotal of Capacity-Related Improvements</i>                                                                                                                                                                                                     |                                                                    | <i>\$500,000</i>                |
| <b>Condition Recommendations (by size and quantity) – Pipes with CCTV Footage</b>                                                                                                                                                                    |                                                                    |                                 |
| Replace 8" diameter                                                                                                                                                                                                                                  | 205,283                                                            | \$45,586,000                    |
| Replace 10" diameter                                                                                                                                                                                                                                 | 4,089                                                              | \$934,000                       |
| Replace 12" diameter                                                                                                                                                                                                                                 | 15,761                                                             | \$5,239,000                     |
| Replace 15" diameter                                                                                                                                                                                                                                 | 6,810                                                              | \$2,111,000                     |
| Replace 18" diameter                                                                                                                                                                                                                                 | 4,404                                                              | \$2,193,000                     |
| Replace 21" diameter                                                                                                                                                                                                                                 | 336                                                                | \$64,000                        |
| Replace 27" diameter                                                                                                                                                                                                                                 | 862                                                                | \$263,000                       |
| Replace 36" diameter                                                                                                                                                                                                                                 | 220                                                                | \$128,000                       |
| PDR Study of Large Diameter Condition Pipelines                                                                                                                                                                                                      | \$25,000 per segment                                               | \$100,000                       |
| <i>Subtotal of Condition-Related Improvements, CCTV Pipes</i>                                                                                                                                                                                        |                                                                    | <i>\$56,618,000</i>             |
| <b>Condition Recommendations - Structures</b>                                                                                                                                                                                                        |                                                                    |                                 |
| Maintenance Holes                                                                                                                                                                                                                                    |                                                                    | \$4,800,000                     |
| Siphon Structures                                                                                                                                                                                                                                    |                                                                    | \$1,984,000                     |
| Siphon Pipelines                                                                                                                                                                                                                                     | 2,875                                                              | \$22,522,000                    |
| Lift Station                                                                                                                                                                                                                                         |                                                                    | \$6,458,000                     |
| <b>Totals</b>                                                                                                                                                                                                                                        |                                                                    |                                 |
| <b>Total</b>                                                                                                                                                                                                                                         |                                                                    | <b>\$92,882,000<sup>2</sup></b> |
| <b>Notes</b>                                                                                                                                                                                                                                         |                                                                    |                                 |
| 1. Total Project Cost rounded to nearest thousand dollars.                                                                                                                                                                                           |                                                                    |                                 |
| 2. Cost includes 20 percent Contingency; 30 Percent Engineering, Legal, and Administrative Costs; 10 Percent Contractor GCs in addition to Construction Costs. 10 Percent Contractor GCs not included for survey, flow monitoring, CCTV, and studies |                                                                    |                                 |

ES.12 CIP SUMMARY

Figure ES-6 and Figure ES-7 summarize the CIP costs discussed in this section by year and by planning horizon, respectively. The total CIP cost is estimated at \$92.9M in 2019 Q1 dollars, and \$120.8M based on a 3 percent escalation year-to year.

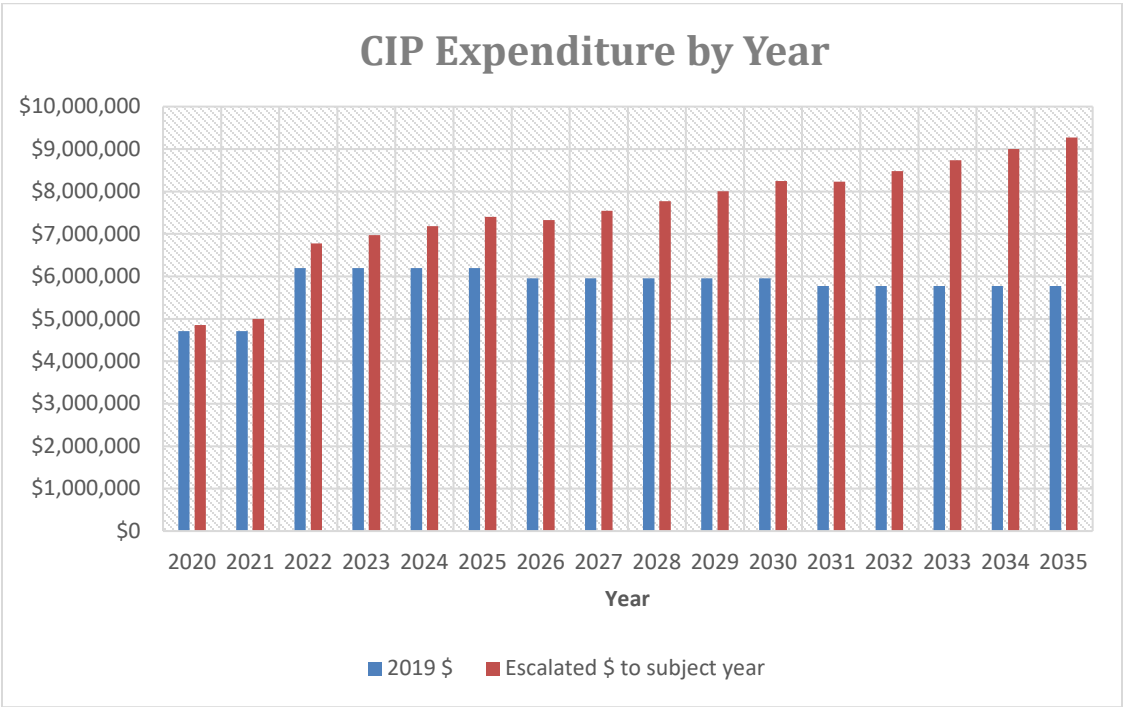


Figure ES-6: CIP Costs per Year

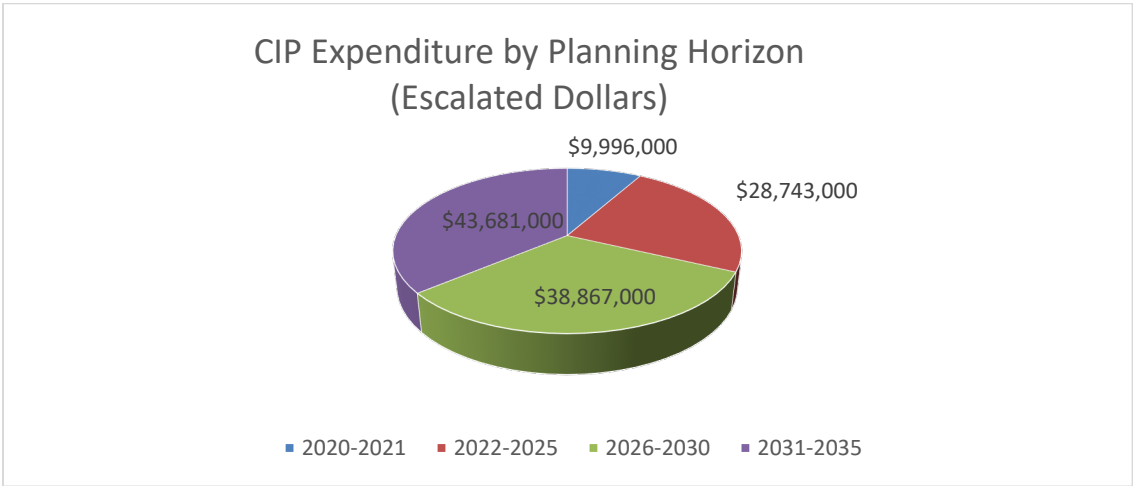


Figure ES-7: CIP Costs by Planning Horizon

## EXECUTIVE SUMMARY

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SECTION 1

# Introduction







# 1.0 INTRODUCTION

This section provides an overview of the 2019 Sewer Master Plan (SMP) Update for the San Bernardino Municipal Water Department (SBMWD). A brief narrative of the project background, the scope of work, and a description of the report sections to follow is presented.

## 1.1 BACKGROUND

The City of San Bernardino Public Works Department (City PW) previously updated the SMP in 2002, with a planning horizon of Year 2015. The responsibility for Operation and Maintenance of the Sewer Collections infrastructure was transferred from City PW to the SBMWD on May 1, 2017, necessitating an update of the 2002 SMP. During this update, Stantec, in development of the 2019 SMP Update, created an inventory of existing facilities, a model of the sewer system, and identified hydraulic deficiencies. The SBMWD sewer collection system consists of the following major facilities:

- Approximately 38,085 sewer connections
- Approximately 493 miles of gravity sewers and force mains.
- Approximately 8,200 maintenance holes
- 15 active lift stations; 12 small lift stations throughout the collection system, and three (3) large lift stations at or adjacent to the WRP
- 12 system siphons

It is noted that the values above are accurate as of the time of the SMP and the GIS is continuously being updated by SBMWD.

## 1.2 OBJECTIVES AND SCOPE OF WORK

The SMP must be updated to reflect changes in the system, establish a new baseline condition assessment, and develop a plan to guide the future operation and maintenance of the sewer collection system. This project has several key objectives. These objectives are to:

- 1) assess the condition of the sewer collection system and major facilities;
- 2) identify existing hydraulic deficiencies and pipeline problems;
- 3) project future demands; and
- 4) identify needed improvements to accommodate future growth, facilitate an orderly and planned expansion of the collection system to accommodate future development as well as correct existing system deficiencies, and

## SECTION 1.0 - INTRODUCTION

The scope of work of this project consists of the following tasks:

- Updating the GIS sewer data to the correct spatial reference and incorporating new facilities known to the SBMWD.
- Creating a new sewer model using Innovyze InfoSWMM software and other modeling tools;
- Evaluating the condition of existing lift stations, and select siphons and maintenance holes;
- Identifying existing and future hydraulic deficiencies;
- Performing a CCTV inspection and cleaning for pipelines 12-inches in diameter and greater;
- Integrating the CCTV inspection reports and videos, lift station findings, model results, GIS data, and maintenance hole findings into condition assessment;
- and
- Preparing a final priority list of repairs, upgrades, and replacements necessary for the sewer collection system to meet all current and future demands.

### 1.3 DATA SOURCES

For the preparation of this report, Stantec reviewed the relevant data provided by the SBMWD. Data included, but was not limited to:

- Previously completed 2002 Sewer Master Plan (by City PW) and 2015 Water Master Plan (by SBMWD);
- Historical billing data;
- As-built drawings (as requested) and facility plans;
- Existing sewer facilities (GIS) layer;
- Existing Sewer Model (H2OMAP);
- Last 5 years of sanitary sewer overflow records and sewer system improvements;
- flow monitoring data;
- Known areas of hydraulic issues;
- Specific future developments\
- SCADA data

## 1.4 REPORT ORGANIZATION

This Sewer Master Plan is divided into 10 sections as follows:

**Section 1 – Introduction:** Introduces the report background and objectives.

**Section 2 – Study Area Characteristics:** Environmental and physical characteristics of the study area.

**Section 3 – Existing Sewer System:** Describes the existing sewer collection system and facilities

**Section 4 – Water Demands and Wastewater Characteristics:** Historical water demands and wastewater flow loading, and ratios based on the demand analysis and future land use.

**Section 5 – Computer Model Development:** Discussion of the sewer model development and creation, including quality assurance and control checks.

**Section 6 – System Calibration:** Description of the process of calibrating the computer model to real flow monitoring data

**Section 7 – Planning and Design Criteria:** Establishes the criteria applied when using the model to analyze the system, and the thresholds for identifying areas of concern and projects.

**Section 8 – Sewer Capacity Evaluation:** Discusses findings from the model evaluation of the existing and future collection system.

**Section 9 – Condition Assessment:** Details the condition assessment of pipes based on GIS and CCTV, as well as assessment of SBMWD facilities such as Maintenance holes, lift stations, and siphons.

**Section 10 – Capital Improvement Program (CIP):** Presents the final capital improvement recommendations identified for this SMP Update.

## 1.5 ACKNOWLEDGEMENTS

Stantec wishes to acknowledge and thank all SBMWD's staff for their assistance in completing this 2019 SMP.

## SECTION 1.0 - INTRODUCTION

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## SECTION 2

# Study Area Characteristics







## **2.0 STUDY AREA CHARACTERISTICS**

### **2.1 STUDY AREA**

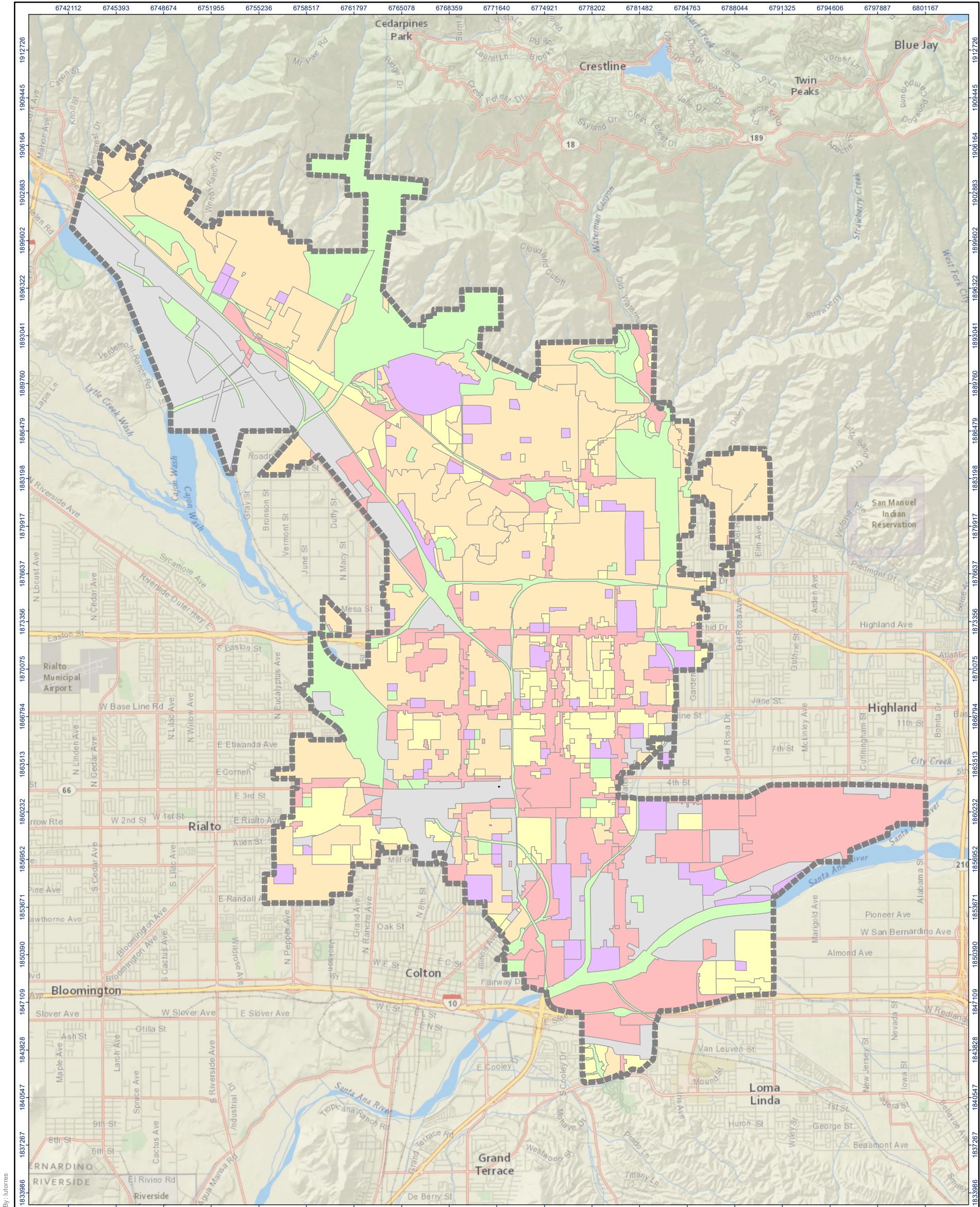
The San Bernardino Municipal Water Department (SBMWD) was formed as a municipal utility by Article 9 of the City of San Bernardino Charter, as adopted on January 6, 1905. A new Charter was approved in 2016, changing the governing structure of the City to a Council-Manager format. SBMWD's potable water service area encompasses approximately 45-square miles of the City's 62 square miles and serves water to roughly 200,000 individuals throughout both the City of San Bernardino and the unincorporated areas of San Bernardino County. The SBMWD service area is bounded by the San Bernardino National Forest to the north, by East Valley Water District (EVWD) and Redlands Municipal Utilities Department to the east, by the cities of Loma Linda and Colton to the south, and by West Valley Water District, the City of Rialto, and the Muscoy Mutual Water Company to the west. SBMWD serves the western two-thirds of the City of San Bernardino, with EVWD serving the eastern third.

The sewer collection system and Water Reclamation Plant (WRP) is currently operated and maintained by the SBMWD. The WRP was constructed in 1958 and is a 33 million gallons per day (MGD) Regional Secondary Treatment facility that provides wastewater treatment services for the Cities of San Bernardino and Loma Linda, East Valley Water District, San Bernardino International Airport, Patton State Hospital, and areas of unincorporated San Bernardino County. A service area map and overview of the service area can be found on Figure 2-1.

## SECTION 2.0 – STUDY AREA CHARACTERISTICS

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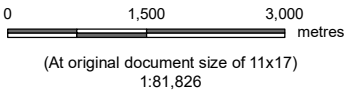
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Legend

Land Use Classification

- Single-family Residential
- Multi-family Residential
- Commercial
- Industrial
- Public
- Open Space

SBMWD Water Service Boundary



Project Location      Prepared by L.Torres on 2019-11-22  
San Bernardino County  
California  
Client/Project      Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.

2-1

Title

SBMWD Master Plan Study Area

Notes

1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

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## 2.2 GEOGRAPHY

### 2.2.1 Existing Land Use

The City of San Bernardino is largely comprised of single and multiple family residential land use based on the general plan land use data from Geographic Information System (GIS) database of the City of San Bernardino. Zoning information is verified for this SMP by overlaying the land use data with aerial imagery and adjusting any areas within the City to the appropriate land use category. SBMWD land use data is consolidated into six distinct categories: commercial, industrial, multiple family residential, open space, public, and single family residential. In addition to these categories, some parcels are categorized under specific plan and are not determined by the general plan land use. This generalized land use for the existing system is mapped on Figure 2-2.

Based on the land use, about 34 percent of the SBMWD service area is single family residential, 6 percent is public, 16 percent is industrial, 18 percent is commercial, 9 percent is multiple family residential, and 16 percent is open space. Table 2-2 shows the breakdown of generalized land use category and the percentage of area each category that occupies the existing SBMWD service area.

**Table 2-1  
Existing Land Use from General Plan**

| Land Use                  | Area (acres)  | Percent of SBMWD General Plan Area |
|---------------------------|---------------|------------------------------------|
| Commercial                | 6,235         | 18%                                |
| Industrial                | 5,534         | 16%                                |
| Multi-family Residential  | 3,095         | 9%                                 |
| None                      | 5,452         | 16%                                |
| Public                    | 1,989         | 6%                                 |
| Single-family Residential | 11,742        | 34%                                |
| <b>Total</b>              | <b>34,046</b> | <b>100%</b>                        |

*Source: City of San Bernardino General Plan Land Use. Downloaded from the County of San Bernardino on March 28, 2014 (<ftp://gis1.sbcounty.gov/>).*

### 2.2.2 Climate

San Bernardino is located in a Mediterranean climate region where temperatures typically range between 50 to 80 degrees Fahrenheit (°F). The warmest month of the year is August with an average maximum temperature of about 96.0 (°F), while January is the coldest month of the year with an average minimum temperature of 41.3 (°F). Table 2-3 shows the average monthly temperatures in San Bernardino, California.

Annual precipitation data from the last ten years (i.e., 2008 to 2017) is presented in Table 2-3. San Bernardino experiences an average of approximately 10.9 inches of rainfall each year (based on annual precipitation data from 2008 to 2017). Precipitation is especially sparse between the months of May and October. The greatest rainfall occurs during the winter months. On average, December is the wettest month of the year with an average rainfall of approximately 2.91 inches. Average monthly precipitation that occurs in the area is shown in Table 2-4.

## SECTION 2.0 – STUDY AREA CHARACTERISTICS

**Table 2-2**  
**Average Monthly Temperatures**

| Month      | Jan  | Feb  | Mar  | Apr  | May  | Jun  | Jul  | Aug  | Sep  | Oct  | Nov  | Dec  | Annual |
|------------|------|------|------|------|------|------|------|------|------|------|------|------|--------|
| Max<br>°F  | 68.2 | 68.2 | 73.7 | 75.7 | 81.8 | 88.7 | 95.3 | 96.0 | 93.1 | 82.1 | 75.1 | 65.4 | 80.3   |
| Mean<br>°F | 54.8 | 55.5 | 59.9 | 62.0 | 67.4 | 72.8 | 79.4 | 79.9 | 77.0 | 67.8 | 61.0 | 53.4 | 65.9   |
| Min<br>°F  | 41.3 | 42.7 | 46.1 | 48.3 | 53.0 | 56.8 | 63.5 | 63.7 | 60.8 | 53.4 | 46.8 | 41.4 | 51.5   |

Source: National Oceanic and Atmospheric Administration National Data Center Climatological Daily Data Tables for Station USC00047306 (Redlands).

**Table 2-3**  
**Annual Total Precipitation**

| Year | Rainfall (inch) |
|------|-----------------|
| 2008 | 11.98           |
| 2009 | 6.54            |
| 2010 | 26.69           |
| 2011 | 8.77            |
| 2012 | 9.01            |
| 2013 | 6.43            |
| 2014 | 9.17            |
| 2015 | 7.53            |
| 2016 | 12.34           |
| 2017 | 10.27           |

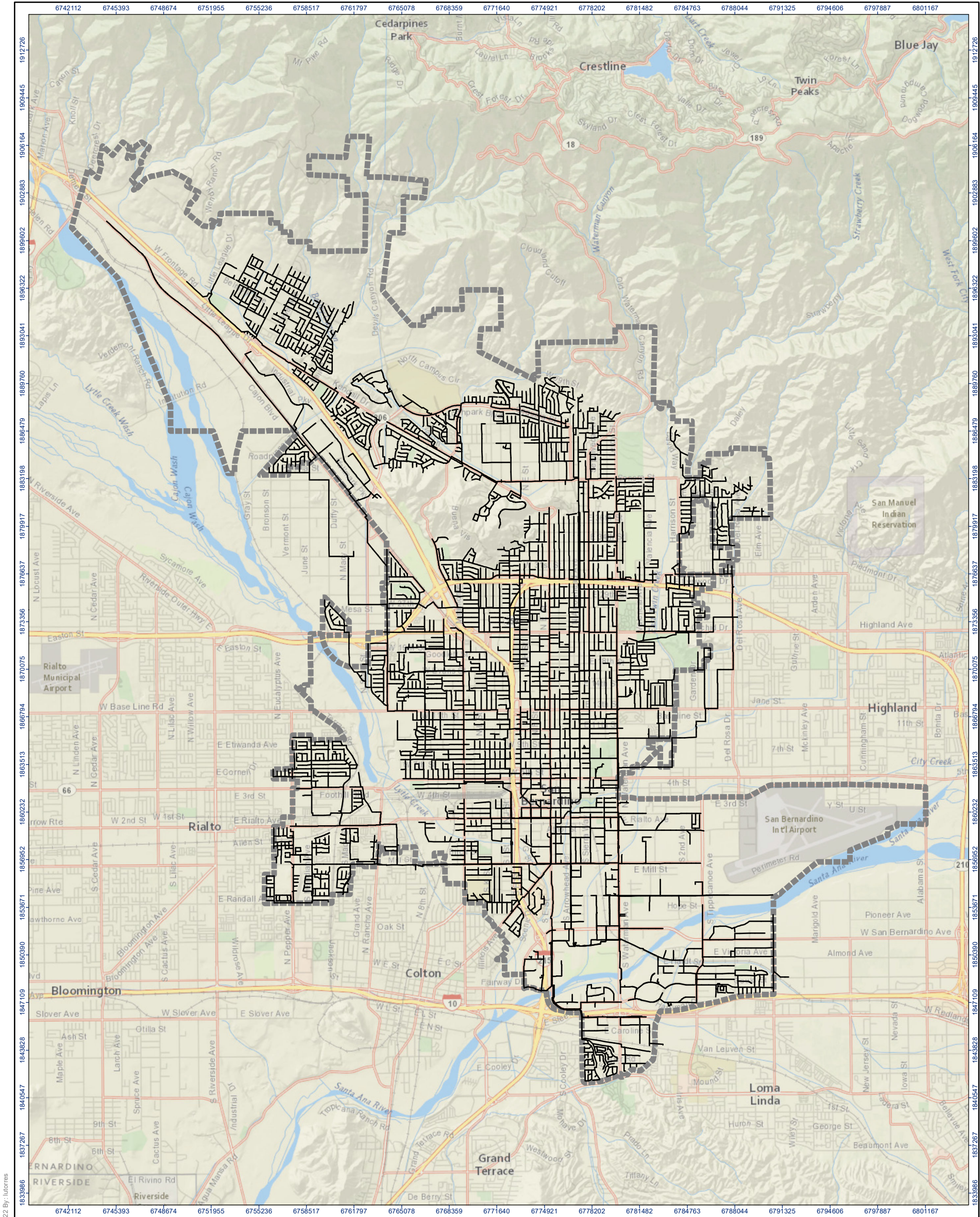
Source: U.S. Historical Climatology Network, data from station USC00047306, Redlands, California

**Table 2-4**  
**Average Total Monthly Precipitation**

| Month                          | Jan  | Feb  | Mar  | Apr  | May  | Jun  | Jul  | Aug  | Sep  | Oct  | Nov  | Dec  |
|--------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Average Total<br>Rainfall (in) | 1.69 | 1.80 | 0.71 | 0.88 | 0.29 | 0.01 | 0.08 | 0.17 | 0.03 | 0.36 | 0.92 | 2.91 |

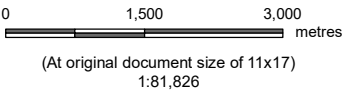
Source: U.S. Historical Climatology Network, data from station USC00047306, Redlands, California. Based on data from 2005 to 2015.





Legend

- Sewer Pipes
- SBMWD Water Service Boundary



Project Location San Bernardino County California  
Client/Project Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.

2-1

Title

SBMWD Water Service Boundary

Notes  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.





## SECTION 2.0 – STUDY AREA CHARACTERISTICS

### 2.2.3 Existing Population

According to the 2017 U.S. Census Bureau, the City of San Bernardino has an estimated population of 216,995 with an average of 3.56 persons per household between 2012 and 2016. The 2010 Census cited a population of 209,961, a change of 7,034 people, or 3.4 percent. Comparatively, the national population growth rate is estimated at 5.5 percent.

Population information is used to verify flow data for the SBMWD system, and to determine the increase in flow generation within the area based on growth rate of the population. Population information is provided by 2017 U.S. Bureau of Census data and population projections are based on the 2017 U.S. Bureau of Census national growth rate of 5.5 percent.

According to the San Bernardino County LAFCO Countywide Service Review for Wastewater (Figure 4.3), the City of San Bernardino contains disadvantaged communities within its service area. A disadvantaged community (DAC) is defined as a “community within an annual median household income that is less than 80 percent of the statewide annual median household income”, according to the State of California Proposition 50 §79505.5(a). The U.S. Census Bureau reported median household income between 2013-2017 (in 2017 dollars) for the State of California as \$61,169, 80% of which would equal approximately \$48,935. The U.S. Census Bureau cited the median household income for the same time period (2013-2017) equal to \$41,027 (2017 dollars), thus classifying portions of the City of San Bernardino largely as a DAC. Additionally, the owner-occupied housing unit rate between 2013 and 2017 is 46.8%, according to the US Census Bureau. As a result, the remaining 53.2% is either renter occupied or vacant. This information supports the consensus that the City of San Bernardino is comprised of disadvantaged communities which can negatively affect SBMWD financial capacity to support required capital improvements.

### 2.2.4 Future Population Projections

According to the 2015 Regional Urban Water Management Plan (UWMP), the SBMWD water service area is approximately 45 square miles, providing water to approximately 200,000 people (2015) in the City of San Bernardino and unincorporated areas of San Bernardino County. Using a combination of census data and growth forecast tools, the projected population for SBMWD for the next 20 years is: 212,990 in 2025; 220,031 in 2030; 227,306 in 2035; and 234,821 in 2040.

The demand associated with future growth within the San Bernardino service area is discussed in detailed in Section 4.

## SECTION 2.0 – STUDY AREA CHARACTERISTICS

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SECTION 3

# Existing Sewer System







## **3.0 EXISTING SEWER SYSTEM**

The existing wastewater collection system consists of 493 miles of pipes, 15 active lift stations, 12 siphons, approximately 38,300 sewer connections, and a water reclamation plant (WRP). The collection system is comprised primarily (approximately 94 percent) of vitrified clay pipe (VCP) with the remainder of pipelines constructed of Acrylonitrile-Butadiene-Styrene (ABS), concrete, asbestos cement, ductile iron, Polyvinylchloride (PVC), Reinforced Concrete Pipe (RCP), and steel, among others.

### **3.1 GRAVITY SYSTEM**

Information is based upon SBMWD's GIS database that was updated to include Sewer Collection information provided by the City of San Bernardino Public Works Department in 2017. Attributes used from the GIS data include diameter, depth, invert elevations, material, and length. The following section further describes the components of the system.

#### **3.1.1 Gravity Mains**

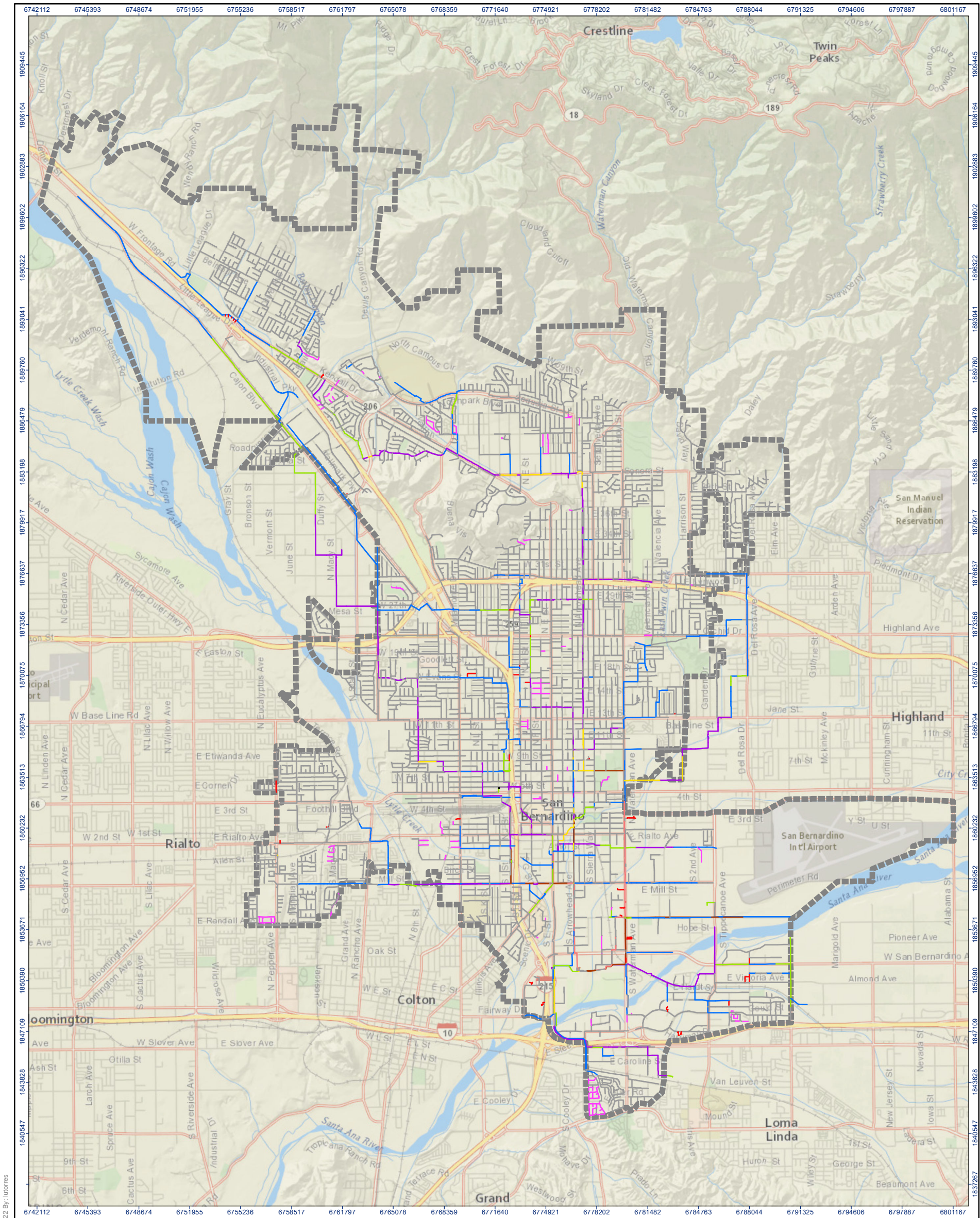
The collection system consists of 493 miles of pipes ranging from 4- to 60-inches in diameter. It is noted that the SBMWD GIS reflects 493 miles of pipeline at the time of the SMP, and the Department is continually updated their database. Table 3-1 presents the distribution of pipe sizes for the SBMWD collection system. The entire gravity system colored by pipe size is shown on Figure 3-1. Unknown pipe diameters (80 pipes with a total length of approximately 2 miles) did not have associated pipe lengths within GIS. Unknown pipe diameters often exist when sufficient information is not available to confirm size, due to lack of as-built data or field confirmation. It is recommended that these pipes are field surveyed and confirmed for future Master Plan updates.

## SECTION 3.0 – EXISTING SEWER SYSTEM

**Table 3-1  
Pipes by Diameter Summary**

| <b>Diameter<br/>(in)</b> | <b>Total Length<br/>(feet)</b> | <b>Total Length<br/>(miles)</b> | <b>Percentage of<br/>Total Length<br/>(%)</b> |
|--------------------------|--------------------------------|---------------------------------|-----------------------------------------------|
| 8 or less                | 1,977,578                      | 374.5                           | 75.97%                                        |
| 10                       | 108,347                        | 20.5                            | 4.16%                                         |
| 12                       | 123,115                        | 23.3                            | 4.73%                                         |
| 14                       | 3,895                          | 0.7                             | 0.15%                                         |
| 15                       | 105,876                        | 20.1                            | 4.07%                                         |
| 16                       | 2,862                          | 0.5                             | 0.11%                                         |
| 18                       | 56,158                         | 10.6                            | 2.16%                                         |
| 20                       | 2,960                          | 0.6                             | 0.11%                                         |
| 21                       | 50,472                         | 9.6                             | 1.94%                                         |
| 22                       | 570                            | 0.1                             | 0.02%                                         |
| 24                       | 40,745                         | 7.7                             | 1.57%                                         |
| 27                       | 48,873                         | 9.3                             | 1.88%                                         |
| 28                       | 37                             | 0.0                             | 0.00%                                         |
| 30                       | 16,508                         | 3.1                             | 0.63%                                         |
| 33                       | 6,109                          | 1.2                             | 0.23%                                         |
| 36                       | 21,967                         | 4.2                             | 0.84%                                         |
| 39                       | 2,021                          | 0.4                             | 0.08%                                         |
| 42                       | 1,999                          | 0.4                             | 0.08%                                         |
| 45                       | 428                            | 0.1                             | 0.02%                                         |
| 48                       | 6,770                          | 1.3                             | 0.26%                                         |
| 54                       | 13,183                         | 2.5                             | 0.51%                                         |
| 60                       | 595                            | 0.1                             | 0.02%                                         |
| Unknown                  | 11,888                         | 2.3                             | 0.46%                                         |
| <b>TOTAL</b>             | <b>2,602,957</b>               | <b>493</b>                      | <b>100%</b>                                   |





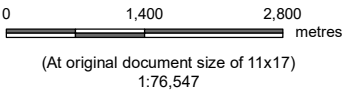
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Sewer Pipe Diameter

- Unknown
- 4" - 6"
- 8" - 10"
- 12" - 15"
- 16" - 20"
- 21" - 27"
- 28" - 33"
- 36" - 42"
- 45" - 60"



SBMWD Water Service Boundary



Project Location San Bernardino County California  
Client/Project Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.

3-1

Title

Distribution of Sewer Pipe Diameter for the SBMWD Collection System

Notes

- Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
- Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.





## SECTION 3.0 – EXISTING SEWER SYSTEM

### 3.1.1.1 Pipeline Material

Pipe materials that make up the SBMWD collection system were also reviewed. Materials are coded in the GIS information provided by SBMWD and are denoted by abbreviations. As with some of the other data provided for this master plan, some pipes have no material abbreviation for or were given an otherwise unknown abbreviation. For the SBMWD collection system, Table 3-2 shows a summary of pipe materials in the collection system.

**Table 3-2**  
**Pipe Material Summary**

| <b>Abbreviation</b> | <b>Description</b>               | <b>Cumulative Length of Pipe (feet)</b> | <b>Cumulative Length of Pipe (miles)</b> | <b>Percentage of Total System (%)</b> |
|---------------------|----------------------------------|-----------------------------------------|------------------------------------------|---------------------------------------|
| ABS                 | Acrylonitrile-Butadiene-Styrene  | 23,061                                  | 4.4                                      | 0.9%                                  |
| ACP                 | Asbestos Cement                  | 3,727                                   | 0.7                                      | 0.1%                                  |
| CIP                 | Cast Iron Pipe                   | 5,898                                   | 1.1                                      | 0.2%                                  |
| CMLC                | Concrete Mortar Lined and Coated | 11,663                                  | 2.2                                      | 0.4%                                  |
| Conc                | Concrete                         | 3,263                                   | 0.6                                      | 0.1%                                  |
| DIP                 | Ductile Iron Pipe                | 4,792                                   | 0.9                                      | 0.2%                                  |
| HDPE                | High Density Polyethylene        | 595                                     | 0.1                                      | 0.0%                                  |
| PCC                 | Prestressed Concrete Cylinder    | 531                                     | 0.1                                      | 0.0%                                  |
| PVC                 | Polyvinylchloride                | 87,368                                  | 16.5                                     | 3.4%                                  |
| RCP                 | Reinforced Concrete Pipe         | 14,854                                  | 2.8                                      | 0.6%                                  |
| STL                 | Steel                            | 991                                     | 0.2                                      | 0.0%                                  |
| TRNS                | Transite                         | 493                                     | 0.1                                      | 0.0%                                  |
| UNK                 | Unknown                          | 771                                     | 0.1                                      | 0.0%                                  |
| VCP*                | Vitrified Clay Pipe              | 2,444,949                               | 463.1                                    | 93.9%                                 |
| <b>Total</b>        |                                  | <b>2,602,957</b>                        | <b>493</b>                               | <b>100%</b>                           |

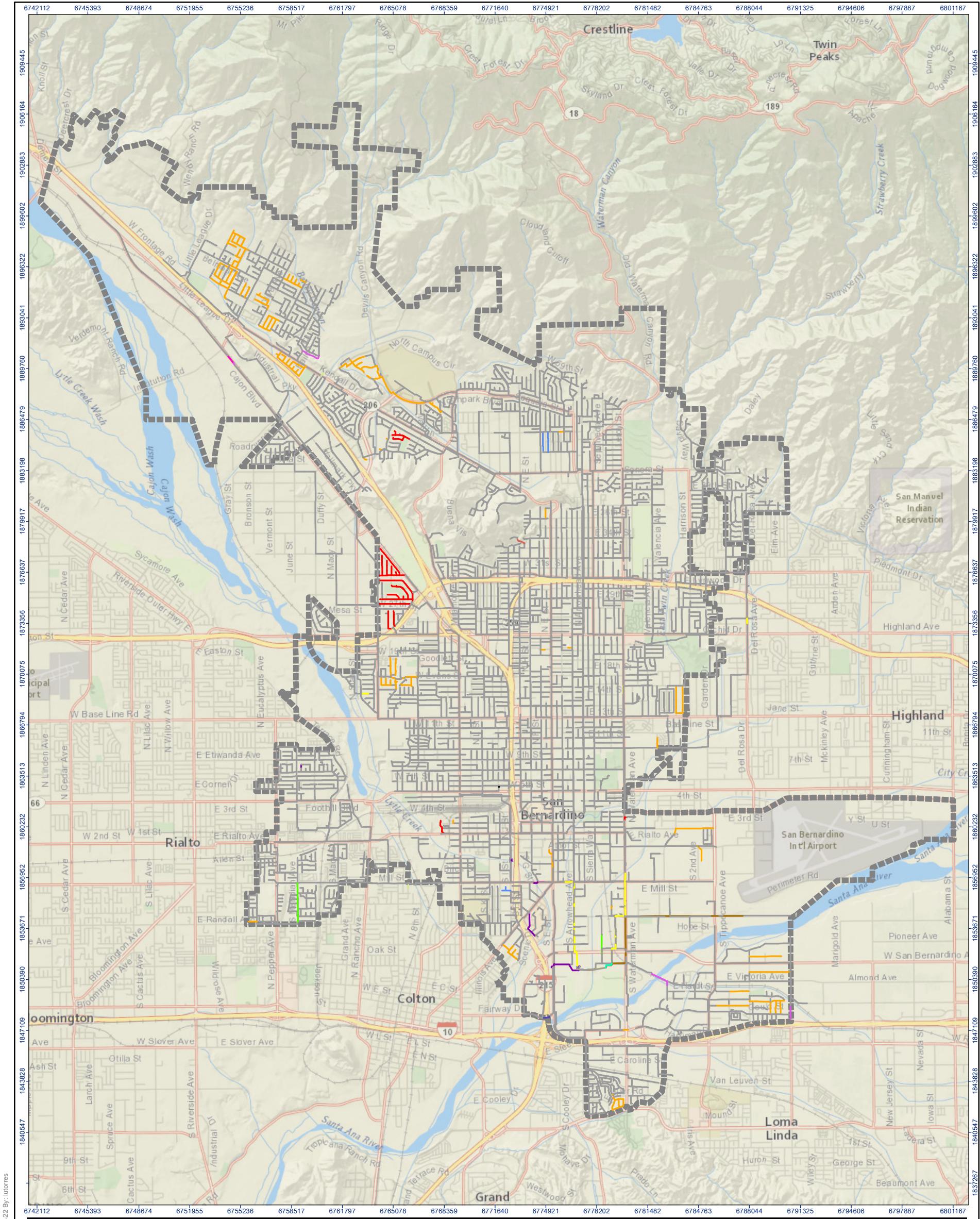
\*The system is continuously being updated and it appears that prior unknown entries were assumed to be VCP.

As shown in the table, the majority of the SBMWD system is VCP\*, which makes up 94 percent of the system. The next most common material is PVC Pipe, which comprises three percent of the system. Of the remaining materials, none make up more than one percent of the total system by length. Figure 3-2 shows SBMWD's system color coded by material.

## SECTION 3.0 – EXISTING SEWER SYSTEM

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## Legend

### Sewer Pipe Material

- ABS
- ACP
- CIP

- CMLC
- Conc
- DIP
- HDPE
- PCC

- PVC
- RCP
- STL
- TRNS
- UNK
- VCP\*

SBMWD Water Service Boundary

0 1,400 2,800 metres  
(At original document size of 11x17)  
1:76,547



Project Location San Bernardino County, California  
Client/Project Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.

3-2

Title

Distribution of Sewer Pipe Material for the SBMWD Collection System

\*The system is continuously being updated and it appears that prior unknown entries would be VCP.

Notes  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

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## SECTION 3.0 – EXISTING SEWER SYSTEM

### 3.1.1.2 Main Trunk Lines

Wastewater generated within the SBMWD Treatment Service Area flows predominately by gravity to the WRP. Flows are conveyed first by small (less than 18" in diameter) collection pipelines, then to larger (18 inches and greater in diameter) transmission mains, and finally to one of three main trunk lines: Arrowhead, "E" Street, and East Interceptor. These three main trunk lines serve to intercept and aggregate sewer flows prior to being pumped into the WRP. The average inflows for the three main trunk lines are listed in Table 3-3.

**Table 3-3**  
**Summary of Main Trunk Lines**

| Trunk                                          | Pipe Diameter (inches) | Pipe Material | Flow (MGD) |
|------------------------------------------------|------------------------|---------------|------------|
| Arrowhead: Arrowhead Avenue & Orange Show Road | 54                     | RCP           | 6.00       |
| "E" Street: "E" Street & Chandler Place        | 20                     | CI            | 2.80       |
| East Interceptor: Amos Avenue & Dumas Street   | 54                     | RCP           | 12.14      |

### 3.1.2 Siphons

The SBMWD collection system has 12 inverted siphons. Inverted siphons are used to carry flow under a channel, river, or other interfering structure. Gravity flow is maintained by the upstream head that provides the energy required for flow through the siphon.

Inverted siphons can be comprised of one or multiple barrels. The SBMWD siphons consist of two single-barrel, seven double-barrel, and three-triple barrel siphons. Table 3-4 lists the SBMWD system siphons. Information on how the siphons are modeled is provided in Section 4. An assessment of siphon structures is presented in Appendix M.

**Table 3-4**  
**Summary of SBMWD Siphons**

| No. | Siphon                             | Cross Street         | Obstacle            | Pipe Size (inches) |
|-----|------------------------------------|----------------------|---------------------|--------------------|
| 1   | Mill Street                        | G Street             | Lytle Creek Channel | 24, 24             |
| 2   | Waterman Avenue (Vanderbilt)       | s/o Orange Show Road | Santa Ana River     | 8, 12              |
| 3   | Perris Hill Park                   | n/o 21st Street      | Twin Creek Channel  | 8, 10              |
| 4   | Tippecanoe Avenue*                 | n/o 9th Street       | Warm Creek Channel  | 14, 24             |
| 5   | "I" Street                         | n/o Mill Street      | Lytle Creek Channel | 18, 24             |
| 6   | "E" Street (San Bernardino Siphon) | n/o Hospitality Lane | Santa Ana River     | 8, 12              |
| 7   | "E" Street (Loma Linda)            | n/o Hospitality Lane | Santa Ana River     | 14, 16, 20         |
| 8   | Baseline Street*                   | e/o Canejo           | Del Rosa Channel    | 14, 24             |
| 9   | Zanga                              | s/w of Cooley        | Mission Channel     | 6, 10              |
| 10  | Santa Fe                           | s/w of Cooley        | Santa Ana River     | 10, 12, 20         |
| 11  | Inland Center Mall Drive           | n/e of "G" Street    | Lytle Creek Channel | 10, 18             |
| 12  | 6th Street*                        | e/o Waterman Avenue  | Twin Creek Channel  | 33                 |

\* To be transferred to EVWD

## **SECTION 3.0 – EXISTING SEWER SYSTEM**

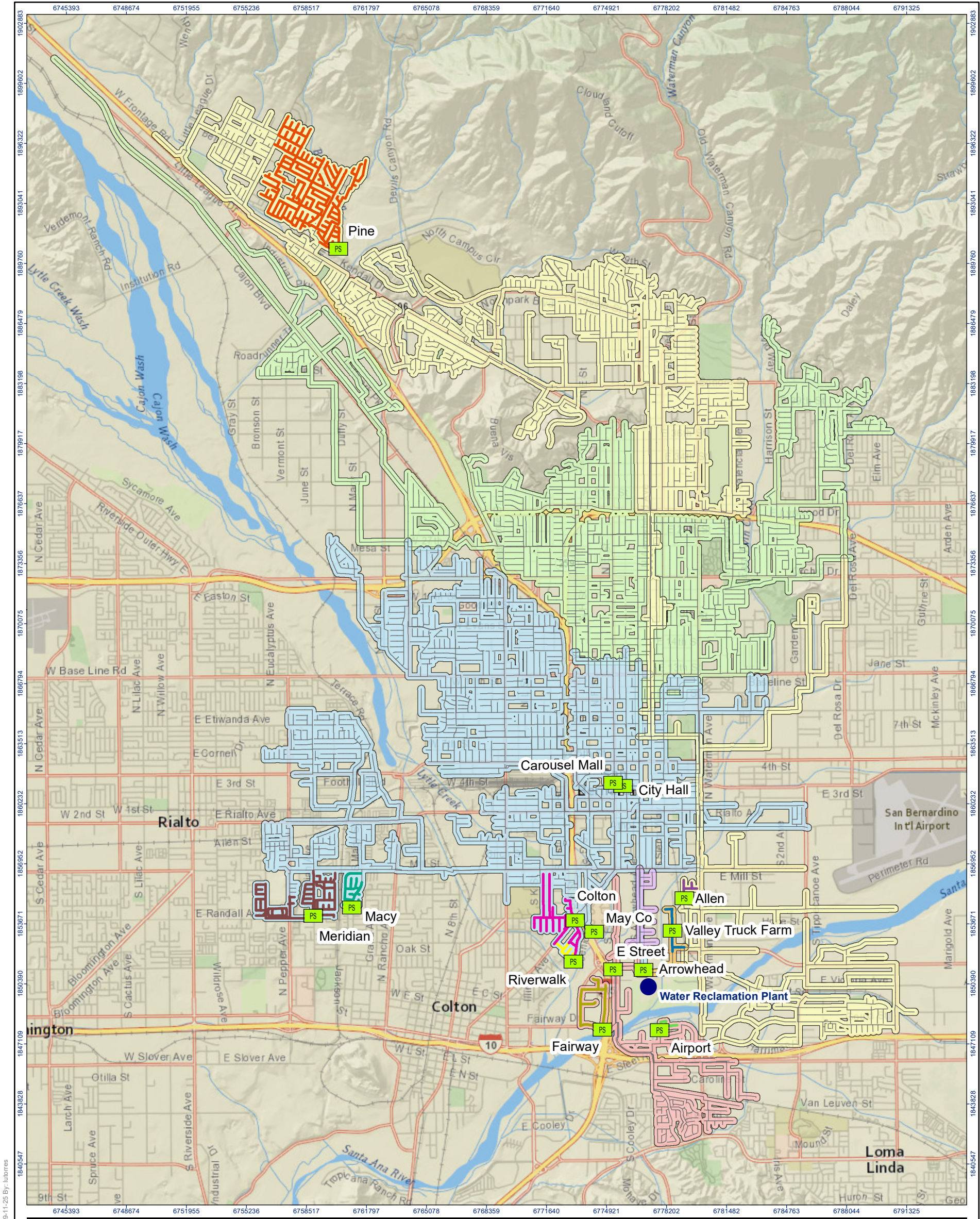
### **3.1.3 Flow Diversions**

The SBMWD system has several locations where flow has been diverted to relieve the original pipe when it can no longer accommodate peak flow. Flow is split between sewers at interconnection points that may occur at a common maintenance hole or a connecting section of sewer line constructed between parallel sewers. There are 112 locations of flow splits per the GIS data.

## **3.2 PRESSURE SYSTEMS**

Where gravity flow is no longer possible, a pressurized system pumps flow from low points in the system to higher elevations. SBMWD currently operates 15 lift stations (LS) within its system. The locations of these lift stations are shown on Figure 3-3.





Legend

Pipe

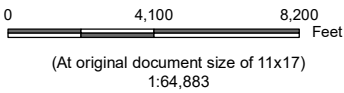
No Minor LS Associated

Minor Lift Station

- Airport LS
- Allen LS
- Carousel LS

- Colton LS
- Fairway LS
- Macy LS
- Meridian LS
- Pine LS
- Riverwalk LS
- Valley Truck Farm LS

- Arrowhead
- E Street
- East
- Arrowhead / E Street
- Arrowhead / East
- WRP Drain Line
- Water Reclamation Plant



Project Location San Bernardino County California  
Prepared by KHernandez on 2019-07-31  
Updated by LTorres on 2019-11-25  
Client/Project Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.

3-3

Title

Lift Station Map

\*Riverwalk LS feeds into Colton LS

Notes

- Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
- Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.





## SECTION 3.0 – EXISTING SEWER SYSTEM

### 3.2.1 Lift Stations

SBMWD operates 15 lift stations within its collection system. There are two to five pumping units for each lift station, with varying motor size from 3 to 200 horsepower (hp). SBMWD's three largest lift stations are the Arrowhead, "E" Street, and East Interceptor Lift Stations. Information on each lift station can be found in Table 3-5. A detailed description of each lift station and a current assessment of condition is presented in Appendix K, and lift station assessment forms are presented in Appendix L.

**Table 3-5  
Lift Stations**

| Station No. | Station Name     | Station Location                                    | No. of Pumps | Horsepower Per Pump              | Individual Pump Capacity (gpm)         |
|-------------|------------------|-----------------------------------------------------|--------------|----------------------------------|----------------------------------------|
| 1           | Carousel         | "E" Street & Court Street                           | 2            | 2                                | 300                                    |
| 2           | May Co.          | Inland Center Mall                                  | 2            | 10                               | 450                                    |
| 3           | Colton           | Inland Center Drive & I-215 Freeway                 | 2            | 10                               | 600                                    |
| 4           | Fairway          | Fairway Drive & Camino Real Drive                   | 2            | 15                               | 1,420                                  |
| 5           | Airport          | Commercenter-West & Airport Drive                   | 2            | 3                                | 220                                    |
| 6           | Truck Farm       | Washington Avenue & Ennis Street                    | 2            | 5                                | 250                                    |
| 7           | Allen            | Allen Street & Central Avenue                       | 2            | 5                                | 220                                    |
| 8           | Pine             | Christine Street & Christopher Street               | 2            | 15                               | 225                                    |
| 9           | City Hall        | 3rd. Street & "D" Street                            | 2            | 3                                | 250                                    |
| 10          | Meridian         | Meridian Avenue & Randall Avenue                    | 2            | 30                               | 600                                    |
| 11          | Macy             | Macy Street & Isabella Drive                        | 2            | 15                               | 225                                    |
| 12          | Riverwalk        | Scenic Drive & Riverwalk Drive                      | 2            | Not available                    | 200                                    |
| 13          | Arrowhead        | SBWRP (Part of SBMWD WRP)                           | 5            | 225 (pumps 1-4) and 200 (pump 5) | 14,400 (pumps 1-4) and 13,500 (pump 5) |
| 14          | "E" Street       | "E" Street & Chandler Place (Adjacent to SBMWD WRP) | 3            | 200                              | 4,500                                  |
| 15          | East Interceptor | SBWRP (Part of SBMWD WRP)                           | 3            | 60                               | 12,500                                 |

### 3.2.2 Force Mains

Force mains are pressurized pipes that carry flow from a lift station to a discharge point, usually a gravity sewer maintenance hole. The SBMWD collection system contains approximately 13,628 ft. of force main ranging from 4- to 54-inches in diameter. These force mains service the 15 lift stations described above. Force main information based on SBMWD's GIS database is provided in Table 3-6.

## SECTION 3.0 – EXISTING SEWER SYSTEM

**Table 3-6**  
**SBMWD Collection System Force Main**

| Lift Station Name | Lift Station Location                 | Size (inch) | Length (ft.) |
|-------------------|---------------------------------------|-------------|--------------|
| Airport           | Commercenter-West & Airport Drive     | 6           | 348          |
| Allen             | Allen Street & Central Avenue         | 4           | 210          |
| Arrowhead         | SBWRP (Part of SBMWD WRP)             | 54          | 250          |
| Carousel          | "E" Street & Court Street             | 8           | 90           |
| City Hall         | 3rd. Street & "D" Street              | 8           | 200          |
| Colton            | Inland Center Drive & I-215 Freeway   | 8           | 787          |
| "E" Street        | SBWRP (Part of SBMWD WRP)             | 20, 24, 30  | 2340         |
| East Interceptor  | SBWRP (Part of SBMWD WRP)             | N/A         | N/A          |
| Fairway           | Fairway Drive & Camino Real Drive     | 10          | 465          |
| Macy              | Macy Ave & Isabella Drive             | 6           | 1586         |
| May Co.           | Inland Center Mall                    | 8           | 1650         |
| Meridian          | Meridian Avenue & Randall Avenue      | 8           | 2540         |
| Pine              | Christine Street & Christopher Street | 4           | 1300         |
| Valley Truck Farm | Washington Avenue & Ennis Street      | 6           | 1190         |
| Riverwalk         | Scenic Drive & Riverwalk Drive        | 8           | 672          |

### 3.3 WATER RECLAMATION PLANT AND RIX FACILITY

The SBMWD collection system and the satellite collections systems for the City of Loma Linda and East Valley Water District flows to the Water Reclamation Plant (WRP) located at 399 Chandler Place, San Bernardino, CA 92408 between "E" Street and Waterman Avenue south of Orange Show Road. The current plant capacity is 33 MGD. Wastewater is treated at the WRP to secondary effluent limits before being sent to the Rapid Infiltration and Extraction (RIX) Facility in Colton, CA where it is treated to tertiary effluent limits before being discharged to the Santa Ana River.



## SECTION 4

# Water Demands and Wastewater Characteristics







## **4.0 WATER DEMANDS AND WASTEWATER CHARACTERISTICS**

### **4.1 METHODOLOGY**

This section documents the methodology used in the Sewer Master Plan for developing wastewater demands within the San Bernardino Municipal Water Department (SBMWD) wastewater collections service area. This section references the results of the 2018 Sewer Flow Monitoring and Inflow/Infiltration Study (Flow Study) and water billing data received from SBMWD.

The proposed methodology estimates existing sewer demands based on water billing data and future sewer demands based on projected land use and water demands. Water to wastewater ratios, which compare the amount of wastewater generated for an area against the amount of potable water purchased, were developed for each land use type based on the Flow Study. These ratios were applied to the volumes of potable water consumed according to SBMWD billing data to determine existing wastewater demands. Future sewer generation is similarly estimated by applying water to wastewater ratios to future land use and projected water usage.

### **4.2 WATER DEMAND**

#### **4.2.1 Historical Water Demand**

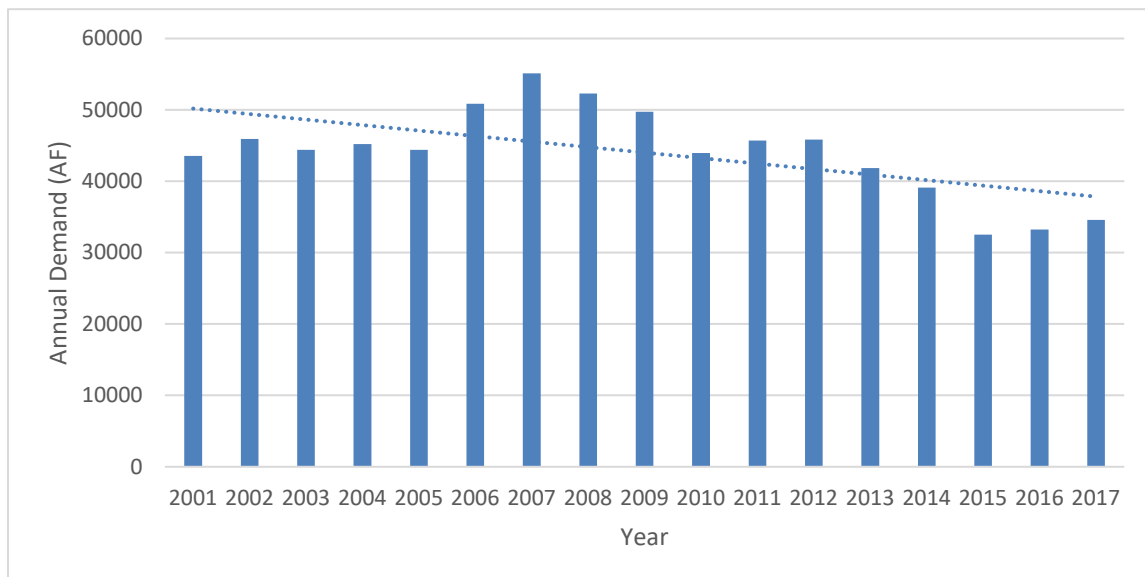
As of 2017, SBMWD maintains approximately 44,826 water meters and serves approximately 34,583 acre-feet of potable water annually. The SBMWD's billing data is classified into five main categories: residential, commercial, landscape irrigation, fire protection, and other. Single-family residential users were the largest category and accounted for nearly 49 percent of the total potable demand. From 2001 through 2017, annual water demand fluctuated, with a minimum of 32,529 acre-feet in 2015 as shown in Table 4.1. The maximum demand of 55,135 acre-feet occurred in 2007, before the economic depression and state-wide drought which drove conservation measures that decreased water demand (SBMWD-DWR Annual Summary Reports). SBMWD's demand history and 17-year trend is shown in Figure 4.1. Values from 2008-2013 are provided by the 2015 - Water Facilities Master Plan (WFMP); values from 2014-2017 are based on SBMWD provided billing data.

It is noted that the SBMWD wastewater collections service area consists of approximately 38,332 sewer connections within SBMWD's water service area; approximately 3,356 water meters do not have corresponding sewer accounts and are thus assumed to be on septic. While this assumption is made as a conservative estimate for the purposes of projecting future flows, it is noted that the true number of septic accounts have not been confirmed and the number may be less. There may be scenarios where a single business or entity has multiple water meters but only one sewer connection, and thus this value should not be taken as a confirmed number of septic customers in the service area.

## SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS

**Table 4.1**  
**Yearly Water Demands**

| <u>Year</u> | <u>Water Demands (AF)</u> |
|-------------|---------------------------|
| 2001        | 43,566                    |
| 2002        | 45,930                    |
| 2003        | 44,397                    |
| 2004        | 45,198                    |
| 2005        | 44,384                    |
| 2006        | 50,842                    |
| 2007        | 55,135                    |
| 2008        | 52,281                    |
| 2009        | 49,725                    |
| 2010        | 43,952                    |
| 2011        | 45,694                    |
| 2012        | 45,827                    |
| 2013        | 41,844                    |
| 2014        | 39,125                    |
| 2015        | 32,529                    |
| 2016        | 33,245                    |
| 2017        | 34,583                    |



**Figure 4-1 Historical Water Demand 2001-2017**

## SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS

### 4.3 WASTEWATER VOLUMES

#### 4.3.1 Flow Monitoring

Wastewater flow monitoring was performed in two phases to establish baseline sanitary sewer flows, peak flow conditions, estimate sewer capacity, and produce data for model calibration. Phase 1 of the Flow Study was conducted over a period of 6.5 weeks and monitored flow at ten large-diameter (12-inches in diameter or greater) pipelines, isolating flow from major sewerage basins. Flow data collected in Phase 1 are used for calibration of the collection system model and evaluation of rain-dependent infiltration and inflow (RDI/I) analysis. Phase 2 was conducted over 4.5 weeks at ten small-diameter pipeline flow metering sites and isolated smaller basins with a single land use type (residential, commercial, etc.). The specific flow monitoring sites per the Flow Study are identified by Phase in Table 4.2 below and each location is presented on Figure 4.2. The Flow Study is presented in Appendix B.

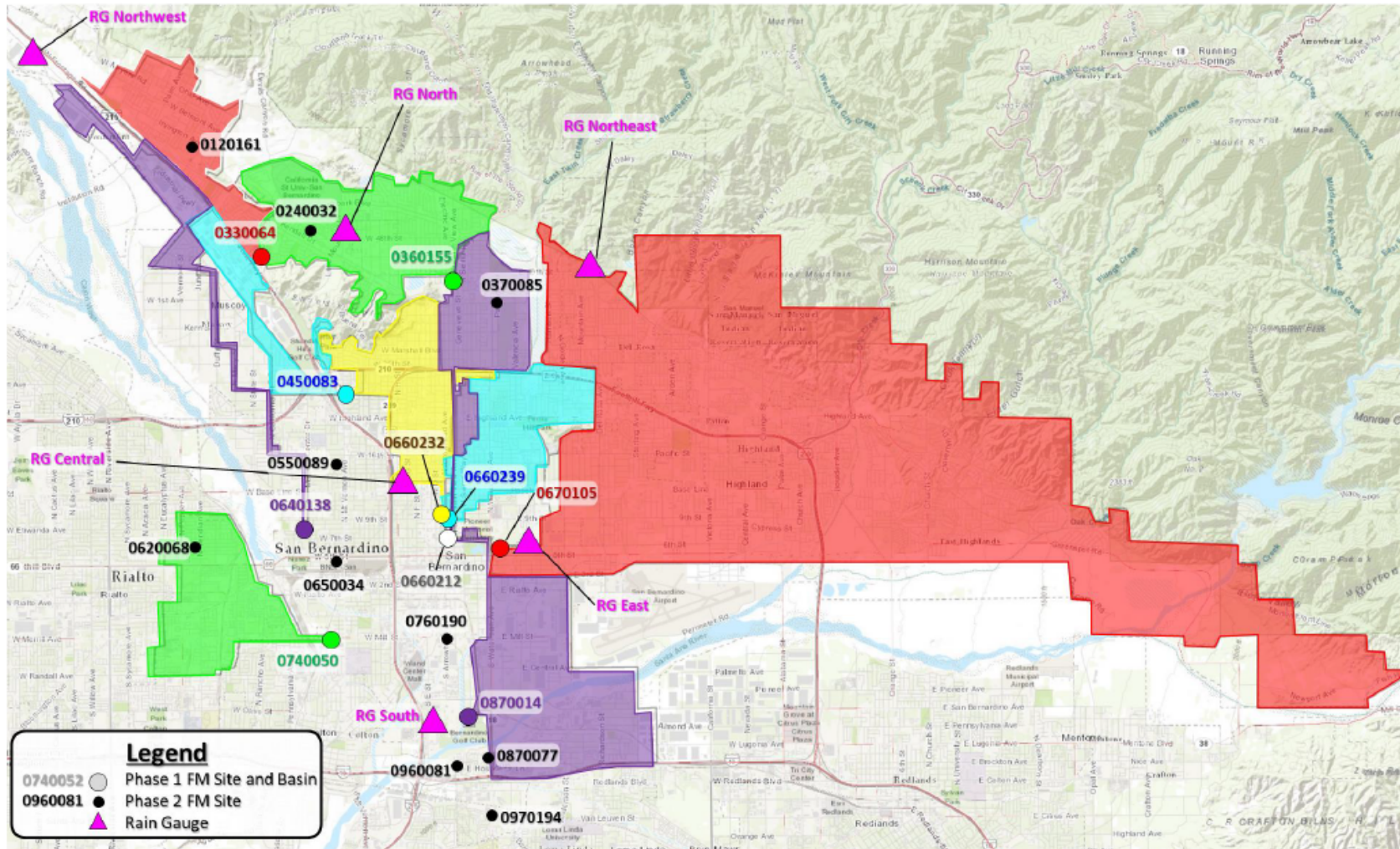
**Table 4.2: Flow Monitoring Locations**

| <u>Monitoring Site</u>               | <u>Pipe Monitored</u> | <u>Dia. (in)</u> | <u>Location</u>                                             |
|--------------------------------------|-----------------------|------------------|-------------------------------------------------------------|
| <b>Phase 1 Flow Monitoring Sites</b> |                       |                  |                                                             |
| SMH 0330064                          | West Inlet            | 27               | Driveway northwest of University Parkway and N State Street |
| SMH 0360154                          | North Inlet           | 33               | Mountain View Ave, south of Ralston Ave                     |
| SMH 0450083                          | West Inlet            | 18               | 1275 W 27th Street                                          |
| SMH 0640138                          | North Inlet           | 27               | W 8th Street and Medical Center Drive                       |
| SMH 0660212                          | West Inlet            | 30               | W 7th Street and N Pershing Avenue                          |
| SMH 0660232                          | North Inlet           | 24               | N Arrowhead Avenue north of W 9th Street                    |
| SMH 0660239                          | East Inlet            | 21               | 248 W 9th Street                                            |
| SMH 0670105                          | East Inlet            | 33               | 6th Street west of Cooley Street                            |
| SMH 0740052 <sup>1</sup>             | West Inlet            | 12               | W Mill Street west of S Grape Street                        |
| SMH 0870014                          | East Inlet            | 54               | E Dumas Street, east of S Washington Avenue                 |
| <b>Phase 2 Flow Monitoring Sites</b> |                       |                  |                                                             |
| SMH 0120161                          | NW Inlet              | 8                | Washington Avenue and Laura Lane                            |
| SMH 0240032                          | North Inlet           | 8                | 1494 Creekside Drive                                        |
| SMH 0370085                          | West Outlet           | 8                | E Parkdale Drive and Parkside Drive                         |
| SMH 0550089                          | West Inlet            | 8                | W 15th Street east of N Pico Avenue                         |
| SMH 0620068                          | North Inlet           | 8                | N Meridian Avenue and W 6th Street                          |
| SMH 0650034                          | East Outlet           | 8                | W Kingman ST, west of N Mt Vernon Ave                       |
| SMH 0760190                          | North Inlet           | 8                | S Pershing Avenue and W Mill Street                         |
| SMH 0870077                          | North Outlet          | 15               | S Waterman Avenue and E Vanderbilt Way                      |
| SMH 0960081                          | East Inlet            | 8                | Commercenter Dr, north of Hospitality Ln                    |
| SMH 0970151                          | South Inlet           | 8                | Industrial Rd east of S Waterman Ave E                      |

<sup>1</sup>This monitoring site partially captured the intended sewershed as the flow monitoring was taken on a 21" parallel main that included an additional sewershed.



## SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS



Note: colors shown in this figure are intended to differentiate sewerage basins only. The colors do not represent any additional basin information. Per Department's request, East Valley Water District (EVWD) service area were included in FM 0670105 basin.

**Figure 4-2 Map of Flow Monitoring Sites, Basins and Rain Gauges**

## **SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS**

### **4.3.1.1 Infiltration and Inflow**

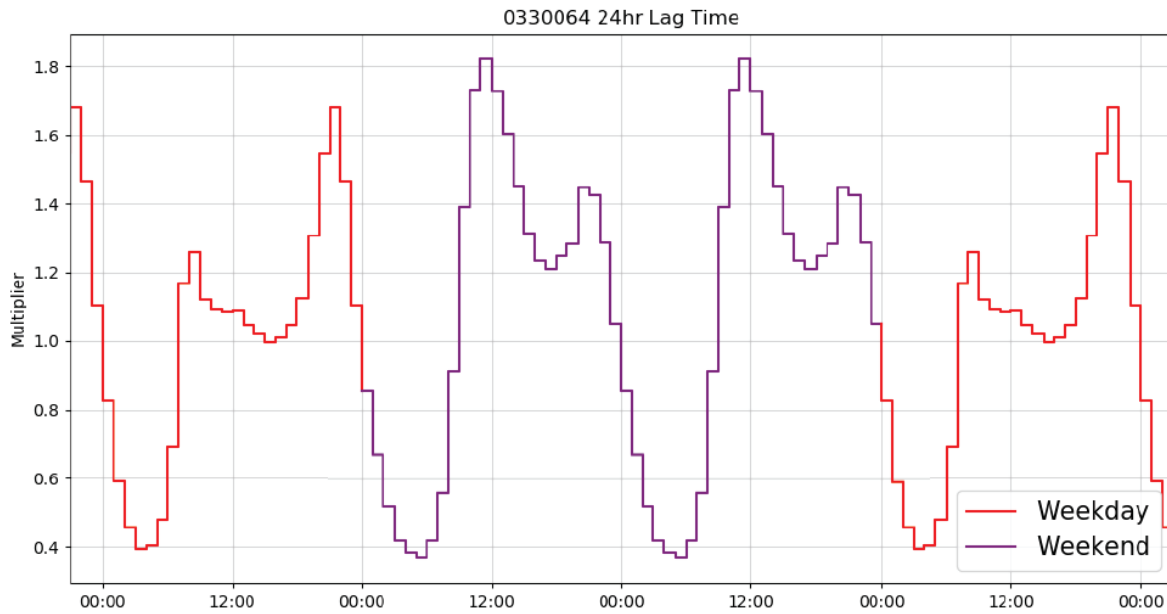
Infiltration and inflow refer to excess water that enters sewer lines from groundwater infiltration and stormwater inflow. Groundwater infiltration occurs as a result of groundwater entering broken pipes, cracks along sewer pipes and maintenance hole structures, misaligned joints, and maintenance holes, and can increase after a storm event when groundwater levels rise. Inflow occurs most prominently during storm events and is caused by rainfall directly entering the sewer system from various sources, such as through the maintenance hole covers, sump pumps, downspout connections, and cross connections with storm collection pipelines. Rainfall-derived inflow and infiltration (RDI/I) for the SBMWD system was measured and analyzed as part of the Flow Study.

Rainfall data was gathered from six rain gauges throughout the SBMWD collection system. Rainfall was triangulated and distributed to the sewerage basins per the Inverse Distance Weighting (IDW) method. The rainfall totals were approximately 30 percent lower than historical normal rainfall levels over the same period. All rain events for the rain gauges were classified as less than 1-year rainfall events. An RDI/I analysis was performed on the six defined rainfall events that occurred during Phase 1 of monitoring. The results of these analyses are described in detail in the Flow Study in Appendix B. The RDI rates (referring strictly to infiltration, not inflow) were extremely low or negligible for the flow monitoring sites, therefore an RDI analysis contribution could not be significantly separated from the sewer base flow. Most of the RDI/I values correspond to inflow sources.

### **4.3.1.2 Diurnal Patterns and Peaking Factors**

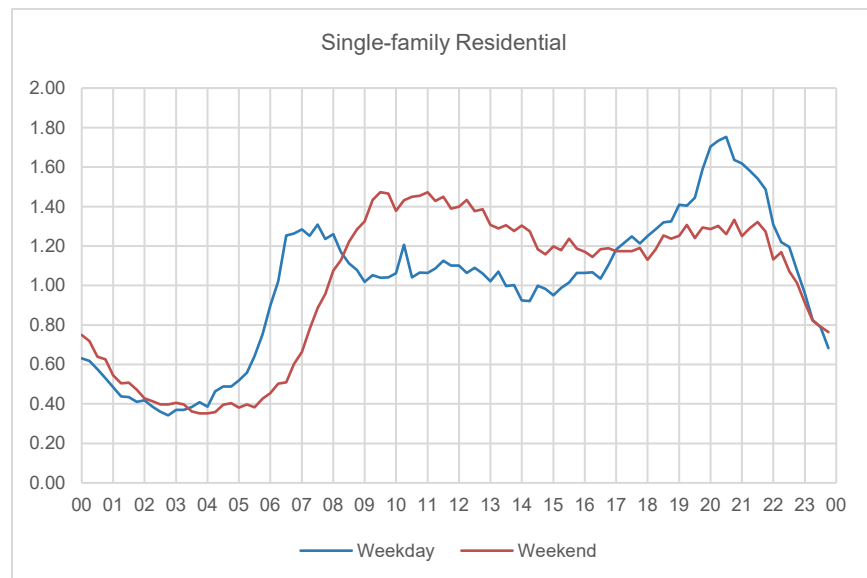
Diurnal curve patterns represent flow over a typical 24-hour period and are used in the model to modify average daily flows and represent variations in the average based on time of use. Diurnal patterns were created for each flow monitoring location during Phase I. Figure 4-3 shows an example of a diurnal curve pattern for flow monitoring point 0330064. Diurnal curves were created both with and without 24-hour lag time after rainfall events to confirm any differences immediately after a rain event. Diurnal curves for the remaining flow monitoring points, both with and without lag time, can be found in Appendix C. Lag time is defined as a period of time allowed for at end of a rainfall event before a diurnal curve is created, such that the after effects of the rainfall (inflow and infiltration which can be evident beyond the rainfall event itself) is no longer appreciable at the meters and the diurnal curve can be assumed to represent dry weather conditions.

## SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS



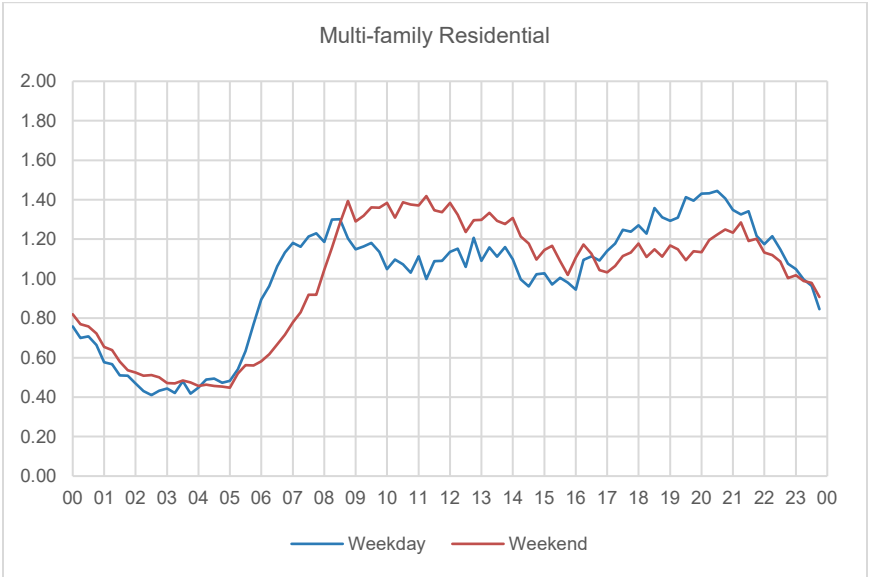
**Figure 4-3 FM 0330064 Diurnal – with lag time**

Diurnal curves were also developed for each land use type based on the Phase II flow monitoring results. Figure 4-4 through Figure 4-7 below show the weekday and weekend diurnal curves for single-family residential, multi-family residential, commercial, and industrial areas. It should be noted that the higher increase in flows later at night is consistent with the diurnal curves in nearby areas.

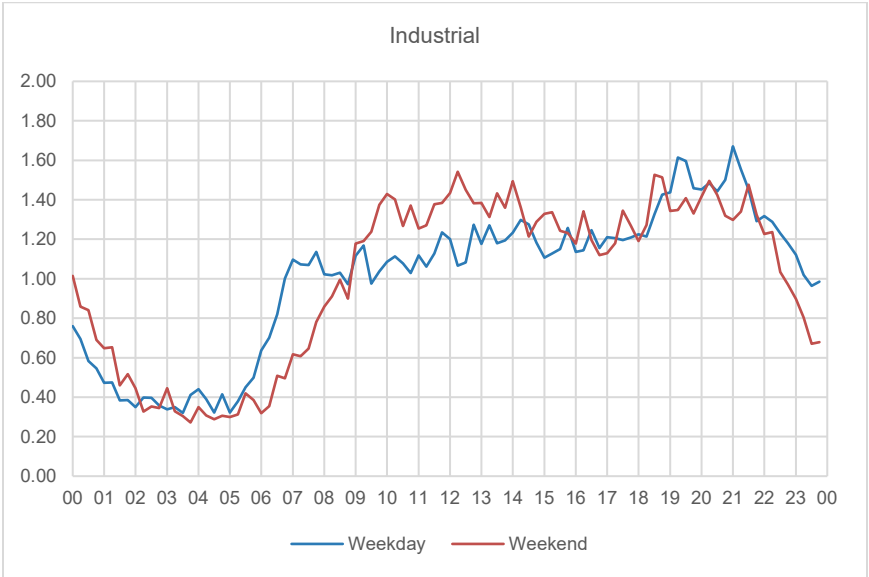


**Figure 4-4 Diurnal Pattern for Single-Family Residential Land Use**

**SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS**



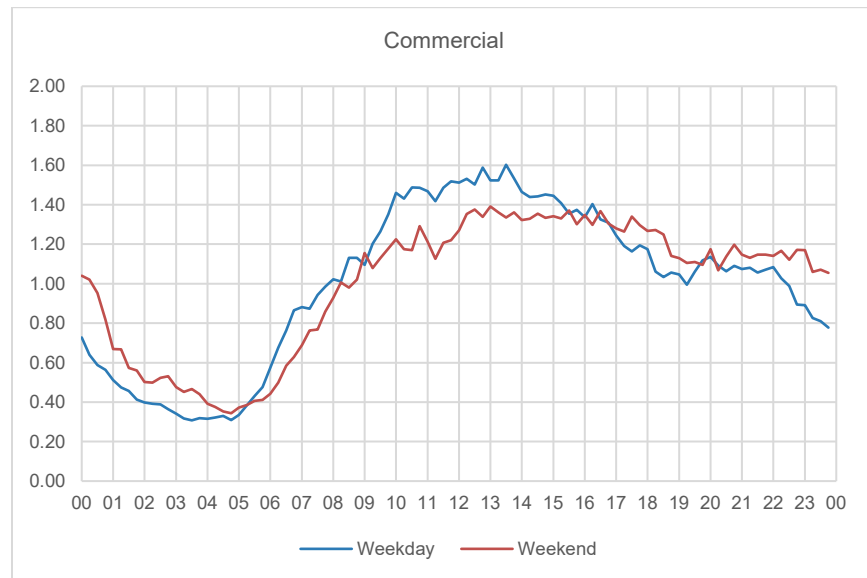
**Figure 4-4 Diurnal Pattern for Multi-family Residential Land Use**



**Figure 4-6 Diurnal Pattern for Industrial Land Use**



## SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS



**Figure 4-5 Diurnal Pattern for Commercial Land Use**

Table 4.3 shows the peaking factors per the Flow Study, shown schematically on Figure 4.7. The peak flows and flow levels reported are from the measurements taken during the flow monitoring period. Per the Flow Study, the following capacity analysis terms are defined as follows:

- **Wet Weather Peaking Factor:** defined as the peak wet weather measured flow divided by the average dry weather flow. Peaking factors are influenced by many factors including size/topography of the tributary area, proximity to lift stations, and the characteristics of RDI/I that enters the collection system. Flow attenuation and flow restrictions will also affect the peaking factor. For the Flow Study, a wet weather peaking factor was developed; for scaling of average flows to maximum dry weather flows, a separate dry weather peaking factor is developed during demand allocation in the model.
- **d/D Ratio:** The d/D ratio is the measured depth of flow (d) divided by the pipe diameter (D). The d/D ratio for each site was computed based on the maximum depth of flow for the study (i.e. Maximum d/D ratio).

## SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS

**Table 4.3: Wet Weather Peaking Factor Analysis Results**

| <u>Monitoring Site</u>               | <u>Wet Weather Peaking Factor</u> | <u>Pipe Diameter, D (in)</u> | <u>Maximum d/D ratio</u> |
|--------------------------------------|-----------------------------------|------------------------------|--------------------------|
| <b>Phase 1 Flow Monitoring Sites</b> |                                   |                              |                          |
| SMH 0330064                          | 2.3                               | 27                           | 0.36                     |
| SMH 0360154                          | 1.9                               | 33                           | 0.29                     |
| SMH 0450083                          | 1.9                               | 18                           | 0.35                     |
| SMH 0640138                          | 3.2                               | 27                           | 0.26                     |
| SMH 0660212                          | 1.8                               | 30                           | 0.29                     |
| SMH 0660232                          | 1.7                               | 24                           | 0.29                     |
| SMH 0660239                          | 1.9                               | 21                           | 0.64                     |
| SMH 0670105                          | 1.6                               | 33                           | 0.55                     |
| SMH 0740052 <sup>1</sup>             | 6.5 <sup>2</sup>                  | 12                           | 0.51                     |
| SMH 0870014                          | 1.8                               | 54                           | 0.44                     |
| <b>Phase 2 Flow Monitoring Sites</b> |                                   |                              |                          |
| SMH 0120161                          | 2.5                               | 8                            | 0.45                     |
| SMH 0240032                          | 2.4                               | 8                            | 0.32                     |
| SMH 0370085                          | 3.9                               | 8                            | 0.31                     |
| SMH 0550089                          | 3.6                               | 8                            | 0.22                     |
| SMH 0620068                          | 2.0                               | 8                            | 0.30                     |
| SMH 0650034                          | 8.4 <sup>3</sup>                  | 8                            | 0.61                     |
| SMH 0760190                          | 3.8                               | 8                            | 0.37                     |
| SMH 0870077                          | 2.2                               | 15                           | 0.33                     |
| SMH 0960081                          | 4.5                               | 8                            | 0.33                     |
| SMH 0970151                          | 1.8                               | 8                            | 0.73                     |

<sup>1</sup>This monitoring site partially captured the intended sewershed as the flow monitoring was taken on a 21" parallel main that included an additional sewershed.

<sup>2</sup> This peaking factor is unusually high due to a very low average dry weather flow value. Average dry weather flow for this site is measured to be approximately 0.052 mgd.

<sup>3</sup> This peaking factor is unusually high due to a very low average dry weather flow value. Average dry weather flow for this site is measured to be approximately 0.029 mgd.

## SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS

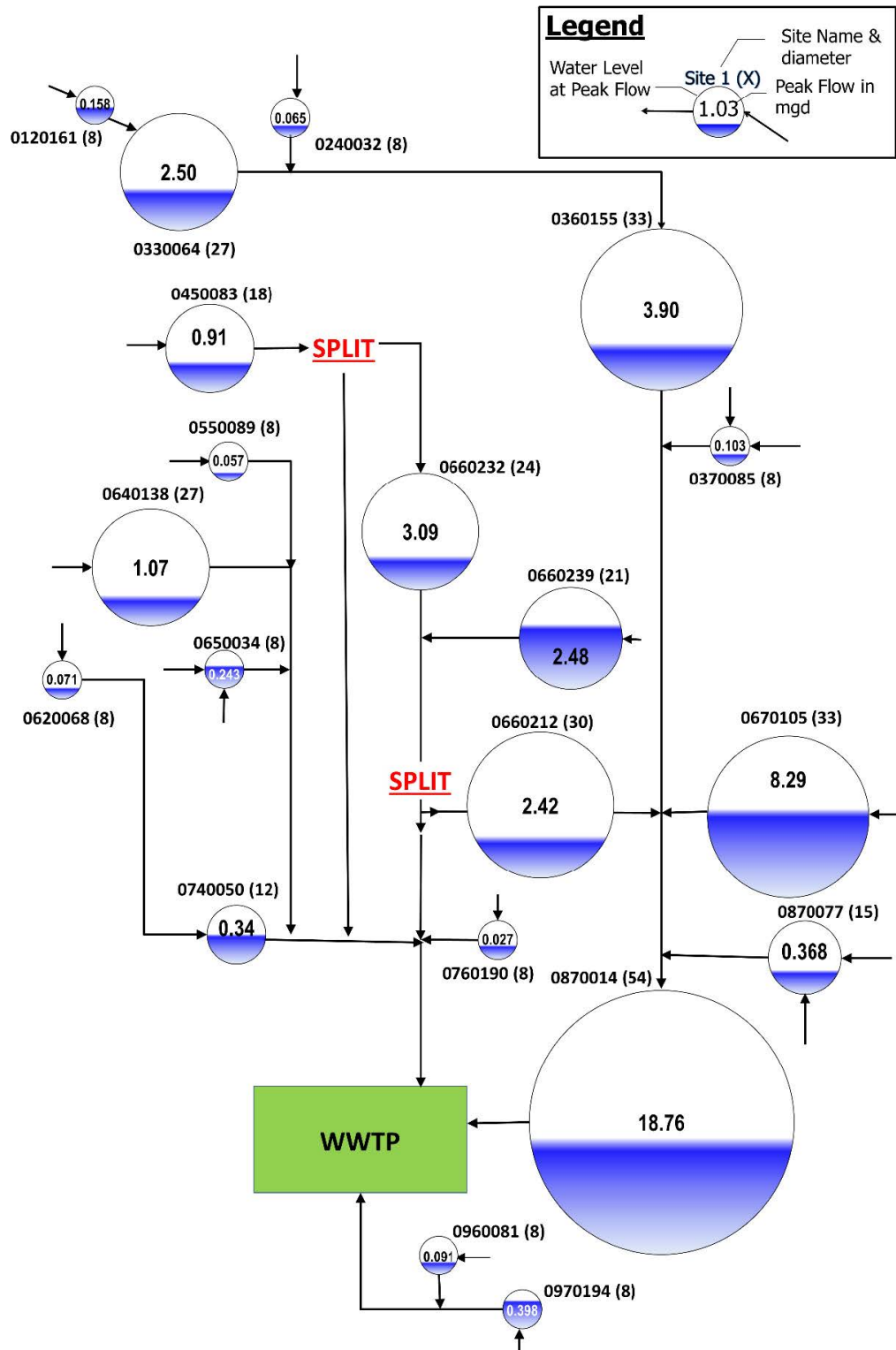


Figure 4-6 Peak Flow Schematic

## **SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS**

Based on the areas observed during the flow monitoring period and the findings of V&A, the SBMWD wastewater system experiences insignificant groundwater infiltration. This assumption is based on the selected flow monitoring locations and the wet weather experienced during the flow monitoring analysis, and there may be significant infiltration in areas that were not monitored as part of the Flow Study. Additionally, any areas where high groundwater levels are known by SBMWD should be considered higher risk for possible infiltration issues. Rises in groundwater levels also pose a risk for increased infiltration throughout the system.

Per the Flow Study, the primary source of SBMWD's RDI/I stems from inflow. This will be accounted for in the model by using the peak factors identified in Table 4.3 for wet weather analysis. Peaking factors from Phase 1 flow monitoring will be incorporated into the model, as these represent larger sub-sewersheds and are more reflective of SBMWD's overall system response. The peaking factor for future undeveloped areas should be lower than the peaking factors seen in SBMWD's existing system, due to improved pipe construction methods resulting in less inflow and infiltration. The peaking factor for future undeveloped areas will be 1.5, based on industry standards for new developments. This will be applied to any newly installed pipelines, and areas with no current infrastructure that are expected to be developed per the General Plan land use.

### **4.3.2 Base Wastewater Flows**

Base wastewater flow is the typical flow created in a collection system without contributions from RDI/I and typically includes flow from residential, commercial, industrial, public, and other customers in an area during dry weather periods. Infiltration and inflow are added to the base flow to generate the total daily flow. Base flow typically has a diurnal pattern, with flow rates increasing and decreasing over the course of each day based on when customers generate wastewater. For example, typical residential weekday wastewater flows are greater during the early morning and late afternoons as people use water before and after work and are less during the late evening and morning hours.

#### **4.3.2.1 Water to Wastewater Ratios**

To determine base sewer flows and projections of sewer demands, water to wastewater ratios are developed. These ratios estimate a direct relationship between metered water demand and wastewater flows and are applied to water demand projections from the 2015 Water Master Plan (2015 WMP) and other planning documents.

Flow monitoring sites in Phase II of the Flow Study monitored wastewater flow from areas comprised primarily of a single land use type: single-family residential, multi-family residential, commercial, or industrial. Monitoring data were collected from these sites from March to April 2018 with data collected in 15-minute intervals. These flow monitoring data points were compared directly with SBMWD billing data for customer water consumption in March and April 2018. The water to wastewater ratio were then calculated by dividing the volume of wastewater from the Flow Study by the volume of water consumed per the billing data. Table 4.4 below summarizes the water to wastewater ratios for each Phase II Flow Study monitoring site.



## SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS

**Table 4.4: Water to Wastewater Ratios**

| <b><u>Phase II<br/>Monitoring Site</u></b> | <b><u>Land Use</u></b>    | <b><u>Average Water<br/>Supplied<sup>a</sup><br/>(MGD)</u></b> | <b><u>Average<br/>Wastewater Flow<sup>b</sup><br/>(MGD)</u></b> | <b><u>Water to<br/>Wastewater Ratio</u></b> |
|--------------------------------------------|---------------------------|----------------------------------------------------------------|-----------------------------------------------------------------|---------------------------------------------|
| 0120161                                    | Single Family Residential | 0.087                                                          | 0.064                                                           | 0.74                                        |
| 0240032                                    | Multi-Family Residential  | 0.030                                                          | 0.031                                                           | 1.03 <sup>c</sup>                           |
| 0370085                                    | Single Family Residential | 0.073                                                          | 0.028                                                           | 0.39                                        |
| 0550089                                    | Single Family Residential | 0.018                                                          | 0.018                                                           | 1.00 <sup>c</sup>                           |
| 0620068                                    | Single Family Residential | 0.069                                                          | 0.034                                                           | 0.50                                        |
| 0650034                                    | Industrial                | 0.044                                                          | 0.030                                                           | 0.70                                        |
| 0760190                                    | Commercial                | 0.012                                                          | 0.008                                                           | 0.64                                        |
| 0870077                                    | Commercial                | 0.121                                                          | 0.173                                                           | 1.43 <sup>c</sup>                           |
| 0960081                                    | Commercial                | 0.046                                                          | 0.023                                                           | 0.49                                        |
| 0970151                                    | Multi-Family Residential  | 0.087                                                          | 0.023                                                           | 0.26                                        |

<sup>a</sup> Average Water Supplied is defined by SBMWD's billing data for March and April 2018

<sup>b</sup> Wastewater flow is the average daily flow observed at the flow monitoring site between March 1, 2018 and April 2, 2018 over the period of dry weather days in that timeframe.

<sup>c</sup> These ratios show that more wastewater was produced per the flow monitoring study than water purchased per the billing data. See text for further discussion of these ratios

Generally, water demand should be higher than wastewater flow, so the water to wastewater ratio is expected to be less than 1.0. Flow monitoring sites 0240032, 0550089, and 0870077 displayed water to wastewater ratios of 1.00 or higher. These values were removed from the average land use water to wastewater ratio as Stantec as unable to verify any sources of wastewater other than from potable water use that would be causing these ratios. It is highly unusual for water and wastewater demand to be equivalent, or for wastewater volume to be higher than the water consumed. There are several possible causes of why these ratios occur, including but not limited to:

- Incomplete water billing data
- Errors in the flow monitoring data
- Unknown sources of wastewater
- Water consumption from private sources or outside agencies within the sewershed
- Inaccurate GIS data that does not represent the true connections of pipelines

As part of this Master Plan, Stantec will recommend additional actions that SBMWD can take to further investigate these ratios, including additional flow monitoring, in order to further refine the model for future updates.

The quantity of land uses sampled, and their individual statistical significance is appropriate for a planning study, however any usage of the computer model output to support specific design projects may require further model refinement.

## SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS

- Based on the analysis using short-term flow monitoring data on specific land use and water billing data, the initial water to wastewater ratios for the main land use types are: Single-family residential: 0.66
- Multi-family residential: 0.64
- Commercial: 0.85
- Industrial: 0.70

These initial water to wastewater ratios were developed using limited data (4 flow monitors for single family, 2 for multi-family, 3 for commercial, 1 for industrial) and are not solely relied upon to represent the water to wastewater ratios for the system. During model calibration, these ratios are adjusted based on comparison of the model results with the flow data from the Phase 1 meters, treatment plant flows, and other data sources. During the model development and calibration, these water to wastewater ratios will be adjusted based on the results of the Phase I Flow Study. This is done by assigning flows to the model based on the water billing data and using the above water to wastewater ratios as a starting point. Total modeled flows for the Phase 1 sewersheds are then compared to the data from the Flow Study, and the ratios and land use factors are adjusted globally in the model to get good agreement between the model and the data. This ensures that the overall flows are accurate at a system-wide level in accordance with Calibration criteria, and that any water to wastewater ratios used have been modified as necessary to represent system flows as accurately as possible. Therefore, the water to wastewater ratios presented above, and the total system demands for existing and future presented below, are subject to change based on the findings from the calibration effort.

### 4.3.2.2 Geothermal Customers

SBMWD noted that the meter data provided for the SMP did not include two industrial customers near the WRP who use geothermal water and discharge to the sewer system. These customers include the Animal Shelter at 333 Chandler Place and Job Options Laundry at 1110 Washington Avenue; they purchased 16,000 and 133,000 gallons per day on average in 2019, respectively. These customers discharge sewer water into the SBMWD system, either through one of the WRP lift stations or directly to the headworks. This flow enters the system adjacent to the WRP and is not thought to have any upstream effects in the system. However, further investigation is needed to confirm how they connect into the system and account for their sewage contribution in future updates to the SMP.

### 4.3.3 Existing Wastewater Flows

Existing wastewater flows were calculated by applying water to wastewater ratios to SBMWD's current billing data, customer GIS data, parcel layer, and meter layer. Stantec reviewed the meter and customer GIS layer, and based on the land use identified in those layers, applied the water duty factors as presented in the 2015 WFMP. This is the same methodology used to get existing demands in the current WFMP, though newer data was used for this effort. Water billing data was also used to determine current consumption rates for each of the land use types

Once an existing water demand was established, water to wastewater ratios were applied to the water demands in order to develop wastewater flows for the existing system. Stantec reviewed the current billing to establish water customers that did not have wastewater accounts, and these were removed from the demands prior to conversion to wastewater flows. This was done to account for septic customers who have a water demand but do not contribute wastewater flow to the collection system.

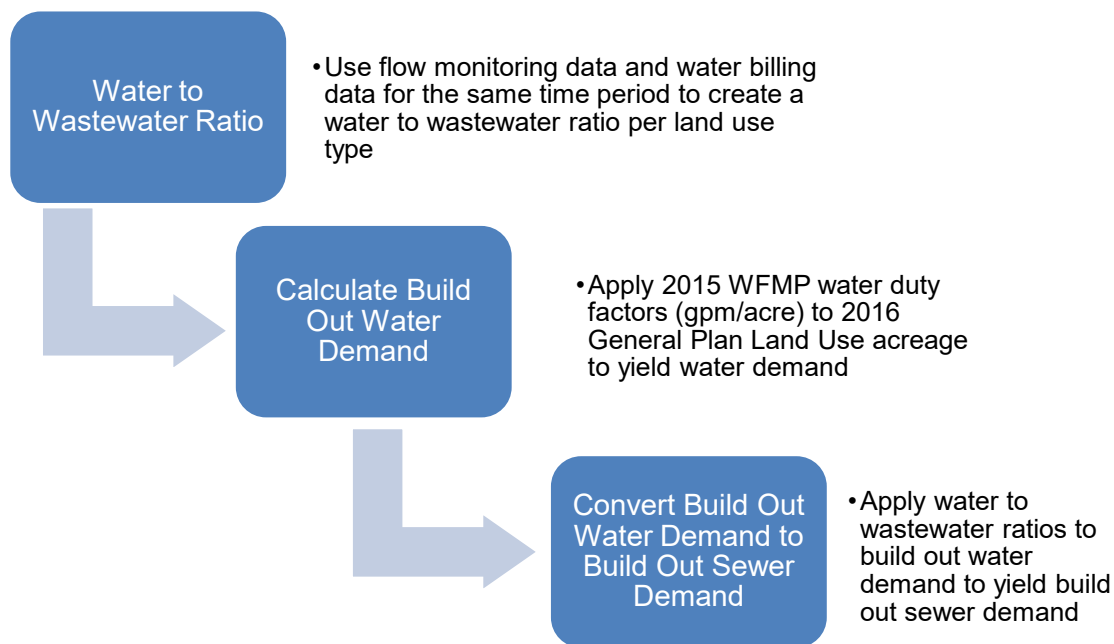
## SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS

Billing records provided by SBMWD were used to identify land use type for many of the customers, however some records did not indicate a land use type. For these situations, Stantec used GIS zoning data for San Bernardino to establish land use types for all customers in the billing data geospatially. This exercise yielded a final water customer list with all septic contributions removed, and with a land use assigned for each customer.

The results of the existing wastewater flow analysis yielded a total existing wastewater flow of 14,632 AFY for the SBMWD collection system service area. Given the approximately 34,583 acre-feet of potable water demand annually, this would yield a system wide water to wastewater ratio of 0.415. Given the amount of water customers who are on septic and do not contribute to wastewater flows, as well as land uses that have little to no contribution to the system but have a water demand such as parks, this ratio is an agreement with Stantec's experience for similar water systems. The wastewater flows of 14,362 AFY are used as an initial loading in the model and are further refined and adjusted during model calibration.

### 4.3.4 Future Wastewater Projections

Build-out wastewater projections were developed for Year 2060. Wastewater projections were developed from water demand projections and duty factors presented in the UWMP and the 2015 SBMWD Water Master Plan. The process used to develop these projections is shown on Figure 4-8



**Figure 4-7: Future Projection Methodology**

#### 4.3.4.1 Water Demand Projections

Water demand projections were calculated using two different methods which yielded significantly different results. The following subsection discusses the two methods that were used, and captures the decisions made by SBMWD for water demand projections to be used in this Master Plan.

## SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS

### Method 1 – Land-Use based with Water Facilities Master Plan factors

Water demand projections were developed using the latest general plan land use GIS layer obtained from San Bernardino Associated Governments (SANBAG) in conjunction with SBMWD's 2015 WFMP water duty factors. The 2015 WFMP build-out water demand was estimated at 74,056 AFY. Using an updated General Plan land use layer and applying the 2015 WFMP water duty factors, the build-out water demand was estimated at 83,430 AFY. The difference in build-out water demand with this methodology is due to the updated general plan land use layer and associated demand with those land use changes. The calculations used in the 2015 WFMP were not available to review for this analysis, so Stantec is not able to confirm if the method of calculation used for that study differed or if there were any identifiable errors in those calculations. A comparison of the two values are found in Table 4.5.

**Table 4.5: 2015 WFMP Build Out Water Demand Comparison**

| <b><u>2015 WFMP<br/>Build Out Water<br/>Demand</u></b> | <b><u>2017 Build Out<br/>Water Demand<br/>using 2015 WFMP<br/>Duty Factors</u></b> |
|--------------------------------------------------------|------------------------------------------------------------------------------------|
| 74,056 AFY                                             | 83,430 AFY                                                                         |

Based on discussions with SBMWD staff, year 2060 water demand projections were very high compared to current demands and trends. Comparison of SBMWD water billing data shows that the 2015 WFMP projected a significantly higher demand that is likely not reflective of recent conservation measures and other trends. As such, it was decided to reference additional planning documents to establish a 2060 projection more in line with recent data.

### Method 2 – UWMP based Projections

After noting that the future water demand for Method 1 was too high for the future scenario in the model, the 2015 UWMP values were compared against SBMWD billing data. Table 4.6 below shows the 2015 UWMP water demands values are closer to the SBMWD water billing data for both 2014 and 2015.

**Table 4.6: 2015 WFMP Water Demand Comparison**

| <b><u>Year</u></b> | <b><u>SBMWD Water<br/>Billing Data<br/>(AFY)</u></b> | <b><u>2015 WFMP (adj.<br/>SBx, conservation)<br/>(AFY)<sup>1</sup></u></b> | <b><u>2015 UWMP (Less<br/>Sales, Transfers,<br/>and NRW) (AFY)</u></b> |
|--------------------|------------------------------------------------------|----------------------------------------------------------------------------|------------------------------------------------------------------------|
| 2014               | 39,125                                               | 51,000                                                                     | 38,741                                                                 |
| 2015               | 32,529                                               | 52,000                                                                     | 32,241                                                                 |
| 2016               | 33,245                                               | 51,000                                                                     | N/A                                                                    |
| 2017               | 34,583                                               | 49,000                                                                     | N/A                                                                    |

1. These values are approximated from Figure 4-4 from the 2015 WFMP.

After comparing 2015 UWMP and 2015 WFMP data against SBMWD billing data, the future water demands presented in each document were analyzed. The 2015 UWMP projections did not extend to year 2060, therefore the values from 2045 to 2060 were determined by applying a 3.7% growth rate for every 5-year period. The 3.7% growth rate was the average 5-year growth rate for Years 2020 to 2035 in the UWMP. These values are shown in Table 4.7 below.



## SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS

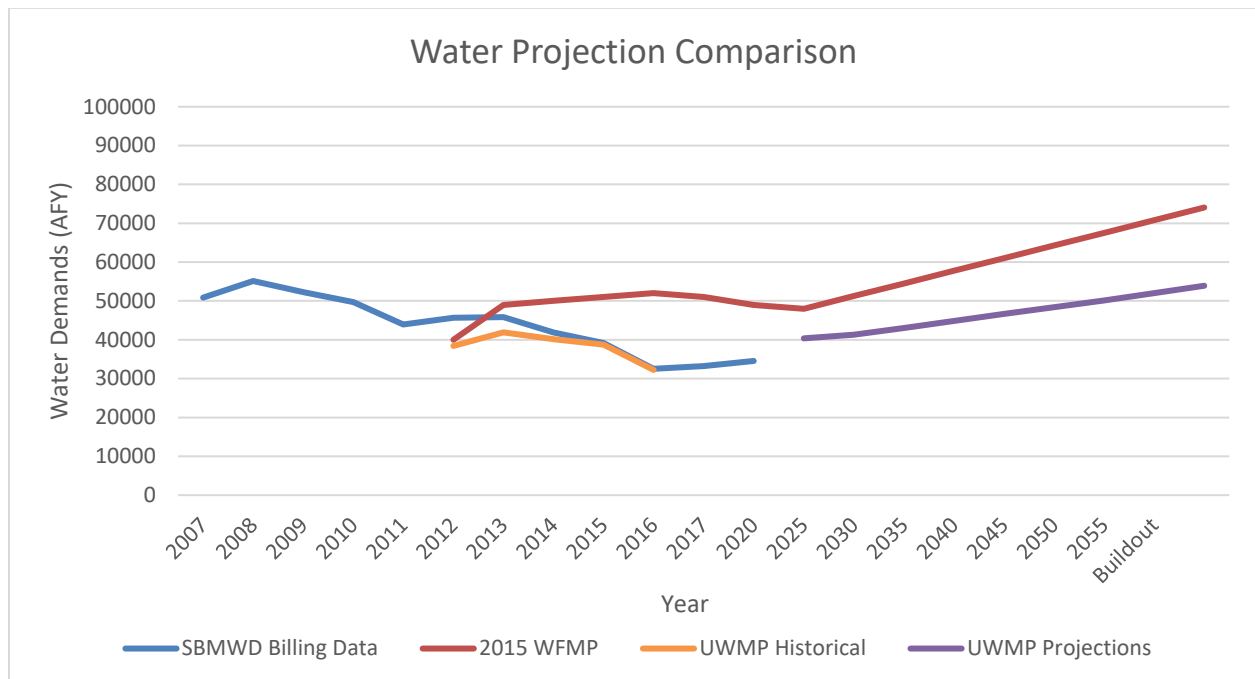
**Table 4.7: 2015 WFMP Build Out Water Demand Comparison**

| <u>Year</u> | <u>2015 WFMP (adj. SBx, conservation) (AFY)<sup>1</sup></u> | <u>2015 UWMP (Less Sales, Transfers, and NRW) (AFY)</u> |
|-------------|-------------------------------------------------------------|---------------------------------------------------------|
| 2020        | 48,000                                                      | 40,369                                                  |
| 2025        | 51,257                                                      | 41,294                                                  |
| 2030        | 54,514                                                      | 43,039                                                  |
| 2035        | 57,771                                                      | 44,823                                                  |
| 2040        | 61,028                                                      | 46,649                                                  |
| 2045        | 64,285                                                      | 48,368 <sup>2</sup>                                     |
| 2050        | 67,542                                                      | 50,149 <sup>2</sup>                                     |
| 2055        | 70,799                                                      | 51,997 <sup>2</sup>                                     |
| 2060        | 74,056                                                      | 53,912 <sup>2</sup>                                     |

1. These values are approximated from Figure 4-4 from the 2015 WFMP.

2. These values are interpolated from the UWMP by extending the average 3.7% growth rate per 5 years.

A graphical comparison of the 2015 WFMP projects, SBMWD billing data, and the UWMP data can be found in Figure 4.8. It should be noted that there is a gap in data between the historical data provided by the 2015 UWMP and the UWMP projections, which begin in Year 2020.



**Figure 4-8 Historical Water Demand 2001-2017**

## **SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS**

After discussion with SBMWD staff, it was determined that the trendline of the UWMP projections are in better agreement with current data as compared to the 2015 WFMP. It was determined that the Year 2060 water demand projection of 53,912 based on the 2015 UWMP growth rates would be used as the future water buildout demand projection.

### **4.3.4.2 Wastewater Demand Projections**

Using the water to wastewater ratios developed in Section 4.3.2.1, the general plan land use, and the Year 2060 water demand projections, the Year 2060 wastewater projections total 37,876 AFY or 33.81 MGD. This value represents the ultimate future build-out for the service area based on the general plan and is a conservative estimate of the ultimate conditions in the sewer collection system. Projections for future flow were made with consideration of projections from the 2015 UWMP.

### **4.3.4.3 Known Developments**

The following subsection is included within the Master Plan to account for specific developments known to the Department and reflected on the will-serve list. It is assumed that these specific plans are included within the general plan land use layer obtained from SANBAG. During demand allocation in the sewer model, Stantec will further check demands at individual model nodes in order to verify that the future demands account for these developments. Table 4.8 indicates whether these plans are specifically called out within the General Plan land use layer or are assumed to be embedded within the projected growth in the area. Where specific plans are not explicitly identified in the general plan land use, information was not available to add the expected sewer demand to the Year 2060 projections. Thus, it is assumed that this growth is accounted for within the collections system service area growth, and demand nodes at these locations are reviewed to verify. Descriptions of the Verdemon Heights development and status of other known developments is discussed below.

Verdemon Heights is a residential community located in the northwestern corner of the City. The Verdemon Heights Area Plan proposes to develop 3,409 acres in four planned tracts in the 2300 Pressure Zone and 2100 Pressure Zone for residential development. Verdemon Heights has a gentle north-south slope at the base of the San Bernardino Mountains and several seasonal creeks that can carry significant volumes of water during rain events and seasonal snow melt conditions. The Verdemon Heights development is proposed to be completed in two phases. Phase I includes the construction of two reservoirs, two booster stations, and 15,000 feet of water and sewer pipeline. Phase II will include the construction of an additional reservoir, booster pump station, and 7,500 feet of additional pipeline.

The status of additional known developments detailed in the SBMWD's 2015 WMP have been updated in Table 4.8 below.

## SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS

**Table 4.8: City of San Bernardino Specific Plans**

| <u>Specific Plan Name</u>                                                   | <u>Project Status</u>                                                                                                                                                                                                             | <u>General Plan Inclusion</u> |
|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Arrowhead Springs Specific Plan                                             | Property has been obtained and plans to develop the site are moving forward.                                                                                                                                                      | Yes                           |
| CALMAT (A.K.A. Cajon Creek Specific Plan)                                   | A significant portion of this area has been developed. Projects include FedEx, North San Bernardino Industrial Park (Phases I and II) and Ridge One B1 and Ridge One B2.                                                          | Yes                           |
| Highland Hills Specific Plan                                                | Status Unknown.                                                                                                                                                                                                                   | No                            |
| Paradise Hills Specific Plan (A.K.A. University Hills)                      | Project has not been built. Although there is a Specific Plan for this project area, it will likely not be developed for at least 10 years.                                                                                       | Yes                           |
| Paseo Las Placitas Specific Plan (A.K.A. Mt. Vernon Corridor Specific Plan) | Project Complete                                                                                                                                                                                                                  | Yes                           |
| San Bernardino International Trade Center Specific Plan                     | Some development has occurred including Stater Brothers and Amazon facilities, among others. IVDA General Aviation project is currently complete. An additional 680,000 square foot warehouse project is currently in plan check. | No                            |
| University District Specific Plan                                           | University District covers a large area of about 6,300 acres. Most of this area has been developed.                                                                                                                               | Yes                           |
| University Business Park Specific Plan                                      | This area is now complete, and the last phase of residential housing is currently in construction.                                                                                                                                | Yes                           |

## **SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS**

### **4.3.4.4 Septic Conversion**

This section incorporates information obtained from the LAFCO Countywide Service Review for Wastewater.

Several customers within the City of San Bernardino's sphere of influence and SBMWD's sewer collection service area are lacking sewer connections and may contribute flows to septic systems. These areas are referred to as an unincorporated area. Sphere of influence is defined as a plan for the probable physical boundaries and service area of a local agency, as determined by the LAFCO per Government Code Section 56076.

The LAFCO Countywide Service Review for Wastewater analyzed areas within San Bernardino County that are considered disadvantaged unincorporated communities (DUC). DUC are categorized as a disadvantaged community (defined by State of California Proposition 50 §79505.5(a)), an inhabited area comprising no less than 10 dwellings in close proximity to one another and within a collection agency's sphere of influence.

LAFCO identified unincorporated homes, portions of which are classified as DUC, within City of San Bernardino's sphere of influence. Many homes within the unincorporated area are served by septic systems, some septic systems are close to water wells and/or impaired water body, and some homes are adjacent to existing sewer lines. The LAFCO Countywide Service Review for Wastewater recommended the following for the City of San Bernardino's DUC:

- Request additional out-of-agency service agreements with landowners served by septic systems and therefore reduce human created nitrates entering the groundwater.
- City outreach program to inform landowners with properties adjacent to sewer lines that connection to a municipal collection system is feasible.

For this Master Plan, septic customers were identified through review of the SBMWD billing data, and identification of water customers who did not have a current wastewater account. Water demands for these customers were removed prior to assigning existing wastewater demand so as to not influence the overall water to wastewater ratios. However, for the future 2060 planning scenario, it is assumed all septic customers will have been converted to sewer, and the water to wastewater ratios are applied to all future water customers.



## **SECTION 4.0 – WATER DEMANDS AND WASTEWATER CHARACTERISTICS**

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SECTION 5

Model Build



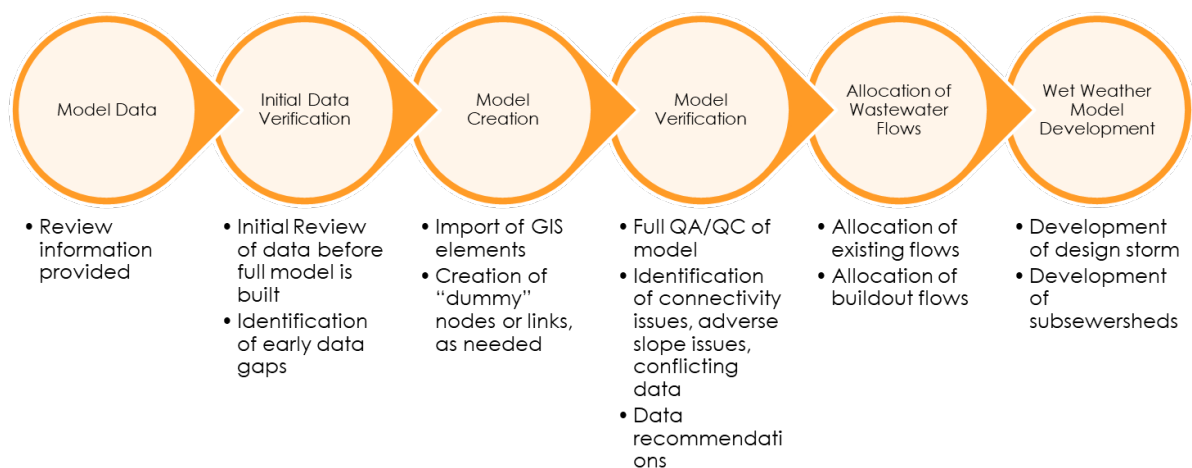




## 5.0 COMPUTER MODEL DEVELOPMENT

This section describes the creation of SBMWD's sewer system hydraulic model. The process of building the model included data collection, model element construction, allocation of existing and buildout wastewater flows, and wet weather model development. Once the model is built, initial model results are then calibrated against real world data; this process is discussed in Section 6.

Figure 5-1 shows an overview of the model development. The model development begins with review of data collection and initial data verification. The model is subsequently created and then verified to identify any connectivity issues, adverse slope issues, or conflicting data. After verifying the model, wastewater flows are then allocated for each scenario (existing and build out). Finally, the model is further prepared for wet weather analysis. Each of these steps will be discussed in the section.



**Figure 5-1 Overview of Model Development Process**

### 5.1 MODEL DATA

A key element in creation of a hydraulic model is the collection and application of system data to define the elements and parameters of the model. This section describes the data used for the model, the extent of the data used, and the software selected to model the SBMWD system. While Section 1.3 details the data collection task for the full SMP project, Table 5-1 details the data used specifically to build the model and how it was employed in the model development process. Other data sources were referenced throughout the process, but Table 5-1 summarizes the main sources of data used.



**Table 5-1 Data and Use in Model Development**

| <b>Data Description</b>                     | <b>Use in Model Development</b>                                                                                                                                                                                                                                                                                          |
|---------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Shapefile of sewer mains                    | Shapefile of sewer mains was used as the basis of the pipes in the sewer model. Attributes from this shapefile used include diameter, material, upstream maintenance hole ID, downstream maintenance hole ID, Pipe ID, Main Type (gravity or force main), Siphon (True/False), Pipe Length, Owner (SBMWD/Private/Others) |
| Shapefile of sewer maintenance holes        | Shapefile of sewer maintenance holes was used as the basis of the nodes in the sewer model. Attributes from this shapefile used include sewer maintenance hole ID ('SMH'), maintenance hole depth, and rim elevation.                                                                                                    |
| Shapefile of clean outs                     | Shapefile of cleanouts was added to the nodes in the sewer model; Attributes from this shapefile used include Cleanout ID, invert elevation, and rim elevation.                                                                                                                                                          |
| Shapefile of lift stations                  | Shapefile of lift stations was used to identify the location and name of each lift station. Each lift station was included in the hydraulic model and modeled as an ideal lift station.                                                                                                                                  |
| LiDAR data                                  | LiDAR data was used to verify rim elevations from the sewer maintenance hole layer. Where rim elevations were absent, LiDAR data was used to interpolate missing rim elevation.                                                                                                                                          |
| Sewer atlas maps                            | Sewer atlas maps were used as reference where connectivity was broken or incomplete, or data conflicted.                                                                                                                                                                                                                 |
| Historical billing data                     | Historical water billing data was used to determine if customers were existing sewer customers or septic customers.                                                                                                                                                                                                      |
| Shapefile of water meters                   | Shapefile for water meters was used to allocate wastewater flows into the hydraulic model. This is discussed further in Section 5.5.                                                                                                                                                                                     |
| SCADA data                                  | SCADA data from WRP lift stations was used for model calibration purposes                                                                                                                                                                                                                                                |
| Lift station as-builts                      | As-builts were used to assist in modeling the lift stations.                                                                                                                                                                                                                                                             |
| Shapefiles for future proposed developments | Shapefiles for proposed developments were used to assist in allocation for future build out demands.                                                                                                                                                                                                                     |
| Results of TKE maintenance hole survey      | Results of the TKE maintenance hole survey were incorporated into the GIS to resolve rim elevation discrepancies. The purpose of this survey and its incorporation into the model is discussed further in Section 5.2                                                                                                    |

### 5.1.1 Data Extent

The hydraulic model built for this SMP was an all pipes model. This means that all pipes and maintenance holes in the provided GIS data were included in the model with limited exceptions. Any pipes or maintenance holes that were designated as having a private owner in the GIS metadata were not included in the model unless their removal would

## SECTION 5.0 – COMPUTER MODEL DEVELOPMENT

cause a connectivity issue within the system. Additionally, cleanouts that were at the end of a line were not included in the model, though cleanouts that were necessary to connect pipe segments remained. Since some cleanout and maintenance holes have the same IDs, the inclusion of cleanouts can cause errant pipe creation within the model. Therefore, cleanouts were included or removed from the model where necessary.

It is noted that in some instances, records of the SBMWD system were in disagreement with each other. For example, there were pipes displayed in atlas maps and reference documents that were not present in the GIS database. Based upon discussion with SBMWD and their recent update of their GIS database prior to and at the beginning of this SMP project, GIS was considered the primary data source for building the model. Discrepancies between data sources were reported to and discussed with SBMWD staff.

### 5.1.2 Software Selection

InfoSWMM software was selected by SBMWD to model their sewer system. InfoSWMM is a fully dynamic geospatial wastewater modeling and management software application. The application is fully ArcGIS integrated, which allows for a modeling system that can be operated within the ArcGIS environment and access to all of the advanced ArcGIS functions. During model build, Stantec employed a data flagging tool, which easily identifies modifications to any parameter (i.e. diameter, invert elevation, upstream/downstream maintenance hole ID). This data flagging tool is particularly useful for identifying assumptions made during model build during later updates. The data flagging tool allowed for as needed assumptions during the model build and verification task (discussed further in Section 5.4), which were then sent to SBMWD for review and comment. By providing the flagged shapefile of pipes and nodes to SBMWD, additional investigation can more easily be coordinated on the assumed attributes in question.

## 5.2 INITIAL DATA VERIFICATION

At the beginning of the model build process, data is reviewed to identify any discrepancies or significant data gaps that may affect model development. After first review of the data provided by SBMWD, discrepancies between rim elevations of maintenance holes in GIS and ground elevations from LiDAR data at the same location were noted. When not directly available in the GIS, invert elevations are calculated by subtracting maintenance hole depth from the rim elevation. Therefore, significant discrepancies in ground and rim elevations in LiDAR data and the GIS could result in variations in invert elevations which translate to significant differences in pipe slopes. Because of the gravity flow in a sewer, accurate invert elevations are one of the primary factors affecting how sewage flows through the collection system. Review of the data did not indicate if one of the sources was more reliable than the other.

Based on the severity of the discrepancies and to provide more information for the model build, SBMWD authorized Stantec to contract TKE Engineering to complete a system wide maintenance hole survey at 889 locations to represent a sample of the system. The GIS and LiDAR discrepancies initially identified are summarized in Table 5-2.

**Table 5-2 Summary LiDAR versus GIS Discrepancies**

| LiDAR vs GIS Data Difference | Frequency   |
|------------------------------|-------------|
| 0-1 ft                       | 825         |
| 1-5 ft                       | 7181        |
| 5-10 ft                      | 236         |
| Greater than 10 ft           | 131         |
| <b>Total</b>                 | <b>8373</b> |

After identification of the LiDAR and GIS discrepancies, a prioritized list of maintenance holes were provided to SBMWD. The following methodology was used to identify which maintenance holes to survey:

- Priority Level 1 (Highest Priority) - Maintenance holes where: 1) Invert elevation is missing and LiDAR difference is greater than five feet, or 2) Maintenance hole invert elevation is missing and cannot be interpolated, or 3) LiDAR difference is greater than five feet.
- Priority Level 2 – Maintenance hole invert elevation is missing but can be interpolated
- Priority Level 3 – Clean out invert elevation was missing or clean out rim elevation differed from LiDAR by more than five feet.

The highest priority was given to maintenance hole inverts elevations that were missing, as an assumption for this missing parameter would be based on maintenance hole depth and rim elevation. Higher priority was given to maintenance holes where the invert could not be interpolated from nearby maintenance holes. This occurred if there were missing inverts on multiple, contiguous pipe segments. Lower priority was given to maintenance holes where the invert could be interpolated by neighboring maintenance holes. The lowest priority was for data discrepancies at clean outs. While many cleanouts are included in the hydraulic model as nodes, no demand would be assigned to them, thus making them of less significance than the maintenance holes.

An initial list of 579 maintenance holes was provided to SBMWD based on the criteria listed above. Upon review of the discrepancies, SBMWD elected to widen the survey to 889 maintenance holes. Selected data from the TKE survey was incorporated into an updated version of the GIS by SBMWD and provided for the model build. Some data collected was used as reference during model build based on significant differences with neighboring maintenance holes that had not been surveyed. The updated version of the GIS provided in May 2019 forms the basis of the final hydraulic model.

### 5.3 MODEL CREATION

The easy identification of model elements is important as it provides for better understanding and use of the model. A unique identifier is required for each element. In order to maintain connectivity between the SBMWD GIS database and the model, identification for the maintenance holes is based on maintenance hole “SMH” attribute field. Identification for the pipes in the model is based on the sewer main shapefile’s “PIPEID” attribute field which is the concatenation of the upstream and downstream maintenance hole for the pipe segment. For example, if the upstream maintenance hole ID for a pipe is ‘0390052’ and the downstream maintenance hole ID is ‘0390051’, the Pipe ID

## SECTION 5.0 – COMPUTER MODEL DEVELOPMENT

would be '03900520390051'. In the model, pipes are represented as links and maintenance holes are represented as nodes. Not every node in the model will represent a maintenance hole. "Dummy" nodes were added at times to fix connectivity issues or help with modeling system components (e.g. lift stations). New nodes in the model that are not associated to SBMWD maintenance holes are labeled under the format STN\_XXX. Many siphons in the collection system have two barrels with the same upstream and downstream maintenance hole; in these instances, a suffix ("\_A" and "\_B") were added to siphon IDs to distinguish between barrels.

All lift stations were included within the model, however most of the pump curves were not available for inclusion in the model. In the absence of data, an ideal pump curve was used which assumes all inflow equals outflow. Pump capacities were incorporated by setting flow limitations equivalent to pump capacity on the downstream pipe exiting the lift station. Thus, if the lift station was showing higher capacity than the actual total pump capacity, it could be identified.

Force mains identified in the GIS (per the Main Type attribute field) were included as pressurized pipes within the model. The three influent lines into the SBMWD Arrowhead Lift Station were simulated using outfalls. The WRP Drain line was also included in the model, simulated as an outfall.

Total flow balance was confirmed and flow comparisons between Arrowhead Lift Station data and model data were completed during the calibration process.

## 5.4 MODEL VERIFICATION

As part of the model development process, Stantec conducted a review of the sewer attribute data imported into the model and identified various data inconsistencies. These include conflicting data between sources and different GIS layers, missing data, and missing model elements causing network connectivity issues (i.e. orphaned pipe networks that do not appear to connect to an eventual outfall). Data inconsistencies were discussed with SBMWD for further investigation. Where additional data was not available, Stantec proceeded with the model build using engineering assumptions and direction from SBMWD staff. It is recommended that SBMWD continue to update their database through field investigation and survey to further validate the model during future updates. This section discusses issues encountered during the verification process.

### 5.4.1 Verification Results

Once all GIS data was input into the model, a thorough quality assurance and quality control (QA/QC) of the entire system was conducted. To execute this QA/QC process, tools within the modeling software and manual data checks using spreadsheets were employed to ensure accuracy in the model creation. The following QA/QC checks were performed as part of the model build:

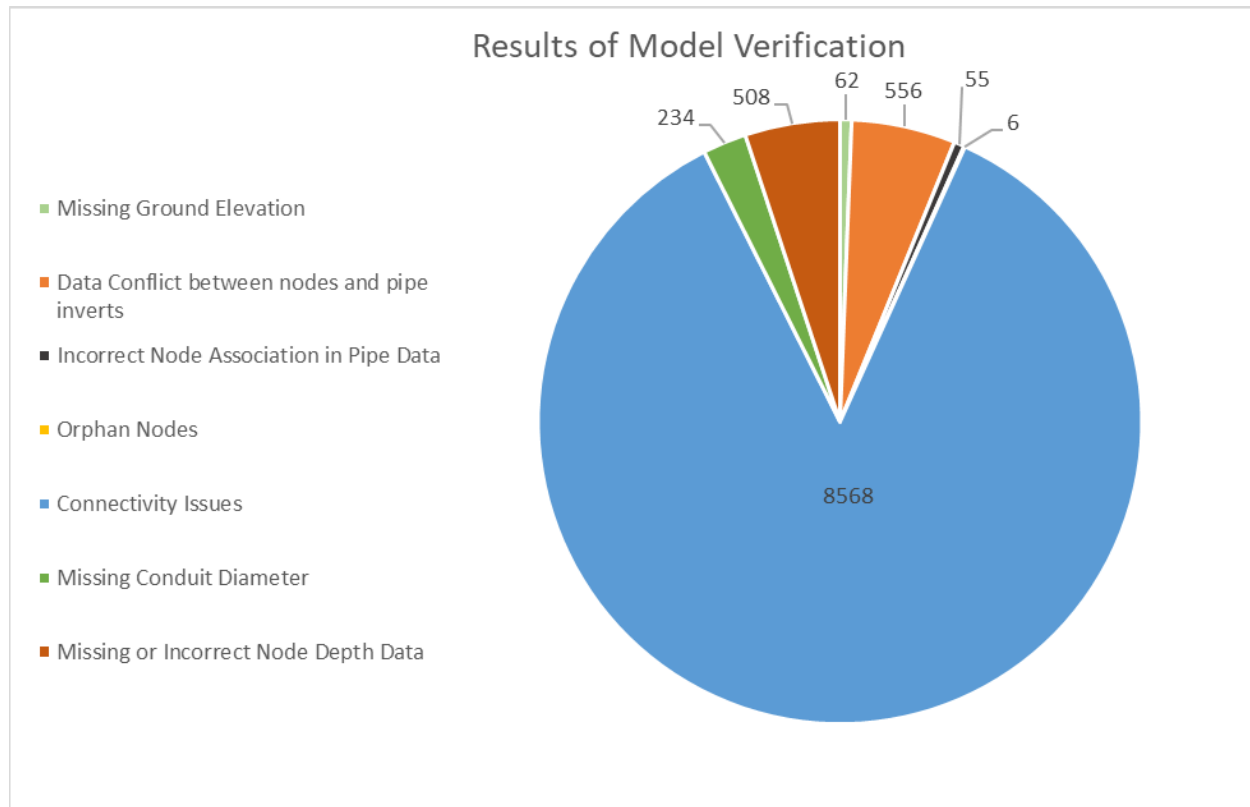
- Review of pipes not connected to a maintenance hole
- Review of abandoned and orphaned maintenance holes
- Verification of maintenance hole rim elevations
- Review of missing or errant pipe diameters



## SECTION 5.0 – COMPUTER MODEL DEVELOPMENT

- Review of hydraulic profiles to verify connectivity and downhill slope

The QA/QC process resulted in identification of several connectivity issues, along with conflicting data between nodes and pipes. The results of the QA/QC review, by type of issue and number of occurrences, is presented in Figure 5-2



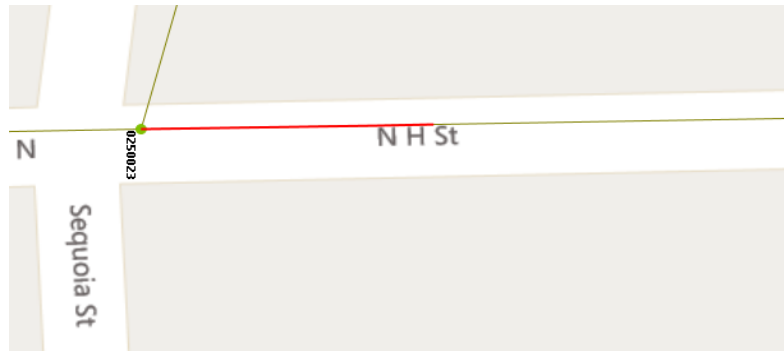
**Figure 5-2 Results of Model Verification**

The following subsections present examples of each issue and note the preferred solution methodology. It is noted that these assumptions add uncertainty to the final model and should be investigated for future model updates. Any deviations from SBMWD's original GIS was flagged using ICM's flagging tool which will aid in identifying any assumptions made during future updates.

### 5.4.1.1 Connectivity Issues

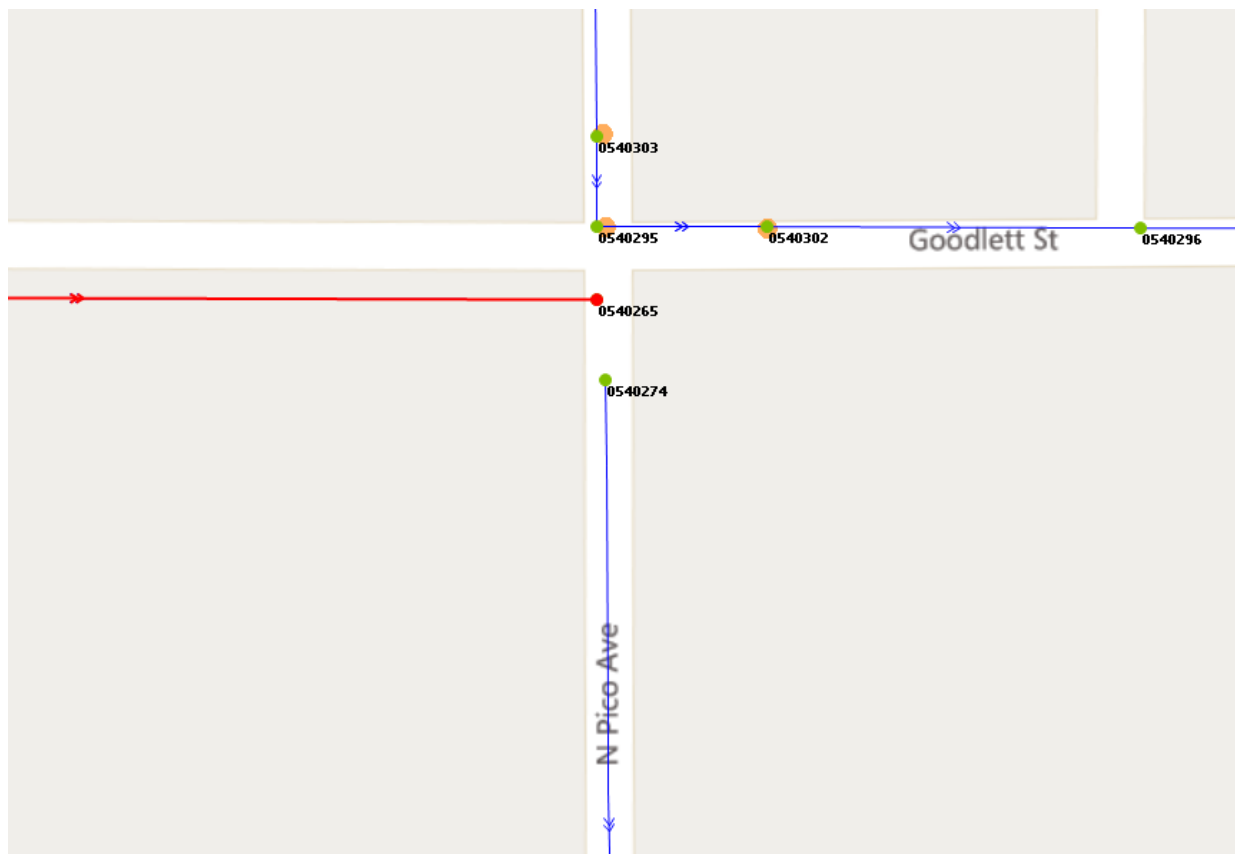
Connectivity issues made up the majority of the identified issues during model verification. Connectivity issues were often solved on a case-by-case basis. Figure 5-3 and Figure 5-4 show two different types of connectivity issues. Figure 5-3 shows a pipe-to-pipe connection; the model requires all pipes to be connected through nodes. As a result, a dummy maintenance hole was added to fix this connectivity issue.

## SECTION 5.0 – COMPUTER MODEL DEVELOPMENT



**Figure 5-3 Pipe-to-Pipe Connectivity Issue**

Figure 5-4 shows the pipe flowing east and coming to a dead end. This creates a subnetwork that is unconnected to the main network, and thus not connected to an outfall. In total, there were 36 subnetworks identified. The orange circles in Figure 5-4 represent TKE survey data points. Results of the TKE survey were used to help resolve potential connectivity issues where available. These issues were resolved manually for each subnetwork. All subnetworks were connected through this process and all flow in the model flow to the system outfalls.



**Figure 5-4 Missing Pipe Connectivity Issue**

### 5.4.1.2 Incorrect Node Association within Pipe Data

Incorrect node association within the pipe attributes can also result in connectivity issues. Figure 5-5 shows an example of incorrect node association. The pipe called out has the downstream node identified within the pipe data as SMH 0730100, however from the network it shows that the downstream node should actually be SMH 0730099. Incorrect node association can also cause connectivity issues when the modeling software assigns connections automatically. These errors are resolved through manual review and reconnecting elements on a case-by-case basis.

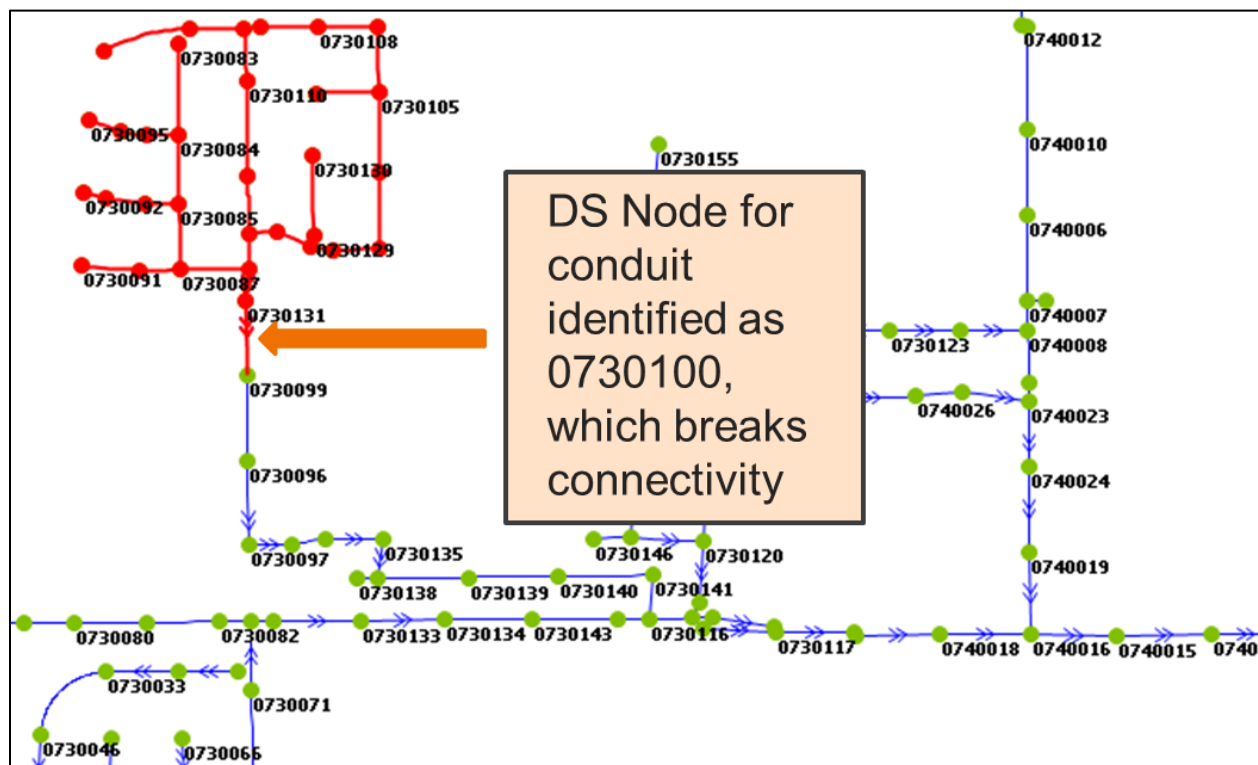


Figure 5-5 Incorrect Node Association within Pipe data

5.4.1.3 Data Conflict between Maintenance Holes and Pipe Inverts

The next most prevalent data conflict was data conflicts between the maintenance hole and pipe invert layer. Figure 5-6 shows an example of two locations where the maintenance hole invert and the pipe invert do not align. These instances were resolved according to whether maintenance hole or pipe data were more consistent with neighboring infrastructure (i.e. maintain a constant slope or downhill flow trajectory).

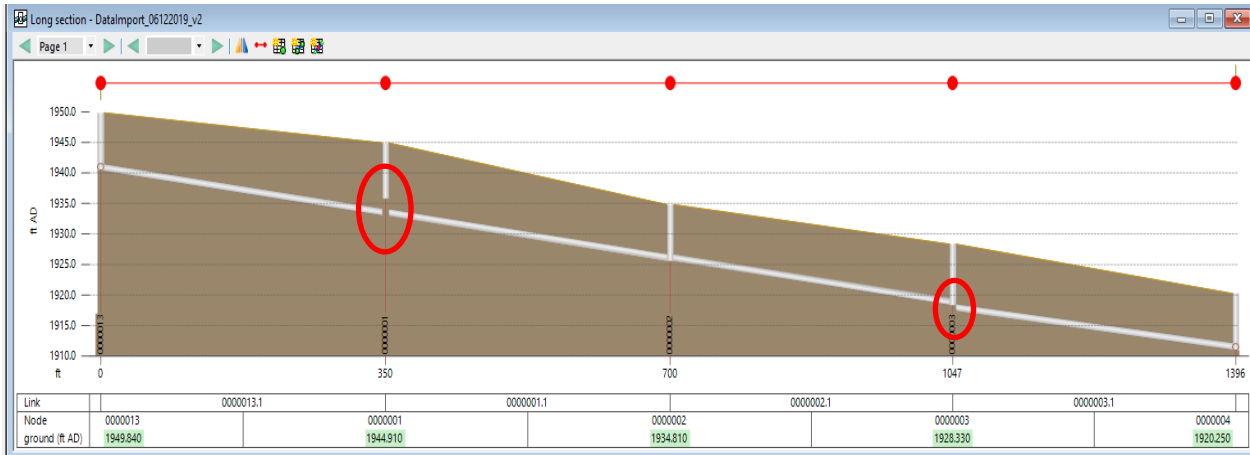


Figure 5-6 Data Conflict between Maintenance Holes and Pipe Inverts

5.4.1.4 Missing or Incorrect Node Depth Data

The third most prevalent type of data issue is incorrect node, or maintenance hole, depth data. Figure 5-7 shows an example of incorrect node depth data, as the maintenance hole depth is within inches of the ground elevation. Missing or incorrect node depth data was often interpolated based on pipe slope of neighboring lines. Upstream or downstream pipe slopes were extended to adjacent pipes in order to correct the depth.

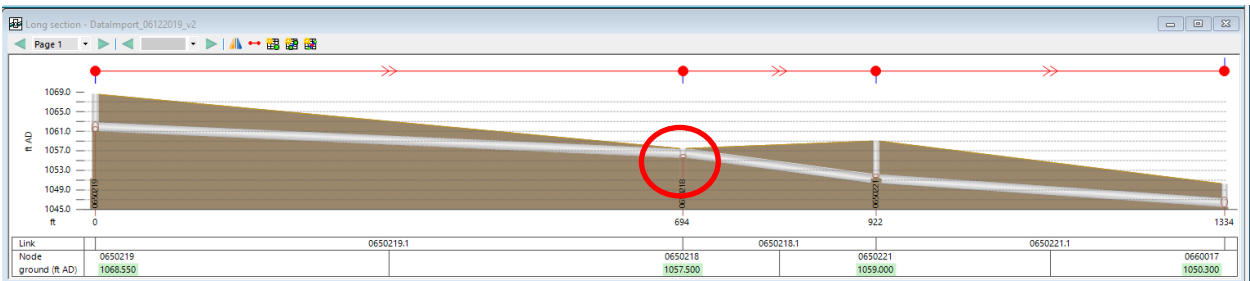


Figure 5-7 Missing or Incorrect Node Depth Data



5.4.1.5 Missing Ground Elevation

As indicated in Table 5-1, LiDAR data was used to interpolate ground elevation when it was absent. Figure 5-8 shows an example of a node with missing ground elevation. The maintenance hole locations were overlaid onto the LiDAR data to obtain the ground or rim elevation. The rim elevation was cross-checked with surrounding ground elevation per GIS and Google Earth to confirm relative accuracy.

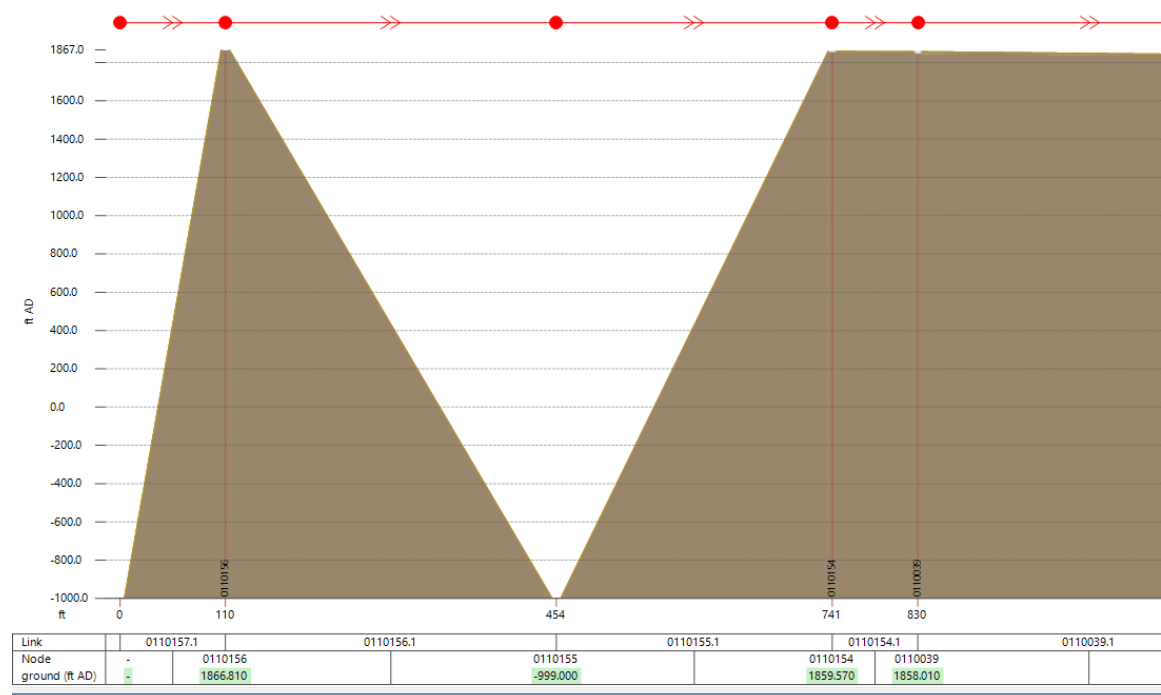


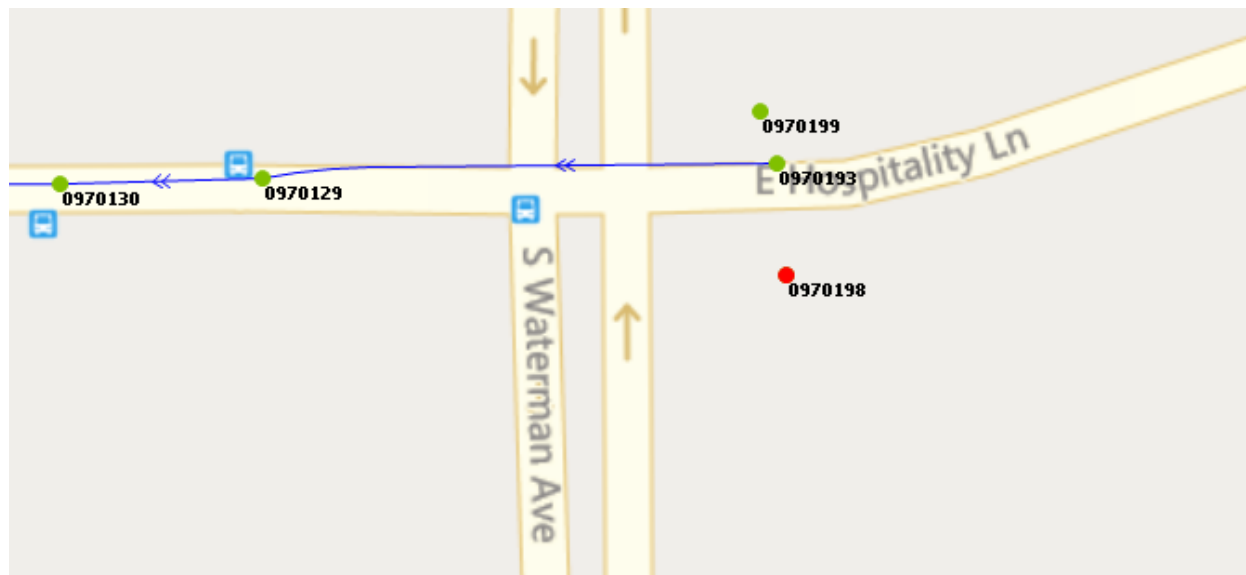
Figure 5-8 Missing Ground Elevation

5.4.1.6 Missing Pipe Diameter

Pipe diameters missing from the GIS were assumed based on upstream and downstream pipe diameters. Of the 234 missing pipe diameters, many of the missing diameters were for privately owned pipes. Upon removing the privately-owned pipes in the model, as noted in Section 5.1, approximately 17 diameters were missing. These were corrected on a case by case basis.

### 5.4.1.7 Orphan Nodes

Orphan nodes were examined to determine if connectivity should be modified. Figure 5-9 shows an example of two orphan nodes identified during model verification. Many of the orphan nodes were cleanouts; any cleanouts not connected to pipes were removed from the model.



**Figure 5-9 Orphan Nodes**

Stantec reviewed the results of the verification process and implemented solutions as noted. A copy of the flagged GIS data after assumptions were made was provided to SBMWD to help with identification and investigation of these issues for future model updates.

### 5.4.2 Adverse Slopes

Hydraulic profile checks were conducted to verify any uphill or adverse slopes found within the system. Stantec found uphill or adverse slopes within the system, typically as a result of two different sources:

- 1) Adverse slopes within the original GIS, or
- 2) Adverse slopes caused by incorporation of the TKE survey data. The results of the TKE survey showed that stretches of pipe may have a different depth than shown in the GIS. As the TKE survey was intended to investigate issues between GIS rim elevations and LiDAR, multiple maintenance holes were often surveyed in any given area. At times, these individual maintenance hole surveys showed invert elevations that varied significantly from the data in the GIS. If survey data was used, it would result in additional adverse sloping pipes being introduced into the model.

After discussion with SBMWD, it was confirmed that there are adverse sloping pipes within the system. However, there was often not sufficient information available to determine which pipes have genuine adverse slopes and which were a result of data error. Adjustments to the model were made where TKE survey data was available or when

## SECTION 5.0 – COMPUTER MODEL DEVELOPMENT

slopes seemed unlikely, based on engineering judgement. However, it is suggested that pipes with adverse slopes in the GIS be field investigated for future updates.

### 5.4.3 Data Recommendations

Based on the model development phase of this project, the following is recommended to improve the data for future model updates:

- Further investigate issues flagged within GIS, either through record research or field investigation
- Confirm pipes that have adverse slope in the GIS database
- Modify duplicate pipe IDs or maintenance hole and cleanout IDs in the GIS database
- Collect pump curves data for system lift stations
- Continue field survey of maintenance holes
- Field verify assumed connections within the model

## 5.5 ALLOCATION OF WASTEWATER FLOWS

There are two demand scenarios within the hydraulic model, existing and build out. Section 4 outlines how the existing and buildout wastewater flows are calculated. Existing wastewater flows were developed from the water consumption data and water-to-wastewater ratios developed from Phase 2 of the flow monitoring program conducted by V&A. Build out demands were developed using the UWMP, water-to-wastewater ratios, and specific future developments. This subsection describes the methodology for assigning both existing and build out demands in the model. Section 6 will describe the calibration process of the model, where the model checked against observed flows from the flow monitoring study.

### 5.5.1 Allocation of Existing Wastewater Flows

Existing wastewater flows were allocated using geocoded water meter data. Metered water customers that were charged for sewer in March and/or April 2018 were considered active sewer customers. If water charges were present for March/April, but no sewer charges were incurred, it was assumed these customers were using septic systems and do not contribute wastewater flows to the collection system. Metered customers were then aggregated based on nearest maintenance hole node. The water demand associated with that meter was adjusted based on the results of the flow monitoring data to yield a wastewater demand, as detailed in Section 4. Demands from septic customers were removed from the existing scenario to reflect the current demand seen in the collection system.

#### 5.5.1.1 Allocation of Outside Agency Flow

There are three outside agencies whose sewer flows contribute to SBMWD's sewer collection system, but their water is not provided by SBMWD. These agencies are East Valley Water District, Loma Linda, and Muscoy Mutual. These outside agency flows were added to the model using specific point loads. Loma Linda flows were aggregated and assigned to the respective north and south Loma Linda meter locations. East Valley sewer flows were distributed

## SECTION 5.0 – COMPUTER MODEL DEVELOPMENT

amongst 14 different nodes, consistent with East Valley's recent sewer model. The quantity of flow sent to SBMWD from EVWD is based on a March and April average MGD per EVWD data. Muscoy Mutual sewer flows were assigned to one maintenance hole based on estimates from the flow monitoring data. Figure 5-10 shows the location of these outside agencies with respect to SBMWD's water service boundary. Figure 5-10 also shows the sewer demand attributed to each outside agency for the existing and build out scenarios.

### 5.5.2 Allocation of Build out Wastewater Flows

Per Section 4, buildout demands are comprised of the following:

- Existing sewer customers, with demands scaled to buildout values
- Septic customers
- Outside agency flows
- Specific development demands

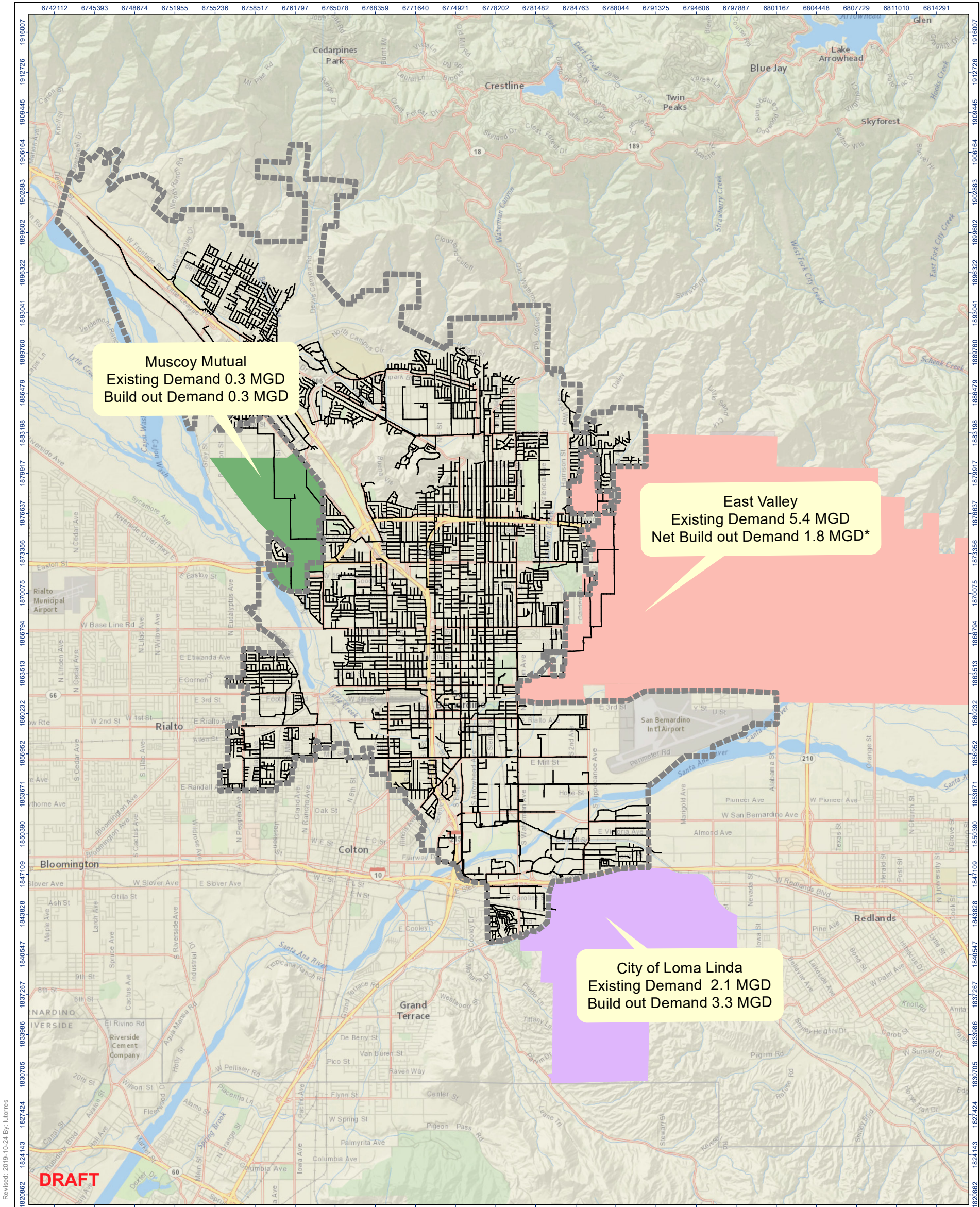
The maintenance holes that were used to assign flow for existing customers and outside agencies did not change in the buildout scenario. Demands from septic customers were assigned to the nearest maintenance hole, using the same process as the existing customers. Demands from known specific developments, as noted in Section 4, were assigned to the nearest existing maintenance hole. It is understood that infrastructure would likely be extended to these future developments but assigning demands to the nearest downstream maintenance hole will show the effects on the existing system due to these additional developments.



## SECTION 5.0 – COMPUTER MODEL DEVELOPMENT

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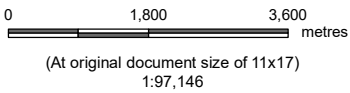
Revised: 2019-10-24 By: ltorres  
\\us0385-pdfs01\shared\_projects\22450116514 Electronic Media\Report Figures\Section 5\ChWtrDept\_Map.mxd

## Legend

-  SBMWD Water Service Boundary
- Areas Outside Agency**
-  East Valley Water District
-  City of Loma Linda
-  Muscoy Mutual
-  Sewer Pipes

\* Net demand use equal to total East Valley demand minus 10 MGD due to Sterling Natural Resource Center

**Notes**  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.



**Project Location** San Bernardino County  
California  
**Client/Project** Prepared by LTorres on 2019-10-24  
Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.

**5-10**

Title

**Build out and Existing Demands for  
Areas Outside of SBMWD Service  
Area**

**DRAFT**

Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.





## 5.6 WET WEATHER MODEL DEVELOPMENT

Additional modifications to the model were needed to simulate wet weather flows and evaluate its effect on the collection system. This section describes the approach used to evaluate wet weather response in the system, development of the design storm, and subcatchment creation.

### 5.6.1 RTK Method

An empirical approach was used for characterization of the wet weather response in the collection system. This approach is based on I/I assessment methodology recommended by U.S. EPA and the Water Environment Research Foundation (WERF) and supports capacity assessment, condition assessment prioritization, and solution development.

The hallmark of this approach is using flow monitoring data directly to determine what percentage of rainfall (R-value) enters into the sanitary sewer system in the form of fast (inflow), medium (private property inflow), and slow (infiltration) responses. This simple method was used such that the wet-weather response can be scaled with various design storms, regardless of what storm frequency occurred during the flow monitoring period.

EPA Sanitary Sewer Overflow Analysis and Planning (SSOAP) Toolbox was used to determine the R-value. Figure 5-11 illustrates how wet-weather responses were calculated using the three-unit hydrographs in this toolbox.

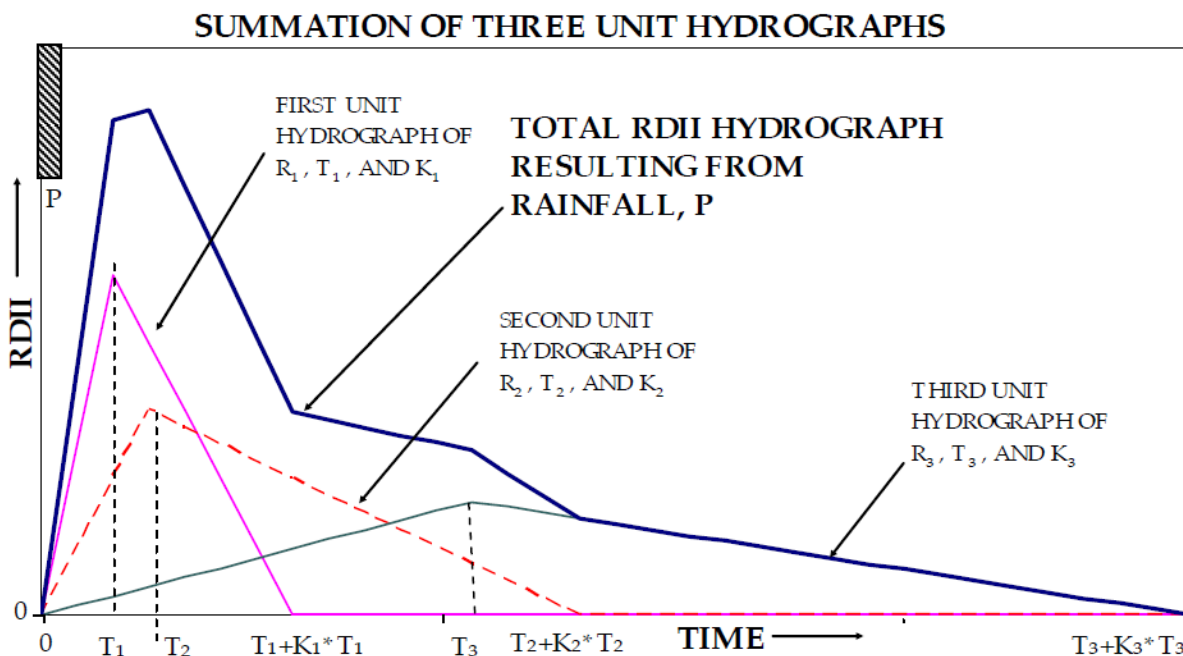


Figure 5-11 Wet Weather Response Unit Hydrographs



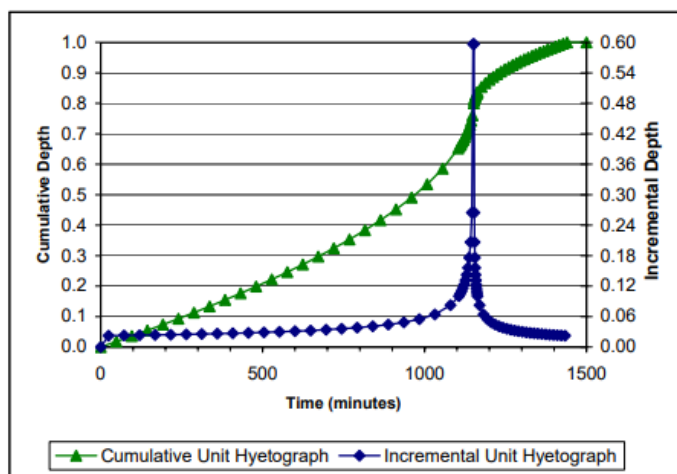
## SECTION 5.0 – COMPUTER MODEL DEVELOPMENT

Using the SSOAP Toolbox, Stantec estimates that approximately 0.5% of rainfall volume enters into the sewer system. Almost all of the rainfall volumes entering into the sewer system can be classified as fast response (inflow / first unit hydrograph). There is no evidence any significant rainfall derived infiltration occurring within the sewer system during the flow monitoring period.

### 5.6.2 Development of Design Storm

The design storm was developed by combining the unit hyetograph created from the LA County Department of Public Works Hydrology Manual and NOAA's Precipitation-Frequency Atlas 14 data for San Bernardino. The time distribution for 2-year, 10-year, and 25-year storm was developed as follows:

- The LA County's 24-hour cumulative unit hyetograph (Figure 5-12) was converted into a 15-minute interval hyetograph by interpolating the incremental rain values.



**Figure 5-12 Cumulative Unit Hyetograph per LA County DPW Hydrology Manual**

- The precipitation frequency estimates for 2-year, 5-year, and 10-year storms with duration of 24 hours were obtained from NOAA's Precipitation-Frequency Atlas 14. The values for each storm are circled in Figure 5-13.

## SECTION 5.0 – COMPUTER MODEL DEVELOPMENT

| PDS-based precipitation frequency estimates with 90% confidence intervals (in inches) <sup>1</sup> |                                     |                        |                        |                        |                        |                        |                        |                        |                        |                        |
|----------------------------------------------------------------------------------------------------|-------------------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| Duration                                                                                           | Average recurrence interval (years) |                        |                        |                        |                        |                        |                        |                        |                        |                        |
|                                                                                                    | 1                                   | 2                      | 5                      | 10                     | 25                     | 50                     | 100                    | 200                    | 500                    | 1000                   |
| 5-min                                                                                              | 0.102<br>(0.085-0.124)              | 0.138<br>(0.115-0.168) | 0.184<br>(0.152-0.224) | 0.220<br>(0.181-0.271) | 0.270<br>(0.214-0.343) | 0.307<br>(0.238-0.399) | 0.344<br>(0.261-0.458) | 0.382<br>(0.281-0.524) | 0.432<br>(0.305-0.619) | 0.471<br>(0.321-0.698) |
| 10-min                                                                                             | 0.147<br>(0.122-0.178)              | 0.198<br>(0.164-0.240) | 0.263<br>(0.218-0.321) | 0.316<br>(0.260-0.388) | 0.386<br>(0.307-0.491) | 0.440<br>(0.342-0.571) | 0.493<br>(0.374-0.657) | 0.547<br>(0.403-0.751) | 0.620<br>(0.437-0.887) | 0.675<br>(0.460-1.00)  |
| 15-min                                                                                             | 0.177<br>(0.147-0.215)              | 0.239<br>(0.199-0.290) | 0.318<br>(0.264-0.388) | 0.382<br>(0.314-0.470) | 0.467<br>(0.371-0.594) | 0.532<br>(0.413-0.691) | 0.596<br>(0.452-0.795) | 0.662<br>(0.488-0.908) | 0.750<br>(0.529-1.07)  | 0.817<br>(0.556-1.21)  |
| 30-min                                                                                             | 0.265<br>(0.221-0.322)              | 0.357<br>(0.297-0.434) | 0.476<br>(0.395-0.580) | 0.571<br>(0.470-0.702) | 0.699<br>(0.555-0.889) | 0.795<br>(0.618-1.03)  | 0.892<br>(0.676-1.19)  | 0.990<br>(0.729-1.36)  | 1.12<br>(0.791-1.61)   | 1.22<br>(0.832-1.81)   |
| 60-min                                                                                             | 0.389<br>(0.324-0.472)              | 0.525<br>(0.436-0.638) | 0.699<br>(0.579-0.852) | 0.839<br>(0.689-1.03)  | 1.03<br>(0.815-1.31)   | 1.17<br>(0.907-1.52)   | 1.31<br>(0.992-1.75)   | 1.45<br>(1.07-1.99)    | 1.65<br>(1.16-2.36)    | 1.79<br>(1.22-2.66)    |
| 2-hr                                                                                               | 0.557<br>(0.463-0.676)              | 0.730<br>(0.606-0.887) | 0.953<br>(0.790-1.16)  | 1.13<br>(0.931-1.39)   | 1.38<br>(1.09-1.75)    | 1.56<br>(1.21-2.03)    | 1.74<br>(1.32-2.32)    | 1.93<br>(1.42-2.65)    | 2.18<br>(1.54-3.12)    | 2.38<br>(1.62-3.52)    |
| 3-hr                                                                                               | 0.682<br>(0.567-0.827)              | 0.884<br>(0.734-1.07)  | 1.15<br>(0.949-1.40)   | 1.36<br>(1.12-1.67)    | 1.64<br>(1.30-2.09)    | 1.86<br>(1.45-2.42)    | 2.08<br>(1.57-2.77)    | 2.30<br>(1.69-3.16)    | 2.60<br>(1.84-3.72)    | 2.83<br>(1.93-4.19)    |
| 6-hr                                                                                               | 0.943<br>(0.785-1.15)               | 1.21<br>(1.01-1.47)    | 1.56<br>(1.29-1.90)    | 1.84<br>(1.51-2.26)    | 2.22<br>(1.77-2.83)    | 2.52<br>(1.96-3.27)    | 2.81<br>(2.13-3.75)    | 3.12<br>(2.30-4.28)    | 3.53<br>(2.49-5.05)    | 3.85<br>(2.62-5.70)    |
| 12-hr                                                                                              | 1.25<br>(1.04-1.51)                 | 1.60<br>(1.33-1.95)    | 2.07<br>(1.71-2.55)    | 2.45<br>(2.04-2.97)    | 2.96<br>(2.48-3.62)    | 3.36<br>(2.61-4.37)    | 3.77<br>(2.86-5.02)    | 4.18<br>(3.08-5.74)    | 4.75<br>(3.35-6.80)    | 5.19<br>(3.54-7.69)    |
| 24-hr                                                                                              | 1.66<br>(1.47-1.92)                 | 2.16<br>(1.91-2.44)    | 2.81<br>(2.48-3.25)    | 3.35<br>(2.93-3.91)    | 4.08<br>(3.46-4.92)    | 4.65<br>(3.86-5.72)    | 5.23<br>(4.24-6.59)    | 5.84<br>(4.60-7.56)    | 6.66<br>(5.04-8.98)    | 7.30<br>(5.34-10.2)    |
| 2-day                                                                                              | 2.03<br>(1.80-2.34)                 | 2.68<br>(2.37-3.09)    | 3.34<br>(3.13-4.10)    | 3.94<br>(3.73-4.96)    | 4.64<br>(4.44-6.32)    | 5.01<br>(4.99-7.39)    | 6.01<br>(5.51-8.57)    | 7.63<br>(6.01-9.87)    | 8.76<br>(6.63-11.8)    | 9.66<br>(7.07-13.5)    |
| 3-day                                                                                              | 2.18<br>(1.93-2.52)                 | 2.92<br>(2.58-3.37)    | 3.91<br>(3.45-4.52)    | 4.73<br>(4.14-5.51)    | 5.86<br>(4.96-7.06)    | 6.75<br>(5.60-8.30)    | 7.67<br>(6.22-9.66)    | 8.64<br>(6.81-11.2)    | 9.97<br>(7.55-13.4)    | 11.0<br>(8.07-15.4)    |
| 4-day                                                                                              | 2.33<br>(2.06-2.68)                 | 3.15<br>(2.78-3.63)    | 4.24<br>(3.74-4.91)    | 5.16<br>(4.51-6.02)    | 6.43<br>(5.45-7.75)    | 7.43<br>(6.17-9.14)    | 8.47<br>(6.86-10.7)    | 9.56<br>(7.54-12.4)    | 11.1<br>(8.38-14.9)    | 12.3<br>(8.98-17.1)    |
| 7-day                                                                                              | 2.67<br>(2.36-3.07)                 | 3.67<br>(3.25-4.24)    | 5.04<br>(4.44-5.83)    | 6.18<br>(5.40-7.20)    | 7.77<br>(6.58-9.36)    | 9.04<br>(7.50-11.1)    | 10.4<br>(8.39-13.0)    | 11.7<br>(9.26-15.2)    | 13.7<br>(10.4-18.5)    | 15.2<br>(11.1-21.3)    |
| 10-day                                                                                             | 2.88<br>(2.55-3.32)                 | 4.01<br>(3.55-4.63)    | 5.55<br>(4.90-6.42)    | 6.84<br>(5.99-7.98)    | 8.66<br>(7.33-10.4)    | 10.1<br>(8.38-12.4)    | 11.6<br>(9.40-14.6)    | 13.2<br>(10.4-17.1)    | 15.4<br>(11.7-20.8)    | 17.2<br>(12.6-24.0)    |
| 20-day                                                                                             | 3.55<br>(3.14-4.09)                 | 5.01<br>(4.43-5.78)    | 7.01<br>(6.18-8.11)    | 8.70<br>(7.61-10.1)    | 11.1<br>(9.39-13.4)    | 13.0<br>(10.8-16.0)    | 15.0<br>(12.2-18.9)    | 17.1<br>(13.5-22.2)    | 20.2<br>(15.3-27.2)    | 22.6<br>(16.5-31.5)    |
| 30-day                                                                                             | 4.18<br>(3.70-4.81)                 | 5.89<br>(5.21-6.79)    | 8.23<br>(7.26-9.52)    | 10.2<br>(8.94-11.9)    | 13.0<br>(11.0-15.7)    | 15.3<br>(12.7-18.8)    | 17.7<br>(14.3-22.3)    | 20.3<br>(16.0-26.2)    | 23.9<br>(18.1-32.2)    | 26.8<br>(19.6-37.4)    |
| 45-day                                                                                             | 5.04<br>(4.46-5.81)                 | 7.01<br>(6.20-8.09)    | 9.72<br>(8.57-11.2)    | 12.0<br>(10.5-14.0)    | 15.3<br>(13.0-18.5)    | 18.0<br>(14.9-22.1)    | 20.8<br>(16.8-26.2)    | 23.8<br>(18.7-30.8)    | 28.1<br>(21.2-37.8)    | 31.5<br>(23.1-44.0)    |
| 60-day                                                                                             | 5.94<br>(5.26-6.85)                 | 8.12<br>(7.19-9.37)    | 11.1<br>(9.82-12.9)    | 13.7<br>(12.0-16.0)    | 17.4<br>(14.7-20.9)    | 20.4<br>(16.9-25.0)    | 23.5<br>(19.1-29.6)    | 26.9<br>(21.2-34.8)    | 31.7<br>(24.0-42.8)    | 35.6<br>(26.1-49.7)    |

<sup>1</sup> Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS). Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values. Please refer to NOAA Atlas 14 document for more information.

Estimates from the table in CSV format:

**Figure 5-13 NOAA Precipitation-Frequency Atlas 14**

- The time of peak on the hyetograph was modified to align with the time of peak seen for dry weather flow.
- The unit hyetograph was then multiplied by the 2-year, 10-year, or 25-year precipitation for each respective analysis.

### 5.6.3 Development of Subcatchment for Wet Weather Analysis

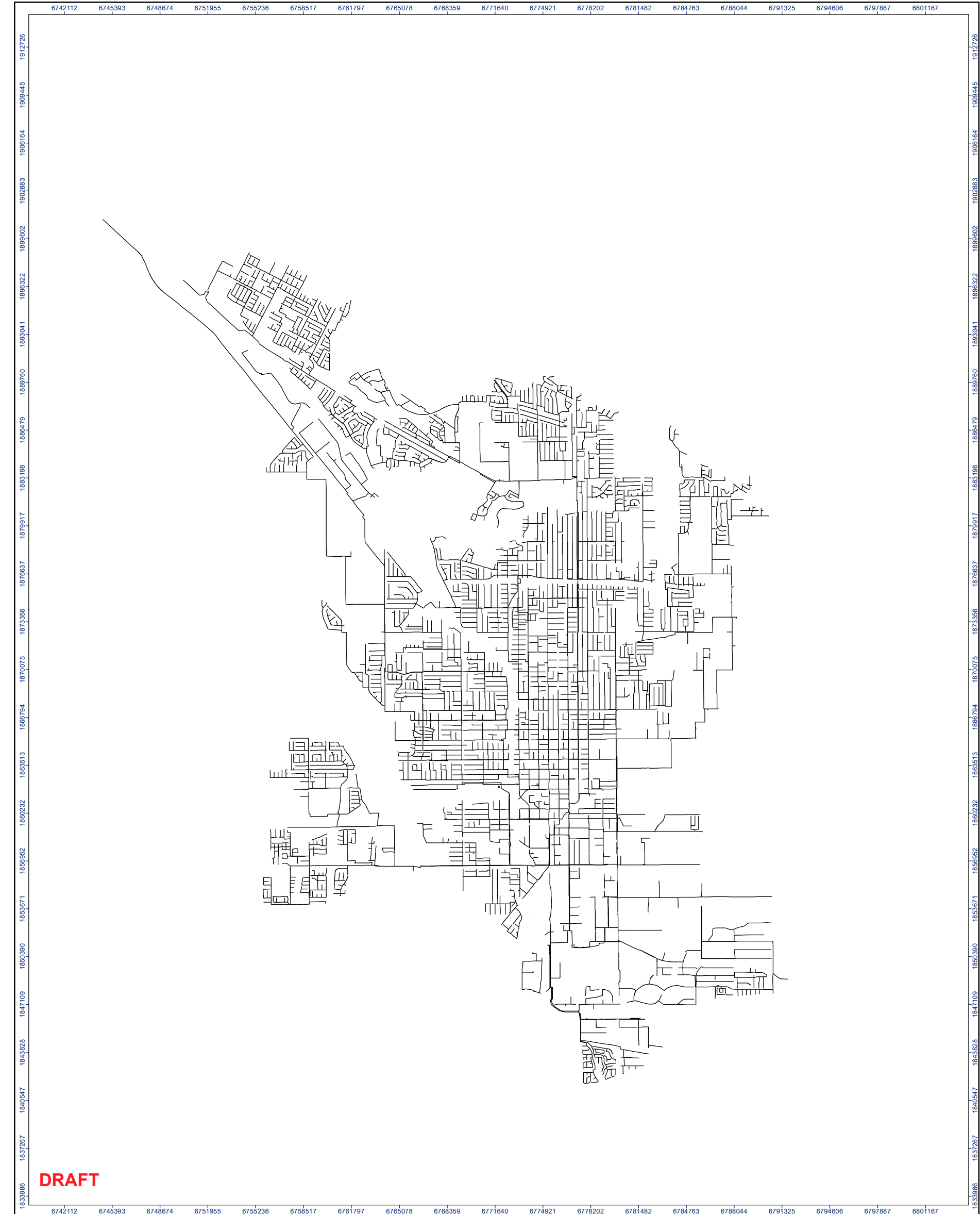
The purpose of creating subcatchments during the model development is to allow rainfall derived inflow and infiltration that enters into the sewer system to spread evenly throughout the sewer system. In theory, every maintenance access hole should have its own subcatchment. However, that will result over 7,000 subcatchments which would become overly detailed and difficult to manage when comparing to SBMWD's flow monitoring results. To achieve a balance between evenly spreading rainfall derived inflow and infiltration into the sewer system and the resolution of the flow monitoring results, Stantec first divided the SBMWD sewer boundary area into 11 subareas (10

## **SECTION 5.0 – COMPUTER MODEL DEVELOPMENT**

Phase 1 flow monitoring locations and Arrowhead Lift Station). Stantec further divided each subarea into 20-40 subcatchments. The number of subcatchments for each subarea was decided case-by-case basis. The size of each subsewershed was determined based on the network connectivity and amount of the non-modeling pipes within each subarea. Each subcatchment was assigned to a modeled maintenance hole. Lastly, Stantec conducted quality assurance and quality control of these subcatchments manually by visually inspecting the delineation and the assigned maintenance hole locations. Figure 5-14 shows a map with all the subcatchments.

### **5.7 SUMMARY**

The model build resulted in a functional hydraulic model that incorporated SBMWD's most recent GIS database, results of the recently completed LiDAR survey and maintenance hole survey, as well as multiple other data sources provided by SBMWD. The model verification process yielded identification of a variety of data inconsistencies that have been addressed and flagged for future investigation. The final model is assigned existing and future flows and is set up for wet weather analysis by creating design storms and discrete subcatchments for assigning wet weather flow to the model nodes. The next step in the SMP Update process is calibration of the model to flow monitoring data in order to adjust assigned flows to actual conditions, which is described in Section 6.



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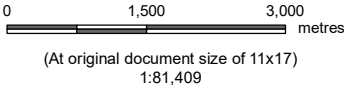
## Legend

— Sewer Pipes

### Subcatchments

- 0330064
- 0360154
- 0450083
- 0640138
- 0660212

- 0660232
- 0660239
- 0670105
- 0740052
- 0870014
- WWTP



**Project Location** San Bernardino County California  
**Client/Project** Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.

5-14

Title

Subcatchments for Wet Weather Analysis

DRAFT

**Notes**  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.







SECTION 6

Calibration







# 6.0 CALIBRATION

The main objective of the model calibration is to adjust and confirm model parameters such that the model is adequately representing the existing collection system. Calibration is the process of comparing the model simulations with the observed monitoring data and making adjustments to model assumptions in order to get better agreement with the data. Flow, depth, velocity, volume, and flow patterns information were used in this comparison process during the model calibration. This model calibration consists of two parts: dry weather and wet weather calibration.

As discussed in Section 4, the Phase 1 locations collected flow from large areas and were deployed for the purposes of model calibration. Before the calibration began, Stantec examined the Phase 1 flow monitoring results with respect to flow, depth, and velocity. The purpose of reviewing the flow monitoring data is to avoid correcting the model based on questionable observed flow data. Figure 6-1 shows an example data quality control plot created for FM 0450083 during the March flow monitoring period. The flow, velocity, and depth line graphs are shown for the month of March, with weekends represented by pink bars. The top plot is a hydrograph showing the rainfall for each day, in inches, the middle plot shows daily water depth and velocity, and the bottom plot is a scatterplot showing water depth vs. velocity. The flow, depth, and velocity graphs were examined to determine if any anomalies occurred during weekdays.

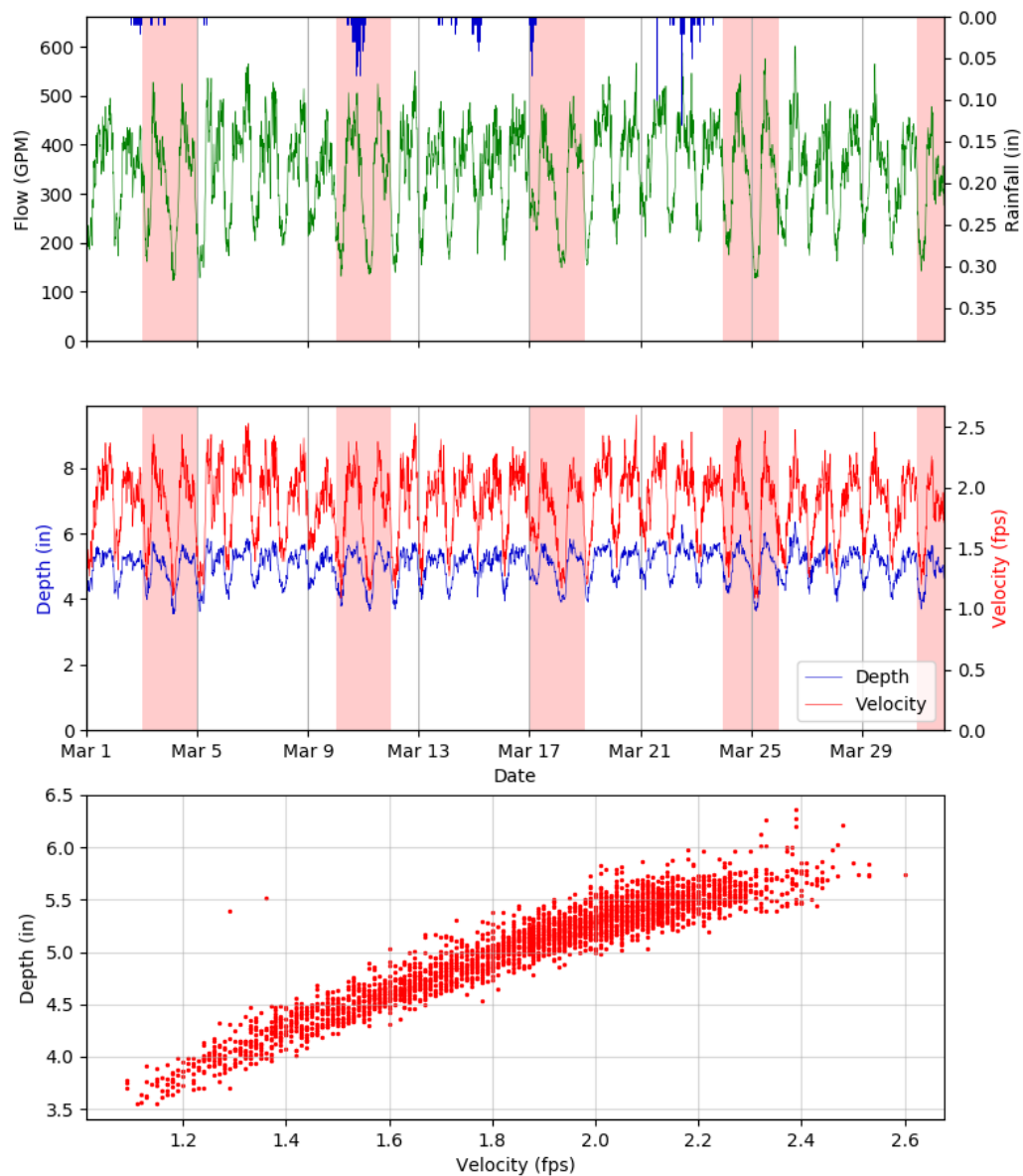
The scatterplot (bottom plot of Figure 6-1) depicts velocity along the x-axis and depth measurement along the y-axis. The relationship between velocity and depth for a given flow meter can be estimated from the Manning's curve, which shows how the distribution of this scatterplot should look like under uniform flow conditions. When the scatter plot deviates from the Manning's line, it may indicate that the system is operating outside of uniform flow. This scatterplot also shows the consistency of flow behavior at the flow monitoring location.

The scatterplot is often helpful in understanding if a given flow meter is a viable candidate to use for calibration. Appendix E shows the full data quality control plots for all ten Phase 1 flow meters for both February and March. While some scatterplots did show some deviation from the Manning's line, all ten were still initially used for dry weather calibration purposes. The scatterplots provided reference for which flow meters may have difficulty meeting the calibration threshold based on their adherence to the Manning's curve. Outliers and flow meters that were deemed unsuitable for dry weather calibration purposes are discussed further in Section 6.2.1.

Days that experienced rainfall or any unexpected patterns were removed, and average diurnal curves were created for both a standard weekday and weekend for each flow meter. This was done for dry weather calibration to ensure that there was no rainfall data influencing results.



## SECTION 6.0 – CALIBRATION



**Figure 6-1 Flow Meter 0450083 March Results**

### 6.1 DRY WEATHER CALIBRATION

To calibrate the hydraulic model to dry weather flow, the typical dry weather weekday flow is compared to the same locations in the hydraulic model and compared on an hour by hour basis. The criteria of dry weather calibration is to have a 10 percent or less difference between the modeled and observed data collected during dry weather periods. Model results and flow monitoring data are compared on a total volumetric basis, in addition to peak flow, depth, and velocity. Some variation from these criteria are expected for any calibration, and engineering judgement must be used to identify the cause of the discrepancies, make modifications to the model, and decide when the calibration cannot be further improved with the data available. This may occur when any changes to an out-of-criteria meter will cause more error in other calibration points.

Figure 6-2 through Figure 6-4 show a summary of the calibration results for dry weather peak flow, depth and velocity. The gray line in these figures represent a one-to-one relationship between the modeled and observed data, i.e. when the model results are identical to the observed results. The dashed orange line shows a +/- 10% difference between the observed and modeled results. The green solid line represents a +/- 20% difference between the observed and modeled results. Figure 6-2 shows a total of 13 calibration points, 10 from the flow monitoring data and an additional 3 calibration points for the three influent lines to the WRP. The three influent lines to the WRP were used only for flow calibration, as depth (Figure 6-3) and velocity (Figure 6-4) data was not available from these datasets. Calibration to the overall WRP influent lines aids in confirming total system demand from each part of the system to a certain extent as there are flow splits that can direct sewer flows to multiple WRP influent lines.

Stantec completed the model calibration under dry weather conditions and achieved the following results:

1. Most of the modeled peak flow results (Figure 6-2) are within the 10% of the observed peak under dry weather conditions with two exceptions (FM 0360154 and FM 0740052). Detailed calibration plots for each flow monitoring location can be found in Appendix F. Stantec reviewed the two exceptions and concluded that the model is calibrated and adequate to support the master planning. Section 6.1.1 documents the contributing factors behind these two data outliers.
2. Most of the modeled peak depth results (Figure 6-3) are within the 10% threshold or exactly on the 10% threshold line, except for outlier FM 0740052 (See Section 6.1.1).
3. Most of the modeled velocity results (Figure 6-4) are within the 10% threshold, with the exception of dry weather flow at FM 740052 (See Section 6.1.1).

SECTION 6.0 – CALIBRATION

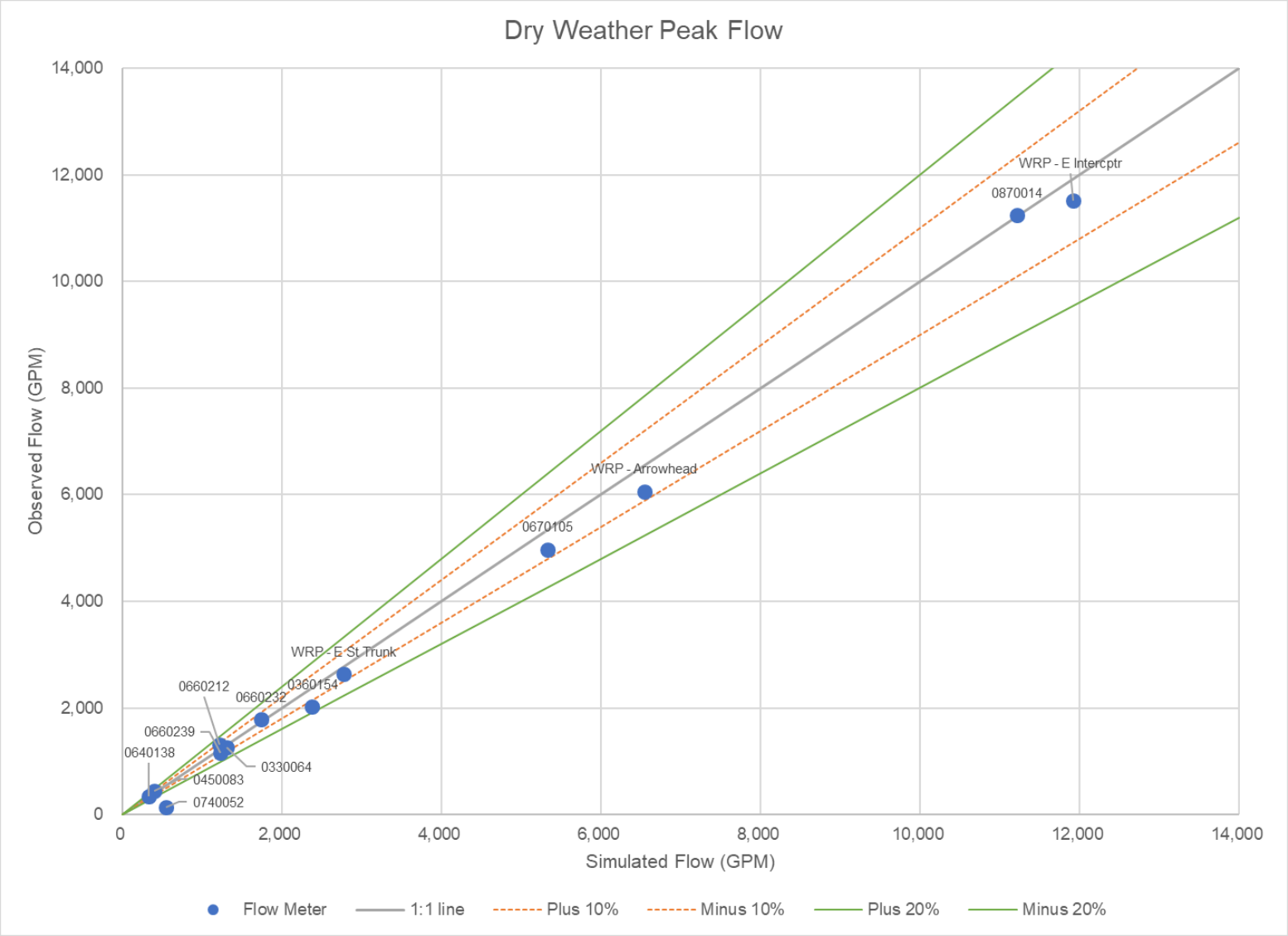


Figure 6-2 Summary of Dry Weather Peak Flow Calibration Results

SECTION 6.0 – CALIBRATION

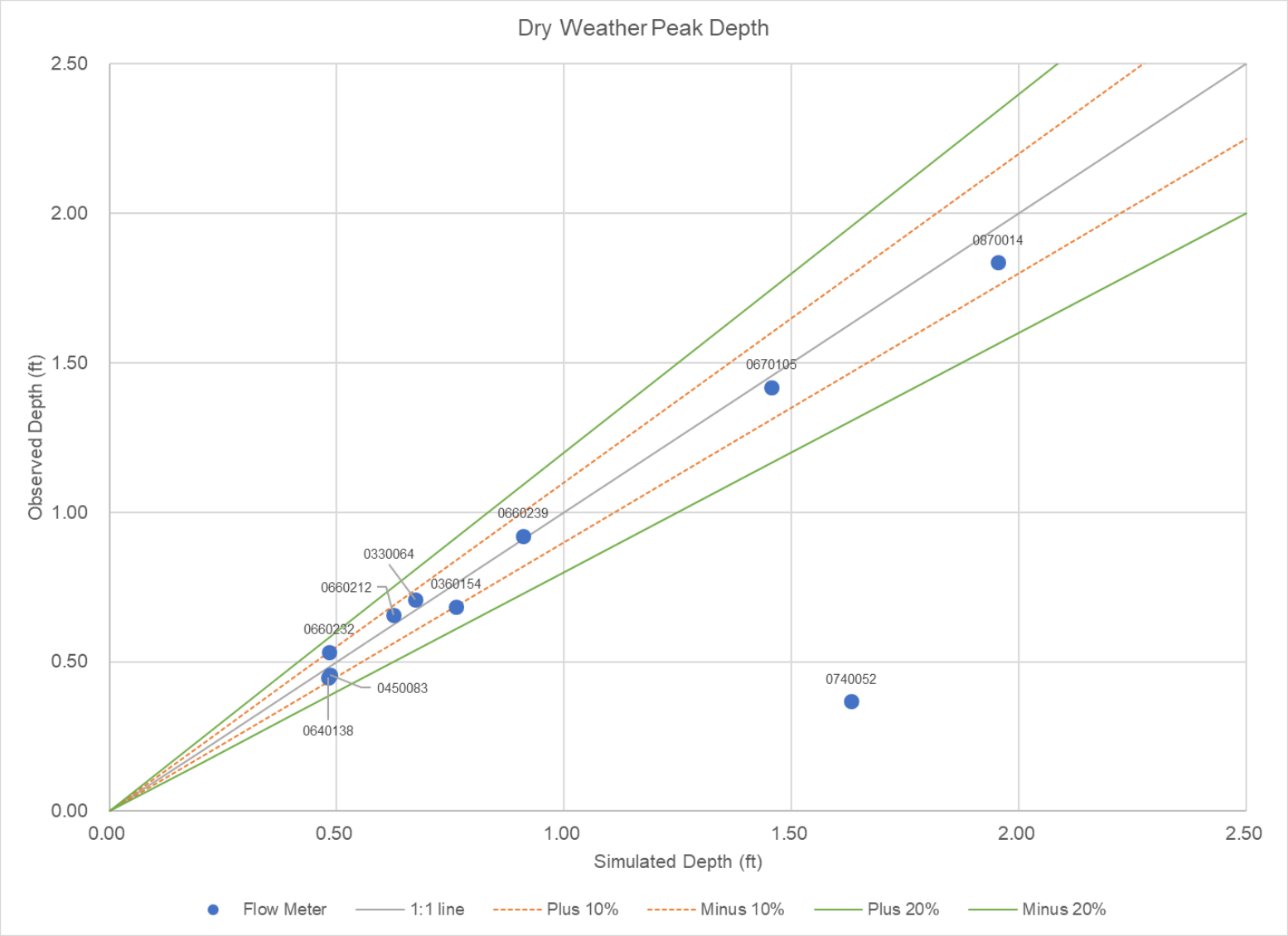


Figure 6-3 Summary of Dry Weather Peak Depth Calibration Results



SECTION 6.0 – CALIBRATION

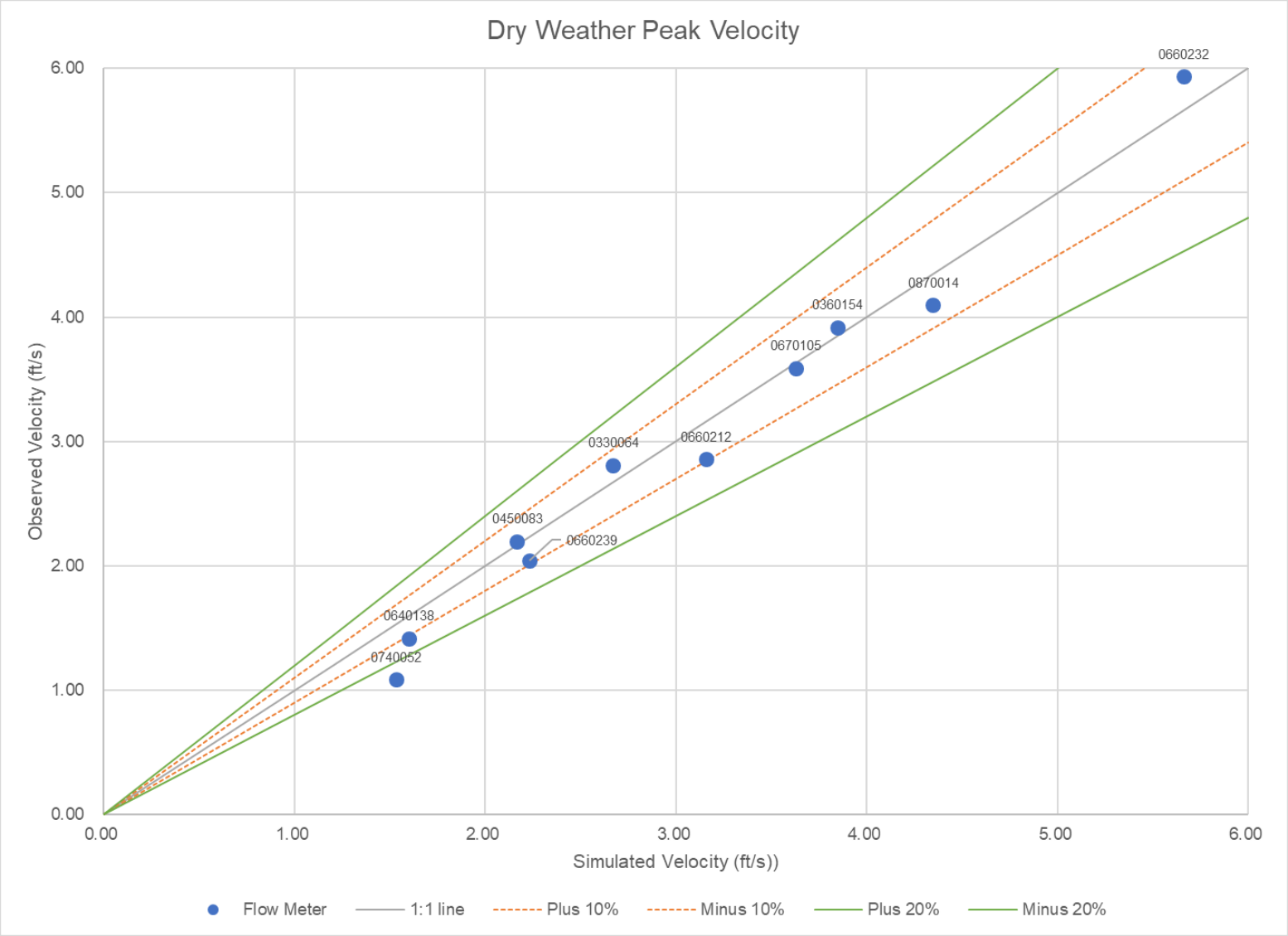


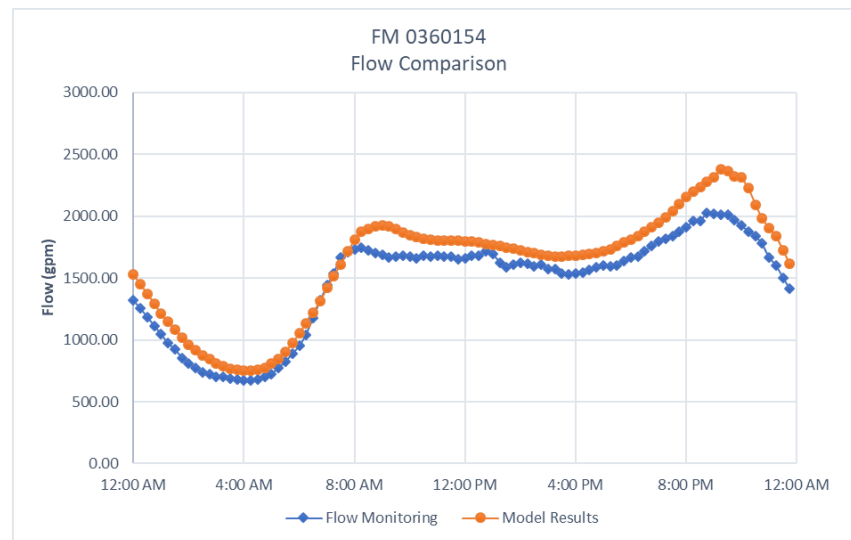
Figure 6-4 Summary of Dry Weather Peak Velocity Calibration Results

## SECTION 6.0 – CALIBRATION

### 6.1.1 Dry Weather Calibration Outliers

#### **FM 0360154**

FM 0360154 exceeds the 10% calibration threshold for peak flow but does fall within the 20% difference. Figure 6-5 shows a comparison between model simulation results and observed data. The model results for dry weather peak flow are slightly higher than the observed flows for hours 20:00 to 24:00. However, the modeled and observed data are extremely similar for the low flow conditions occurring between 4:00 to 8:00 AM. Additional calibration modifications to FM 0360154 would result in too little modeled flow earlier in the morning. While the flow does not fall into the 10% calibration threshold, the model was an 89% match compared to observed flows when averaging all 15-minute reporting data. As such, calibration could not be improved further, and Figure 6-5 represents the final calibration of this meter. The results of the calibration were discussed with SBMWD staff to communicate the reasons for not adjusting flows further.



**Figure 6-5 FM 0360154 Peak Flow Comparison**

#### **FM 0740052**

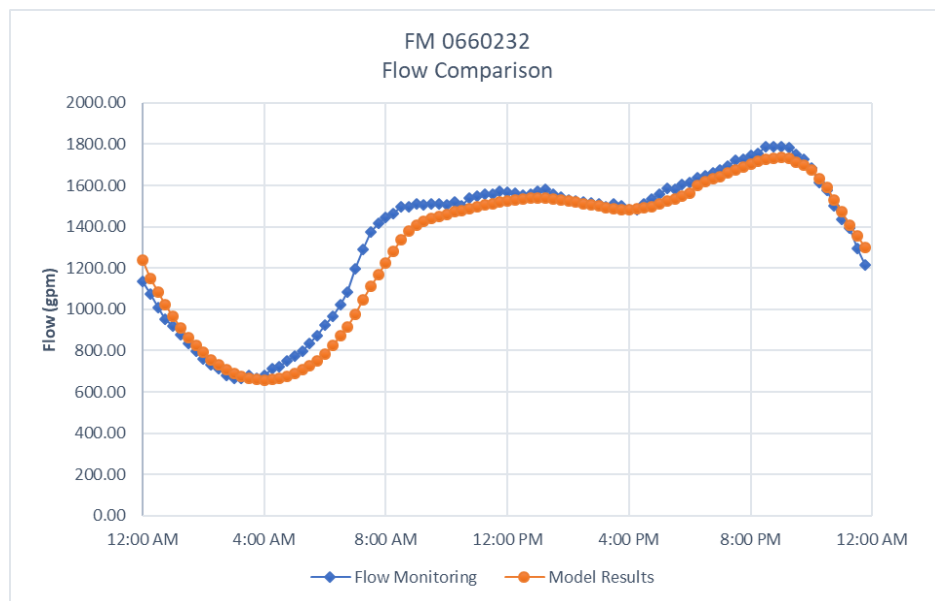
During calibration, flow monitoring data from FM 0740052 proved difficult to calibrate to as it had both very low flow and a high peak over the course of a typical day. After a field investigation by SBMWD staff, a new line in the area not captured by the flow monitor (designated as the “West Residential,” area) was identified parallel to the line monitored at SMH 0740052. This is discussed in more detail Section 4.

SBMWD further investigated the line that was monitored for a potential flow split, upon Stantec request, as agreement with the model could not be achieved and it was suspected that there may be a weir present at the maintenance hole. SBMWD staff noted that in September of 2018, a crew inspected maintenance hole 0740057 and found the 12-inch main was partially blocked with debris. The debris was cleared the following day, however, as the flow monitoring occurred prior to the debris clearing, it is suspected that the low flow and high peak is due to blockage in the pipe. As such, FM 0740052 was deemed unsuitable for calibration. This flow monitoring point shows as an outlier for both wet and dry weather calibration, for flow, depth, and velocity comparisons.

## SECTION 6.0 – CALIBRATION

### 6.1.2 Example Comparison Plots – FM 0660232

This subsection shows the comparison of model and flow monitor data at one calibration point for the dry weather calibration process. Figure 6-6 through Figure 6-8 show an hourly comparison between the model and the observed flow monitoring results for FM 0660232. This calibration point was chosen as an example because it shows how calibration involves consideration of all the parameters for a flow monitoring location and deciding upon a final result that optimizes all three plots. Figure 6-6 and Figure 6-8 show that the flow and velocity were very similar between the model and the flow monitoring results. Further modifying this calibration point to obtain closer modeled results for total depth would yield less accurate calibration results for flow and velocity. As such, the depth was not adjusted further. Detailed comparison plots for the all dry weather calibration points can be found in Appendix F.



**Figure 6-6 FM 0660232 Flow Comparison Plot**

SECTION 6.0 – CALIBRATION

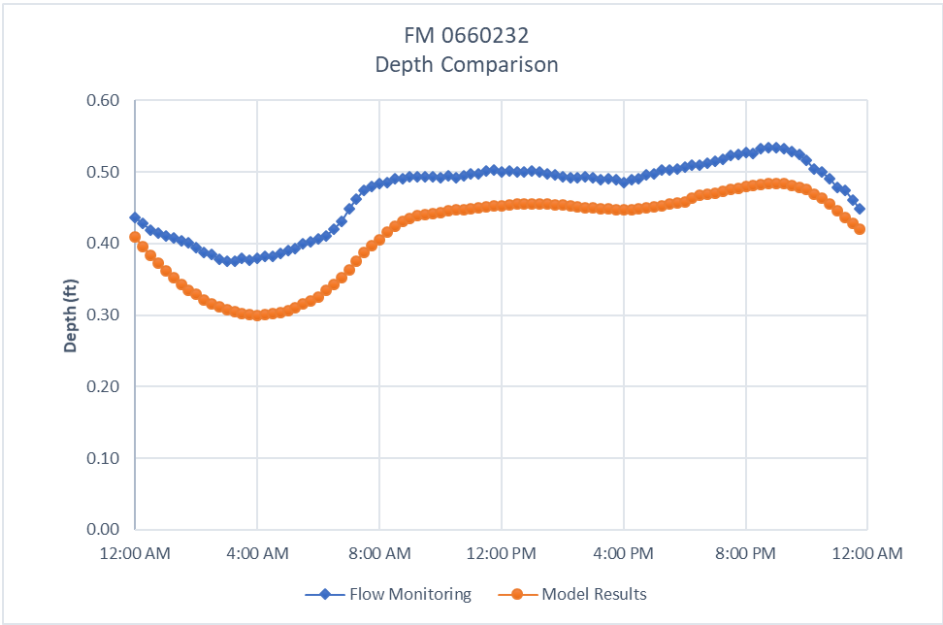


Figure 6-7 FM 0660232 Depth Comparison Plot

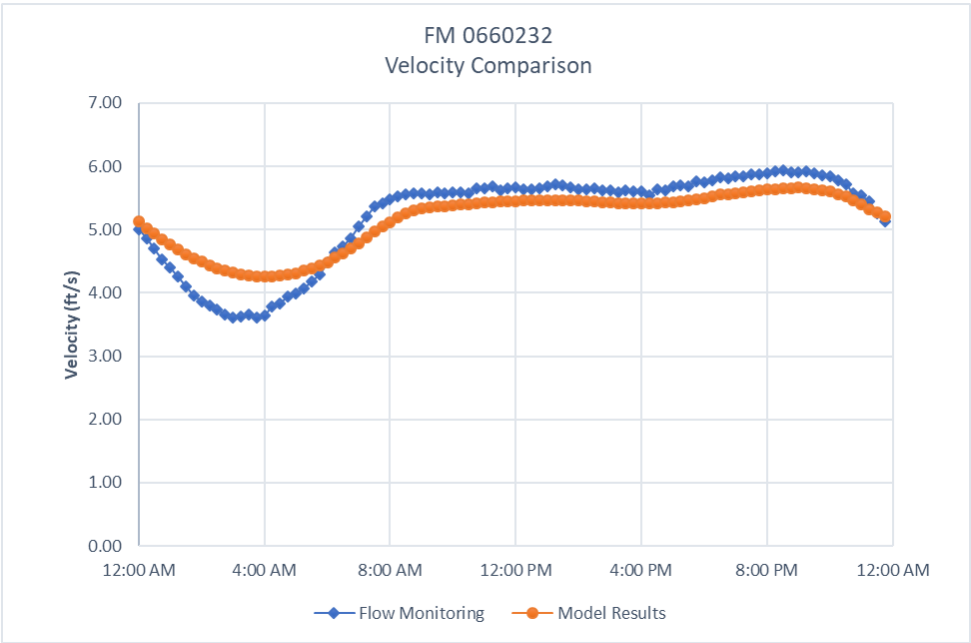


Figure 6-8 FM 0660232 Velocity Comparison Plot



## 6.2 WET WEATHER CALIBRATION

Section 5 discusses the modifications to the model needed to evaluate wet weather flow in the system. In order to evaluate the system capacity during storm events, the model is first calibrated to wet weather conditions. Typical wet weather calibration is for two storm events. This subsection discusses selection of the calibration storm events and the wet weather calibration process. After calibration is complete, design storms are used to analyze potential impacts of various storm frequencies.

### 6.2.1 Selection of Calibration Event

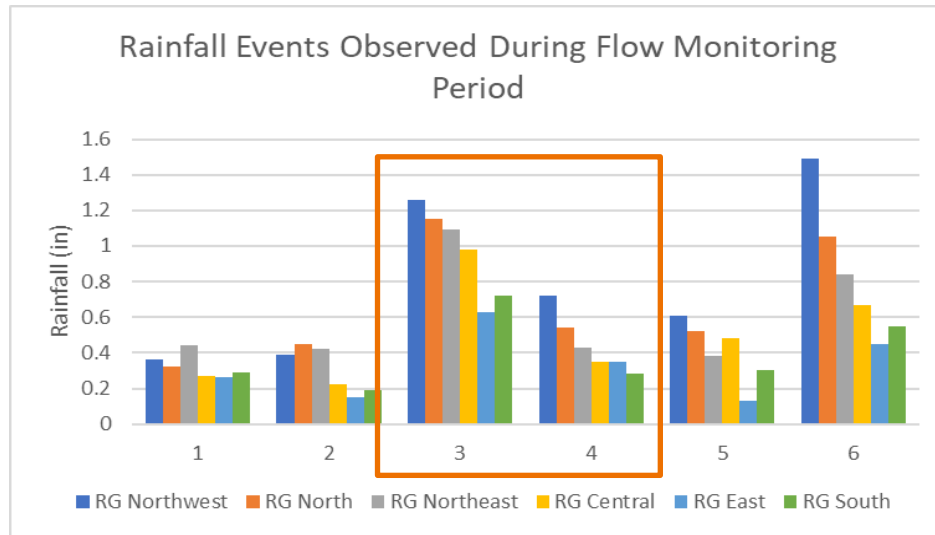
The data from six rain gauges installed at different locations was analyzed to characterize rainfall during the monitoring period. Typically, one smaller event and one larger event is chosen for the calibration process. Of the six events shown in Table 6-1 that occurred during the flow monitoring period, event 3 (March 10<sup>th</sup> 2018) and 4 (March 14<sup>th</sup> 2018) were selected for model calibration purposes.

Events 1 and 2 were not selected as the rainfall was not significant enough across all gauges for there to be a substantial flow response. For the smaller storm event, event 4 was chosen over event 5 as the Rain Gauge East had minimal flow during event 5. For the larger storm calibration, event 3 was chosen instead of event 6 as the rainfall had a more even distribution across the system. Event 6 showed a concentration specifically in the Northwest part of the system, with minimal rainfall in east and south. The distribution of rainfall per event is shown on Figure 6-9. Location of the rain gauges during the flow monitoring period is shown on Figure 6-10.

**Table 6-1 Rain Events**

| Rainfall Event | Date      | RG Northwest | RG North | RG Northeast | RG Central | RG East | RG South |
|----------------|-----------|--------------|----------|--------------|------------|---------|----------|
| 1              | 2/27/2018 | 0.36         | 0.32     | 0.44         | 0.27       | 0.26    | 0.29     |
| 2              | 3/2/2018  | 0.39         | 0.45     | 0.42         | 0.22       | 0.15    | 0.19     |
| 3              | 3/10/2018 | 1.26         | 1.15     | 1.09         | 0.98       | 0.63    | 0.72     |
| 4              | 3/14/2018 | 0.72         | 0.54     | 0.43         | 0.35       | 0.35    | 0.28     |
| 5              | 3/16/2018 | 0.61         | 0.52     | 0.38         | 0.48       | 0.13    | 0.3      |
| 6              | 3/22/2018 | 1.49         | 1.05     | 0.84         | 0.67       | 0.45    | 0.55     |

## SECTION 6.0 – CALIBRATION



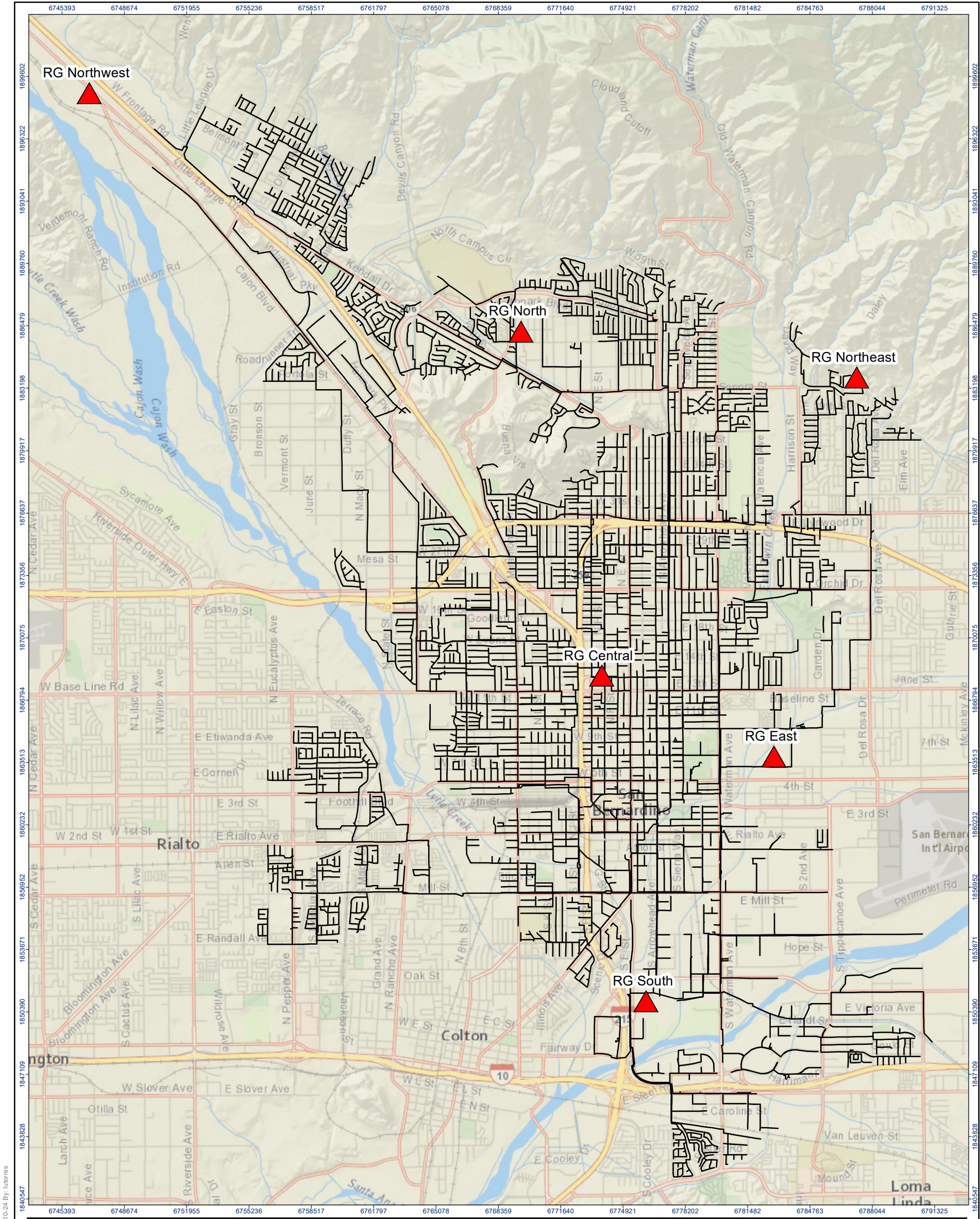
**Figure 6-9 Rainfall Events Observed During Flow Monitoring Period**

The six rainfall events were classified as less than 1-year rainfall events for San Bernardino based on the National Oceanic and Atmospheric Administration (NOAA) Rainfall Frequency Atlas. Even though the events collected during the monitoring period were less than a 1-year rainfall event, they were enough to elicit response from the flow monitoring sites and were therefore adequate for model calibration to wet weather flow conditions.

## **SECTION 6.0 – CALIBRATION**

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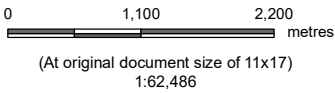




## Legend

-  Rain Gauge Location
-  Sewer Pipes

**Notes**  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.



**Project Location** San Bernardino County  
California  
**Client/Project** Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.

**6-10**

Title

**Location of Rain Gauges**







## SECTION 6.0 – CALIBRATION

### 6.2.2 Wet Weather Calibration Results

Figure 6-11 through Figure 6-13 show the calibration plots for wet weather peak flow, depth, and velocity. While dry weather calibration results aim to achieve less than a 10% difference between modeled and observed results, the industry standard for wet weather calibration is within 20%. The main objective during wet weather calibration and analysis is to capture the peak values for flow, depth, and velocity and ensure the system can cope with these extremes. Thus, if the overall model results are within 20% of the observed results, assuming the peak is captured properly, the calibration is deemed acceptable.

Stantec completed the model calibration under wet weather conditions and achieved the following results:

1. Figure 6-11 shows a summary of the wet weather peak flow calibration results. FM 0740052 is outside the 20% difference, and was deemed unsuitable for calibration, per the discussion in Section 6.1.2. The other calibration point outside of the 20% threshold is FM 0640138, specifically during rainfall event 4. This location is discussed further in Section 6.2.4. The remaining flow monitoring points are within the 20% threshold applicable for wet weather calibration and adequately represent peak conditions.
2. Figure 6-12 shows a summary of wet weather peak depth calibration results. The two wet weather events at FM 0740052 are outside of the 20% wet weather calibration threshold. All remaining calibration points for the two wet weather events are within a 20% difference for modeled and observed results and adequately represent peak conditions.
3. Figure 6-13 shows a summary of the wet weather peak velocity calibration results. Similar to the flow and depth results, the velocity comparison for FM 0740052 is outside of the 20% threshold for both rain events. Additionally, FM 0640138 is also outside of the 20% threshold for velocity during rainfall event 4. The remaining calibration points are within the 20% threshold and match peak conditions.

SECTION 6.0 – CALIBRATION

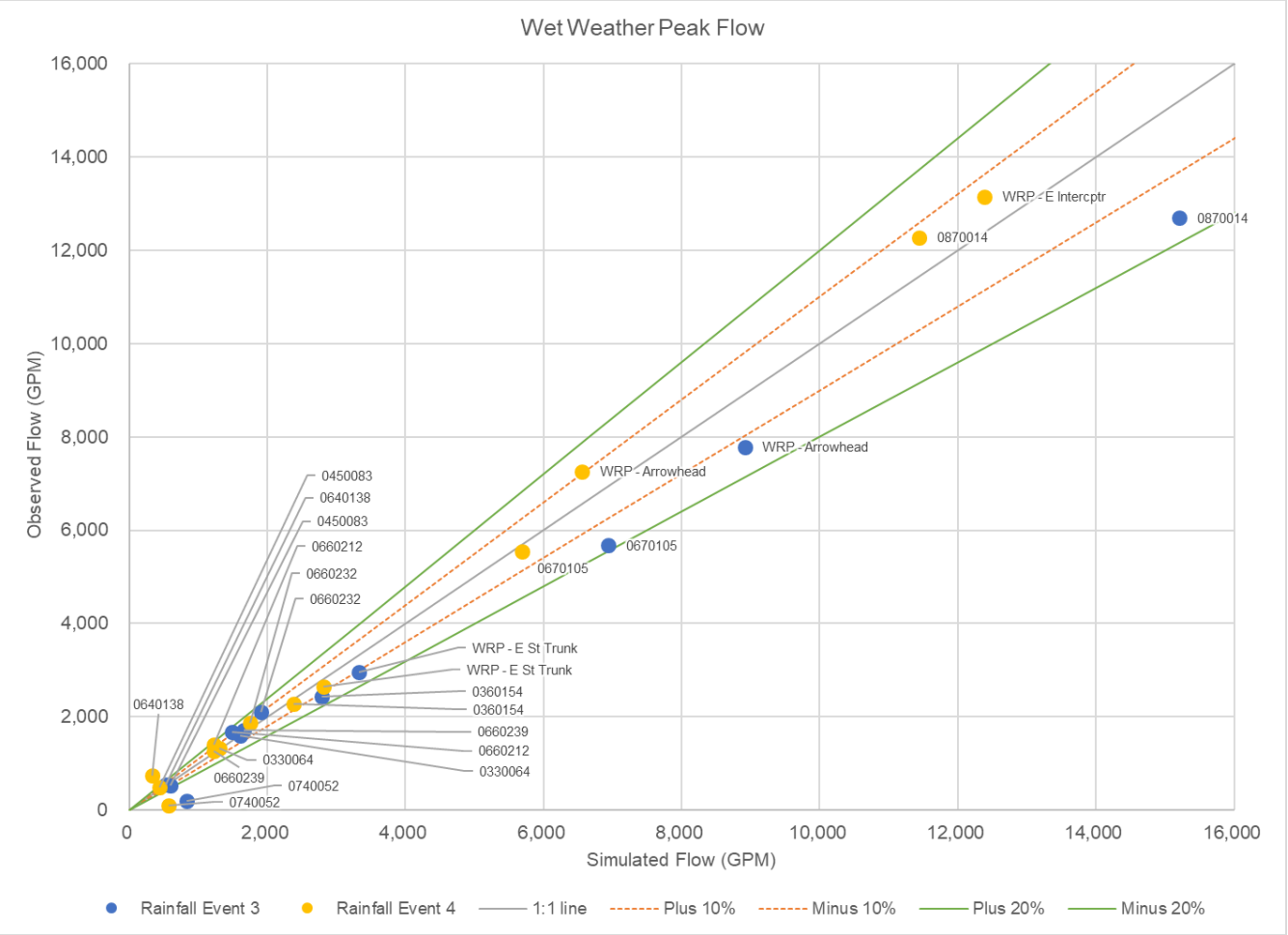


Figure 6-11 Summary of Wet Weather Peak Flow Calibration Results

SECTION 6.0 – CALIBRATION

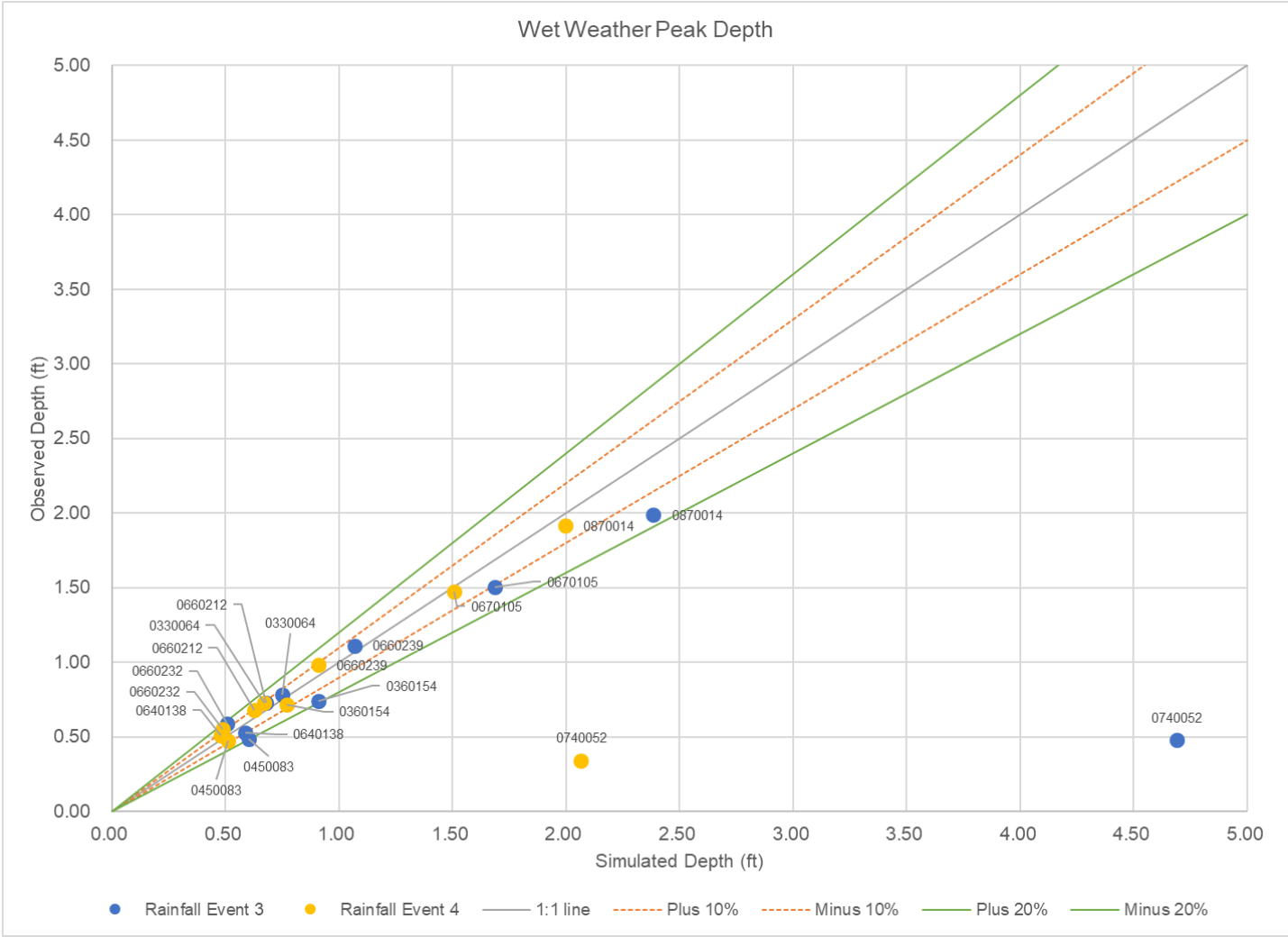
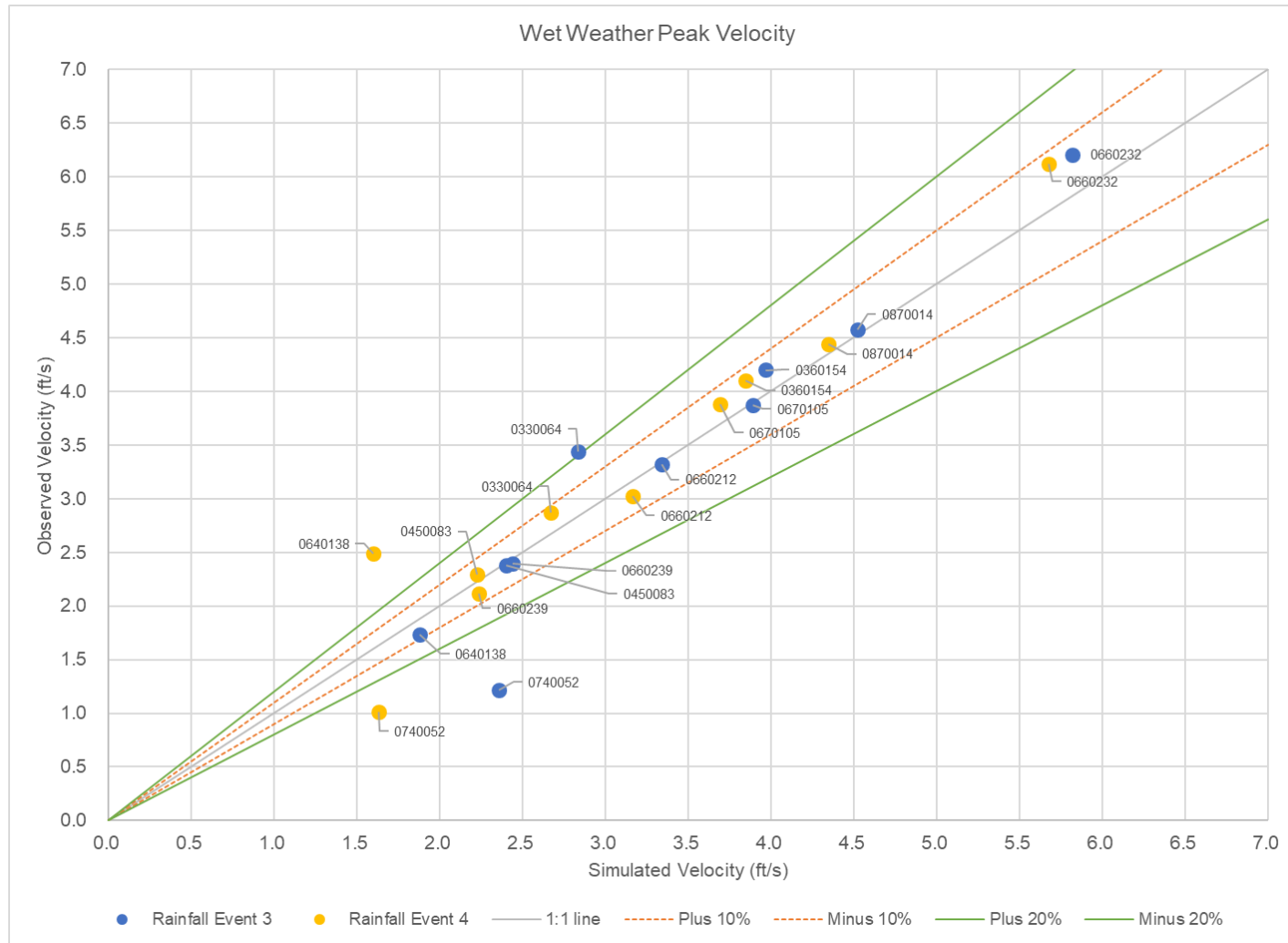


Figure 6-12 Summary of Wet Weather Peak Depth Calibration Results

## SECTION 6.0 – CALIBRATION

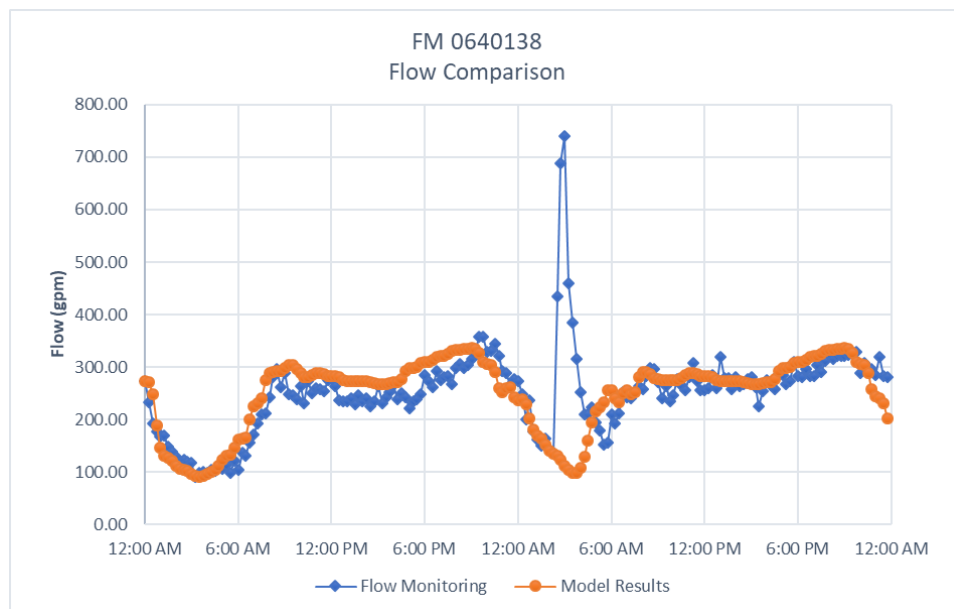


**Figure 6-13 Summary of Wet Weather Peak Velocity Calibration Result**



### 6.2.3 FM 0740052 and FM 0640138

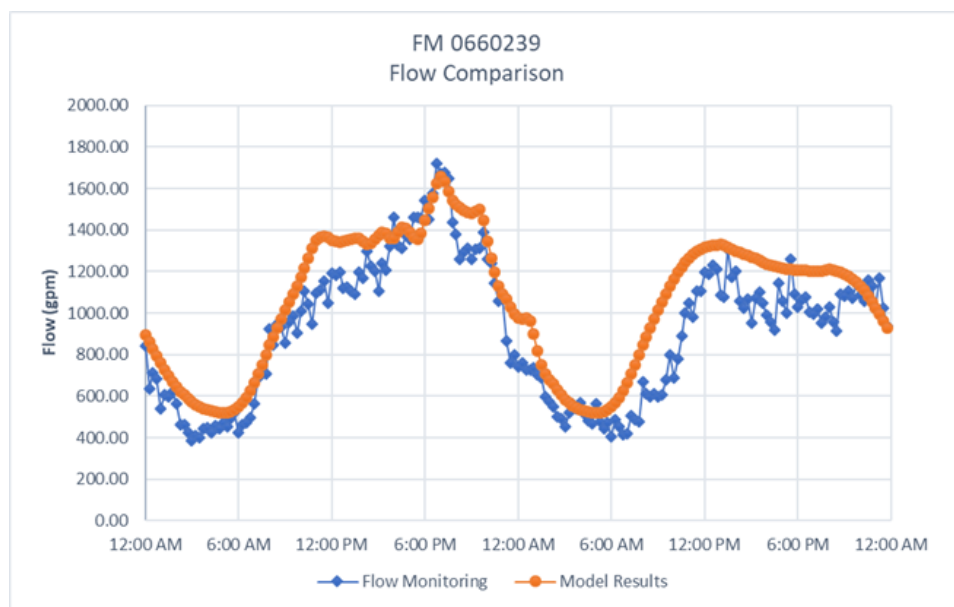
As discussed in Section 6.1.2, FM 0740052 was an outlier for the flow, depth, and velocity calibration plots for wet weather due to partial blockage in a pipe. In addition, FM 0640138 was outside of the 20% criteria for both the flow and velocity calibrations for rainfall event 4. Figure 6-14 shows the modeled results and the observed flow monitoring results for FM 0640138 during rainfall event 4. The observed flow monitoring results show a peak of flow occurring on March 15<sup>th</sup>, between 2:30am and 4:30am. This extreme peak was compared to the nearest rain gauge to this flow monitoring point, the central rain gauge. After looking at the rainfall data collected at the central rain gauge, only 0.2 inches of rain occurred between 2:30am to 4:30am. The remaining rain gauges across the system experienced similar amounts of rainfall during this time. As such, it was determined that the peak flow occurring between 2:30-4:30am was due to a localized flow event and was not reflective of wet weather flows. This location was not calibrated any further.



**Figure 6-14 FM 0640138 Flow Comparison**

### 6.2.4 Example Comparison Plots – FM 0660239

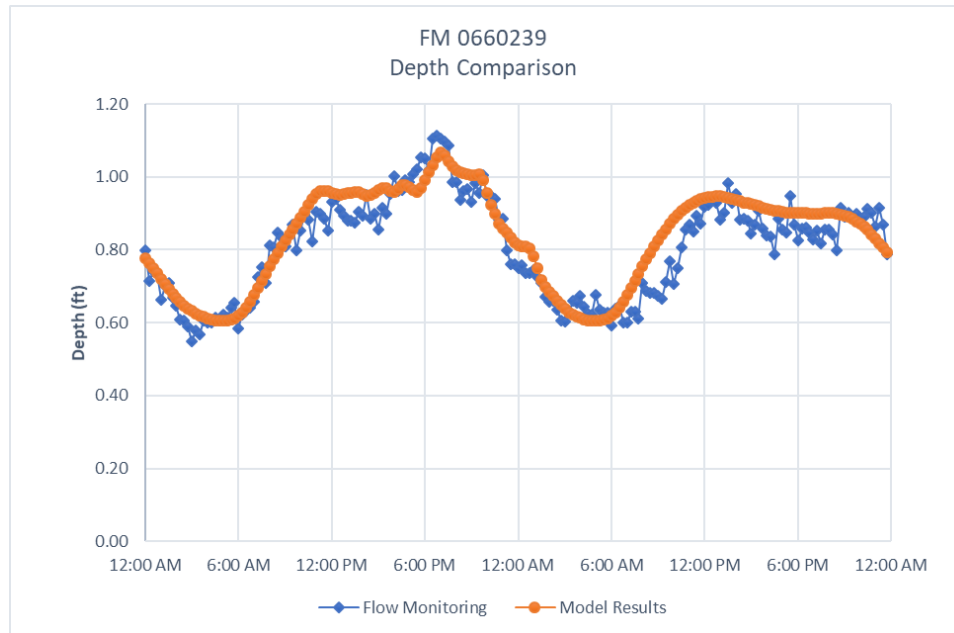
This subsection shows the comparison plots for flow, depth, and velocity for one flow monitoring (FM 0660239) point during wet weather calibration. FM 0660239 is located in West 9<sup>th</sup> St. between N Arrowhead Ave and N Mountain View Ave, in the east side of the system. These plots highlight the goal of wet weather calibration, which is to capture the peak flow, depth, or velocity. Figure 6-15 shows the flow comparison between modeled and observed results for FM 0660239 during rainfall event 3. The peak flow in the observed results matches the peak simulated by the model. While the simulated flow may be larger than the observed flow during 6:00 am to 12:00pm, this calibration was deemed acceptable as the peak was captured and the overall match between simulated and observed results were within 20%. Comparison plots for all wet weather calibration points are presented in Appendix F.



**Figure 6-15 FM 0660239 Flow Comparison**

Figure 6-16 shows the depth comparison between the modeled results and the observed flow monitoring results for FM 0660239. The peak depth was a close match between the modeled results and the observed flow monitoring results. In addition, the peak depth observed in the flow monitoring results was well represented in the modeled results.

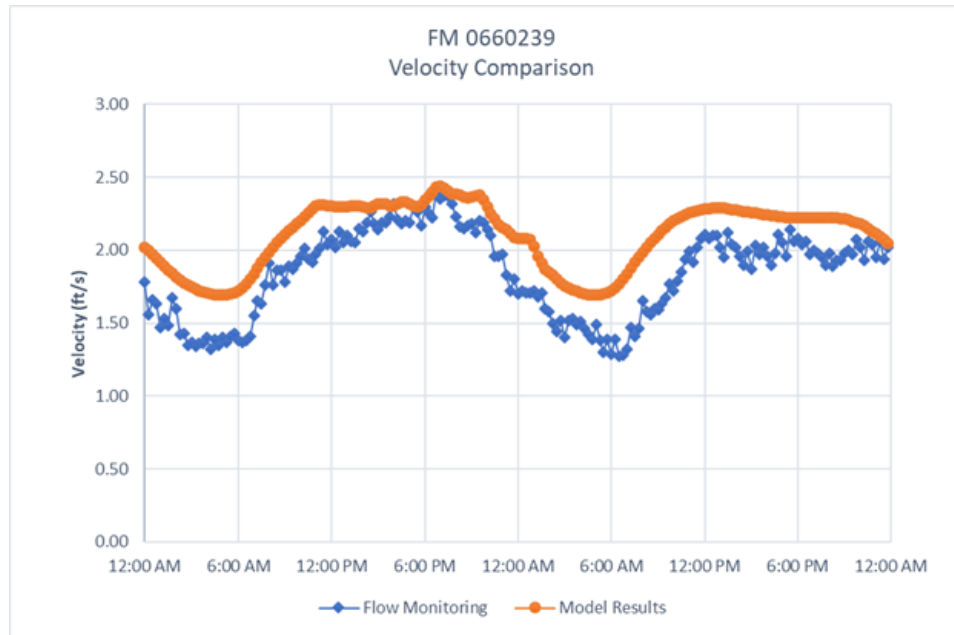
## Calibration



**Figure 6-16 FM 0660239 Depth Comparison**

Figure 6-17 shows the peak velocity comparison between the model results and the flow monitoring data. As previously noted, the main goal of wet weather calibration is to confirm that the model matches the peak flow, depth, or velocity observed in the flow monitoring results. The model results in Figure 6-17 do capture the peak velocity observed during the flow monitoring results for rainfall event 3. The overall model results are higher than the observed results, though the average difference between the model and the flow monitoring results are within the 20% threshold. Because the model reflects the peak experienced during velocity seen in flow monitoring data well and the overall difference is within accepted limits, the calibration of this flow monitoring point was deemed acceptable.

## Calibration



**Figure 6-17 FM 0660239 Velocity Comparison**

The model was calibrated for typical dry weather event and two wet weather events. Overall for dry weather calibration, results were within the 10% threshold of variation with observed values. There were two outliers for dry weather calibration. FM 0740052 which was removed from calibration as further investigation revealed that there was partial blockage in a pipe. As described in Section 6.1.1, FM 0360154 was an outlier for peak flow, as it fell within the 20% difference but not within the 10% difference. Overall for wet weather calibration, the peak flow, velocity and depth for both events were within the 20% threshold of variation with observed values. There were two outliers not included in the wet weather calibration, FM 0740052 (similar to dry weather) and FM 0640138. A localized wet weather event was captured by FM 0640138, showing a higher peak flow than the rest of the rain gauge data, and thus was deemed not reflective of typical wet weather response.



SECTION 7

# Planning Criteria







## SECTION 7.0 – PLANNING AND DESIGN CRITERIA

# 7.0 PLANNING AND DESIGN CRITERIA

This chapter documents the planning and design criteria used to develop flows and assess the capacity of infrastructure for the San Bernardino Municipal Water Department's (SBMWD) Sewer Master Plan Update. This section describes the criteria used to size replacement, parallel, or new facilities for both pipelines and lift stations.

Planning criteria are established for the evaluation of the SBMWD sewer collection system to uniformly assess system performance. Peaking factors and flow analysis are determined based on the 2018 Sewer Flow Monitoring and Inflow/Infiltration Study (V&A, 2018) (Flow Study). The criteria was developed using the City of San Bernardino Department of Public Works Sewer Policy & Procedures (1987) and industry-standard planning criteria used in the systems of similar utilities, local codes, engineering judgment, and commonly accepted industry standards. The industry standards are ranges of values that are appropriate for the planning criteria and are used to verify that the values developed are reasonable.

## 7.1 RECOMMENDED DESIGN CRITERIA FOR GRAVITY MAINS

The following subsections provide recommended design criteria for gravity sewer mains in the SBMWD system.

### 7.1.1 Peak Design Flow

Based on wastewater treatment plant inflows, maximum day demand peaking factors have been developed specific to this master plan. In addition, data from the Flow Study was used to develop diurnal flow curves by land use type. New sewer system pipelines should be sized for partially full conditions at peak dry weather flow (PDWF). PDWFs are for design purposes and do not include increases in flow rates due to rainfall-derived infiltration and inflow (RDII). An analysis of RDII and its contribution to system flows is discussed in Section 5 of the Flow Study, and in **Chapter 4 – Water Demands and Wastewater Characteristics**. The PDWFs used for this study are presented in **Chapter 6 - Calibration**.

### 7.1.2 Pipe Friction

A Manning's  $n$  value of 0.014 for vitrified clay pipe (VCP) and 0.012 for Polyvinylchloride (PVC) will be used to analyze hydraulic conditions in gravity sewers for all pipe sizes in the SBMWD system. These values are typical for sanitary sewer systems in good condition. If instances of sediment deposition, obstructions or other impeding factors are known, a higher value will be used to represent those conditions. A Hazen-Williams  $C$  factor of 120 will be used to analyze hydraulic conditions for all force mains in the system.

### 7.1.3 Minimum Pipe Size

Minimum sewer pipe diameter for any new or replacement pipelines should be 8 inches.

## SECTION 7.0 – PLANNING AND DESIGN CRITERIA

### 7.1.4 Flow Depth Ratio ( $d/D$ )

Typically, sewer systems in climates that do not experience significant rainfall are designed to have a maximum flow depth ( $d$ ) to pipe diameter ( $D$ ) ratio ( $d/D$ ) at PDWF conditions. Under this design scenario, increased flows from usage spikes or RDII during infrequent wet-weather conditions can be conveyed by the remaining available cross-sectional area of the sewer pipe. The recommended  $d/D$  ratios for the collection system are:

- Maximum  $d/D$  ratio for all sewers less than 15 inches in diameter should be 0.50 during PDWF.
- Maximum  $d/D$  ratio for all sewers greater than or equal to 15 inches in diameter should be 0.5 during PDWF.

The above criteria will be used for all new pipes in the system. The criteria will also be used to assess whether existing pipes have sufficient hydraulic capacity or need relief. Any pipes identified over these thresholds will be documented in this Sewer Master Plan Update.

While improvements will be recommended for capacity-deficient sewer pipes, a  $d/D$  ratio threshold of 0.75 is recommended to flag improvement projects for immediate implementation. A  $d/D$  ratio of 0.75 indicates a nearly full pipe condition that can result in upstream pipe segments becoming surcharged by means of a backwater condition. Any modeled pipes with  $d/D$  ratio exceeding 0.75 at PDWF will be recommended for improvement.

### 7.1.5 Slope and Velocity

To minimize potential for grit and debris accumulation in the collection system, all trunk and collector sewers should be designed with hydraulic slopes sufficient to maintain mean velocities at average dry weather flow (ADWF) of greater than or equal to 3 feet per second (ft/s). To minimize the potential for scouring and pipe erosion, the maximum allowable velocity in sewer pipes should not be greater than 8 ft/s. Minimum pipe slope should be 0.0044 ft/ft except in cul-de-sac streets where the pipe slope should be no less than 0.01 ft/ft. Minimum pipe slope for all pipes will be determined such that minimum velocity is 3 ft/s during average dry weather flow.

### 7.1.6 Material

New gravity pipeline will be assumed to be PVC for pipes less than 18 inches in diameter, and vitrified clay pipe (VCP) for 18 inches to 42 inches in diameter pipes. For pipelines greater than 42 inches in diameter, Fiber-glass reinforced pipe (FRP), and concrete with liner is recommended. Material criteria are used to calculate planning level costs for capital improvements in Section 10 – Capital Improvement Program.

### 7.1.7 Summary of Design Criteria

**Table 7-2** summarizes the criteria used for gravity mains for this master plan.

## SECTION 7.0 – PLANNING AND DESIGN CRITERIA

**Table 7-1: Summary of Sewer Design Criteria**

| Design Criteria                                                     | Value  |
|---------------------------------------------------------------------|--------|
| Minimum pipe velocity                                               | 3 ft/s |
| Maximum pipe velocity                                               | 8 ft/s |
| $d/D$ ratio for $d$ less than 15 inches                             | 0.5    |
| $d/D$ ratio for $d$ greater than or equal to 15 inches              | 0.5    |
| $d/D$ ration for initiating improvements                            | 0.75   |
| Manning's $n$ for PVC (gravity sewers)                              | 0.012  |
| Manning's $n$ for VCP (gravity sewers) and all other pipe materials | 0.014  |
| Maintenance hole friction head loss during ADWF                     | 0.1 ft |
| Maintenance hole friction head loss during Peak flow                | 0.5 ft |

### 7.2 MAINTENANCE HOLES

Maintenance holes should be installed on sewers at all changes in slope, changes in size of pipe, changes in vertical or horizontal alignment, and at all intersections of main line sewers. Maintenance hole spacing should be 350 to 400 feet for pipes less than 15 inches in diameter, and 500 feet for pipes 15 inches in diameter and larger, with considerations made for line size, alignment, grade, and flow rates. The friction loss for maintenance holes during average dry weather flow conditions should be 0.1 ft, while the loss through a maintenance holes during peak flow should not exceed 0.5 ft. The Department provide standards on their websites for maintenance holes including standard maintenance holes flow channels, precast reinforced concrete maintenance holes, drop maintenance holes, clean outs, maintenance holes covers and frames. These standards further address material, size, diameter depth, and other maintenance hole attributes.

### 7.3 SPECIAL PROJECTS

In addition to the recommended design criteria for gravity sewers, the recommended design criteria for non-gravity sewer improvement projects are discussed in this section. These non-gravity sewer improvement projects include such facilities as lift stations, force mains, weirs, and siphons and are classified as special projects. Special projects are defined as any non-gravity conveyance of flow and should be avoided where possible, but often this type of infrastructure is required based on the hydraulic conditions and geography of a system. Recommended design criteria for these facilities are summarized in **Table 7-3**.

## SECTION 7.0 – PLANNING AND DESIGN CRITERIA

**Table 7-2: Design Criteria for Special Projects**

| Item             |                                     | Recommended Values                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------------------|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Special Projects | Lift Stations, Force Mains, Siphons | <ul style="list-style-type: none"><li>• Lift Stations and force mains will be avoided whenever possible.</li><li>• Average Dry Weather Flow (ADWF) (existing conditions) velocity = 3.0 fps minimum.</li><li>• Hazen-William's "C" factor of 120 will be used to analyze hydraulic conditions for all force mains in the system</li><li>• Force mains shall be sized to provide a design velocity no less than 4 ft. per second with all pumps running and 3.0 fps during normal operations.</li><li>• Maximum velocity shall be 10 fps.</li><li>• Siphons shall achieve a minimum velocity of 4.0 fps at during maximum average day flow</li><li>• Siphons shall have a minimum of two barrels to facilitate maintenance and repair</li><li>• Private force mains should be avoided whenever possible.</li></ul> |
|                  | Diversion Structures and Weirs      | <ul style="list-style-type: none"><li>• New diversion structures will be avoided whenever possible</li><li>• Maintain existing diversion structures open with no control setting whenever possible</li><li>• If a gate/stop-log setting is required for a diversion structure, maintain a fixed setting for all flow conditions whenever possible</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

### 7.4 SPECIAL CONDITIONS

Deviations from these criteria may be necessary in defining specific improvement projects for an existing sewer collection system due to the restrictions imposed by existing upstream and downstream conditions. In these special circumstances, design criteria will need to be determined on a case-by-case basis.



## SECTION 8

# Sewer Capacity Evaluation







## **8.0 SEWER CAPACITY EVALUATION**

This section presents the existing and build out system analysis in the calibrated hydraulic model. The model is used to assess dry and wet-weather flows for both planning horizons. This section concludes with capacity recommendations to address findings from this analysis.

### **8.1 SYSTEM EVALUATION**

The system was evaluated using results from the hydraulic model and applying the planning criteria discussed in Section 7. Each scenario, existing and build out, was evaluated for dry and wet weather results. The existing scenario was evaluated for dry weather, three wet weather design storms; a two-, ten-, and 25-year storm. Based on results from the existing analysis and discussion with SBMWD, the build out scenario was evaluated for dry weather and for a 2-year wet weather storm.

According to the planning criteria, a depth/diameter (d/D) ratio of 0.75 for modeled pipes was used as a trigger for this analysis; this section also shows pipes showing a modeled d/D ration between 0.5 to 0.75.

#### **8.1.1 Existing System Evaluation**

The model was built and calibrated as described in sections 5 and 6, respectively, in order to evaluate the sewer capacity under dry and wet weather conditions.

##### **8.1.1.1 Dry Weather Analysis**

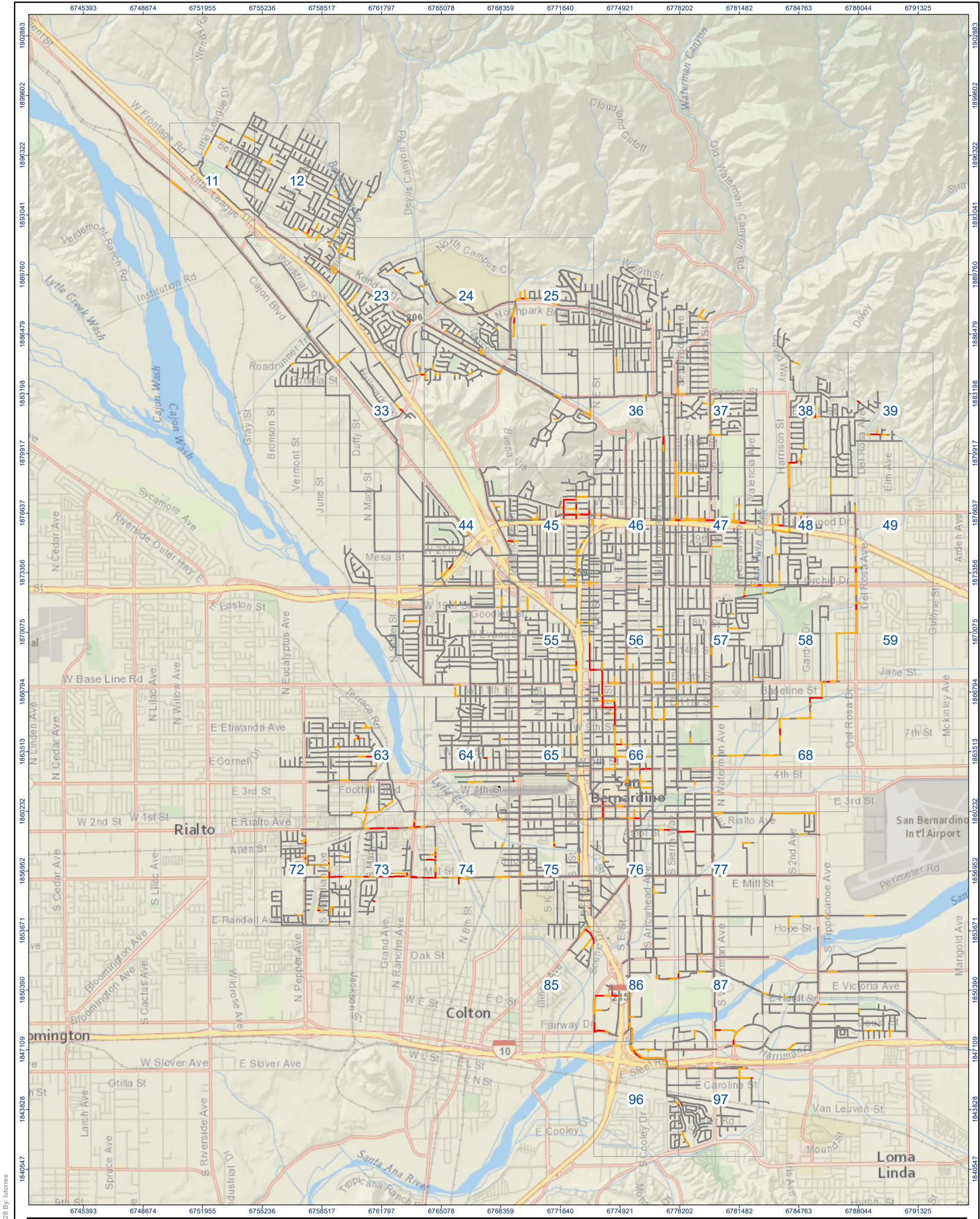
To evaluate the sewer capacity under dry weather condition, the model was built to simulate 24 hours of flow according to the dry weather calibrated results. The continuous simulation provides sufficient information to evaluate the system under all flow (low and peak) conditions during dry weather days.

Results for the existing dry weather analysis showed that 168 pipes reached a capacity of 75% or above under peak dry weather conditions. Figure 8-1 displays a system map with location of these pipes shown in red. Figure 8-2 shows a chart of the total length and number of pipes with a d/D ratio greater than or equal to 0.75 for small (less than 15 inches in diameter) and large (15 inches or greater in diameter) pipes as well as pipes with a d/D ratio between 0.50 and 0.75. It is noted that 2 of the 168 pipes with a d/D ratio greater than or equal to 0.75 are upstream of the SNRC diversion on the East Trunk Sewer and are planned to be transferred to EVWD after construction of the recycling facility.

## SECTION 8.0 – SEWER CAPACITY EVALUATION

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## Legend

### Sewer Pipes - Existing Dry Weather d/D ratio

- 0.0 - 0.499 (7,514)
- 0.5 - 0.749 (693)
- 0.75 - 1.0 (168)
- SBMWD Old Grids

**Notes**  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

0 1,250 2,500 metres  
(At original document size of 11x17)  
1:65,324



**Project Location** San Bernardino County  
California  
**Client/Project** Prepared by LTorres on 2019-10-28  
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Figure No.

8-1

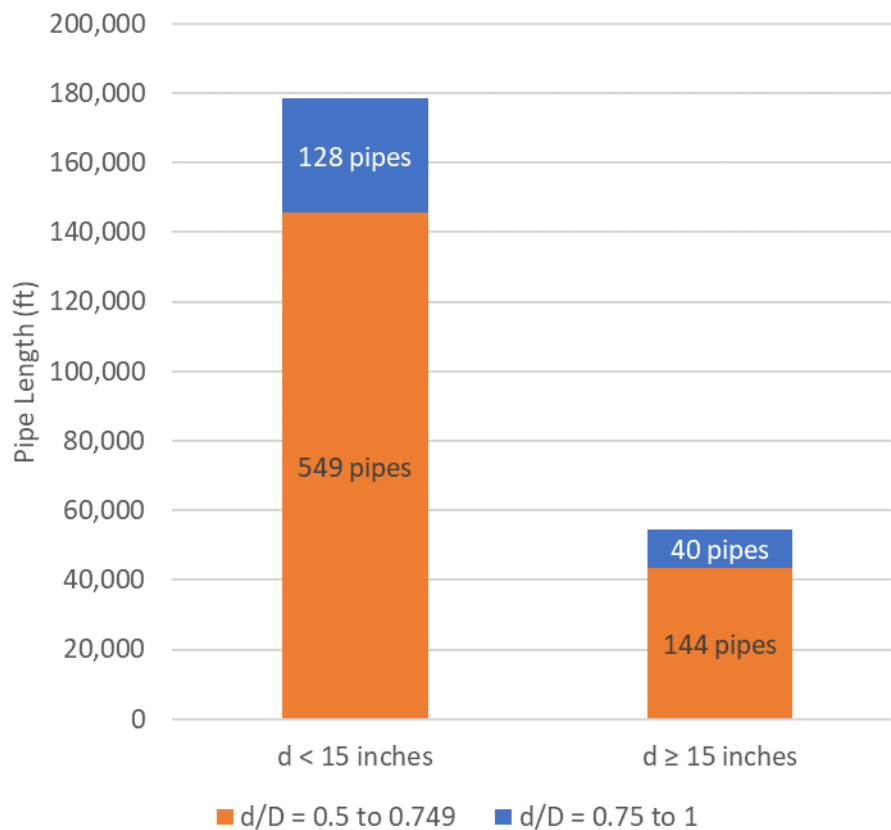
Title

Capacity Results for Existing Dry Weather  
Scenario





## SECTION 8.0 – SEWER CAPACITY EVALUATION

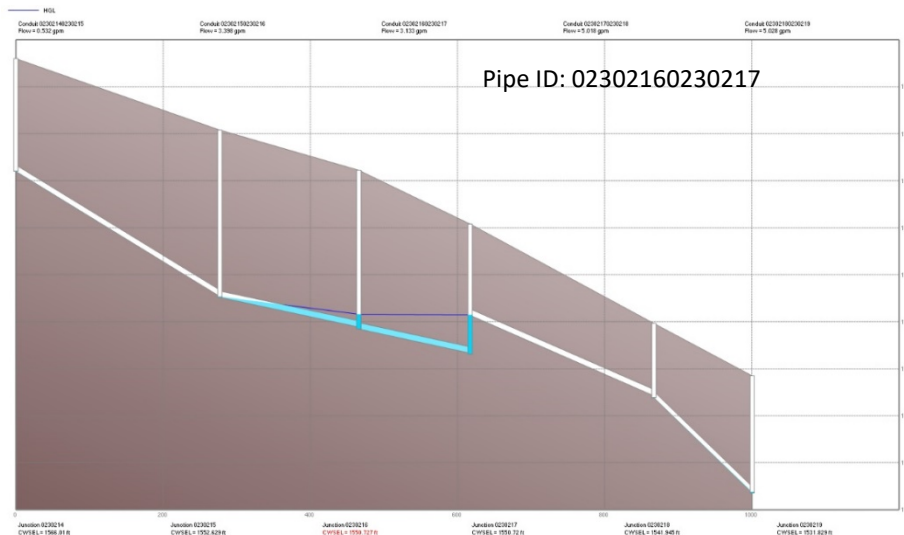


**Figure 8-2 Existing Dry Weather Capacity by d/D ratio and Diameter**

Section 5 outlines the data limitations encountered during model build. To confirm the results of the dry weather capacity analysis, all 168 pipes (43,864 ft) with d/D ratios of 0.75 or above were inspected manually. This was done by looking at the hydraulic profile of each pipe during peak flow conditions. Visual inspection allowed for identification of the cause of the capacity limitation, and they are categorized as follows:

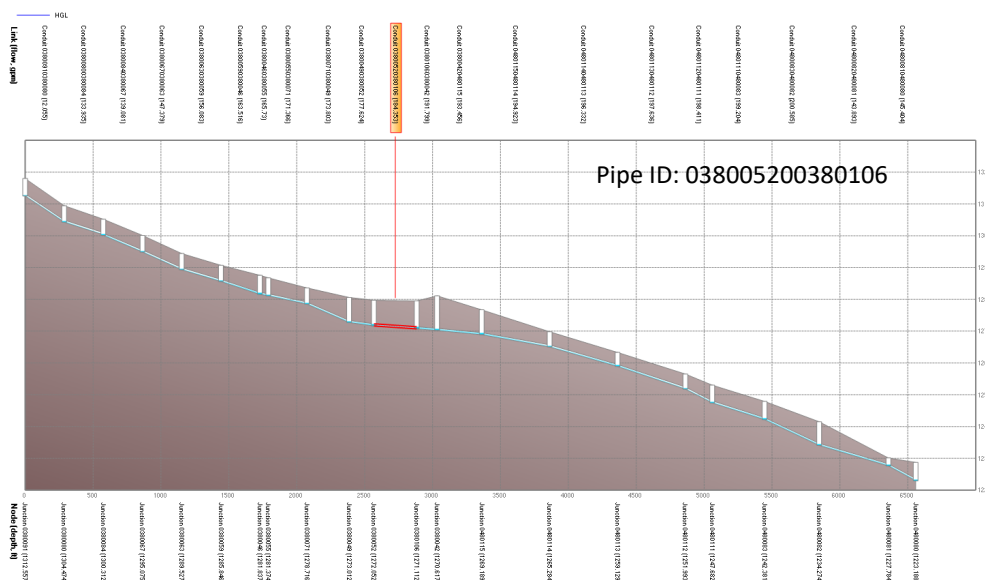
1. **Suspected GIS data issue:** While the pipe shows a d/D greater than or equal to 0.75, the limit in capacity is likely due to a suspected GIS issue, not a physical limitation in capacity. This cause was determined when the profile showed adverse slopes that could not be confirmed, unconfirmed pipe offsets, or pipe slopes that were abnormally steep. Figure 8-3 shows an example of a suspected GIS issue in the model.

## SECTION 8.0 – SEWER CAPACITY EVALUATION



**Figure 8-3 Example of Suspected GIS Issue**

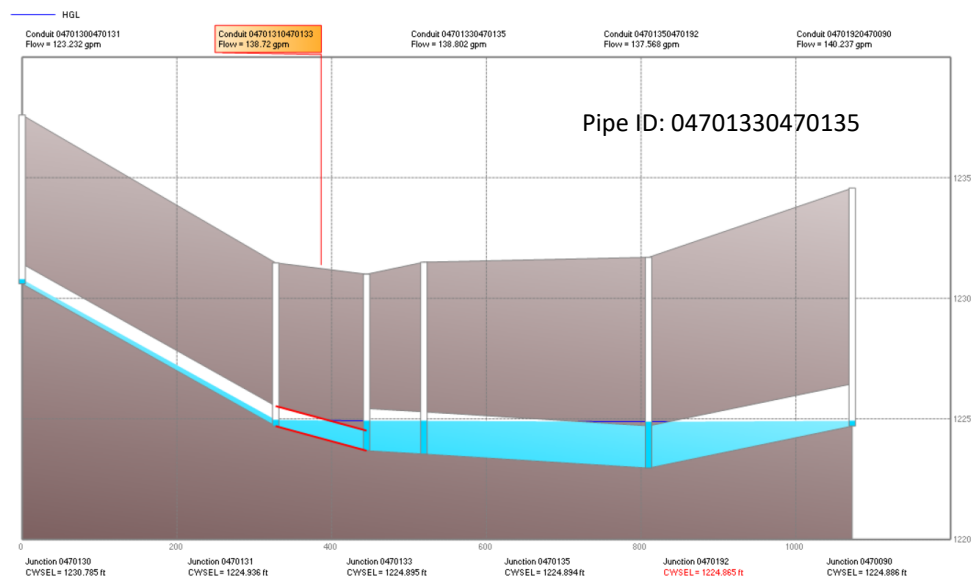
2. **True capacity issue:** If no immediate upstream or downstream GIS issues were identified, an extended profile of the pipe was reviewed, usually covering roughly half a mile from upstream to downstream. If, after examining the extended profile, no suspected GIS issues can be identified it is deemed a “true” capacity issue. Figure 8-4 shows an extended profile of Pipe ID 038005200380106. After examination of this profile, this pipe was categorized as having a true capacity issue.



**Figure 8-4 Example of True Capacity Issue**

3. **Pipe constriction issue:** A pipe constriction issue is a specific type of the suspected GIS issues. When the profile shows significant reduction in pipe diameter (more than 1 ft), it is categorized as a pipe constriction issue. Figure 8-5 shows an example of this type of model result.

## SECTION 8.0 – SEWER CAPACITY EVALUATION



**Figure 8-5 Example of Pipe Constriction Issue**

These results were presented and discussed with SBMWD staff to determine the preferred course of action to apply in the model. It was decided that pipes with Issue Type 2, or true capacity issues, should be investigated to determine the capacity needed to satisfy existing and build out demand scenarios. The remaining issues identified would continue to be investigated by SBMWD staff and updated information would be incorporated into future updates. Table 8-1 summarizes the count of pipes for each type of identified error and the proposed solution. Appendix G presents the profiles investigated during this exercise.

**Table 8-1 Summary of Capacity Issue Types**

| Issue Type   | Description                                                            | Count      | Proposed Solution                |
|--------------|------------------------------------------------------------------------|------------|----------------------------------|
| 1            | Suspected GIS issue (significant invert offset, steep negative slopes) | 130        | Field survey/confirmation        |
| 2            | True Capacity issue                                                    | 31         | Upgrade capacity                 |
| 3            | Pipe Contractions (possible GIS issue)                                 | 7          | Field survey/future confirmation |
| <b>Total</b> |                                                                        | <b>168</b> |                                  |

### 8.1.1.2 Wet Weather Analysis

To evaluate the sewer capacity under wet weather condition, the model was used to simulate flow for a two-year, ten-year, and 25-year storm. The results for each storm event are discussed in this section.

#### Two-Year Storm Analysis Results

Simulation of a two-year design storm in the model yielded 345 pipes with a d/D ratio greater than 0.75, comprising a total length of 101,878 ft. In addition to these 345 pipes, the following seven maintenance holes showed flooding in the model:

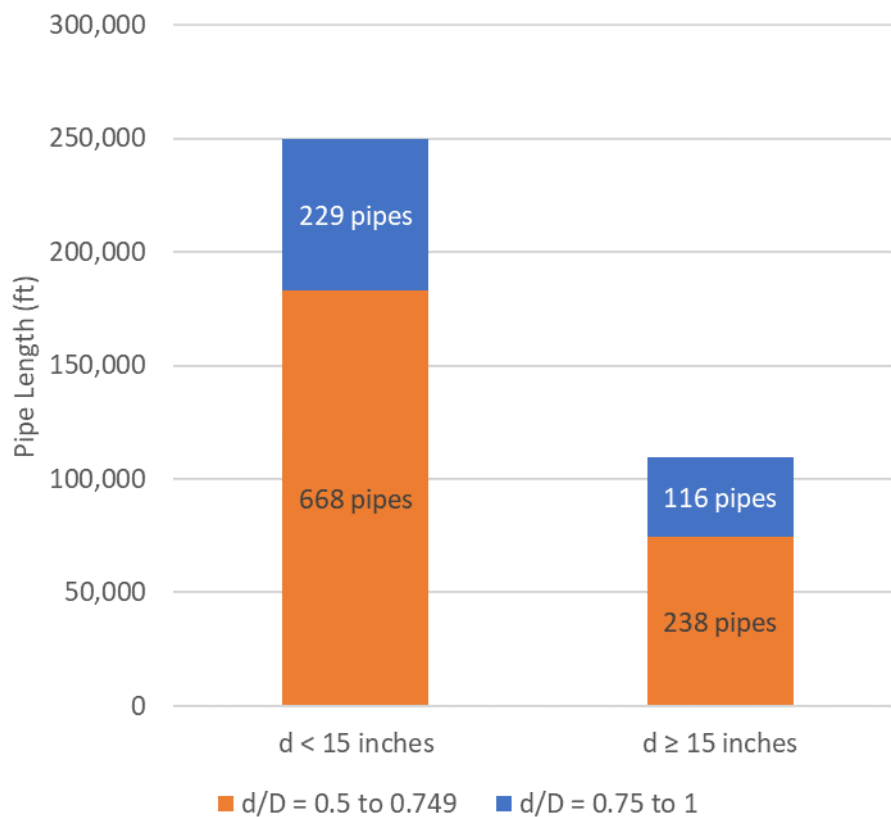
- SMH 0380048



## SECTION 8.0 – SEWER CAPACITY EVALUATION

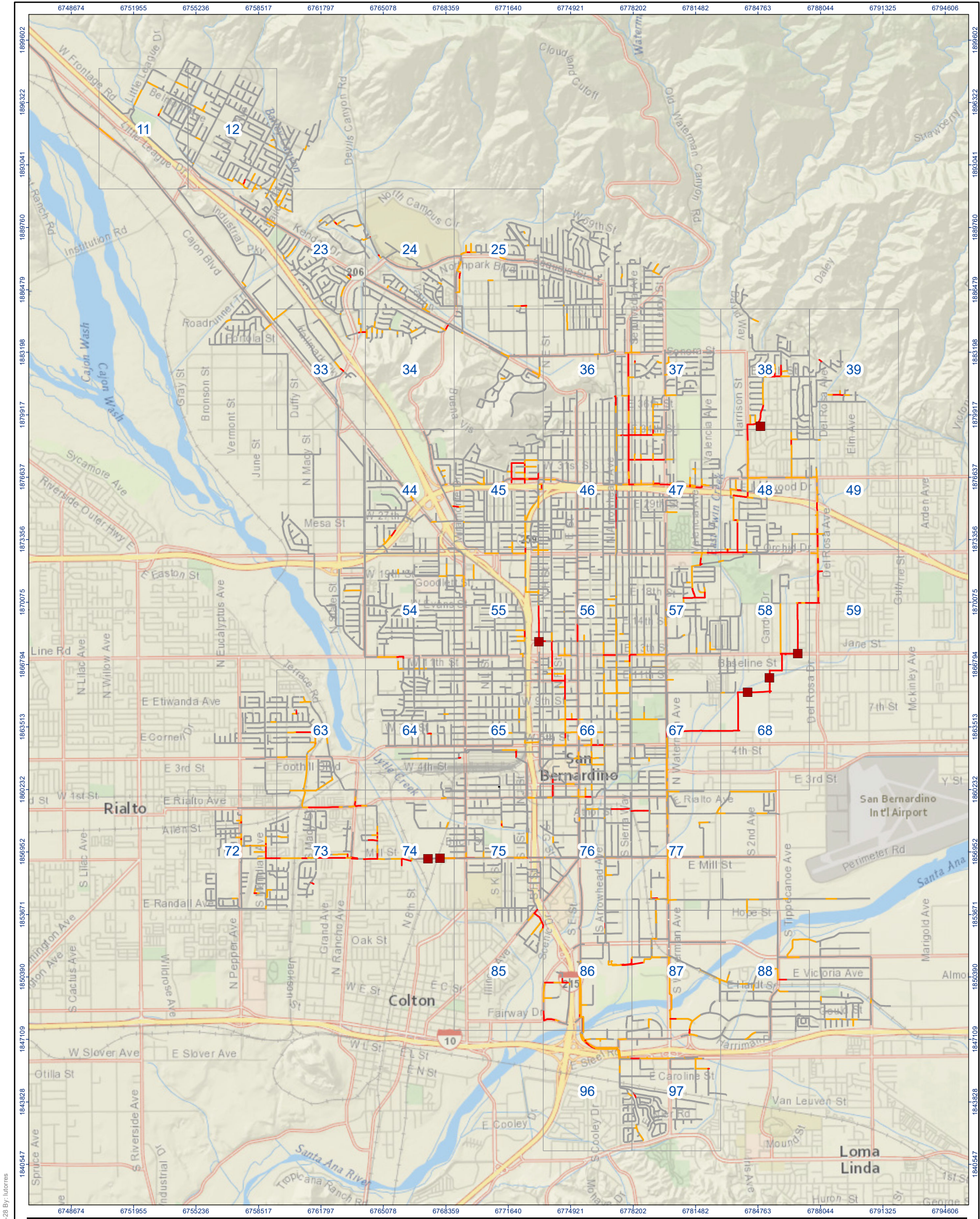
- SMH 0550154
- SMH 0580055 - (Upstream of the SNRC diversion on the East Trunk Line)
- SMH 0680039
- SMH 0680043
- SMH 0740052
- SMH 0740054

Figure 8-6 displays a chart of the total length and number of pipes with a d/D ratio greater or equal to than 0.75 for small (less than 15 inches in diameter) and large (15 inches or greater in diameter) pipes, as well as pipes with a d/D ratio between 0.50 and 0.75. Figure 8-7 shows the 345 pipes with d/D ratios greater than or equal to 0.75, as well as the seven flooded nodes (maintenance holes) during the two-year storm simulation. One of the flooded nodes and 33 of the 345 pipes with d/D ratios greater than or equal to 0.75 are upstream of the SNRC diversion and are planned to be transferred to EVWD after construction of the recycling facility.



**Figure 8-6 Existing Wet Weather 2-Year Storm Capacity by d/D Ratio and Diameter**





## Legend

### Sewer Pipes - Existing 2-year Storm d/D ratio

- 0.00 - 0.499 (7,118)
- 0.5 - 0.749 (906)
- 0.75 - 1.0 (345)
- Flooding Junctions
- SBMWD Old Grids

**Notes**  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

0 1,200 2,400 metres  
(At original document size of 11x17)  
1:62,356



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Figure No.

8-7

**Capacity and Flooding Results for Existing Wet Weather Scenario (2-year Storm)**





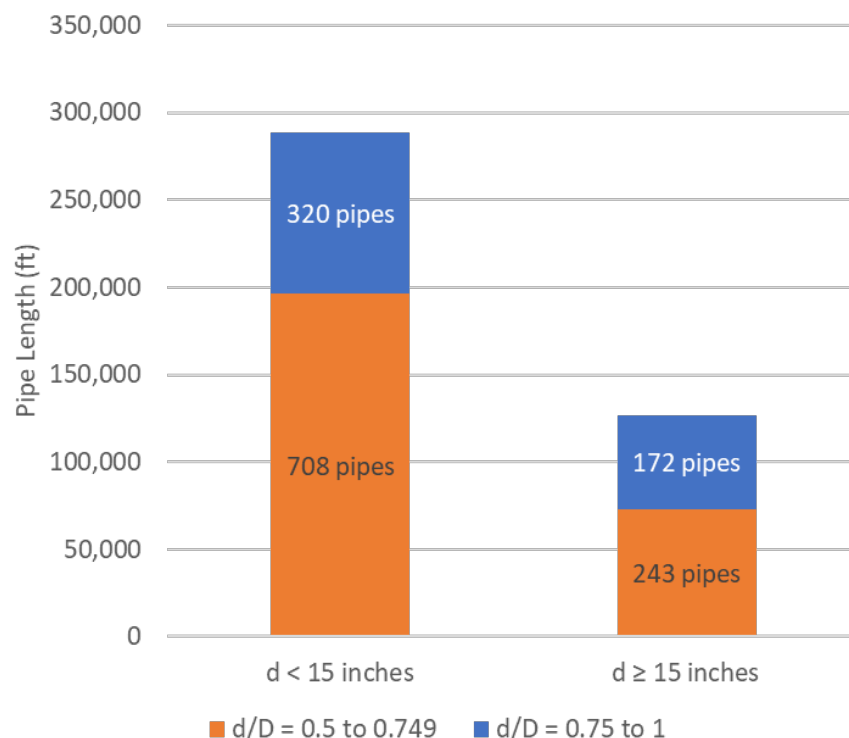
## SECTION 8.0 – SEWER CAPACITY EVALUATION

### Ten-year Storm Results

The ten-year storm simulation shows 492 pipes with d/D ratios greater than or equal to 0.75 and 15 flooded nodes. 55 of the 492 pipes are upstream of the SNRC diversion, as are 2 of the 15 flooded nodes. In addition to the seven nodes that flood during the two-year storm analysis, the ten-year storm shows the following eight additional maintenance hole IDs flooded:

- SMH 0360169
- SMH 0380100
- SMH 0470028
- SMH 0470035
- SMH 0470087
- SMH 0470163
- SMH 0580054 - (Upstream of the SNRC diversion on the East Trunk Line)
- SMH 0860134

Figure 8-8 displays a chart of the total length and number of pipes with a d/D ratio greater than or equal to 0.75 for small (less than 15 inches in diameter) and large (15 inches or greater in diameter) pipes, as well as pipes with a d/D ratio between 0.50 and 0.75. Figure 8-9 shows in red the location of these pipes as well as the 15 nodes that are flooded during the 10-year storm analysis.



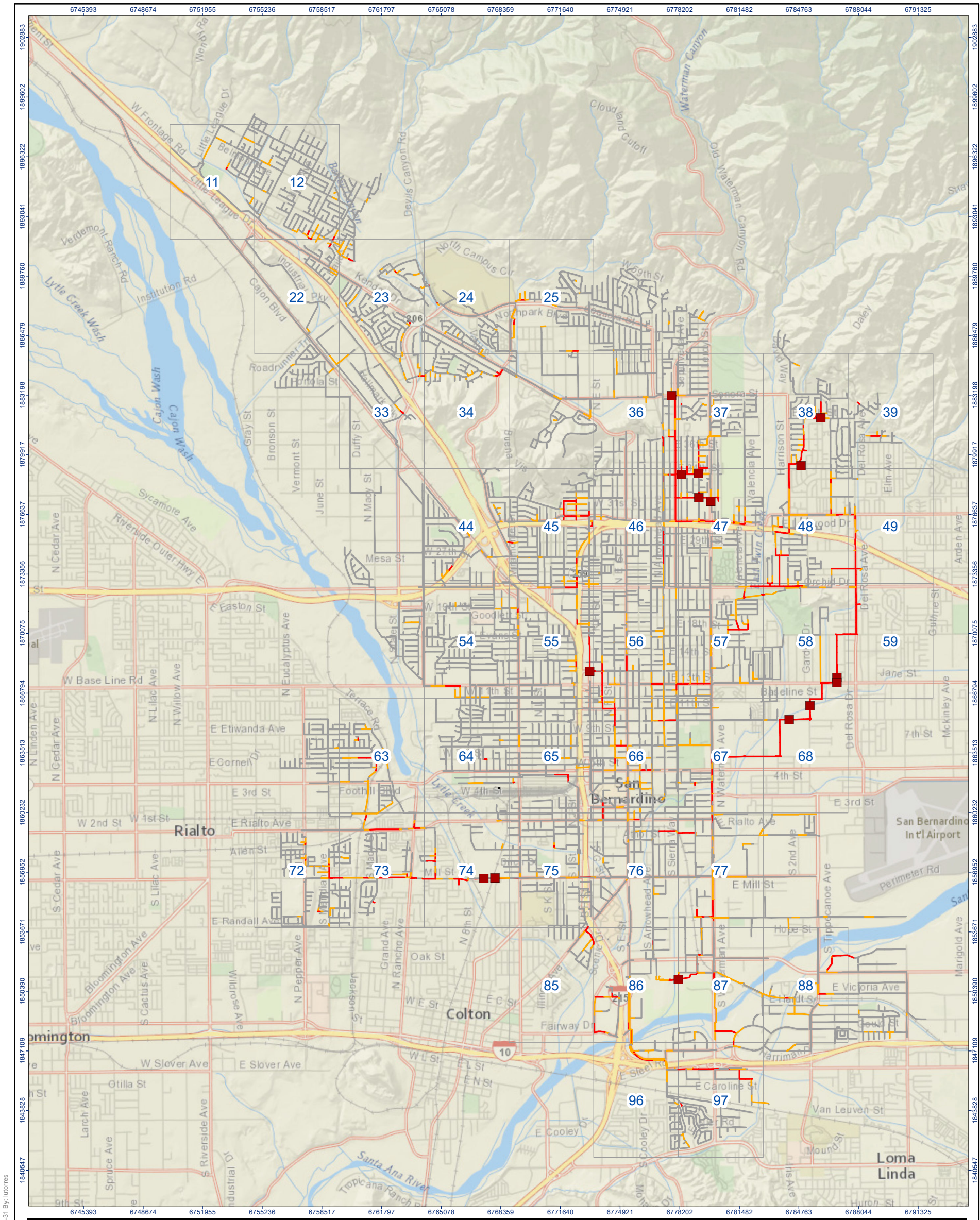
**Figure 8-8 Existing Wet Weather 10-Year Storm Capacity by d/D Ratio and Diameter**



## SECTION 8.0 – SEWER CAPACITY EVALUATION

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## Legend

### Sewer Pipes - Existing 10-year Storm d/D ratio

- 0.00 - 0.499 (6,932)
- 0.5 - 0.749 (951)
- 0.75 - 1.0 (492)
- SBMWD Old Grids
- Flooding Junctions

**Notes**  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

0 1,250 2,500 metres  
(At original document size of 11x17)  
1:65,324



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Figure No.

8-9

**Capacity and Flooding Results for Existing Wet Weather Scenario (10-year Storm)**





## SECTION 8.0 – SEWER CAPACITY EVALUATION

### 25-year Storm Results

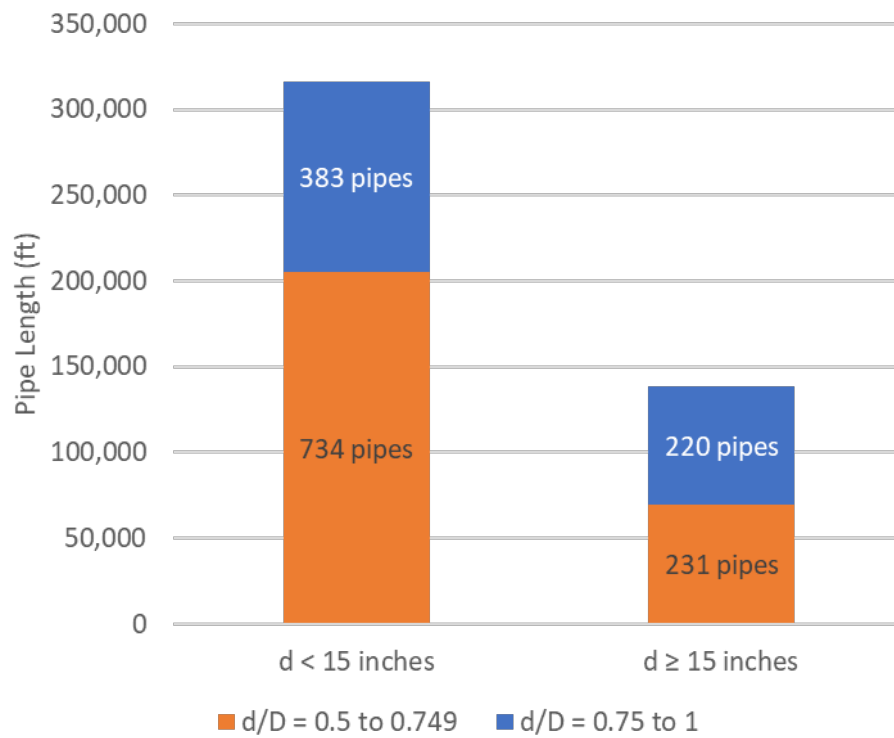
The 25-year storm results for the existing scenario show a total of 603 pipes with d/D greater than or equal to 0.75 and 25 total nodes that are flooded. 68 of the 603 pipes with d/D greater than or equal to 0.75 and four of the flooded nodes are upstream of the SNRC diversion. Figure 8-10 displays a chart of the total length and number of pipes with a d/D ratio greater than or equal to 0.75 for small (less than 15 inches in diameter) and large (15 inches or greater in diameter) pipes, as well as pipes with a d/D ratio between 0.50 and 0.75. The flooded nodes consisted of the seven nodes which exhibited flooding during the two-year storm, eight nodes that exhibited flooding during the ten-year storm, and 10 additional nodes that showed flooding at the 25-year storm. The maintenance hole IDs for the ten new nodes exhibiting flooding are:

- SMH 0360164
- SMH 0470164
- SMH 0480011
- SMH 0480013
- SMH 0560049
- SMH 0580002 - (Upstream of the SNRC diversion on the East Trunk Line)
- SMH 0580059 - (Upstream of the SNRC diversion on the East Trunk Line)
- SMH 0680026
- SMH 0870017
- SMH 0880088

Figure 8-11 shows in pipes with d/D greater than or equal to 0.75 in red in addition to the 25 flooded nodes.

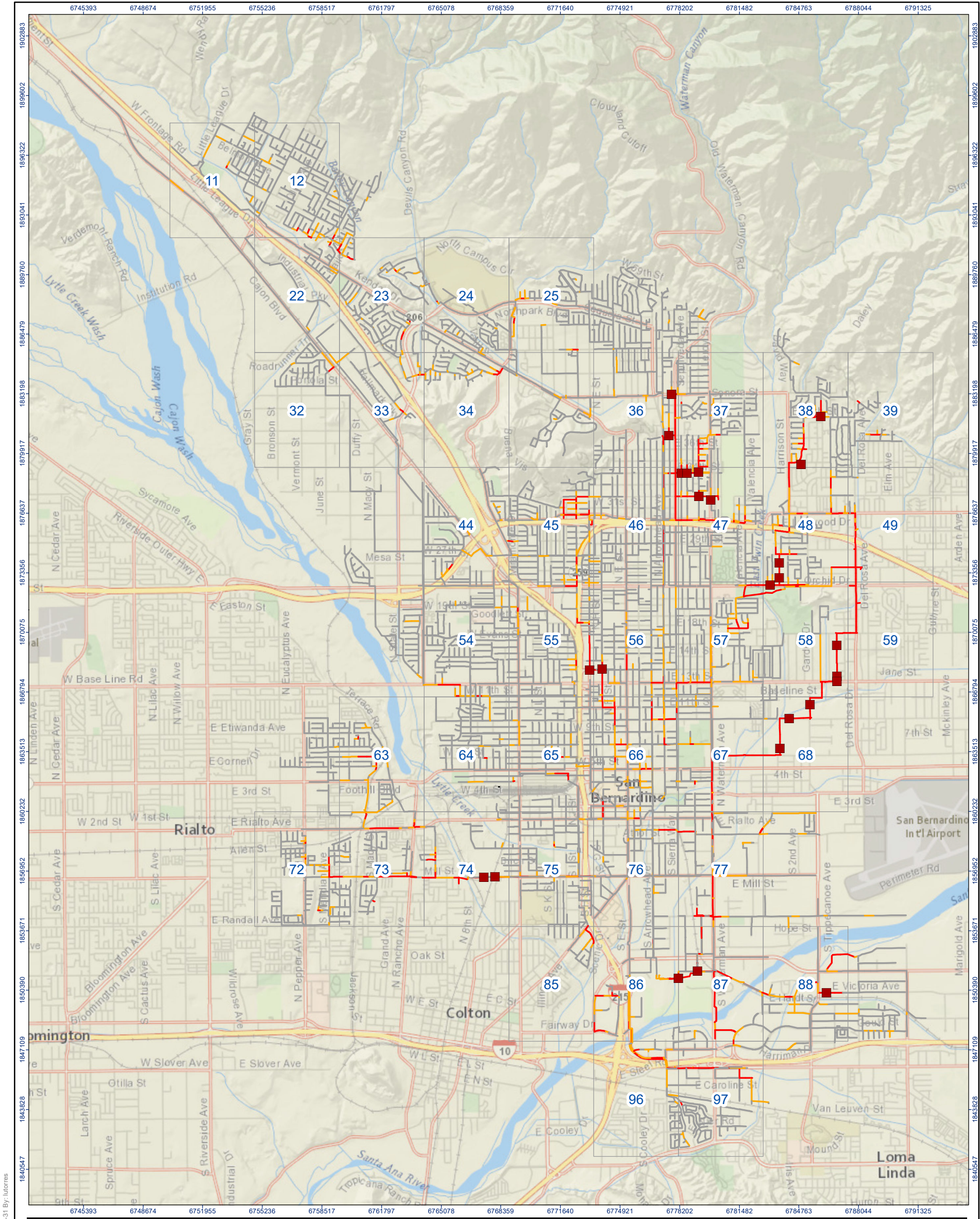


## SECTION 8.0 – SEWER CAPACITY EVALUATION



**Figure 8-10 Existing Wet Weather 25-year Storm Capacity by d/D Ratio and Diameter**



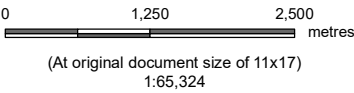


## Legend

### Sewer Pipes - Existing 25-year Storm d/D ratio

- 0.0 - 0.499 (6,807)
- 0.5 - 0.749 (965)
- 0.75 - 1.0 (603)
- SBMWD Old Grids
- Flooding Junctions

**Notes**  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.



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Figure No.

8-11

**Capacity and Flooding Results for Existing Wet Weather Scenario (25-year Storm)**





### 8.1.2 Build Out Evaluation

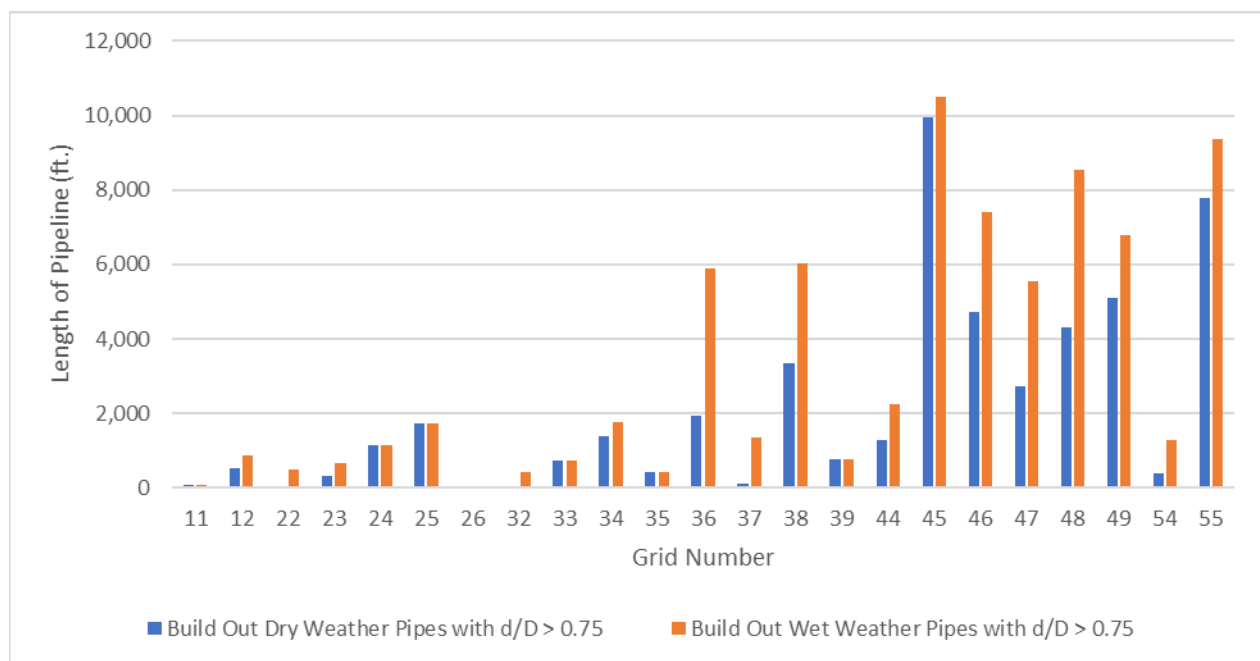
The build out scenario has additional flow due to multiple future developments, septic customers that are assumed to be converted, and additional infill from projected population growth. Using the demand assumptions indicated in Sections 4, the system capacity was evaluated for dry weather and for a 2-year wet weather storm for the build out scenario. The following subsections discuss the dry weather and wet weather 2-year storm results.

#### 8.1.2.1 Dry Weather Analysis

For the build out dry weather analysis, a total of 461 pipes were identified as having a d/D greater than or equal to 0.75. Additionally, six nodes were identified as flooded during the build out dry weather scenario. Figure 8-14 shows the location of these pipes and they are listed in full in Appendix G.

#### 8.1.2.2 Wet Weather Analysis – 2 Year Storm

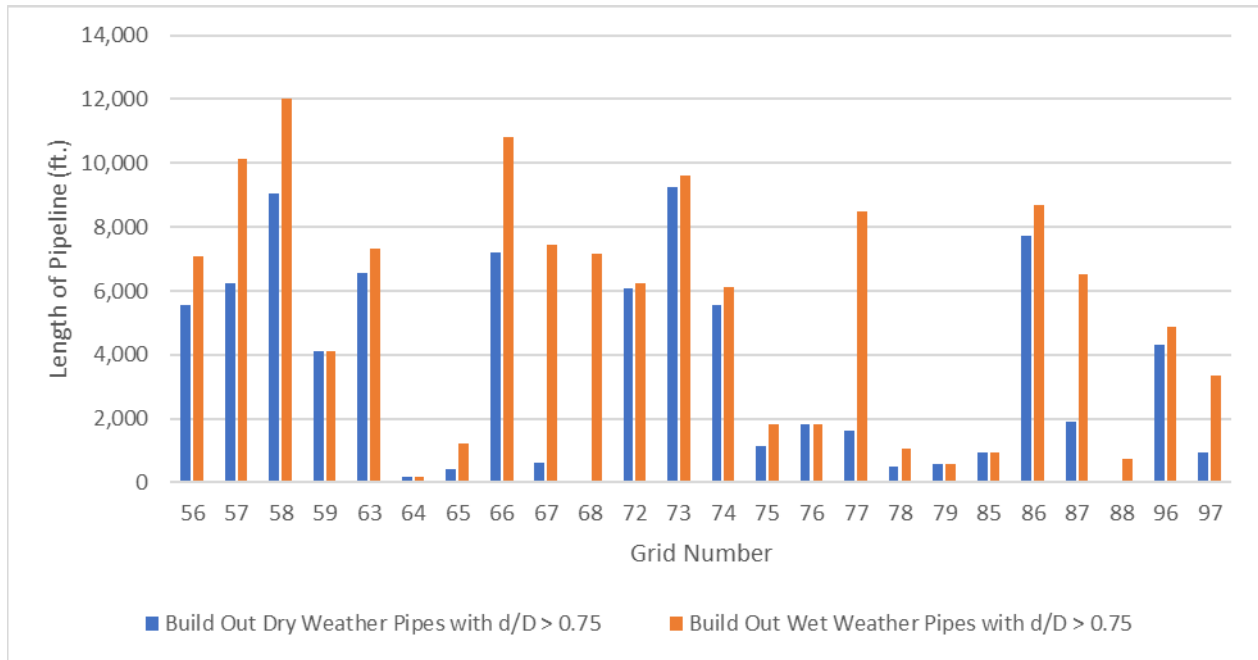
The wet weather storm that was analyzed for the build out scenario was the two-year design storm. After loading a two-year storm frequency into the build out scenario, 694 pipes showed a d/D greater than or equal to 0.75. In addition to the same six nodes that flooded in the build out dry weather scenario, 16 nodes also flooded during the build out wet weather two-year storm analysis. Figure 8-12 and Figure 8-13 summarize the total length of pipeline with modeled d/D results greater than or equal to 0.75 in the dry and wet weather build out scenarios, organized by grid. Figure 8-15 shows the pipes and flooded nodes identified in the two-year wet weather build out scenario.



**Figure 8-12: Summary of Pipeline with d/D Greater than or Equal to 0.75, Grids 1-55**

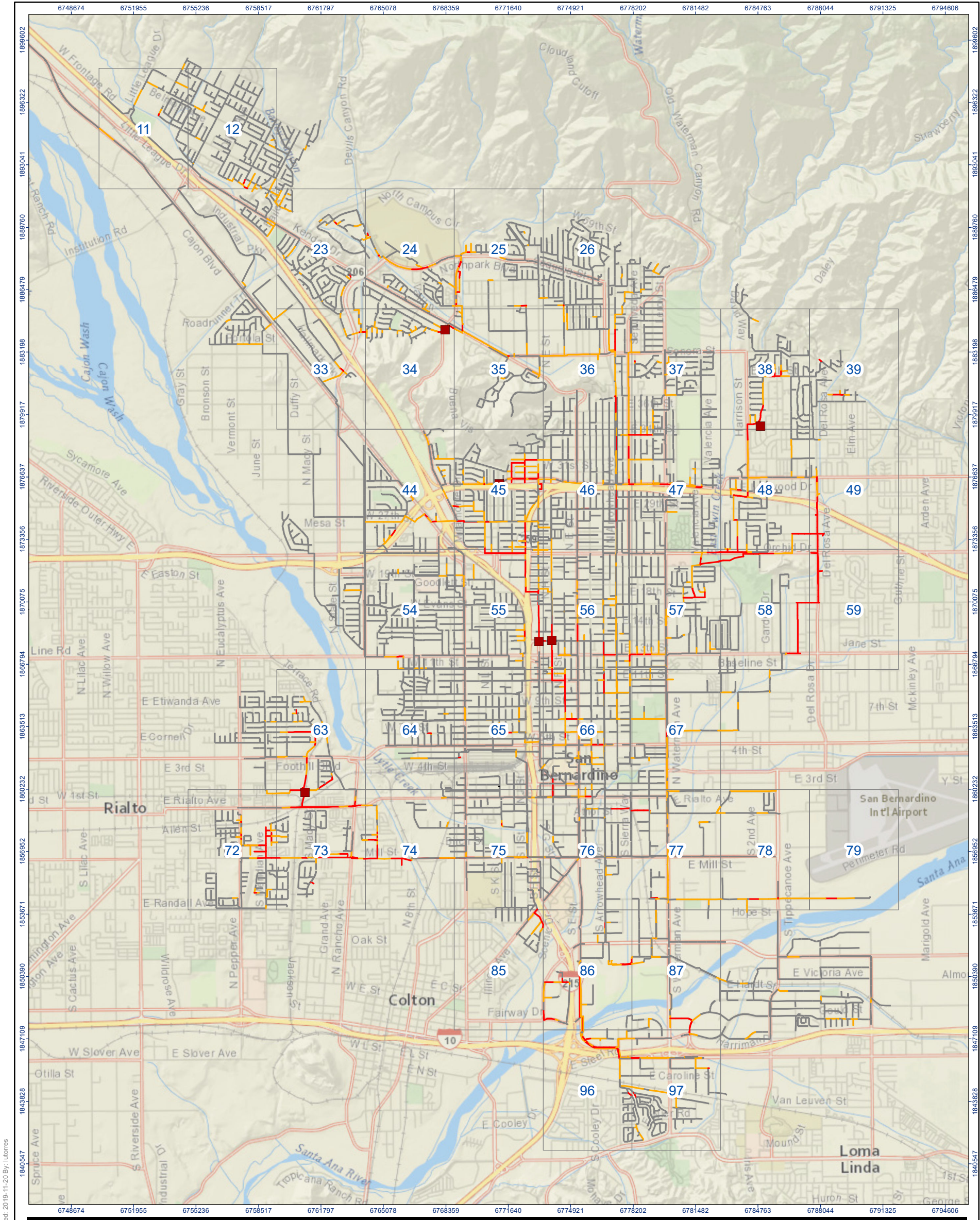


## SECTION 8.0 – SEWER CAPACITY EVALUATION



**Figure 8-13 Summary of Pipeline with d/D Greater than or Equal to 0.75, Grids 56-97**





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## Legend

### Sewer Pipes - Build out Dry Weather d/D ratio

- 0.0 - 0.499 (6,817)
- 0.50 - 0.749 (1,111)
- 0.75 - 1.00 (461)
- Flooding Junctions
- SBMWD Old Grids

**Notes**  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

0 1,100 2,200 metres  
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Figure No.

8-14

Title

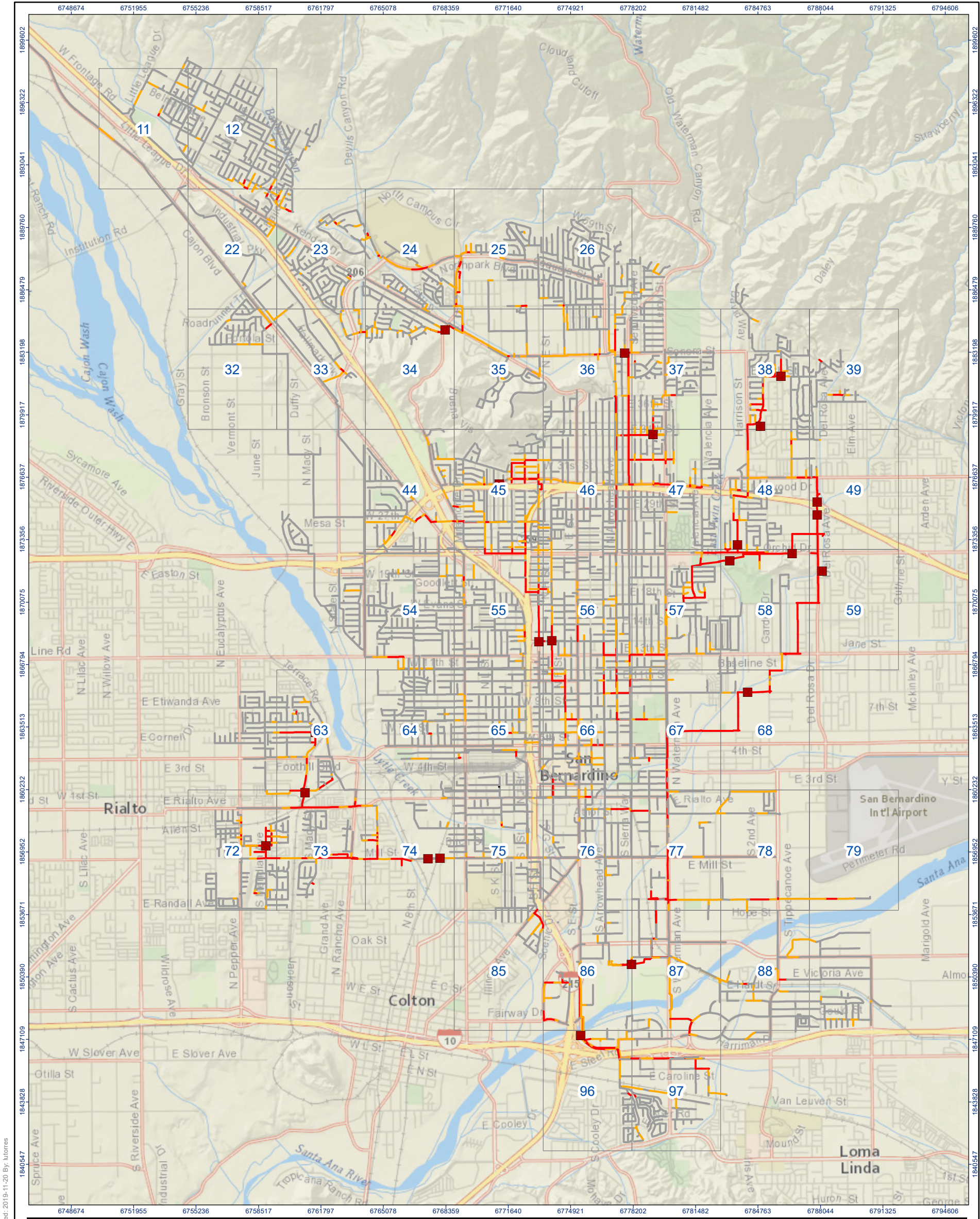
**Capacity and Flooding Results for Build out Dry Weather Scenario**

Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.









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## Legend

### Sewer Pipes - Build out Wet Weather d/D ratio

- 0.0 - 0.499 (6,591)
- 0.5 - 0.749 (1,104)
- 0.75 - 1.0 (694)
- Flooding Junctions
- SBMWD Old Grids

**Notes**  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

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(At original document size of 11x17)  
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Figure No.

8-15

Title

Capacity and Flooding Results for Build out Wet Weather Scenario (2-year Storm)

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## 8.2 CAPACITY RECOMMENDATIONS

The following subsections summarize the improvement recommendations for both the existing and build out scenarios.

### 8.2.1 Existing System Improvements

Per discussions with SBMWD, the pipes identified for existing dry weather capacity issues were addressed by building improvements in the model and testing the solution through iterative model runs. Of the 168 pipes identified as having a d/D greater than or equal to 0.75, only 31 were identified as having true capacity issues that were not caused by suspected GIS issues. These 31 pipes were investigated further, and capacity improvements were built into the model to address the capacity deficiencies.

In addition to the existing dry weather capacity improvements, improvements were also modeled to fix the existing flooded nodes. Of the seven nodes identified as flooding as a result of the two-year storm, only three were due to capacity issues. The remaining four had suspected GIS issues present that seemed to contribute to the flooding. The modeled improvements for both existing dry weather capacity issues and two-year wet weather flooding nodes are listed in Table 8-2.

**Table 8-2 Existing System Capacity Improvements**

| Pipe ID        | d/D at Existing | Old Diameter (in) | New Diameter (in) | d/D at Buildout | Comment                                                                                                                         |
|----------------|-----------------|-------------------|-------------------|-----------------|---------------------------------------------------------------------------------------------------------------------------------|
| 03800520380106 | 0.83            | 8                 | 12                | 0.61            | 2-year flooding of 0380048                                                                                                      |
| 03801060380042 | 0.81            | 8                 | 12                | 1               | 2-year flooding of 0380048. 12" diameter is sufficient for build out, but 4 downstream pipes must also be upsized at build out. |
| 05501470550146 | 1               | 12                | 15                | 0.66            | 2-year flooding of 0550154                                                                                                      |
| 05501480550154 | 1               | 15                | 18                | 0.56            | 2-year flooding of 0550154                                                                                                      |
| 05501540560032 | 1               | 8                 | 12                | 0.63            | 2-year flooding of 0550154                                                                                                      |
| 05600280660054 | 1               | 8                 | 15                | 0.49            | 2-year flooding of 0550154                                                                                                      |
| 05600290560028 | 1               | 8                 | 15                | 0.49            | 2-year flooding of 0550154                                                                                                      |
| 05600310560029 | 1               | 8                 | 15                | 0.51            | 2-year flooding of 0550154                                                                                                      |
| 05600320560031 | 1               | 8                 | 15                | 0.49            | 2-year flooding of 0550154                                                                                                      |
| 05700100570006 | 0.77            | 10                | 15                | 0.91            | Pipe diameter is satisfactory, but 7 upstream/downstream pipes must also be upsized at build out.                               |
| 06600580660073 | 0.76            | 8                 | 12                | 0.53            |                                                                                                                                 |
| 06600600660077 | 1               | 8                 | 12                | 0.62            |                                                                                                                                 |
| 06600640660077 | 1               | 8                 | 12                | 0.39            |                                                                                                                                 |

## SECTION 8.0 – SEWER CAPACITY EVALUATION

| Pipe ID        | d/D at Existing | Old Diameter (in) | New Diameter (in) | d/D at Buildout | Comment                                                                                                                                                          |
|----------------|-----------------|-------------------|-------------------|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 06600720660058 | 0.85            | 8                 | 12                | 0.6             |                                                                                                                                                                  |
| 06600770660072 | 1               | 8                 | 12                | 0.68            |                                                                                                                                                                  |
| 06601020660096 | 0.8             | 8                 | 15                | 0.44            |                                                                                                                                                                  |
| 06601400660141 | 0.75            | 8                 | 15                | 0.64            |                                                                                                                                                                  |
| 06601460660158 | 0.76            | 8                 | 12                | 0.53            |                                                                                                                                                                  |
| 06601580660159 | 0.78            | 8                 | 15                | 0.69            |                                                                                                                                                                  |
| 06600730660092 | 0.74            | 8                 | 12                | 0.76            | Pipe diameter is satisfactory, but 3 upstream/downstream pipes must also be upsized at build out.                                                                |
| 06600960660103 | 0.72            | 8                 | 15                | 0.67            | Downstream effect of upsizing 06601020660096                                                                                                                     |
| 06601440660146 | 0.59            | 8                 | 12                | 0.44            | Related to upsizing of 06601460660158                                                                                                                            |
| 05600490560039 | 1               | 8                 | 21                | 0.63            | May be also GIS issue as upstream diameter is 21" and downstream pipe diameter is 27". 15" upsize would be acceptable for existing, but 21" needed at build out. |
| 06600230660060 | 1               | 8                 | 12                | 0.51            |                                                                                                                                                                  |
| 06600540660056 | 1               | 8                 | 12                | 0.49            |                                                                                                                                                                  |
| 06600560660023 | 0.87            | 8                 | 12                | 0.49            |                                                                                                                                                                  |
| 06601040660107 | 0.78            | 8                 | 12                | 0.49            |                                                                                                                                                                  |

Although 31 pipes were identified as needing capacity improvements for the existing dry weather scenario, only 18 pipes pertaining to existing dry weather capacity issues are shown in Table 8-1. The remaining 13 pipes all fell into the West Residential area previously discussed in Section 6. Figure 8-16 and Figure 8-17 show the stretch of pipe in question. While there are GIS issues present within the highlighted pipe segments, there were also pipes that seemed to have actual capacity issue. Upon further discussion with SBMWD, it was agreed that a special area study would be conducted for this area, assuming investigation of approximately 100 maintenance holes to confirm invert elevations and flow monitoring at three locations to confirm the quantity and pattern of flow in this area.

### 8.2.2 Build Out System Improvements

8.27



## SECTION 8.0 – SEWER CAPACITY EVALUATION

8-17 show these areas of concern, and a table of all pipes with limited capacity (summarized by grid) can be found in Appendix G. It is recommended that SBMWD continue to monitor these pipes and reference this list when new development or significant changes in wastewater generation occur in specific regions of the service area.

### 8.2.3 Final Capacity Recommendations

After further discussion with SBMWD, it was agreed that the modeled capacity improvements discussed in Section 8.2.1 should be investigated further before inclusion into a Capital Improvement Program (CIP). Based on the data issues identified during the model build process, further investigation and confirmation of model results with field data is warranted. It is recommended that SBMWD:

- Continue to investigate the data issues identified in Section 5.
- Pursue the special area study for the West Residential area as identified in Section 8.2.1.
- Continue to survey maintenance holes in the system to confirm invert elevations
- Use survey results to confirm connectivity between pipelines
- Conduct flow studies to confirm the d/D ratios presented in Table 8-2
- Update the GIS database with data obtained from these efforts
- Recalibrate the model after updating with these field investigations and reassess the recommended projects and areas of concern.

These steps will help refine the model and confirm if the capacity issues identified are indeed necessary.

SECTION 9

# Condition Assessment





## **9.0 CONDITION ASSESSMENTS**

This section summarizes the condition assessment work completed as part of the 2019 SMP Update. For this update, Stantec performed an analysis of the condition of the SBMWD gravity pipelines based on the available CCTV videos and analysis by Innerline Engineering (Innerline) and Houston and Harris PCS, Inc., (H&H) and City's GIS data. Stantec also completed inspection of SBMWD lift stations, siphons, and maintenance holes through our subconsultants, V&A Engineers (V&A), and TKE Engineering (TKE), as well as with Stantec staff. The findings from these efforts are summarized in this section. Section 10 – Capital Improvement Program presents the capital project recommendations and costs that emanated from these analyses.

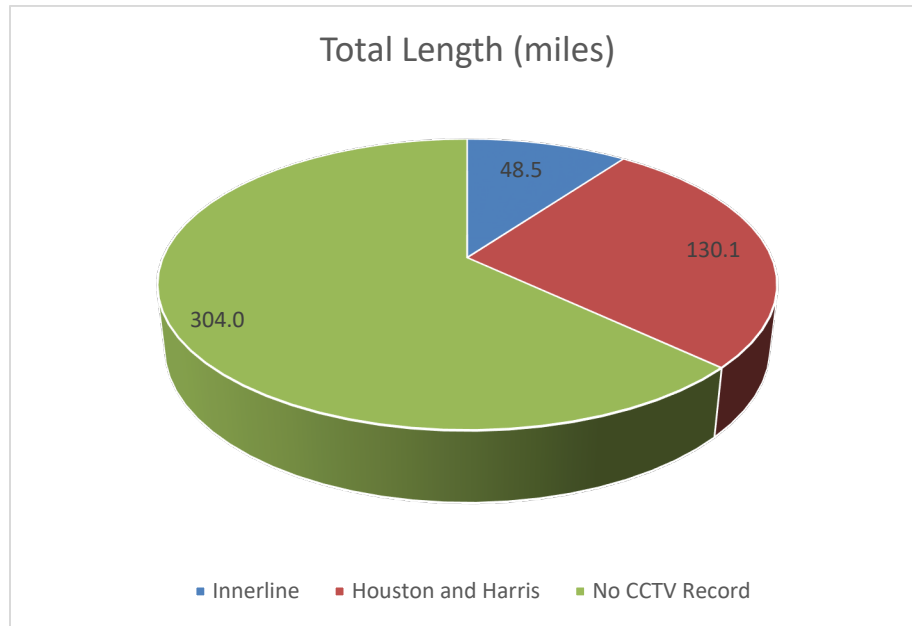
### **9.1 GRAVITY MAINS**

#### **9.1.1 CCTV Program**

As part of the contract to update SBMWD's sewer master plan, Stantec and Innerline delivered a CCTV and cleaning program of pipelines 12 inches and greater in diameter not previously addressed by H&H. In addition to this work, SBMWD provided Stantec with videos and reports from the H&H CCTV program conducted previous to the update; this effort was conducted by H&H under contract with the City of San Bernardino and prior to the transfer to the Department. Stantec used the findings from these efforts, including review of CCTV video; analysis of PACP and risk scoring; review of reports and pictures; and conversations with SBMWD staff to complete the system-wide condition assessment of pipe condition. Figure 9-1 summarizes the length of gravity mains where CCTV was available. Pipe with CCTV footage are mapped on Figure 9-2. A small number pipes from the historical H&H data were not able to be located based on the provided pipe reference data (i.e. the pipe identifications could not be matched to the SBMWD GIS) or were excluded as Innerline had more recent inspection data for sewer pipes. All videos, reports, tracking, and pictures from Innerline's work as part of this project effort have been submitted to SBMWD for reference.

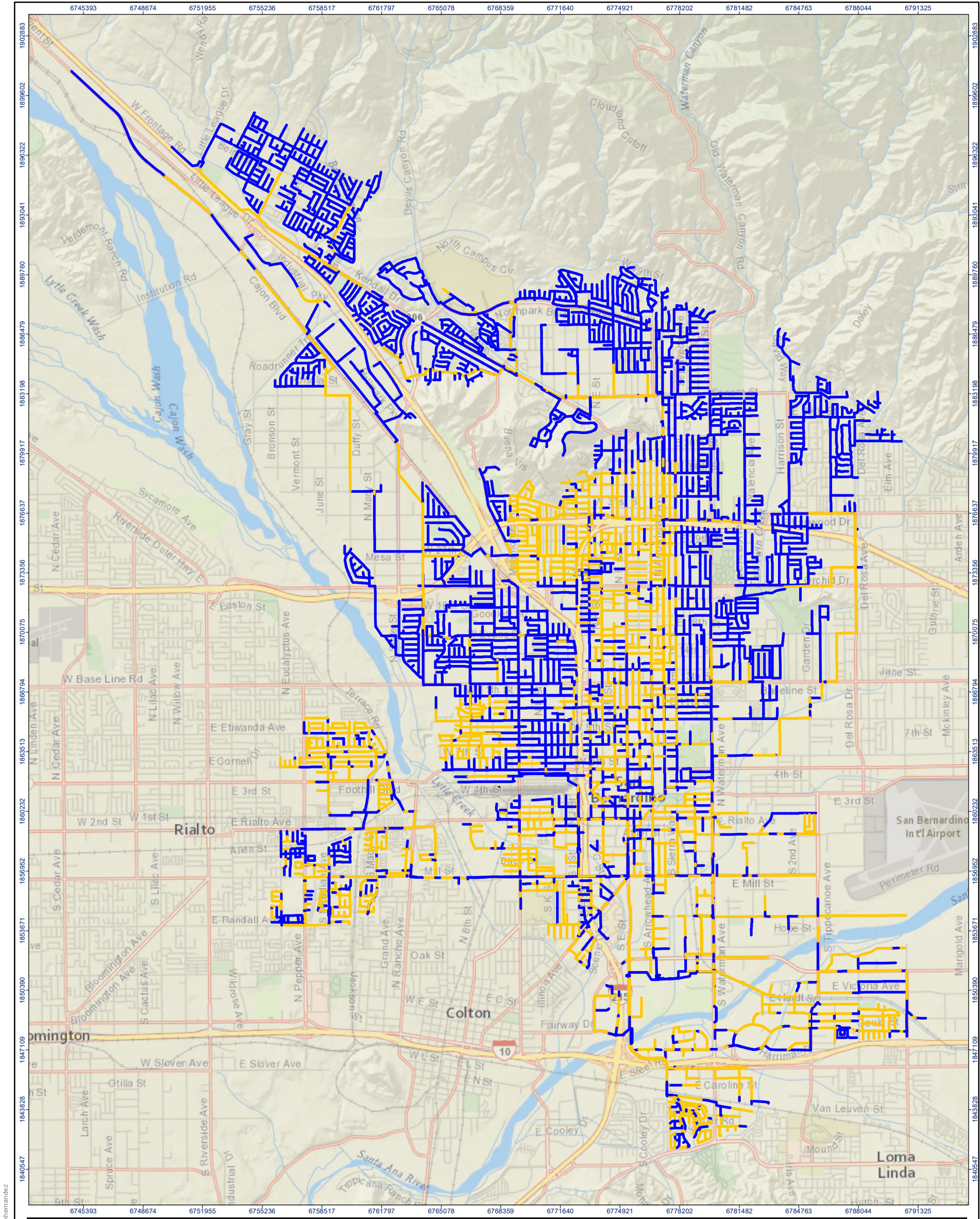


## SECTION 9.0 - CONDITION ASSESSMENTS



**Figure 9-1 Pipe Lengths by CCTV Records**

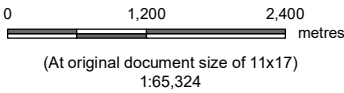




## Legend

### Record Present

- CCTV
- No CCTV



**Project Location** San Bernardino County  
California  
**Client/Project** Prepared by LTorres on 2019-10-25  
Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.

**9-2**

Title

**Pipes with CCTV Records**

#### Notes

- Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
- Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.





## SECTION 9.0 - CONDITION ASSESSMENTS

### 9.1.2 Condition Assessment of Pipelines

Stantec completed the condition assessment of pipelines using a risk-based assessment to determine recommended actions and the timing of those actions. This risk-based assessment approach consists of determining an overall risk score for individual pipes by factoring both likelihood of failure (LoF) and consequence of failure (CoF). The LoF takes into consideration the physical state of a pipe or factors that will contribute to the deterioration of a pipe to estimate the probability of a pipe collapse. The CoF score focuses on the impact a pipe failure would have on the system by looking at physical, environmental, social, and economic factors surrounding that pipe.

Recent CCTV records are the most accurate indicator of each pipes' LoF; visual records provide direct evidence of pipe defects. Therefore, pipes with CCTV records were analyzed using CCTV as the sole LoF criteria and it is recommended that any pipe have CCTV completed before a rehabilitation or replacement project is initiated.

#### 9.1.2.1 Methodologies

This section describes the methodology for prioritization of pipelines based on LoF and CoF criteria and calculation of an overall adjusted risk score.

##### 9.1.2.1.1 Prioritization

The prioritization of pipe defects is determined using the overall risk score calculated from the CoF and LoF scores. Because not all gravity pipes have CCTV records, LoF for pipes without CCTV data is based on GIS data and physical attributes. Gravity mains were divided into two groups for the condition assessment: gravity mains with and without CCTV footage available. CCTV from Innerline, H&H, and from SBMWD directly were used for the analysis.

Stantec and SBMWD worked together to define LoF and CoF criteria pertinent to the service area. Each criterion was scored on a scale of 1 – 5 with 5 being the highest risk and 1 being the lowest. Appendix H and Appendix I discuss the scoring parameters and details the weighting of each criterion for LoF and CoF, respectively.

A risk score out of 100 was calculated for all pipes within the SBMWD system. If a pipe had a CCTV records, the following equation was applied. Any pipe that scored over 100 was assigned 100 as the maximum risk score. LoF criteria (i.e. the CCTV results) are weighted five times higher than CoF criteria in this equation.

$$LoF \times 20 + CoF \times 4 = Risk\ Score$$

If a pipe did not have a CCTV record, the LoF score was multiplied by the CoF score to calculate the overall risk score. This score was adjusted to a 1-to-100 scale according to the highest raw risk score. This scale adjustment results in an analogous score range between pipes with and without CCTV footage.

$$\frac{LoF \times CoF}{(LoF \times CoF)_{max}} = Adjusted\ Risk\ Score$$

##### 9.1.2.1.2 CIP Recommendation Guide

Since pipes should have a CCTV record before a replacement or rehabilitation action takes place, the recommendation for pipes with CCTV footage and pipes without CCTV footage are different. Review of the CCTV records allows for an appropriate replacement or rehabilitation action to be identified. Therefore, pipes with CCTV



## SECTION 9.0 - CONDITION ASSESSMENTS

footage are recommended for a rehabilitation or replacement action or are recommended for future CCTV; while pipes without CCTV footage are prioritized by grid into SBMWD's continuing CCTV program based on risk and grid location.

A decision tree was developed to specify replacement, rehabilitation, or CCTV action for each pipe. Actions such as possible CIPP, possible point repair, and expedited replacement were assigned to each pipe. To adhere to the best practice of having CCTV records before assigning a replacement or rehabilitation action, CCTV was the only action assigned to pipes without footage. However, using the adjusted risk score for non-CCTV pipes will help identify what areas and pipes to focus on to help mitigate risk and identify issues early.

### Recommendation Guide for Pipes with CCTV

The risk scores for pipes with CCTV footage help establish pipe prioritization but are not designed to be used for determining replacement or rehabilitation actions for individual pipes. To determine the action, the CCTV records were analyzed using the decision tree shown in Figure 9-3. The following criteria are key assumptions for the decision tree:

1. Any pipe that has no defects or no greater than a grade 1, 2, or 3 defect are recommended for reassessment via CCTV after high risk pipes are addressed.
2. Any pipe with a grade 5 defect will be recommended for project development to begin for replacement or rehabilitation. Pipes with three or more grade 5 defects were individually reviewed by Stantec to determine which pipes warrant expedited replacement.
3. Where the most severe defect for a pipe is grade 4, rehabilitation through possible CIPP is recommended. This recommendation changes to possible point repair if there are three or less grade 4 defects and the pipe is larger than 15 inches.

## SECTION 9.0 - CONDITION ASSESSMENTS

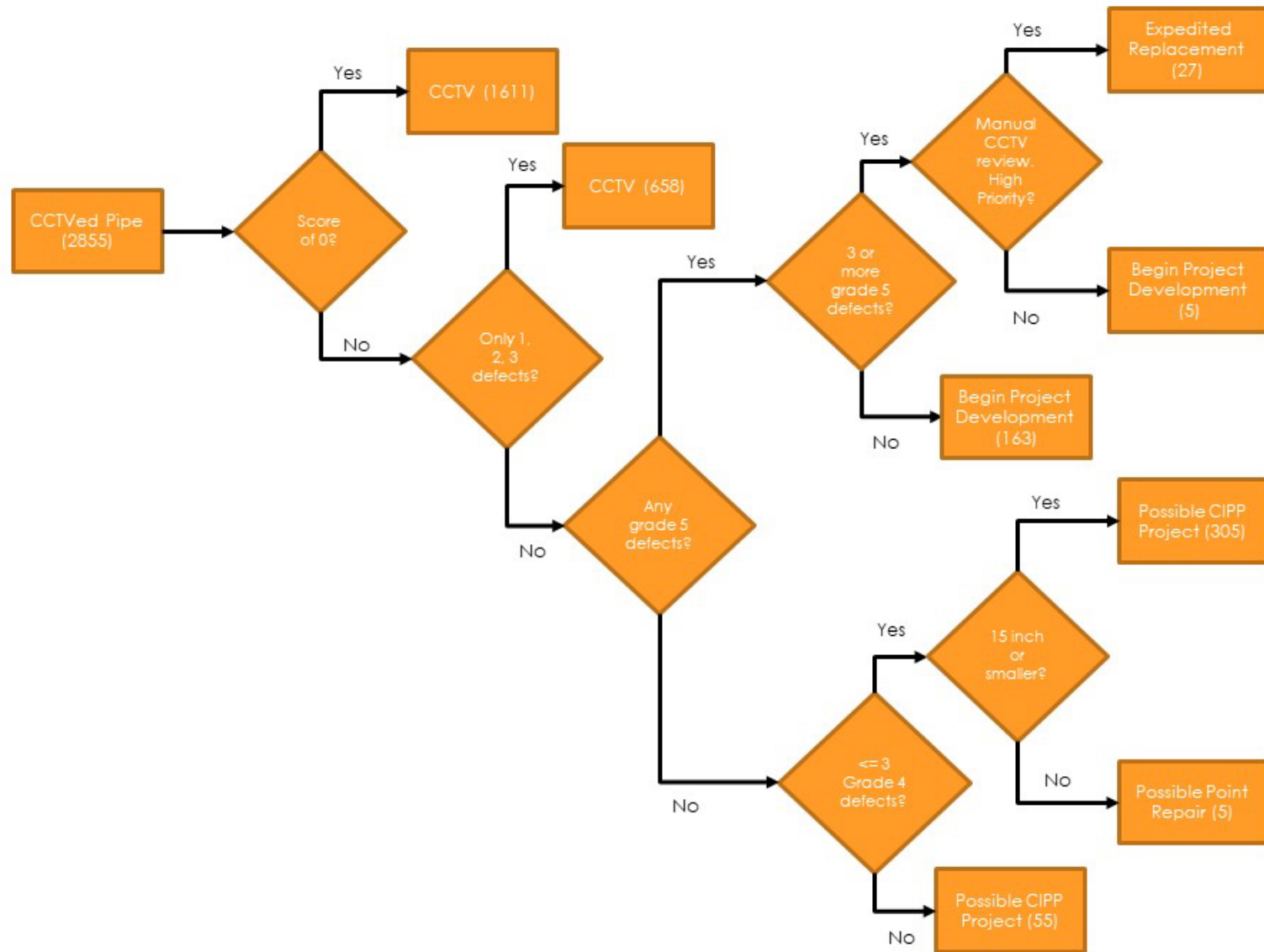


Figure 9-3 R&R Action Decision Tree



## SECTION 9.0 - CONDITION ASSESSMENTS

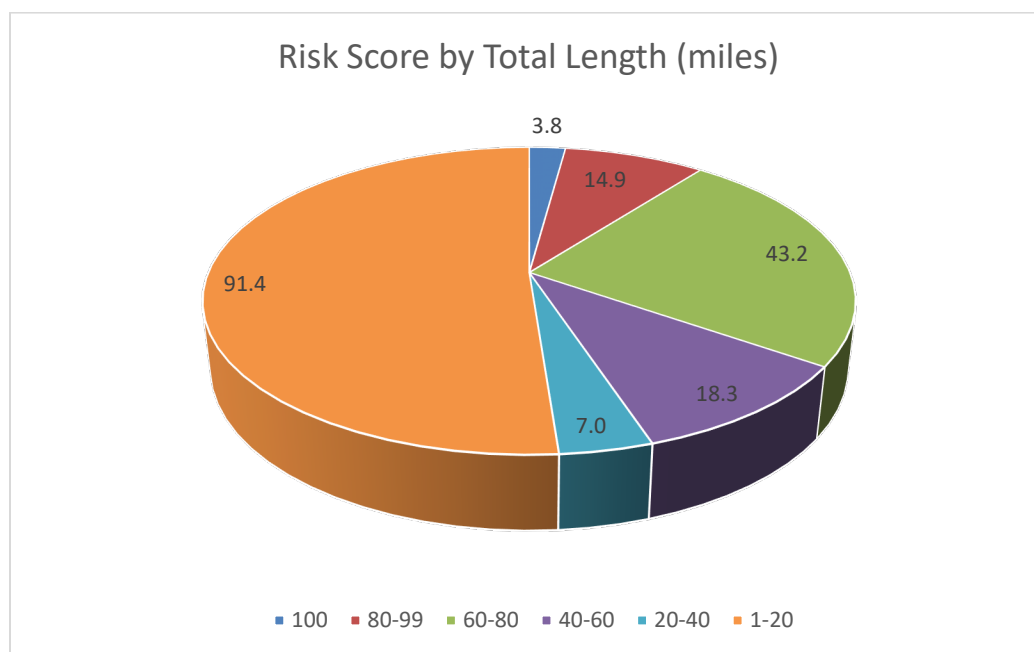
### Recommendation Guide for Pipes without CCTV

Pipes without CCTV records were prioritized such that future CCTV efforts could be coordinated to address the highest risk pipes first. Addressing pipes in order of adjusted risk score alone would not be practical or cost effective for SBMWD to implement as pipes would be spread out across the entire sewer system. Therefore, a grid-based approach is recommended; grids with the highest average adjusted risk score of pipes within that grid are targeted first. All pipes needing CCTV in that grid are recommended for CCTV as a group. This helps save time and money in completing the rest of their CCTV program in furtherance of obtaining video on all pipes. The CCTV effort will continue to be a part of SBMWD's yearly maintenance activities.

### 9.1.2.2 Results

#### 9.1.2.2.1 Pipes with CCTV Records

A breakdown of the scoring for pipes with CCTV records is shown in Figure 9-4. Over half the pipe received a score of less than 20, meaning they are of low concern for rehabilitation or replacement. Figure 9-5 shows the location of each pipe according to the overall risk score.



**Figure 9-4 Breakdown of Risk Scores**

The rehabilitation and replacement action assigned to each pipe through the decision tree presented in Figure 9-3 are summarized in Table 9.2. The majority of pipes are recommended for future CCTV and 27 are recommended for expedited replacement based on the review of the pipes with three or more grade 5 defects. The result of this manual CCTV review to determine the high priority pipes is summarized in Table 9.3, with the pipes identified as “high” or



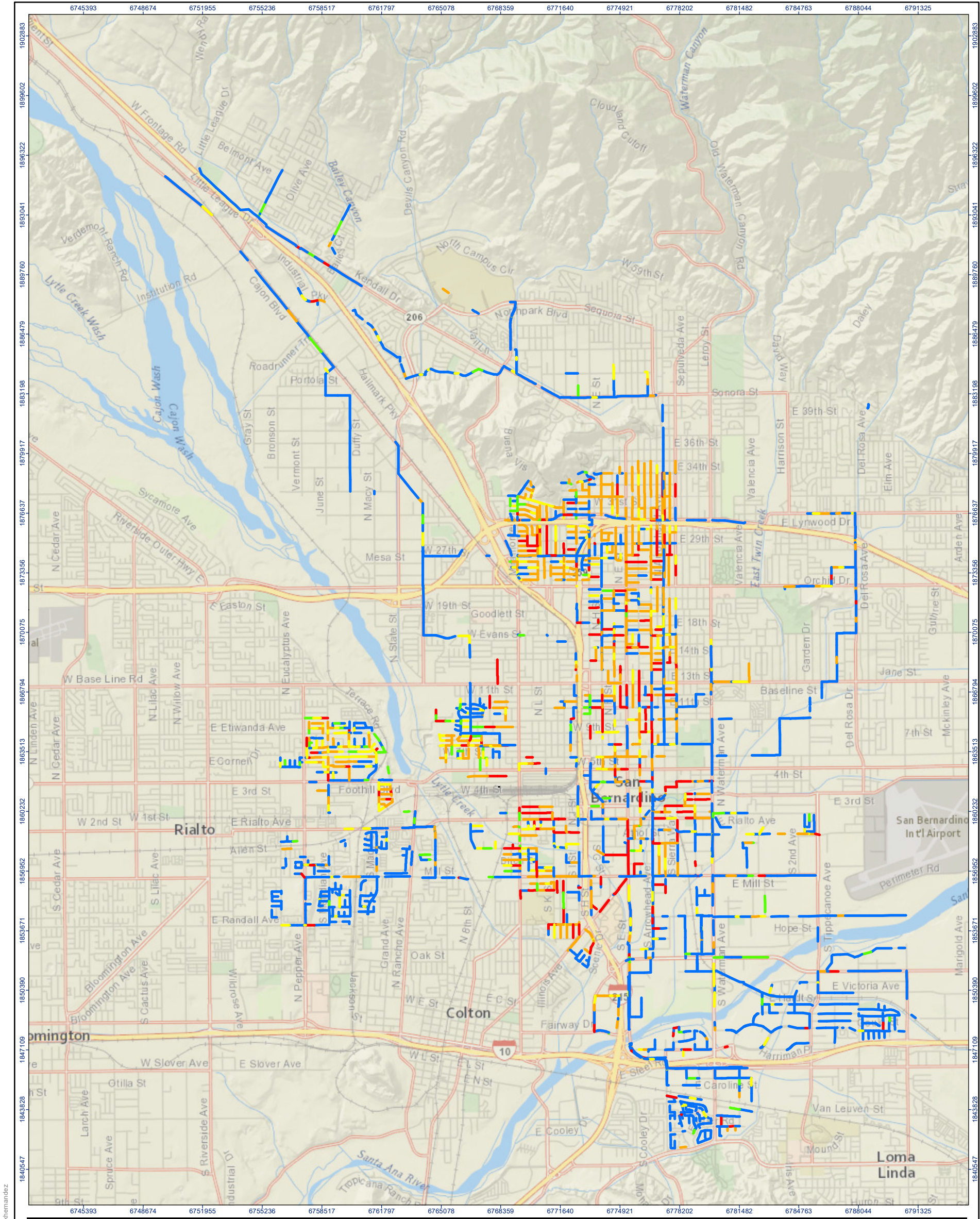
## SECTION 9.0 - CONDITION ASSESSMENTS

“medium to high” priority being the 27 pipes listed in Table 9.2. Figure 9-6 maps the location of each action for CCTV pipes on the system map.

**Table 9.1: Rehabilitation and Replacement Actions for CCTV Pipes**

| <u>R&amp;R Action</u>        | <u>Number of Pipes</u> | <u>Total Length<br/>(ft)</u> | <u>Total<br/>Length<br/>(miles)</u> |
|------------------------------|------------------------|------------------------------|-------------------------------------|
| PDR Study                    | 3                      | 2,081                        | 0.4                                 |
| Expedited<br>Replacement     | 26                     | 12,347                       | 2.3                                 |
| Begin Project<br>Development | 194                    | 81,246                       | 15.4                                |
| Possible CIPP                | 363                    | 144,189                      | 27.3                                |
| Possible Point Repair        | 5                      | 1,338                        | 0.3                                 |
| CCTV                         | 2,274                  | 701,556                      | 132.9                               |





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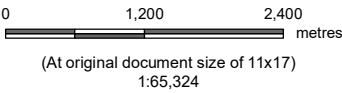
Legend

Sewer Pipes

CCTV Risk Score

- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 100

**Notes**  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.



**Project Location** San Bernardino County  
California  
**Client/Project** Prepared by LTorres on 2019-10-25  
Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.

9-5

Title

Risk Score for CCTV Pipes

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## SECTION 9.0 - CONDITION ASSESSMENTS

**Table 9.2: Manual CCTV Review Findings**

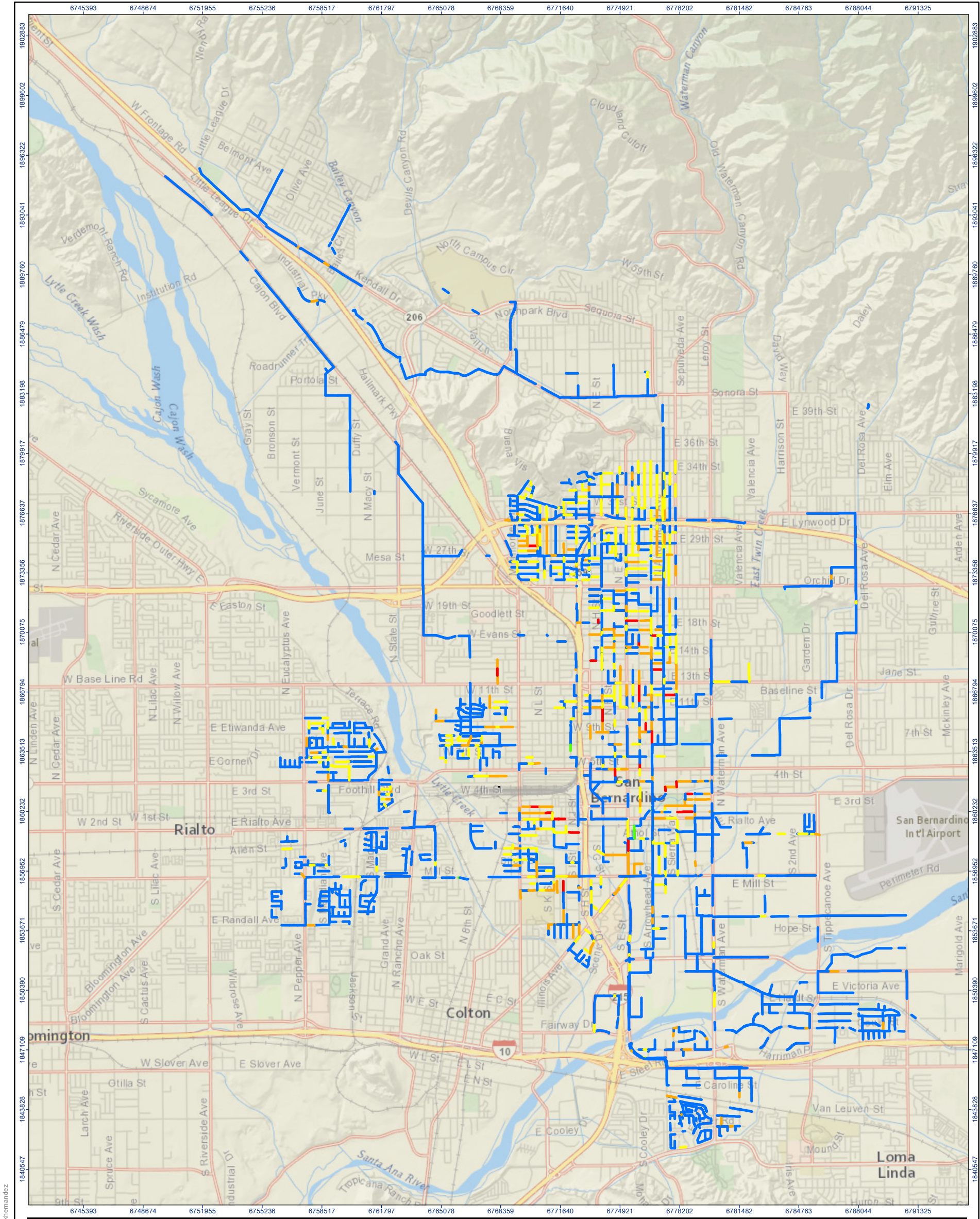
| #  | Pipe ID        | R&R Action                | Notes                                                                                                                                                                                                                                                                   |
|----|----------------|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | 04501400450146 | Expedited Replacement     | <b>High priority.</b> Two locations with broken pipe at the hinges and soil visible                                                                                                                                                                                     |
| 2  | 04501450450147 | Begin Project Development | <b>Medium priority.</b> Broken pipe at three locations driving replacement. Continuous multiple cracking for a majority of pipe.                                                                                                                                        |
| 3  | 04602210460222 | Begin Project Development | <b>Low priority.</b> Replacement recommended due to broken pipe with soil visible and sag at end of pipe. Cracks and fractures run the entire length of pipe                                                                                                            |
| 4  | 04602580460259 | Begin Project Development | <b>Low priority.</b> Replacement recommended due to broken pipe @ 55' & 112'                                                                                                                                                                                            |
| 5  | 05401660540164 | Begin Project Development | <b>Medium priority.</b> 8" VCP -There are a few broken locations which makes this more suited for replacement, but there may be a potential to CIPP, but would need to confirm with vendor regarding "broken" / "fractured" pipe locations. Specifically, around 345.2' |
| 6  | 05401720540166 | Expedited Replacement     | <b>Medium to high priority.</b> Roots infiltrating. Fractures and Broken segments                                                                                                                                                                                       |
| 7  | 05401750540172 | Begin Project Development | <b>Medium priority.</b> Joint offset medium at flowline. Roots infiltrating sewer through fractures                                                                                                                                                                     |
| 8  | 05501450560035 | Expedited Replacement     | <b>Medium to high priority.</b> Multiple broken or hole with voids and soil visible. <b>Lateral @33' bringing lots of soil into pipe.</b>                                                                                                                               |
| 9  | 05502280560057 | Begin Project Development | <b>Low to Medium priority.</b> Replacement recommended to repair pipe sag & possible cross-bored utility with soil (large rocks) visible, potential to be brought into pipe with surcharge                                                                              |
| 10 | 05600960560092 | Expedited Replacement     | <b>Medium to high priority.</b> Relatively short segment of pipe with three significant structural defects                                                                                                                                                              |
| 11 | 05601000560090 | Expedited Replacement     | <b>High priority.</b> Pipe surface seems significantly deteriorated causing multiple holes with soil and voids visible                                                                                                                                                  |
| 12 | 05601300560128 | Begin Project Development | <b>Medium priority.</b> Broken @ 197.56' @ joint @ flowline. Sag in pipe and broken piece at 297' driving replacement.                                                                                                                                                  |
| 13 | 05601480560138 | Expedited Replacement     | <b>High priority.</b> Multiple holes with voids or soil visible. Lateral @ 105.43' JOL in lateral, soil visible above offset. Sag in downstream section of pipe                                                                                                         |
| 14 | 05601510660153 | Expedited Replacement     | <b>Medium to high priority.</b> Multiple holes with voids or soil visible                                                                                                                                                                                               |
| 15 | 05601790560180 | Expedited Replacement     | <b>High priority.</b> Multiple holes with voids visible on lower half of pipe - further erosion is possible even with lower water levels                                                                                                                                |
| 16 | 05601870560165 | Expedited Replacement     | <b>High priority.</b> Multiple large joint offsets, broken pipe with soil visible driving replacement                                                                                                                                                                   |
| 17 | 05602080560206 | Expedited Replacement     | <b>Medium to high priority.</b> Multiple joint offsets, multiple fractures and holes with soil visible, multiple intruding taps                                                                                                                                         |
| 18 | 05602710560174 | Expedited Replacement     | <b>High priority.</b> Significant broken pipe/ hole on top of pipe - sediment in bottom of pipe. <b>Sediment infiltrating @ 598' @ Joint</b>                                                                                                                            |
| 19 | 05701160570092 | Expedited Replacement     | <b>High priority.</b> Possible pipe collapse 95-100% of flow blocked at 380'. Multiple holes with soil and voids visible                                                                                                                                                |
| 20 | 06500250650024 | Expedited Replacement     | <b>High priority.</b> Pipe collapse/sharp sag causing at least 50% reduction in cross section                                                                                                                                                                           |
| 21 | 06600230660020 | Expedited Replacement     | <b>Medium to high priority.</b> Hole with void visible, and multiple defective taps or intruding taps (allowing soil to infiltrate                                                                                                                                      |
| 22 | 06601010660100 | Expedited Replacement     | <b>High priority.</b> Three points with a hole void visible and broken pipe with soil visible.                                                                                                                                                                          |
| 23 | 06601670660181 | Expedited Replacement     | <b>Medium to high priority.</b> HSV @ 208' is missing all pipe above water level and HSV @ 280' is missing top of pipe material.                                                                                                                                        |
| 24 | 06601680660165 | Expedited Replacement     | <b>High priority.</b> Partial pipe collapse, crown of pipe missing @ 438', and multiple breaks in pipe                                                                                                                                                                  |



## SECTION 9.0 - CONDITION ASSESSMENTS

| #  | Pipe ID        | R&R Action                | Notes                                                                                                                                                                                                                                                                                                                    |
|----|----------------|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 25 | 06601860660146 | Expedited Replacement     | <b>Medium to high priority.</b> Large hole with soil visible along with multiple fractures. Sag. Large fracture along crown of pipe (64') "high priority"                                                                                                                                                                |
| 26 | 06602650660254 | Expedited Replacement     | <b>High priority.</b> Replacement recommended to fix deformations, hinge fractures/ broken pipe and sag                                                                                                                                                                                                                  |
| 27 | 06602660660264 | Expedited Replacement     | <b>Medium to high priority.</b> There is a sag between 92.4 and 135' which would make replacement a better choice.                                                                                                                                                                                                       |
| 28 | 06700760670077 | Expedited Replacement     | <b>High priority.</b> Two large holes with soil/voids visible. Survey is incomplete                                                                                                                                                                                                                                      |
| 29 | 07501300750131 | Expedited Replacement     | <b>Medium to high priority.</b> Replacement recommended due to hinge fractures, broken pipe section, and sag in the pipe. Survey is incomplete. Sag shows Water Level around 30% instead of 10% called out in report. FH @ crown @ beginning of survey.                                                                  |
| 30 | 07501650750162 | Expedited Replacement     | <b>High priority.</b> Broken @ 12 o'clock                                                                                                                                                                                                                                                                                |
| 31 | 07501900750192 | Expedited Replacement     | <b>Medium to high priority.</b> Multiple holes with soil visible - smaller holes relative to other pipes but can still erode backfill. Multiple intruding taps                                                                                                                                                           |
| 32 | 07502000750168 | Expedited Replacement     | <b>High priority.</b> Portion of pipe with hole void visible appears to be moving. Other holes voids or soils visible, 20% deformed in some areas                                                                                                                                                                        |
| 33 | 07600940760095 | Begin Project Development | Check as-builts to confirm egg-shaped 48"- VCP called out. <b>If so, no action needed.</b> Pipe looks like egg-shaped clay tile pipe. First 77' difficult to see. (camera is also not completely centered in pipe)                                                                                                       |
| 34 | 07600950760105 | Begin Project Development | Egg-Shaped VCP tile. (7600950760105_20190411) - @4:45 in video it looks like there is a broken tile @ 2 o'clock not documented in report, @6:20 cracked tile at 2 o'clock, @8:25 in video broken tile at 2 o'clock. Overall pipe is in fair shape. Could CIPP to extend life of line, confirm with vendor for egg-shape. |
| 35 | 07600960760094 | Expedited Replacement     | <b>Medium to high priority.</b> Brick sewer under tile? Multiple locations where tile has broken off. Operator does not inspect all broken locations to determine if soil or voids are visible. No survey past 174.6'. Pipe length is 662'                                                                               |
| 36 | 07700010760202 | Expedited Replacement     | <b>Medium to high priority.</b> Cross-bored utility caused two holes with voids visible. Additional holes with voids and soil visible, Joint offset. JOM @ 572.2 not suitable for CIPP                                                                                                                                   |



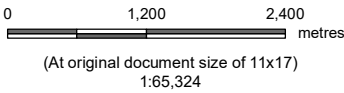


## Legend

### Sewer Pipes

#### R&R Action

- Expedited Replacement
- Begin Project Development
- Possible CIPP
- Possible Point Repair
- CCTV



Project Location San Bernardino County  
California  
Client/Project Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.

9-6

Title

R&R Recommendation for CCTV Pipes

#### Notes

- Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
- Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

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## SECTION 9.0 - CONDITION ASSESSMENTS

### 9.1.2.2.1 Pipes without CCTV Records

The 304 miles of pipe that do not have recent CCTV footage are spread across 59 grids in the SBMWD service area as shown in Figure 9-7. After averaging the adjusted risk score for each of the 59 grids for all non-CCTV pipes within them, grids were ranked in order of highest average adjusted risk score. This data is presented in Table 9.3 with Grid 86 being ranked 1<sup>st</sup> priority for CCTV. Figure 9-8 shows the grids grouped into 5 priority levels divided evenly based on the total length of pipe.

**Table 9.3: Grid Prioritization for CCTV Efforts**

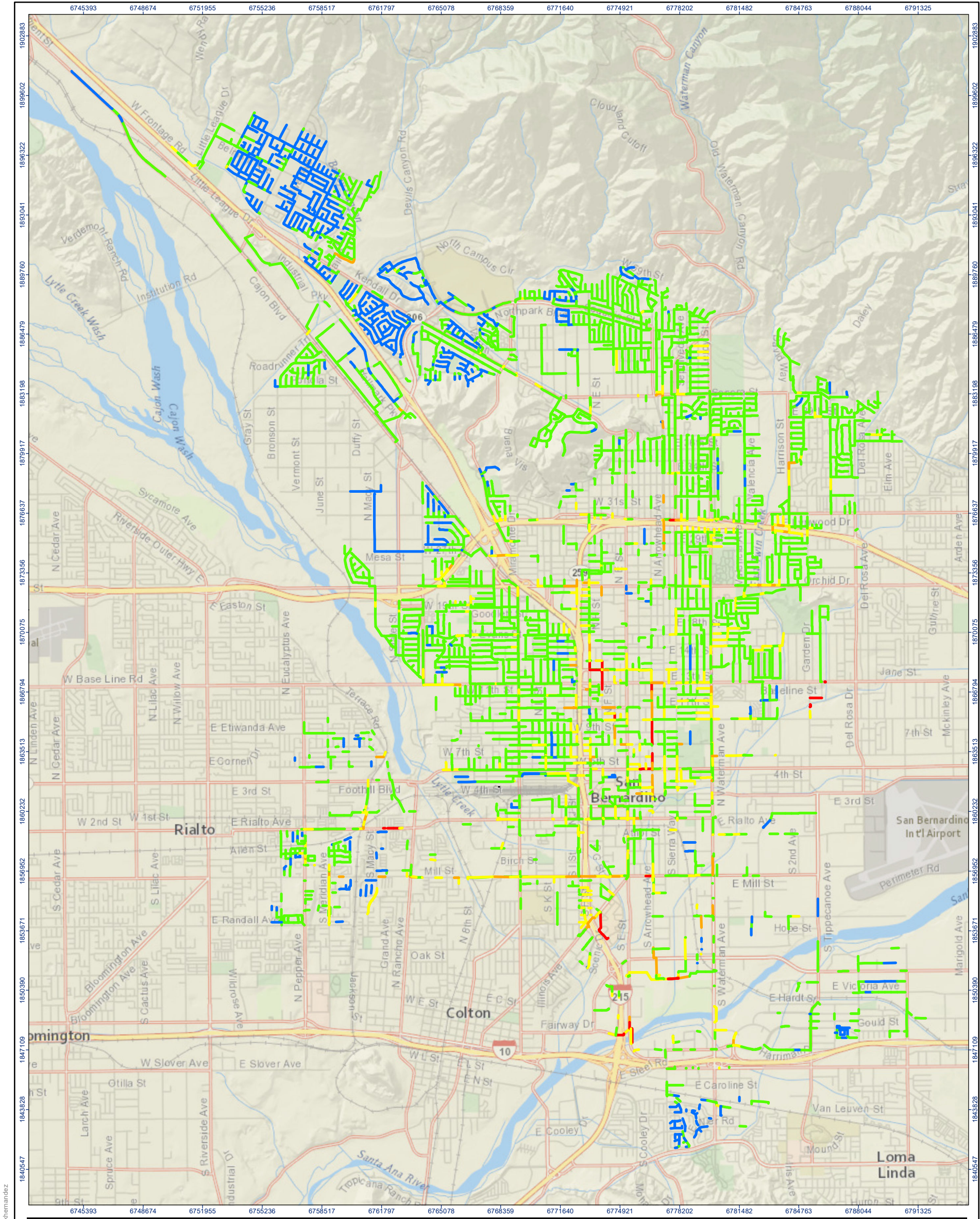
| Grid | Rank | Length (ft) |
|------|------|-------------|
| 86   | 1    | 18,912      |
| 76   | 2    | 30,195      |
| 68   | 3    | 4,365       |
| 56   | 4    | 31,108      |
| 74   | 5    | 9,229       |
| 66   | 6    | 58,268      |
| 75   | 7    | 29,915      |
| 67   | 8    | 24,923      |
| 46   | 9    | 24,820      |
| 77   | 10   | 14,518      |
| 57   | 11   | 78,308      |
| 48   | 12   | 44,868      |
| 55   | 13   | 83,960      |
| 45   | 14   | 13,136      |
| 73   | 15   | 17,023      |
| 58   | 16   | 22,560      |
| 47   | 17   | 65,273      |
| 36   | 18   | 51,220      |
| 65   | 19   | 74,538      |
| 54   | 20   | 82,710      |
| 64   | 21   | 25,798      |
| 87   | 22   | 9,760       |
| 49   | 23   | 2,314       |
| 28   | 24   | 2,753       |
| 72   | 25   | 34,798      |
| 53   | 26   | 30,882      |
| 27   | 27   | 12,794      |
| 85   | 28   | 2,520       |
| 63   | 29   | 9,918       |
| 35   | 30   | 25,650      |
| 21   | 31   | 1,676       |
| 44   | 32   | 47,166      |
| 33   | 33   | 20,472      |
| 38   | 34   | 44,818      |
| 78   | 35   | 6,782       |
| 26   | 36   | 70,251      |
| 37   | 37   | 61,343      |
| 22   | 38   | 23,142      |
| 98   | 39   | 3,342       |
| 62   | 40   | 6,997       |
| 96   | 41   | 9,220       |
| 89   | 42   | 15,190      |



## SECTION 9.0 - CONDITION ASSESSMENTS

| Grid | Rank | Length (ft) |
|------|------|-------------|
| 43   | 43   | 17,308      |
| 97   | 44   | 12,293      |
| 39   | 45   | 15,742      |
| 10   | 46   | 3,634       |
| 88   | 47   | 11,936      |
| 25   | 48   | 38,476      |
| 34   | 49   | 18,187      |
| 11   | 50   | 30,649      |
| 32   | 51   | 17,356      |
| 24   | 52   | 37,443      |
| 13   | 53   | 16,775      |
| 01   | 54   | 1,539       |
| 23   | 55   | 56,516      |
| 0    | 56   | 948         |
| 00   | 57   | 3,290       |
| 12   | 58   | 74,342      |
| 02   | 59   | 1,125       |





Legend

Sewer Pipes

nonCCTV Risk Score

0 - 20

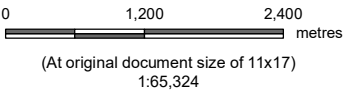
20 - 40

40 - 60

60 - 80

80 - 100

**Notes**  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.



**Project Location** San Bernardino County  
California  
**Client/Project** Prepared by LTorres on 2019-10-25  
Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.

9-7

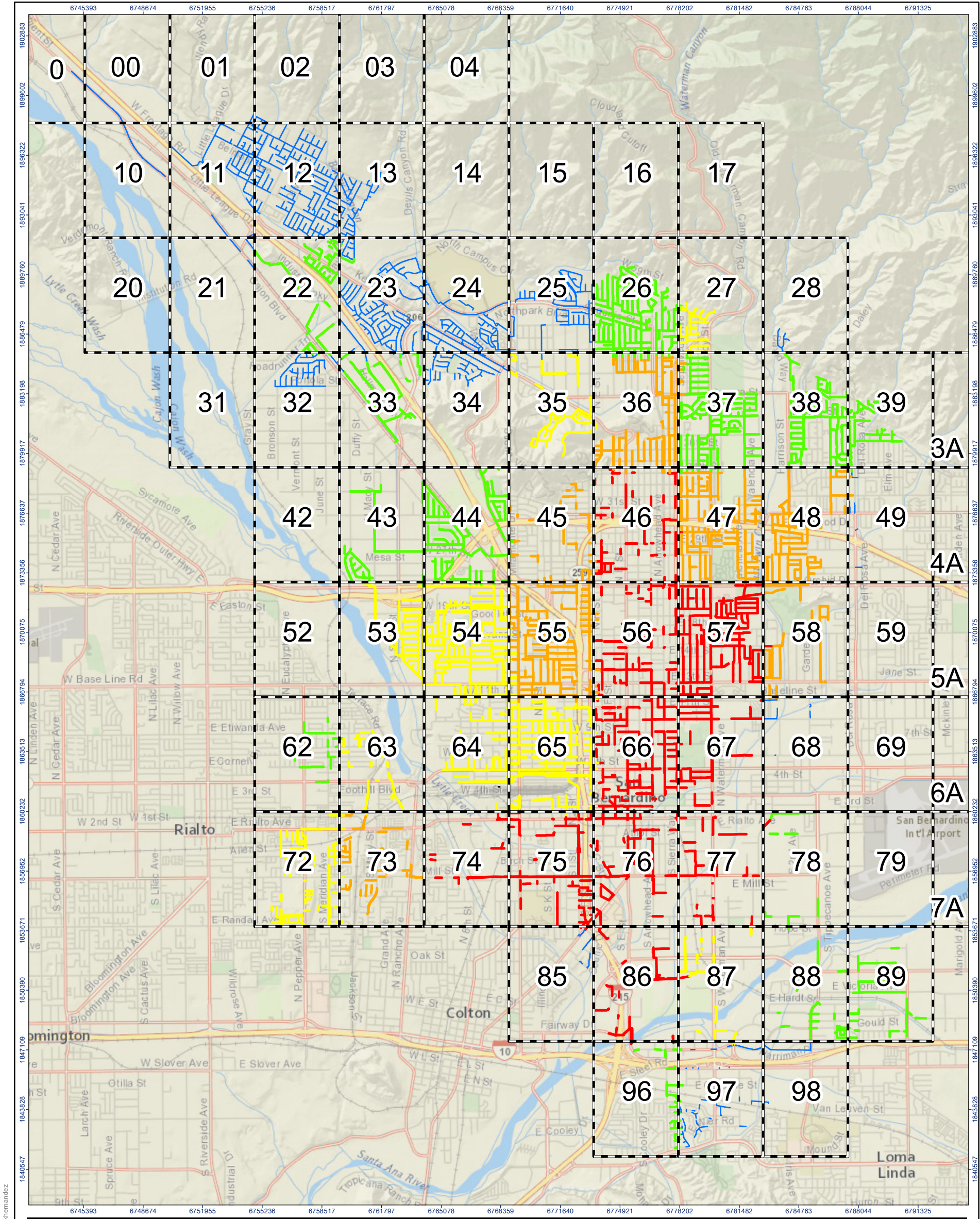
Title

Risk Score for nonCCTV Pipes







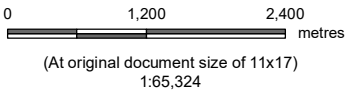


Legend

Sewer Pipes

CCTV Effort Priority

- Highest Priority
- High Priority
- Moderate Priority
- Low Priority
- Lowest Priority
- Grids



Project Location San Bernardino County California  
Client/Project Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.  
9-8

Grid Prioritization for CCTV Efforts

Notes  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
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## 9.2 LIFT STATIONS

### 9.2.1 Lift Station Assessments

Condition assessments were performed for SBMWD's fifteen lift stations to review elements like drainage, equipment, and instrumentation at each location. The condition assessments evaluated each facility for continued operation and necessary improvements needed in the immediate, short term, and long-term scenarios. Identified deficiencies and proposed recommendations and upgrades can be found in the final Lift Station Assessment Report included as Appendix K. This report includes photos for each lift station and document general, mechanical, structural, electrical, and communication components of the lift station.

### 9.2.2 Results

After the evaluation of each lift station, recommendations were made based on the findings of the site visits. A summary of the recommendations for each lift station are shown in Table 9.4. Further detail can be found in Appendix K. These recommendations are used and prioritized in the capital improvement program presented in Section 10 to produce a final list of projects. While the Lift Station Assessment Report categorizes individual issues by priority, the CIP prioritizes improvements by lift station so that repairs don't need to be made on multiple occasions.

It is noted that SBMWD has expressed interest in phasing out self-priming type lift stations. As SBMWD addresses the condition assessment recommendations listed here for self-priming type lift stations, analysis should be done to assess the relative cost of rehabilitating the lift stations versus replacement. For this SMP Update, the only self-priming lift station recommended for replacement is Meridian Lift Station.

**Table 9.4: Lift Station Recommendations**

| Lift Station Number | Lift Station Name     | Summary of Recommendations                                                                                                                                                                                                                                                                 |
|---------------------|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| LS#1                | Carousel Lift Station | Replace ladder to dry pit<br>Replace 2x 2hp pumps and motors<br>Replace control panel<br>Install ultrasonic level measurement<br>Install SCADA equipment and connect to SCADA<br>Replace dry pit (assume 8' diameter, 10' deep dry pit)                                                    |
| LS#2                | May Co Lift Station   | Remove ladder from wet well<br>Install new retaining wall<br>Replace Control Panel<br>Install ultrasonic level measurement<br>Replace generator<br>Recoat piping<br>Recoat dry pit<br>Replace wet well<br>Install SCADA equipment and connect to SCADA<br>Replace 2x 10hp pumps and motors |
| LS#3                | Colton Lift Station   | Replace ladder to dry pit<br>Install dry pit ventilation system<br>Install overturn restraint for propane tank<br>Replace level switches                                                                                                                                                   |
| LS#4                | Fairway Lift Station  | Replace intrusion alarm<br>2x 15 HP Pump replacement<br>Pipe support replacement                                                                                                                                                                                                           |

## SECTION 9.0 - CONDITION ASSESSMENTS

| Lift Station Number | Lift Station Name              | Summary of Recommendations                                                                                                                                                                                                     |
|---------------------|--------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                     |                                | Concrete spot repair<br>Install ultrasonic level measurement<br>Coating repair on piping<br>Install SCADA equipment and SCADA integration<br>Relocate control panel to above grade                                             |
| LS#5                | Airport Lift Station           | Install ultrasonic level measurement<br>Replace 2x 3hp pumps and motors<br>Replace backup float switch<br>Recoat piping<br>Install SCADA equipment and connect to SCADA<br>Relocate electrical panel to above grade            |
| LS#6                | Valley Truck Farm Lift Station | Replace ventilation fan<br>Rehabilitate wet well<br>Replace 2x 5hp pumps and motors                                                                                                                                            |
| LS#7                | Allen Lift Station             | Replace wet well hatch (assume 4' x 6' dimension)<br>Replace 2x 5hp pumps and motors<br>Add fence (assume 50 LF chain link fence with privacy slats)                                                                           |
| LS#8                | Pine Lift Station              | Concrete spot repair<br>Resurface and Coat wet well<br>Replace control panel<br>Replace 2x 15hp pumps and motors                                                                                                               |
| LS#9                | City Hall Lift Station         | Replace wet well hatch (assume 4' x 6' dimension)<br>Replace 2x 3hp pumps and motors                                                                                                                                           |
| LS#10               | Meridian Lift Station          | Full replacement with submersible pump type lift station                                                                                                                                                                       |
| LS#11               | Macy Lift Station              | Install overturn restraint for propane tank<br>Replace uninterruptible power supply<br>Reconfigure piping<br>Replace 2x 15hp pumps and motors                                                                                  |
| LS#12               | Riverwalk Lift Station         | Replace 2x 7.5 hp pumps and motors                                                                                                                                                                                             |
| AA                  | Arrowhead Lift Station         | 3x Wet well hatch replacement<br>Concrete wall and ceiling spot repair<br>Drain cover replacement<br>4x 225 HP Pump Replacement<br>Coating repair on piping<br>4x 24" Gate valve replacement<br>4x 24" Check valve replacement |
| BB                  | E street lift station          | Install ultrasonic level measurement<br>Replace 3x 200hp pumps and motors                                                                                                                                                      |
| CC                  | East Interceptor Lift Station  | 3x Trough liner replacement<br>3x Deflector shield support replacement<br>3x 60 HP Archimedes Screw pump motor replacement<br>3x Archimedes Screw pump gear rehabilitation                                                     |

### 9.3 SIPHONS ASSESSMENTS

Eighteen existing siphon structures were evaluated by V&A Consulting Engineers who performed confined space entry and documented the condition of the structures. Recommendations for siphon structure rehabilitation are based on V&A's assessment and are documented in the table below. The full report from V&A's assessment is included as Appendix L.

## SECTION 9.0 - CONDITION ASSESSMENTS

**Table 9.5: Siphon Recommendations**

| Siphon                                       | Upstream /<br>Downstream<br>Structure | Recommendation | Recommendation Notes                                                                                                                  |
|----------------------------------------------|---------------------------------------|----------------|---------------------------------------------------------------------------------------------------------------------------------------|
| Mill Street - Lytle Creek Channel            | Upstream                              | Rehab          | Remove T-lock liner<br>Resurface and recoat<br>Replace brick and mortar weir wall                                                     |
|                                              | Downstream                            | Rehab          | Remove T-lock liner<br>Resurface and recoat                                                                                           |
| Waterman Avenue - Santa Ana River Channel    | Upstream                              | Replace        | 2 covers                                                                                                                              |
|                                              | Downstream                            | Rehab          | Remove T-lock liner<br>Resurface and recoat                                                                                           |
| Perris Hill Park - Twin Creek Channel        | Upstream                              | Rehab          | Resurface and recoat                                                                                                                  |
|                                              | Downstream                            | Rehab          | Resurface and recoat<br>Modify flow channel                                                                                           |
| I street - Lytle Creek Channel               | Upstream                              | Rehab          | Remove T-lock liner<br>Resurface and recoat                                                                                           |
|                                              | Downstream                            | Rehab          | Remove T-lock liner<br>Resurface and recoat                                                                                           |
| San Bernardino Siphon - Santa Ana River      | Upstream                              | Rehab          | Remove existing spray on liner<br>Reform flow channel<br>Resurface and recoat                                                         |
|                                              | Downstream                            | Rehab          | Resurface and recoat<br>Modify flow channel                                                                                           |
| Loma Linda Siphon - Santa Ana River Channel  | Upstream                              | Rehab          | Remove existing spray on liner and T-lock liner<br>Remove existing MH frames and covers over siphon inlet bay<br>Resurface and recoat |
|                                              | Downstream                            | Rehab          | Remove T-lock liner<br>Resurface and recoat                                                                                           |
| Zanga - Mission Channel                      | Upstream                              | Rehab          | Remove ladder rungs<br>Address root intrusion<br>Resurface and recoat                                                                 |
|                                              | Downstream                            | Rehab          | Remove ladder rungs<br>Fill abandoned connection<br>Injection corrosion inhibitor<br>resurface and recoat                             |
| Santa Fe - Santa Ana River                   | Upstream                              | Rehab          | Remove flap gates and ladder rungs<br>Resurface and recoat                                                                            |
|                                              | Downstream                            | Rehab          | Remove ladder rungs<br>Resurface and recoat<br>Replace frame and cover                                                                |
| Inland Center Mall - Santa Ana River Channel | Upstream                              | Rehab          | Resurface and recoat                                                                                                                  |
|                                              | Downstream                            | Rehab          | Resurface and recoat<br>Pour new concrete collar around frame and cover                                                               |



## 9.4 DETAILED MAINTENANCE HOLE INSPECTIONS

A sample of 101 maintenance holes was selected from SBMWD's GIS for condition assessment. These maintenance holes were selected from across the SBMWD system to represent different system conditions. TKE performed field assessments from grade and provided photographs of the interior and surface of each maintenance hole assessed. Recommendations for each maintenance hole were developed from TKE's findings and scaled to SBMWD's entire system of 8,009 maintenance holes to develop anticipated rehabilitation and replacement actions that may be needed in the future. The breakdown of TKE's findings and the corresponding scaled amount of maintenance holes in SBMWD's system are presented in Table 9.6 below.

**Table 9.5: Maintenance hole Recommendations**

| Recommendation | Number of Maintenance Holes from TKE Survey | Percentage | Estimated Number of Maintenance Holes in the SBMWD System |
|----------------|---------------------------------------------|------------|-----------------------------------------------------------|
| No Action      | 14                                          | 1.3        | 1,110                                                     |
| Rehabilitation | 57                                          | 5.1        | 4,520                                                     |
| Replacement    | 30                                          | 2.7        | 2,379                                                     |

These results provide a general estimate of the number of maintenance holes in the SBMWD that may need to be rehabilitated or replaced based on a relatively small sample size (1.1 percent of the total system maintenance holes). It is recommended SBMWD continue to investigate the system maintenance holes and record the number of locations needing rehabilitation or replacement to further refine the estimates in Table 9.6. The recommendations for maintenance hole rehabilitation and replacement presented in Section 10 are based on the available resources of SBMWD and is not directly correlated to the estimates in Table 9.6.

## 9.5 SUMMARY

The condition assessment for the SMP Update addressed pipelines (both with and without CCTV footage), maintenance holes, siphons, and lift stations. The results from these assessments and analyses are summarized herein and full reports and findings are presented in the Appendices. The results from this assessment program along with results from the hydraulic model analysis are used to build the Capital Improvement Program described in Section 10.



## SECTION 10

# Capital Improvement Program







## **10.0 CAPITAL IMPROVEMENT PROGRAM**

This section presents the recommendations, projects, and further investigations identified during the preparation of SBMWD's 2019 SMP Update. Unit costs used to estimate project costs, as well as methodology used to estimate the costs for more specific recommendations, additional studies, and other recommendations are also identified.

Recommendations are organized both by facility type (i.e. pipes, maintenance holes, siphons, etc.), and by planning horizon: immediate recommendations (to be initiated in the next two years), near term (2022-2025), long-term (2026-2030) and a final year 2031-2035 horizon. The projects were developed in response to the findings presented in previous sections. A summary of costs for all estimates can be found at the end of this section.

### **10.1 PROJECT COST ESTIMATING BASIS**

The Capital Improvement Plan (CIP) project cost estimates are planning level cost estimates. Costs may change significantly during design through construction. These estimates have an expected accuracy range of -50 percent to +100 percent. This range depends on the technological complexity of the projects, appropriate reference information, and the inclusion of an appropriate contingency. Accuracy could exceed this range in unusual circumstances. The estimate was prepared using a combination of parametric estimating factors and local experience in delivering projects similar to those that constitute SBMWD's CIP.

Costs are based on Stantec's experience with costs of similar projects in Southern California, and recent bids received by SBMWD. Due to fluctuations in the market and the level of information available during the planning stage, this estimate should only be used for planning purposes and a more rigorous estimate should be prepared during detailed studies and design. The unit costs presented below include a 30 percent allowance for Engineering, Legal, and Administration (ELA), a 20 percent allowance for construction contingency, and, where applicable, a 10 percent allowance for Contractor General Conditions (for construction projects only, not applied to studies).

#### **10.1.1 Pipe Replacement and Rehabilitation Unit Costs**

Table 10-1 shows a summary of the unit costs for gravity sewers and force mains and Table 10-2 shows unit costs for CIPP and point repairs for pipes. The cost for replacement using PVC and VCP are presented; it is assumed that PVC will be used for pipes less than 18 inches in diameter, and VCP is assumed for all larger diameter pipes. Costs for CIPP rehab are also presented in this table. Methodology for costing a project as a rehabilitation or replacement are presented in Section 9. All improvements are assumed to take place under asphalt road and the depths provided from GIS and LiDAR were used to calculate depths and the associated unit cost to be applied. For some pipelines, a point repair rehabilitation is assumed. For these pipelines, point repair costs were based on 10 linear feet of CIPP per repair, three days of bypass pumping per repair at \$2,500 per day, and three repairs per pipe. Based on the cost estimating approach, point repair is economically advantageous for pipes greater than 15-inch diameter when compared to CIPP of a typical 300-foot line. This is in line with Stantec's experience with pipe replacement and rehabilitation projects. Point repair unit costs are included in Table 10-2.



## SECTION 10.0 - CAPITAL IMPROVEMENT PROGRAM

**Table 10-1: Pipe Replacement Unit Costs (2019 Q1 dollars)**

|               | PVC (dollars per inch diameter per linear foot) |            |             | VCP (dollars per inch diameter per linear foot) |            |             |
|---------------|-------------------------------------------------|------------|-------------|-------------------------------------------------|------------|-------------|
|               | Depth below ground surface                      |            |             | Depth below ground surface                      |            |             |
|               | Up to 8 ft                                      | 8 to 12 ft | 12 to 16 ft | Up to 8 ft                                      | 8 to 12 ft | 12 to 16 ft |
| Diameter (in) |                                                 |            |             |                                                 |            |             |
| 8             | \$ 477                                          | \$ 553     | \$ 629      | \$ 561                                          | \$ 651     | \$ 740      |
| 10            | \$ 503                                          | \$ 603     | \$ 629      | \$ 592                                          | \$ 709     | \$ 740      |
| 12            | \$ 655                                          | \$ 705     | \$ 781      | \$ 770                                          | \$ 829     | \$ 918      |
| 15            | \$ 629                                          | \$ 692     | \$ 755      | \$ 740                                          | \$ 814     | \$ 888      |
| 18            | \$ 684                                          | \$ 720     | \$ 792      | \$ 756                                          | \$ 918     | \$ 1,005    |
| 21            | \$ 777                                          | \$ 819     | \$ 882      | \$ 882                                          | \$ 947     | \$ 1,036    |
| 24            | \$ 888                                          | \$ 912     | \$ 984      | \$ 984                                          | \$ 1,005   | \$ 1,036    |
| 27            | \$ 972                                          | \$ 1,026   | \$ 1,080    | \$ 1,107                                        | \$ 1,066   | \$ 1,153    |
| 30            | \$ 1,080                                        | \$ 1,110   | \$ 1,170    | \$ 1,200                                        | \$ 1,095   | \$ 1,184    |
| 36            | \$ 1,224                                        | \$ 1,332   | \$ 1,404    | \$ 1,408                                        | \$ 1,512   | \$ 1,538    |
| 42            | \$ 1,428                                        | \$ 1,512   | \$ 1,596    | \$ 1,642                                        | \$ 1,681   | \$ 1,954    |
| 48            | \$ 1,536                                        | \$ 1,728   | \$ 1,824    | \$ 1,766                                        | \$ 1,920   | \$ 2,112    |
| 54            | \$ 1,728                                        | \$ 1,836   | \$ 1,998    | \$ 1,987                                        | \$ 2,106   | \$ 2,322    |
| 60            | \$ 1,800                                        | \$ 2,040   | \$ 2,220    | \$ 2,160                                        | \$ 2,280   | \$ 2,520    |

**Table 10-2: Pipe Rehabilitation and Repair Unit Costs (2019 Q1 dollars)**

|          | Repair Type    |                        |
|----------|----------------|------------------------|
| Diameter | CIPP (dollars) | Point Repair (dollars) |
| 8        | \$ 56          | \$ 44,064              |
| 10       | \$ 75          | \$ 46,800              |
| 12       | \$ 96          | \$ 49,824              |
| 15       | \$ 127         | \$ 54,343              |
| 18       | \$ 162         | \$ 59,328              |
| 21       | \$ 194         | \$ 63,972              |
| 24       | \$ 229         | \$ 69,017              |
| 27       | \$ 270         | \$ 74,880              |
| 30       | \$ 420         | \$ 96,480              |
| 36       | \$ 637         | \$ 127,713             |
| 42       | \$ 756         | \$ 144,864             |
| 48       | \$ 927         | \$ 169,401             |
| 54       | \$ 1,188       | \$ 207,072             |
| 60       | \$ 1,529       | \$ 256,112             |

### 10.1.2 Lift Station Unit Costs

Table 10-3 and Table 10-4 show unit costs for lift stations including pump upsizing and replacement, respectively. These unit costs were applied to the lift station improvements where applicable; some lift station repairs and recommendations were costed on an individual basis due to the specificity of the recommendation and are discussed later in this section.

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**Table 10-3: Lift Station Upsize Unit Costs (2019 Q1 dollars)**

| Price Estimating Basis - Lift Station Upsize |                                |                                                           |                                     |                    |
|----------------------------------------------|--------------------------------|-----------------------------------------------------------|-------------------------------------|--------------------|
| New Pump Size (hp)                           | Construction Cost (Dollars/hp) | 30 Percent Engineering, Legal Administrative (Dollars/hp) | 20 Percent Contingency (Dollars/hp) | Total (Dollars/hp) |
| 0-10                                         | \$ 12,200                      | \$ 3,660                                                  | \$ 2,440                            | \$ 18,300          |
| 11-25                                        | \$ 9,800                       | \$ 2,940                                                  | \$ 1,960                            | \$ 14,700          |
| 26-50                                        | \$ 8,100                       | \$ 2,430                                                  | \$ 1,620                            | \$ 12,150          |
| 51-75                                        | \$ 6,500                       | \$ 1,950                                                  | \$ 1,300                            | \$ 9,750           |
| 76-100                                       | \$ 4,900                       | \$ 1,470                                                  | \$ 980                              | \$ 7,350           |
| 101-150                                      | \$ 4,100                       | \$ 1,230                                                  | \$ 820                              | \$ 6,150           |
| 151-200                                      | \$ 3,900                       | \$ 1,170                                                  | \$ 780                              | \$ 5,850           |
| 201-250                                      | \$ 3,700                       | \$ 1,110                                                  | \$ 740                              | \$ 5,550           |
| 251-300                                      | \$ 3,400                       | \$ 1,020                                                  | \$ 680                              | \$ 5,100           |
| 301-400                                      | \$ 3,300                       | \$ 990                                                    | \$ 660                              | \$ 4,950           |
| 401-500                                      | \$ 3,000                       | \$ 900                                                    | \$ 600                              | \$ 4,500           |

**Table 10-4: Pump Replacement Unit Costs (2019 Q1 dollars)**

| Price Estimating Basis - Pump Replacement |                                |                                                           |                                     |                    |
|-------------------------------------------|--------------------------------|-----------------------------------------------------------|-------------------------------------|--------------------|
| New Pump Size (hp)                        | Construction Cost (Dollars/hp) | 30 Percent Engineering, Legal Administrative (Dollars/hp) | 20 Percent Contingency (Dollars/hp) | Total (Dollars/hp) |
| 0-10                                      | \$ 4,100                       | \$ 1,230                                                  | \$ 820                              | \$ 6,150           |
| 11-25                                     | \$ 3,300                       | \$ 990                                                    | \$ 660                              | \$ 4,950           |
| 26-50                                     | \$ 2,700                       | \$ 810                                                    | \$ 540                              | \$ 4,050           |
| 51-75                                     | \$ 2,200                       | \$ 660                                                    | \$ 440                              | \$ 3,300           |
| 76-100                                    | \$ 1,700                       | \$ 510                                                    | \$ 340                              | \$ 2,550           |
| 101-150                                   | \$ 1,400                       | \$ 420                                                    | \$ 280                              | \$ 2,100           |
| 151-200                                   | \$ 1,300                       | \$ 390                                                    | \$ 260                              | \$ 1,950           |
| 201-250                                   | \$ 1,300                       | \$ 390                                                    | \$ 260                              | \$ 1,950           |
| 251-300                                   | \$ 1,200                       | \$ 360                                                    | \$ 240                              | \$ 1,800           |
| 301-400                                   | \$ 1,100                       | \$ 330                                                    | \$ 220                              | \$ 1,650           |
| 401-500                                   | \$ 1,000                       | \$ 300                                                    | \$ 200                              | \$ 1,500           |

### 10.1.3 Maintenance Hole Replacement and Rehabilitation Costs

Maintenance hole replacement and rehabilitation costs were developed based on conversations with SBMWD staff, review of quotes from subconsultants, and Stantec's experience with similar projects. Stantec assumes the following costs for maintenance repair and replacement as presented in Table 10-5.

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**Table 10-5: Maintenance Hole Unit Costs (2019 Q1 Dollars)**

| Item           | Unit Cost per Maintenance Hole including Contingency + ELA + Contractor GCs |
|----------------|-----------------------------------------------------------------------------|
| Raising        | \$ 4,500                                                                    |
| Rehabilitation | \$ 6,800                                                                    |
| Replacement    | \$ 12,000                                                                   |

It is noted that the final recommendation for maintenance hole projects were based on a yearly program budget of \$300,000 as discussed in Section 9. The unit costs presented in Table 10-5 are presented as a general guideline to SBMWD when applying their yearly budget for maintenance hole rehabilitation and replacement projects.

### 10.1.4 Units Costs for Further Studies and Investigations

Several studies are recommended in this section to confirm results from the hydraulic evaluation and condition assessment work. These studies were costed on a case-by-case basis and will be discussed individually.

## 10.2 CAPITAL IMPROVEMENT PROJECTS

The CIP recommendations are presented by facility type and summary tables by planning horizon are presented at the end of the section. CIP cutsheets—single page summaries of capital improvement budget line items—are presented in Appendix N for all recommendations in this CIP. Recommendations for operation and maintenance actions are also summarized at the end of this section. Appendix O presents the CIP summary workbook provided to SBMWD for this update. Table 10-6 shows a summary of the CIP by facility type.

**Table 10-6: Summary of CIP Recommendations by Facility Type (2019 Q1 Dollars)**

| Improvement Type                                                                  | Length (ft)                                                        | Total Cost <sup>1</sup> |
|-----------------------------------------------------------------------------------|--------------------------------------------------------------------|-------------------------|
| <b>Capacity Recommendations</b>                                                   |                                                                    |                         |
| Pipeline and Siphon Flow Study                                                    | Flow Monitoring of 40 sites at an assumed cost of \$3,800 per site | \$150,000               |
| Special Area GIS Study - West Residential                                         | [100 MHs + 1 month of Flow Monitoring at 3 locations]              | \$100,000               |
| Pipeline Flow Study                                                               | Flow Monitoring of 40 sites at an assumed cost of \$3,800 per site | \$150,000               |
| GIS Study                                                                         | Survey of 900 maintenance holes                                    | \$100,000               |
| <i>Subtotal of Capacity-Related Improvements</i>                                  |                                                                    | <i>\$500,000</i>        |
| <b>Condition Recommendations (by size and quantity) – Pipes with CCTV Footage</b> |                                                                    |                         |
| Replace 8" diameter                                                               | 205,283                                                            | \$45,586,000            |
| Replace 10" diameter                                                              | 4,089                                                              | \$934,000               |
| Replace 12" diameter                                                              | 15,761                                                             | \$5,239,000             |
| Replace 15" diameter                                                              | 6,810                                                              | \$2,111,000             |
| Replace 18" diameter                                                              | 4,404                                                              | \$2,193,000             |
| Replace 21" diameter                                                              | 336                                                                | \$64,000                |
| Replace 27" diameter                                                              | 862                                                                | \$263,000               |
| Replace 36" diameter                                                              | 220                                                                | \$128,000               |
| PDR Study of Large Diameter Condition Pipelines                                   | \$25,000 per segment                                               | \$100,000               |
| <i>Subtotal of Condition-Related Improvements, CCTV Pipes</i>                     |                                                                    | <i>\$56,618,000</i>     |
| <b>Condition Recommendations - Structures</b>                                     |                                                                    |                         |

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|                                                                                                                                                                                                                                                      |       |                                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|---------------------------------|
| Maintenance Holes                                                                                                                                                                                                                                    |       | \$4,800,000                     |
| Siphon Structures                                                                                                                                                                                                                                    |       | \$1,984,000                     |
| Siphon Pipelines                                                                                                                                                                                                                                     | 2,875 | \$22,522,000                    |
| Lift Station                                                                                                                                                                                                                                         |       | \$6,458,000                     |
| <b>Totals</b>                                                                                                                                                                                                                                        |       |                                 |
| <b>Total</b>                                                                                                                                                                                                                                         |       | <b>\$92,882,000<sup>2</sup></b> |
| <b>Notes</b>                                                                                                                                                                                                                                         |       |                                 |
| 1. Total Project Cost rounded to nearest thousand dollars.                                                                                                                                                                                           |       |                                 |
| 2. Cost includes 20 percent Contingency; 30 Percent Engineering, Legal, and Administrative Costs; 10 Percent Contractor GCs in addition to Construction Costs. 10 Percent Contractor GCs not included for survey, flow monitoring, CCTV, and studies |       |                                 |

### 10.2.1 Capacity Recommendations – Pipes with CCTV Footage

When performing the model build and analysis for the 2019 SMP Update, several issues with GIS data reliability and the availability of supporting data were identified. These issues are discussed in Sections 5, 6, and 8. Initial results of the hydraulic model analysis and recommendations were presented to SBMWD staff and are detailed in Section 8. Upon discussion with staff it was decided that due to model uncertainty and data inconsistencies, the projects identified to address capacity efficiency require further study before inclusion in CIP. Therefore, all CIP recommendations to address capacity deficiencies are studies and further investigatory actions to confirm model results and define detailed project recommendations for later inclusion into an updated CIP.

The following table shows general recommendations for the phasing recommended to address capacity deficiencies identified in the model. As more data and information are gathered through these studies identified in Table 10-7, the findings from these additional efforts should be used to create a final prioritization of capacity projects adopted by SBMWD.

**Table 10-7: Prioritization of Capacity Driven Projects**

| Analysis                                                     | Study Recommendations                                                                                                                                                                                             |
|--------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Existing Wet Weather 2-year storm frequency results          | Recommendations to resolve maintenance hole flooding at the 2-year storm frequency are recommended for the short-term timeframe. These are the next most likely locations for full or surcharged pipelines.       |
| Existing Dry Weather Capacity Results                        | Dry Weather Capacity projects are recommended for the short-term timeframe. These are the most likely areas modeled to have full or surcharged pipes in the system based on current model results.                |
| Existing Wet Weather 10-year storm frequency results         | It is recommended that SBMWD develop a wet weather monitoring plan and conduct further hydraulic studies for these locations. Any projects identified are recommended for the long-term horizon.                  |
| Buildout Dry and Wet Weather (2-year storm) Capacity Results | Areas of concern were identified for SBMWD to monitor as new developments occur. These areas will likely need long term monitoring but no projects are anticipated in the horizons identified in this SMP Update. |

Studies identified to address the deficiencies identified in Section 8 are discussed in the following subsections.



## **SECTION 10.0 - CAPITAL IMPROVEMENT PROGRAM**

### **10.2.1.1 Pipeline and Siphon Flow Study -**

Sources of uncertainty in the hydraulic model include the pipe and maintenance hole attributes such as invert elevation, slope, and in some cases, connectivity. Because the amount and depth of flow in modeled pipelines are dependent upon these attributes for accuracy, infrastructure identified as being capacity deficient should be further investigated to determine if the deficiency is accurate or caused by data error. In furtherance of this recommendation, a flow study is recommended to verify flow volumes and available capacity in the affected pipelines. Section 8 details the pipe segments identified for each model scenario that were determined to be outside of accepted criteria established in Section 7. Table 10-7 details the relative priority for each of these model scenarios and the order in which discrepancies should be investigated. For the immediate horizon of the CIP, it was assumed that 40 locations would be investigated with an estimated cost for flow monitoring of roughly \$3,800 per location. The locations prioritized for this study are those showing capacity deficiency in the existing dry weather and existing 2-year storm wet weather scenarios. In addition, there are several siphons in the SBMWD system that, based upon spreadsheet analysis and model flows, are not meeting minimum velocity criteria during average day flows. These siphons should be flow monitored for velocity and volume to confirm the model flows and confirm whether replacement is needed.

### **10.2.1.2 Special Area GIS Study - West Residential**

The West Residential portion of the SBMWD service area was selected as an area for flow monitoring and calibration of the hydraulic model and is shown in Figure 10-1. Unfortunately, as described in Sections 4, 6 and 8, the pipeline that was monitored only collected a small portion of the flow from this area, and flow in the larger transmission line that collects from this area was not captured. This caused difficulty in properly calibrating the area and as such, results in the model for this area are unreliable. In addition to the lack of calibration data, the GIS data and maintenance hole survey data for this area conflicted at many locations and it was difficult to confidently resolve the modeled flows and physical characteristics for this area. To build more confidence in the model, it is recommended that SBMWD conduct a detailed GIS study for this location. It is further recommended that the transmission pipeline conveying the majority of flow for this area be included in the flow study discussed previously. This study estimate is \$100,000, including ELA and contingency, which assumes a survey of 100 maintenance holes and one month of flow monitoring at three locations.

### **10.2.1.3 Pipeline Flow Study**

This is a continuation of the study discussed in Section 10.2.1.1 but is slated for the 2022-2025 planning horizon instead of the 2020-2021. The previous study is intended to get flow data for immediate capacity concerns as discussed in Section 8, and for double-barreled system siphons (single barreled pipelines are recommended for replacement and will be discussed in section 10.2.3.4). The pipelines recommended for this study are any outstanding capacity deficiencies identified in Section 8 for the existing dry and wet weather planning horizons. Table 10-7 can be used as a reference for the relative importance of the capacity deficiencies identified in Section 8. This study is assumed to address 40 sites at an average cost per location of \$3,800, including ELA and contingency, for a total study estimate of \$150,000.

### **10.2.1.4 GIS Study**

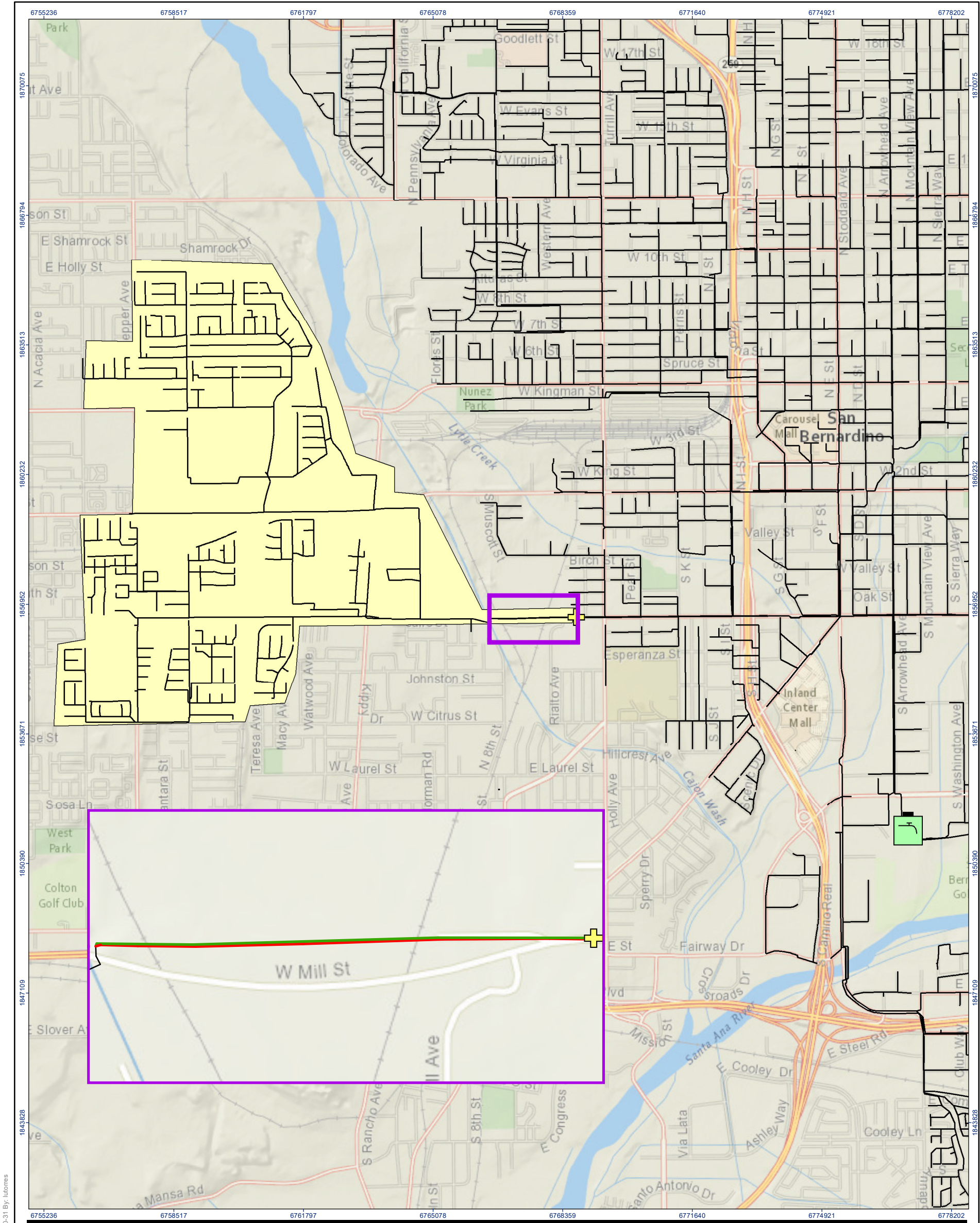
To improve the GIS data accuracy, it is recommended that SBMWD undertake a system wide maintenance hole survey to continue upon the work done for this SMP update. There was significant disagreement between this study

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and existing GIS data. Discrepancies between these two data sets caused adverse slopes and raised connectivity questions in many cases. Stantec has assumed that this study will address roughly 900 maintenance holes. These locations should be selected upon reevaluation of the GIS database after Immediate Horizon recommendations have been implemented. It is anticipated that SBMWD may require additional survey after the completion of this second study and may also consider conducting the work with in-house staff to save costs. Stantec recommends that SBMWD eventually survey at least one third of their maintenance holes (never having more than two contiguous locations without a survey) so that the survey data can be used to define the entire network and eventually supersede the existing GIS data; therefore there would be no maintenance holes without at least one neighboring location with survey data so that all locations will have updated location data, or it can be interpolated from a direct neighbor.

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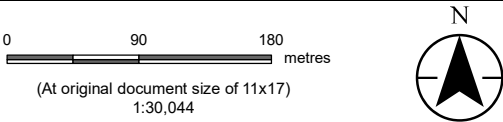


C:\Users\lutorres\OneDrive - Stantec\Office\365\San Bernardino\ol\UXDs\FlowMeterMap.mxd      Revised: 2019-10-31 By: lutorres

Legend

-  Flow Meter Location
-  Sewer Pipe
-  Subcatchment
-  SBMWD WRP
-  Sewer Pipe
-  Actual Location
-  Expected Location

**Notes**  
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet  
2. Background: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.



Project Location      Prepared by L.Torres on 2019-10-31  
San Bernardino County  
California  
Client/Project      Contract No. 1674

San Bernardino Municipal Water Department  
2019 Sewer Master Plan

Figure No.

10-1

Title

West Residential Study Area

Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.





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### 10.2.2 Condition Recommendations - Pipes with CCTV Footage

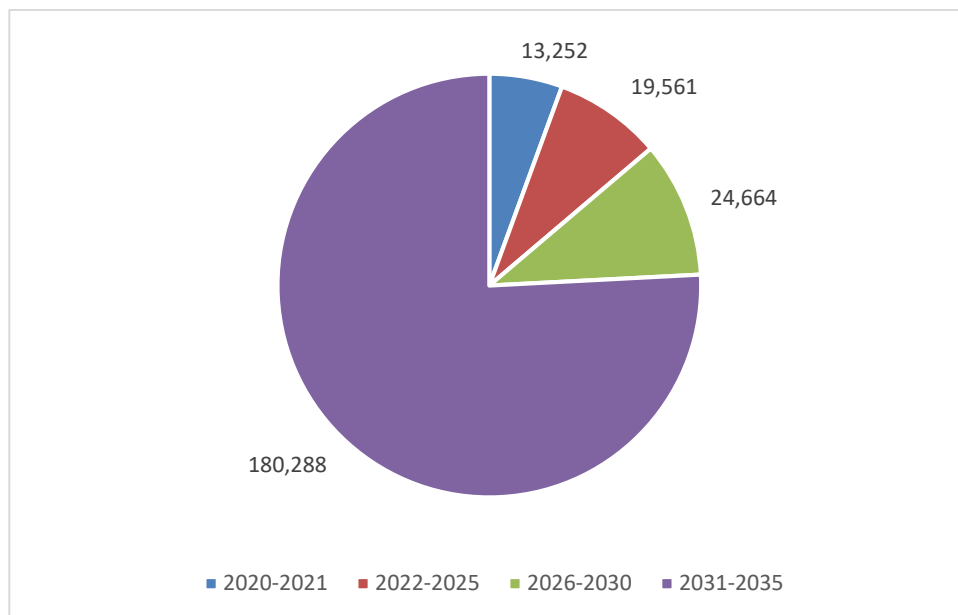
#### 10.2.2.1 Replacement and Rehabilitation of Pipeline

Using the decision tree shown in Figure 9-3 in Section 9, either CCTV, CIPP, point repair, or replacement was recommended for pipes with CCTV records. If a pipeline had a score of zero or had defects with a grade of 1, 2, or 3, it was recommended for future CCTV and included in the non-CCTV pipes recommendations discussed in Section 9 and in subsection 10.7. Pipelines with grade 5 defects are the most pressing for SBMWD and to properly assign a rehabilitation and replacement action, the videos and reports from the 36 worst pipeline (having 3 or more grade 5 defects) were reviewed and are discussed in Section 9. These pipelines are prioritized highest with a few exceptions; in discussion with SBMWD staff any pipeline recommended for replacement that is greater than 36" in diameter requires a PDR level study to assess options for rehabilitation, bypass pumping, and other considerations specific to large diameter transmission mains. All other pipes were assigned a rehabilitation or replacement action (based on the decision tree presented in Section 9) and a planning horizon (based on the adjusted risk score). Table 10-8 summarizes the pipe condition recommendations by length and cost for the four planning horizons, while Figure 10-2 and Figure 10-3 show a pie chart summarizing the recommendations by length and cost, respectively.

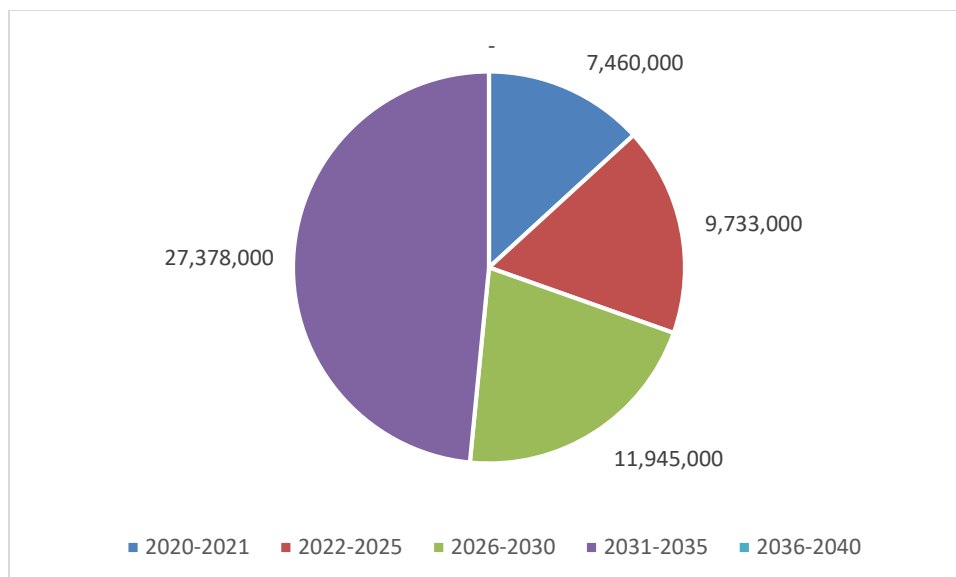
**Table 10-8: Summary of Pipes Rehabilitation and Replacement Costs per Horizon**

|              | Length (ft.)           |                     |                      |                      |
|--------------|------------------------|---------------------|----------------------|----------------------|
| Diameter     | Immediate              | Short Term          | Long Term            | 2031-2035            |
| 8            | 9,268                  | 18,269              | 22,794               | 154,952              |
| 10           | -                      | -                   | -                    | 4,089                |
| 12           | 2,986                  | 791                 | 298                  | 11,686               |
| 15           | -                      | 252                 | 1,276                | 5,282                |
| 18           | 828                    | 249                 | 296                  | 3,031                |
| 21           | -                      | -                   | -                    | 336                  |
| 27           | 170                    | -                   | -                    | 692                  |
| 36           | -                      | -                   | -                    | 220                  |
| <b>Total</b> | <b>13,252</b>          | <b>19,561</b>       | <b>24,664</b>        | <b>180,288</b>       |
|              | Cost (2019 Q1 Dollars) |                     |                      |                      |
| Diameter     | Immediate              | Short Term          | Long Term            | 2031-2035            |
| 8            | \$ 4,475,000           | \$ 8,775,000        | \$ 10,899,000        | \$ 21,437,000        |
| 10           | -                      | -                   | -                    | \$ 934,000           |
| 12           | \$ 2,037,000           | \$ 518,000          | \$ 29,000            | \$ 2,655,000         |
| 15           | -                      | \$ 191,000          | \$ 750,000           | \$ 1,170,000         |
| 18           | \$ 761,000             | \$ 250,000          | \$ 267,000           | \$ 915,000           |
| 21           | -                      | -                   | -                    | \$ 64,000            |
| 27           | \$ 188,000             | -                   | -                    | \$ 75,000            |
| 36           | -                      | -                   | -                    | \$ 128,000           |
| <b>Total</b> | <b>\$ 7,461,000</b>    | <b>\$ 9,734,000</b> | <b>\$ 11,945,000</b> | <b>\$ 27,378,000</b> |

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**Figure 10-2: Pipe Rehabilitation and Replacement Length (ft.) per Horizon**



**Figure 10-3: Pipe Rehabilitation and Replacement Cost per Horizon (2019 Q1 Dollars)**

### 10.2.2.2 PDR of Large Diameter Pipes

Because of the challenges involved with rehabilitation and replacement of large diameter pipes (greater than 36" in diameter) specific PDR level investigations are recommended. Challenges for addressing large transmission pipelines include bypass pumping, available right-of-way, utility interference, among others. Additionally, there are options for the repair of large diameter pipelines that may offer some cost-savings for SBMWD that can be further investigated during a PDR study. Table 10-9 shows the four pipelines recommended for further study.

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**Table 10-9: Large Diameter Pipelines for PDR Study**

| Pipe ID        | Pipe Length | Pipe Diameter | Grid ID | CoF Score | LoF Score | Adjusted Risk Score |
|----------------|-------------|---------------|---------|-----------|-----------|---------------------|
| 07600950760105 | 681         | 48            | 76      | 3.72      | 5.00      | 100.00              |
| 07600940760095 | 732.9       | 48            | 76      | 3.63      | 5.00      | 100.00              |
| 07600960760094 | 667.5       | 48            | 76      | 3.50      | 4.96      | 100.00              |
| 08700140860134 | 634.3       | 54            | 86      | 3.84      | 2.10      | 71.62               |

These pipelines have recent CCTV available and the adjusted risk score is based on CCTV results, with the exception of 08700140860134. That pipeline would be included in the future CCTV recommendation, however, a structure discovered on this pipeline by SBMWD staff warranted detailed study. According to SBMWD staff, the Old Headworks Facility concrete structure located east of the WRP and the Twin Creek Channel and south of Dumas Street shows visible concrete and rebar damage that appears to be Level 4 on V&A's Vanda Concrete Corrosion Index Rating System. This location is shown on Figure 10-4.



**Figure 10-4: Concrete Structure on Pipeline 08700140860134**

The cost for the PDR studies of the four pipelines listed on Table 10-9 are assumed at \$25,000 for each pipe segment for a total project cost of \$100,000. This includes contingency and ELA.



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### **10.2.3 Condition Recommendations – Structures**

#### **10.2.3.1 Maintenance Holes**

A sample of 101 maintenance holes were selected from SBMWD's GIS for condition assessment. The condition assessments were conducted from grade and provided photographs of the interior and surface of each maintenance hole assessed, X-Y coordinates in GIS, and depths among other information. This assessment and Stantec's review of the 101 locations are discussed in detail in Section 9. Based upon discussions with SBMWD staff, a line item budget of \$300,000 has been allocated each year to address maintenance hole rehabilitation and replacement. This effort can be delivered in conjunction with maintenance hole and pipeline survey actions described in section 10.2.1 in order to save costs of mobilization and minimize impacts to traffic and local business.

#### **10.2.3.2 Lift Stations**

This SMP included condition assessment and operational review of SBMWD's lift stations. The findings and recommendations are discussed in Section 9, a lift station assessment report is included as Appendix K. A summary of project costs and recommended planning horizons are included in Table 10-10. Lift stations were given a priority ranking based on the severity of the existing defects and consequence of failure. SBMWD staff indicated that the Meridian Lift Station currently sees the most operational difficulties and should be replaced as soon as possible. SBMWD has also indicated that all self-priming type lift stations in their system (Valley Truck Farm, Pine, Meridian, and Macy Lift Stations) experience more operational difficulties than other lift station types. The costs presented below reflect replacement of Meridian Lift Station and rehabilitation of other lift stations. If SBMWD continues to experience issues with self-priming type lift stations, replacement or conversion of those lift stations should be considered during preliminary design of rehabilitation projects.

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**Table 10-10: Summary of Lift Station Recommendation Costs (2019 Q1 Dollars)**

| Lift Station Number    | Priority | Lift Station Name              | Recommended Time Horizon | Estimated Construction Cost | Contingency + ELA + Contractor GCs | Total Cost          |
|------------------------|----------|--------------------------------|--------------------------|-----------------------------|------------------------------------|---------------------|
| LS 10                  | 1        | Meridian Lift Station          | 2020-2021                | \$ 632,000                  | \$ 379,000                         | \$ 1,011,000        |
| CC                     | 2        | East Interceptor Lift Station  | 2022-2025                | \$ 76,000                   | \$ 46,000                          | \$ 122,000          |
| AA                     | 3        | Arrowhead Lift Station         | 2022-2025                | \$ 1,238,000                | \$ 743,000                         | \$ 1,981,000        |
| LS 4                   | 4        | Fairway Lift Station           | 2022-2025                | \$ 167,000                  | \$ 100,000                         | \$ 267,000          |
| LS 3                   | 5        | Colton Lift Station            | 2022-2025                | \$ 177,000                  | \$ 106,000                         | \$ 282,000          |
| LS 2                   | 6        | May Co Lift Station            | 2022-2025                | \$ 253,000                  | \$ 152,000                         | \$ 404,000          |
| LS 5                   | 7        | Airport Lift Station           | 2026-2030                | \$ 64,000                   | \$ 39,000                          | \$ 103,000          |
| LS 8                   | 8        | Pine Lift Station              | 2026-2030                | \$ 153,000                  | \$ 92,000                          | \$ 245,000          |
| LS 6                   | 9        | Valley Truck Farm Lift Station | 2026-2030                | \$ 95,000                   | \$ 57,000                          | \$ 153,000          |
| LS 11                  | 10       | Macy Lift Station              | 2026-2030                | \$ 174,000                  | \$ 104,000                         | \$ 278,000          |
| LS 7                   | 11       | Allen Lift Station             | 2026-2030                | \$ 55,000                   | \$ 33,000                          | \$ 88,000           |
| BB                     | 12       | E street lift station          | 2026-2030                | \$ 784,000                  | \$ 470,000                         | \$ 1,254,000        |
| LS 9                   | 13       | City Hall Lift Station         | 2026-2030                | \$ 35,000                   | \$ 21,000                          | \$ 57,000           |
| LS 1                   | 14       | Carousel Lift Station          | 2026-2030                | \$ 73,000                   | \$ 44,000                          | \$ 116,000          |
| LS 12                  | 15       | Riverwalk Lift Station         | 2026-2030                | \$ 62,000                   | \$ 37,000                          | \$ 98,000           |
| <b>Total 2020-2021</b> |          |                                |                          | <b>\$ 632,000</b>           | <b>\$ 379,000</b>                  | <b>\$ 1,011,000</b> |
| <b>Total 2022-2025</b> |          |                                |                          | <b>\$ 1,910,000</b>         | <b>\$ 1,146,000</b>                | <b>\$ 3,057,000</b> |
| <b>Total 2026-2030</b> |          |                                |                          | <b>\$ 1,494,000</b>         | <b>\$ 896,000</b>                  | <b>\$ 2,390,000</b> |
| <b>Total</b>           |          |                                |                          | <b>\$ 4,036,000</b>         | <b>\$ 2,422,000</b>                | <b>\$ 6,458,000</b> |

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### 10.2.3.3 Siphon Structures

Existing siphon structures were evaluated by via confined space entry to document conditions of the structures. Recommendations for siphon structure rehabilitation are documented in Table 10-11 below. Costs for recommendations are included in the table following description of the recommendations.

**Table 10-11: Siphon Structure Costs (2019 Q1 Dollars)**

| Siphon                                            | Upstream/<br>Down-<br>stream | Notes                                                                                                                                                          | Estimated<br>Construction<br>Cost | 20% Contingency<br>+ 30% ELA + 10%<br>GCs | Total<br>Project<br>Cost | Time<br>Horizon |
|---------------------------------------------------|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-------------------------------------------|--------------------------|-----------------|
| Mill Street - Lytle<br>Creek Channel              | US                           | Remove T-lock liner<br>Resurface and recoat structure interior<br>Replace brick and mortar weir wall                                                           | \$73,000                          | \$44,000                                  | \$117,000                | Short-Term      |
|                                                   | DS                           | Remove t-lock liner<br>Resurface and recoat structure interior                                                                                                 | \$65,000                          | \$39,000                                  | \$104,000                | Short-Term      |
| Perris Hill Park -<br>Twin Creek<br>Channel       | US                           | Resurface and recoat structure interior                                                                                                                        | \$91,000                          | \$54,000                                  | \$145,000                | Short-Term      |
|                                                   | DS                           | Resurface and recoat structure interior<br>Modify flow channel                                                                                                 | \$73,000                          | \$44,000                                  | \$117,000                | Short-Term      |
| San Bernardino<br>Siphon - Santa Ana<br>River     | US                           | Remove existing spray on liner<br>Reform flow channel<br>Resurface and recoat structure interior                                                               | \$81,000                          | \$49,000                                  | \$130,000                | Short-Term      |
|                                                   | DS                           | Resurface and recoat structure interior<br>Modify flow channel                                                                                                 | \$40,000                          | \$24,000                                  | \$63,000                 | Short-Term      |
| Loma Linda Siphon<br>- Santa Ana River<br>Channel | US                           | Remove existing spray on liner and T-lock<br>liner<br>Remove existing MH frames and covers<br>over siphon inlet bay<br>Resurface and recoat structure interior | \$98,000                          | \$59,000                                  | \$157,000                | Short-Term      |
|                                                   | DS                           | Remove t-lock liner<br>Resurface and recoat structure interior                                                                                                 | \$65,000                          | \$39,000                                  | \$103,000                | Short-Term      |

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| Siphon                                                                | Upstream/<br>Down-<br>stream | Notes                                                                                                                        | Estimated<br>Construction<br>Cost | 20% Contingency<br>+ 30% ELA + 10%<br>GCs | Total<br>Project<br>Cost | Time<br>Horizon |
|-----------------------------------------------------------------------|------------------------------|------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-------------------------------------------|--------------------------|-----------------|
| Zanga - Mission<br>Channel                                            | US                           | Remove ladder rungs<br>Address root intrusion<br>Resurface and recoat structure interior                                     | \$33,000                          | \$20,000                                  | \$53,000                 | Short-Term      |
|                                                                       | DS                           | Remove ladder rungs<br>Fill abandoned connection<br>Injection corrosion inhibitor<br>resurface and recoat structure interior | \$50,000                          | \$30,000                                  | \$79,000                 | Short-Term      |
| Waterman Avenue<br>- Santa Ana River<br>Channel                       | US                           | Replace 2 maintenance hole covers                                                                                            | \$82,000                          | \$49,000                                  | \$131,000                | Long-Term       |
|                                                                       | DS                           | Remove t-lock liner<br>Resurface and recoat structure interior                                                               | \$42,000                          | \$25,000                                  | \$68,000                 | Long-Term       |
| I street - Lytle<br>Creek Channel                                     | US                           | Remove t-lock liner<br>Resurface and recoat structure interior                                                               | \$62,000                          | \$37,000                                  | \$100,000                | Long-Term       |
|                                                                       | DS                           | Remove t-lock liner<br>Resurface and recoat structure interior                                                               | \$57,000                          | \$34,000                                  | \$92,000                 | Long-Term       |
| Santa Fe - Santa<br>Ana River                                         | US                           | Remove flap gates and ladder rungs<br>Resurface and recoat structure interior                                                | \$111,000                         | \$67,000                                  | \$177,000                | Long-Term       |
|                                                                       | DS                           | Remove ladder rungs<br>Resurface and recoat structure interior<br>Replace frame and cover                                    | \$114,000                         | \$69,000                                  | \$183,000                | Long-Term       |
| Inland Center Mall -<br>Santa Ana River<br>Channel                    | US                           | Resurface and recoat                                                                                                         | \$54,000                          | \$33,000                                  | \$87,000                 | Long-Term       |
|                                                                       | DS                           | Resurface and recoat structure interior<br>Pour new concrete collar around frame<br>and cover                                | \$49,000                          | \$29,000                                  | \$78,000                 | Long-Term       |
| <b>Total</b>                                                          |                              |                                                                                                                              | <b>\$1,240,000</b>                | <b>\$744,000</b>                          | <b>\$1,983,000</b>       |                 |
| Note: All costs in this table are rounded to nearest thousand dollar. |                              |                                                                                                                              |                                   |                                           |                          |                 |



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### 10.2.3.4 Siphon Pipelines

Siphon pipelines listed in SBMWD's GIS were assessed in the hydraulic model to determine if a minimum scouring velocity of 4 ft/s was achieved at least once per day. The results of that analysis are discussed in Section 9. For siphons with multiple barrels the hydraulic model assumed both were in operation. Given GIS inaccuracies and hydraulic model results showing that none of the siphons meet the minimum velocity required, it is recommended that SBMWD confirm the results of the hydraulic model with the flow study described in section 10.2.1.1. For the CIP, only single barreled siphons were recommended for replacement as they do not meet the planning criteria discussed in Section 7.

Single barrel siphons will require a redundant barrel installed for maintenance and reliability purposes. It was assumed that any structure attached to a single barrel siphon would need to be replaced during installation of the second barrel. If a siphon occurs in succession to another siphon (i.e. multiple siphons use a common diversion structure), costs for structure replacement were not double counted. A 2019 construction cost of \$48,000 was used for structure replacement.

Table 10-12 summarizes the siphon pipelines recommended for improvement to double barrel and the associated costs and planning horizon.

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**Table 10-12: Siphon Pipeline Recommendation Costs (2019 Q1 Dollars)**

| US MH ID                                                           | DS MH ID | Location                                      | Pipe Diameter (inches) | Approximate Length (feet) | Estimated Construction Cost | Cont., ELA, and GC  | Total Project Cost   | Time Horizon |
|--------------------------------------------------------------------|----------|-----------------------------------------------|------------------------|---------------------------|-----------------------------|---------------------|----------------------|--------------|
| 0560312                                                            | 0560157  | W Base Line St, East of N Arrowhead Ave       | 8                      | 600                       | \$2,633,300                 | \$1,580,000         | \$4,213,300          | Short-Term   |
| 0660342                                                            | 0660341  | Carousel Mall                                 | 8                      | 385                       | \$1,672,000                 | \$1,003,200         | \$2,675,200          | Short-Term   |
| 0670102                                                            | 0670103  | E 6th St, East of Cooley St                   | 33                     | 120                       | \$1,622,400                 | \$973,400           | \$2,595,800          | Short-Term   |
| 0530102                                                            | 0530103  | W 16th St, West of N State St University Pkwy | 8                      | 123                       | \$576,600                   | \$346,000           | \$922,600            | Long-Term    |
| 0530103                                                            | 0530104  | W 16th St, West of N State St University Pkwy | 8                      | 291                       | \$1,279,000                 | \$767,400           | \$2,046,400          | Long-Term    |
| 0530104                                                            | 0530105  | W 16th St, West of N State St University Pkwy | 8                      | 318                       | \$1,391,894                 | \$835,100           | \$2,227,000          | Long-Term    |
| 0530105                                                            | 0530068  | W 16th St, West of N State St University Pkwy | 8                      | 147                       | \$739,400                   | \$443,600           | \$1,183,000          | Long-Term    |
| 0530106                                                            | 0530103  | W 16th St & Colorado Ave                      | 8                      | 136                       | \$631,000                   | \$378,600           | \$1,009,600          | Long-Term    |
| 0660341                                                            | 0660036  | Carousel Mall                                 | 8                      | 230                       | \$1,086,400                 | \$651,800           | \$1,738,200          | Long-Term    |
| 0660343                                                            | 0660113  | W 8th St near N D St                          | 8                      | 185                       | \$898,200                   | \$538,900           | \$1,437,100          | Long-Term    |
| 0970197                                                            | 0970161  | E Weir Rd, east of Steele Rd                  | 8                      | 340                       | \$1,546,300                 | \$927,800           | \$2,474,100          | Long-Term    |
| <b>Total</b>                                                       |          |                                               |                        |                           | <b>\$ 14,077,000</b>        | <b>\$ 8,446,000</b> | <b>\$ 22,522,000</b> |              |
| Notes:                                                             |          |                                               |                        |                           |                             |                     |                      |              |
| 1. All costs in this table are rounded to nearest thousand dollar. |          |                                               |                        |                           |                             |                     |                      |              |



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### 10.3 IMMEDIATE PLANNING HORIZON – 2020-2021

The immediate planning horizon comprises recommendations necessary to provide reliable wastewater service. These projects are recommended for immediate development and implementation and are assumed to be completed over the next two years. Some projects may take longer than two years to implement extending out funding. SBMWD provided budgetary goals for each planning horizon and as such, the projects recommended for these horizons are intended to address the most pressing projects within the budget limitations communicated by SBMWD. For the immediate horizon, a yearly CIP budget of \$5 million per year was used as the threshold for project inclusion. Table 10-13 summarizes the CIP projects identified for the immediate planning horizon.

**Table 10-13: Immediate Horizon (2020-2021) CIP Project Summary**

| Facility                                                                                                                                                                                                                                                                  | Length (ft)                                                        | Project Cost (Dollars) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|------------------------|
| <b>Capacity Based Recommendations</b>                                                                                                                                                                                                                                     |                                                                    |                        |
| Pipeline and Siphon Flow Study                                                                                                                                                                                                                                            | Flow monitoring of 40 sites at an assumed cost of \$3,800 per site | \$150,000              |
| Special Area GIS Study - West Residential                                                                                                                                                                                                                                 | [100 MHs + 1 month of flow monitoring at 3 locations]              | \$100,000              |
| <b>Condition Recommendations – Pipes with CCTV Footage</b>                                                                                                                                                                                                                |                                                                    |                        |
| Replacement of 8" diameter                                                                                                                                                                                                                                                | 9,268                                                              | \$4,475,000            |
| Replacement of 12" diameter                                                                                                                                                                                                                                               | 2,986                                                              | \$2,037,000            |
| Replacement of 18" diameter                                                                                                                                                                                                                                               | 828                                                                | \$761,000              |
| Replacement of 27" diameter                                                                                                                                                                                                                                               | 170                                                                | \$188,000              |
| PDR Study Large Diameter Pipelines                                                                                                                                                                                                                                        | \$25,000 per segment                                               | \$100,000              |
| <b>Condition Recommendations – Structures</b>                                                                                                                                                                                                                             |                                                                    |                        |
| Maintenance Holes                                                                                                                                                                                                                                                         | \$300,000 per year                                                 | \$600,000              |
| Lift Station                                                                                                                                                                                                                                                              |                                                                    | \$1,011,000            |
| <b>Totals</b>                                                                                                                                                                                                                                                             |                                                                    |                        |
| <b>Subtotal, 2019 Dollars</b>                                                                                                                                                                                                                                             |                                                                    | <b>\$9,422,000</b>     |
| <b>Escalated Total, 2021 Dollars</b>                                                                                                                                                                                                                                      |                                                                    | <b>\$9,996,000</b>     |
| <b>Average Yearly CIP Cost (2019 Dollars)</b>                                                                                                                                                                                                                             |                                                                    | <b>\$4,711,000</b>     |
| <b>Average Yearly CIP Cost (Escalated)</b>                                                                                                                                                                                                                                |                                                                    | <b>\$4,925,000</b>     |
| <b>Notes:</b>                                                                                                                                                                                                                                                             |                                                                    |                        |
| 1. Total Project Cost rounded to nearest thousand dollar                                                                                                                                                                                                                  |                                                                    |                        |
| 2. Total Project Cost includes 20 Percent Construction Contingency; 30 Percent Engineering, Legal, and Administrative Costs; 10 Percent Contractor GCs in addition to Construction Costs. 10 Percent Contractor GCs not included for survey, flow monitoring, and studies |                                                                    |                        |
| 3. Escalation assumes 3 Percent annual inflation. Costs are escalated on a year-to-year basis and averaged over the horizon.                                                                                                                                              |                                                                    |                        |

## 10.4 SHORT TERM PLANNING HORIZON – 2022-2025

Table 10-14 summarizes the recommended projects for the short term, 2022-2025 planning scenario. For the short-term horizon, a yearly CIP budget of \$7.1 million per year was used as the threshold for project inclusion.

**Table 10-14: Short Term Horizon (2022-2025) CIP Project Summary**

| Facility                                                                                                                                                                                                                                                                        | Length (ft)                                                        | Total Project Cost (Dollars) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|------------------------------|
| <b>Capacity Recommendations - Pipes</b>                                                                                                                                                                                                                                         |                                                                    |                              |
| Pipeline Flow Study                                                                                                                                                                                                                                                             | Flow monitoring of 40 sites at an assumed cost of \$3,800 per site | \$150,000                    |
| GIS Study                                                                                                                                                                                                                                                                       | Survey of 900 maintenance holes                                    | \$100,000                    |
| <b>Pipes with CCTV Footage</b>                                                                                                                                                                                                                                                  |                                                                    |                              |
| Replacement of 8" diameter                                                                                                                                                                                                                                                      | 18,269                                                             | \$8,775,000                  |
| Replacement of 12" diameter                                                                                                                                                                                                                                                     | 791                                                                | \$518,000                    |
| Replacement of 15" diameter                                                                                                                                                                                                                                                     | 252                                                                | \$191,000                    |
| Replacement of 18" diameter                                                                                                                                                                                                                                                     | 249                                                                | \$250,000                    |
| <b>Condition Recommendations – Structures</b>                                                                                                                                                                                                                                   |                                                                    |                              |
| <b>Maintenance Holes</b>                                                                                                                                                                                                                                                        | \$300,000 per year                                                 | \$1,200,000                  |
| <b>Siphon Structures</b>                                                                                                                                                                                                                                                        |                                                                    | \$1,069,000                  |
| <b>Siphon Pipelines</b>                                                                                                                                                                                                                                                         | 1,105                                                              | \$9,484,000                  |
| <b>Lift Station</b>                                                                                                                                                                                                                                                             |                                                                    | \$3,057,000                  |
| <b>Totals</b>                                                                                                                                                                                                                                                                   |                                                                    |                              |
| <b>Subtotal, 2019 Dollars</b>                                                                                                                                                                                                                                                   |                                                                    | <b>\$24,794,000</b>          |
| <b>Escalated Total, 2024 Dollars</b>                                                                                                                                                                                                                                            |                                                                    | <b>\$28,743,000</b>          |
| <b>Average Yearly CIP Cost (2019 Dollars)</b>                                                                                                                                                                                                                                   |                                                                    | <b>\$6,198,500</b>           |
| <b>Average Yearly CIP Cost (Escalated)</b>                                                                                                                                                                                                                                      |                                                                    | <b>\$7,084,000</b>           |
| <b>Notes:</b>                                                                                                                                                                                                                                                                   |                                                                    |                              |
| 1. Total Project Cost rounded to nearest thousand dollar                                                                                                                                                                                                                        |                                                                    |                              |
| 2. Total Project Cost includes 20 Percent Construction Contingency; 30 Percent Engineering, Legal, and Administration Costs; 10 Percent Contractor GCs in addition to Construction Costs. 10 Percent Contractor GCs not included for survey, flow monitoring, CCTV, and studies |                                                                    |                              |
| 3. Escalation assumes 3 Percent annual inflation. Costs are escalated on a year-to-year basis and averaged.                                                                                                                                                                     |                                                                    |                              |

## 10.5 LONGTERM PLANNING HORIZON – 2026-2030

Table 10-15 summarizes the recommended projects for the long term, 2026-2030 planning scenario. For the long term horizon, a yearly CIP budget of \$8 million per year was used as the threshold for project inclusion.

**Table 10-15: Long Term Horizon (2026-2030) CIP Project Summary**

| Facility                                                                                                                                                                                                                                                                        | Length (ft) | Total Project Cost (Dollars) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|------------------------------|
| <b>Pipes with CCTV Footage</b>                                                                                                                                                                                                                                                  |             |                              |
| Replacement of 8" diameter                                                                                                                                                                                                                                                      | 22,794      | \$10,899,000                 |
| Replacement of 12" diameter                                                                                                                                                                                                                                                     | 298         | \$29,000                     |
| Replacement of 15" diameter                                                                                                                                                                                                                                                     | 1,276       | \$750,000                    |
| Replacement of 18" diameter                                                                                                                                                                                                                                                     | 296         | \$267,000                    |
| <b>Condition Assessment</b>                                                                                                                                                                                                                                                     |             |                              |
| <b>Maintenance Holes</b>                                                                                                                                                                                                                                                        |             | \$1,500,000                  |
| <b>Siphon Structures</b>                                                                                                                                                                                                                                                        |             | \$915,000                    |
| <b>Siphon Pipelines</b>                                                                                                                                                                                                                                                         | 1,770       | \$13,038,000                 |
| <b>Lift Station</b>                                                                                                                                                                                                                                                             |             | \$2,390,000                  |
| <b>Totals</b>                                                                                                                                                                                                                                                                   |             |                              |
| <b>Subtotal, 2019 Dollars</b>                                                                                                                                                                                                                                                   |             | <b>\$29,788,000</b>          |
| <b>Escalated Total, 2028 Dollars</b>                                                                                                                                                                                                                                            |             | <b>\$38,867,000</b>          |
| <b>Average Yearly CIP Cost (2019 Dollars)</b>                                                                                                                                                                                                                                   |             | <b>\$5,957,600</b>           |
| <b>Average Yearly CIP Cost (Escalated)</b>                                                                                                                                                                                                                                      |             | <b>\$7,780,200</b>           |
| <b>Notes</b>                                                                                                                                                                                                                                                                    |             |                              |
| 1. Total Project Cost rounded to nearest thousand dollar                                                                                                                                                                                                                        |             |                              |
| 2. Total Project Cost includes 20 Percent Construction Contingency; 30 Percent Engineering, Legal, and Administration Costs; 10 Percent Contractor GCs in addition to Construction Costs. 10 Percent Contractor GCs not included for survey, flow monitoring, CCTV, and studies |             |                              |
| 3. Escalation assumes 3 Percent annual inflation. Costs are escalated on a year-to-year basis and averaged.                                                                                                                                                                     |             |                              |



## 10.6 2031-2035 HORIZON

Table 10-16 summarizes the recommended projects for the short term, 2031-2035 planning scenario. For the immediate horizon, a yearly CIP budget of \$9 million per year was used as the threshold for project inclusion.

**Table 10-16: 2031-2035 Horizon CIP Project Summary**

| Facility                                                                                                                                                                                                                                                                        | Length (ft) | Total Project Cost (Dollars) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|------------------------------|
| <b>Pipes with CCTV Footage</b>                                                                                                                                                                                                                                                  |             |                              |
| Replacement of 8" diameter                                                                                                                                                                                                                                                      | 154,952     | \$21,437,000                 |
| Replacement of 10" diameter                                                                                                                                                                                                                                                     | 4,089       | \$934,000                    |
| Replacement of 12" diameter                                                                                                                                                                                                                                                     | 11,686      | \$2,655,000                  |
| Replacement of 15" diameter                                                                                                                                                                                                                                                     | 5,282       | \$1,170,000                  |
| Replacement of 18" diameter                                                                                                                                                                                                                                                     | 3,031       | \$915,000                    |
| Replacement of 21" diameter                                                                                                                                                                                                                                                     | 336         | \$64,000                     |
| Replacement of 27" diameter                                                                                                                                                                                                                                                     | 692         | \$75,000                     |
| Replacement of 36" diameter                                                                                                                                                                                                                                                     | 220         | \$128,000                    |
| <b>Condition Assessment</b>                                                                                                                                                                                                                                                     |             |                              |
| <b>Maintenance Holes</b>                                                                                                                                                                                                                                                        |             | \$1,500,000                  |
| <b>Totals</b>                                                                                                                                                                                                                                                                   |             |                              |
| <b>Subtotal, 2019 Dollars</b>                                                                                                                                                                                                                                                   |             | <b>\$28,878,000</b>          |
| <b>Escalated Total, 2033 Dollars</b>                                                                                                                                                                                                                                            |             | <b>\$43,681,000</b>          |
| <b>Average Yearly CIP Cost (2019 Dollars)</b>                                                                                                                                                                                                                                   |             | <b>\$5,776,000</b>           |
| <b>Average Yearly CIP Cost (Escalated)</b>                                                                                                                                                                                                                                      |             | <b>\$8,744,000</b>           |
| <b>Notes</b>                                                                                                                                                                                                                                                                    |             |                              |
| 1. Total Project Cost rounded to nearest thousand dollar                                                                                                                                                                                                                        |             |                              |
| 2. Total Project Cost includes 20 Percent Construction Contingency; 30 Percent Engineering, Legal, and Administration Costs; 10 Percent Contractor GCs in addition to Construction Costs. 10 Percent Contractor GCs not included for survey, flow monitoring, CCTV, and studies |             |                              |
| 3. Escalation assumes 3 Percent annual inflation. Costs are escalated on a year-to-year basis and averaged.                                                                                                                                                                     |             |                              |

## **10.7 ADDITIONAL RECOMMENDATIONS**

### **10.7.1 Recommendations for Pipelines without CCTV Footage**

SBMWD pipelines were assessed through results of the CCTV program conducted by Stantec and Innerline Engineering. The results of these efforts were analyzed by Stantec engineers and findings were applied across the full system according to pipe attributes as described in Section 9.

Pipelines that were not part of the Innerline or Houston and Harris CCTV efforts are analyzed based on LoF and CoF criteria and recommendations are made for future CCTV of these pipes based on their overall risk score and location. These prioritized pipelines were then overlaid onto the SBMWD grid system in GIS in order to assign priorities to each grid for future CCTV activities. Addressing future CCTV on a grid by grid basis will allow for efficiency and cost-savings as opposed to addressing pipes individually based on adjusted risk score alone. Figure 9-8 in Section 9 shows a map of the grid prioritization resulting from this exercise. The grids are ranked by priority and all pipes within a grid are assigned the same prioritization. Table 10-17 summarizes the total length of pipes in the different priority grids, and the number of grids included in each category. For instance, the highest priority grids are the 11 grids that scored the highest average risk score, and totals 324,561 ft of pipeline. The thresholds between categories were established by assigning roughly 320,000 feet of total pipeline into each category. The thresholds between priority were set manually to separate the pipelines into roughly equal priority categories.

The cost of this program is anticipated to be delivered through SBMWD operations and maintenance program and has not been included in the costs of this CIP.

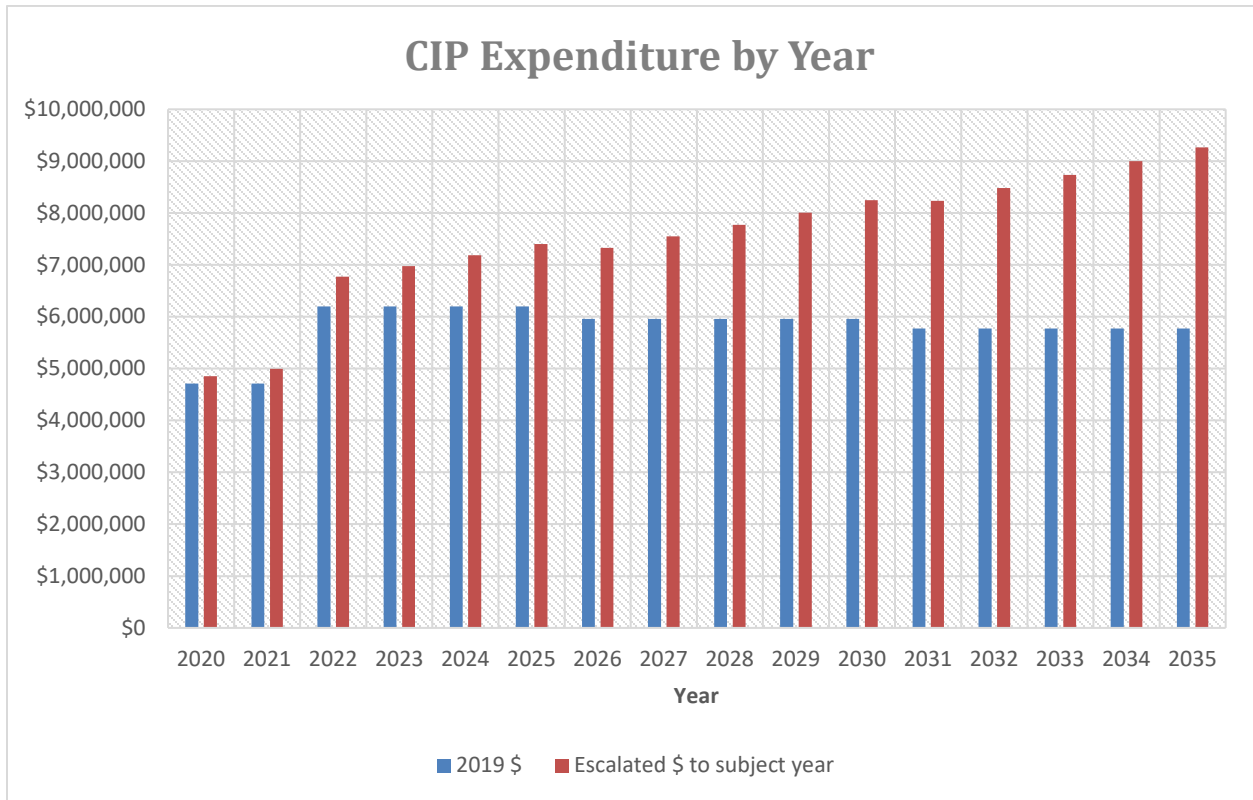
**Table 10-17: Recommendations for future CCTV prioritization**

| <b>Priority</b>   | <b>Total Length (ft)</b> | <b>Number of grids</b> |
|-------------------|--------------------------|------------------------|
| Highest Priority  | 324,561                  | 11                     |
| High Priority     | 298,040                  | 7                      |
| Moderate Priority | 314,436                  | 12                     |
| Low Priority      | 327,655                  | 13                     |
| Lowest Priority   | 328,904                  | 16                     |

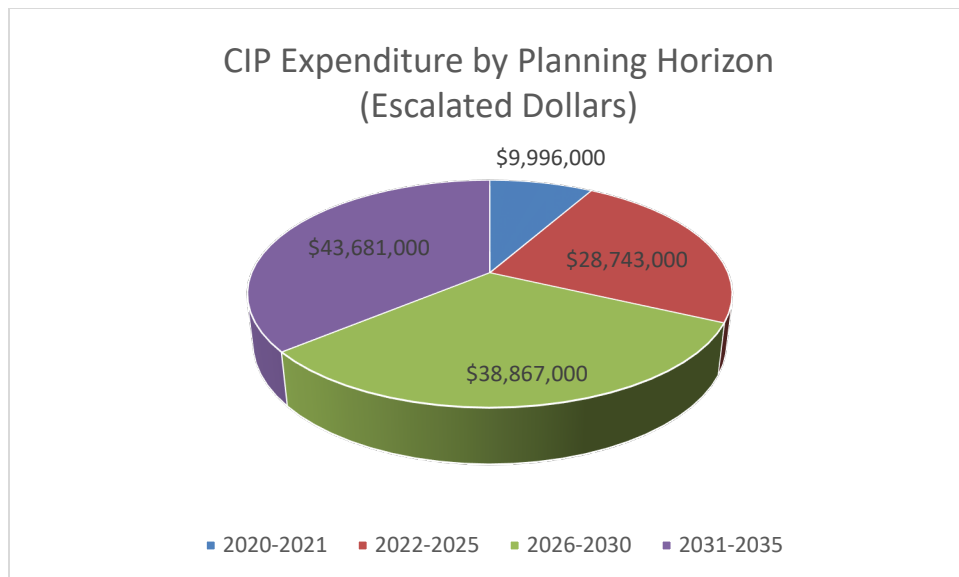
## **10.8 CIP SUMMARY**

Figure 10-5 and Figure 10-6 summarize the CIP costs discussed in this section by year and by planning horizon, respectively. The total CIP cost is estimated at \$92.9M in 2019 Q1 dollars, and \$120.8M based on a 3 percent escalation year-to year.

## SECTION 10.0 - CAPITAL IMPROVEMENT PROGRAM



**Figure 10-5: CIP Costs per Year**



**Figure 10-6: CIP Costs by Planning Horizon**







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