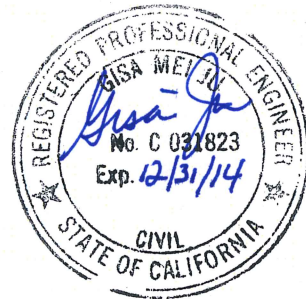




City of San Bruno Sewer Master Plan Final Report

Prepared by:



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List of Abbreviations

ADWF	Average Dry Weather Flow
APN	Assessor Parcel Number
Baykeeper	San Francisco Baykeeper
BWF	Base Wastewater Flow
CCTV	Closed-Circuit Television
CDO	Cease and Desist Order
CIP	Capital Improvement Program or Capital Improvement Plan
CIPP	Cured-in-Place Pipe
City	City of San Bruno
CMMS	Computerized Maintenance Management System
d/D	Ratio of flow depth to pipe diameter
DEM	Digital Elevation Model
DWF	Dry Weather Flow
EMS	Engineering Mapping Solutions
ENR CCI	Engineering News Record Construction Cost Index
FOG	Fats, Oils, and Grease
fps	Feet per second
FY	Fiscal Year
GIS	Geographic Information System
gpd	Gallons per day
GWI	Groundwater Infiltration
HDPE	High Density Polyethylene (Pipe)
I/I	Infiltration and Inflow
LPR	Lining Point Repair
MFR	Multi-Family Residential
mgd	Million Gallons per Day
MH	Manhole
MPR	Major Point Repair
NASSCO	National Association of Sewer Service Companies
NAVD88	North American Vertical Datum 1988
NGVD29	National Geodetic Vertical Datum 1929
PACP	Pipeline Assessment and Certification Program

PDWF	Peak Dry Weather Flow
PR	Point Repair
PS	Pump Station
PVC	Polyvinyl Chloride (Pipe)
PWWF	Peak Wet Weather Flow
RDI/I	Rainfall Dependent Infiltration and Inflow
RMC	RMC Water and Environment
R/R	Rehabilitation/Replacement
RWQCB	Regional Water Quality Control Board, San Francisco Bay Region
SECAP	System Evaluation and Capacity Assurance Plan
SFR	Single Family Residential
SQR	Structural Quick Rating
SSMP	Sewer System Management Plan
SSO	Sanitary Sewer Overflow
SWRCB	State Water Resources Control Board
V&A	V&A Consulting Engineers
VCP	Vitrified Clay Pipe
WQCP	Water Quality Control Plant
WWF	Wet Weather Flow
WWPF	Wet Weather Peaking Factor

Executive Summary

This report presents the results and recommendations of the Sewer Master Plan for the City of San Bruno (City). The report was prepared by RMC Water and Environment (RMC) under an agreement with the City dated December 22, 2010 and an amendment dated July 12, 2013.

The objective of this Master Plan is to update the City's previous sewer Master Plan and Infiltration/Inflow Study prepared in 2000. The Master Plan will also meet the requirements of the Statewide General Waste Discharge Requirements for Sanitary Sewer Systems, which require that every sanitary sewer system agency in California prepare a Sewer System Management Plan (SSMP) which includes a System Evaluation and Capacity Assurance Plan (SECAP) and a plan for rehabilitation and replacement of sewers based on their condition.

The City is subject to infiltration and inflow (I/I) of extraneous groundwater and stormwater into the sanitary sewer system, resulting in high wet weather flows during storm events. As a result, sanitary sewer overflows (SSOs) have occurred at several locations in the system during large storms. SSOs in dry weather also occur due to pipe blockages from debris, roots, and grease. Furthermore, the average age of the sewer system is more than 60 years, with a substantial portion over 80 years. In some areas of the system, conditions such as flat pipe slopes and difficult access present difficult challenges for the City's operation and maintenance crews.

In 2009, as part of its process to update its utility rate structures, the City adopted policy objectives for its water and wastewater systems designed to ensure a high level of customer service and rehabilitate the systems so that their functionality would be assured into the future. For the wastewater system, those objectives included reducing the number of SSOs, supporting system assessment through sewer main television inspections, and reducing the average age of sewer infrastructure. The City defined the program components that would be needed to meet those level of service objectives. For wastewater, they included pump station improvements, improvements to system capacity, mitigation of sewer main accessibility issues, and a 25-year sewer main replacement schedule.

In 2011 the City was issued a Cease and Desist Order (CDO) by the San Francisco Bay Regional Water Quality Control Board and also entered into a Consent Decree with San Francisco Baykeeper (Baykeeper), a non-governmental organization, both of which require the City to implement a number of measures targeted at reducing SSOs. This Master Plan report is also intended to satisfy the specific requirements of the CDO and Consent Decree related to sewer system condition assessment, preparation of a Capacity Assurance Plan, and development of a long-range Capital Improvement Program (CIP) for the sewer system.

ES-1 Existing Sewer System and Service Area

The City's sewer system serves a population of about 40,000 within the San Bruno city limits. The system includes approximately 85 miles of gravity sewer mains, 2 miles of pressure (force) mains, and 6 sewage pump stations. All wastewater is conveyed to the City of South San Francisco's Shaw Road Pump Station, from where it is pumped to the South San Francisco/San Bruno Water Quality Control Plant (WQCP), which is jointly owned by the two cities but operated by South San Francisco. **Figure ES-1** shows the existing sewer system.

The majority of the gravity sewer system (about 70 percent) consists of 6-inch pipe, and about 80 percent is less than 10 inches in diameter. The oldest portions of the system date to the 1920s, with most of the area located west of I-280 developed in the 1950s and 1960s. The primary sewer pipe material in the sewer system is vitrified clay pipe with plastic materials used for newer sewer construction and rehabilitation.

The sewer system also includes approximately 11,000 private sewer laterals. The City assumes responsibility for the maintenance and repair of the lower portion of the laterals located within the public right-of-way for laterals that have an approved cleanout.

ES-2 Capacity Assessment and Capacity Improvement Plan

The capacity of the sewer system was assessed using a hydraulic model. The assessment focused on the trunk sewer network, the system of pipes that convey flow generated throughout the system to the Shaw Road Pump Station. The modeled network includes gravity sewers 10 inches in diameter and larger and additional 6- and 8-inch pipes, totaling about 20 miles or 23 percent of the length of sewers in the sewer system, plus two of the system pump stations (Crestwood and Lomita Park) and associated force mains. The modeled network is shown in Figure ES-1.

Flow loads to the model were developed from census data, customer water use data, estimates of additional flows from potential future development, and from a flow monitoring program conducted for this study. Flow monitoring was conducted at 12 sites in the sewer system during the winter 2010/11, with rainfall data also collected by three temporary rain gauges. The purpose of the monitoring was to obtain data to confirm base wastewater flows and to quantify the I/I response of the system to rainfall. The flow monitoring data was used to estimate the amount of I/I for various areas of the system and to confirm, through model calibration, that the hydraulic model reasonably simulates the actual performance of the system during both dry and wet weather conditions.

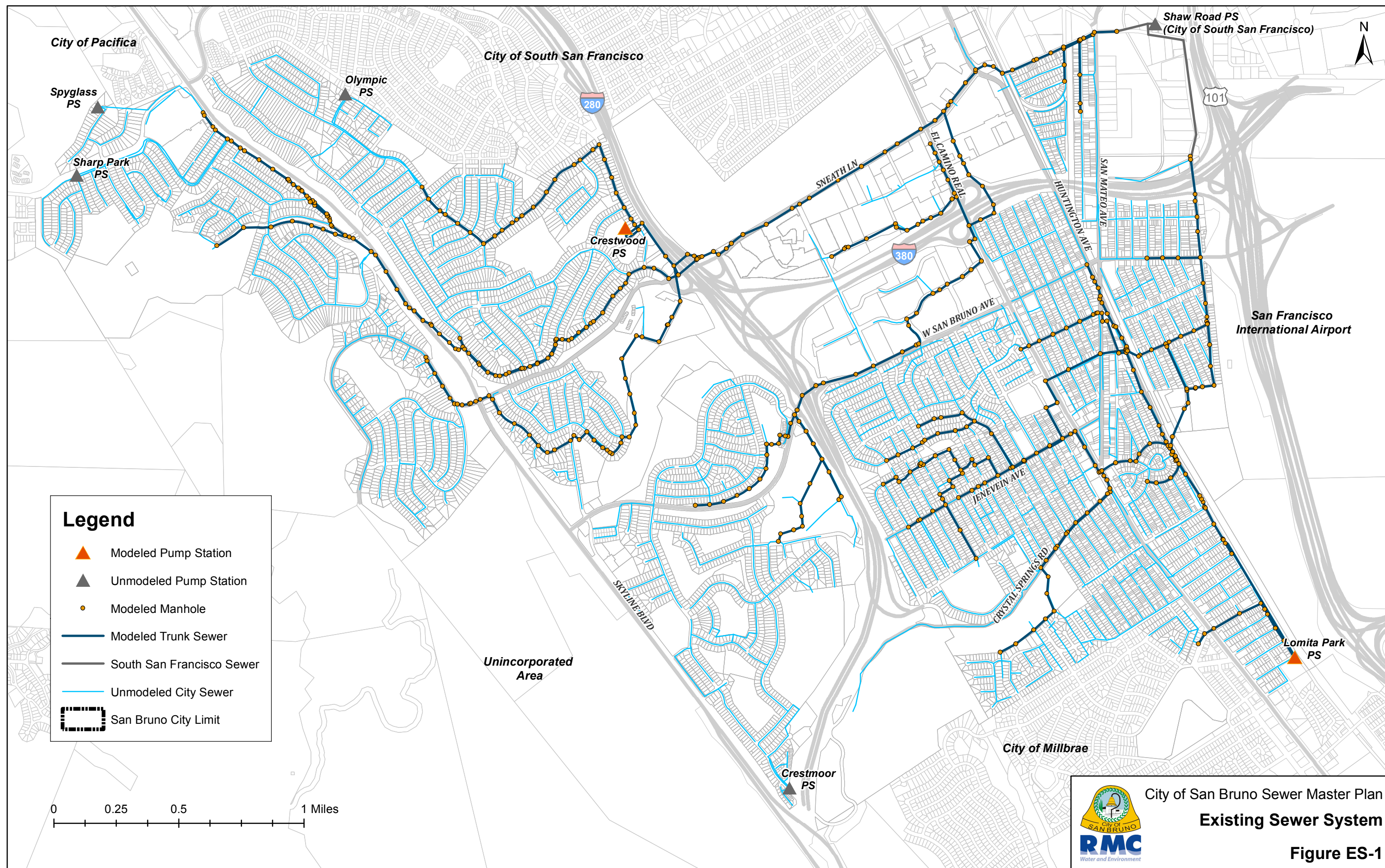
Design Storm

As specified in the City's Consent Decree with Baykeeper, the capacity of the system was assessed with respect to a design rainfall event, defined as a 10-year recurrence frequency, 24-hour duration storm with a temporal rainfall distribution based on guidelines established in the U.S. Department of Agriculture Natural Resources Conservation Service publication Technical Release 55, "Urban Hydrology for Small Watersheds." This document defines a particular synthetic rainfall distribution, called an "SCS Type 1A" storm, which is applicable to areas in northwestern California. The SCS Type 1A rainfall distribution was applied to rainfall data specific to the San Carlos area to develop a specific "Design Storm" for this study. The 24-hour Design Storm rainfall ranges from 3.6 to 4.4 inches, depending on location, with a peak intensity ranging from 0.57 to 0.69 inches per hour. The design storm is comparable in size to notable large rainfall events that have occurred in the San Francisco Bay Area over the past several years, including the storms of December 31, 2005, and January 25, 2008.

Capacity Analysis Results

The hydraulic model was run with the 10-year Design Storm to identify areas of the trunk sewer system that would not have adequate capacity to convey the peak wet weather flows generated by that event. Capacity was considered inadequate whenever the model predicted that the peak flows would result in overflows from the system or surcharge (flow above the crown of sewer pipes) to within four feet of manhole rims. Pump station capacity was considered inadequate if the peak flows exceeded the station's firm capacity (capacity with the largest pump not in operation).

The modeling indicated gravity pipeline capacity deficiencies in a number of areas of the sewer system, including locations along Taylor and Florida Avenues, Kains Avenue and Artichoke Joe's parking lot, Crystal Springs, Jenevein, Huntington, and San Antonio Avenues, and Crestwood Drive. Many of the deficiencies are locations of historical wet weather overflows.



The City's 2000 Sewer Master Plan identified a number of predicted capacity deficiencies and recommended construction of relief sewers, as well as substantial sewer rehabilitation to reduce I/I. The City confirms that most of the relief sewer projects were completed but not all of the sewer rehabilitation work was done. Note that although the 2000 study used a different design storm (a 5-year, 6-hour event), model runs conducted with the current hydraulic model using the 5-year storm rainfall resulted in similar peak flows and predicted capacity deficiencies as with the 10-year Design Storm used for this study.

The current Master Plan predicts a number of areas with potential wet weather capacity deficiencies that were not identified in the 2000 Master Plan. Some of the possible reasons for these differences between the two Master Plans include more refined flow monitoring in the current study, more accurate metering equipment available today, and the more accurate hydraulic model used for this Master Plan. Furthermore, the flow monitoring for the 2000 Master Plan was conducted in 1997, over 15 years ago. In the time since, the condition of the sewers has likely deteriorated, with a resulting increase in I/I throughout the system. While the exact reasons for the higher flows and additional areas of capacity deficiencies identified in the current Master Plan cannot be determined definitively, the data and modeling conducted support the results.

Based on the model results, improvement projects to address the predicted capacity deficiencies were developed. The projects primarily involve replacing existing deficient sewers with larger diameter pipes, or diverting flows to other existing sewers with available capacity or to proposed new pipes. Proposed sewer improvements were tested in the model to confirm that they would eliminate the identified capacity deficiencies and to confirm that sewers and pump stations downstream of the upsized pipes could handle the higher peak flows.

Ten capacity improvement projects were identified, totalling about 13,000 feet of new or replacement (upsized) gravity sewers, as well as pump upgrades at the Crestwood and Olympic Pump Stations to provide adequate firm capacity. **Table ES-1** lists the identified capacity improvement projects, including location, description of proposed improvements, and estimated planning level costs.

The results of the modeling of proposed pipe capacity improvements indicated that peak flows reaching the Shaw Road Pump Station from San Bruno during the Design Storm, after construction of the recommended capacity improvement projects, would be about 25.4 million gallons per day (mgd) under existing development conditions and 26.6 mgd with future development included. It is recommended that the City work closely with the City of South San Francisco to ensure that capacity requirements of jointly-used facilities are coordinated.

Infiltration/Inflow

The City's sewer system is subject to significant amounts of I/I, resulting in high peak flows during wet weather events, and capacity deficiencies as described above. Wet weather peaking factors (ratio of Design Storm peak wet weather flow to average dry weather flow) range from about 3 to over 15, with several areas having peaking factors exceeding 10. However, even reducing peak I/I in the worst areas would not be sufficient to eliminate the immediate need for capacity improvement projects to reduce the risk of wet weather SSOs.

However, the City recognizes the benefit of reducing I/I in the long-term, as reducing I/I also reduces the costs for pumping and treatment, and provides the added benefit of further improving the condition of the sewer system, which in turn can reduce maintenance requirements and the risk of dry weather blockages and overflows. Through its sewer condition assessment and rehabilitation/replacement program, discussed in the next subsection, the City will be able to implement gradual improvements to the sewer system, which will help reduce I/I. Sewer rehabilitation can also be supplemented with other targeted programs, such as smoke testing and enforcement to eliminate sources of direct stormwater inflow (through illegal connections such as roof and area drains, or unknown cross-connections to the storm drain system), as well as programs that facilitate replacement of private sewer laterals.

Table ES-1: Capacity Improvement Projects

Project ID	Project Name	Description	Estimated Capital Cost ^a
C-1	Crestmoor Canyon	Replace 1,400 ft. of 8" pipe with 10" pipe in easement along pedestrian trail through Crestmoor Canyon	\$ 520,000
C-2	Crestwood Drive	Replace 1,600 ft. of 8" pipe with 12" pipe and realign pipe as needed in Valleywood Dr. and Crestwood Dr.	\$ 1,070,000
C-3	Crestwood PS Influent Sewer	Replace 600 ft. of 8" pipe with 12" pipe	\$ 279,000
C-4	Jenevein Avenue Bypass	Install 600 ft. of new 8" bypass pipe; upsize 700 feet of 6" to 8" pipe with 8" to 10" pipe; and install a weir to divert flow to bypass pipe in Jenevein Ave.	\$ 774,000
C-5A	Kains Avenue Bypass	Install a new 200-ft. section of 15" PVC bypass pipe in Kains Ave. to divert flow to the new 18" sewer on Huntington Ave.	Project has been constructed
C-5B ^b	Kains Ave Improvement	Replace 1,000 ft. of 10" pipe with 12" pipe in Kains Ave; install new 10" pipe in San Mateo Ave. south of Kains flowing north and connecting to the new 15" bypass (Project C-5A)	\$ 1,700,000
C-6	Crystal Springs Avenue	Replace 3,400 ft. of 6" to 8" pipe with 10"- to 15" pipe in City Park easement, Crystal Springs Ave., and El Camino Real; and install weirs in manholes between parallel sewers in Crystal Springs Ave.	\$ 2,193,000
C-7 ^c	San Mateo Avenue Bypass	Install 2,000 feet of new 18" pipe in San Mateo Ave. and divert most flow at Taylor Ave. into the new 18" sewer; abandon the existing 6" pipe along west side of San Mateo Ave. and reconnect laterals to new sewer.	\$ 1,491,000
C-8	San Antonio Avenue	Replace 1,500 feet of 6" to 8" pipe with 8" to 12" pipe in Santa Inez Ave. and San Antonio Ave. to Lomita Park Pump Station	\$ 813,000
C-9	Crestwood PS Capacity Upgrade	Replace three of the existing pumps with larger pumps	\$ 463,000
P-1	Olympic PS and Force Main Replacement	Replace existing pump station structure and upgrade pumps and major equipment; replace 2,600-feet of 6-inch diameter DIP force main with new 8-inch HDPE force main	\$ 3,100,000
Total			\$ 12,403,000

- a. Includes 30% allowance for contingencies and 35% allowance for design engineering, administration, construction management, and legal costs.
- b. Cost estimated by City (includes additional 300 feet of pipe in Huntington Ave. south of San Bruno Ave.)
- c. Because of the potential challenges of construction along San Mateo Avenue, several alternative alignments were also developed for this project. All of the alternative alignments would be longer than the San Mateo Avenue alignment. It is recommended that the City conduct more detailed analyses of these potential alternative alignments as part of pre-design of the project

ES-3 Condition Assessment and Rehabilitation/Replacement Program

The condition of the gravity sewer system was evaluated through review of closed-circuit television (CCTV) inspection data collected by the City in 2009, 2010, and 2012 by a CCTV inspection contractor employed by the City. The City has adopted the Pipeline Assessment and Certification Program (PACP) guidelines developed by the National Association of Sewer Service Companies (NASSCO), which are considered the current standard of the industry for recording CCTV inspection data.

Condition ratings were developed for the inspected sewers using the PACP system, which assigns grades to all observed defects based on their type and severity. To utilize the condition rating and defect information, RMC, in conjunction with City staff, developed a decision process to determine the appropriate sewer renewal method for sewers with defects warranting near-term repair. The focus of the analysis was on pipes with major defects that could result in structural failures; large offset joints, which can impede inspection and cleaning equipment; and significant root intrusion, which can cause blockages resulting in SSOs. Each inspected pipe was analyzed and reviewed in more detail as necessary to identify the apparent most cost-effective method of renewal (e.g., localized point repair, lining, or replacement) to address these issues; or if renewal was not considered necessary at this time, the pipe was identified for continued maintenance.

Table ES-2 Summarizes these results according to the primary reason for the pipe being identified for renewal. As indicated in the table, about 23 percent of the inspected sewers require some type of repair, rehabilitation, or replacement to address major structural defects, large offset joints, or significant root intrusion.

Table ES-2: Sewer Renewal Decision Analysis Results

Sewer Renewal Reason and Decision	No. of Inspected Pipe Segments	Percentage of Pipe Segments	Length of Inspected Pipe Segments (ft.)	Number of Localized Repairs
Major Structural Defects	373	18.7%	92,335	255
<i>Replace</i>	173	8.7%	40,959	0
<i>Line</i>	23	1.2%	6,538	14
<i>Localized Repair</i>	177	8.9%	44,839	241
Large Offset Joints	50	2.5%	10,819	38
<i>Replace</i>	16	0.8%	3,962	0
<i>Localized Repair</i>	34	1.7%	6,857	38
Significant Root Intrusion	40	2.0%	11,203	2
<i>Replace</i>	30	1.5%	8,600	0
<i>Line</i>	10	0.5%	2,603	2
Renewal Subtotal	463	23.2%	114,357	295
Maintain (re-inspect in future)	1,497	75.0%	318,292	0
Re-inspect (inspection was incomplete)	35	1.8%	10,988	0
TOTAL^a	1,995	100 %	443,638	295

- a. Does not include approximately 6,800 feet of pipes that could not be inspected due to restricted access or surcharged conditions. These pipes are planned for inspection in 2014.

In addition to the sewer rehabilitation recommended based on the analysis of CCTV inspection data, several specific areas of the sewer system have been identified by City staff as having particularly burdensome maintenance issues and requirements. These areas were evaluated for the Master Plan, and improvement projects, listed in **Table ES-3**, were developed to address several of these areas. The projects include the following:

- **Trenton Drive Easement.** The easement sewer behind Trenton Drive has been subject to past SSOs due to root intrusion and is very difficult to access. This project would rehabilitate or replace the existing easement sewer and construct an access road.
- **The Avenues.** The area of the city located east of the Caltrain tracks and south of I-380 is characterized by small diameter pipes (mostly 5- and 6-inch) laid on very flat slopes, resulting in excessive maintenance requirements. This project would involve replacement of the sewers in this area with industry-standard 8-inch pipes at steeper slopes.

Table ES-3: Additional Sewer Rehabilitation Projects

Project ID	Project Name	Description	Estimated Capital Cost ^a
R-1	Trenton Easement Improvement	Replace approx. 3,400 ft. of 6" and 8" pipe with 8" and 10" pipe in easement behind Trenton Drive to San Bruno Ave.; also construct new access road.	\$ 2,361,000
R-2	Avenues Area Sewer Replacement	Replace approx. 21,300 ft. of 5", 6", and 8" pipe with 8" pipe at steeper slopes or to re-route flow; install 2,200 ft. of new 8" pipe; abandon 800 ft. of 6" pipe in sewer easement.	\$ 14,778,000

a. Includes 30% allowance for contingencies and 35% allowance for design engineering, administration, construction management, and legal costs.

City staff also identified a number of other sewers in various locations throughout the system with known maintenance problems due to root intrusion, poor access, flat slopes, and poor structural condition. These pipes have also been planned for rehabilitation or replacement in the Master Plan.

Ultimately, the City needs to plan for rehabilitation or replacement of sewers throughout the system as they reach the end of their useful service lives. Using data from sewer inspections analyzed for this study, a statistical analysis was developed relating the probability of pipe "failure" (i.e., the time when a pipe would need some type of structural repair or replacement) to pipe age. Based on this probability distribution, the mean age of "failure" of San Bruno pipes was determined to be about 90 years (although newer pipes, e.g., those constructed since the 1970s, would be expected to last longer due to better construction methods and materials). Using the probability curve, a projection of long-term sewer renewal requirements was made for the entire system. Based on this projection, it was estimated that an additional 15 miles of sewers (i.e., in addition to the sewers identified for sewer rehabilitation based on CCTV inspections and the maintenance problems described above) would need to be rehabilitated or replaced in the next 20 years, primarily in the oldest parts of the system (pipes that are currently more than 70 years old). This level of sewer replacement is consistent with the City's level of service goal by addressing existing sewers that have reached the end of their useful service lives within a 25-year rehabilitation schedule. Note also that replacement of the pipes in the oldest areas would also allow the City to reconstruct sewers in areas of the system that now have relatively flat slopes and therefore excessive maintenance requirements.

ES-4 Long-Range Capital Improvement Program

The recommended 20-year CIP includes capacity improvement projects; sewer repair, rehabilitation, and replacement to address significant structural and maintenance issues and aging infrastructure; and pump station upgrades as identified by previous assessments by the City. The CIP is divided into three phases (Years 1 to 5, 6 to 10, and 11 to 20), reflecting relative priorities for construction.

Capacity improvement projects, which are needed to reduce the risk of potentially large volume SSOs due to lack of capacity in the trunk system to convey peak wet weather flows for a 10-year frequency Design Storm, were considered high priority for construction. Those projects addressing areas of historical wet weather overflows and/or know surcharging were assigned to Phase 1 of the CIP.

Pump station projects were prioritized based on safety, reliability, and aesthetics, as identified in the City's 2008 pump station evaluation. Two specific projects, the Olympic and Spyglass Pump Station Improvements, were assigned to the highest priority group.

Sewer rehabilitation projects considered critical by the City, such as the Trenton Easement Sewer Improvement, were also assigned high priority for construction. The remaining sewer rehabilitation work identified through the sewer condition assessment and City staff's knowledge of historical maintenance problem areas was prioritized using a risk-based approach that considered each pipe's likelihood of failure (condition) and other factors that reflect the potential consequence of failure. Sewer repairs and replacements to address major structural defects (e.g., Grade 5 and Grade 4 defects, which are required to be corrected within two or five years, respectively, under the City's Consent Decree) are considered the highest priority with respect to sewer rehabilitation because they present the greatest risk of structural failure, followed by projects to address large offset joints (which do not present a risk of structural failure but may impede inspection or cleaning equipment), significant root intrusion, and other issues that result in very high maintenance requirements (e.g., sewers at higher risk for blockages due to insufficient flow velocity or substandard diameters). Over 20 miles of pipes were identified for full-segment rehabilitation or replacement based on their structural condition or maintenance history, and approximately 200 additional pipes require spot repairs to address localized structural defects.

In addition to addressing the capital project needs identified in the capacity assurance and sewer rehabilitation plans, the City intends to continue efforts for overall rehabilitation of the sewer system to replace aging sewers and reduce I/I. It is expected that over the next 20 years, additional sewer rehabilitation and replacement needs will be identified through future sewer inspection activities. Based on projections of long-term sewer renewal needs, it is anticipated that an additional 15 miles of sewers that are reaching the end of their useful lives will also require renewal during the 20-year CIP timeframe.

Estimated costs for capacity improvement projects and sewer rehabilitation/replacement were based on recent bids provided by the City and cost data from similar projects. The costs are conceptual level estimates, considered to have an estimated accuracy range of -30 to +50 percent, suitable for use for budget forecasting, CIP development, and project evaluations, with the understanding that refinements to the project details and costs would be necessary as projects proceed to design and construction. All costs are presented in current dollars and include a 30 percent allowance for contingencies for unknown conditions, as well as an allowance of 35 percent of estimated construction cost for design engineering, administration, construction management, and legal costs.

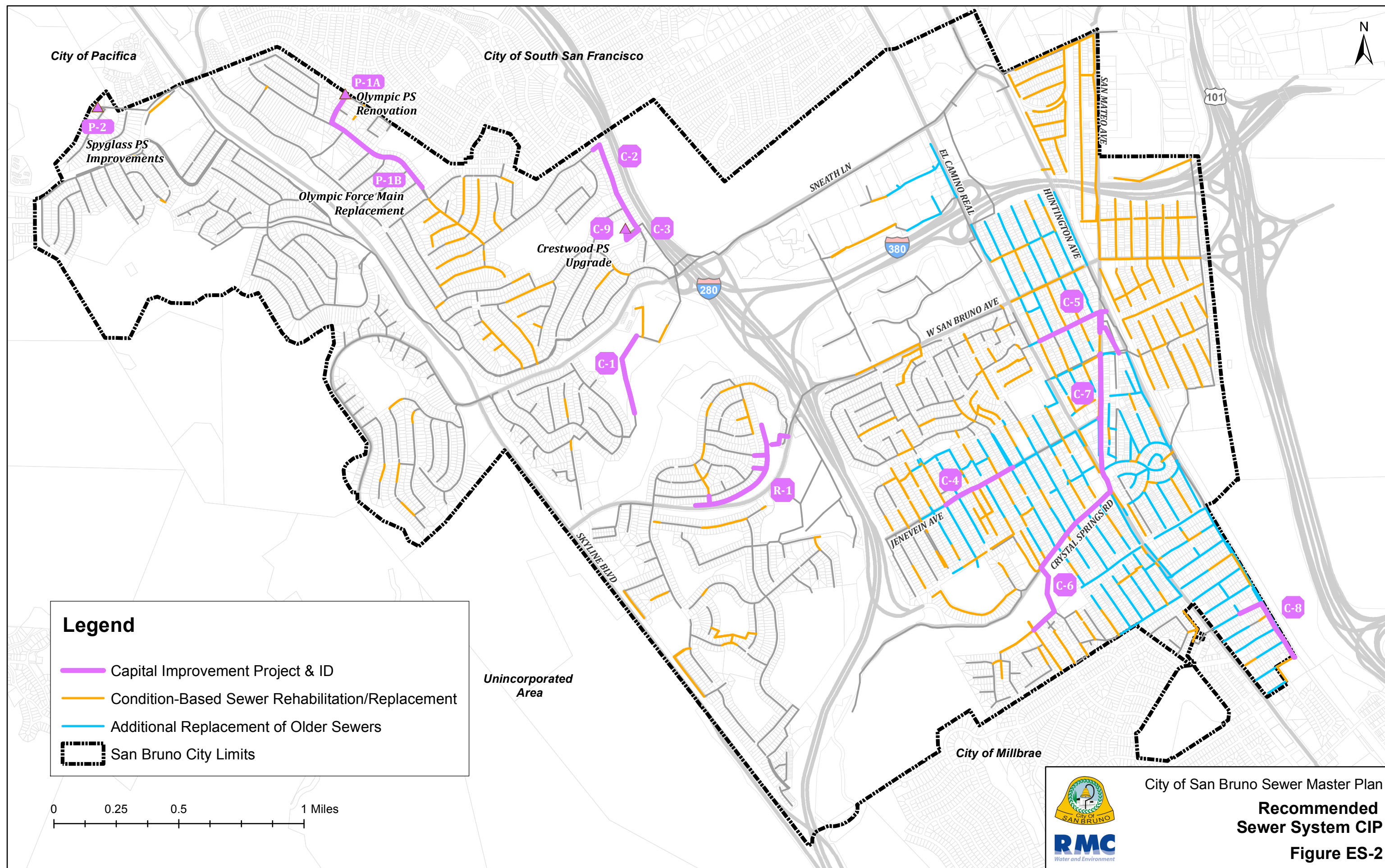
The recommended 20-year sewer system CIP is presented in **Table ES-4** and **Figure ES-2**.

Table ES-4: Recommended Sewer System Capital Improvement Program

Project ID ^a	Project Name	Est. Capital Cost	Avg. Annual CIP Budget
Years 1-5			
C-1	Crestmoor Canyon	\$ 520,000	
C-4	Jenevein Avenue Bypass	\$ 770,000	
C-5B	Kains Ave Improvement	\$ 1,700,000	
C-6	Crystal Springs Avenue	\$ 2,190,000	
C-7	San Mateo Avenue Bypass	\$ 1,490,000	
R-1	Trenton Easement Improvement	\$ 2,360,000	
P-1	Olympic PS Renovation & Force Main Replacement	\$ 3,100,000	
P-2	Spyglass PS Improvements	\$ 1,000,000	
	Sewer Rehabilitation Based on Condition Assessment ^b	\$ 11,000,000	
	Sewer Spot Repair	\$ 1,250,000	
	Equipment Purchase	\$ 600,000	
	Subtotal - Years 1-5	\$ 26,000,000	\$ 5,200,000
Years 6-10			
C-2	Crestwood Drive	\$ 1,070,000	
C-3	Crestwood PS Influent Sewer	\$ 280,000	
C-8	San Antonio Avenue	\$ 810,000	
C-9	Crestwood PS Capacity Upgrade	\$ 460,000	
	Other Pump Station Improvements	\$ 2,000,000	
	Sewer Rehabilitation Based on Condition Assessment ^b	\$ 30,000,000	
	Sewer Spot Repair	\$ 650,000	
	Equipment Purchase	\$ 600,000	
	Subtotal - Years 6-10	\$ 36,000,000	\$ 7,200,000
Years 11-20			
	Sewer Rehabilitation Based on Condition Assessment	\$ 26,000,000	
	Additional Rehabilitation of Older Sewers	\$ 44,000,000	
	Sewer Spot Repair	\$ 500,000	
	Equipment Purchase	\$ 1,000,000	
	Subtotal - Years 11-20	\$ 71,500,000	\$ 7,200,000
TOTAL CIP		\$ 133,500,000	\$ 6,700,000

a. Projects within each phase are not prioritized.

b. Includes portions of the Avenues sewer replacement project (R-2).



Chapter 1 Introduction

This report presents the results and recommendations of the Sewer Master Plan for the City of San Bruno (City). The report was prepared by RMC Water and Environment (RMC) under an agreement with the City dated December 22, 2010 and an amendment dated July 12, 2013. This introductory chapter provides background information on the objectives and scope of the Master Plan, the City's sewer system and service area, and the contents and organization of the Master Plan report.

1.1 Background and Study Objectives

Prior to this study, the City last prepared a Master Plan for its sanitary sewer system in 2000. That study included a flow monitoring program, hydraulic modeling of the system, and development of proposed sewer improvement projects to provide capacity relief, rehabilitate pump stations, and reduce infiltration/inflow (I/I). In the period since the 2000 Master Plan, the City has made several improvements to the sewer system, including construction of a number of the capacity improvement projects recommended in the 2000 Master Plan, as well as various sewer repairs and replacements and pump station upgrades. The City also initiated a closed-circuit television (CCTV) inspection program for gravity sewers; and has developed mapping of the system in a geographic information system (GIS).

The City has been required to monitor and report occurrences of sanitary sewer overflows (SSOs) since 2004, initially to the San Francisco Bay Regional Water Quality Control Board (RWQCB or Regional Board), and later (since 2007) to the State Water Resources Control Board (SWRCB) under the Statewide General Waste Discharge Requirements for Sanitary Sewer Systems adopted in 2006. Under these regulations, the City was also required to prepare and adopt a Sewer System Management Plan (SSMP), including plans and programs for addressing the operation and maintenance of the system and assessing its condition and capacity. The City is required to audit and update its SSMP regularly.

As a result of SSOs that have occurred in the system in past years, the Regional Board issued a Cease and Desist Order (CDO) to the City in July 2011. The City also entered into a Consent Decree with San Francisco Baykeeper (Baykeeper), requiring it to implement a number of measures targeted at reducing SSOs. The CDO and Consent Decree have similar requirements, including preparing an SSO reduction plan; implementing system-wide cleaning, root control, and fats, oils and grease (FOG) control programs and a computerized maintenance management system (CMMS) linked to GIS; conducting sewer and manhole condition assessment and pump station repair and rehabilitation; preparing a System Evaluation and Capacity Assurance Plan (SECAP); developing a capital improvement plan (CIP) and budget for needed system improvements; and implementing a private sewer lateral program. The CDO and Consent Decree also contain SSO performance standards with maximum allowable number of SSOs specified for each year through 2020.

This Master Plan report updates the 2000 Master Plan and specifically addresses the condition assessment of the system (based on inspection data collected to date), the SECAP, and development of a CIP, as required by the CDO and Consent Decree.

1.2 Study Area

The study area for this Master Plan consists of the City of San Bruno. The sewer system serves a population of about 40,000 within the city limits and does not convey any flows from outside the city. **Figure 1-1** shows the study area. The city is bounded on the north by the City of South San Francisco, on the northwest by the City of Pacifica, on the west by undeveloped areas of San Mateo County, on the south by the City of Millbrae, and on the east by the San Francisco International Airport. The oldest parts of the City, primarily located east of El Camino Real and west of El Camino Real in the southern portion of the City, were developed in the early 1900s, and the sewer infrastructure was constructed largely in the 1920s through 1940s. The western portions of the City were primarily developed in the 1950s and 1960s.

The city is now largely built out, with only a few areas of potential new development, although there are redevelopment plans for areas along the El Camino Real and Caltrain transit corridor.

1.3 Existing Sewer System

The City's sanitary sewer system includes approximately 85 miles of gravity sewer mains, 2 miles of pressure (force) mains, and six sewage pump stations. All sewage is conveyed to the City of South San Francisco's Shaw Road Pump Station, from where it is pumped to the South San Francisco/San Bruno Water Quality Control Plant (WQCP). The plant is jointly owned by the two cities but operated by South San Francisco.

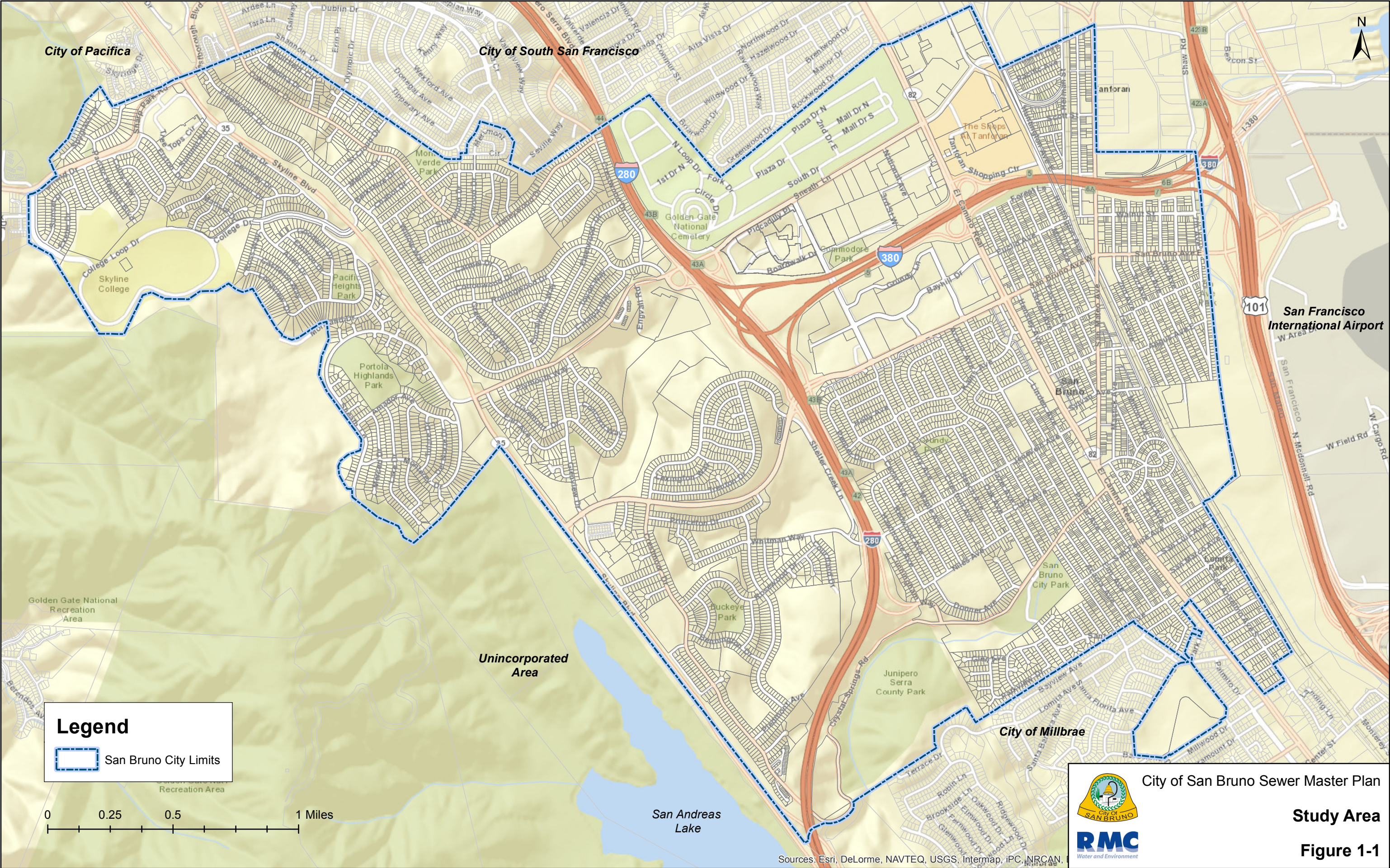
Figure 1-2 shows the existing sewer system layout. **Table 1-1** tabulates the footage of pipe by diameter. As noted in the table, over 60 percent of the gravity sewer mains are 6 inches in diameter, and over 85 percent are less than 10 inches.

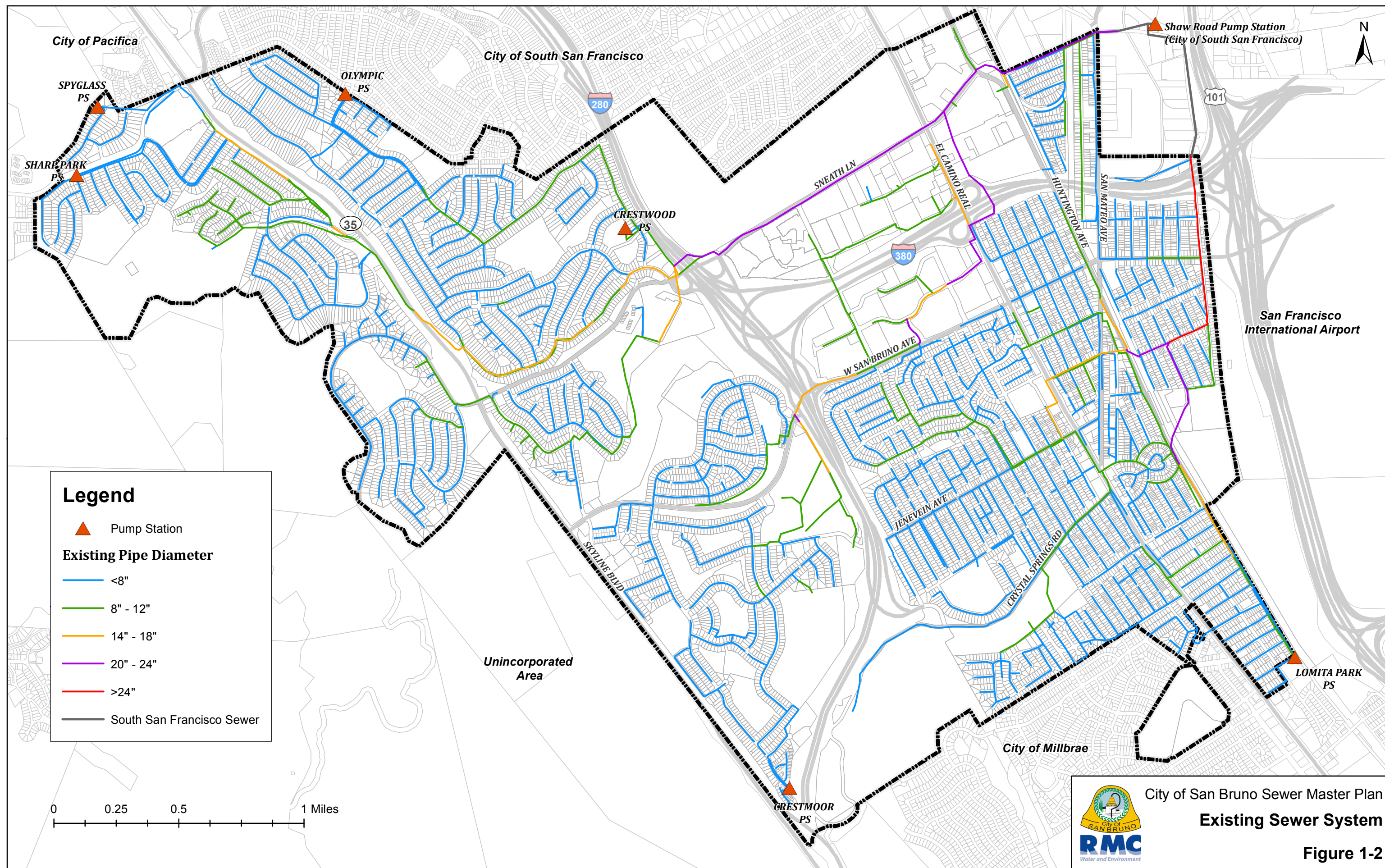
Table 1-1: Sewer System Inventory

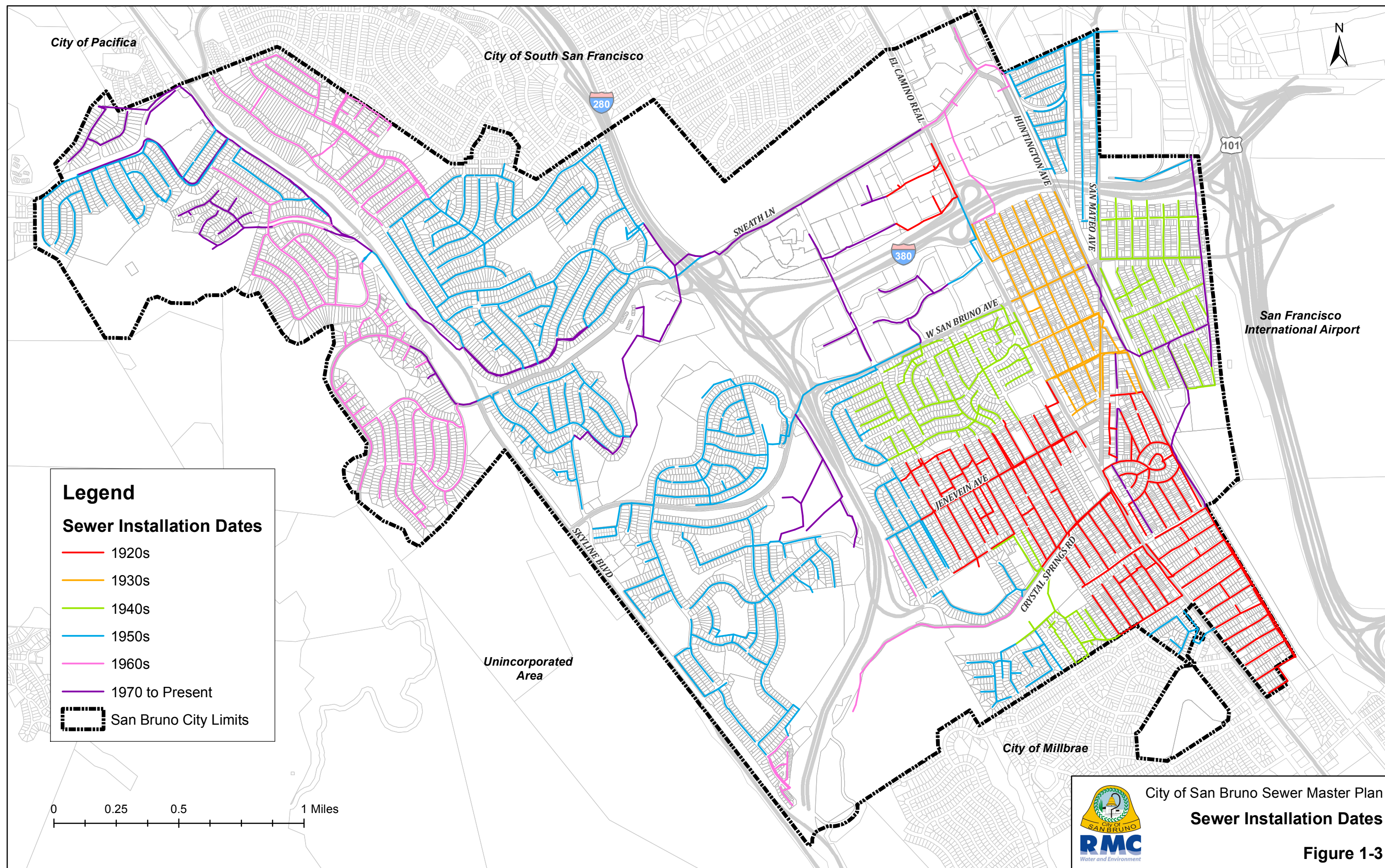
Pipe Size (in.)	Length (feet)	Length (miles)	Percent of Total
Gravity Sewers			
<6 or unknown	19,700	3.7	4.4%
6	307,200	58.2	68.2%
8	45,300	8.6	10.1%
10	24,200	4.6	5.4%
12	17,100	3.2	3.8%
14-16	6,700	1.3	1.5%
18	9,200	1.7	2.0%
20-21	4,000	0.8	0.9%
24	13,500	2.6	3.0%
30-36	3,500	0.7	0.8%
Subtotal	450,400	85.3	100.0%
Force Mains	12,000	2.3	
Total	462,400	87.6	

As is common in most San Francisco Bay Area communities, the primary pipe material in the sewer system is vitrified clay pipe (VCP), though some newer and/or rehabilitated sewers have been constructed of plastic materials. The estimated age of sewers in the system (based on decade of installation) is shown in **Figure 1-3**. As shown in the figure, the oldest sewers date to the 1920s.

The sewer system also includes approximately 11,000 private sewer laterals. The City assumes responsibility for the maintenance and repair of the lower portion of the sewer laterals located within the public right-of-way for laterals that have an approved cleanout.







1.4 Scope of Study

The scope of the Master Plan, as well as a brief discussion of work conducted under each task, is described below.

- **Task 1 – Project Coordination.** Periodic progress meetings and teleconferences were held with City staff to review project status and discuss project issues, and monthly status reports were prepared to document the work completed.
- **Task 2 – Conversion of Sewer System Map to GIS.** The City's GIS map of the sewer system was updated by RMC's subconsultant, Engineering Mapping Systems (EMS). Sewer data attributes (e.g., manhole rim and invert elevations), where shown on the City's older AutoCAD mapping, were populated in the GIS database. The updated GIS map was used as the basis for building the hydraulic model in Task 5. The map will be updated again following completion of the study to reflect more complete information and updates to the map made by City staff during the course of the study, and to allow production of a sewer map book. In the future, the City will maintain the map in GIS, which will also be linked to its new CMMS.
- **Task 3 – Data Collection and Review.** This task involved assembling, organizing, and reviewing maps, documents, and data related to the sewer system, including the previous Master Plan report; maps and drawings of sewer system facilities and recent sewer improvement projects; pump curves and operating data; water use and customer account data; the City's General Plan and other relevant planning information; sewer maintenance and CCTV inspection data; and sewer design standards and specifications.
- **Task 4 – Flow Monitoring.** A plan for flow and rainfall monitoring in the sewer system during the 2010/11 wet weather season was developed. The program included 12 flow meters and three rain gauges installed for a period of approximately two months. The monitoring was conducted by RMC's subconsultant, V&A Consulting Engineers.
- **Task 5 – Hydraulic Model Development.** In this task, a hydraulic model of the City's trunk sewer system was developed using InfoWorks™ CS software. Sewersheds were delineated to define areas loading to the model, and flow loads to the model were compiled using water use and land use data and flow factors representing unit base wastewater flow (BWF) rates, diurnal BWF patterns, and I/I. The model was calibrated for dry and wet weather conditions using the flow monitoring data collected under Task 4.
- **Task 6 – System Performance Evaluation and Improvement Needs.** The model was used to determine sewer system capacity requirements and identify capacity deficiencies under peak wet weather flow conditions, defined based on a design storm and system performance criteria. Areas of the system with high rates of I/I were identified, and the potential effectiveness of reducing peak flows by reduction of I/I through sewer system rehabilitation was assessed. Potential solutions to capacity deficiencies were identified and tested in the model, and capacity improvement projects and associated costs were developed based on these analyses.
- **Task 7 – Condition Assessment and Rehabilitation/Replacement Program.** In this task, the City's CCTV inspection data were reviewed, and a process was developed to utilize the data to develop preliminary rehabilitation/replacement (R/R) decisions. The R/R decision process was implemented by developing a set of database queries with the results linked to the sewer pipes in GIS. Based on the query results, the defect data reports and images from selected inspections were reviewed to confirm the validity of the preliminary R/R decisions. Estimated costs for sewer R/R were developed for incorporation into the long-range CIP in Task 8. In addition to the condition assessment based on CCTV data, rehabilitation projects were developed to address maintenance

problem areas identified by City staff and the anticipated need for replacement of older sewers as they reach the end of their useful lives over the next 20 years.

- **Task 8 – Long-Range Capital Improvement Plan Development.** The recommended capacity and rehabilitation projects were prioritized for incorporation into near-term (5-year) and long-term CIPs.
- **Task 9 – Master Plan Preparation.** This report was prepared to present the results and recommendations of the study.

1.5 Report Organization

The contents of each of the chapters and appendices of this Master Plan report are described below.

Executive Summary

The Executive Summary provides a brief, stand-alone summary of the Master Plan report, with emphasis on the major findings and recommendations.

Chapter 1- Introduction

This introductory chapter provides background information on the objectives and scope of the Master Plan, the City's sewer system and service area, and the contents and organization of this report.

Chapter 2 – Hydraulic Model Development

This chapter describes the modeled sewer system, development of the model network and sewershed areas, the flow monitoring program and basis for estimating model flows, and the calibration of the model for dry and wet weather conditions.

Chapter 3 – Capacity Assessment and Capacity Improvement Program

This chapter defines the basis for the capacity assessment of the system, including the selected design storm and performance criteria; describes the identified capacity deficiencies based on the model results; presents the design criteria used to develop capacity improvements; and presents the recommended capacity improvement projects. Each project is documented with a general description and planning level cost estimate. The chapter also identifies areas of the system with high I/I and discusses the potential benefits of I/I reduction and the methods for detecting and reducing I/I.

Chapter 4 – Condition Assessment and Rehabilitation/Replacement Program

This chapter describes the City's CCTV data and the R/R decision process developed and applied to the data. The results of the R/R decision analysis and recommended rehabilitation program and estimated costs are presented. The rehabilitation program also includes projects targeted at addressing maintenance problems in the system and providing for replacement of aging infrastructure.

Chapter 5 – Long-Range Capital Improvement Program

This chapter presents the sewer projects that are recommended for inclusion in the City's near-term and long-term CIPs based on the results of the capacity and condition assessments. The CIP includes a recommended schedule for project implementation and associated capital costs that will form the basis for the City's financial plan for the sewer system. Recommendations for project implementation are also provided.

The appendices to the report provide additional detailed information to support the findings and recommendations presented in the report chapters, including plots of flow monitoring data and model calibrations, detailed project descriptions and cost estimates for improvement projects, and recommended rehabilitation/replacement decisions for inspected sewers.

Chapter 2 Hydraulic Model Development

This chapter documents the development of the hydraulic model that was used to assess the capacity of the City's sewer system. The chapter provides an overview of the model development process, including descriptions of the modeled sewer network and sewersheds, the flow monitoring program conducted for this study, the basis for estimating wastewater flows, and the calibration of the model.

The modeling utilized InfoWorks™ CS, a fullydynamic hydraulic modeling software supported by a GIS-based modeling interface.

2.1 Modeling Terminology

Key modeling terminology is defined below.

- **Network** refers to the representation of the physical facilities being modeled. Modeled network components include pipes, manholes, and pump stations.
- **Nodes** are primarily manholes, but also include pump station wet wells and outfalls (discharge points from the modeled system). Key data associated with nodes include manhole ground elevations and pump station wet well elevations and cross-sectional areas.
- **Pipes** or **conduits** are connections between nodes, and include both gravity sewers and force mains. Key data associated with pipes are upstream and downstream node IDs, pipe length, diameter, roughness factor, and upstream and downstream invert elevations.
- **Pumps** are modeled individually, connecting pump station wet wells with the upstream node of associated force mains. Data associated with pumps include type (e.g., fixed or variable speed), on and off levels, pump capacities, and pump discharge curves.
- **Subcatchments** (also called sewersheds) are areas that contribute flow to the modeled sewer network and represent the unmodeled sewers in the sewer system. Data associated with subcatchments include sanitary flow (computed based on population, water use, or other available data), type of diurnal sanitary flow profile (which is a function of land use), infiltration/inflow (I/I) parameters, and the node at which the flow from the subcatchment enters the modeled system.
- **Model loads** are the flows entering the modeled sewer system from each subcatchment. Model loads include residential and commercial sanitary or base wastewater flow (BWF), groundwater infiltration (GWI), and rainfall-dependent I/I (RDI/I). As a sum, they represent the total wastewater flow applied to the model.
- **Models** are the combination of a modeled network, its associated subcatchments and loads, and other data files (e.g., rainfall, diurnal profiles, inflows from other areas, etc.) that comprise a specific model scenario.

2.2 Modeled System

The modeled network includes pipes 10 inches and larger in diameter and additional 6- and 8-inch lines that serve as “trunk” sewers. In total, the network includes about 20 miles of pipelines, or about 23 percent of total length of sewers in the system, including about 7 miles of 6- and 8-inch sewers. The model includes two of the six system pump stations (Crestwood and Lomita Park). The network has two model outfalls at the discharge points to the South San Francisco system on Seventh Avenue immediately north of I-380 and on Tanforan Avenue at San Mateo Avenue. The model network is shown in **Figure 2-1**.

The City's sewer area was divided into 210 sewersheds, called "subcatchments" in InfoWorks, with an overall average size of about 10 acres per subcatchment. Each subcatchment "loads" to a manhole in the modeled network.

2.2.1 Network Data and Data Validation

The data used to define the model network and associated attributes were derived primarily from the City's GIS and AutoCAD sewer maps, which were combined into GIS as part of this project. The updated GIS includes the locations of sewer manholes, sewer mains, and pump stations; manhole IDs and rim elevations; and pipe diameters, lengths, and invert elevations. The GIS and AutoCAD map data were supplemented by information from record drawings for recent sewer projects constructed by the City and by field inspections by City staff in selected locations. The San Mateo County Digital Elevation Model (DEM) was used to populate ground elevations for manholes that did not have elevations in the AutoCAD map.

Pump stations were modeled based on information documented in a pump station study completed by the City in 2008, and additional available information provided by City staff. The information includes pump types and capacities, wet well dimensions and elevations, and operating levels and pump curves.

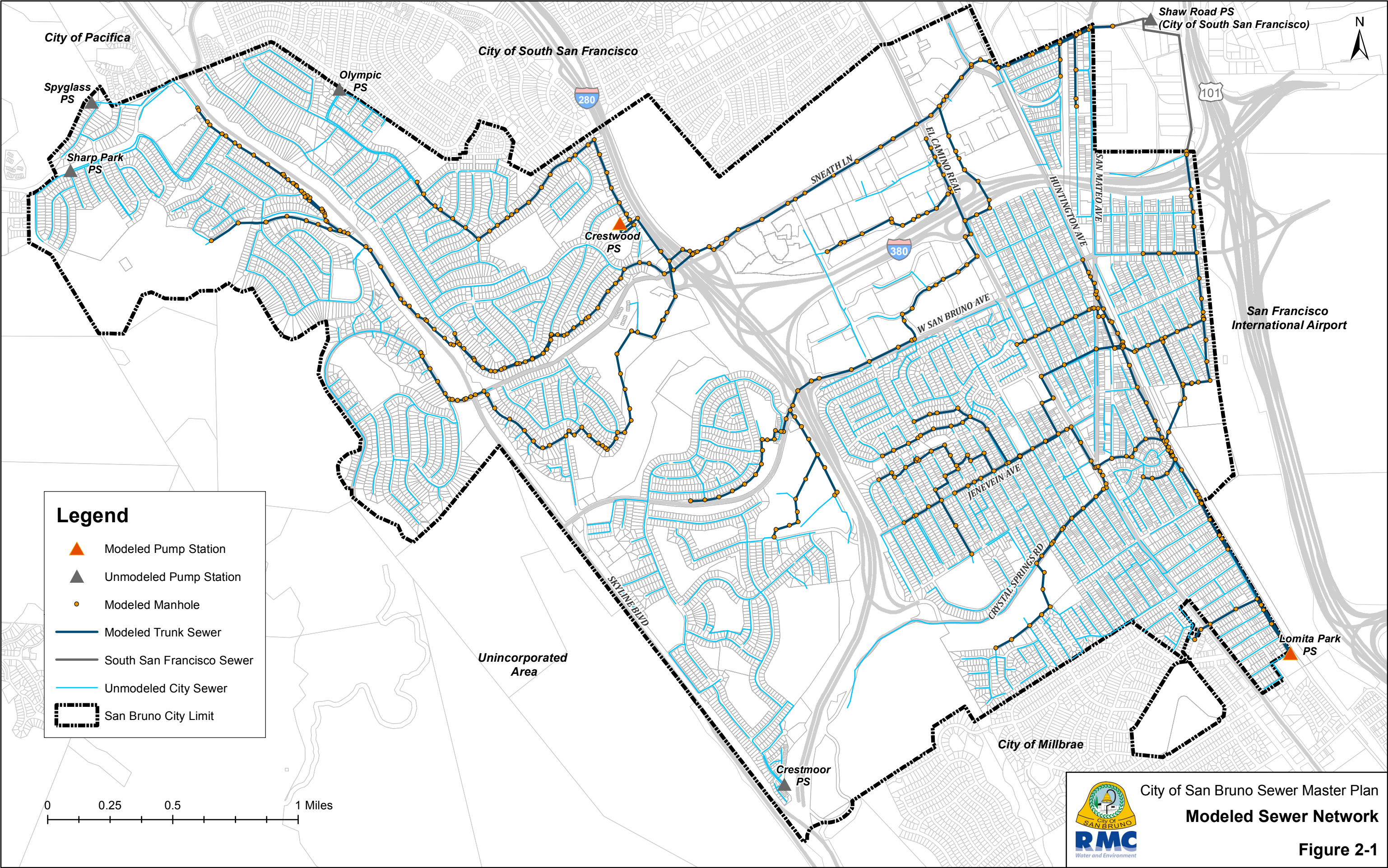
After the model network was defined, a procedure was followed to fill in missing information, validate the network data, and create a fully connected network, as follows:

- The modeled network was checked for connectivity. This means that all manholes are connected by pipes, and that pipes are generally connected in the correct direction (from upstream to downstream) to create a fully-connected system. Connectivity was corrected in several locations based on record drawings and field inspection information from City maintenance staff.
- Manhole and pipe attribute data were populated based on rim, invert, and diameter data from the GIS and AutoCAD files. Where rim data were missing, values were populated using San Mateo County's DEM. Where invert elevations were missing, values were interpolated between known points where appropriate or entered based on recent record drawings or manhole depth measurements provided by City staff. Pipe lengths were based on graphical length from the sewer map.
- After filling in missing data, modeled pipeline profiles were reviewed, and areas with suspect data were discussed with City staff.
- Subcatchments were delineated to define areas tributary to the modeled pipe network. Each subcatchment was assigned to a manhole in the modeled system to define where the model load from that subcatchment enters the modeled sewer system.
- Global parameters which are required by the model were populated, such as manhole diameters (assumed to be 4 feet), Manning's 'n' (assumed to be 0.013 for all pipes), and headloss factors.

2.2.2 Downstream Boundary Conditions

As noted previously, the San Bruno system hydraulic model has two model outfalls where flows are discharged to sewers in South San Francisco and conveyed to the Shaw Road Pump Station. As part of the Flow Metering Study¹ prepared for the City in 2011, Whitley Burchett & Associates conducted a manhole survey and developed a spreadsheet hydraulic model of the Seventh Avenue trunk sewer from the San Bruno city limit to the Shaw Road Pump Station. RMC utilized these results to define the downstream hydraulic gradeline boundary condition for the trunk sewer in the San Bruno model.

¹ Final San Bruno Flow Metering Study, Whitley Burchett & Associates, May 2011



2.3 Flow Monitoring Program

As part of the Master Plan, 12 temporary meters and 3 recording rain gauges were installed by V&A Engineers (V&A), subcontractor to RMC, from January 4 to March 7, 2011. **Figure 2-2** shows the locations of the flow meters and rain gauges. The figure also shows the associated tributary area (basin) for each flow meter. Note that four of the meters (Meters 2, 10, 11, and 12) were located downstream of other meters; therefore, the tributary areas shown for these meters in Figure 2-2 are the “incremental” areas between the flow meter and tributary basins of the upstream flow meters. **Table 2-1** lists the flow meter locations, pipe diameters, and upstream meters.

Table 2-1: Flow Meter Locations

Meter ID	Location	Meter Manhole ID ^a	Pipe Upstream Manhole ID	Pipe Dia. (in.) ^b	Upstream Meters
FM1	Influent to Crestwood Pump Station	5008	308	8	--
FM2	Rollingwood Dr. east of Crestwood Drive	393	392	14	4
FM3	San Bruno Golf Center	1856	1855	8	--
FM4	Skyline Blvd. north of Sneath Lane	1375	1374	18	--
FM5	San Bruno Ave. west of Cherry Ave.	1402	1403	18	--
FM6	Huntington Ave. south of Georgia Ave.	61	59	18	--
FM7	Taylor Ave. at Mastick Ave.	70	1457	10	--
FM8	E. Angus Ave. at Green Ave.	99	1841	12	--
FM9	Artichoke Joe's Casino parking lot	1792	1794	10	--
FM10	Seventh Ave. north of Walnut Ave.	819	821	36	6,7,8,9
FM11	Shops at Tanforan parking lot	1835	1834	24	5
FM12	Tanforan Ave. west of Dollar Ave.	Temp06 ^c	Temp05 ^c	24	1,2,3,11

a. Meter installed in inlet pipe to manhole (i.e., at downstream manhole of pipe).

b. Measured diameter.

c. Manholes not shown on City's GIS map.

All of the meters were area-velocity type gravity flow meters, which record flow depth and velocity and compute flow rate based on average flow velocity and the cross-sectional area of flow (a function of flow depth and pipe diameter).

The purpose of the flow monitoring program was to quantify the flows in the system to provide data with which to calibrate the hydraulic model (discussed later in this chapter), and to quantify the I/I response to storm events in various areas of the system. Approximately 6-1/2 inches of rain fell during the flow monitoring period, most during the last half of February 2011. **Figure 2-3** shows a plot of the hourly rainfall for one of the rain gauges, and **Figure 2-4** shows a typical plot of measured flow for one flow meter. **Appendix A** includes plots of the rainfall and flow data for all of the rain gauges and meters.

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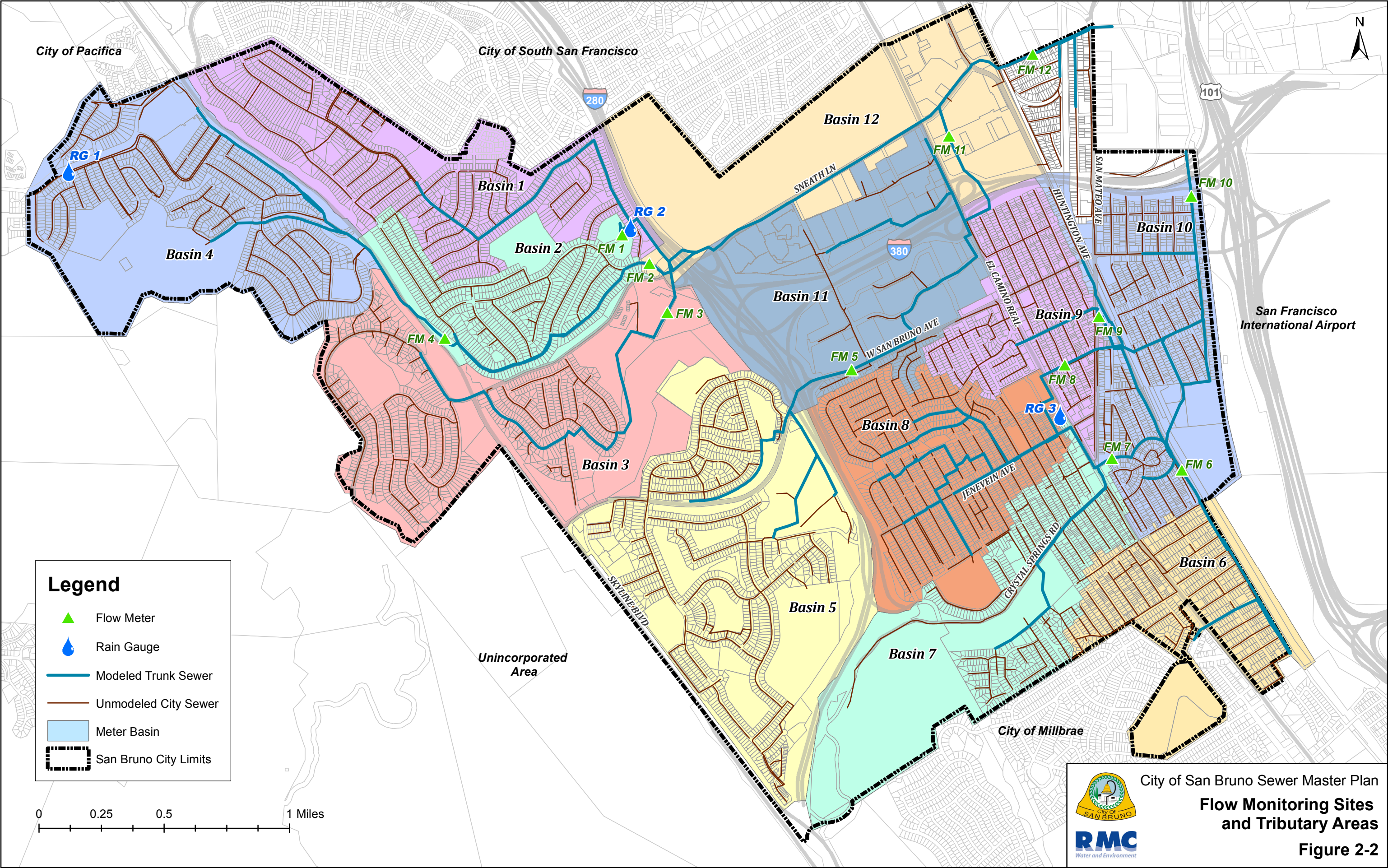
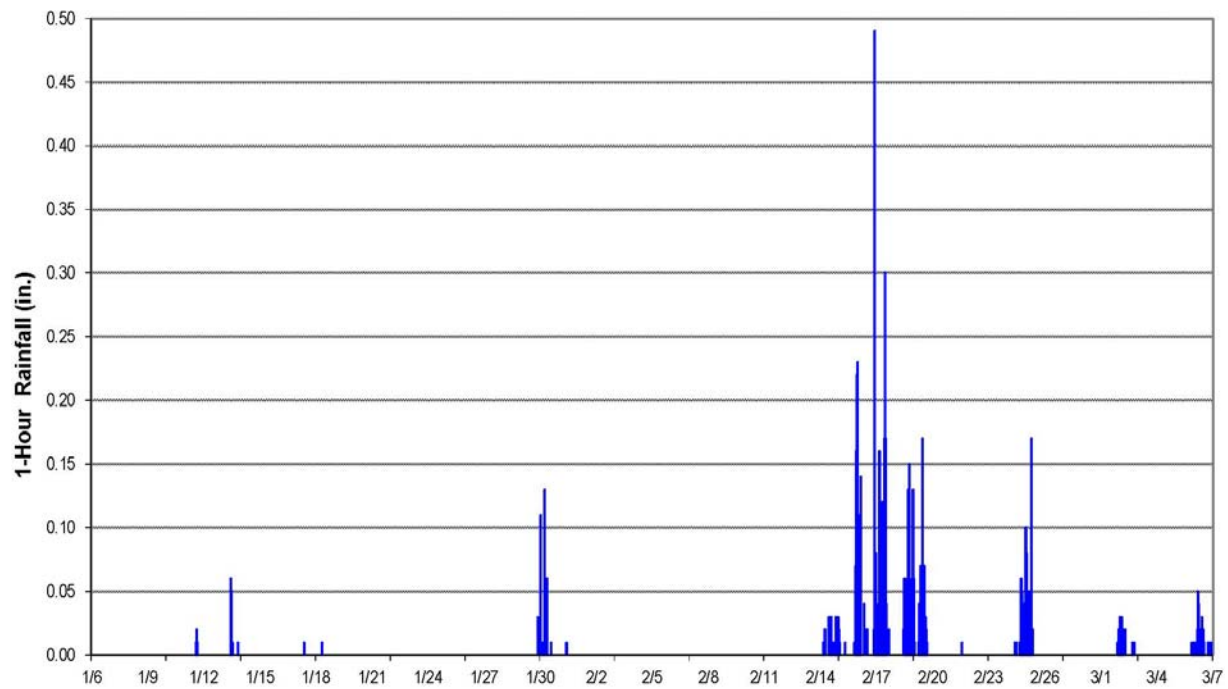
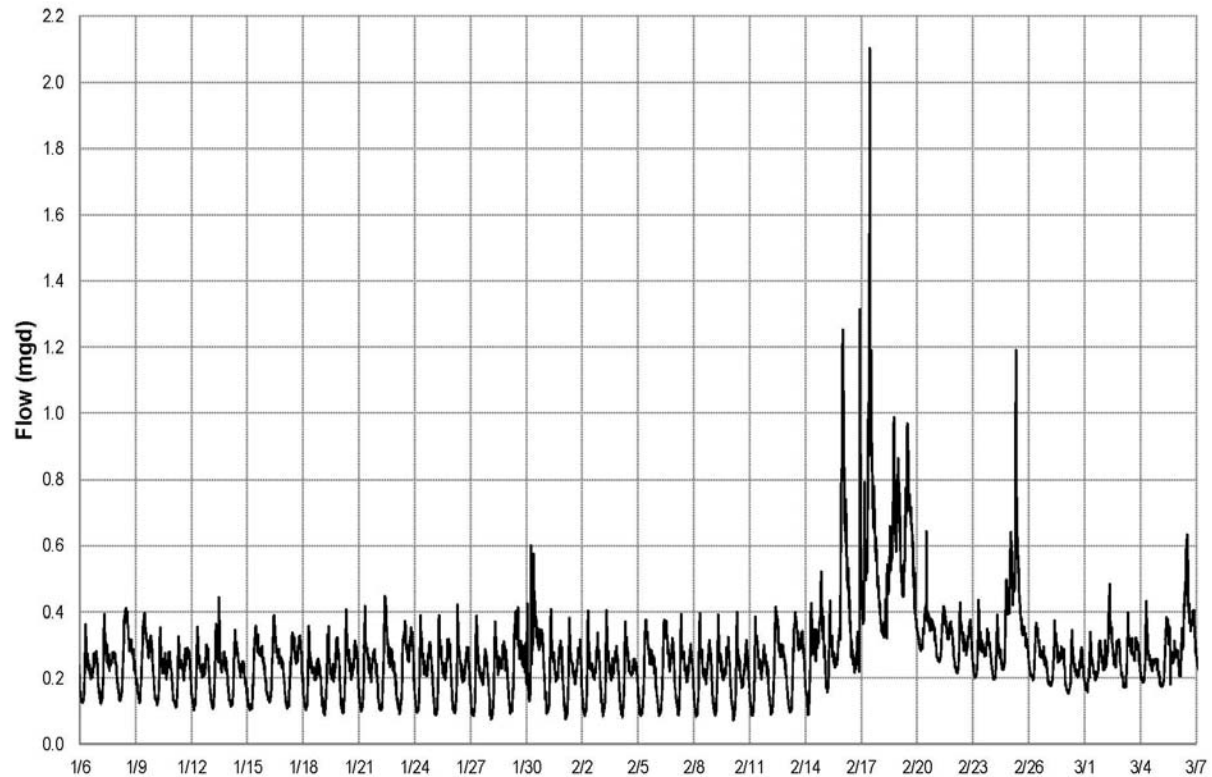


Figure 2-3: Plot of Typical Rainfall for Flow Monitoring Period (Rain Gauge 3)**Figure 2-4: Plot of Typical Flow Data for Flow Monitoring Period (Meter 8)**

Note that the City has had permanent meters (Palmer-Bowlus flumes) installed on the two major trunk sewers from which flow enters the South San Francisco system and is then conveyed to the Shaw Road Pump Station. One of those meters is located on the 36-inch Seventh Avenue trunk sewer immediately north of I-380 and the other on the 24-inch Tanforan Avenue trunk sewer west of San Mateo Avenue. In recent years, the meters have not been operating reliably and there have been concerns about their accuracy. The Flow Metering Study completed by the City in 2011 evaluated the meters and recommended improvements. The City is currently in the process of implementing those improvements.

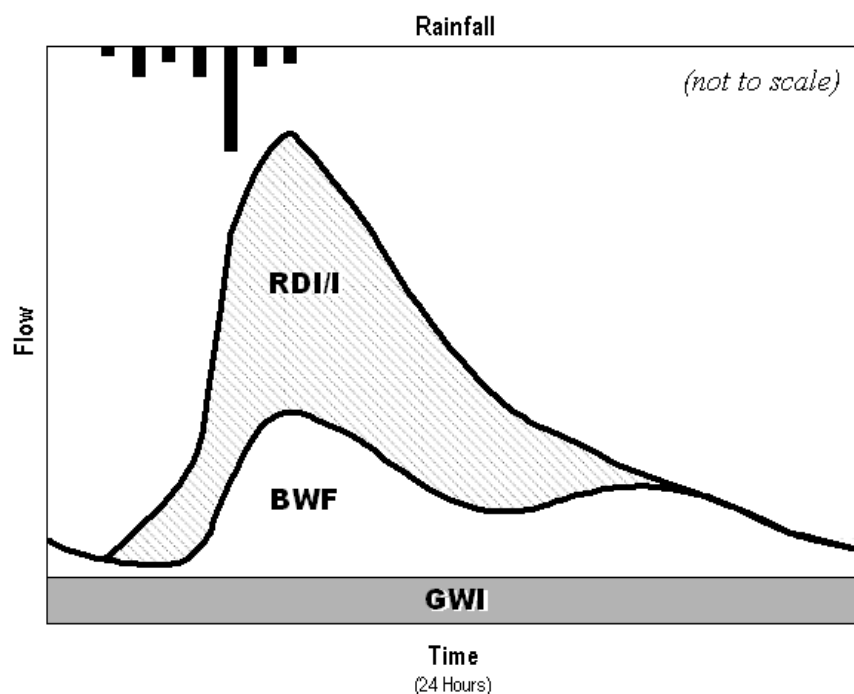
2.4 Flow Estimating Methodology

This section describes the methodology for estimating wastewater flows for loading to the hydraulic model.

2.4.1 Wastewater Flow Components

Wastewater flows typically include three components: base wastewater flow (BWF), groundwater infiltration (GWI), and rainfall-dependent infiltration/inflow (RDI/I). BWF represents the sanitary and process flow contributions from residential, commercial, institutional, and industrial users of the system. GWI is groundwater that infiltrates into the sewer through defects in pipes and manholes. GWI is typically seasonal in nature and remains relatively constant during specific periods of the year. RDI/I is storm water inflow and infiltration that enter the system in direct response to rainfall events. RDI/I can occur through direct connections such as holes in manhole covers or illegally connected roof leaders or area drains (called “direct inflow”), or through defects in sewer pipes, manholes, and service laterals. RDI/I typically results in short term peak flows that recede quickly after the rainfall ends. These three flow components are illustrated conceptually in **Figure 2-5**.

Figure 2-5: Wastewater Flow Components



Dry weather flow (DWF) consists of BWF plus GWI, while wet weather flow (WWF) adds the RDI/I component.

2.4.2 Base Wastewater Flow

Existing residential and non-residential base wastewater flows were estimated using information compiled at the parcel level (approximately 13,000 parcels) and then aggregated into the 210 model subcatchments. The total residential and non-residential BWF for each model subcatchment were calculated by summing the BWF for all parcels within that subcatchment.

Existing Flows

Existing BWF was determined based on 2010 census population at the block level for residential users and on water billing data provided by the City for non-residential users. (Note: water billing data was not used for residential users because it appeared that records for some parcels were missing from the database provided.) Metered water use during the winter months most closely approximates wastewater generation, since outdoor water use is at a minimum. Therefore, meter readings taken in recent winter periods were used as the basis for estimating non-residential BWF.

Census population was assigned to residential parcels within each census block. The population for parcels located within each subcatchment was then totaled to provide the total population of each subcatchment. Based on a comparison of the residential population from the 2010 census and the City's water billing data in selected areas, a per capita flow rate of 55 gallons per day (gpd) was applied to the population data to estimate the City's residential BWF. This per capita rate was confirmed by comparing modeled sewer flows to actual metered flows during model calibration, as discussed later in Section 2.5.

Future Flows

Although the City is largely built out, there are a few identified near-term planned developments, as well as anticipated intensification consistent with the City's General Plan and Transit Corridors Specific Plan. As part of the City's recent Water System Master Plan study, the City's water planning consultant (West Yost Associates) met with the City's Redevelopment Agency staff to review anticipated developments and areas of intensification, and this information was provided for use on the Sewer Master Plan. **Figure 2-6** shows the location of planned developments, and **Table 2-2** lists each of the development areas and the anticipated development.²

² City of San Bruno Water System Master Plan, Chapter 3 – Water Demands, West Yost Associates, Draft August 2011

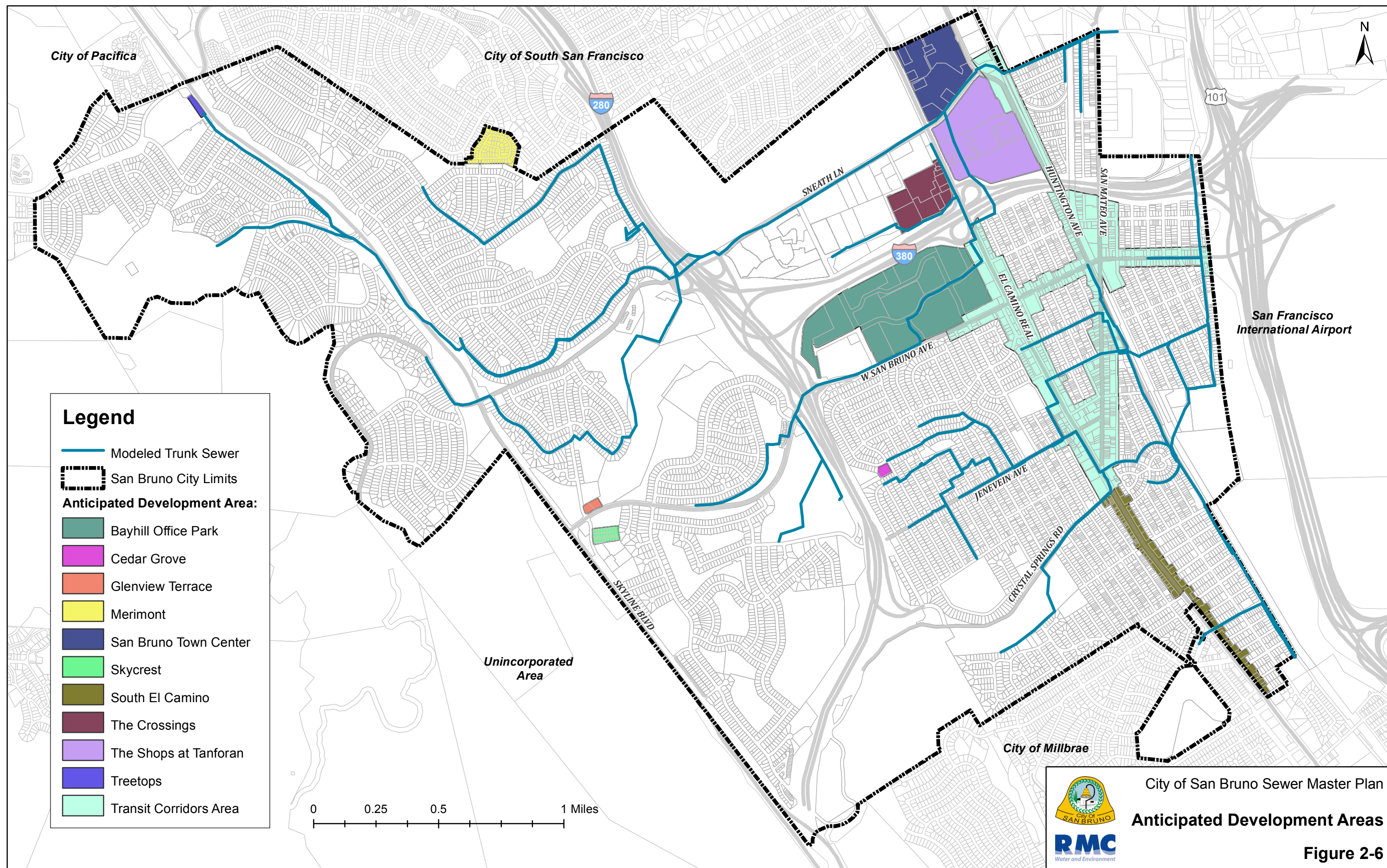
Table 2-2: Anticipated Development Areas

Area	Anticipated Development
Bayhill Office Park	683,200 sq. ft. office space
Cedar Grove	14 single-family dwelling units
Glenview Terrace	16 single-family dwelling units
Merimont	24 single-family dwelling units (24 of 70 total remaining to be built)
San Bruno Town Center	165,200 sq. ft. commercial space
Skycrest	12 single-family dwelling units (12 of 24 total remaining to be built)
South El Camino	103 single-family dwelling units
The Crossings	350 multi-family dwelling units 14,500 sq. ft. commercial space 350 hotel rooms
The Shops at Tanforan	263,900 sq. ft. commercial space
Treetops	308 multi-family dwelling units (vacant units being reconstructed)
Transit Corridors Plan	1,610 multi-family dwelling units 1,136,000 sq.ft. office/retail 190 hotel rooms

The following flow factors were used to calculate BWF from these developments. These flow factors are based on an analysis of census housing data and the City's water consumption data, as well as factors commonly used at the master planning level for similar communities.

- For residential properties:
 - Single family residential (SFR) = 170 gpd/unit
 - Multi-family residential (MFR) = 130 gpd/unit
- Hotels = 150 gpd/room
- Non-residential properties = 0.12 gpd/sq.ft of building floor space

For developed parcels which are not included in any planned redevelopment areas, the current flow based on 2010 census population, with a per capita flow rate of 55 gpd (for residential parcels), or on water billing data (for non-residential parcels) was assumed to characterize their BWF in the future.

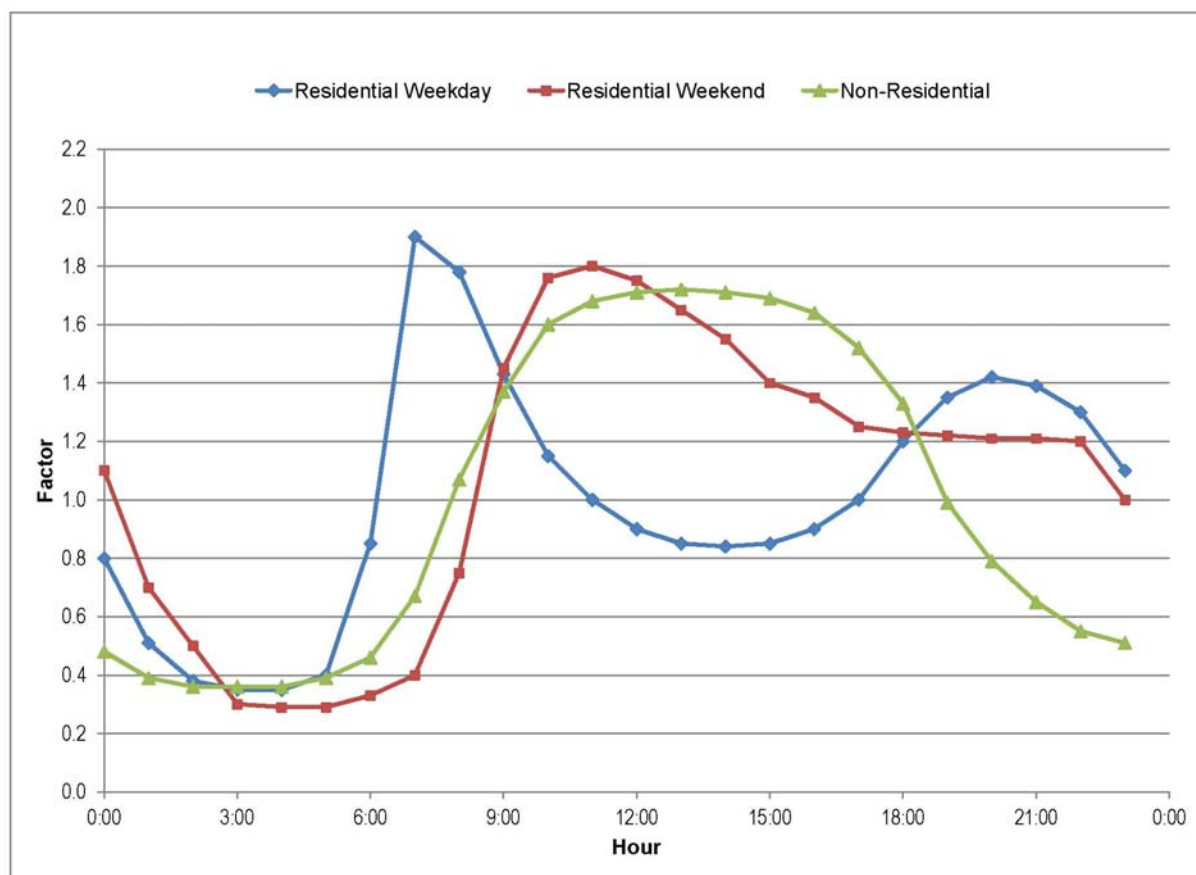


BWF Diurnal Profiles

In domestic wastewater systems, BWF varies throughout the day, typically peaking early on weekday mornings (later on weekends) and again in the evening hours in residential areas. BWF patterns in commercial and industrial areas depend on specific land use types but are typically characterized by a more uniform flow that lasts throughout working hours.

The variations in BWF on a typical day are represented by diurnal profiles. Diurnal profiles are defined by a set of hourly factors that are applied to the average BWF for each subcatchment. For San Bruno, separate sets of diurnal profiles were defined for weekdays and weekends and for residential and non-residential development. Profiles were developed based on monitored flows for smaller meter areas that isolated specific land use types, and are similar to those observed in other similar communities. **Figure 2-7** shows the diurnal profiles used in the model.

Figure 2-7: Diurnal Profiles



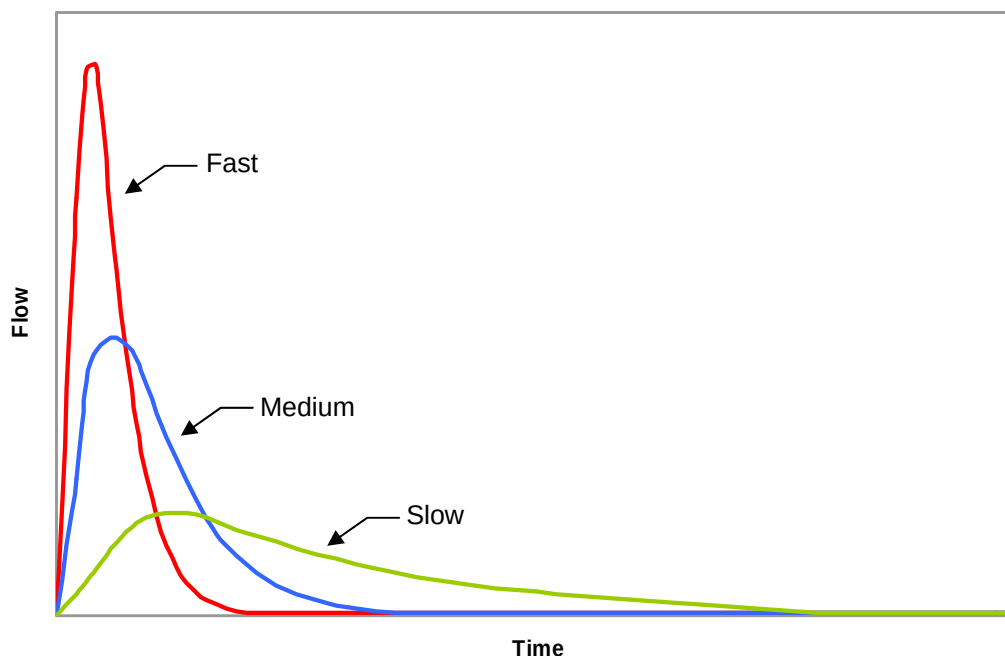
2.4.3 Groundwater Infiltration

GW I is typically applied in the model as a constant load in addition to the BWF. The amount of GW I in any particular area is determined during model calibration by comparing the modeled flows to actual observed dry weather flows at points in the system where flow meter data are available. Where modeled BWF is less than monitored dry weather flow, the difference is assumed to represent GW I. The GW I determined at the monitoring location is then distributed to the meter tributary area on a per-acre basis. Note that because GW I is seasonal in nature, the modeled GW I represents a typical GW I rate during the wet weather season rather than a dry season (summertime) GW I.

2.4.4 Rainfall-Dependent I/I

RDI/I flows result from rainfall events that produce infiltration and inflow of storm water runoff into the sewer system. RDI/I flows are defined by the magnitude, shape, and timing of the RDI/I response. RDI/I varies depending on many factors, including the magnitude and intensity of the storm event, area topography, type of soil, and the condition of the sewers, manholes, and sewer service laterals. In a dynamic model, RDI/I is typically computed as a percentage of the rainfall (sometimes referred to as the “R value”) falling on the contributing area of a subcatchment for each of three or more hydrograph components, representing different response times to rainfall, e.g., fast, medium, and slow, as illustrated in **Figure 2-8**. (The contributing area is assumed to be the sum of the area of all developed parcels, except for large open areas such as parks, cemeteries, and parking lots.) Summing all of the component hydrographs for the entire duration of the rainfall event results in the total RDI/I hydrograph for the event for that subcatchment. Note that although the “slow” RDI/I component can contribute significantly to the total RDI/I volume, the “fast” component has the biggest impact on the magnitude of the peak wet weather flow.

Figure 2-8: RDI/I Hydrograph Components



The model parameters defining the RDI/I flows to the system within a given meter area are determined by comparing modeled wastewater flow at the meter location to the measured wastewater flow during one or more rainfall events, as discussed in the model calibration section later in this chapter. The same calibrated parameters are generally applied to all subcatchments within each meter area.

2.5 Model Calibration

Model calibration is the process of comparing model-computed flows to observed (monitored) flows and adjusting various model parameters until the model is accurately simulating flows in the sewer system. The model was calibrated for both dry and wet weather conditions.

2.5.1 Dry Weather Calibration

The 7-day dry period from February 5 to 11, 2011 was used as the dry weather calibration period for comparing flow data to the model results. This period was selected because it was not impacted by previous rainfall and a majority of the meters showed consistent readings.

The primary focus of the dry weather calibration was to confirm that the calculated average BWF based on population and winter water consumption was consistent with the measured flows at the meter locations. The dry weather calibration confirmed the per capita flow rate of 55 gpd used to estimate residential BWF.

The second objective of the dry weather calibration was to confirm the diurnal profiles used to represent the hourly variations in BWF. The curves shown in Figure 2-7 were developed based on the calibration.

Finally, GWI was added when the observed (metered) dry weather hydrographs were greater than the model-simulated hydrographs by a relatively constant value throughout the day. GWI was applied to four of the meter basins, with rates ranging from 370 to about 2,900 gpd/acre. The additional flow seen at the meters was distributed to upstream subcatchments on an area-weighted basis. It should be noted that it may be difficult to assess the actual amount of GWI, as the relative accuracy of the flow monitoring data, water consumption data, and other model assumptions will affect the amount of flow attributed to GWI. However, this methodology is considered adequate for modeling purposes.

Table 2-3 summarizes the existing and future average BWF and DWF for the City's sewer system. In this table, DWF represents a dry (non-rainfall) period during the wet weather season, as was used for the dry weather model calibration.

Table 2-3: City of San Bruno Dry Weather Flow Summary

Flow Component	Flow (mgd)	
	Existing (2010)	Future
Residential BWF	2.26	2.58
Non-Residential BWF	0.45	1.03
Total Average BWF	2.72	3.61
Estimated Wet Season GWI ^a	0.60	0.62
Total Wet Season Average DWF	3.32	4.23

a. Calculated based on difference between metered non-rainfall period flows and estimated BWF as described in subsection 2.4.2.

2.5.2 Wet Weather Calibration

During wet weather calibration, parameters are adjusted to accurately simulate the volume and timing of RDI/I for monitored storm events. The entire period between mid-February and early March was used for wet weather calibration, with specific attention paid to storm events between February 14 and February 19. The total rainfall during this six-day period for the analysis period was approximately

4-1/2 inches. Rainfall was assigned to subcatchments using data from the closest of three rain gages maintained by V&A during the monitoring period.

The wet weather calibration resulted in a good match between modeled and metered flows for both peak and volume. Plots of model vs. metered flow for the mid-February wet weather period are included in **Appendix B**.

Total wet weather flows in the San Bruno system are also presented in the following section in the context of a “Design Storm” that is used for analysis and planning of sewer system capacity improvements (see Table 3-4, footnote h).

Chapter 3 Capacity Assessment and Capacity Improvement Program

The capacity performance of the system and need for capacity improvements were evaluated using the calibrated hydraulic model described in Chapter 2. This chapter discusses the criteria on which the capacity assessment was based and presents the model results and proposed capacity improvement projects. The potential benefits of reducing I/I in the system are also discussed.

3.1 Design Flow and Performance Criteria

Sewer system capacity is assessed with respect to the system's performance under a design flow condition. The subsections below define the design flow criteria used for the capacity assessment and the criteria for assessing system performance and identifying system capacity deficiencies.

3.1.1 Design Storm Condition

The use of wet weather design events as the basis for sewer capacity evaluation is a well-accepted practice. The approach is to first calibrate a hydraulic model of the system to match wet weather flows from observed storm(s), and then apply the calibrated model to a design rainfall event to identify capacity deficiencies and size improvement projects. The design event may be synthesized from rainfall statistics, or may be an actual historical rainfall event of appropriate duration and intensity. Other considerations for the design event include the spatial variation of the rainfall and the timing of the storm relative to the diurnal base wastewater flow pattern.

Selection of a design rainfall event is typically based on an allowable level of risk, often expressed as the return period. It is recognized that while wet weather overflows are highly undesirable, it is not cost-effective to provide capacity for the largest possible storm event. Regulatory agencies have not adopted standard criteria for return periods, so each agency must choose a target return period based on desired level of service, potential impacts of overflows, and cost.

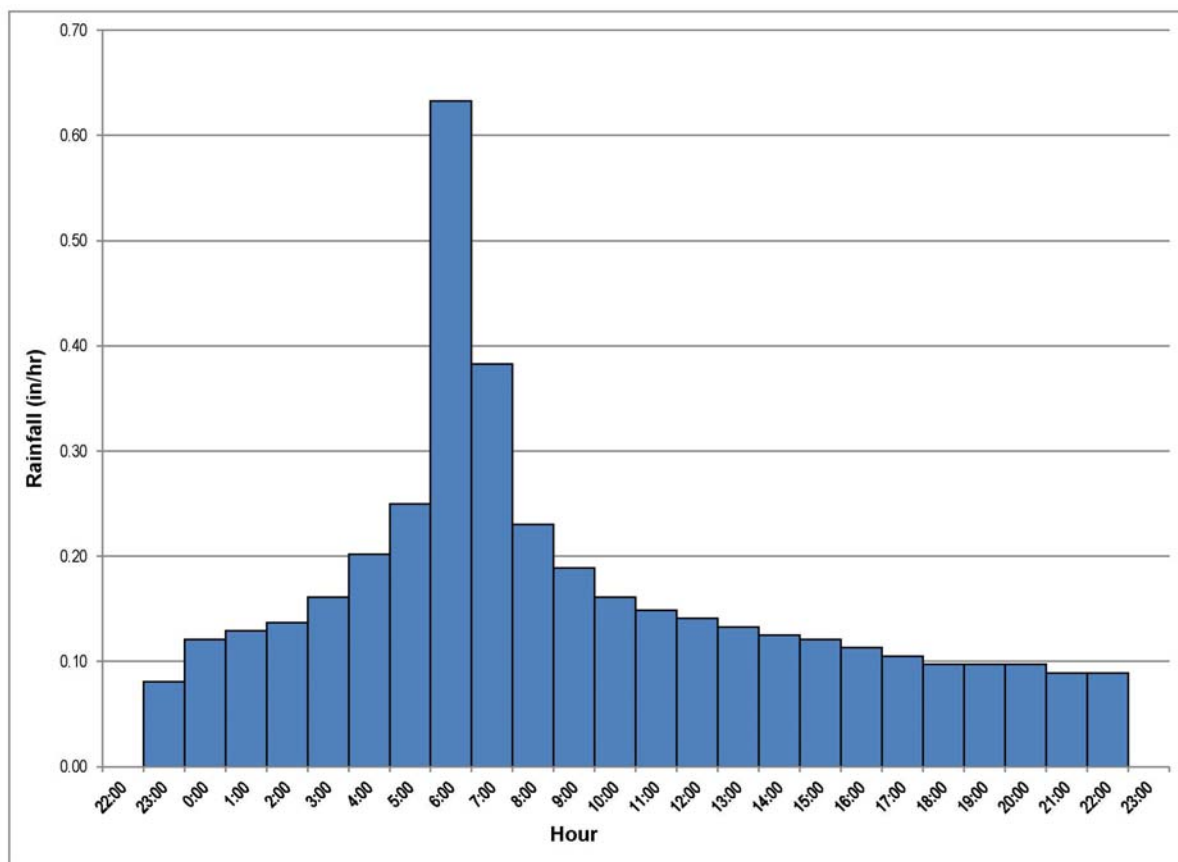
As specified in the Consent Decree with Baykeeper, the City has used a synthetic 10-year recurrence frequency, 24-hour duration "Design Storm" for assessing the hydraulic capacity of its sewer system. The 24-hour Design Storm rainfall for San Bruno ranges from 3.6 to 4.4 inches, depending on location, as determined from NOAA Atlas 14 Point Precipitation Frequency Estimates.³ The Design Storm includes shorter durations of intense rainfall as determined by the distribution curve for a Type IA storm as referenced in Appendix B of the USDA guidance document Urban Hydrology for Small Watersheds TR-55 (June 1986), with a peak hour intensity ranging from 0.57 to 0.69 inches.

The timing of the design storm also affects the resultant peak wet weather flows. If the design storm is timed such that the peak RDI/I occurs at the same time as the peak BWF ("peak-on-peak"), the total PWWF will be higher than if the design storm occurs under average or minimum BWF conditions. The City has elected to set the timing of the design storm rainfall such that the peak RDI/I resulting from the design storm occurs at or near the time of peak BWF flow (which typically occurs around 7 a.m. on a weekday) for most areas of the system. Timing the storm to produce peak-on-peak results is generally thought to create a return period of the peak wastewater *flow* that is greater than the return period of the design rainfall event.

Figure 3-1 shows a histogram of the Design Storm rainfall at the location of the Crestwood Pump Station. The design storm is comparable in size to other notable large rainfall events that have occurred over the past several years, such as the storms of December 31, 2005 and January 25, 2008.

³ <http://hdsc.nws.noaa.gov/hdsc/pfds/>

Figure 3-1: Design Rainfall Event



Note: Design Storm rainfall magnitude varies by location. The above graph represents rainfall at the location of the Crestwood Pump Station.

Note that a comparison was made to the 5-year, 6-hour design storm that was used for the City's 2000 Sewer Master Plan. As synthesized for the 2000 Master Plan, the 5-year storm had a higher peak hour rainfall intensity than the 10-year, 24-hour storm developed for this Master Plan. Model runs conducted for this study using the calibrated InfoWorks model with the 5-year, 6-hour storm rainfall resulted in similar peak flows in the system as with the 10-year, 24-hour Design Storm.

For future scenarios, the sewer system's response to rainfall is assumed to remain the same as existing conditions (other than for alternative scenarios in which targeted I/I reduction is considered). This implies that any increase in I/I due to deterioration of existing sewers will be offset by a decrease due to sewer rehabilitation or replacement, and that new sewers and laterals will contribute minimal I/I flows.

3.1.2 Capacity Deficiency Criteria

Capacity deficiency or performance criteria are used to determine when the capacity of a sewer pipeline or pumping facility is exceeded to the extent that a capacity improvement project (e.g., a relief sewer, larger replacement sewer, or pump station capacity expansion) is required. Capacity deficiency criteria are sometimes called "trigger" criteria in that they trigger the need for a capacity improvement project. These criteria may differ from "design criteria" that are applied to determine the size of a new facility, which may be more conservative than the performance criteria.

It is important that the capacity deficiency criteria be coordinated with the peak design flow criteria. For example, if the peak design flow considers only peak dry weather flow and little or no I/I, the

deficiency criteria should be conservative (e.g., require pipes to flow less than full during dry weather flow to allow capacity for I/I that may increase the flow under a wet weather condition). On the other hand, if the peak design flow includes I/I from a large, relatively infrequent design storm event, it is appropriate to allow the sewers to flow full or even surcharged to some extent, since the peak flows will be infrequent and brief in duration.

For San Bruno, since the design storm PWWF represents an infrequent, 10-year return period event coinciding with a conservative BWF condition, the City considers it acceptable to allow surcharging over the pipe crown, provided the hydraulic grade line (water level) remains at least four feet below the ground surface. During peak dry weather conditions, however, sewers should be able to convey the peak flow without surcharge.

Performance criteria for pump stations are based on their firm capacity, defined as pumping capacity with the largest pumping unit out of service. Force mains are considered to be capacity deficient if maximum velocity exceeds 8 feet per second (fps) during design peak wet weather flow or 6 fps during normal peak dry weather flow.

3.2 Capacity Analysis Results

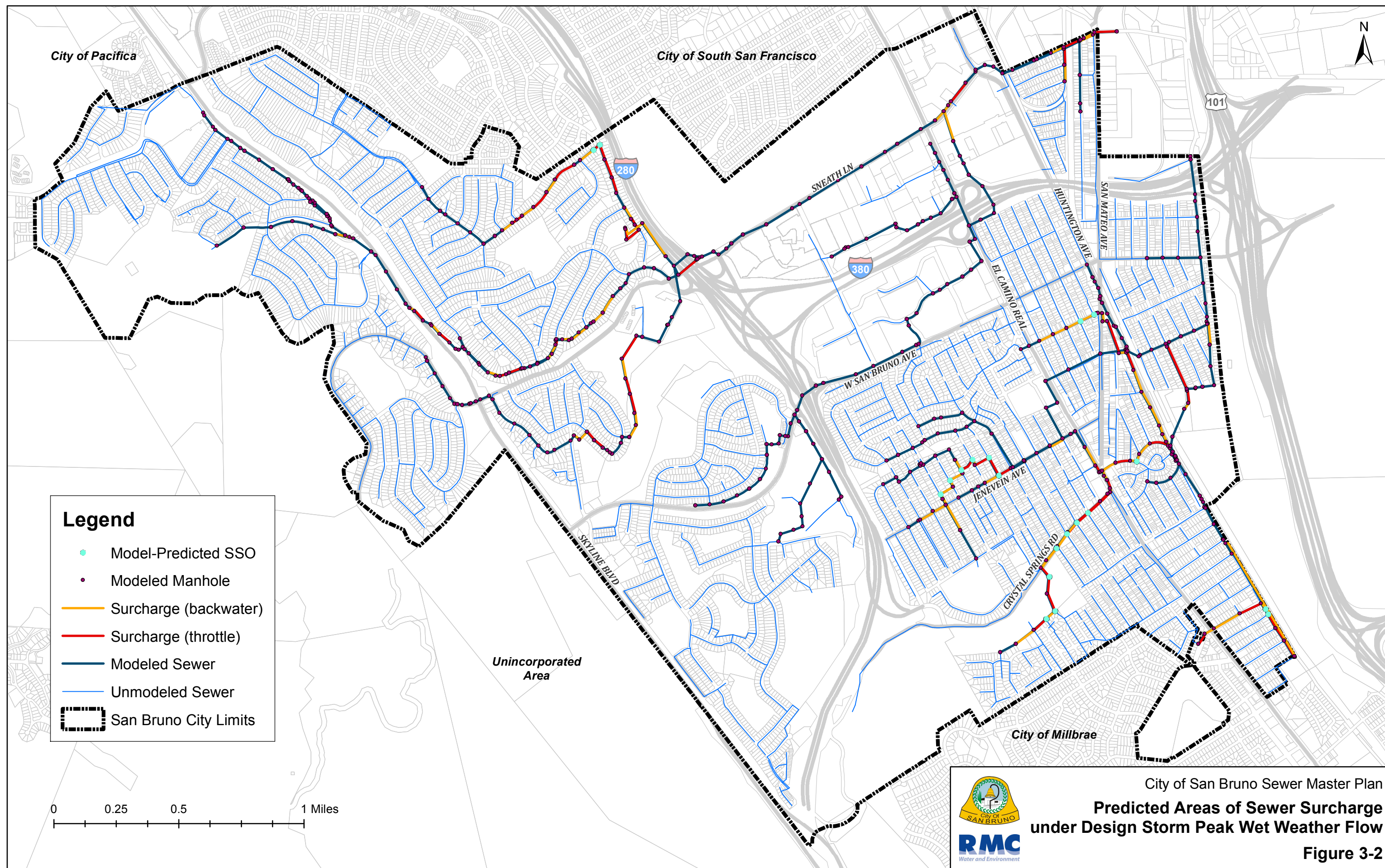
The calibrated model was run for existing and future conditions to identify areas of the system that fail to meet the specified performance criteria during predicted Design Storm peak wet weather flows. No capacity deficiencies in the system were identified for dry weather conditions other than the section of sewer that parallels San Mateo Avenue and then runs through the Artichoke Joe's Casino parking lot between Kains and Angus Avenues. This sewer has historically had capacity issues, and the City is currently implementing a project to bypass flows through a new connector from Kains Avenue to the new trunk sewer that is being constructed in Huntington Avenue as part of Caltrain improvements.

3.2.1 Gravity Sewer System Deficiencies

Figure 3-2 shows the location of model-predicted surcharged sewers and potential overflows during future Design Storm peak wet weather flow conditions. Pipes shown in red are predicted to be surcharged due to “throttle” conditions, indicating that the full pipe capacity of the pipe is less than the predicted peak flow. Pipes shown in orange are predicted to be surcharged due to backwater from a downstream throttle condition. The locations of model-predicted overflows during the Design Storm are shown as blue circles in the figure. It should be noted that the location of model-predicted overflows may not reflect the actual locations where overflows would occur or have occurred in the past, due to other physical conditions (e.g., root intrusion or debris) that are not reflected in the model, or system storage that is available in the smaller diameter, unmodeled pipes. However, historical wet weather overflows have occurred in the vicinity of several of the locations where overflows are predicted by the model.

As noted above, predicted surcharge in a particular pipe does not necessarily indicate a capacity deficiency at that particular location, as flows can back up due to a downstream capacity deficiency and cause extensive surcharging or even overflows upstream due to backwater effects. However, relieving upstream deficiencies can also create additional or more severe capacity deficiencies downstream of the relieved pipe, and therefore these downstream areas would also require relief. For example, providing relief for the capacity deficiencies identified along Crystal Springs Avenue would increase the flows to the downstream sewers in Taylor and Florida Avenues in the “Cupid Row” area, thereby increasing the peak flow and predicted surcharge and potential overflows in those lines. These effects were considered in developing the capacity improvement projects described later in this chapter.

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Based on the model calibration runs, the predicted surcharged conditions along Taylor and Florida Avenues, Kains Avenue and Artichoke Joe's parking lot, Crystal Springs, Jenevein, Huntington, and San Antonio Avenues, and Crestwood Drive were also predicted to occur under the storms observed during the flow monitoring period, and were confirmed by flow monitoring data for several of the meters that were located along those reaches. Wet weather overflows have, in fact, occurred at or near many of these locations during past large storm events.

3.2.2 Comparison to Previous Master Plan Findings

The City's 2000 Sewer Master Plan identified a number of areas of predicted capacity deficiencies, and recommended approximately 50,000 feet of relief sewers, as well as substantial sewer rehabilitation throughout the system that would reduce I/I by 22 percent systemwide. The City confirms that most of the relief sewer projects recommended in the 2000 Master Plan were completed; however, not all of the sewer rehabilitation work was done. The current Master Plan predicts a total future design storm PWWF of 26.6 mgd assuming that upstream hydraulic restrictions are relieved by capacity improvements (see footnote h in Table 3-4), compared to the 2000 Master Plan estimate of 21.2 mgd (before rehabilitation). (Note: as discussed in Section 3.1.1, although the master plans used different design storms, simulations of both storms using the calibrated model developed in this study produced similar flows, so the differences between the results of the two studies cannot be attributed to the different design storms.)

The current Master Plan also predicts a number of areas with potential wet weather capacity deficiencies that were not identified in the 2000 Master Plan. Some of the possible reasons for these differences include the more refined flow monitoring (greater number of flow meters installed) for the current study, more accurate metering equipment available today, and the more accurate hydraulic model used for this Master Plan. Furthermore, the flow monitoring for the 2000 Master Plan was conducted in 1997, over 15 years ago. In the time since, the condition of the sewers has likely deteriorated, with a resulting increase in I/I throughout the system. While the exact reasons for the higher flows and additional areas of capacity deficiencies identified in the current Master Plan cannot be determined definitively, the data and modeling conducted support the results.

3.2.3 Pump Stations

The City operates six sewer pump stations, two of which (Crestwood and Lomita Park) are included in the modeled network. These two pump stations were evaluated to determine if they had adequate capacity to convey future design peak wet weather flows. The peak flows to the other pump stations were estimated based on the flow contribution from tributary subcatchments.

Table 3-1 compares the total and firm capacity of each modeled pump station to the modeled flows under existing and future flow conditions. The firm capacities for the modeled pump stations were determined using manufacturer pump curves and information from pump station surveys prepared by City staff. A ten percent reduction in calculated capacity was also incorporated to account for wear and tear on the pumps. The table indicates that both Crestwood and Lomita Park Pump Stations have sufficient total capacity to convey design storm peak wet weather flows, but the Crestwood Pump Station does not have sufficient firm capacity. (The Lomita Park Pump Station is considered to have adequate firm capacity within the expected accuracy of the flow projections). Based on the estimated flows and reported design capacities for the unmodeled pump stations, the Olympic Pump Station may also need capacity upgrades to handle the Design Storm PWWF. The City is already planning a major renovation of this pump station, including new wet well, pumps, and force main replacement.

Table 3-1: Pump Station Capacity Results

Pump Station	No. of Pumps	Est. Total Capacity (mgd)	Est. Firm Capacity ^a (mgd)	Existing PWWF ^b (mgd)	Future PWWF ^b (mgd)
Modeled Pump Stations					
Crestwood	4	1.58	1.24	1.49	1.51
Lomita Park	2	1.28	1.01	1.04	1.06
Unmodeled Pump Stations^c					
Crestmoor	2	--	0.36	0.07	0.07
Olympic	2	--	0.29	0.4	0.4
Sharp Park	2	--	1.4	0.8	0.8
Spyglass	2	--	0.29	0.3	0.3

- Capacity with largest pump out of service. For modeled pump stations, determined based on pump curves.
- For modeled pump stations, represents flow after capacity improvement projects are constructed to relieve upstream bottlenecks. For unmodeled stations, represents sum of flows from tributary subcatchments.
- For unmodeled pump stations, PWWF was estimated based on subcatchment BWF and I/I characteristics of overall flow meter basin, also taking into consideration estimated peak flows based on historical station operation. Estimated firm capacity is based on the pump station design flow as documented in 2008 Pump Station Study⁴ or reported by City staff. Total capacity not determined.

3.3 Capacity Improvement Projects

This section describes the sewer improvement projects that would be needed to reduce the risk of the overflows in the sewer system due to insufficient capacity for design peak wet weather flows. The assumptions that were used to define the projects are also discussed. Each project is documented in further detail in **Appendix C** with an individual plan map and project information sheet that provides project details, key considerations, and a planning-level construction and capital cost estimates.

Capacity improvement projects were identified to address the potential deficiencies identified through the capacity analysis. For each identified gravity sewer capacity deficiency, a project was developed to replace the existing pipe with a larger pipe, or to divert flow to a new pipe or to another existing pipe with available capacity.

Figure 3-3 shows an overview of the sewer system capacity project locations, and **Table 3-2** and **Table 3-3** list all of the identified capacity improvement projects, including location, description of proposed improvements and capacity deficiencies addressed, and estimated planning level costs. Explanation of project sizing criteria and basis of cost estimates is provided in the following subsections. Prioritization of projects as part of the overall sewer system capital improvement program is discussed in Chapter 5.

⁴ Bonneau Dickson, P.E., Wastewater Pump Station Safety, Aesthetics, and Reliability Evaluation Study, November 20, 2008.

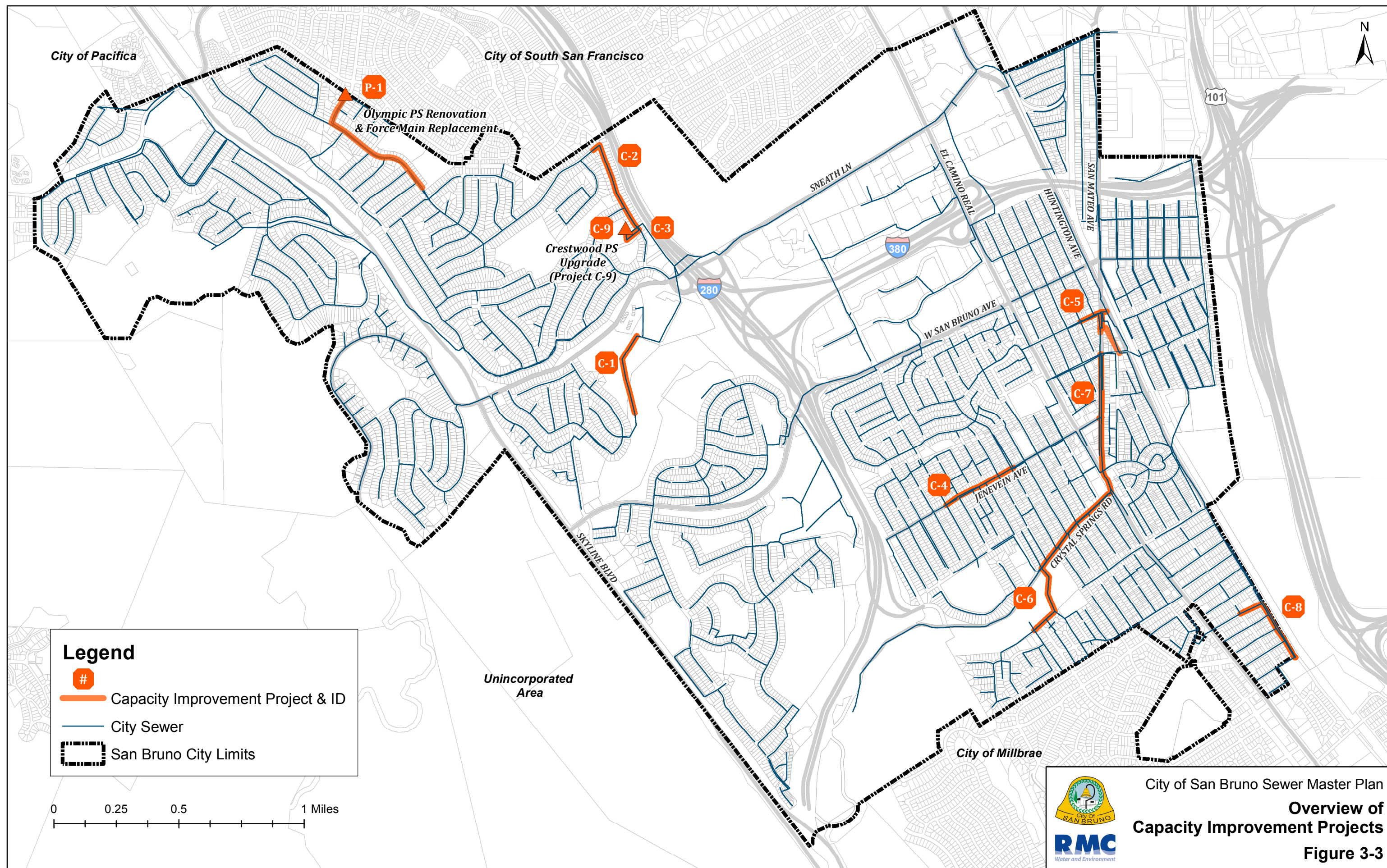


Table 3-2: Capacity Improvement Projects

Project ID	Project Name	Location	Description	Problem Addressed/Comments
C-1	Crestmoor Canyon	Easement along pedestrian trail through Crestmoor Canyon between Concord Way and Engvall Ct.	Replace approximately 1,400 feet of 8-inch pipe with 10-inch pipe	Addresses capacity deficiencies in existing sewers.
C-2	Crestwood Drive	Valleywood Dr. west of Crestwood Dr.; Crestwood Dr. from Valleywood Dr. to south of Fleetwood Dr.	Replace approximately 1,600 feet of 8-inch pipe with 12-inch pipe and realign pipe as needed	Addresses capacity deficiencies in existing sewers. Project could be eliminated by diverting flows from Olympic Pump Station to the Westborough Water District system.
C-3	Crestwood PS Influent Sewer	Crestwood Drive at Crestwood Pump Station	Replace approximately 600 feet of 8-inch pipe with 12-inch pipe	Addresses capacity deficiencies in existing sewers. Project could be eliminated by diverting flows from Olympic Pump Station to the Westborough Water District system.
C-4	Jenevein Avenue Bypass	Jenevein Ave. from Cherry Ave. to Cypress Ave.	Install approximately 600 feet of new 8-inch bypass pipe; upsize approximately 700 feet of 6- to 8-inch pipe with 8- to 10-inch pipe; install a weir to divert flow to bypass pipe	Addresses capacity deficiencies in easement sewers north of and parallel to Jenevein Ave. that are located between and under houses. The existing sewers have maintenance problems and have experienced previous SSOs.
C-5A	Kains Avenue Bypass	Kains Ave. from San Mateo Ave. to Huntington Ave.	Install a new 200-foot section of 15-inch PVC bypass pipe to divert flow to the new 18-inch sewer on Huntington Ave.	Addresses capacity deficiencies in existing sewers through Artichoke Joe's parking lot and along Huntington Ave. to Cupid Row that have resulted in SSOs. Note: This project has already been constructed in conjunction with the Caltrain Huntington Ave. improvement project.
C-5B	Kains Ave Improvement	Kains Ave. from Hensley Ave. to San Mateo Ave.; San Mateo Ave. south of Kains Ave.	Replace approximately 1,000 feet of 10-inch pipe with 12-inch pipe in Kains Ave; replace existing sewers in San Mateo Ave south of Kains Ave. with 10-inch pipe flowing north and connecting to the new 15-inch bypass sewer (Project C-5A)	Addresses capacity deficiency in existing sewer in Kains Ave. east of Masson Ave. and allows abandonment of portion of sewer through Artichoke Joe's parking lot (the remaining portion of the sewer will become a lateral serving Artichoke Joe's).
C-6	Crystal Springs Avenue	Easement through San Bruno City Park from City Park Way to Crystal Springs Ave.; Crystal Springs Ave. from Oak Ave. to El Camino Real; El Camino Real from Crystal Springs Ave. to Taylor Ave./San Mateo Ave. intersection	Replace approximately 3,400 feet of 6- to 8-inch pipe with 10- to 15-inch pipe; install weirs in manholes between parallel sewers in Crystal Springs Ave.	Addresses capacity deficiencies in existing sewers that have resulted in SSOs.
C-7 ^a	San Mateo Avenue Bypass	San Mateo Ave. from Taylor Ave. to Angus Ave.	Install approximately 2,000 feet of new 18-inch pipe; install a weir to divert most flow at Taylor Ave. into the new 18-inch sewer; abandon the existing 6-inch pipe along west side of San Mateo Ave. and reconnect laterals to new sewer; install new pipes to connect flow from sewers in Jenevein Ave. and Angus Ave. to new 18-inch sewer	Addresses capacity deficiencies in sewers in the Cupid Row area that have resulted in SSOs, and allows abandonment of existing shallow 6-inch pipes in San Mateo Ave. sidewalk. Will also allow future abandonment of existing 6-inch easement sewers between San Mateo Ave. and Mastick Ave.
C-8	San Antonio Avenue	Santa Inez Ave. from San Anselmo Ave. to San Antonio Ave.; San Antonio Ave. from Santa Inez Ave. to Lomita Park Pump Station	Replace approximately 1,500 feet of 6- to 8-inch pipe with 8- to 12-inch pipe	Addresses capacity deficiencies in existing sewers.
C-9	Crestwood Pump Station Capacity Upgrade	Crestwood Pump Station	Replace three of the existing pumps with larger pumps	Addresses lack of firm pumping capacity for Design Storm PWWF
P-1	Olympic Pump Station and Force Main Replacement	Olympic Pump Station; Olympic Dr. from pump station to Oakmont Dr.; Oakmont Dr. from Olympic Dr. to Berkshire Dr.	Replace existing pump station structure and upgrade pumps and major equipment; replace 2,600-feet of 6-inch diameter DIP force main with new 8-inch HDPE force main	Addresses aging infrastructure, maintenance and reliability issues, and potential lack of firm pumping capacity.

a. Because of the potential challenges of construction along San Mateo Avenue, several alternative alignments were also developed for this project, including alignments along Taylor and Mastick Avenues; El Camino Real and Angus Avenue; Taylor, Florida, and Huntington Avenues; and Taylor, Florida, and 1st Avenues. All of the alternative alignments would be longer than the San Mateo Avenue alignment. It is recommended that the City conduct more detailed analyses of these potential alternative alignments as part of pre-design of the project. Brief descriptions and maps of the alternatives are included with the Project C-7 documentation in Appendix C.

Table 3-3: Estimated Costs of Capacity Improvement Projects

Project ID	Project Name	Estimated Construction Cost	Estimated Capital Cost
C-1	Crestmoor Canyon	\$ 385,000	\$ 520,000
C-2	Crestwood Drive	\$ 792,000	\$ 1,070,000
C-3	Crestwood PS Influent Sewer	\$ 207,000	\$ 279,000
C-4	Jenevein Avenue Bypass	\$ 574,000	\$ 774,000
C-5A	Kains Avenue Bypass	Project has been constructed.	
C-5B ^a	Kains Avenue Improvement	\$ 1,300,000	\$ 1,700,000
C-6	Crystal Springs Avenue	\$ 1,625,000	\$ 2,193,000
C-7	San Mateo Avenue Bypass	\$ 1,105,000	\$ 1,491,000
C-8	San Antonio Avenue	\$ 602,000	\$ 813,000
C-9	Crestwood Pump Station Upgrade	\$ 343,000	\$ 463,000
P-1 ^a	Olympic Pump Station Renovation and Force Main Replacement	\$ 2,300,000	\$ 3,100,000
Total		\$ 9,233,000	\$ 12,403,000

a. Cost estimated by City staff.

3.3.1 Project Sizing Criteria

For gravity sewer capacity improvement projects identified as part of this Master Plan, replacement or new pipes were sized to convey the future Design Storm PWWF with no (or only minimal) surcharge. Existing pipe slopes and depths were preserved when upsizing sewers in-place. Model runs with all capacity projects in place were made to determine the impact of increased capacity from upstream projects on peak flows in pipes downstream of those projects to verify that no additional sewer system capacity deficiencies would result.

3.3.2 Cost Criteria

Costs for capacity improvement projects were estimated based on input from the City and RMC experience with similar projects. These cost estimates are planning or conceptual level estimates, and are considered to have an estimated accuracy range of -30 to +50 percent. This level of accuracy corresponds to an “order of magnitude” or “Class 5” cost estimate as defined by the American Association of Cost Estimators. These estimates are suitable for use for budget forecasting, CIP development, and project evaluations, with the understanding that refinements to the project details and costs would be necessary as projects proceed into the design and construction phases. All costs have been adjusted to an Engineering News Record Construction Cost Index (ENR CCI) of approximately 10,208, which represents the January 2012 ENR CCI for the San Francisco Area.

Cost criteria include baseline unit construction costs for gravity sewers based on open-cut installation. Open cut construction was assumed for all projects, although pipe bursting could be determined during design to be a viable method based on site specific conditions. Costs for gravity trunk sewers vary with pipe diameter and depth, and include replacement of lower laterals and installation of cleanouts at the property line. Allowances added to the baseline construction cost include mobilization/demobilization and project-specific costs for bypass pumping, traffic control for work in roadways, and a delay factor (additional construction time) for remove and replace projects. A 30 percent allowance for contingencies for unknown conditions was also included for all projects, as well as an allowance of 35 percent of construction cost for design engineering, administration, construction management, and legal costs.

3.3.3 Detailed Project Descriptions

Detailed descriptions and maps of the sewer system capacity improvement projects are presented in **Appendix C**. The descriptions are each contained on a single page and follow a standard format that consists of a summary project description (project location, length, pipe sizes, estimated capital cost, and discussion of any specific project assumptions, issues, or other considerations) followed by a detailed planning level cost breakdown. The maps show the projects on an aerial photo background, indicating the project pipe segments, key manhole IDs, and existing and proposed pipe sizes.

3.4 Infiltration/Inflow

The San Bruno sewer system is subject to significant amounts of I/I, resulting in high peak flows during wet weather events. As described previously, the flow monitoring data and hydraulic model were used to characterize the I/I response in various areas of the system and to quantify the peak I/I and peak wet weather flows generated in each area.

Table 3-4 summarizes the I/I response in each meter basin in terms of peak RDI/I per foot of pipe and acre of contributing sewered area, and the ratio of PWWF to ADWF, referred to as the wet weather peaking factor, for the Design Storm.

Wet weather peaking factors based on the model-predicted flow for the 10-year Design Storm range from about 3 to 16. **Figure 3-4** shows the range of wet weather peaking factors by area, and **Figure 3-5** shows peak RDI/I per acre. The highest peaking factors (greater than 10) occur in the Pacific Heights/Sharp Park area (Basin 4) and oldest Rollingwood subdivisions (Basin 2), as well as in the very old areas in the southeastern portion of the City (Basins 6, 7, and 8). The highest peak RDI/I rates occur in Basins 6 and 7. Many of the capacity deficiencies in the system were found in the trunk sewers serving these areas with high I/I.

The shape of the RDI/I hydrograph may provide some indication of the types of I/I sources. The flow monitoring and wet weather calibration plots shown in Appendices A and B show that some of the meters, for example Meter 7, which captures the flow tributary to the trunk sewers in Crystal Springs Avenue, and Meter 6, which captures flow from the Lomita Park area and vicinity, both have a very spiky and quick response, which can be indicative of direct inflow sources as well as rapid infiltration into shallow pipes and laterals. Further investigations, such as smoke testing, would help confirm the potential sources of the I/I in these areas.

An analysis was conducted to determine if reducing peak RDI/I in the system could eliminate the need for some capacity improvement projects. Model runs were conducted assuming various levels of RDI/I reduction in the subcatchments tributary to these projects. The RDI/I reductions were applied to the “fast” and “medium” response components of RDI/I (see Figure 2-8). RDI/I reductions ranging from 10 to 50 percent were modeled. The results indicated that with only one exception, these levels of RDI/I reduction would not be sufficient to eliminate the need for the identified capacity improvements, although they could possibly reduce the required pipe size or extent (length) of the improvements. The one exception was Project C-1, Crestmoor Canyon, for which the modeling indicated that a 30 percent peak RDI/I volume reduction in meter basin 3 could eliminate the need for capacity relief. Based on experience and studies done in other areas, however, this level of I/I reduction would require a comprehensive rehabilitation approach, that is, all or most of the sewer mains (approximately 40,000 feet of pipe) and at least the lower portions of the private service laterals would need to be rehabilitated throughout this area. This would require a significant financial investment over a relatively short period of time, the cost of which would likely far exceed the cost of the capacity improvements alone.

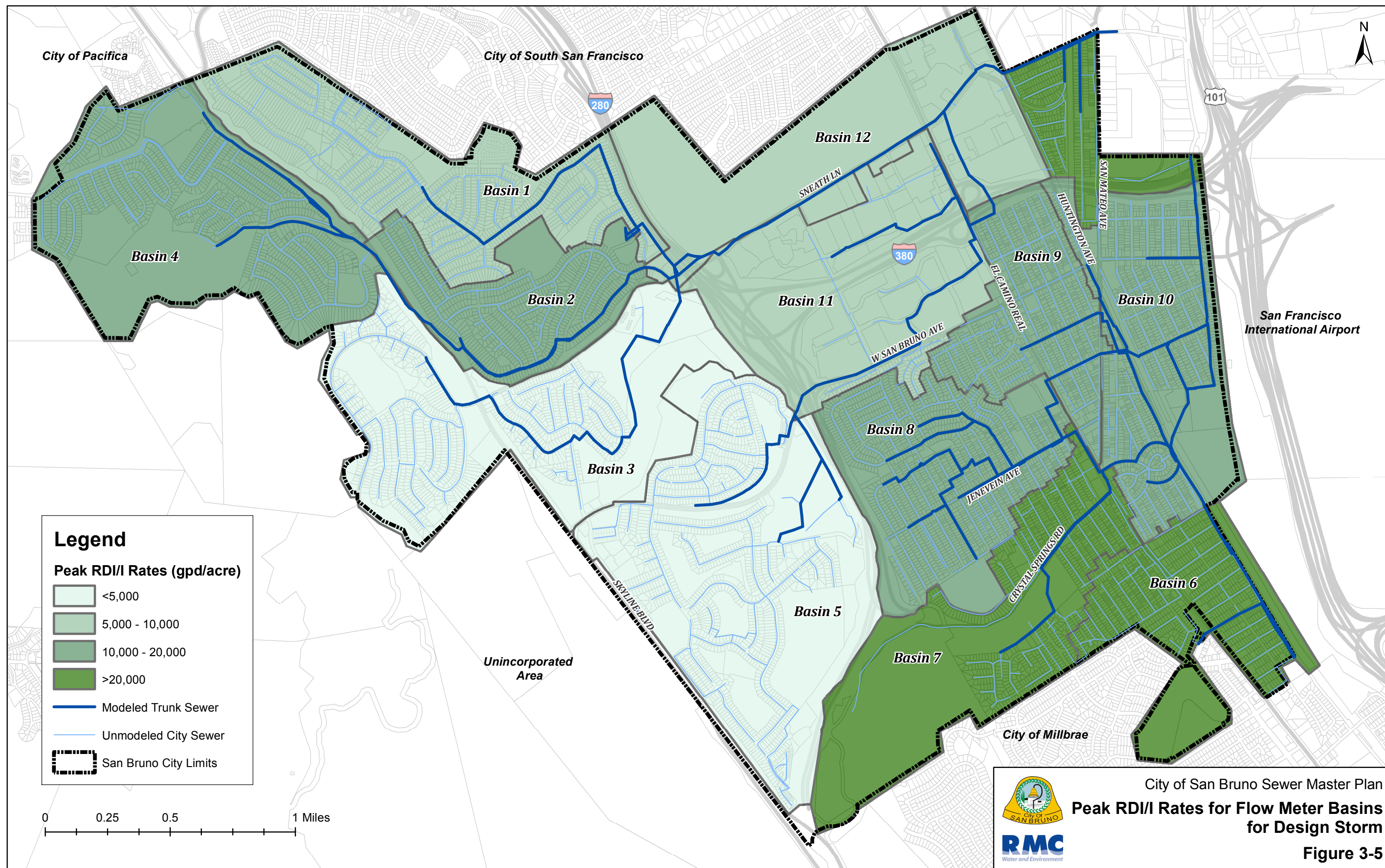
Table 3-4: Peak I/I by Sewer Basin

Sewer Basin ^a	Contributing Area (ac.) ^b	ADWF (mgd) ^c	Peak RDI/I (mgd) ^d	PWWF (mgd) ^e	Unit Peak RDI/I Rate (gpd/ac)	Unit Peak RDI/I Rate (gpd/ft)	Wet Weather Peaking Factor ^f
1	197	0.19	1.14	1.51	5,800	34	7.8
2	112	0.11	1.45	1.65	12,900	56	14.6
3	170	0.17	0.79	1.09	4,700	20	6.3
4	228	0.23	3.36	3.75	14,700	73	16.3
5	291	0.47	0.84	1.57	2,900	15	3.4
6	98	0.23	2.50	2.90	25,500	86	12.7
7	111	0.31	4.19	4.62	37,800	123	15.0
8	176	0.21	1.96	2.36	11,200	40	11.1
9	103	0.25	1.22	1.63	11,800	33	6.4
10	170	0.37	2.01	2.49	11,900	38	6.8
11	132	0.31	1.15	1.56	8,600	52	5.0
12	91	0.38	0.79	1.14	8,600	79	3.0
Total ^g	1,917	3.32	22.2	27.2 ^h	11,600	49	8.2

Note: Basin flows based on existing development (not including future growth).
mgd = million gallons per day.

- For meters with upstream basins, represents the incremental meter basin area, as shown on Figure 2-2.
- Net area of developed parcels.
- Average dry weather flow. Includes groundwater infiltration during non-rainfall periods, representing approximately 18 percent of overall ADWF (may be higher in some basins and negligible in others).
- Peak rainfall-dependent I/I flow for Design Storm. Represents sum of peak flows for individual subcatchments within each basin.
- Peak wet weather flow for Design Storm. Represents sum of peak flows for individual subcatchments within each basin; does not reflect flow routing through the system (which would typically reduce the peak flows).
- Ratio of PWWF to ADWF for Design Storm.
- Includes small unmetered area (approximately 100 acres).
- Sum of basin flows; does not reflect flow routing through system. Total estimated PWWF discharged into South San Francisco (sum of flow in Seventh Avenue and Tanforan Avenue trunk sewers) without sewer system capacity improvements is 23.1 mgd; with capacity improvements, estimated PWWF is 25.4 mgd under existing conditions and 26.6 mgd with future development included.

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That said, however, the City recognizes the benefit of reducing I/I in the long-term, as reducing I/I also reduces the costs for pumping and treatment. If achieved through sewer rehabilitation and replacement, I/I reduction provides the added benefit of further improving the condition of the sewer system, which in turn could reduce maintenance requirements and the risk of dry weather blockages and overflows. Therefore, it is in the City's best interest to construct needed capacity improvements in order to minimize the potential near-term risks of wet weather overflows, but at the same time, continue a long-term program of sewer rehabilitation to improve the overall condition of the system and reduce I/I systemwide. Potential methods of I/I source detection and control are described below.

3.4.1 I/I Source Detection and Control Methods

A necessary step in identifying potential I/I control measures is a realistic assessment of the actual sources of I/I in the sewer system. Based on the pattern and magnitude of flows in the City's sewer system, the likely sources of RDI/I flows are defects in sewers and service laterals, and possibly some direct connections (e.g., illegally connected roof and area drains, direct connections from the storm drain system, etc.). Appropriate I/I control methods depend on the type and sources of I/I. Control methods must include detection as well as correction. Potential methods are described in the following paragraphs.

Direct Inflow Sources

Direct inflow sources can contribute significantly to both volume and peak rates of I/I, and have the greatest probability of being cost effective to eliminate. The main methods used to detect and locate direct inflow sources are smoke and dye testing (dye testing is used primarily as a confirmatory test). Smoke testing is considered to be a relatively easy and inexpensive method (cost is approximately \$0.50 per foot if a substantial length of pipe is tested), and discovery of just a few direct storm drain cross-connections, for example, can make the effort worthwhile. However, unless there is some indication or knowledge of the existence of direct connections in the system, finding them may require an extensive smoke testing program, which requires public notification measures and access onto private property to document the smoke returns. For this reason, smoke testing is generally targeted at specific areas with high peak RDI/I rates.

Elimination of direct inflow connections requires disconnection of the source and re-direction of the drainage to an appropriate location. This may simply be to the ground surface (as in the case of roof drains), or connection to a nearby storm drain or street gutter. In general, each identified source needs to be evaluated on a case-by-case basis to identify the appropriate corrective measure.

Generally the most numerous type of sources found during smoke testing are not direct inflow connections but defects in shallow pipes, primarily laterals. Rehabilitation of laterals may be a challenging institutional issue (see discussion below on correction of private property I/I sources).

Manholes subject to ponding or located in drainage courses may also be sources of direct inflow. The amount of I/I depends on the manhole location, type of manhole cover (number and size of holes), and the condition of the cover and frame. Physical inspection of manholes is the most effective way to identify such conditions, and correction is relatively straightforward (replace cover, realign frame, raise manhole to grade, remove or relocate manhole in watercourse, etc.). Physical inspection can be conducted in conjunction with sewer inspection or routine cleaning work, or as a separate activity.

Infiltration Sources in Sewer Mains and Manholes

Infiltration sources are defects in sewer pipes or manholes caused by defective materials or construction, general deterioration, or damage caused by physical conditions such as ground movement or settlement, traffic loads, or root intrusion. Infiltration sources (defects) are detected by inspection: visual inspection in the case of manholes and CCTV inspection for sewer mains. However, visual observation of active I/I is generally not feasible since the RDI/I generally occurs for only short

periods during rainfall events, and the pipes may fill up during those periods, making CCTV inspection difficult or impossible.

Infiltration correction methods involve rehabilitation or replacement of entire pipe segments or manholes or spot repair of localized defects. There are numerous materials and methods used for this type of rehabilitation. In general, however, the cost per unit amount of I/I removed is relatively high, since the defects individually contribute relatively small amounts of flow. It is recognized that infiltration in the sewer system will “migrate” to other nearby defects that are left un-repaired. Therefore, a fairly extensive area of the system may need to be included in the rehabilitation effort in order to achieve substantial flow reduction. Furthermore, reductions greater than about 30 percent can rarely be achieved without also addressing the infiltration from private laterals. Generally, rehabilitation to reduce infiltration is cost effective only if a significant amount of infiltration can be isolated to a relatively small area, or there are extremely costly improvements required downstream to convey, treat, and dispose of the excess flow.

I/I Sources on Private Property

I/I sources on private property are primarily defective laterals, but may also include broken cleanouts or cleanout caps, or directly connected roof and area drains. Smoke testing is the primary method for detecting private property I/I sources. For more aggressive programs, building or property inspections can be conducted, and/or laterals can be CCTV inspected or tested for leaks using air or water pressure tests. These types of inspections and tests generally require that the lateral have cleanout access, ideally at both the connection to the building plumbing and at or near the property line. However, new technologies are now available, such as cameras that can be “launched” up the lateral during CCTV inspection of the mainline, that make it easier to inspect private laterals.

As discussed earlier in this chapter, analysis of the extent of sewer system rehabilitation to reduce I/I that would be required to eliminate the need for capacity improvement projects indicates that sewer and lateral rehabilitation costs would far exceed the cost of improvements to increase system capacity to handle peak wet weather flows. Therefore the capacity assessment concludes that repair and replacement of private laterals would not be a cost-effective measure for addressing capacity related issues in the San Bruno sewer system.

Chapter 4 Condition Assessment and Rehabilitation/ Replacement Program

This chapter describes the process used to assess the condition of the gravity sewer system by closed-circuit television (CCTV) inspection, the methods used to analyze the data to identify needed repairs and rehabilitation/replacement (R/R) needs, and presents the recommended sewer system R/R program. Additional sewer rehabilitation needs to address areas of the system with specific maintenance problems identified by City staff are also addressed.

The recommended gravity sewer R/R projects are included in the capital improvement program presented in Chapter 5. The program is based on characteristics of the City's sewer system and results of sewer inspections performed in 2009, 2010, and 2012. The R/R program also includes projects needed to address maintenance issues identified by City staff and replacement of aging infrastructure (sewers that are anticipated to reach the end of their useful lives in the next 20 years).

The condition of the pump stations and force mains are not specifically addressed in this Master Plan, although the capital improvement program presented in Chapter 5 includes improvement projects for those facilities previously identified by the City, based on the previous assessment of the system pump stations conducted in 2008.

4.1 Condition Assessment Methodology

CCTV inspection is the basic method used by the City to gather the data required to assess gravity sewer condition. This section describes the City's program, including data documentation standards and condition grading.

4.1.1 CCTV Inspection Program

The City initiated its CCTV inspection program in 2009. A CCTV contractor, Veolia (formerly Pacific Liners), was hired to perform the work. The initial pipes to be inspected were selected by City staff, focusing on the most problematic areas of the system first. The contractor used PicAx CCTV software to capture the data and video and still images. Approximately 40 percent of the system was inspected during 2009 and 2010, and most of the remaining 60 percent in 2012 (approximately 1.3 miles of sewers had not yet been inspected at the time this report was prepared due to restricted access or surcharged conditions, but are planned to be completed in 2014).

Effective use of CCTV inspection data requires that the data recorded be consistent, complete, and of high quality; and that it is captured in a format that can be readily accessed for analysis. Current industry best practice is to use Pipeline Assessment and Certification Program (PACP) standards developed by the National Association of Sewer Service Companies (NASSCO), which specify observation codes and grades to be applied to all structural and maintenance-related defects.

The initial CCTV inspection data collected in 2010 was not captured using the NASSCO PACP defect coding standard. Therefore, the City contracted with Holmes International to convert the codes to PACP format and consolidate the individual inspection databases contained on over 75 DVDs to a single consolidated database. Additional corrections to the database were also made to rectify manhole numbering to be consistent with the City's GIS. The corrected, consolidated database was then provided to RMC for the condition assessment work. The 2012 inspections, however, were completed in accordance with PACP standards.

4.1.2 Condition Grading and Rating

Under the PACP standard, all structural defects are assigned a Structural Grade of 1 to 5, with Grade 5 representing severe defects that require attention in the short-term and Grade 1 representing minor defects. The grades for individual defects observed on a manhole-to-manhole pipe segment can be

combined in various ways to determine an overall structural condition rating for the pipe. The PACP manual suggests several approaches for this purpose, including summing the grades of all defects or averaging the grades. While such approaches may be useful for screening pipes in terms of overall condition, they are not particularly useful for deciding which pipes require immediate or near-term attention. What is most important in such decisions is the presence of major defects and the number of such defects. For example, a single Grade 5 defect in a pipe requires action, while five Grade 1 defects do not, even though they both have a PACP Segment Grade Score of 5. The number of major defects is significant since it helps determine whether point repair(s) or manhole-to-manhole rehabilitation (e.g., lining or replacement) would be most appropriate.

Because it provides the best overall rating method for the purposes of decision making, the PACP Quick Structural Rating (QSR) is recommended as the primary rating system for condition assessment. The rating is a four-digit code that indicates the number of defects having the two highest grades. For example, a QSR of 5132 indicates the worst defect was a Grade 5 defect (of which there was only one occurrence), and the next worst defect was Grade 3 (of which there were 2 occurrences).

4.2 Rehabilitation/Replacement Decision Process

Based on the inspection data collected under the City's CCTV inspection program, a formal decision process was developed to facilitate the use of the data in determining appropriate actions to repair, rehabilitate, or replace defective sewers pipes or to continue to monitor and maintain sewers that are not in need of renewal in the near future. In the context of the discussion in this report, the terms "renewal" and "rehabilitation/replacement" are used to designate any type of action that results in a structural improvement to the sewer pipe, including a point repair, short-segment lining, or lining or replacement of an entire manhole-to-manhole pipe reach.

The decision process is designed to set clear criteria for identifying pipes requiring accelerated actions, pipes requiring renewal, and selection of an appropriate repair, rehabilitation, or replacement method. The process is illustrated in the flow diagram in **Figure 4-1**. The diagram depicts how the data for each pipe segment is systematically evaluated using decision points to drive an objective preliminary decision outcome based on its condition, the types of defects it contains, and the estimated cost-effectiveness of various renewal methods. The input, decision points, and potential decision outcomes are described in **Table 4-1** and discussed in more detail below.

The decision outcomes resulting from the decision process are intended to support review of the CCTV inspection data by providing a preliminary decision. Outcomes from the decision process indicating a renewal action are further reviewed to validate the decision. The review consists of detailed review of CCTV inspection defect data as well as viewing of selected video or defect photo images and CCTV reports when deemed necessary. In addition, other factors such as pipe capacity, location, maintenance history, and constructability issues might be assessed and considered. Finally, other considerations, such as a goal of reducing infiltration, could also influence the choice of renewal method for a particular pipe or area of the system.

4.2.1 Defect Categorization and Terminology

Under the PACP system, pipeline defects are categorized by type (e.g., structural or operation & maintenance) and severity (Grade 1 to 5). Defects of certain type and severity can be considered "major" defects, requiring some type of renewal action. Examples of major defects include collapsed, broken or fractured pipe, holes, obstacles or laterals ("taps") intruding significantly into the pipe, and significant corrosion in concrete or asbestos cement pipes.

Figure 4-1: Sewer Renewal Decision Process Flow Diagram

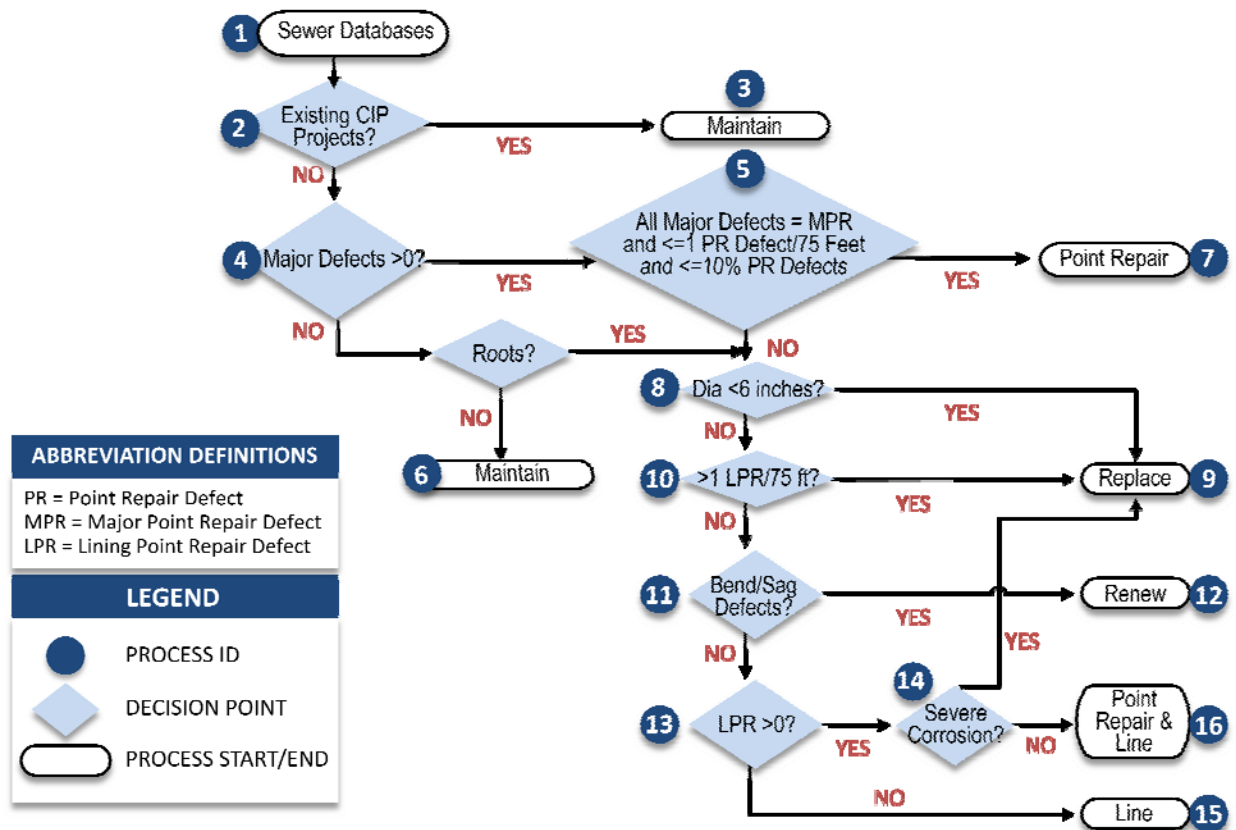


Table 4-1: Sewer Renewal Decision Process Explanations

Process ID	Type	Description	Explanation
1	Input	Sewer Databases	The data sets, including CCTV defects, defect code categorization, and pipe attribute data, used for pipe renewal decision-making.
2	Decision	Project scheduled or completed?	This asks whether the pipe has already been repaired or if there is a project scheduled that will address its existing defects. If yes, then a "Maintain" outcome results. If no, then the pipe will continue through the process.
3	Outcome	Maintain	Decision to continue ongoing maintenance of the pipe segment because, in its current condition, it does not warrant additional action in the near-term.
4	Decision	Major Defects > 0?	This asks whether the pipe segment has any major defects. If yes, then the pipe will continue through the decision process. If no, then a "Maintain" outcome results, unless there are significant root defects (see Decision 6).
5	Decision	Major Defect Count =1 or (All Major Defects=MPR & <= 1 PR Defect/75 feet & <= 30% PR Defects)	This determines if a point repair is feasible. This is indicated if there is only one major defect in the pipe segment, or if the following three criteria are met: 1) all major defects can be addressed using a point repair solution (Major Defects = MPR); 2) there are no more than 1 point repair defect per 75 feet of pipe (more than that suggests that the pipe should be lined or replaced); and 3) no more than 30 percent of the pipe should require point repair (anything more is not likely to be a cost-effective solution).
6	Decision	Root Defect Count >10	This asks whether the pipe segment has 10 or more occurrences of problematic roots, indicating that renewal is warranted. If no, then a "Maintain" outcome results.
7	Outcome	Point Repair	Decision to perform one or more localized repairs on the pipe segment to address defects.
8	Decision	Dia <= 6 inches?	This asks whether the pipe is 6-inch diameter or smaller. If so, then lining is not considered feasible and the decision will be to "Replace" the pipe. If the answer is no, then this pipe segment will continue through the process.
9	Outcome	Replace	Decision to replace the pipe because it failed one of the conditions necessary for the pipe to be point repaired or lined.
10	Decision	> 1 LPR/75 feet?	This asks whether there is more than 1 LPR per 75 feet. More than 1 LPR per 75 feet would cost the equivalent of replacement. If this is the case, then the decision will be to "Replace" the pipe instead. If this is not the case, the pipe will continue through the process.
11	Decision	Bend/Sag Defects?	This asks whether there are bend or sag defects in the pipe. If so, then further evaluation will be needed to determine if the defect needs to be repaired, can be repaired, and if lining is feasible. If yes, then the decision will be "Renew". If no, then the pipe will continue through the process.
12	Outcome	Line or Replace (engr. review)	This outcome indicates that City staff must evaluate whether to line or replace the pipe segment based on an engineering review of the pipe defects.
13	Decision	LPR > 0?	This asks whether the pipe has any PRs that need to be addressed prior to lining. If yes, then the result will be to continue through the process. If no, the result will be a decision to "Line"
14	Decision	Severe Corrosion?	This asks whether severe corrosion exists in the pipe which would likely preclude point repairs. If yes, then the result will be to "Replace" the pipe. If no, then the result will be to "Point Repair + Line" the pipe.
15	Outcome	Line	Decision to line the pipe.
16	Outcome	Point Repair + Line	Decision to perform necessary PRs and line the pipe.

Some types of defects may be able to be addressed by a localized point repair. Defects that can be corrected by point repair are referred to as “point repair” (PR) defects. Major defects that can potentially be corrected by point repair are called “major point repair” (MPR) defects. Some major defects, such as corrosion, may be problematic to address through point repair and may require a more extensive renewal method such as lining or replacement. Once a pipe has been identified as a candidate for renewal due to the presence of one or more major defects, the possibility of renewal of the other non-major PR defects in that pipe segment is also evaluated. If there are a relatively large number of defects requiring point repair, then at some point it becomes more cost-effective to line or replace the entire pipe segment. In cases where lining of the pipe (rather than complete replacement) is being considered, then certain types of defects (e.g., offset joints, protruding laterals) may need to be repaired before the pipe can be lined. These defects are referred to as “lining point repair” (LPR) defects.

4.2.2 Decision Process Recommendations

The decision process can result in several potential outcomes, which are defined below:

- **Maintain** is a decision to maintain the pipe in its current condition as part of an ongoing maintenance program. Depending on its condition rating, subsequent CCTV inspection of the pipe after a designated time interval may be specified.
- **Point Repair** is a decision to perform a localized repair (e.g., replacement of a short section of pipe or installation of a short-segment liner)
- **Line** is a decision to perform an internal lining of a pipe using a trenchless rehabilitation method such as slip-lining or cured-in-place pipe (CIPP). This is sometimes accompanied by a point repair required prior to lining.
- **Replace** is a decision to replace an entire manhole-to-manhole pipe segment. Replacement could be done by open cut construction or pipe bursting.

4.3 Condition Assessment and Renewal Decision Results

The results of the condition assessment and sewer renewal decision process for San Bruno are presented below.

Figure 4-2 presents the pipe condition ratings expressed as the highest structural defect grade for each specific pipe. Approximately 198 segments, or about 10 percent of the inspected pipes, had at least one occurrence of a structural defect of Grade 5. Note that some very severe defects may have already been corrected by point repairs by the City following their discovery during inspection.

Figure 4-3 shows the results of the renewal decision process in terms of the indicated renewal method based on the decision process described above. **Table 4-2** summarizes these results according to the primary reason for the pipe being selected for renewal. Approximately 23 percent of the inspected sewers (463 pipe segments) are identified for some type of repair, rehabilitation, or replacement. Of these, approximately 91 percent are due to structural defects (including large offset joints). Of the segments requiring renewal, about 54 percent are identified for manhole-to-manhole rehabilitation or replacement. However, as described later in this chapter, other considerations may change the renewal method for specific pipes.

Table 4-2: Sewer Renewal Decision Analysis Results

Sewer Renewal Reason and Decision	No. of Inspected Pipe Segments	Percentage of Pipe Segments	Length of Pipe Segments (ft.)	Percentage of Total Pipe Length	Number of Localized Repairs
Major Structural Defects	373	18.7%	92,335	20.8%	255
<i>Replace</i>	173	8.7%	40,959	9.2%	0
<i>Line</i>	23	1.2%	6,538	1.5%	14
<i>Localized Repair</i>	177	8.9%	44,839	10.1%	241
Large Offset Joints	50	2.5%	10,819	2.4%	38
<i>Replace</i>	16	0.8%	3,962	0.9%	0
<i>Localized Repair</i>	34	1.7%	6,857	1.5%	38
Significant Root Intrusion	40	2.0%	11,203	2.5%	2
<i>Replace</i>	30	1.5%	8,600	1.9%	0
<i>Line</i>	10	0.5%	2,603	0.6%	2
Renewal Subtotal	463	23.2%	114,357	25.8%	295
Maintain (re-inspect in future)	1,497	75.0%	318,292	71.7%	0
Re-inspect (inspection was incomplete)	35	1.8%	10,988	2.5%	0
TOTAL^a	1,995	100 %	443,638	100 %	295

a. Does not include approximately 6,800 feet of pipes that could not be inspected due to restricted access or surcharged conditions but are planned for inspection in 2014.

4.4 Other Sewer Rehabilitation/Replacement Needs

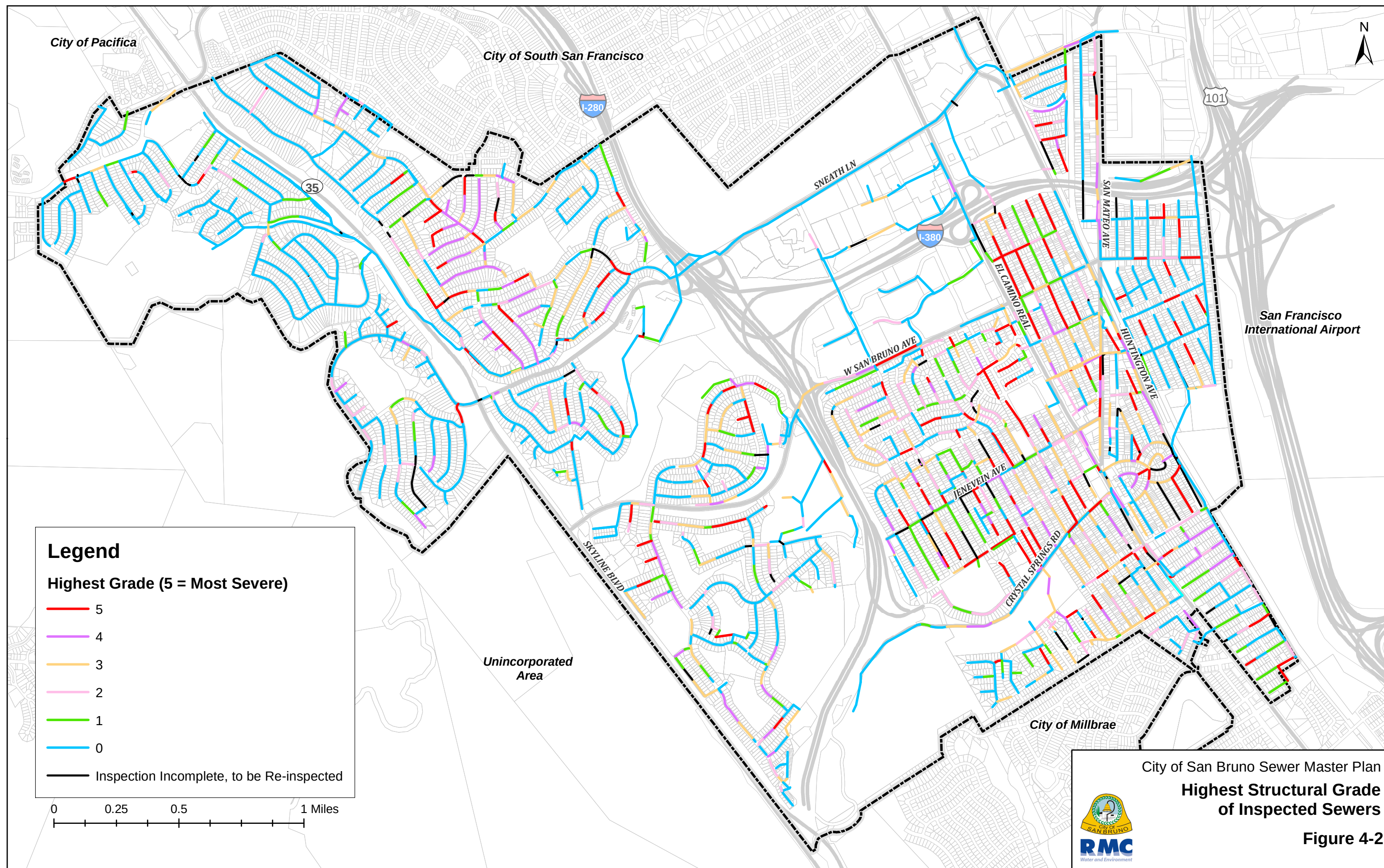
Several areas of the sewer system have been identified by City staff as having particularly burdensome maintenance issues and requirements. These areas were evaluated for the Master Plan, and improvement projects developed to address those issues. The following paragraphs describe these areas and the recommended improvements.

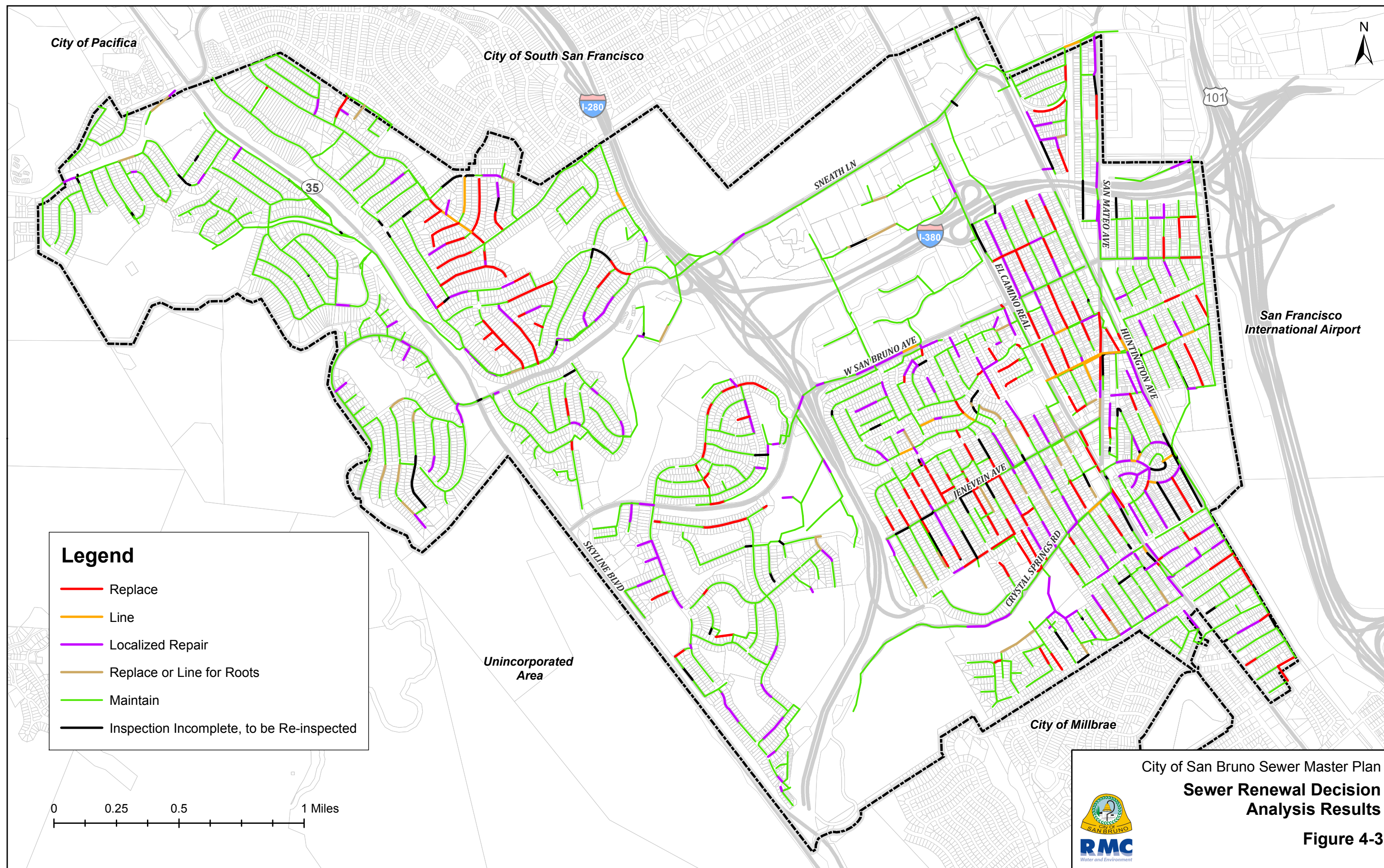
4.4.1 Trenton Drive Easement

This area consists of a sewer constructed in an easement behind the houses on Trenton Drive from approximately 500 feet west of Essex Court to north of Charleston Avenue. The existing sewer is an 8-inch diameter pipe that effectively serves as a trunk sewer for approximately 400 parcels located along Crestmoor and Trenton Drives and connecting streets from Rosewood Drive north to roughly Charleston Avenue. The sewer extends east from the Trenton Drive easement down a steep hillside and through a condominium complex on Livingston Terrace to San Bruno Avenue.

Heavy eucalyptus tree growth, resulting in significant root intrusion into the sewer, and lack of access to the sewer easement, present major maintenance issues for the City. The sewer has had previous SSOs, and maintenance staff have observed high flows in this pipe even during dry weather.

The recommended improvements for the Trenton Drive easement sewer would include rehabilitation or replacement of the easement pipes and construction of an access road in the easement. Although the hydraulic modeling indicates that an 8-inch pipe would have adequate capacity to convey the predicted peak wet weather flows, City staff recommend upsizing to a 10-inch pipe to provide an added factor of safety. The City is currently evaluating the best method to address the issues in this sewer.





4.4.2 “The Avenues”

The area of the city referred to as “the Avenues” comprises the area east of the Caltrain tracks and south of I-380. The sewer system in this area (originally known as Belle Air Park) was constructed in about 1940. The sewer slopes are very flat, and the system includes many 5-inch diameter pipes, with most of the others being 6-inch diameter. Sewers along San Mateo Avenue and 1st through 6th Avenues generally flow north and south toward the nearest east-west streets (Walnut Street, San Bruno Avenue, Pine Street, and Angus Avenue), and the sewers along these streets convey the flow east to the 36-inch trunk sewer in 7th Avenue.

Because of the flat slopes and substandard pipe sizes, the sewers in this area require cleaning on a very frequent basis (often weekly), placing heavy demand on City staff resources. Addressing this problem would require major reconstruction of the sewer system in this area. Accordingly, a new sewer layout was developed for the Avenues area that would allow for replacement of the sewers with 8-inch pipes constructed on steeper slopes. Fortunately, the depth of the 36-inch sewer in 7th Avenue would allow for connection of the new steeper sewers without the need for pumping.

4.4.3 Jenevein Avenue Easement Sewers

A number of sewers are constructed in easements in the area around Jenevein Avenue between Cedar Avenue and Cypress Avenue. Several of these easement sewers have experienced past SSOs, and in some locations, the sewer runs under existing buildings. The City is currently rehabilitating a 250-foot sewer in an easement between Cherry and Chestnut Avenues due to its location underneath and adjacent to existing structures.

Because of the topography in the area, eliminating the easement sewers would require re-routing flows to the trunk sewer in Jenevein Avenue by construction of new sewers along many of adjacent streets, as well as a new sewer in Jenevein Avenue from Cedar Avenue to Hazel Avenue, at depths of up to 30 feet or more. Some sewer laterals that may now be connected to the easement lines would also need to be re-routed. Construction of such a project would be very expensive. It should be noted that capacity improvement Project C-4 will provide capacity relief for some of these easement sewers by re-routing upstream flow to a new relief sewer in Jenevein Avenue, therefore relieving the hydraulic load on the easement trunk sewer. It is recommended that the City conduct more in-depth evaluation of alternatives for this area, including potential rehabilitation or replacement of the existing easement lines, in order to identify the most viable and cost-effective solution for this area.

4.4.4 Other Known Maintenance Problem Areas

City staff have identified a number of other sewers with known maintenance problems, primarily root intrusion, but also issues with poor access, flat slopes, and poor structural condition. These lines comprise about 40,000 feet of pipe in various locations throughout the system. Specific solutions for each pipe would ultimately be based on CCTV inspection results and an evaluation of site-specific conditions and other considerations.

4.4.5 Areas with Insufficient Pipe Slopes

City staff have noted that many pipes in the portion of the system located roughly east of El Camino Real (and in some cases as far west as Acacia Avenue) may be constructed at slopes that are insufficient for maintaining adequate flow velocities, and therefore require frequent cleaning. Although the slopes of many of these pipes may meet the standard design criterion of 2 feet per second (fps) minimum velocity at half or full pipe, many of them serve only a few blocks of connections and therefore may not have sufficient flows to achieve self-cleaning velocities under normal dry weather conditions. A number of sewer agencies require steeper slopes for smaller diameter sewers or pipes that are considered “terminal” sewers, which would be appropriate for these areas of San Bruno.

Providing increased pipe slopes in these areas would require major sewer reconstruction. Such sewer replacement would be feasible as long as downstream points of connection to the major trunk sewer network are sufficiently deep to allow the connecting sewers to be deepened. Based on the elevations of the critical sewer crossings under the Caltrain tracks from Huntington Avenue at Angus Avenue and near Florida Avenue and Cupid Row, and the new sewer bypass pipe constructed at Kains, these locations do provide several feet of elevation drop which would allow upstream slopes to be increased. Furthermore, the City would also have the opportunity to design several of the proposed capacity improvement projects, namely the San Mateo Avenue Bypass (Project C-7), downstream portions of the Crystal Springs Avenue project (Project C-6), and the San Antonio Avenue project (Project C-8) at deeper elevations, which would facilitate replacing connecting sewers at steeper slopes in these areas.

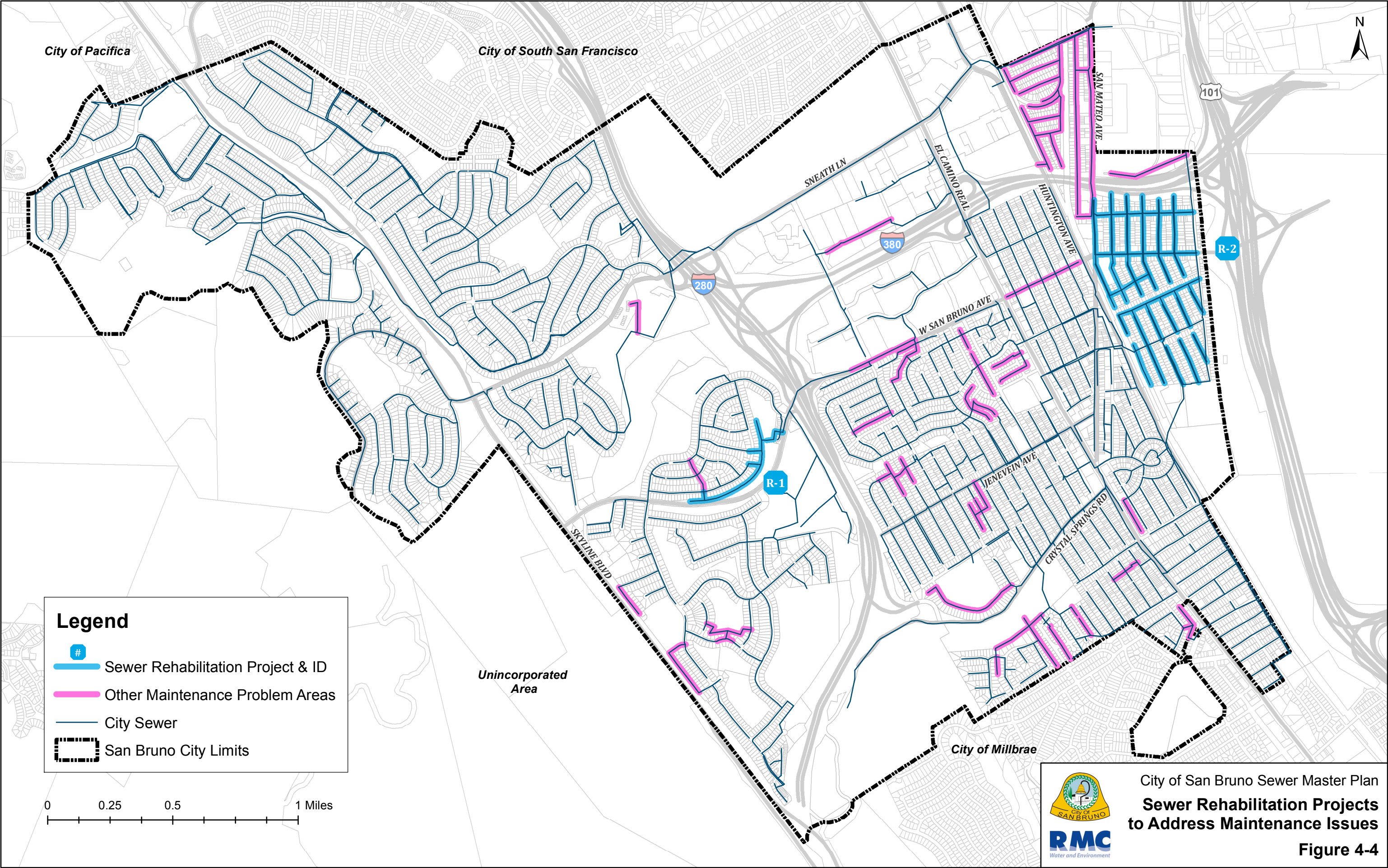
The areas of the system with insufficient pipe slopes are, for the most part, the oldest portions of the system, constructed largely in the 1920s and 1930s (as well as the Avenues area discussed above). Therefore, it is expected that many sewers in these areas would require structural rehabilitation in the next 20 to 30 years. It would therefore be possible to coordinate the re-design of these pipes as part of the City's ongoing sewer replacement program.

4.4.6 Proposed Projects

Specific projects to address the Trenton Drive sewer easement and the Avenues area were developed for inclusion in the Master Plan CIP (the solution for eliminating the sewers in the Jenevein Avenue area easements requires further study and is therefore not included at this time). **Table 4-3** provides a description of these two projects and estimated costs. Detailed descriptions and maps of the projects are also included following the capacity improvement projects in **Appendix C**. **Figure 4-4** shows the locations of these projects and other maintenance problem pipes.

Table 4-3: Additional Sewer Rehabilitation Projects

Project ID	Project Name	Description	Estimated Construction Cost	Estimated Capital Cost
R-1	Trenton Easement Improvement	Replace approx. 3,400 ft. of 6" and 8" pipe with 8" and 10" pipe in easement behind Trenton Drive to San Bruno Ave.; also construct new access road.	\$ 1,749,000	\$ 2,361,000
R-2	Avenues Area Sewer Replacement	Replace approx. 21,300 ft. of 5", 6", and 8" pipe with 8" pipe at steeper slopes or to re-route flow; install 2,200 ft. of new 8" pipe; abandon 800 ft. of 6" pipe in sewer easement.	\$ 10,947,000	\$ 14,778,000



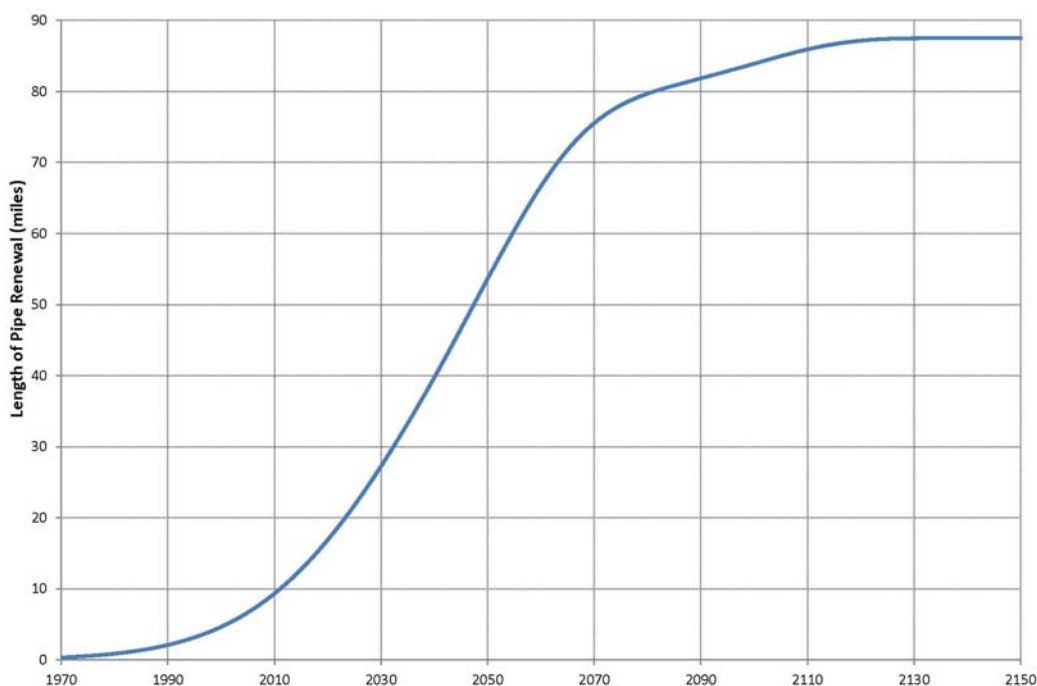
4.5 Replacement of Older Sewers

The existing sewers in the San Bruno system range in age from new to over 90 years old (see Figure 1-3). The results of the sewer condition assessments for the initial 40 percent of the system that was inspected in 2009 and 2010, which has an age distribution that is similar to that of the overall system, were analyzed to develop a statistical probability of pipe “failure” based on sewer age. In this case, “failure” was defined as the time when some sort of structural renewal (repair or replacement) would be required based on the renewal decision analysis methodology described earlier in this chapter. A probability density function (probability of pipe failure as a function of age) was developed using a Weibull distribution, a standard statistical distribution used for these types of failure analyses. Based on this probability distribution, the mean age of “failure” of existing San Bruno sewers (based on the data for the inspected pipes) was determined to be about 90 years. The one exception is for newer pipes (e.g., pipes constructed or replaced since 1970) which were not represented in significant numbers in the inspected group. It would be anticipated that those newer pipes would likely have longer service lives than the majority of the existing system, which was primarily constructed prior to 1970.

Using the probability density curve, a long-term projection of required sewer renewal was calculated. **Figure 4-5** shows the projected cumulative amount of renewal over time, and indicates that there is approximately 10 miles of sewer renewal “backlog” (deferred renewal) at the current time. (Note that while the City has been conducting sewer replacement work over the past 10 years, many of those projects were not driven by sewer condition but were constructed for purposes of increasing system conveyance capacity in areas identified in the City’s previous Master Plan.) The curve indicates that within the next 20 years, almost 30 miles of sewers (over 30 percent of the system) will likely require some type of renewal action.

While some pipes may undoubtedly last longer than the system mean life of 90 years, and some pipes may require repair or replacement at an earlier date, a plan that targets areas of the system based on age is a reasonable approach for estimating budget requirements for a long-term sewer replacement program. Based on this approach, sewers installed during the 1920s, 1930s, and early 1940s would be targeted for replacement in the next 20 years.

Figure 4-5: Cumulative Amount of Required Sewer Pipe Renewal



4.6 Recommended Sewer Rehabilitation Program

While the results of the renewal decision analysis presented in Section 4.3 indicate an appropriate method of renewal for each specific pipe in the system based primarily on its current structural condition, other issues and needs may dictate a different recommendation. For example, it may be advisable to replace an old, six-inch clay pipe that has required excessive maintenance due to root intrusion or flat slope, even though, when evaluated solely based on its current condition, only one or more localized repairs might be needed to address significant structural defects. Therefore, other factors such as sewer age, need to address maintenance issues, and need for additional hydraulic capacity (as determined by the capacity assessment presented in Chapter 3) were used to refine the sewer rehabilitation recommendations. Specifically, the following assumptions were made:

- Pipes identified for capacity improvement (“C projects”) were assumed to be replaced with a larger pipe as determined by the capacity assessment in Chapter 3.
- Pipes identified by City staff with problematic maintenance issues, including those in the Trenton Drive Easement and the Avenues areas, were assumed to be replaced.
- Pipes greater than 70 years old that are expected to reach the end of their useful lives within the next 20 years were also assumed to be replaced.
- All other pipes were assumed to be addressed using the method identified through the renewal decision analysis.

Note that pipes with Grade 4 or 5 structural defects that are recommended for replacement but not scheduled within the time frames required for repair in the City’s Consent Decree (2 years for Grade 5 defects, 5 years for Grade 4 defects) may also need spot repairs of these defects prior to scheduled replacement.

4.6.1 Sewer Rehabilitation Costs

Planning-level construction costs were estimated for sewer rehabilitation. Typical unit costs are shown in **Table 4-4**. These unit costs were based on information from the City and from similar projects contained in RMC’s cost database.

Table 4-4: Unit Construction Costs for Sewer Rehabilitation

Item	Unit	Unit Cost
Pipe Replacement ^a	\$/foot	\$206 to \$238
Point Repair	\$/repair	\$7,000
Lower Lateral Replacement	\$/lateral	\$4,000

- a. Costs shown are for existing pipe sizes in range of 6 to 12 inches (which comprise over 90 percent of the system), assuming open cut remove and replace construction and average site conditions. Costs include materials, excavation and backfill, pipe installation, traffic control, bypass pumping, surface restoration, and manhole replacement as needed. All 5- and 6-inch pipes requiring renewal were assumed to be replaced with 8-inch pipes.

The unit costs are intended to represent the long-term average cost of many projects and are based on the following assumptions:

- A very high percentage of projects will consist of smaller diameter pipes in streets with low traffic and favorable soil and groundwater conditions.

- Open-cut pipe replacement is assumed; however, trenchless technologies such as pipe bursting and CIPP could be applied as determined by local conditions.
- Manholes are assumed to be replaced whenever a manhole-to-manhole pipe segment is replaced; however, minor repair or rehabilitation may be adequate for some manholes based on actual condition.
- The projects will be over a mile in length, allowing for economies of scale.
- All lower laterals will be replaced whenever an entire manhole-to-manhole sewer segment is replaced (applied only for 15-inch and smaller sewers based on an assumed lateral spacing of 38 feet).

An additional 5 percent for mobilization and demobilization plus an additional 30 percent allowance for contingencies for unknown conditions were added to determine total estimated construction costs. Estimated capital costs include an additional allowance of 35 percent of construction cost for design engineering, administration, construction management, and legal costs. The costs reflect an Engineering News Record Construction Cost Index (ENR CCI) of approximately 10,208, which represents the January 2012 ENR CCI for the San Francisco Area.

The recommended projects, project phasing, and total estimated costs of the sewer rehabilitation program are presented in the recommended capital improvement program in Chapter 5.

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Chapter 5 Long-Range Capital Improvement Program

The previous two chapters presented the recommended capacity assurance and sewer rehabilitation/replacement (R/R) programs for improvements to the sewer system. These projects are focused on reducing the risk of sanitary sewer overflows (SSOs) due to wet weather flows exceeding system capacity, structural failures in sewer pipelines, or significant maintenance problems.

This chapter summarizes the recommended Capital Improvement Program (CIP) including estimated costs, priorities, and schedule for near-term (5-year) and long-term (20-year) improvements. Guidelines for implementation of the CIP are also presented.

5.1 Sewer System Capital Improvement Program

The recommended CIP includes capacity improvement projects, rehabilitation of sewers in poor structural condition and in areas identified as significant maintenance problems, and upgrades to several system pump stations.

The recommended capacity improvement projects were shown in Figure 3-3. The capacity improvement program includes ten projects to provide adequate capacity in the system to handle a 10-year recurrence frequency Design Storm without significant risk of overflows.

Sewer repairs and replacements to address major structural defects are considered the highest priority with respect to sewer rehabilitation because they present the greatest risk of structural failure, followed by projects to address large offset joints (which do not present a risk of structural failure but may impede inspection or cleaning equipment) and significant root intrusion. Root intrusion increases the risk of SSOs due to blockages, but can be controlled by effective maintenance (rodding and/or root foaming) in the interim period before the sewers are rehabilitated. The City has developed a root control plan as part of its overall maintenance program. Figure 4-3 showed the sewers that are recommended for repair, rehabilitation, or replacement to address major structural defects, large offset joints, and significant root intrusion. Note that many of these pipes have Grade 5 and/or Grade 4 structural defects (see Figure 4-2), which are required under the City's Consent Decree to be corrected within two or five years, respectively, or re-inspected to confirm that the condition has not changed.

Based on its 2008 pump station evaluation study, the City has identified the need for various improvements to several system pump stations, the highest priority being upgrades to the Spyglass Pump Station and a major renovation/redesign for the Olympic Pump Station and force main. A copy of the list of recommended pump station improvements from the 2008 study is included in **Appendix D** (note that some of this work, notably the upgrades to the Sharp Park Pump Station, has already been completed). As discussed previously, although the Olympic Pump Station was not included in the hydraulic model, the re-built pump station may also require increased capacity to handle the projected peak wet weather flows for the 10-year Design Storm.

In addition to addressing the capital project needs identified in the capacity improvement, structural sewer rehabilitation, and pump station upgrade plans, additional sewer rehabilitation and replacement projects have been identified to address specific areas of the system with identified maintenance problems. These projects were shown in Figure 4-4, and include improvements to the Trenton Drive easement sewer, replacement of sewers in the Avenues area of the system, and replacement of sewers in various locations identified by City staff as having specific maintenance problems.

It is also expected that over the next 20 years, additional sewer rehabilitation and replacement needs will be identified through future inspection activities. Based on projections of long-term sewer renewal needs, it is anticipated that about 30 miles of sewers, primarily the older portions of the system, would require renewal over the next 20 years. Therefore, in addition to the near-term sewer rehabilitation work estimated based on the CCTV inspection, and other specific identified projects described in Chapter 4, an

additional 15 miles of sewers in the oldest parts of the system would be targeted for replacement during this time period, at an estimated cost of about \$48 million.

The City also intends to continue efforts for overall rehabilitation of the sewer system to reduce I/I. In implementing its sewer rehabilitation program, the City may choose to conduct more extensive rehabilitation (e.g., manhole-to-manhole pipe replacement or lining rather than just localized point repairs of major defects, or include additional adjacent pipe segments in the rehabilitation work) to match these objectives and will prioritize its sewer rehabilitation program accordingly.

5.1.1 CIP Project Prioritization

A risk-based approach was used to prioritize the CIP projects. Projects were grouped into three phases, representing relative priorities: Phase 1 (years 1 to 5), Phase 2 (years 6 to 10), and Phase 3 (years 11 to 20). In general, capacity improvement projects, which are needed to reduce the risk of potentially large volume SSOs due to lack of capacity in the trunk sewer system to convey design storm peak flows, were considered high priority for construction. These projects were assigned to the first two phases of the program, with projects addressing areas of historical SSOs and/or known surcharging being assigned to Phase 1. Sewer rehabilitation and pump station projects considered critical by the City, such as the Trenton Easement Sewer Improvement and Olympic and Spyglass Pump Station Improvements, were also assigned to the highest priority group.

The remaining sewer rehabilitation work identified through the structural condition assessment and City staff's knowledge of historical maintenance problem areas was prioritized using a risk-based approach which assigns a score to each pipe in the system based on the combination of its likelihood of failure (i.e., its condition) and potential consequence of failure. Consequence of failure factors included the relative size of the area served by the pipe (as indicated by pipe diameter); potential impact on commuters (as indicated by type of road); impacts to the community (e.g., higher potential impacts in business districts and near hospitals, schools, and other community facilities); potential environmental impact in the event of a spill (as measured by distance to surface waters); and legal/regulatory compliance (potential penalties due to non-compliance with the City's Consent Decree and CDO requirements). A combination of the risk score and the number of Grade 4 and 5 structural defects per pipe were used to group the sewers identified for full-segment rehabilitation or replacement (renewal) into priority groups, as shown in **Table 5-1**.

Note that because sewer replacement in the Avenues area will involve changes to pipe depths and, in some cases, flow direction, it was not possible to prioritize that work based solely on condition or risk scores of individual pipe segments. A few pipes with high scores that can be replaced earlier without impacting the overall hydraulic configuration of the proposed system were assigned to Phase 1, with the remainder of the work in that area proposed for Phase 2 due to its relatively high cost.

Due to the requirements of the City's Consent Decree, spot repairs (or monitoring by periodic CCTV inspection) will be required for pipes with at least one Grade 5 or Grade 4 structural defect that are not proposed for full segment renewal until Phase 2. A budget for spot repairs is included in the CIP to address these pipes, as well as for other pipes for which only spot repairs were indicated as needed through the R/R decision analysis.

Figure 5-1 shows the proposed timeframe for sewer rehabilitation or replacement for pipes identified for full segment renewal (other than capacity improvements) as part of the 20-year CIP.

Table 5-1: Sewer Renewal Prioritization

Phase (Priority)	Description	No. of Pipes	Pipe Length (miles)
1	Pipes with 5 or more Grade 4 or 5 structural defects	40	1.9
	Pipes with 3 to 4 Grade 4 or 5 structural defects and high risk scores	21	1.0
	Other high priority pipes ^a	8	0.5
	Subtotal	69	3.4
2	Pipes with 3 to 4 Grade 4 or Grade 5 structural defects and lower risk scores	20	0.8
	Pipes with 1 to 2 Grade 4 or 5 structural defects	96	4.2
	Pipes with other structural defects needing repair (not Grade 4 or 5) and high risk scores	18	1.0
	Remaining Avenues area pipes	67	3.4
	Subtotal	201	9.4
3	Pipes with other structural defects needing repair (not Grade 4 or 5) and lower risk scores	48	2.4
	Other pipes with maintenance problems	137	6.2
	Other older sewers (installed early 1940s and earlier)	340	15.0
	Subtotal	525	23.6
	Total	795	36.4

a. Includes selected pipes in Avenues area and easement sewer between Cherry and Chestnut Avenues.

5.1.2 Recommended CIP

The recommended sewer system 20-year CIP is presented in **Figure 5-2** and **Table 5-2**. The table shows the projects recommended for implementation during each phase of the program and estimated capital costs. As described previously, high priority capacity improvements and sewer renewal have been assigned to the first five years of the CIP. Other projects have been assigned to CIP years 6 through 10 or 11 through 20 based on financial considerations and their relative priorities as discussed above. The CIP also includes budget for sewer spot repairs during each phase and for purchase of sewer maintenance and inspection equipment, including a new vacuum-combination unit (Vactor) and video inspection truck.

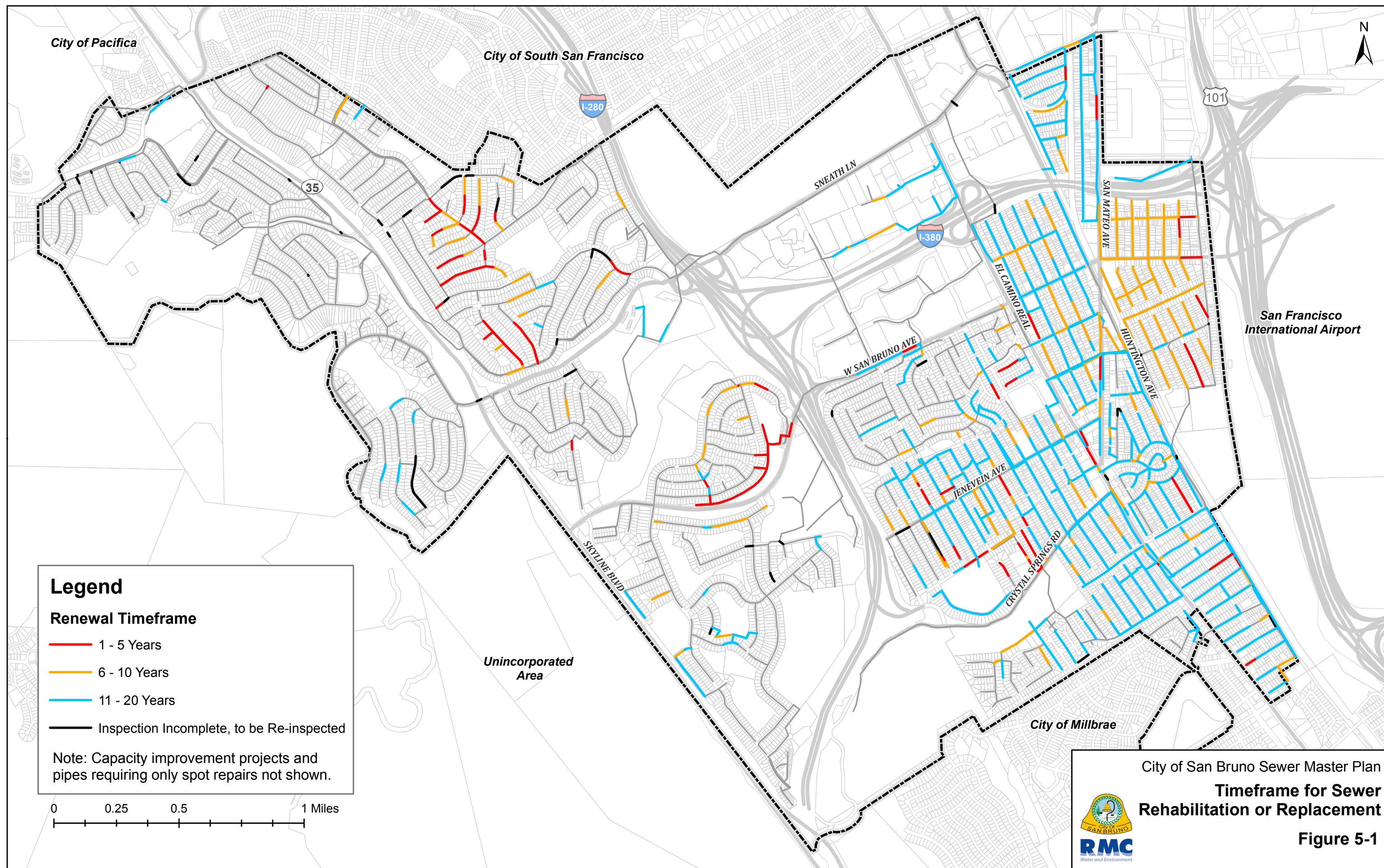
5.2 Implementation Recommendations

The following paragraphs provide guidelines for implementing the CIP.

5.2.1 Inflow Identification and Elimination

A number of areas in the system were identified with particularly high peak rates of I/I (see Table 3-4). The City could consider conducting smoke testing in the areas with the highest peak I/I rates, specifically basins 6 and 7, to identify potential sources of direct inflow into the sewer system such as roof downspouts and area drains directly connected to the sanitary sewer system, or cross-connections between the sanitary and storm drain systems. Smoke testing could also help identify potential sources of infiltration from sewer laterals and, to some extent, sewer mains and manholes. Based on the smoke testing results, the City could take steps to enforce correction of any direct inflow sources or defective laterals or cleanouts on private property, and to eliminate any direct connections in the public system that may be found.

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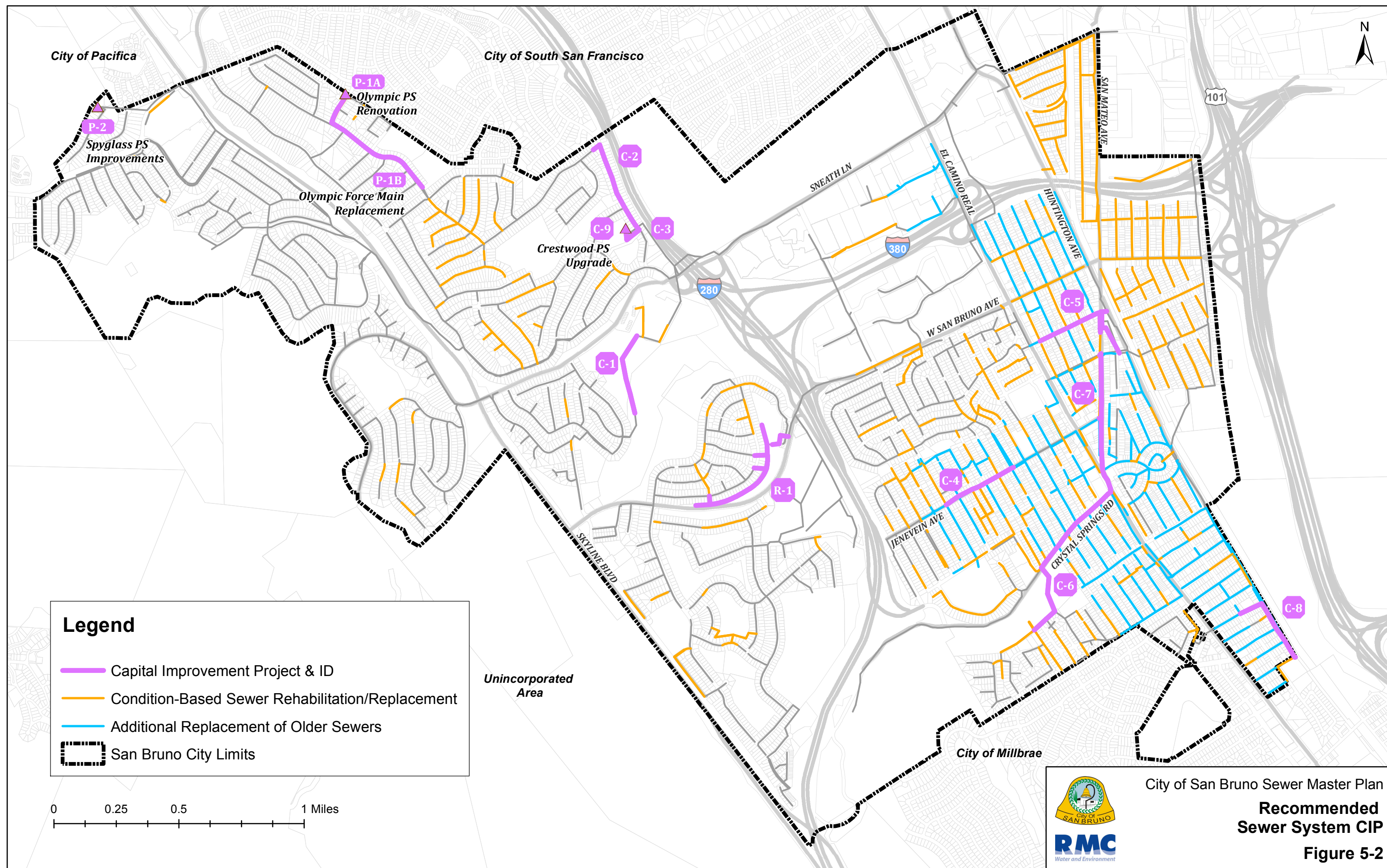


Table 5-2: Recommended Sewer System Capital Improvement Program

Project ID ^a	Project Name	Est. Capital Cost	Avg. Annual CIP Budget
Years 1-5			
C-1	Crestmoor Canyon	\$ 520,000	
C-4	Jenevein Avenue Bypass	\$ 770,000	
C-5B	Kains Ave Improvement	\$ 1,700,000	
C-6	Crystal Springs Avenue	\$ 2,190,000	
C-7	San Mateo Avenue Bypass	\$ 1,490,000	
R-1	Trenton Easement Improvement	\$ 2,360,000	
P-1	Olympic PS Renovation & Force Main Replacement	\$ 3,100,000	
P-2	Spyglass PS Improvements	\$ 1,000,000	
	Sewer Rehabilitation Based on Condition Assessment ^b	\$ 11,000,000	
	Sewer Spot Repair	\$ 1,250,000	
	Equipment Purchase	\$ 600,000	
	Subtotal - Years 1-5	\$ 26,000,000	\$ 5,200,000
Years 6-10			
C-2	Crestwood Drive	\$ 1,070,000	
C-3	Crestwood PS Influent Sewer	\$ 280,000	
C-8	San Antonio Avenue	\$ 810,000	
C-9	Crestwood PS Capacity Upgrade	\$ 460,000	
	Other Pump Station Improvements	\$ 2,000,000	
	Sewer Rehabilitation Based on Condition Assessment ^b	\$ 30,000,000	
	Sewer Spot Repair	\$ 650,000	
	Equipment Purchase	\$ 600,000	
	Subtotal - Years 6-10	\$ 36,000,000	\$ 7,200,000
Years 11-20			
	Sewer Rehabilitation Based on Condition Assessment	\$ 26,000,000	
	Additional Rehabilitation of Older Sewers	\$ 44,000,000	
	Sewer Spot Repair	\$ 500,000	
	Equipment Purchase	\$ 1,000,000	
	Subtotal - Years 11-20	\$ 71,500,000	\$ 7,200,000
TOTAL CIP		\$ 133,500,000	\$ 6,700,000

a. Projects within each phase are not prioritized.

b. Includes portions of the Avenues sewer replacement project (R-2).

5.2.2 Flow Verification

While the model was calibrated as best possible based on available data, there are areas where there was no flow meter near enough to the project deficiency location to verify the need for a project or where the model results indicated capacity issues that have not been visually observed in the system. In these cases, it is recommended that additional investigation be conducted to further verify the flows and deficiency results for those projects. Verification could be conducted by temporary flow or surcharge monitoring, or by visual observation of flow levels during storm events.

5.2.3 Parallel vs. Replacement Pipes

The capacity improvement projects identified in the Master Plan have largely been based on replacement of deficient sewers with larger diameter pipes. Capacity relief may also be provided by installation of a parallel sewer. The parallel sewer could be designed as an overflow relief pipe for wet weather flows only, thereby reducing the potential maintenance issues due to low dry weather flow velocities in a larger pipe. The decision to replace or parallel a deficient sewer should also consider the physical condition of the existing pipe and its predicted remaining useful life, the availability of pipeline corridors for new sewer construction, and operation and maintenance concerns. This decision should be coordinated with the City's on-going condition assessment program and process for identifying sewer rehabilitation or replacement needs.

5.2.4 Alternative Alignments

While efforts were made as part of the master planning work to identify potential constructability issues associated with proposed pipeline projects, some projects could be difficult to construct in existing or proposed alignments due to unknown utility conflicts, lack of available corridors for new pipelines, significant traffic or neighborhood disruption, or other factors. Therefore, evaluation of alternative alignments (e.g., construction in parallel streets) for some projects may be warranted.

5.2.5 Diversions

Several of the recommended capacity improvement projects consist of diversions of flow from a capacity-deficient sewer to an existing or new sewer with available capacity. Under dry weather conditions, however, this could result in very low flow velocities in the sewers downstream of the diversions, which could cause potential problems with sediment or grease deposition and odor. Therefore, before implementation, diversion projects should be evaluated to identify potential low velocity issues. Potential solutions might include channeling of the flow in the diversion manhole or constructing overflow weirs to allow dry weather flow to continue downstream in the original flow direction. In some cases, more frequent cleaning of the potential problem areas might be required.

5.2.6 Pre-Design Activities

Pre-design work for all projects would include topographic surveys as needed to confirm new pipeline alignments, geotechnical investigations, utility research, constructability reviews, permit applications as needed, and refinement of project cost estimates.

5.2.7 Model and Master Plan Updates

This Master Plan has been prepared to facilitate both use of the information in capital improvement project planning and design, as well as to allow the City to update the Plan in the future as the need arises. The model should be kept up-to-date with new sewer improvements, rehabilitation projects, and changes in sewer system flows. The Master Plan should be updated whenever there are major changes in planning assumptions, or at a minimum every five to ten years.